# IIT Mandi Courses

December 24, 2024

## Contents

# 1 CAIR Courses

## 1.1 AR 501/ ME 452: Robot Kinematics, Dynamics, and Control

**Course Code: AR501/ ME452**

**Course Name : Robot Kinematics, Dynamics, and Control**

L-T-P-C : 3-1-0-4
Intended for : UG, PG and Ph.D
Prerequisite : Consent of faculty advisor
Mutual Exclusion : None
Approval: 50th BoA

**Course Contents:**

- **Introduction to Robotics:** Basic definitions, mechanism, degree of freedom, Rigid Body Motions - Fundamentals, Classification of robots, actuators, sensors, and control systems. (3 hours)
- **Kinematics:** Tracking Rigid Bodies (position and orientation), Coordinate transformation, Differential Kinematics, Kinematic Chains - Forward Kinematics (FK), Inverse Kinematics (IK), Differential Manipulator Kinematics. (11 hours)
- **Dynamics:** Rigid Body Dynamics - Dynamics of Constrained Particles, Dynamics of a Rigid Body; Manipulator Dynamics - Dynamics of Serial Manipulators, Manipulator Dynamics with Constraints. (11 hours)
- **Trajectory generation:** Determining the joint variables for desired trajectory. (5 hours)
- **Control:** Fundamentals of Control - Linear Time Invariant Systems with Single Input and Output, Feedback Control and Stability, PID Controller, State Estimation in Feedback Systems; Manipulator Control - Local vs Centralized Motion Control Strategies, Indirect vs Direct Force Control Strategies. (12 hours)

**Laboratory/practical/tutorial Modules:**

Kinematics, Dynamics, Trajectory generation, Control

**Textbooks:**

1. Kevin M. Lynch and Frank C. Park, **Modern Robotics: Mechanics, Planning, and Control**, Cambridge University Press, 2017.
2. Craig John J., **Introduction to robotics: Mechanics & Control**, 3rd Edition, Pearson, 2008.
3. M. W. Spong and M. Vidyasagar, **Robot Dynamics and Control**, John Wiley, 1989.

4. Murray R., Li Z., and Sastry S., **A Mathematical Introduction to Robotic Manipulation**, CRC Press.

5. Siciliano B., Sciavicco L., Villani L. and Oriolo G., **Robotics: Modeling, Planning and Control**, Springer.

**References:**

1. Ellis G., **Control System Design Guide**, Elsevier.

2. Jazar R. N., **Theory of Applied Robotics: Kinematics, Dynamics, and Control**, Springer.

3. Moon F., **Applied Dynamics**, Wiley-VCH.

4. Astrom K. and Murray R., **Feedback Systems: An Introduction for Scientists and Engineers**, Princeton.

5. Friedland B., **Control System Design: An Introduction to State-Space Methods**, Dover.

## 1.2 AR 502: Advanced Design Practicum

**Course Number : AR 502**

**Course Name : Advanced Design Practicum**

Credit Distribution : 3-0-2-4
Intended for : PG and PhD
Prerequisite : Consent of faculty advisor
Mutual Exclusion : None
Approval: 50th BoA

**Course Contents:**

- **Introduction:** Engineering design - How to select an engineering problem, stages of solving a problem, documentation in Engineering, Machine and a robot - Different aspects of robotics, current problems in robotics. Drives and motion, pneumatic, hydraulic systems, clutch and brake. (3 hours)
  - Practical 1: Microelectronics, onboard computer, IoT, embedded electronic and materials to be used in the lab Manufacturing techniques - additive and subtractive manufacturing. (3 hours)
- **Design of Mechanical Systems:** Introduction to CAD by 3D modeling software, Drawing of parts and assemblies, Computer-Aided Manufacturing and prototyping, Brief Introduction to robotic systems, Joints and transformations on ROS. (5 hours)
  - Practical 2: Introduction to Mechanical assembly, bill of materials, 3D modeling software and design of parts and assemblies and Static Stress Simulation. (3 hours)
  - Practical 3: Simulation in ROS environment (3 hours)

- **Integration of Intelligent Control:** Sensor and Actuator selection and sizing, Determination of Power Source, Design of Power distribution, microcontroller, and motor driver circuits, Developing PCB boards and feasibility testing, Introduction to standard electronic connectors and American Wire Gauge. (7 hours)
  - Practical 4: Sizing of sensors motors and linear actuators and integration into mechanical design. (3 hours)
  - Practical 5: Circuit Design using CAD tool and making PCBs manually and demonstration of CNC based PCB printing. (3 hours)
- **Programming and Signals:** Introduction to Programming; procedural vs object-oriented programming, Object-Oriented programming in practice, Signals; communication via PWM, UART, Design of hardware and software interrupts. (6 hours)
  - Practical 6: Introduction to Programming; procedural vs object-oriented programming. (3 hours)
  - Practical 7: Signals; communication via PWM, UART; connecting two microcontrollers. (3 hours)
  - Practical 8: Design of hardware and software interrupts. (3 hours)
- **Integration of Compute and networks:** Introduction to microcontroller coding and interfacing with the ros API, Introduction to ROS packages and their deployment, Introduction to IoT and IP sending receiving packets on client-server networks, Control of robotic platforms over IP, Deployment of real-time decision pipelines on the robot. (6 hours)
  - Practical 9: Intro to rosserial and connecting microcontrollers to ROS. (3 hours)
  - Practical 10: Introduction to esp8266; control via blynk. (3 hours)
  - Practical 11: Deployment of conditional path planning on robot and testing. (3 hours)
- **Final project:** Project towards design and development of functional Robotic system.

**Textbooks:**

1. Owen Bishop, **Robot Builder's Cookbook**
2. Gaurav Verma, **Autodesk Fusion 360**
3. Godfrey C. Onwubolu, **Introduction to SOLIDWORKS: A Comprehensive Guide with Applications in 3D Printing**

**References:**

1. Morgan Quigley, **Brian Gerkey and Programming Robots with ROS**

## 1.3 AR 503: Mechatronics

Course Number : AR 503
Course Name : Mechatronics
Credit Distribution : 3-0-0-3
Intended for : UG, PG and PhD
Prerequisite : Consent of faculty advisor
Mutual Exclusion : None
Approval: 50th BoA

**Course Contents:**

- **Introduction to Mechatronics:** Introduction, Examples of Mechatronic systems, Electric circuits and components, Review of fundamentals of Electronics and its applications, Number systems: binary, hexadecimal and Review of C programming, CNC machines and Industrial Robots. (4 hours)
- **Mechatronics elements:** Sensors and transducers, Displacement, Position & Proximity Sensors, Force, Fluid pressure, Liquid flow sensors, temperature, light sensor, Acceleration and, Vibration measurement, Performance terminology of sensors, Semiconductor sensors and micro-electromechanical systems (MEMS). (8 hours)
- **Microprocessors, microcontrollers, and Closed-loop controllers:** Digital circuits, Microprocessors, Microcontrollers, Programming of Microcontrollers, P, I, PID Controllers, Digital Controllers, Program Logic Controllers, Input/output & Communication systems, Fault finding. (4 hours) Signal conditioning: Introduction to signal processing, Op-Amp as a signal conditioner, Analog to Digital Converter, and Digital to Analog Converter. (4 hours)
- **Actuators, Drives, and mechanisms:** Stepper motors, Actuators, Motor sizing, Power transmission: gears (rack and pinion, spur, planetary, worm, bevel, crown, harmonic) and belt drives; Ball screws, linear motion bearings, cams, systems controlled by camshafts, electronic cams, indexing mechanisms, tool magazines, and transfer systems. Torque, speed, and power equations, efficiency, and inertia. (6 hours)
- **Hydraulic and Pneumatic system:** Flow, pressure, direction control valves, actuators, and supporting elements, hydraulic power packs, pumps, and design of hydraulic circuits. Pneumatic system production, distribution and conditioning of compressed air, system components and graphic representations, design of systems. (6 hours)
- **Modelling and system response:** Mechanical, Electrical, Fluid system modelling, Dynamic response, Transfer function and frequency response. (6 hours)
- **Final project on mechatronics:** Group project towards design and fabrication of functional Mechatronics systems. (4 hours)
- **Laboratory/practical/tutorial Modules:** Microprocessors, microcontrollers, and Closed-loop controllers, Signal conditioning, Actuators, Drives, and mechanisms, Hydraulic and Pneumatic system, Modelling and system response.

**Textbooks:**

1. Bolton, William, **Mechatronics: electronic control systems in mechanical and electrical engineering**, Pearson Education.
2. Mahalik, Nitaigour, Premchand, **Mechatronics**, Tata McGraw-Hill.
3. Bishop, Robert H, **Mechatronics: an introduction**, CRC Press.
4. Devdas Shetty and Richard A. Kolk, **Mechatronics system**, Cengage Learning.
5. G. Hegde, **Mechatronics**, Jones and Bartlett.

**References:**

1. G.W. Kurtz, J.K. Schueller, P.W. Claar II, **Machine design for mobile and industrial applications**, SAE.
2. HMT ltd. **Mechatronics**, Tata Mcgraw-Hill.
3. T.O. Boucher, **Computer automation in manufacturing - an Introduction**, Chappman and Hall.
4. Kevin Lynch, Nicholas Marchuk, Matthew Elwin, **Embedded Computing and Mechatronics with the PIC32 Microcontroller**, Newnes.
5. R. Iserman, **Mechatronic Systems: Fundamentals**, Springer.
6. Musa Jouaneh, **Fundamentals of Mechatronics**, Cengage Learning.

## 1.4 AR 504: Robot Programming

Course Number : AR 504
Course Name : Robot Programming, Modeling, and Simulation
Credit Distribution : 2-0-2-3
Intended for : UG, PG and PhD
Prerequisite : Consent of faculty advisor
Mutual Exclusion : None
Approval: 50th BoA

**Course Contents:**

- **ROS (Robot operating system):** Prerequisites, basic structure, ROS master, ROS node, ROS topics, ROS msg, ROS bag record and play, rqt graph, rqt plot, ROS publisher, and subscriber node. (10 hours)
- **URDF modeling:** Basic structure of urdf file, robot links and joints and its representation inside the urdf, writing urdf from scratch for a robot of interest, urdf test, and visualization. (12 hours)

- **Robot simulation environments:** Brief description of various simulation platforms for robots. Demonstration in PyBullet and Gazebo. Import plane with zero and nonzero orientation. Import urdf of interest and fetch joint and pose info. Test the movement of interest in context to the model. Import multiple models in the simulation environments. (10 hours)

- **Robot control in the simulation environment:** Automatic heading correction, robot navigation to the goal, and visual servoing. Case studies and course projects. (10 hours)

- **Laboratory/practical/tutorial Modules:** ROS, URDF modelling, Robot simulation environments, Robot control in the simulation environment

**Textbooks:**

1. Joseph L., **Mastering ROS for Robotics Programming: Design, build, and simulate complex robots using the Robot Operating System**.

2. Quigley, Morgan, Brian Gerkey, and William D. Smart, **Programming Robots with ROS: a practical introduction to the Robot Operating System**, O'Reilly Media, Inc., 2015.

**References:**

1. **ROS Tutorials** by ROS.org

2. PyBulletQuickguide: https://usermanual.wiki/Document/pybullet20quickstart20guide.479068914

## 1.5 AR 505: Principles of Robot Autonomy

Course Number : AR 505
Course Name : Principles of Robot Autonomy
Credit Distribution : 3-0-0-3
Intended for : UG, PG and PhD
Prerequisite : Consent of faculty advisor
Mutual Exclusion : None
Approval: 50th BoA

**Course Contents:**

- **Introduction:** Brief overview along with motivation and potential applications. (1 hours)

- **Robotic Perception:** Robotic sensors, robotic sensor calibration and its importance, robot vision vs computer vision, robot localization, artificial neural networks for robot perception. (16 hours)

- **Robot Motion Planning:** Overview, Configuration space, Free space, Target space, obstacle space, traditional and machine learning based planning algorithms. (14 hours)

- **Robot control:** P, PI, PD and PID controller, visual servoing, and multi-robot control. (11 hours)

**Text Books:**

1. Choset, Howie, Kevin M. Lynch, Seth Hutchinson, George A. Kantor, and Wolfram Burgard, **Principles of robot motion: theory, algorithms, and implementations**, MIT press, 2005.

2. Apolloni, Bruno, et al., (eds.), **Machine learning and robot perception**, Vol. 7. Springer Science & Business Media, 2005.

**References:**

1. Cuesta, Federico, and Aníbal Ollero, **Intelligent mobile robot navigatio**,. Vol. 16. Springer Science & Business Media, 2005.

2. Steve LaValle, Planning Algorithms, Cambridge Univ. Press, 2006.

3. Mouha, Radouan Ait, Deep Learning for Robotics, **Journal of Data Analysis and Information Processing,** 9.02:63, 2021.

## 1.6 AR 506: Cognitive Robotics

Course Number : AR 506
Course Name : Cognitive Robotics
Credit Distribution : 3-0-0-3
Intended for : UG, PG and PhD
Prerequisite : Consent of faculty advisor
Mutual Exclusion : None
Approval: 50th BoA

**Course Contents:**

- **Introduction:** Introduction to Cognitive Robotics and Human-Robot Interaction, Smart Materials. (6 hours)

- **Brain physiology and neural signal transmission:** Architecture of the Brain, Nerve cells, Synchronization Models, Electroencephalography. (6 hours)

- **Intelligence architecture:** Theories of Intelligence, Kuramoto Model, Child-Robot Interaction. (10 hours)

- **Artificial cognitive systems:** Cognitive architectures, The CRAM cognitive architecture. (10 hours)

- **Functional programming:** Robot manipulation and task-level robot programming using ROS, The CRAM plan language. (10 hours)

**Textbooks:**

1. Cangelosi A. and Asada M., **Cognitive Robotics**, The MIT Press, 2022.
2. Samani H., **Cognitive Robotics**, CRC Press, 2015.

**References:**

1. Purves D., et al., **Neuroscience**, Sinauer Associates, 2004.
2. Pfeifer R. and Bongard J., **How the body shapes the way we think-A New View of Intelligence**, MIT Press.
3. Raol J. R., and Ayyagari R., **Control Systems: Classical, Modern, and AI-Based Approaches**, CRC Press.

## 1.7 AR 507: Probabilistic Robotics

Course Number : AR 507
Course Name : Probabilistic Robotics
Credit Distribution : 3-0-0-3
Intended for : UG, PG and PhD
Prerequisite : Consent of faculty advisor
Mutual Exclusion : None
Approval: 50th BoA

**Course Contents:**

- **Introduction to Probability Theory and Linear Algebra:** Sample space and events, Conditional probability, Expected value and variance. Uniform, normal, exponential random variables. Systems of linear equations, Linear dependence and independence, Operations with Matrices, Eigenvalues and eigenvectors. (6 hours)
- **Robot Motion:** Probabilistic kinematics, Velocity motion model, Odometry motion model. (4 hours)
- **Sensors for robotics:** Coordinate frame transformations, camera model, camera calibration, Sonar, Lidar, GPS, etc. (5 hours)
- **Recursive State Estimation:** Bayesian filter, Kalman filter (KF), EKF, & Particle filter. (11 hours)
- **Robot Localization, Mapping, and SLAM:** Localization problems, Markov localization, EKF localization, Grid localization, Monte Carlo localization, Occupancy grid mapping algorithm, EKF SLAM. (16 hours)

**Textbooks:**

1. Sebastian Thrun, Wolfram Burgard and Dieter Fox, **Probabilistic Robotics**, MIT press, 2005.
2. Papoulis A. and Pillai S. U., Probability, **Random Variable, and Stochastic Processes**.

**References:**


1. **Probabilistic Robotics**: http://www.probabilistic-robotics.org/
2. Strang G., **Linear Algebra and its Applications**.
3. Ron Larson, **Calculus: Elementary Linear Algebra**, 8th Edition, Cengage Learning, 2017.


## 1.8 AR 508: Marine Robotics

Course Number : AR 508
Course Name : Marine Robotics
Credit Distribution : 3-0-0-3
Intended for : UG, PG and PhD
Prerequisite : Consent of faculty advisor
Mutual Exclusion : None
Approval: 50th BoA

**Course Contents:**

- **Types of Marine robots and applications:** Introduction to the types of marine robots, Classification based on applications, Approach for deployment, operation and maintenance of marine robots such as surface vehicles and underwater vehicles (ASVs, AUVs, ROVs, underwater gliders and floats). (4 hours)
- **Vehicle design:** Mechanical design of marine robots, structures, materials, pressure hull, Vehicle parameters and performance metrics including pressure, buoyancy, stability, ballasting, propulsion, power, speed, range, and cost of transport (COT). (8 hours)
- **Vehicle mathematical modelling:** Classification of models, Rigid body Kinematics, frame transformations between body, flow, and non-accelerating frames, Euler angles, quaternions, Rigid-Body Kinetics, Equations of motion (Linear and nonlinear), Hydrostatics, maneuvering model, coupled motion model, environmental disturbances. (8 hours) Navigation: Marine Sensors and navigational strategies for localization using dead-reckoning, SLAM and uncertainty/probabilistic approaches, and Observer-based design. (6 hours)
- **Guidance:** Path planning algorithms and path following strategies include line of sight guidance strategies, pure pursuit guidance, constant bearing guidance, and trajectory tracking. (6 hours)
- **Control:** Modelling and control using PID controllers, open-loop stability, and state feedback control, maneuverability system architectures, and actuator models. (6 hours)
- **Final project:** Student project towards modelling of a marine robot using MATLAB. (4 hours)

**Textbooks:**

1. **Handbook of Marine Craft Hydrodynamics and Motion Control**, 2nd Edition, Wiley.

2. Beard, R. W. and T. W. McLain, Small **Unmanned Aircraft: Theory and Practice**, Princeton University Press.

3. Moore S.W., Bohm H., and Jensen V., **Underwater Robotics: Science, Design, and Fabrication**.

**References:**

1. Triantafyllou MS, Franz S. Hover, **Maneuvering and control of marine vehicles**, Lecture Notes, Department of Ocean Engineering Massachusetts Institute of Technology Cambridge, Massachusetts USA.

2. Antonelli, G., **Underwater robots In Encyclopedia of Systems and Control,** (pp. 2384-2388), Cham: Springer International Publishing.

## 1.9 AR 509: Deep Learning for Robotics

Course Number : AR 509
Course Name : Deep Learning for Robotics
Credit Distribution : 3-0-2-4
Intended for : PG and PhD
Prerequisite : Consent of faculty advisor
Mutual Exclusion : None
Approval: 50th BoA

**Course Contents:**

- **Introduction to Deep Learning for Robotics:** Supervised learning for robotics applications, Backpropagation to train neural networks, Overfitting, and Neural network architecture for several robot functions. (6 hours)

- **Neural networks for robot motion control:** Neural networks for inverse kinematic motion calculation, Training with techniques such as dropout and regularization, Solving high-dimensional problems by dimension reduction with principal component analysis (PCA). (10 hours)

- **Reinforcement Learning:** Write a reinforcement learning agent with PyTorch, Overview of Reinforcement Learning Coach - a state-of-the-art reinforcement learning framework. (10 hours)

- **Temporal data and neural networks:** Backpropagation through time and vanishing or exploding gradients, Variations of recurrent neural networks (RNN), and LSTMs to implement them in PyTorch. (10 hours)

- **Laboratory/practical/tutorial Modules:** Neural networks for robot motion control, Reinforcement Learning, Temporal data and neural networks. (6 hours)

**Textbooks:**

1. Iosifidis A. and Tefas A., **Deep Learning for Robot Perception and Cognition**, Elsevier.

2. Arana-Daniel N., Alanis A. Y., Lopez-Franco C., **Neural Networks for Robotics: An Engineering Perspective**, CRC Press.

3. Nath V. and Levinson S. E., **Autonomous Robotics and Deep Learning**, Springer.

**References:**

1. Sutton R. and Barto A., **Reinforcement Learning: An Introduction**, MIT Press.

2. Russell S. and Norvig P., **Artificial Intelligence: A Modern Approach**, Prentice Hall.

## 1.10 AR 510: Underactuated Robotics

Course Number : AR 510
Course Name : Underactuated Robotics
Credit Distribution : 3-0-0-3
Intended for : UG, PG and PhD
Prerequisite : Consent of faculty advisor
Mutual Exclusion : None
Approval: 50th BoA

**Course Contents:**

- **Introduction to Underactuated Robotics:** Motivation, Fully-actuated vs Underactuated systems, Feedback equivalence, Input and State constraints. (6 hours)

- **Robot dynamics and model-based control:** Nonlinear dynamics with a constant torque, Acrobots, Cart-poles, and Quadrotors. (6 hours)

- **Dynamic programming:** Lyapunov analysis; Trajectory optimization, Trajectory stabilization; Policy search; Multibody parameter estimation, Formulating control design as an optimization. (6 hours)

- **Simple models of walking and running:** Limit cycles, Simple models of walking such as Rimless wheel, Compass gait, Kneed walker, Curved feet, Simple models of running such as Spring-loaded inverted pendulum (SLIP), Hopping robots, Toward human-like running. (8 hours)

- **Planning and control through contact:** Sampling-based motion planning, Complete motion planning, Feedback motion planning, Planning as Combinatorial + Continuous Optimization. (8 hours)

- **Stochastic dynamics:** Stochastic/ robust control, Master equation, Stationary distribution, Costs and constraints for stochastic systems, Finite Markov Decision Processes, From linear models to deep models. (8 hours)

**Textbooks:**

1. Tedrake R., **Underactuated Robotics: Algorithms for Walking, Running, Swimming, Flying, and Manipulation**, MIT Press.

**References:**

1. Xin X. and Liu Y., **Control Design and Analysis for Underactuated Robotic Systems**, Springer.

2. Birglen L., Laliberte T., and Gosselin C., **Underactuated Robotic Hands**, Springer.

## 1.11 AR 511: Autonomous Mobile Robots

Course Number : AR 511
Course Name : Autonomous Mobile Robots
Credit Distribution : 3-0-0-3
Intended for : UG, PG and PhD
Prerequisite : Consent of faculty advisor
Mutual Exclusion : None
Approval: 50th BoA

**Course Contents:**

- **Robot locomotion:** Types of locomotion using hopping, leg, wheel. Types of mobile robots: ground robots (wheeled and legged robots), aerial robots, underwater robots, and water surface robots. Discussion on stability, maneuverability, and controllability. (4 hours)

- **Robot kinematics and dynamics:** Forward and inverse kinematics, degree of freedom and maneuverability, holonomic and nonholonomic constraints, kinematic models of wheeled and legged robots, dynamics simulation, Classification of models, Rigid body dynamics, Lagrange-Euler and Newton-Euler methods. Computer-based dynamic (numerical) simulation of different robots. (12 hours)

- **Sensors for mobile robot navigation:** Proprioceptive/Exteroceptive and passive/active sensors, performance measures of sensors, sensors for mobile robots like global positioning system (GPS), position sensor, gyroscope, accelerometer, magnetic compass, inclinometer, Doppler effect-based sensors, laser scanner, infrared rangefinder, visual and motion; uncertainty in sensing and filtering. (6 hours)

- **Navigation:** Localization, error propagation model, Probabilistic map-based localization, Autonomous map building, Simultaneous localization and mapping (SLAM). (6 hours)

- **Motion and path planning:** Line of sight guidance strategies, Collision free path planning, sensor-based obstacle avoidance, and trajectory tracking. Path planning algorithms based on A-star, Dijkstra, Voronoi diagrams, and probabilistic roadmaps (PRM), rapidly exploring random trees (RRT), Markov Decision Processes (MDP), and stochastic dynamic programming (SDP). (8 hours)

- **Modern mobile robots:** Swarm systems, Cooperative and collaborative systems, and autonomous mobile manipulation. (4 hours)

- **Final project:** Student project towards design, fabrication, and programming of a mobile robot. (4 hours)

**Textbooks:**

1. Siegwart, Roland, Illah Reza Nourbakhsh, and Davide Scaramuzza, **Introduction to autonomous mobile robots**, MIT press, 2011.

2. Dudek, Gregory, and Michael Jenkin, **Computational principles of mobile robotics**, Cambridge university press, 2010.

3. Melgar, E. R., Diez, C. C., **Arduino and Kinect Projects: Design, Build, Blow Their Minds**.

**References:**

1. Peter Corke, Robotics, **Vision and Control: Fundamental Algorithms in MATLAB**, Springer Tracts in Advanced Robotics.

2. S. M. LaValle, **Planning Algorithms**, Cambridge University Press, 2006. (Online)

3. Thrun, S., Burgard,W., and Fox, D., **Probabilistic Robotics**, MIT Press.

4. H. Choset, K. M. Lynch, S. Hutchinson, G. Kantor, W. Burgard, L. E. Kavraki, and S. Thrun, **Principles of Robot Motion: Theory, Algorithms and Implementations**, PHI Ltd.

## 1.12 AR 512: Rapid Prototyping and Tooling

Course Number : AR 512
Course Name : Rapid Prototyping and Tooling
Credit Distribution : 3-0-2-4
Intended for : UG, PG and PhD
Prerequisite : Consent of faculty advisor
Mutual Exclusion : None
Approval: 50th BoA

**Course Contents:**

- **Product Development**: Manufacturing processes classification, Different manufacturing systems. Introduction, History, Definitions, and evolution of Rapid Prototyping. Need of RPT in context to batch production, FMS, CIM, and its application. Introduction & Need for the compression in Product development Growth of RPT Industry and Classification of RPT. (6 hours)

- **Stereolithography (SLA)**: System and principles, process parameters, SLA process details, data preparation, data files of SLA, machine details, and applications of

SLA. (4 hours) Selective Laser Sintering (SLS): Introduction, SLS operation principle, and machine types, process parameters, and data preparation for SLS. (4 hours)

- **Fused Deposition Modelling (FDM) and Solid Ground curing (SGC)**: Introduction, FDM principles, process parameters, path generation & application of FDM. Principle of SGC operation, SGC machine details and application. (6 hours)
- **Laminate Object Manufacturing (LOM)**: Operation principle, materials, process details & application, Concepts modelers – Principle, Thermal Jet Printer, Sander model maker – Explanation, 3-D Printer. (4 hours)
- **Rapid tooling**: Indirect rapid tooling, Silicon Rubber tooling, Aluminium filling epoxy tooling, Spray metal tooling, Direct rapid tooling, Quick cast process, copper Polyamide, DMILS – explanation, sand casting tooling, soft tooling & hard tooling. (6 hours)
- **Software for RPT**: STL files, Overview of Solid view, software communicator, Internet-based software, Collaboration tools. (4 hours)
- **Other aspects of Rapid Manufacturing**: Introduction, factors influencing accuracy, Repetitive masking, and deposition. Beam interference solidification, Holographic interference solidification special topics on RPT using metallic alloys. Programming in RPT modelling, Slicing, Internal Hatching, Surface skin films, and support structure. Data preparation errors, part building errors, errors in finishing, and influence of build orientation. (6 hours)
- **Final project**: Student project towards RPT using 3D modelling software. (2 hours)
- **Laboratory/practical/tutorial Modules**: Rapid tooling, Software for RPT

**Textbooks:**

1. Chua. C.K, **Rapid Prototyping**, Wiley.
2. Amitav Ghosh, **Introduction to Rapid Prototyping**, Northwest Publication, New Delhi.
3. Frank W. Liou, **Rapid Prototyping and Engineering Applications**, CRC Press.
4. Burns. M, **Automated Fabrication**, PHI.
5. Hilton. P.D. et al., **Rapid Tooling**, Marcel Dekker.

**References:**

1. Jacobs P.F, **Stereolithography and other Rapid Prototyping and Manufacturing Technologies**, ASME.
2. Beaman. J.J et. al., **Solid freeform fabrication**, Kluwer.

3. Pham. D.T and Dimov. S.S, **Rapid Manufacturing; the Technologies and Application of RPT and Rapid tooling**, Springer, London.

4. Gibson, I., Rosen, D.W. and Stucker, B, **Additive manufacturing technologies** (Vol. 17), Springer, 2014.

5. Hopkinson, N., Hague, R. and Dickens, P. (eds.), **Rapid manufacturing: an industrial revolution for the digital age**, John Wiley & Sons, 2006.

6. Pham, D. and Dimov, S.S, **Rapid manufacturing: the technologies and applications of rapid prototyping and rapid tooling**, Springer Science & Business Media, 2012.

7. Kamrani, A.K. and Nasr, E.A., **Engineering design and rapid prototyping**, Springer Science & Business Media.

8. Gebhardt, A., **Understanding additive manufacturing**.

## 1.13 AR 513: Unmanned Aerial Systems (UAS)

Course Number : AR 513
Course Name : Unmanned Aerial Systems (UAS)
Credit Distribution : 3-0-0-3
Intended for : UG, PG and PhD
Prerequisite : Consent of faculty advisor
Mutual Exclusion : None
Approval: 50th BoA

**Course Contents:**

- **Introduction**: Historical background of UAS, Current trends in UAS, Introduction to Unmanned Aerial Robotics (UAVs) and quadrotors. (5 hours)

- **Geometry and Mechanics**: Frame Rotations, Representations and Coordinate Systems, Kinematics and dynamics of system model, Derivation of Aerodynamic Forces. (6 hours)

- **Perception and State Estimation**: Sensors on-board, Inertial sensing, Concepts of Kalman Filtering, Inertial Navigation System design. (8 hours)

- **Flight Control**: Planar and three-dimensional dynamic models, Linear controllers for these models, Proportional Integral Derivative control, Linear Quadratic Regulator control, Linear Model Predictive Control. (8 hours)

- **Path Planning**: Collision-free Navigation, Structural Inspection Path Planning, Target Follow, Coordinated Motion, Collaborative Aerial Manipulation, Autonomous Exploration. (7 hours)

- **Final project**: Student project towards simulation and design of UAS. (8 hours)

**Textbooks:**

1. Paul Gerin Fahlstrom, Thomas James Gleason, **Introduction to UAV Systems**, Wiley.
2. Reg Austin, **Unmanned Aircraft Systems: UAVS Design, Development and Deployment**, Wiley.
3. R. Kurt Barnhart, Douglas M. Marshall, Eric Shappee, **Introduction to Unmanned Aircraft Systems**, CRC Press.

**References:**

1. Kenzo Nonami et. al., **Autonomous Flying Robots: Unmanned Aerial Vehicles and Micro Aerial Vehicles**, Springer.
2. Kimon P. Valavanis, George J. Vachtsevanos, **Handbook of Unmanned Aerial Vehicles**, Springer.

## 1.14 AR 514: Vision and Learning Based Control

Course Number : AR 514
Course Name : Vision and Learning Based Control
Credit Distribution : 3-0-0-3
Intended for : UG, PG and PhD
Prerequisite : Consent of faculty advisor
Mutual Exclusion : None
Approval: 50th BoA

**Course Contents:**

- **Introduction:** Overview, motivation, and real-world practical applications. (1 hours)
- **Visual Sensor Model and Calibration**: Camera model, Coordinate Frames and Transforms, Intrinsic camera calibration, and extrinsic camera calibration. (10 hours)
- **Visual Servoing:** Image Jacobian, Robot Jacobian, Image Based Visual Servoing, Position Based Visual Servoing, Eye-in-hand and Eye-to-hand Configurations, Comparison among different class of visual servoing. (14 hours)
- **Robot Learning:** Basic concepts of reinforcement learning, reinforcement learning algorithms. Robot learning by demonstration. (14 hours)
- **Hybrid Method Design:** Comparative analysis for various methods. Explore, understand and identify different ways to design a hybrid scheme to control the given system of interest. Case study and course projects. (3 hours)

**Textbooks:**

1. Corke, Peter I., and Oussama Khatib, **Robotics, vision and control: fundamental algorithms in MATLAB**, Vol. 73, Springer, 2011.

2. Vakanski, Aleksandar, and Farrokh Janabi-Sharifi, **Robot learning by visual observation**, John Wiley & Sons, 2017.

**References:**

1. Ijspeert, Auke Jan, et al., Dynamical movement primitives: learning attractor models for motor behaviors, **Neural computation,** 25.2, 328-373, 2013.

2. Chaumette, François, and Seth Hutchinson, **Visual servo control: I. Basic approaches**, IEEE Robotics & Automation Magazine, 13.4 82-90, 2006.

3. Chaumette, François, and Seth Hutchinson, **Visual servo control, II, Advanced approaches** [Tutorial], IEEE Robotics & Automation Magazine 14.1: 109-118, 2007.

## 1.15 AR 515: Sensors and State Estimation

Course Number : AR 515
Course Name : Sensors and State Estimation
Credit Distribution : 3-0-0-3
Intended for : UG, PG and PhD
Prerequisite : Consent of faculty advisor
Mutual Exclusion : None
Approval: 50th BoA

**Course Contents:**

- **Sensors:** Introduction and motivation, different types of sensors and their real time applications, signal conditioning, classic vs smart sensors. (10 hours)

- **Recursive State Estimation:** Overview, basic concept in probability, robot environment interaction, Bayes filter. (7 hours)

- **Filtering Techniques:** Introduction, Kalman Filter (KF), Extended Kalman Filter (EKF), Unscented Kalman Filter (UKF), Particle Filter, and Quantum Stochastic Filtering. (15 hours)

- **Multi-sensor Data Fusion:** Introduction to multi-sensor systems, some examples like Unmanned Aircraft System (UAS), reference frame for multi-sensor fusion, calibration, synchronization, multi-sensor fusion with EKF. Case study and course projects. (10 hours)

**Textbooks:**

1. Thrun, Sebastian, Probabilistic robotics, **Communications of the ACM** 45.3: 52-57, 2002.
2. Fraden, Jacob., **Handbook of modern sensors: physics, designs, and applications**, 357-359, 1998.

**References:**


1. Bhuyan, Manabendra, **Intelligent Instrumentation: Principles and Applications**, CRC Press, 2010.
2. Sawhney, A. K., **Electrical and electronic Measurements and Instrumentation**, 1985.
3. Behera, Laxmidhar, and Indrani Kar, Quantum stochastic filtering, 2005 **IEEE International Conference on Systems, Man and Cybernetics**, Vol. 3. IEEE, 2005.
4. Meijer, Gerard, (ed.), **Smart sensor systems**, John Wiley & Sons, 2008.
5. Jacob Fraden, **Handbook of modern Sensors**, AIP Press, 1997.
6. E. O. Deobelin and D. Manik, **Measurement Systems – Application and Design**, Tata McGraw-Hill, 2004.
7. Yallup, Kevin, and Krzysztof Iniewski, (eds.), **Technologies for smart sensors and sensor fusion**, CRC Press, 2014.
8. Prosser, Stephen J., and Ernest DD Schmidt, **Smart sensors for industrial applications**, Sensor Review, 1997.


## 1.16 AR 516 : Introduction to Blockchain and Web3

**Course Code : AR 516**

**Course Name : Introduction to Blockchain and Web3**

L-T-P-C : 3-0-0-3
Intended for : Undergraduate (Elective)/ Postgraduate
Prerequisite : Knowledge of basic computer terminology
Mutual Exclusion:
Approval: 54th BoA

**Course Contents**

- **Blockchain Technology Introduction** (8 hours)
  - What is Blockchain
  - How it evolved
  - Key Terminologies – Ledger, Smart Contract, Peer Network, Wallet, Hashing, Cryptography, Distributed vs Centralized Database, Blocks, Merkle Trees

- Popular Blockchain Variants – Bitcoin, Ethereum, Hyperleder
- Consensus Algorithms
- Types of Blockchain
- SideChains

- **Cryptocurrency and Bitcoin Introduction** (6 hours)
  - Transformation of Financial Systems
  - How current System Works and Related Problems
  - Distributed Ledger Technology
  - Bitcoin Evolution
  - Bitcoin Ecosystem
  - Bitcoin Clients and Wallets
  - Buy and Sell Bitcoin
  - Bitcoin Transaction and Structure
- **Course outline – Bitcoin Details and Mining Process** (4 hours)
  - Initiating Bitcoin Transaction
  - Transaction Propagation in Distributed Network
  - Role of Miners
  - Block Structure of Bitcoin
  - Merkle Tree Formation
  - Transactions Storage in Digital Ledger
  - Mining Algorithms – Proof of Work
  - Consensus Algorithms
  - Fraud and Hack Inversion mechanism
  - Other Mining Algorithms – Proof of Stake, PBFT
- **Overview of Ethereum Blockchain** (6 hours)
  - Introduction to Ethereum and differences from Bitcoin
  - Introduction to Smart contracts and solidity
  - Ethereum tools and development eco-system
  - Solidity language constructs and programming examples
  - Ethereum clients and Wallets
  - Layer 1 – Layer 2 differences and development
- **Overview of Hyperledger Fabric Blockchain** (4 hours)
  - Enterprise Blockchain and Linux foundation
  - Architecture of Hyperledger Fabric

- Network / explorer / installation.
- Smart contract using Go / Node.JS
- Other Enterprise Blockchains Course outline – Blockchain Applications and Hands on (10 hours)
- Industry wide applications of Blockchain / web3
- Current market size / outlook / industry trends
- Career options and research opportunities

1. **Practical application 1** : Defi based application from finance sector
2. **Practical application 2** : Smart contract / token based application for multiple sectors
3. **Practical application 3**: Trade Bot / AI based prediction models for Crypto.
4. **Practical application 4**: Blockchain based Gaming application.

**Textbooks:**


1. Julie EG, Nayahi JJ, Jhanjhi NZ, editors, **Blockchain Technology: Fundamentals, Applications, and Case Studies**, CRC Press.
2. Li KC, Chen X, Jiang H, Bertino E, editors, **Essentials of Blockchain Technology**, CRC Press.


**References:**


1. Banafa, A., **Blockchain Technology and Applications**, CRC Press, 2022.
2. Laurence, T., **Introduction to Blockchain Technology**, Van Haren, 2019.
3. Kim S, Deka GC, editors, **Advanced Applications of Blockchain Technology**, Springer, 2020.


## 1.17 AR 517 : Introduction to Cyber security

**Course Code : AR 517**

**Course Name : Introduction to Cyber security**

L-T-P-C : 3-0-0-3
Intended for : Undergraduate (Elective)/ Postgraduate
Prerequisite : Knowledge of basic computer terminology
Mutual Exclusion:
Approval: 54th BoA

**Course Modules:**

- Domain 1: Understand the basic fundamentals of cybersecurity including asset, data protection and risk assessment and management
- Domain 2: Learning cryptography, network security and the core concepts of holistic security models and architecture
- Domain 3: Explore the Identity and access management ecosystems
- Domain 4: Respond and mitigate cybersecurity attacks and understanding of the entire landscape

**Course Contents**

**Domain 1: Understanding Security, Total hours – 14 Hours**

- Unit 1: **Understanding Security Governance Principles Types of plans**:
  - Strategic, Tactical and Operational Understanding and Applying Security Concepts, Confidentiality (Data at Rest, Motion and in Process), Integrity (Preventing unauthorized modification) and Availability (Always available data) , Access Control Methodologies: IAAA
  - Understanding Risk Management: Defining Assets Threats, Vulnerabilities risk, Exposure, Breach, Countermeasures, Safeguards, Covering Risk Analysis/Assessment, Qualitative and Quantitative Process, Cost Benefit Analysis, Dealing with Risk (Concept of MATAR), Understanding Risk Frameworks, NIST 800-37 and NIST 800-53A, Control Types: Administrative, Technical and Physical, Control Methodologies or Mechanism, Threat Modelling , Intellectual Property: Trade Secrets, Patent, Copyright and Trademarks
  - Defining the various DRP and BCP Plan and how they help organisation, Detailing the incident response process, and designing an Incident Response Plan workflow. Understanding ISO 27001 and ISO 22301
- Unit 2: **Data and Asset Management**
  - Policies, Standards, Procedures, and Guidelines, Data classification vs categorisation, Security Roles and Responsibilities, Managing the data and asset lifecycle , Destruction, Purging, Clearing Understanding Personal data, Information lifecycle: Creation, Store, use, Achieve and Destroy, GDPR and DORA (Digital Operational Resiliency Act)
- **Suggested Reading**
  - Kim. D., and Solution, M.G., **Fundamentals of Information System Security**, Jones & Bartlett Learning, 2010
  - Paul A. Watters, **Cyber Security: Concepts and Cases**, Create Space Independent Publishing Platform, 2012.
  - Peter W. Singer, Allan Friedman, **Cybersecurity: What Everyone Needs to Know**, Oxford University Press.

  - David Sutton, **Cyber Security: A Practitioner's Guide**, BCS Learning & Development Limited, 2017

Domain 2 : **Network Security and Cryptography,** Total Hours – 14 Hours

- Unit 1 :
  - Understanding Security Models and Architecture Lattice based vs Rule based, Enterprise Security Architecture, Security Frameworks i.e., Risk vs Privacy vs Security
  - Understanding security systems: Client and Server system, Industrial Control Systems (ICS), Cloud-based systems (e.g., Software as a Service (SaaS), Infrastructure as a Service (IaaS), Platform as a Service (PaaS))
  - Cryptography: Understanding Plaintext, ciphertext, key, encrypt, decrypt, IV, Confusion, diffusion, work factor, Key Lifecycle and Management, methods (Symmetric and Asymmetric), Substitution vs Transposition, Hidden watermark, PKI, Hashing, Digital signature, Fundamental of Non-repudiation,
  - Cryptanalytic attacks: MITM, Side Channel attack, Brute Force, Ciphertext only, Known plaintext, fault injection, rainbow attack, Birthday attack
  - Physical Security: Control Category, Deter, Delay, Detect, Assess and Respond, Layered defence inclusive of perimeter , infra , fire detection and suppression and Building Management System (BMS)
- Unit 2 : Network Security
  - OSI Model and TCP/IP Model Layer 1-Layer 7 : Physical, data , network, transport, session, presentation and Application layer
  - Understanding the Networks: WAN, Wireless, IP Protocols, Converged Protocols, Network Authentication Defense in Depth, Routers, switches, Bridge, proxy, Port addressing, Firewalls: Firewall Basics, Types of Firewalls, Network Address Translation Issues, Public and Private address, Ingress and Egress, Understanding Virtualisation Remote Access: Tunnelling,
  - Remote Authentication, Remote Access Management, IPsec Protocols, VLAN

**Suggested Reading**

- Kahate, A. Cryptography and Network Security, McGraw-Hill Higher Ed., 2009.
- Riggs, C., Network Perimeter Security: Building Defence In-Depth, AUERBACH, USA, 2005.
- Northcutt S., Inside Network Perimeter Security, 2nd Edition, Pearson Education, 2005.
- Stallings, W., Network Security Essentials: applications and standards, 3rd Edition, Pearson Education India, 2007.
- Douglas E. Comer, Internetworking with TCP/IP, Principles, Protocols, and Architecture, Addison-Wesley, 5th Edition, Vol 1, 2005 .

- Douglas E. Comer, David L. Stevens, Internetworking with TCP/IP Vol. III, Client Server Programming and Applications, 2nd Eidtion, Addison-Wesley.
- Behrouz A. Forouzan, Data Communications and Networking, McGraw-Hill, 5th edition.
- Domain 3 : Access Control, Total Hours – 6 Hours
- Unit 1: Secure Design Principles
  - Defense of depth, principle of least privilege, Separation of duties, Need to know, Zero Trust Management Approach: Centralised, Decentralised and Hybrid Authorisation vs Authentication, Type of authentications, (Knowledge vs ownership vs characteristic)
  - Single Sign on (SSO) vs Federated Identity, Management of Authorisation mechanism: Rule based access, Role based access, DAC, ABAC, MAC, Identity and access provisioning lifecycle, Understanding Authentication system: OAuth, OpenID SAML, SPML, Remote Authentication, Kerberos, IDaas Identities

**Suggested Reading**

- Omondi Orondo, **Identity & Access Management: A Systems Engineering Approach**
- Bharat Rawal Bryan and Vincent, **Cybersecurity and Identity Access Management**
- "**Web Application Security, A Beginners Guide** ",McGraw-Hill, 2011
- Bhavani Thuraisingham, **Database and Applications Security, Integrating Information Security and Data Management**, Auerbach Publications, 2005.

Domain 4 : **Security Assessment Total Hours** – 8 Hours

- Unit 1: Ethical Hacking and Pen Testing
  - Internal, External and third-party testing. Information Gathering, Vulnerability assessment, Security vulnerabilities and countermeasures. Owasp top 10 attacks, Web server attacks: XSS attacks, CSRF Attacks
  - Application related attacks, Database Related attacks, SQL injection attacks, Buffer overflow attacks and Client-side browser exploits, Penetration testing, Introducing Metasploit
  - Social Engineering attacks, Password attacks, Privilege Escalation, ICS Related attacks, Network Infrastructure Vulnerabilities, IP spoofing, DNS spoofing, Wireless Hacking, WPA, WEP,WPA2
- Unit 2 : Logging and Monitoring
  - IDS, SIEM, UEBA, SOAR, Threat Intelligence (Dark web vs Surface web), Log Management, Continuous monitoring, Egress monitoring, EDR, PCAP, NDR

– SDLC Integrated Security: Maturity models, Software development methods, Change Management, SAST and DAST, Testing a system, Verification vs validation, Testers and Assessors (SOC1 vs SOC2 vs SOC2, Type 1 and Type 2), Metrics (KPI, KRI)

**Suggested Readings**


- Jon Friedman, Mark Bouchard, CISSP,Cyber Threat Intelligence, Definitive GuideTM 2015 .
- Baloch, R., **Ethical Hacking and Penetration Testing Guide**, CRC Press, 2015.
- McClure S., Scambray J., and Kurtz G, **Hacking Exposed**, 6th Edition, Tata McGraw-Hill Education, 2009
- Ross J Anderson, **Security Engineering: A Guide to Building Dependable Distributed Systems**, 2nd Edition, Wiley, 2008.
- Julia H Allen, Sean J Barnum, Robert J Ellison, Gary McGraw, Nancy R Mead, **Software Security Engineering: A Guide for Project Managers**, Addison Wesley, 2008.


**Textbooks:**


1. Michael E. Whitman, Herbert J. Mattord, Principles of Information Security, 6th Edition, Cenage Learning, 2018.
2. Van Kessel, P., **Is cyber security about more than protection?**, EY Global Information Security Survey 2018-2019.
3. Johnston, A.C. and Warkentin, M., **Fear appeals and information security behaviors: An empirical study**, MIS Quarterly, 2010.


**References:**


1. Arce I. et al., **Avoiding the top 10 software security design flaws**, IEEE Computer Society Center for Secure Design (CSD), 2014.
2. Smith, H. J., Dinev, T., & Xu, H., **Information privacy research: an interdisciplinary review**, MIS Quarterly, 2011.
3. Subramanian R., **Security, privacy and politics in India: a historical review**, Journal of Information Systems Security (JISSec), 2010.
4. Acquisti, A., John, L. K., & Loewenstein, G., **What is privacy worth?**, The Journal of Legal Studies, 2013
5. Xu H., Luo X.R., Carroll J.M., Rosson M.B., **The personalization privacy paradox: An exploratory study of decision making process for location-aware marketing**, Decision Support Systems, 2011.

## 1.18 AR 518 : Advanced Blockchain and web3

**Course Code : AR 518**

**Course Name : Advanced Blockchain and web3**

L-T-P-C : 3-0-0-3
Intended for : Undergraduate (Elective) / Postgraduate
Prerequisite : None
Mutual Exclusion:
Approval: 56th BoA

**Course Contents**

- **Advanced Ethereum concepts** (8 Lectures)
  - EIPs (Ethereum Improvement protocols)
  - Top EIPs that have changed the course of Ethereum
  - ERC standards (Ethereum Request for Comment)
  - Top Token standards
  - Smart contract security
  - Hardhat & Truffle
- **Layer 2's, Rollups, DeFi, Web3** (12 Lectures)
  - TLayer 2 chains: What is a Layer 2 chain
  - Differences between L1 and L2 chains
  - Techniques for Layer2 sidechain, State channels, Plasma, Rollups
  - Popular Layer2 chains – Polygon: setting up the wallet and deploying contacts to Layer 2 chains
  - Rollups : What is a Rollup, Optimistic Rollups, ZK Rollups
  - DeFi: Tokenization, DEX, Liquidity markets (AMM & bootstrapping), Stablecoins, Creating and deploying tokens and other smart contracts
  - Web3
  - DAO's
  - Metaverse
- **Third generation Blockchains** (8 Lectures)
  - Third-Generation Blockchain and Major Examples
  - Solana: Introduction, Architecture, consensus, Transaction policy
  - Solana Nodes and Network, Sample transactions
  - Cosmos: Introduction, IBC, Consensus and Network
  - Cosmwasm
- **DEPIN Decentralized Physical Infrastructure Networks** (2 Lectures)

    - Introduction to DEPIN networks
    - Filecoin, Storj, Arweave
    - Render Network
    - Theta Network
    - Helium

- **Hyperledger Fabric** (4 Lectures)
    - Hyperledger Fabric Architecture
    - Setting up and managing a Hyperledger network
    - Chain code development and deployment

- **Practicals, Projects and Assignments** (8 Lectures)
    - Create an ERC20 token, deploy and interact with it
    - Create a contract for Asset tokenisation or real-world scenario like crowdfunding/voting
    - Create Supply Chain Management / Healthcare Records management / Asset Tokenization on Hyperledger fabric

**Text Books:**

1. **Mastering Ethereum: Building Smart Contracts and DApps**
2. **Blockchain with Hyperledger Fabric**, 2nd Edition

**Reference Books:**

1. **Practical Limitations of Ethereum'sLayer**-2RAY NEIHEISER12 , GUSTAVO INÁCIO3, LUCIANA RECH3, CARLOS MONTEZ2, MIGUELMATOS1and LUÍS RODRIGUES1
2. Xiangyu Li, Xinyu Wang, Tingli Kong, Junhao Zheng, and Min Luo, **From Bitcoin to Solana – Innovating BlockchainTowards Enterprise Applications**.
3. Kim S, Deka GC, editors, **Advanced applications of blockchain technology,** Springer, 2020.

# 2 Bio Engineering Courses

## 2.1 BT-101 Fundamentals of Biotechnology

**Course Code: BT 101**
**Course Name: Fundamentals of Biotechnology**
L-T-P-C: 2-0-0-2
Pre-requisite: NIL
Approval: 5th Senate; Roorkee Course

**Course Contents:**

- **Basic Component**: Introduction, structural and chemical components of cell;
- **Molecular mechanism and engineering**: DNA replication, RNA and protein synthesis, mutation and genetic recombination, Protoplast and cell fusion technology, Genetic engineering and PCR;
- **Microbes & fermentation**: Bacteria, fungi, viruses, microbial growth and bioprocess technology, Enzyme kinetics and bioconversion, Immobilization of enzymes, cell and application;
- **Plant and animal biotechnology and safety issues**: Biodiversity, transgenic plants and animals, Biosafety and bioethics;
- **Applications**: Biofuels, Bioremediation, bio-medical applications.

**References:**


1. Smith J. E., **Biotechnology**, 3rd Edition, Cambridge University Press.
2. Walker J. M. and Gingold E. B., **Molecular Biology and Biotechnology**, The Royal Society of Chemistry, UK/Panima Publishing Corporation.
3. Auderisk G. and Auderisk T., **Biology life on Earth**, Macmillan Publishing Company.


## 2.2 BE 101P: Reverse Engineering for Bioengineers

**Course Code : BE101P**
**Course Name : Re**verse Engineering for Bioengineers
**L-T-P-C:** 0-0-2-1
**Intended for :** B.Tech.-M.Tech. Integrated Dual Degree in Bioengineering (Core Course)
**Prerequisite :** No prerequisite (compulsory for Bioengineering students)
**Mutual Exclusion :** NA

**Course Modules :**

The students focus on hardware reverse engineering (RE). In the process of RE students understand existing technologies, functions, features, objects, components and systems. By carefully disassembling, observing, testing, analyzing and reporting, students can understand how something works and suggest ways it might be improved. This process requires careful observation, disassembly, documentation, analysis and reporting. Many times, the reverse engineering process is non-destructive. This means that the object or component can be reassembled and still function just as it did before it was taken apart. Throughout the reverse engineering project, the students are able to think of ways these objects could be improved. Is there some way it could function better? or manufactured less expensively? The students will use observations to make suggestions for improvement of the product. (28 Hours)

**Learning Topics:**

Reverse Engineering of Biotechnological/Biomedical- Devices/ prototypes.

**Textbooks:**

1. Lam, R.H. and Chen, W., **Biomedical Devices: Materials, Design, and Manufacturing**, Springer, 2019.

2. Boccato C, Cerutti S, Vienken J, editors, **Medical devices: improving health care through a multidisciplinary approach** [Internet]. Springer International Publishing, 2022

**References:**

1. Sokovic and Kopac, **RE as necessary phase by rapid product development**, Journal of Materials Processing Technology, 2005

2. Eldad Eilam, **Reversing: Secrets of Reverse Engineering**, Wiley, 2005.

3. Chris Eagle, **The IDA Pro Book: The Unofficial Guide to the World's Most Popular Disassembler**.

## 2.3 BE 201: Cell Biology

**Course Code: BE 201**
**Course Name: Cell Biology**

L-T-P-C: 3-0-2-4
Prerequisite: None
Students intended for: B. Tech M.Tech Integrated Dual Degree Bioengineering students

Approval: 28th Senate; 44 BoA

**Course contents**

- **Cells: The fundamental units of life**

  The structure and ultrastructure of the cell (the prokaryotic cell and the eukaryotic cell). Membrane enclosed Organelles (nucleus, chloroplast, mitochondria, ribosome etc) Model organisms (Yeast; simple eukaryotic cell, Arabidopsis; model plant, Files/worms/mice; model animal [8 Lectures]

- **Cell Membranes and membrane transport**

  Membrane structure (lipid bilayer, and membrane protein), Passive and Active Transport, Ion channels, ATP pumps. Na+ / K+ / Ca+2T pumps uniport, symport antiporter system. Ligand gated / voltage gated channels, Agonists and Antagonists [8 Lectures]

- **The cell-division cycle**

  Cell cycle – Mitosis, Meiosis, Molecules controlling cell cycle, Extra cellular matrix, role of matrix in cell enthrone: Gap junctions, Tight junctions, Desmosomes, Hemidesmosomes [8 Lectures]

- **Cell-cell communication and protein transport**

  General principles of cell signaling, G-protein couple receptor, enzymes-couple receptor, protein sorting, vesicular transport, endocytic pathways [8 Lectures]

- **Techniques used to study cells**

  Cell fractionation, Morphology and identification of cells using microscopic studies like SEM, TEM and Confocal Microscopy. Localization of proteins in cells – Immunostaining. [10 Lectures]

**Lab**

**List of Experiments**

- Introduction to principles of sterile techniques and cell propagation
- Principles of microscopy, phase contrast and fluorescent microscopy
- Gram's Staining
- Leishman Staining
- Trypan Blue Assay
- Staining for different stages of mitosis in Allium Cepa (Onion)

**Text Books:**

1. ruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts, Peter Walter, **Molecular Biology of the Cell**, 6th Edition, Garland Science, 2014.

**References:**

1. Harvey Lodish, Arnold Berk, Chris A. Kaiser, Monty Krieger, Anthony Bretscher, Hidde Ploegh, Angelika Amon, Kelsey C. Martin, **Molecular Cell Biology** - 8th Edition, W.H. Freeman, 2016.

2. George Plopper, David Sharp, Eric Sikorski, **Lewin's Cells**, 3rd Edition, Johns & Bartlett Publishers, 2015

3. Lisa A. Urry, Michael L. Cain, Steven A. Wasserman, Peter V. Minorsky, Jane B. Reece, **Campbell Biology**, 11th Edition, Pearson, 2020.

## 2.4 BE 202: Biochemistry and Molecular Biology

**Course Code: BE 202**
**Course Name: Biochemistry and Molecular Biology**

L-T-P-C: 2-0-2-3
Prerequisite: None
Students intended for: B. Tech M.Tech Integrated Dual Degree Bioengineering students
Elective or Core:
Approval: 28th Senate, 44th BoA

**Course contents**

- **Cell composition**

  Chemical bonds, water, pH and buffers

  Amino acids, peptides and proteins

  Carbohydrates: Monosaccharides, Disaccharides Polysaccharides and glycoconjugate

  Nucleotides and Nucleic acids

  Lipids: Storage lipids, structural lipids, lipid as signal, cofactors and pigments[6 Lectures]

- **Bioenergetics and Biochemical Reaction**

  Bioenergetics and Thermodynamics, ATP, Biological oxidation-reduction reactions, Overview of central and secondary metabolism;

  Amino acid Oxidation: Metabolic fates of amino acids, Nitrogen excretion and urea cycle, amino acid degradation;

  Oxidative Phosphorylation: Electron transport reaction in mitochondria, ATP synthesis, Photophosphorylation, Light absorption and light driven electron flow, ATP synthesis by photophosphorylation [6 Lectures]

- **Cellular energy**

  CBreakdown of Sugar: Glycolysis, Gluconeogenesis and the Pentose Phosphate Pathway;

  The Citric acid cycle;

Fatty acid metabolism: Digestion, metabolism and transport of fats, oxidation of fatty acids, ketone bodies[8 Lectures]

- **Central Dogma of Life**

  Genes and Chromosomes DNA metabolism: DNA replication, DNA repair and recombination

  RNA metabolism: Transcription, RNA processing, RNA dependent RNA and DNA synthesis

  Protein metabolism: The genetic code and Translation Gene Regulation [8 Lectures]

**Lab**

**List of Experiments**

- Preparation of buffers,
- Quantitative determination of proteins,
- Quantitative determination of carbohydrates and lipids,
- Isolation of nucleic acid (DNA or RNA) and its estimation,
- Gel Electrophoresis- Protein and nucleic acid
- DNA amplification using PCR,
- Isolation of chloroplasts, its estimation and assay for Hill reaction

**Text Books:**


1. David L. Nelson, Michael M. Cox, **Lehinger Principles of Biochemistry**, 7th Edition, McMillan Learning, 2017.


**References:**


1. Harvey Lodish, Arnold Berk, Chris A. Kaiser, Monty Krieger, Anthony Bretscher, Hidde Ploegh, Angelika Amon, Kelsey C. Martin, **Molecular Cell Biology** - 8th Edition, W.H. Freeman, 2016.

2. George Plopper, David Sharp, Eric Sikorski, **Lewin's Cells**, 3rd Edition, Johns & Bartlett Publishers, 2015

3. Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts, Peter Walter, **Molecular Biology of the Cell**, 6th Edition, Garland Science, 2014.

## 2.5 BE 203: Enzymology and Bioprocessing

**Course Code: BE 203**
**Course Name: Enzymology and Bioprocessing**

L-T-P-C: 2-0-2-3
Prerequisite: IC136
Students intended for: B. Tech M.Tech Integrated Dual Degree Bioengineering students
Elective or Core:
Approval: 36th BoA

**Course contents**

- **Fundamentals of Enzymology**

  Introduction to Enzymes, Classification of Enzymes, Specificity of Enzyme Action, The Fisher 'lock-and-key' hypothesis, The Koshland 'induced-fit' hypothesis An Introduction to Bioenergetics, Catalysis and Kinetics, Kinetics of Single-Substrate Enzyme- Catalyzed Reactions, The Henri and Michaelis Menten Equation, The Briggs Haldane modification, The Lineweaver-Burk Plot, The Eadie Hofstee and Hanes Plot [8 Lectures]

- **Enzyme Inhibition and Applications**

  Reversible Inhibition: - Competitive Inhibition, Un-competitive Inhibition, Non-competitive Inhibition, Substrate Inhibition, Allosteric Inhibition and Irreversible Inhibition

  Sigmoidal Kinetics and Allosteric Enzymes Case studies pertaining to industrial enzyme(s) [6 Lectures]

- **Introduction to Cellular Bioprocessing**

  Bioprocessing – definition and introduction to control parameters in Bioprocessing such as dissolved oxygen, redox, pH, temperature etc.

  Stoichiometry and Kinetics of cell cultivation – Quantitative description of cell growth and product formation, Kinetic Model of Cell Growth - Monod Model.

  Bioreactor types and their Operating Modes – Batch, fed-batch and continuous[8 Lectures]

- **Fermentation and Downstream Processing**

  Fermentation technology and Downstream processing

  Case studies on lab-scale bioprocessing of biochemicals[6 Lectures]

**Lab**

**List of Experiments**

- Enzyme kinetics –Activity analysis, Effect of substrate concentration, Effect of temperature, Effect of pH

- Process parameter control in Stirred tank Bioreactor, Microbial cultivation in a batch and estimation of growth rates, Fermentation and downstream analysis of end products

**Text Books:**

1. Trevor Palmer, Philip Bonner, **Enzymes**, 2nd Edition, Woodhead Publishing, 2007.

2. Sarfaraz K. Niazi, Justin L. Brown, **Fundamentals of Modern Bioprocessing**, CRC Press, 2017.

**References:**

1. Alejandro G. Marangoni, **Enzyme Kinetics: A Modern Approach**, John Wiley & Sons, 2003.

2. Michael L. Shuler, Fikret Kargi, Matthew De Lisa, **Bioprocess Engineering: Basic Concepts**, 3rd Edition, Prentice Hall, 2017.

## 2.6 BE 301: Biomechanics

**Course Code: BE 301**
**Course Name: Biomechanics**

L-T-P-C: 3-0-2-4
Prerequisite: Mechanics of Rigid Bodies (IC 240)
Students intended for: B. Tech M.Tech Integrated Dual Degree Bioengineering students
Elective or Core:
Approval: 38th BoA

**Course contents**

- **Introduction and Fundamentals**

  what is Biomechanics? Anatomical Concepts in Biomechanics, free-body diagrams and equilibrium; linear and angular kinematics, kinetic equation of motion, work and energy method, application to biological systems: stress, strain, Modulus, strain energy, tension, compression, torsion, bending, buckling. [14 Lectures]

- **Tissues**

  Animal tissues and plant tissues. Classification of animal tissues - hard tissue, soft tissue, properties of plant and animal tissues according to mechanics view point, Structure, Function, composition, material properties and modeling of tissues, Plant tissues - vascular bundles - xylem and phloem. Continuum Mechanics Concepts in Modeling of large deformation, Finite Element Modeling. [14 Lectures]

- **Joints and Movements**

  Classification of joints, forces and stresses, biomechanical analysis joints, Gait, Joint replacement and reasons, Finite Element Modeling. [8 Lectures]

- **Biofluid mechanics**

  Flow properties of blood and others, Fluid flow in plants, Dynamics of fluid flow in the biological system - modeling and experimental approaches, Measurement/Estimation of In-vivo elasticity of fluid transporting vessels.[6 Lectures]

**Lab**

**List of Experiments**

- To determine the tensile properties of a material (root or bones or plants or others).
- To determine the bending properties of a material (root or bones or plants or others).
- To determine the hardness properties of a material.
- To determine the torsional/shear properties of a material (root or bones or plants or others).
- To determine the buckling properties of amaterial (root or bones or plants or others).
- To determine the energy absorbed and toughness of a material (root or bones or plants or others).
- To determine the wear properties of material and different combination of material
- To determine the ground reaction force during normal walking or running.
- Finite ElementModelling and analysis of hard tissue and soft tissue (examples: Bone, ligaments or muscles)
- Fluid flow through the cardiovascular system: Simple modelling and analysis

**Text Books:**

1. M. Nordin and V. H. Frankel, **Basic Biomechanics ofthe Musculoskeletal System**, Lippincott Williams and Wilkins, 2012.
2. Y. C. Fung, **Biomechanics: Mechanical Properties of Living Tissues**, 2nd edition, Springer, 2007.

**References:**

1. K. J. Niklas, **Plant Biomechanics: An engineering approach to plant form and function**, University of Chicago Press, 1992.
2. Ozkaya,Nordin, Goldsheyder and Leger, **Fundamentals of Biomechanics: Equilibrium, Motion, and Deformation**, 3rd Edition, Springer, 2014.
3. R. L.Huston, **Fundamentals of Biomechanics**, CRC Press, 2013.

## 2.7 BE 302: Bioelectric Systems Modeling

**Course Code: BE 302**
**Course Name: Bioelectric Systems Modeling**

L-T-P-C: 3-0-2-4
Prerequisite: IC136, BE201, IC160
Students intended for: B. Tech M.Tech Integrated Dual Degree Bioengineering students
Elective or Core: Core for IDD BE, Elective for other B.Tech students
Approval: 44th BoA

**Course contents**

- **Electrical modeling of cells**

  Charge transport mechanism in cells, application of circuit theory to cell analysis – electrotonus model, Hodgkin Huxley model for membrane current, voltage changes in cell over space and time. Biological cables –the axons, potential outside a long cylindrical cell, exterior potential for an arbitrary pulse, RC modeling of axon as a transmission line, electrical properties of organs and organ-systems. [14 Lectures]

- **Magnetic modeling of cells**

  Magnetic field of a cell in an infinite homogeneous conducting medium, electromagnetic induction, modeling of exterior magnetic field of a cylindrical cell. [2 Lectures]

- **Applications of electrical modeling for biosignal extraction from different organs**

  A. *Biosignal extraction from heart*: Origin of cardiac action potential, electric dipole modeling of heart, atrial depolarization causing P wave, sequential ventricular depolarization causing QRS complex, sub-epicardial repolarization causing T wave, recording of electrocardiogram using leads, stimulating the heart – the pacemakers.

  B. *Biosignal extraction from brain*: Origin of neuronal action potential, origin of electroencephalogram signals, understanding neural oscillations (Alpha- Beta-, Gamma, Delta- and Theta Waves).

  C. *Biosignal extraction at neuromuscular junction*: Origin of action potentials at axon hillock, propagation of bipolar signals in muscle fibers, recording of electromyogram signals.

  D. *Detection of weak magnetic fields*: Magnetocardiograms and magnetoencephalograms [8 Lectures]

- **Feedback and control**

  Basics of control engineering – notion of open loop and closed loop systems, homeostasis from the electrical model perspective, single loop and multiple loop homeostasis, stability of systems, criteria of stability, example study in neurorehabilitation, closed loop control of blood insulin and glucose regulation, closed loop control of brain stimulation. [18 Lectures]

**Lab**

**List of Experiments**

- Cable model of neurons
- Hodgkin Huxley's model of neurons
- Modeling of exterior electric field of a cylindrical cell
- Modeling of electromagnetic induction in living cells
- Modeling of electrical conduction in heart

- Modeling of electrical conduction in brain
- Modeling of electrical conduction in muscles
- Modeling a feedback loop with one and two time constant(s)
- Modeling of homeostasis process
- Stability analysis of physiological systems

**Text Books:**

1. Eugenio Culurciello, Wei Tang, Evan Joon Park, **Biomedical Circuits and Systems**, CRC Press, 2017.
2. Harold S. Burr, **The Fields of Life. Our Links with the Universe**, Ballantine Publishers, 1973.
3. Robert Berker, Gary Selden, **The Body Electric: Electromagnetism And The Foundation Of Life**, Harper Collins Publishers, 1998.

**References:**

1. K. J. Niklas, **Plant Biomechanics: An engineering approach to plant form and function**, University of Chicago Press, 1992.
2. Ozkaya,Nordin, Goldsheyder and Leger, **Fundamentals of Biomechanics: Equilibrium, Motion, and Deformation**, 3rd Edition, Springer, 2014.
3. R. L.Huston, **Fundamentals of Biomechanics**, CRC Press, 2013.

## 2.8 BE 303: Applied Biostatistics

**Course Code: BE 303**
**Course Name: Applied Biostatistics**

L-T-P-C: 3-0-2-4
Prerequisite: IC252, IC272
Students intended for: B. Tech M.Tech Integrated Dual Degree Bioengineering students
Elective or Core: Core for IDD BE, Elective for other B.Tech students

**Course contents**

- **Study design, data acquisition, and presentation**

  Recognize and give examples of different types of data arising in public health and clinical studies. Types of medical studies and .introduction of different study designs (descriptive vs analytical, control groups etc.) and sampling methods (randomization). Risk studies (descriptive, case-control and cohort studies) Measure of important probabilities (incidence, prevalence, sensitivity-specificity-predictivity, morbidity, etc.). Example of study design at the example of a clinical trial for approval process. [10 Lectures]

- **Null hypothesis, Statistical testing**

  Why are there statistical tests in medial and biological sciences? Formulation and examples of null hypothesis for medical and bioengineering applications, subsequent decisions, and error types I + II.

  Overview of tests: location (e.g., t-test), dispersion (e.g., ANOVA (f-test)), comparison of frequencies (chi-square), variance analysis (e.g., inter- and intra-class variance) and regression analysis (linear and logistic regression (ROC-analysis)). Parametric tests are used only where a normal distribution is assumed. These are the t-test (paired or unpaired), ANOVA (one-way non-repeated, repeated; two-way, three-way), linear regression and Pearson correlation.

  Non-parametric tests are used when continuous data are not normally distributed or when dealing with discrete variables. These are chi-squared, Fisher's exact tests, Wilcoxon's matched pairs, Mann-Whitney U-tests, Kruskal-Wallis tests and Spearman rank correlation. Comparison of different tests. Analyze required sample size (calculate the power of a test) and analysis of correct application of a test using specific examples. [15 Lectures]

- **Advanced tools- Introduction to multivariate analysis**

  Multivariate analysis is concerned with the interrelationships among several variables. A specific example for the motivation of multivariate analysis will be given. The course includes the following methods: cluster analysis, principal components analysis, factor analysis, discriminant analysis, etc. Designs of Experiments which will include, one-way, two-way ANOVA, MANOVA study design, confounding and standardization. Difference between multiple linear regression and multivariate regression (e.g., using an example of the Framingham heart study) [7 Lectures]

- **Applications of biostatistics, quality, and potential fallacies**

  Introduction to survival analysis, estimation of survival curves, and proportional hazards model (e.g., example of life expectancy under different conditions). Analysis of different parametric survival functions.

  Quality considerations: Quality of statistical models and quality of data. Dealing with erroneous data, missing values, bias of observer etc.

  Demonstration of statistical fallacies due to data (biased sample, inadequate sample size, incomparable objects), erroneous analysis (linear analysis of nonlinearities, biased data selection, misuse of p-values, etc.) and errors or misuse of presentations (misuse of percentages or wrong base for percentages, misuse of means etc. Misuse of graphical representation. [10 Lectures]

**Lab**

**List of Experiments**

- Introduction to R using RStudio
- Analysis of data used in public health with real life examples
- T-test with biological data set

- ANOV A test with biological data set
- Application of Wilcoxon's Signed Rank test
- Application of Mann Whitney U test
- Kruskal-Wallis-test
- Meta-analysis of the disease data
- Equivalence study
- Cross sectional study
- Regression analysis
- Multivariate Methods
- Categorical data analysis

**Text Books:**


1. Abhaya lndrayan and Rajeev Kumar Malhotra, **Medical biostatistics**, Chapman and Hall, 2017.


**References:**


1. Bernard Rosner, **Fundamentals of Biostatistics**, 8th edition, Cengage Learning Inc., 2015.
2. Wassertheil-Smoler, **Biostatistics and Epidemiology: A Primer for Health and Biomedical Professionals**, Springer-Verlag 2014.
3. Shein-Chung Chow, Jen-Pei Liu, **Design and Analysis of Clinical Trials: Concepts and Methodologies**, 3 rd edition, Wiley, 2016.


## 2.9 BE 304: Bioinformatics

**Course Code: BE 304**
**Course Name: Bioinformatics**

L-T-P-C: 2-0-2-3
Prerequisite: IC136
Students intended for: B. Tech M.Tech Integrated Dual Degree Bioengineering students
Elective or Core: Core for IDD BE, Elective for other B.Tech students
Approval: 38th BoA

**Course contents**

- **Introduction to Bioinformatics**

  What is Bioinformatics? What are the applications of Bioinformatics? [1 Lectures]

- **Introduction to Basic Programming**

  Introduction to basic scripting and programming routinely used for bioinformatics analysis. [10 Lectures]

- **Sequence and Molecular File formats**

  Introduction to different file formats used for biological data. Sequence and molecular file conversion tools. [1 Lecture]

- **Databases in Bioinformatics**

  Introduction to different biological databases, their classification schemes, and biological database retrieval systems. [2 Lectures]

- **Sequence Alignments**

  Introduction to concept of alignment, Scoring matrices, Alignment algorithms for pairs of sequences including Dot Matrix plot, Dynamic programming and Heuristic algorithms such as BLAST, Multiple sequence alignment (Clustal), Global and local alignment algorithms. [12 Lectures]

- **Motif Identification**

  Introduction to motif identification in DNA and proteins including consensus and probabilistic approaches. [2 Lectures]

**Lab**

**List of Experiments**

- Perl programming (3 labs)
- Databases for Bioinformatics and format conversion. (2 labs)
- Sequence similarity (Local alignment, including BLAST) (2 labs).
- Sequence similarity (Global alignment, Clustal) (2 labs).
- Motif Identification (1 lab)

**Text Books:**


1. S.C. Rastogi, N. Mendiratta, P. Rastogi, **Bioinformatics: Methods and Applications Genomics, Proteomics, and Drug Discovery**, 3rd edition, PHI Learning Private Limited, 2011.

2. Z. Ghosh and B. Mallick, **Bioinformatics Principles and Applications**, Oxford University Press, 2015

**References:**


1. Arthur M. Lesk, **Introduction to Bioinformatics**, 3rd edition, Oxford University Press.

2. Richard Durbin, Sean R. Eddy, Anders Krogh, Graeme Mitchison, **Biological Sequence Analysis-Probabilistic Models of Proteins and Nucleic Acids**, Cambridge University Press.

3. Neil C. Jones and Pavel A. Pevzner, **An Introduction to Bioinformatics Algorithms**, MIT Press.


## 2.10 BE 305: Bioethics and Regulatory Affairs

**Course Code: BE 305**
**Course Name: Bioethics and Regulatory Affairs**

L-T-P-C: 1-0-0-1
Prerequisite: IC136
Students intended for: B. Tech M.Tech Integrated Dual Degree Bioengineering students
Elective or Core: Core for IDD BE, Elective for other B.Tech students
Approval: 44th BoA

**Course contents**

- **Introduction to Bioethics**

  Ethics and ethical theory, the nuremberg code, declaration of helsinki, the belmont report, history of ethics, justice and rights, liberty and morality. Deontology, utilitarianism and Principalism, Virtue ethics, Ethics of Care, Human Rights. [4 Lectures]

- **Ethics of research involving human participants**

  Biomedical research involving human participants. Guidelines for research on children, Stem cell research, animal research etc. Ethical issues in Genetic research and studies involving Genetic information. Ethics of investigator-participant relationship, problems of randomized clinical trial, constitution of Ethics Committees, informed consent and its theoretical value (respecting autonomy, nonmaleficence, concept of confidentiality etc.), research on vulnerable population. [5 Lectures]

- **Drug regulatory affairs**

  Pharmaceutical regulatory affairs, national regulatory affairs, drug approval and international drug regulations, regulatory affairs of controlled drug delivery system, regulatory requirements for product approvals, environmental concerns and regulations. National regulatory affairs and bodies – Central Drugs Standard Control Organization (CDSCO) headed by the Drug Controller General of India (DCGI). [5 Lectures]

**Text Books:**

1. Ronald Munson, **Intervention and Reflection: Basic Issues in Medical Ethics**, 10th Edition, Cengage Learning, 2018.

2. Beauchamp, Tom L and Childress, James F., **Principles of Biomedical Ethics**, Oxford University Press, 2019.

**References:**

1. Rachels, James and Stuart Rachels, **Elements of Moral Philosophy**, 5-7th editions, McGraw-Hill, 2012.

2. Richard Durbin, Sean R. Eddy, Anders Krogh, Graeme Mitchison, **Biological Sequence Analysis-Probabilistic Models of Proteins and Nucleic Acids**, Cambridge University Press.

3. NSantoro, Michael A and Thomas M Gorriee, **Ethics and the Pharmaceutical Industry**, Cambridge University Press.

## 2.11 BE 306: Genetic Engineering: principles and applications

**Course Number : BE 306**

**Course Name : Genetic Engineering: principles and applications**

L-T-P-C : 3-1-0-4
Intended for : UG (IDD Bioengg, 3rd year)
Prerequisites : IC136 or consent of the faculty member
Elective or Core : Discipline core
Mutual Exclusion : None
Approval: 50th BoA

**Course Contents:**

**Introduction**: Gene and mRNA structure and properties; analysis of DNA and RNA sequences, DNA and RNA modifying enzymes (Restriction Enzymes, DNA ligase, Klenow enzyme, T4 DNA polymerase, Polynucleotide kinase, Alkaline phosphatase). Introduction to genetic engineering and GMOs. [12 hours]

**PCR and Its Applications** : Primer, Primer designing, Thermostable DNA polymerases, PCR, Types of PCR – multiplex, nested, reverse transcriptase, cDNA synthesis, real-time PCR, touchdown PCR, hot start PCR, colony PCR. Site-directed mutagenesis, Mutation detection, PCR in molecular diagnostics, Viral and bacterial detection. [11 hours]

**Cloning Vectors**: Bacterial and viral based plasmids (PUC19, Bluescript vectors, M13 vectors, SV-40 vectors, Phagemids, Cosmids); Artificial chromosome vectors (YACs; BACs); Plant based vectors, Ti and Ri as vectors, Selection of vectors, Expression vectors (pMal; GST; pET-based vectors) [8 hours]

**Cloning Methodologies**: Restriction Enzyme Based Cloning; PCR Cloning (TOPO or TA); Ligation Independent Cloning (LIC); Seamless Cloning (SC); Recombinational

Cloning; Gibson Assembly (Isothermal Assembly Reaction); Expression cloning, Construction of genomic and cDNA libraries. [12 hours]

**Introduction of DNA into cells**: Introduction of DNA into bacterial cells (transformation methods), viruses (transduction methods), mammalian cells (Transfection techniques), plant tissues (Transfection techniques, particle bombardment), and model organisms (microinjections). [7 hours]

**Genetic engineering applications, case studies and ethical issues**: Recent developments in genetic engineering methods; Applications of genetic engineering in agriculture and medicine; GMOs and GEMs; Socio-economic, cultural, and ethical issues. [6 hours]

**Textbooks:**

1. Terry A. Brown, **Gene Cloning: An Introduction**, 8th Edition, Wiley-Blackwell, 2021.

2. Sandy B. Primrose, Richard Twyman, **Principles of Gene Manipulation and Genomics**, 8th edition, John Wiley Blackwell, 2016.

**References:**

1. Michael R. Green and J. Sambrook, **Molecular Cloning: A Laboratory Manual**, 4th Edition, Vols 1-3, Cold Spring Harbor Laboratory Press, CSHL, 2012.

2. B. Alberts, R. Heald, A. Johnson, D. Morgan, M. Raff, **Molecular Biology of the Cell**, 7th Edition, W.W. Norton & Co Inc, 2022.

3. Relevant research articles/reviews will be advised relating to the topic being taught.

## 2.12 BE 307P: Reverse Engineering for Bioengineers

**Course number : BE 307P**

**Course Name : Reverse Engineering for Bioengineers**

Credit Distribution : 0-0-2-1

Intended for : B.Tech.-M.Tech. Integrated Dual Degree in Bioengineering (Core Course)

Prerequisite : No prerequisite (compulsory for Bioengineering students)

Mutual Exclusion : NA

Approval: 50th BoA

**Course Contents:**

The students focus on hardware reverse engineering (RE). In the process of RE students understand existing technologies, functions, features, objects, components and systems. By carefully disassembling, observing, testing, analyzing and reporting, students can understand how something works and suggest ways it might be improved. This process requires careful observation, disassembly, documentation, analysis and reporting. Many times, the reverse engineering process is non-destructive. This means that the object or component can be reassembled and still function just as it did before it was taken apart. Throughout the reverse engineering project, the students are able to think of ways these objects could be improved. Is there some way it could function better? or manufactured less expensively? The students will use observations to make suggestions for improvement of the product.

**Learning Topics:**

Reverse Engineering of Biotechnological/Biomedical- Devices/ prototypes.

**Text books:**

1. Lam, R.H. and Chen, W., **Biomedical Devices: Materials, Design, and Manufacturing**, Springer, 2019.

2. Boccato C, Cerutti S, Vienken J, editors, **Medical devices: improving health care through a multidisciplinary approach** [Internet], Cham: Springer International Publishing; 2022

**References:**

1. Sokovic and Kopac, RE as necessary phase by rapid product development, **Journal of Materials Processing Technology**, 2005

2. Eldad Eilam, **Reversing: Secrets of Reverse Engineering**, Wiley 2005.

3. Chris Eagle, **The IDA Pro Book: The Unofficial Guide to the World's Most Popular Disassembler**

## 2.13 BE 308: Introduction to Biomanufacturing

**Course number : BE 308**
**Course Name : Introduction to Biomanufacturing**
Credit Distribution : 3-0-2-4
Intended for : B.Tech.-M.Tech. Integrated Dual Degree in Bio-Engineering
Prerequisite : IC 136 Understanding Biotechnology and its Applications or Consent of Faculty Member
Mutual Exclusion : NA
Approval: 50th BoA

**Course Contents:**

- **Manufacturing of Biomolecules:** Introduction to Biologicals, Biomolecules for industrial application, Stages of biomanufacturing, Case studies, Expression systems, Nutritional strategies/cell culture media, Cell growth, Bioreactor design, operation, and control. (12 Hours)

- **Production, Isolation & Purification:** Cell separation: centrifugation and depth filtration, Chromatography, Viral clearance, Ultrafiltration and diafiltration, Bulk filling. (12 Hours)

- **Industrial Scaleup:** Applicable Regulations and Guidelines, GMP and GDP. Clinical evaluation, Registration or licensing, Quality assessment, Stages of Process Development- early, mid, late, Process characterization, Process validation, Scale-up considerations. (12 Hours)
- **Policies & Future Directions in Biomanufacturing:** Bench to bedside concept, Development of new stem-cell- based therapies, tissue engineered, 3D-Bioprinted tissues/ organs, Preclinical studies for first-in-human studies, Discovery process in cell and gene therapy/ tissue engineering, First-in-humans studies, Phase 1 first-in-human studies, target product profile (TPP), Human subject ethical issues. (6 Hours)

**Laboratory Experiments (28 Hours):**

1. Alginate bead encapsulation
2. Chromatography
3. Ultrafiltration and diafiltration
4. Cell separation

**Text books:**

1. Gilleskie, Gary, Charles Rutter, and Becky McCuen, **Biopharmaceutical Manufacturing: Principles, Processes, and Practices**, Walter de Gruyter GmbH & Co KG, 2021.
2. Atala, Anthony, and Julie Allickson, eds., **Translational regenerative medicine**, Academic Press, 2014.
3. Wei Wang , Manmohan Singh, **Biological Drug Products: Development and Strategies**, Wiley, 2013.

## 2.14 BE 401 : Bioengineering Mini Project, Term Paper and Seminar

**Course number : BE401**
**Course Name : Bioengineering Mini Project, Term Paper and Seminar**
Credit Distribution : 0-0-8-4
Intended for : B.Tech.-M.Tech. Integrated Dual Degree in Bio-Engineering
Prerequisite : NA
Mutual Exclusion: NA
Approval: 50th BoA

**Course Contents:**

- **Mini-Project:** This will be floated by the faculties and then students in a group of two will be allocated for the floated projects.

- **Term Paper:** Term paper will be a detailed research focused assignment on a scientific topic. The term paper submitted by the students will be decided by the faculty supervisor.
- **Seminar:** The students will give one seminar on a published research paper relevant to their mini-project.

**Text books:**

1. NA

**References:**

1. NA

## 2.15 BE 501: Anatomy and Physiology

**Course Code: BE 501**
**Course Name: Anatomy and Physiology**

L-T-P-C: 2-0-2-3
Prerequisite: IC136 / BE 201/ BE 202 or equivalent
Students intended for: B. Tech M.Tech Integrated Dual Degree Bioengineering students
Elective or Core: Core for IDD BE, Elective for other B.Tech students
Approval: 44th BoA

**Course contents**

- **Foundations of Anatomy, Physiology and homeostasis**

  Organization of the Human Body, Chemical Foundations –Atoms, Ions, Molecules, Bonds, Solutions comprising different specialized tissues, organs and organ systems. [4 Lectures]

- **Haemopoietic system, Lymphatic System and Endocrine system**

  Composition and functions of blood and its elements, their disorders, blood groups (ABO classification) and their significance, mechanism of coagulation, Anaemias and its types, lymph organs. Anatomy and physiology of Pituitary, thyroid, parathyroid, adrenal and pancreatic glands, specific hormones and disorders of these glands, endocrine control of growth and metabolism; pineal, thymus. [8 Lectures]

- **Cardiovascular and Musculo-skeletal system**

  Anatomy and physiology of the heart, cardiac cycle; circulation of blood, heart rate, blood pressure, ECG and heart sounds, lymphatic vessel, systemic and portal circulation; vascular system –arteries, arterioles, capillaries, venules. Blood pressure and its regulation. Brief outline of cardiovascular disorders like hypertension, myocardial infarction, congestive heart failure, cardiomyopathies and cardiac arrhythmias. Anatomy and physiology of muscular system, types of muscle tissue –skeletal, smooth, cardiac, contraction, muscle fibre regulation, Osseous system - structure, composition and functions of the skeleton, physiological properties of skeletal muscles and their disorders such as Rheumatoid arthritis, Gout etc. [10 Lectures]

- **Digestive and renal System**

  Gross anatomy of the gastro-intestinal tract, functions of its different parts, various gastrointestinal secretions and their role in the absorption and digestion of food, peptic ulcer, ulcerative colitis, hepatic disorder. the renal system structure –Anatomy and physiology kidney; structure of the glomerulus, nephron and network of blood capillaries urinary tract, formation of urine, concentration of urine; regulation of acid-base balance; the chemical acid-base buffer systems of body fluids and Micturition, diuretics and kidney disease. [10 Lectures]

- **Respiratory system**

  Anatomy of lungs, respiratory tract, mechanism and dynamics of respiration, lung volumes, transport of oxygen and carbon dioxide, disorders like cyanosis, Gas transport between the Lungs and tissues. Regulation of respiration. Respiratory adjustments in health and diseases. [4 Lectures]

- **Nervous System**

  Anatomy and physiology of brain, blood-brain barrier, spinal cord, structure and types of the neuron, synapses neurotransmitters, organization of spinal and cranial nerves, central and peripheral nervous system, autonomic nervous system, receptors membrane potentials –graded potentials and action potentials, physiology of vision, audition, olfaction, taste and skin. [6 Lectures]

**Text Books:**

1. Guyton, A.C. and Hall, J.E, **Textbook of Medical Physiology**, 13th edition, Saunders, 2015.

2. Ganong, W.F., **Review of Medical Physiology**, 26th edition, (A Lange Medical book series) McGraw –Hill (International Ed.) 2010.

**References:**

1. Waugh, Anne and Allison Grant, **Ross and Wilson Anatomy and Physiology in Health and Illness**, 12th edition, Churchill –Livingstone / Elsevier, 2014.

2. Carola, R., J.P. Harley and C.R. Noback, **Human Anatomy & Physiology**, 2nd edition, McGraw –Hill, 1992.

3. Vander, A.J., J.H. Sherman and D.S. Luciano, **Human Physiology: The Mechanisms of Body Function**, 5th Edition, McGraw –Hill, 1990.

4. hurana, Indu **A Textbook of Medical Physiology** 2nd edition Elsevier, 2015.

5. Johnson, L.R. **Essential Medical Physiology**, 3rd Edition, Academic Press / Elsevier, 2003.

## 2.16 BE 502: Design and Analysis of Bioalgorithms

**Course Code: BE 502**
**Course Name: Design and Analysis of Bioalgorithms**

L-T-P-C: 2-0-2-3
Prerequisite: IC136, IC152, IC260
Students intended for: B. Tech M.Tech Integrated Dual Degree Bioengineering students
Elective or Core: Core for IDD BE, Elective for other B.Tech students
Approval: 44th BoA

**Course contents**

- **Introduction**

  Background on genomics and proteomics, DNA-RNA gene, protein structures, Importance of Bio-algorithms, Bioinformatics algorithms and examples of algorithms designs, algorithm complexity and speed, Bio-signal processing algorithms and design considerations [4 Lectures]

- **Combinatorial pattern matching algorithms for genomes**

  Hash Tables, Exact matching, Suffix Trees, Keyword Trees, Heuristic similarity search methods, approximate pattern matching, sequence similarity search, sequence alignment, BLAST, and motif finding [9 Lectures]

- **Graph-based and Clustering algorithms**

  Graph terminologies and some basic algorithms, shortest superstring-based DNA sequencing, hybridization-based DNA sequencing, graphs for peptide sequencing, K-means clustering and Hierarchical clustering for gene expressions, graph-based clustering, phylogenetic tree reconstruction. [9 Lectures]

- **Bio-signal processing**

  Pre-processing considerations in bio-signals (for EEG and FMRI), signal decomposition methods, graph-based and clustering algorithms for EEG and FMRI, feature extraction and their uses in diagnosis of diseases. [6 Lectures]

**Text Books:**

1. N.C. Jones and P.A. Pevzner, **An introduction to bioinformatics algorithms**, MIT Press, 2004.

2. K. Najarian, R. Splinter, **Biomedical Signal and Image Processing**, 2nd Edition, CRC Press, 2012.

**References:**

1. T. Cormen, C. Leiserson, R. Rivest, C. Stein, **Introduction to algorithms**, 3rd Edition, MIT Press, 2009.

## 2.17 BE 503: Biosensing and Bioinstrumentation

**Course Code: BE 503**
**Course Name: Biosensing and Bioinstrumentation**

L-T-P-C: 3-0-2-4
Prerequisite: IC161, IC161P, IC260 or equivalent
Students intended for: B. Tech M.Tech Integrated Dual Degree Bioengineering students
Elective or Core: Core for IDD BE, Elective for other B.Tech students
Approval: 33rd Senate, 35th Senate, 44th BoA, 49th BoA

**Course contents**

- **Measurement**

  SI units, systematic and random errors in measurement, expression of uncertainty - accuracy and precision index, propagation of errors, DC potentiometer; bridges for measurement of R, L and C, Q-meter, signal-to-noise ratio, responsivity of a sensor (Transformation of Input-to-output signal). [4 Lectures]

- **Biosignals**

  Origin, nature, and types of Biosignals, Principles of sensing physiological parameters from plants and animals, Bioelectric signals and their characteristics. Chemical and electrochemical biosignals. [3 Lectures]

- **Sensors**

  Classification of transducers and their characteristics, viz. Voltage sensors, Optical sensors, Displacement/Pressure sensors and accelerometers, Chemical sensors, Acoustic sensors – basic principles, signal conditioning considerations, examples (e.g. biopotential electrodes, pulse oximeter, glucose monitor, hearing aid, etc.); Physical biosensors and associated signal conditioning circuits; Chemical biosensors; Antibody based biosensors, DNA based biosensor, Immunoassays for plant and animal pathogen detection, Enzyme linked immune-sorbent assays (ELISA), bio-luminioscent technologies for pathogen detection; Optical sources and detectors: LED, Photo-diode, p-i-n and avalanche photo diode, optical nterferometers: applications in metrology; basics of optical sensing and LASER; basics of magnetic sensing. [16 Lectures]

- **Bioinstrumentation**

  Biopotential Amplifiers, Noise and artefacts and their management, Electrical Isolation (optical and electrical) and Safety of bio-instruments. Generation, Acquisition, and signal conditioning and analysis of biosignals. Principles of measuring blood pressure, bioamperometric enzyme electrode. [15 Lectures]

- **Analytical bio-techniques**

  Principles and applications of UV-Visible-NIR spectroscopy, fluorescence spectroscopy, MR spectroscopy, basics of chromatographic techniques, imaging techniques – principles and applications of microscopy. [4 Lectures]

**Laboratory/practical/tutorial Modules**

Design of measurement circuits, ELISA test, extraction of bio-signals, amplification and isolation of bio-signals, phase contrast microscopy, chemoluminiscence, fluorescence spectroscopy, MR spectroscopy, spectrophotometry, Pulse oximeter, blood pressure measurement device.

**Text Books:**

1. A.G. Webb, **Principles of Biomedical Instrumentation**, Cambridge University Press, 2018.
2. J. G. Webster, **Medical Instrumentation – Application and Design**, 4th edition, John Wiley and Sons, 2020.

**References:**


1. R.S. Khandpur, **Biomedical Instrumentation – Technology and Applications**, Tata McGrawHill, 2017.
2. CS.C. Mukhopadhyay, A.L. Ekuakille, **Advances in Biomedical Sensing, Measurements, Instrumentation and Systems**, Springer-Verlag, Germany, 2018.
3. J. R. Lakowicz, **Principles of Fluorescence Spectroscopy**, Springer Science & Business Media, 2013.
4. H. H. Willard, L. L. Merritt, J. A. Dean, F. A. Settle **Instrumental Methods of Analysis**, CBS publishers and Distributors, 2015.


## 2.18 BE 504: Biomaterials

**Course Code: BE 504**
**Course Name: Biomaterials**

L-T-P-C:3-0-2-4
Prerequisite: IC136, IC241, or consent of faculty
Students intended for: B. Tech M.Tech Integrated Dual Degree Bioengineering students
Elective or Core: Core for IDD BE, Elective for other B.Tech students
Approval: 44th BoA

**Course contents**

- **Introduction to Biomaterials**

  Introduction to biomaterials and its history, Properties of Biomaterials- physico-chemical, mechanical, biocompatibility and biodegradability, Surface properties of biomaterials, Biological responses and Cell-Biomaterial interaction. [8 Lectures]

- **Classes of Biomaterials**

  Polymeric materials and blends, Biopolymers and hydrogels, Metal based biomaterials, Ceramics and bioglasses; Adhesive and sealants, Elastomers. [8 Lectures]

- **Biomaterials Applications**

  Applications of biomaterials in cardiology, nephrology, ophthalmology, dentistry and orthopaedics; Wound healing and dressing materials, skin substitutes and sutures, Applications of Biomaterials in Functional Tissue Engineering and drug delivery systems. [20 Lectures]

- **Device development, Standards and regulatory compliance**

  Biomaterial device development and Regulation, Voluntary consensus standards, Commercialization, corporate considerations, Ethical issues, Clinical trials, Entrepreneurship and post market considerations in biomaterials. [6 Lectures]

**Laboratory**

Lab component of the course will include synthesis/fabrication, characterisation, biocompatibility testing and application of biomaterials. The experiments include.

- Preparation of polymeric nanosphere and characterization
- Drug/Protein loading and release study with polymeric nanospheres
- Preparation and characterization of hydrogels/nanosponges
- Preparation and characterization of electrospun nanofibrous mats
- Biocompatibility Testing
- Preparation of Bioceramics and its characterization

**Text Books:**

1. Editor(s): Buddy D. Ratner et al, **Principles of Biomedical Instrumentation** in Biomaterials Science, 3rd edition, Academic Press.
2. Bikramjit Basu, **Biomaterials Science and Tissue Engineering: Principles and Methods**, Cambridge University Press, 2017.

**References:**

1. Bikramjit Basu, **Biomaterials for Musculoskeletal regeneration: Concepts**, Springer Nature, 2017.
2. **Advanced Biomaterials: Fundamentals, Processing and Applications**, John Wiley & Sons, 2009.
3. Fredrick H. Silver and David L. Christiansen, **Biomaterials Science and Biocompatability**, Springer.
4. Related journal articles.

## 2.19 BE 505: Computational Biology

**Course Code: BE 505**
**Course Name: Computational Biology**

L-T-P-C: 2-0-2-3
Prerequisite: IC136, BE304, or consent of faculty
Students intended for: B. Tech M.Tech Integrated Dual Degree Bioengineering students
Elective or Core: Core for IDD BE, Elective for other B.Tech students
Approval: 44th BoA

**Course contents**

- **Pattern matching**

  inding regulatory seqeuences in DNA, Motif discovery, Exhaustive search, Greedy motif clustering, wordlets and motifs refinements, Probabilistic solutions (expectation maximisation, Gibbs sampling). [2 Lectures]

- **Genomic Analysis**

  a. Genome assembly with Graphs and Networks,
  b. Gene prediction, Hidden Markov models, Viterbi, expectation maximisation)
  c. Next Generation Sequencing analysis (short read mapping, ChIP-seq and RNA-seq analysis)
  d. Comparative genomics and genome rearragements
  e. Population genomics, Medical genomics, Personal genomics, disease epigenomics, Systems approaches to disease. [14 Lectures]

- **Phylogenetic Inferences**

  Introduction to phylogenetic inferences, Alignments to Distances, probabilistic models of divergence (Jukes Cantor, Kimura, hierarchy), Distances to trees, types of trees, algorithms for tree building (UPGMA, neighbor joining), optimality (least squared error, minimum evolution), Alignements to trees, alignment scoring given a tree, parsimony, greedy vs dynamic programming, maximum likelihood, Max-a-Posteriori, bootstrapping, Tree visualisation. [3 Lectures]

- **Structure prediction and Molecular modelling**

  RNA and protein structure prediction methods, homology modelling and ab – initio structure prediction methods, models of proteins, discrete conformational search, binding and docking, molecular dynamics simulations. [5 Lectures]

- **Biological network analysis and modelling** Gene regulatory networks, Protein interaction networks, Logic modelling of Cell signalling networks, network modelling, formulating models, nonlinear dynamics and stability, steady-state problems, parameter fitting and estimation, basic overview of the modeling of metabolic networks in genome scale by Flux Balance or modeling of reaction kinetic for smaller networks/pathways [4 Lectures]

**Laboratory**

The below mentioned 10 topics will be covered over the 14 weeks:

- Pattern matching
- Genome assembly
- Gene prediction (prokaryotic and eukaryotic)
- Read mapping and NGS data-analysis
- Comparative genomics methods
- Population genomics methods
- Phylogenetic and analysis molecular evolution
- Protein structural analysis (Secondary structure prediction and homology modelling)
- Protein structural analysis (Ab-initio molecular modelling and simulation, docking)
- Biological networks analysis

**Text Books:**

1. Peter Clote, **Computational Molecular Biology: An Introduction** in Biomaterials Science, 2000.
2. Neil C. Jones and Pavel A Pevzner, **An Introduction to Bioinformatics Algorithms (Computational Molecular Biology)**, 2004.

**References:**

1. Ion Mandoiu (Author), Alexander Zelikovsky, **Bioinformatics Algorithms: Techniques and Applications: 03**, Wiley Series in Bioinformatics, 2008.
2. Arthur M. Lesk, **Introduction to Bioinformatics**, 3rd edition, Oxford University Press.
3. Richard Durbin, Sean R. Eddy, Anders Krogh, Graeme Mitchison, **Biological Sequence Analysis-Probabilistic Models of Proteins and Nucleic Acids**, Cambridge University Press.
4. Jonathan Pevsner, **Bioinformatics and Functional Genomics**, 3rd edition, Wiley-Blackwell.

## 2.20 BE 506 : Biological Modelling and Simulation

**Course Code: BE 506**

**Course Name : Biological Modelling and Simulation**

L-T-P-C : 2-0-2-3

Intended for : Core for Integrated Dual Degree Bioengineering students with Specialisation in Computational Bioengineering, elective for other B.Tech and Mtech students, Elective for other UG, PG

Prerequisite : Understanding Biotechnology and its applications (IC136), and Bioinformatics (BE304), Computational Biology (BE505), or with permission of the instructor.

Mutual Exclusion : None

Approval: 43rd BoA, 45th BoA

**Course Contents:**

- **A. Modelling biomolecular structure, interactions and dynamics using atomistic simulations**: (Dr. D. Mohanty, NII) Introduction to Molecular Modelling, Molecular Mechanics (MM) Forcefields & empirical energy functions, Potential energy surface & Energy minimization algorithms, Molecular dynamics (MD), Explicit solvent simulations & Water models, Calculation of energy (E), temperature (T), Pressure (P) and Volume (V). Temperature control by velocity scaling and coupling to heat bath, Equilibration vs Production Dynamics, MD at higher temperatures for enhanced sampling & Simulated Annealing, Analysis of MD trajectories by Principal Component Analysis (PCA) and essential dynamics, MD Simulations in membrane environment, Calculation of Free Energy changes from explicit solvent MD by Free Energy Perturbation (FEP) approach, Monte Carlo (MC) Simulations, Atomistic vs coarse-grained dynamics. (13 hours)
- **B. Systems Biology & Biological Networks:** (Prof James Gomes, IIT Delhi) (2 hours)
- **C. Simulation of cellular subsystems:** Simulation & Analysis of Biochemical Network Models (3 Hours) (Prof James Gomes, IIT Delhi) Simulation of Genome-Scale Metabolic (GSM) Networks, Flux-Balance Analysis (FBA) & Constraint based models (5 Hours) (Dr. Karthik Raman, IIT Chennai) Introduction to Boolean Network Modeling of Gene Regulation (2 hours) (Dr D. Mohanty, NII). (11 hours)
- **D. Population models:** (Dr. Tulika P Srivastava, IIT Mandi) (3 hours)

**Lab Course content: (28 hours)**

The below mentioned 10 topics will be covered over the 14 weeks:

- **A. Atomistic Simulations** (12 hours) (Dr. D. Mohanty & Tulika P. Srivastava)
  - Visualization and analysis of 3D structures of bomolecules and Model building.
  - Energy minimization.
  - Molecular Dynamics Simulation of a Protein using GROMACS.

– Analysis of MD trajectory & Principal Component Analysis (PCA) of MD trajectory.
– Calculation of Free Energy (solvation of methane or amino acids in water) using explicit water simulations.
– MD simulations of a Protein-Ligand complex.
– MD simulation of a model transmembrane peptides in lipid bilayers.

- **B. Analysis of biological networks** (3 hours)
  – Visualization of biological networks and calculation of network parameters using Cytoscape.
- **C. Simulation of cellular subsystems** (8 hours)
  – Simulation & Analysis of biochemical network models using differential equations (COPASI).
  – Flux Balance Analysis using COBRA Tool for simulation of genome scale metabolic networks: Applications to central metabolism of E. coli.
- **D. Population models** (5 hours)
  – Predator-Prey Simulation
  – Modeling spread of infectious disease: COVID19.

**Text books:**


1. Andrew R. Leach, **Molecular Modelling: Principles and Applications**, 2nd Edition.
2. Karthik Raman, **An Introduction to Computational Systems Biology Systems-Level Modelling of Cellular Networks**, Chapman and Hall/CRC, 2021.


**References:**


1. JA McCammon & SC Harvey, **Dynamics of Proteins & Nucleic Acids**, Cambridge University Press.


## 2.21 BE 507: Environmental Impact Assessment

**Course number : BE 507**
**Course Name : Tissue Engineering**
Credit Distribution : 3-0-0-3
Intended for : B.Tech.-M.Tech. Integrated Dual Degree in Bio-Engineering, M. Tech Biotechnology and PhD candidates
Prerequisite : IC 136 Understanding Biotechnology and its Applications or IC 241 Materials Science for Engineers or Consent of Faculty Member
Mutual Exclusion : NA
Approval: 50th BoA

**Course Contents:**

- **Introduction to Tissue Engineering**:The history and scope of tissue engineering, Challenge in imitating nature, Cells as building blocks, Clinical translation (4 Hours)
- **Cellular differentiation and Tissue Development:** Molecular organization in cells, Cell-matrix interactions, Tissue development (4 Hours)
- **Functional Tissue Engineering**: Matrix as growth factor reservoir, Mechanobiology of matrix, Biosimilar materials as scaffolds (6 Hours)
- **3D Tissue Culture Techniques**: Animal cell culture, Biomaterials in tissue engineering, Cell interactions with polymers, conventional 3D scaffolds, 3D printing, 3D bioprinting (8 Hours)
- **Transplantation of Engineered Tissues & Disease Models**: Host Immune Response, Immunomodulation, Disease models, applications of disease models (6 Hours)
- **Orthopaedic Tissue Engineering**: Mesenchymal stem cells, Bone ultrastructure and anatomy, Bone tissue engineering, Articular cartilage tissue engineering, Intervertebral disc tissue engineering, Orthopaedic disease models (8 Hours)
- **Ophthalmic Tissue Engineering**: Stem cells in the eye, Corneal replacements, Ophthalmic disease models (6 Hours)

**Text books:**

1. Robert Lanza, Robert Langer and Joseph Vacanti, **Principles of Tissue Engineering**, Academic press, 2020
2. Bikramjit Basu, **Biomaterials Science and Tissue Engineering: Principles and Methods**, Cambridge University Press, 2017.

**References:**

1. Bikramjit Basu, **Biomaterials for Musculoskeletal regeneration: Concepts**, Springer Nature, 2017.
2. Ravi Birla, **Introduction to tissue engineering: applications and challenges**, John Wiley & Sons, 2014.

## 2.22 BE 598: Thesis Project Part I

**Course Code: BE 598**

**Course Name : Thesis Project Part I**

L-T-P-C :
Credits: 16
**Intended for :** M.Tech Biostudents.
**Prerequisite :**

**Mutual Exclusion :** None
Approval: 9th Senate

**Evaluation Pattern:**

1 seminar presentation at the mid semester. 40% by PI, 20% for report and 40% for final presentation/viva. Evaluation is done by a committee consisting of internal experts.

1 seminar presentation at the semester end. 40% by PI, 20% for report and 40% for final presentation/viva. Evaluation is done by a committee consisting of internal and/or external experts.

## 2.23 BE 599: Thesis Project Part II

**Course Code: BE 599**

**Course Name : Thesis Project Part II**

L-T-P-C :
Credits: 17
**Intended for :** M.Tech Biostudents.
**Prerequisite :**
**Mutual Exclusion :** None
Approval: 9th Senate

**Evaluation Pattern:**

1 seminar presentation at the mid semester. 40% by PI, 20% for report and 40% for final presentation/viva. Evaluation is done by a committee consisting of internal experts.

1 seminar presentation at the semester end. 40% by PI, 20% for report and 40% for final presentation/viva. Evaluation is done by a committee consisting of internal and/or external experts.

## 2.24 BE 698P: Thesis Project Part I

**Course Code: BE 698P**

**Course Name : Thesis Project Part I**

L-T-P-C : 0-0-32-16
**Intended for :** M.Tech Biostudents.
**Prerequisite :**
**Mutual Exclusion :** None
Approval: 9th Senate

**Evaluation Pattern:**

1 seminar presentation at the mid semester. 40% by PI, 20% for report and 40% for final presentation/viva. Evaluation is done by a committee consisting of internal experts.

1 seminar presentation at the semester end. 40% by PI, 20% for report and 40% for final presentation/viva. Evaluation is done by a committee consisting of internal and/or external experts.

## 2.25 BE 699P: Thesis Project Part II

**Course Code: BE 699**

**Course Name : Thesis Project Part II**

L-T-P-C : 0-0-34-17
**Intended for :** M.Tech Biostudents.
**Prerequisite :**
**Mutual Exclusion :** None
Approval: 9th Senate

**Evaluation Pattern:**

1 seminar presentation at the mid semester. 40% by PI, 20% for report and 40% for final presentation/viva. Evaluation is done by a committee consisting of internal experts.

1 seminar presentation at the semester end. 40% by PI, 20% for report and 40% for final presentation/viva. Evaluation is done by a committee consisting of internal and/or external experts.

## 2.26 BY 501: DNA Nanotechnology

**Course Code: BY 501**
**Course Name: DNA Nanotechnology**

L-T-P-C: 3-0-0-3
Prerequisite: IC 136 and faculty consent
Students intended for: B. Tech M.Tech Integrated Dual Degree Bioengineering students
Elective or Core: Core for IDD BE, Elective for other B.Tech students
Approval: 8th Senate

**Course contents**

- **DNA:**

  Brief history about the discovery of the structure of DNA, Concept of DNA helix, Structural features of DNA and its distinction with RNA, Basic concept of gel electrophoresis, DNA amplification and ligation. [6 Lectures]

- **tructural DNA nanotechnology**

  Four arm junction, double crossovers, DNA arrays and Lattices, 3D structure- cube, tetrahedron, dodecahedron octahedron, pyramid, DNA origami. [6 Lectures]

- **Dynamic DNA nanotechnology**

  Reconfigurable DNA based structures, DNA nanomechanical devices, DNA nanomotors, DNA aptamers, DNA walker, DNA Tweezer, DNAzyme – structure function and applications, DNA nanotransport device, molecular cages [10 Lectures]

- **DNA based logic gates**

  AND, OR, NOT, XOR, NAND gates, Single and multiple input DNA logic gates, Circular logic gates, DNA Circuits, DNA computing. [10 Lectures]

- **Module-5**

  DNA directed Assembly of metal, semiconductor nanoparticles and nanoclusters. DNA Scaffolding, DNA nanorobot, Application of DNA assembled structure in chemical, biological and molecular sensing, DNA-based drug and gene delivery, Future Applications. [10 Lectures]

**References:**

A nascent textbook mentioned below will be used as appropriate and several recent articles from peer reviewed journals like Nature, Science, Nature Nanotechnology, ACS Nano, Nanoletters etc. in the field of DNA nanotechnology will be discussed. The course material will be provided.


1. Edited by Chunhai Fan, **DNA Nanotechnology – From Structure to Function**, Springer-Verlag, 2013.

2. Edited by Giampaolo Zuccheri and Bruno Samorì, **DNA Nanotechnology: Methods and Protocols**, Humana Press, Springer Science+Business Media, 2011.


## 2.27 BY 502: Biophysics and Protein Engineering

**Course Code: BY 502**
**Course Name: Biophysics and Protein Engineering**

L-T-P-C: 3-0-0-3
Prerequisite: IC136 and faculty consent
Students intended for: B. Tech M.Tech Integrated Dual Degree Bioengineering students
Elective or Core: Core for IDD BE, Elective for other B.Tech students
Approval:

**Course contents**

- **Introduction**

  Course Introduction, what is biophysics? What will you learn? – A general outline of the course. Outlook: what is the use of what you will learn here? The hierarchy and order of protein structure: amino acids and peptide bonds; the secondary structure: $\alpha$-helices, $\beta$-sheets, turns and loops; super secondary structure – domains and motifs the tertiary and the quaternary structure. Hemoglobin and myoglobin as paradigm proteins, protein characteristics and structure-function relationships. Software and online/freeware tools for analyzing proteins e.g. Rasmol and PyMol. Homology modeling as exercise for structural elucidation of biological macromolecules. [6 Lectures]

- **Intrinsically Disordered Proteins**

  Sequence composition of IDPs, distribution of IDPs in nature and their physiological roles, intrinsically disordered regions, fuzzy complexes, designed linkers, folding and binding mechanisms of IDPs. Protein disorder in signaling and disease in human and plants.

Applications of IDPs or linkers in fusion proteins of clinical importance:. Chimeric Antigen Receptors as an example of multidomain fusion protein involving folded and unfolded polypeptide chains.[6 Lectures]

- **Thermodynamics**

  a brief introduction and thermodynamic principles. Gibbs free energy, thermochemistry and calorimetry. Protein folding theories and structural transitions in polypeptides. [8 Lectures]

- **Biophysical Methods**

  Absorption spectroscopy, UV/VIS spectroscopic analysis of biopolymers. Linear dichroism: transition dipole moments and the orientation of biomolecules. Circular Dichroism: the molecular origins of the rotational strength of molecules. Applications of polarized light interactions with chromophores in protein and DNA with case studies from literature.

  Florescence spectroscopy: basic principles and instrumentation. Florescence of protein and DNA, florescence resonance energy transfer (FRET). Working principle and major application of other spectroscopic methods (FTIR, NMR, mass spectrometry and Ultrafast etc) for proteins. [15 Lectures]

- **Protein Engineering – Basic Principles and Rationale**

  Identification of putative enzymes in sequence databases, bioinformatic analysis. Enzymes, enzyme catalysis and kinetics, factors influencing the speed of enzymatic reaction. Enzyme applications, targets of protein engineering, protein engineering approaches, advantages and limitations. Rational design, comparative design, random methods; prediction of the structure of enzyme variant, evaluation of the effect of mutations on enzyme structure and function. Successful stories of application of protein engineering to improve enzyme catalytic efficiency, enzyme stability and folding. Therapeutic potentials of proteins with specific examples including insulin, anticoagulants, blood substitutes and vaccines. Sequence composition and heteromorphic pairs of proteins. [16 Lectures]

**References:**

A nascent textbook mentioned below will be used as appropriate and several recent papers from peer reviewed journals like Nature, Science, Molecular Therapy, PNAS, Biochemistry, JBC etc.

1. Donald Voet, Charlotte W. Pratt, Judith G. Voet. **Principles of Biochemistry**, 4th edition, Wiley, 2012.

2. David L Nelson, Michael M Cox, Albert L Lehninger. **Lehninger Principles of Biochemistry**, 6th edition, W.H. Freeman, 2013.

3. Irwin H. Segel, **Biochemical calculations: how to solve mathematical problems in general biochemistry**, 2nd edition, Wiley, 1976.

4. T Palmer, P L Bonner, **Enzymes, Biochemistry, Biotechnology, Clinical Chemistry**, 2nd Edition, Woodhead Publishing, 2007.

5. Peter Tompa, Alan Fersht. **Structure and Function of Intrinsically Disordered Proteins**, CRC Press, 2009.

6. David Sheehan, **Physical Biochemistry: Principles and Applications**, 2nd edition, Wiley, 2009.

## 2.28 BY 503: Cellular Fuel and Cellular Communication

**Course Code: BY 503**
**Course Name: Cellular Fuel and Cellular Communication**

L-T-P-C: 3-0-0-3
Prerequisite: IC136 or faculty consent
Students intended for: 3rd and 4th UG, PG
Elective or Core: Elective
Approval: 8th Senate

**Course contents**

- **Module 1**

  Cellular fate of nutrients metabolism:Glucose metabolism; Glucose transporters, Glycolysis, TCA cycle, glycogen synthesis, gluconeogenesis, and glycogenolysis. Metabolism of amino acids and proteins, Metabolism of lipids;oxidation of fatty acids, ketone bodies and ketosis, de novo synthesis of fatty acids, Metabolism of nucleic acids; Biosynthesis and breakdown of purine and pyrimidine nucleotides, Salvage pathways. [15 Lectures]

- **The cellular internet**

  The essential elements of cellular transduction mechanisms that allow signaling from the cell surface to the nucleus; reception, transduction and response. Types of signals: Endocrine, Paracrine,Neural,and Juxtacrine.Receptors and receptor trafficking, Types of Cell surface receptors: G-protein coupled receptors, Receptor tyrosine kinase receptors, Cytokine receptors and Non-tyrosine kinase receptors, Integrin receptors, Toll-like receptors, Ligand gated ion-channels receptors, Receptors with other enzymatic activities.Secondmessengers; Type of secondary molecules; diacylglycerol, phosphatidylinositols, cAMP, cGMP, IP3, and Ca2+. [15 Lectures]

- **Hormone and Endocrine system**

  Body's long distance regulator; Hormones, Local regulators, Neurotransmitters, Neurohormones, and Pheromones. Type of hormones, Major endocrine gland, and Hormone transport, Hormone receptors - cell surfaceand intracellular, Mechanisms of hormone action, Neuroendocrine interactions. [12 Lectures]

**Textbooks:**

1. Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff , Keith Roberts , Peter Walter, **Molecular Biology of the Cell**, 5th edition.

2. David L. Nelson, Michael M. Cox, **Lehninger Principles of Biochemistry**, 6th edition.

3. Mac Hadley, Jon E. Levine , **Endocrinology** 6th Edition, Pearson Prentice Hall Publication (for the endocrinology portion).

**References:**

1. Jane B. Reece, Lisa A. Urry, Michael L. Cain, Steven A. Wasserman, Peter V. Minorsky, Robert B. Jackson, **Campbell Biology**, 10th edition, Benjamin Cummings, 2013.

## 2.29 BY 504: Metabolic Systems Biology

**Course Code: BY 504**
**Course Name: Metabolic Systems Biology**

L-T-P-C: 3-0-2-4
Prerequisite: IC136, or consent of faculty
Students intended for: 3rd and 4th year UG and PG
Elective or Core: Elective
Approval: 8th Senate

**Course contents**

- **Introduction to systems biology and metabolism**

  Components of Biological systems (DNA, RNA, Protein, Metabolites), their properties and function. Overview of cellular metabolism, enzyme kinetics and metabolic pathways. Online resources and Tools to study metabolism – KEGG, ECOCYC etc. [6 Lectures]

- **Introduction to -omics with focus on metabolomics**

  Biological networks and their significance – at the level of genome, transcriptome, proteome, metabolome and fluxome. Metabolomics - applications and its role in systems biology. Analytical methods for detecting and quantifying metabolites. General work flow and Statistical methods in metabolomics. Pathway and metabolome databases. Case study on metabolomics from literature. [8 Lectures]

- **Metabolic pathways, network reconstruction and constraint based flux analysis**

  Pathways of central and secondary metabolism in selected model systems (microbes, plant and animal), Reconstruction of metabolic networks, Stoichiometric matrix. Topological analysis of metabolic network with Elementary flux modes and/or Extreme pathways, Introduction to Constraint based metabolic modelling and Flux Balance analysis. Related software tools and online resources. Case study/studies on Constraint based flux analysis from literature with applications in metabolic engineering and/or drug target identification. [14 Lectures]

- **Introductory 13C based fluxomics**

  Metabolic Phenotypes, Fundamentals of Metabolic Flux analysis. Current practices of 13C Metabolic Flux Analysis – Stable isotope labelling, steady state vs Non-stationary, Isotopomer analysis, Carbon transition networks, mathematical modelling for quantifying fluxes (in-vivo reaction rates), Flux maps. Software tools and online resources. Case study/studies on 13C metabolic flux analysis from literature with applications in metabolic engineering and/or understanding metabolic features in diseases such as cancer. [14 Lectures]

**References:**


1. Editor: Bernhard O. Palsson, **Systems Biology: Properties of Reconstructed Networks**, Cambridge University Press, 2006.

2. Choi, Sangdun (Editor) **Introduction to Systems Biology**, Springer Publishers, 2007.

3. J.Nielsen and M.C. Jewett (Editors), **Metabolomics – A powerful Tool in Systems Biology**, Springer Publishers, 2007.

4. Jens O. Krömer, Lars K. Nielsen, Lars M. Blank (Editors), **Metabolic Flux Analysis-Methods and protocols**, Springer Publishers, 2014.

5. Additional reference material and scientific papers will be provided.


## 2.30 BY 505: Nanobiotechnology

**Course Code: BY 505**
**Course Name: Nanobiotechnology**

L-T-P-C: 3-0-0-3
Prerequisite: IC136, or consent of faculty
Students intended for: 3rd and 4th year UG and PG
Elective or Core: Elective
Approval: 8th Senate

**Course contents**

- **Introduction**

  Definition of nanotechnology, small-strange and useful, why go nano – unique properties of nanomaterials, history of nanotechnology, present and future of nanotechnology, Nano + Light, Engineering optical properties, Band gaps, exciton, quantum confinement, Different kinds of nanomaterials- Metal and semiconductor nanoparticles; Polymeric nanoparticles; Molecular nanoparticles, Forces at the nanoscale, The Nano-Bio interface. [15 Lectures]

- **Nanobiosensing** Definition of sensors, different elements of sensor, introduction to nanobiosensing, Different types of biosensors, surface plasmon resonance based biosensor, electrochemical and potentiometric based biosensor, motion, temperature, chemical, light and pressure sensitive biosensors, Applications of biosensors in molecule analysis; food safety, environmental and biomedical monitoring and detection of biological weapons, Lab on chip devices for sensing and detection. [15 Lectures]

- **Nanomedicine**

  Nanoparticle within a biological environment, Nanoparticle dynamics in biological media, nanoparticles for therapy- drug delivery, gene delivery, protein delivery, photothermal and photodynamic therapy, uptake and toxicology of nanomaterials, Nanomaterials for tissue engineering and prosthetics. Nanoparticles based bioimaging. [12 Lectures]

**Text and Reference Books:**


1. Jeremy Ramsden, **Nanotechnology: An Introduction**, Elsevier Publishers, 2011.
2. C.M. Niemeyer and C. A. Mirkin (Editors), **Nanobiotechnology: Concepts, Applications and Perspectives**,Wiley-VCH Verlag GmbH & Co, 2012.
3. Huw Summers (Editor), **Nanomedicine**, Elsevier Publishers, 2013.
4. Sandro Carrara (Editor), **Nano-Bio-Sensing**, Springer Publishers, 2011.
5. Additionally, other latest research articles related to the topic will be discussed.


## 2.31 BY 506: Advanced Immunology

**Course Code: BY 506**
**Course Name: Advanced Immunology**

L-T-P-C: 3-0-0-3
Prerequisite: IC136, or consent of faculty
Students intended for: 3rd and 4th year UG and PG (MS/MTech, PhD)
Elective or Core: Elective
Approval: 10th Senate

**Course contents**

- **Introduction**

  Cells of immune system; innate and acquired immunity; primary and secondary lymphoid organs; antigens: chemical and molecular nature; haptens; adjuvants; types of immune responses; theory of clonal selection [8 Lectures]

- **IMMUNE RESPONSES** Development, maturation, activation and differentiation of T-cells and B-cells; TCR; antibodies: structure and functions; antibodies: genes and generation of diversity; antigen-antibody reactions; monoclonal antibodies: principles and applications; antigen presenting cells; major histocompatibility complex; antigen processing and presentation; regulation of T-cell and B-cell responses. [16 Lectures]

- **INFECTION AND IMMUNITY**

  Injury and inflammation; immune responses to infections: immunity to viruses, bacteria, fungi and parasites; cytokines; complement; immunosuppression, tolerance; allergy and hypersensitivity; Immunodeficiencies; resistance and immunization; Vaccines. [15 Lectures]

- **Immuno-technology**

  Autoimmunity, Autoimmune disorders and diagnosis [4 Lectures]

**Text Books:**

1. Kuby J, **Immunology**, 7th edition, MacMillan press
2. Janeway, Charles A., et al., **Immunobiology: The Immune System in Health and Disease**, Garland Science.
3. Peter Delves, Seamus Martin, Dennis Burton, Ivan Roitt, **Roitt's Essential Immunology (Essentials)**, Wiley-Blackwell, 2006.

**Reference Books**

1. William E Paul, **Fundamental Immunology**, Lippincott Williams & Wilkins, 2008 .
2. Gerald B. Pier,Jeffrey B. Lyczak, Lee M. Wetzler, **Immunology, Infection, and Immunity**, ASM Press, 2004.
3. Ian Todd, Gavin Spickett, **Lecture Notes: Immunology**, 5th Edition, Wiley -Blackwell, 2005.
4. Richard Coico, Geoffrey Sunshine, **Immunology: A Short Course**, Wiley-Blackwell, 2009

**Articles**

Relevant articles and scientific papers will be provided during class room teaching.

## 2.32 BY 507: Genetic Engineering

**Course Code: BY 507**
**Course Name: Genetic Engineering**

L-T-P-C: 3-0-2-4
Prerequisite: IC136, or consent of faculty
Students intended for: UG/PG
Elective or Core: Elective
Approval: 9th Senate

**Course contents**

- **Introduction**

  What is Genetic Engineering? What will you learn? – A general outline of the course. Scope of the genetic manipulation methods in basic and applied Sciences

  Outlook: what is the use of what you will learn here?

  Gene and importance of gene cloning and analysis of the cloned DNA. History of genetic manipulations and its milestone discoveries [4 Lectures]

- **Principles of gene cloning and DNA analysis**

  The early development of genetics. Invention of the DNA modifying tools and techniques for the gene cloning. Polymerase chain Reaction. Screening positive clones and confirmation of the cloned DNA with sequencing . [4 Lectures]

- **DNA Manipulative Enzymes**

  Nucleases, ligases, polymerases, other DNA modifying enzymes. Enzymes for cutting DNA: restriction endonucleases. The discovery and function of the restriction endonucleases. Type II restriction endonucleases cut DNA at specific nucleotide sequences. Production Blunt and sticky ends of the DNA.

  Restriction digestion of DNA. Analysis of the result of the restriction endonuclease reaction. Separation of the DNA and other molecules by gel electrophoresis. Visualizing DNA molecules in agarose gel. Estimation of the sizes of the DNA and restriction site mapping.

  Ligation: Joining DNA molecules together. The mode of action of DNA ligase sticky ends, blunt ends, linkers and adaptors. [6 Lectures]

  **Practical Classes will follow on this module**

- **Vectors for the gene cloning**

  Bacteriophages: The phage infection cycle, Lysogenic phages. Gene organization in the $\lambda$ DNA molecule, the linear and circular forms of $\lambda$ DNA. M13—a filamentous phage. Viruses as cloning vectors for other organisms.

  Introduction of phage DNA into the bacterial cells: In vitro packaging of $\lambda$ cloning vectors. Introduction of DNA into non-bacterial cells: Transformation of individual cells.

  Cloning Vectors for E. coli: Cloning vectors based on E. coli plasmids.

  More sophisticated/commercialized E. coli plasmid cloning vectors: pUC8—a lac selection plasmid, pGEM3Z—in vitro transcription of cloned DNA, cloning vectors based on M13 bacteriophage, how to construct a phage cloning vector, hybrid plasmid–M13 vectors. Insertion and replacement vectors Cloning of long DNA fragments using a cosmid and other high-capacity vectors.

  Cloning vectors for animals and insects. Viruses as cloning vectors for mammals, marker rescue extends the scope of direct selection. The scope and limitations of marker rescue.

  Identification methods based on detection of the translation product of the cloned gene. A tutorial will follow this module on Software and online/freeware tools for analyzing restriction sites in DNA sequence. Vector NTI software for vector mapping. [16 Lectures]

- **Module-5**

  Functional Genomics: Introduction to Gene knock-down and knock-out methods for bacteria, plant, Drosophila and Mouse organism. [4 Lectures]

- **Applications of Genetic Engineering in Biotechnology**

The applications of Gene cloning and DNA analysis in Biotechnology. Production of protein from the the transgenic organism. Special vectors for expression of foreign genes in the E. coli. The promoter and its importance for an expression vector. Examples of promoters used in E.coli expression vectors. Expression cassettes and gene fusions. General problems with the production of recombinant protein in E. coli. Problems resulting from the sequence of the foreign gene. Problems caused by the host (E. coli). Production of recombinant protein by eukaryotic cells. Recombinant protein from yeast and filamentous fungi. Saccharomyces cerevisiae as the host for production of recombinant protein and advantages of this expression system.

Protein production in mammalian and insect cells. Molecular Pharming—recombinant protein from live animals and Plants.

Gene cloning and DNA analysis in Agriculture: The gene addition/transfer approaches for plant genetic engineering. The $\delta$-endotoxins of Bacillus thuringiensis as an example (bt otton).

Gene cloning and DNA Analysis in Medicine. Production of the recombinant pharmaceuticals. Recombinant insulin: Synthesis and expression of artificial insulin genes. Synthesis of other recombinant human proteins and vaccines.

**Text Books:**

1. A nascent textbook mentioned below will be used as appropriate and several recent papers from peer reviewed journals like Nature, Science, Molecular Therapy, PNAS, Biochemistry, JBC etc.

**Reference Books**


1. T. A. Brown, **Gene Cloning and DNA Analysis: An Introduction**, 6th edition, Wiley, 2010.

2. Sandy Primrose And Richard Twyman, **Principles of Gene Manipulation and Genomics**, 7th edition, Wiley-Blackwell, 2006.

3. Desmond S. T. Nicholl, **An Introduction to Genetic Engineering**, 3rd Edition, Cambridge University Press, 2008.


## 2.33 BY 508: Practical Metabolomics

**Course Code: BY 508**
**Course Name: Practical Metabolomics**

L-T-P-C: 1-0-2-3
Prerequisite: IC136, or consent of faculty; MS, MSc, PhD from Basic Sciences
Students intended for UG/PG
Elective or Core: Elective
Approval: 9th Senate

**Course contents**

- **Module 1**

  **Theory and Tutorials**: Metabolites and metabolite profiling, Metabolomics - applications and its role in systems biology with case studies, Targeted and untargeted metabolomics, General work flow including quenching and sample preparation, Detection and quantification of metabolites by advanced analytical techniques (NMR/Mass spectroscopy, HPLC). Statistical methods (PCA, PLS, PLS-DA) in metabolomics. Pathway and metabolome databases. Software tools available for metabolomics analysis [10 Lectures]

- **Module 2**

  **Practicals** – mini-project involving metabolite profiling and metabolomics experiments based on Module 1 contents. Review and development of Protocols/workflow, Design and conduct of experiments, analytical techniques (NMR, MS, HPLC), Data handling using relevant software, Statistical analysis. Scientific report writing in metabolomics for evaluation. [32 Lectures]

**Reference Books**

1. J.Nielsen and M.C. Jewett (Editors), **Metabolomics – A powerful Tool in Systems Biology**, Springer.

2. Dr. Silas G. Villas et al., **Metabolome Analyses: an Introduction**, John Wiley & Sons.

3. Additional reference material and scientific papers will be provided.

## 2.34 BY 509: Practical OMICs

**Course Number: BY 509**
**Course Name: Practical OMICs**
Credit Distribution: 0.5-0.5-2-3
Prerequisites: Any MS/MSc/PhD students/BTech students with IC 136 course (Understanding Biotechnology & its Applications) or Consent of Faculty member.
Students intended for: B. Tech. 3rd and 4th year, MS/M.Sc/M.Tech., Ph.D.
Elective or Compulsory: Elective
Approval: 50th BoA

**Course Contents:**

- **Theory and Tutorials:** The theoretical aspects of different OMICs methods will be covered. This will include introduction to best experimental practices of experiment designing, sample selection, metadata selection, sample and library preparation for respective OMICs analysis. This will be followed by downstream analysis of OMICs data obtained including read preprocessing, and the respective analysis of OMICs data. (10 hours)

- **Practicals:** Mini projects will be assigned to the student involving one or more OMICs experiments. Experimental protocols will be taught and performed utilising the knowledge gained in Module 1 above on assigned case studies. This will be followed by analysis of the data obtained including hands-on exposure of the state-of-the-art software for respective OMICs data analysis, various available resources, and statistical data analysis for the same.(32 hours)

## 2.35 BY 510: Advanced Cell Biology

**Course Code: BY 510**
**Course Name: Advanced Cell Biology**

L-T-P-C: 3-0-0-3
Prerequisite: IC136, or consent of faculty
Students intended for: UG/PG
Elective or Core: Elective
Approval: 9th Senate

**Course contents**

- **A tour to Cell**

  Exploring Eukaryotic and plant cell; cell components, their structure and function; cytoskeleton network: components and structural functions; Cell-Cell and cellmatrix adhesion; Extracellular Matrix, Plant cell wall, Animal cell membrane; Cell junctions, plasmodesmata, gap junctions, desmosomes and tight junction [8 Lectures]

- **Membrane structure and function**

  Membrane models; evolution of different membrane lipids, Membrane proteins and their functions, Membrane carbohydrates and their roles in cell-cell recognition; The permeability of the bi-layers: transport proteins; Passive, active and co transport by antiporters and symporters, transporter proteins in plant vacuoles exocytosis and endocytosis. [8 Lectures]

- **Cell signalling and transport across cell membranes**

  Signalling molecules and cell surface receptors; intracellular signal transduction; G protein coupled receptors; plant growth factors and hormones-auxins, gibberlines, cytokines and others passive and active transport; transport into prokaryotic cells; endocytosis, exocytosis; entry of viruses and toxins into cells [8 Lectures]

- **Membrane trafficking**

  Translocation of secretory proteins across the ER membrane; protein modifications, folding and quality control in the ER; export and sorting of proteins to mitochondria, chloroplast and peroxisomes. [8 Lectures]

- **Eukaryotic cell cycle**

Biochemical and genetics studies on cell cycle; mechanisms regulating mitotic events; meiosis - a special type of cell division; Cell Birth, lineage and 2 death: Asymmetrical cell division, patterns of stem cell division; Biological description of apoptosis; Molecular basis of cancer, oncogenes and tumor suppressor genes [10 Lectures]

**Text Books and Reference Books**

1. Lodish et al., **Molecular Cell Biology**,5 6th edition or later, W.H. Freeman and Company.
2. Alberts et al., **Molecular Biology of the Cell**, 4th edition or later, Garland Sciences.
3. by David L. Nelson, Michael M. Cox, **Lehninger Principles of Biochemistry**, 6th Edition.
4. L. Stryer, **Biochemistry**, 4th edition, W. H. Freeman & Company.
5. Additional material from recent scientific papers/reviews will be provided

## 2.36 BY 511: Cell Physiology in Health and Diseases

**Course Code: BY 511**
**Course Name: Cell Physiology in Health and Diseases**

L-T-P-C: 3-0-0-3
Prerequisite: IC136, or consent of faculty
Students intended for: B. Tech. 3rd and 4th year, MS/M. Tech., Ph.D.
Elective or Core: Core for M. Tech. Biotechnology, elective for others
Approval: 9th Senate

**Course contents**

- **Introduction to Cell Physiology**

  Introduction to cell physiology, Cells of Eukaryotic system (animal), Cells of Eukaryotic system (Plant)[3 Lectures]

- **Cell membrane physiology I**

  Structure and organization of cell membrane and function, Membrane voltage-gated ion channels: molecular structure and regulation of physiological process, Epilepsy and its biology, Alzheimer and its biology, Sickle cell anemia, Transport across biological membranes, Active/passive, diffusion, ion channels, aqua porins, Cystic fibrosis, polycystic kidney disease, Deafness, Liddle's syndrome. [12 Lectures]

- **Cell membrane physiology II**

  Intra cellular compartments and cell Trafficking, vesicular trafficking, endocytosis and exocytosis, Protein Trafficking, Cell migration and homing, T cell homing. [7 Lectures]

- **Cell Adhesion**

  Cell-to-cell signaling: hormones, receptors and intracellular messengers, Adhesion junctions, integrins, Cell adhesion and its role in immune cell maturation and activation, Adhesion and its role in bacterial/viral disease, Cancer initiation and progression, Extracellular matrix and cell-cell interactions. [14 Lectures]

- **Cell Respiration and Free radicals**

  Cellular respiration, Generation of free radicals and their role in disease progression [6 Lectures]

**Text Books and Reference Books**


1. Nicholas Sperelaki, **Cell Physiology Source Book: A Molecular Approach**, 4th edition.

2. Mordecai P. Blaustein, Mordecai P. Blaustein, Kao Joseph P. Y., Donald R. Matteson, **Cellular Physiology**, 6th edition.

3. Bruce Alberts, Julian Lewis, Alexander Johnson, **Molecular Biology of the Cell**, 6th Edition.


## 2.37 BY 512: Quantitative and Computational Biology

**Course Code: BY 512**
**Course Name: Quantitative and Computational Biology**

L-T-P-C:3-0-0-3
Prerequisite: IC136, or consent of faculty
Students intended for: B. Tech. 3rd and 4th year, MS/M. Tech., Ph.D.
Elective or Core: Core for M. Tech. Biotechnology, elective for others
Approval: 9th Senate

**Course contents**

- **Quantitative Biology**

  Probability Theory, Probability Distributions - Binomial, Gaussian and Poisson Distributions.

  Descriptive statistics: mean, variance and sum of squares; mean and variance of a distribution, random numbers, random sampling.

  Regression analysis: linear, multiple and nonlinear.

  Test of hypotheses: t-test, z-test; Chi-square test of independence.

  Multivariate Analysis: various types of classification, ANOVA, PCA Examples of Statistics in biological data analysis.[21 Lectures]

- **Computational biology: Bioinformatics, bio-algorithms and Tools**

  Introduction to Basic Programming: Introduction to basic scripting and programming routinely used in computational biology.

Biological Databases and Sequence File Formats: Introduction to different biological databases, their classification schemes, and biological database retrieval systems.

Sequence Alignments: Introduction to concept of alignment, Scoring matrices, Alignment algorithms for pairs of sequences, Multiple sequence alignment.

Gene Prediction Methods: What is gene prediction? Computational methods of gene prediction-prokaryotic & eukaryotic.

Molecular Phylogeny: Introduction to phenotypic and molecular phylogeny. Representation of phylogeny, Molecular clocks, Methods of phylogenetic construction, statistical evaluation of the obtained phylogenetic trees.

Introduction to systems biology: Different Omics, Metabolic pathways and networks. [21 Lectures]

**Text Books and Reference Books**


1. Dekking, F.M., Kraaikamp, C., Lopuhaä, H.P., Meester, L.E., **A Modern Introduction to Probability and Statistics - Understanding Why and How**, Springer.

2. Norman Bailey, **Statistical methods in Biology**, Latest edition.

3. S.C. Rastogi, N. Mendiratta, P. Rastogi, **Methods and Applications Genomics, Proteomics, and Drug Discovery**, 3rd Edition, PHI Learning Private Limited.

4. Z. Ghosh and B. Mallick, **Bioinformatics Principles and Applications**, Oxford University Press.

5. Arthur M. Lesk, **Introduction to Bioinformatics**, 3rd edition, Oxford University Press.

6. Latest research articles will be advised related to the topic being taught.


## 2.38 BY 513: Cellular Bioprocess Technology

**Course Code: BY 513**
**Course Name: Cellular Bioprocess Technology**

L-T-P-C: 3-0-0-3
Prerequisite: IC136, or consent of faculty
Students intended for: B. Tech. 3rd and 4th year, MS/M. Tech., Ph.D.
Elective or Core: Core for M. Tech. Biotechnology, elective for others
Approval: 9th Senate

**Course contents**

- **Introduction to Cell culture technology for Bioprocessing**

  Cell culture engineering, cell culture products (metabolites, enzymes etc), Cellular systems as molecular factories – plants and microbial systems relevant to industries. Introduction to Bioprocessing.[3 Lectures]

- **Medium Design and kinetics of cell cultivation**

  Optimization of cell growth environment. A guide for medium design. Types of media and classes of medium components. Components of different cell culture medium. Medium for the Industrial production culture, Stoichiometry and Kinetics of Cell Cultivation – composition, cell mass and size, Quantitative Description of Cell Growth & Product Formation, Kinetic Model of Cell Growth. Monod Model and its Derivatives. [14 Lectures]

- **Fermentation technology, Bioreactor design principles and operating mode**

  Fermentation technology, Bioreactor types and design principles -Simple Stirred Tank Bioreactor, Airlift Bioreactor, Fluidized Bed Bioreactor, Membrane Bioreactor. Operating Mode of Bioreactors - Batch, fedbatch and Continuous Processes. Control strategies of physiological parameters - Oxygen transfer, redox, pH etc. Growth rates. Product recovery and quality analysis. Introduction to Analytical techniques, Scaling Up and Scaling Down for Cell Culture Bioreactors. [16 Lectures]

- **Metabolic engineering, CBP technology and modeling of cellular factories**

  Developing optimal host cells by rational metabolic engineering – an overview. Modelling of metabolic pathways of cellular Systems. Consolidated Bioprocessing (CBP) technology in the context of biofuels and sustainable chemicals. [9 Lectures]

**Text Books and Reference Books**


1. Wei-Shou Hu, **Cell Culture Bioprocess Engineering**.

2. **Encyclopedia of Bioprocess Technology**, John Wiley and Sons.

3. Willem H. van Zyl, Riaan den Haan and Daniel C. la Grange, **Developing organisms for consolidated bioprocessing of Biomass to ethanol**, 2011.

4. Other relevant tutorial material and scientific publications will be provided.


## 2.39 BY 514: Analytical Biotechniques

**Course Code: BY 514**
**Course Name: Analytical Biotechniques**

L-T-P-C: 3-0-0-3
Prerequisite: IC136, or consent of faculty
Students intended for: B. Tech. 3rd and 4th year, MS/M. Tech., Ph.D.
Elective or Core: Core for M. Tech. Biotechnology, elective for others
Approval: 9th Senate

**Course contents**

- **Spectroscopy**

  Principles and applications of UV-Visible spectroscopy, circular dichroism, fluorescence spectroscopy, mass, and infrared spectroscopy, MALDI-TOF, NMR.[12 Lectures]

- **Chromatographic and other separation techniques**

  Principles and applications of different chromatographic techniques, ultrafiltration, phase-partitioning, Gel electrophoresis, two dimensional gel electrophoresis, blotting techniques. [10 Lectures]

- **Imaging Techniques**

  Principles and applications of bright-field, dark-field and phase contrast microscopy, fluorescence microscopy, confocal microscopy, electron microscopy and atomic force microscopy. [12 Lectures]

- **Module IV**

  Principles and applications of Surface plasmon resonance, Flow cytometry, Real Time PCR, ELISA. [8 Lectures]

**Text Books and Reference Books**

1. Charles R. Cantor and Paul Schimmel, **Biophysical Chemistry, Part 2: Techniques for the Study of Biological Structure and Function (Pt. 2)**.
2. Lakowicz, Joseph R. **Principles of Fluorescence Spectroscopy**, 3rd Edition.
3. Michael Hoppert, **Microscopic Techniques in Biotechnology**, 2006.
4. K. Wilson and J. Walker, **Principles and Techniques of Biochemistry and Molecular Biology**

## 2.40 BY 515: Molecular Biotechnology

**Course Code: BY 515**
**Course Name: Molecular Biotechnology**

L-T-P-C: 3-0-0-3
Prerequisite: IC136, or consent of faculty
Students intended for: B. Tech. 3rd and 4th year, MS/M. Tech., Ph.D.
Elective or Core: Core for M. Tech. Biotechnology, elective for others
Approval: 9th Senate

**Course contents**

- **Molecular Structure of Genes and Chromosomes:**

  Chromosomal organization genes and non-coding DNA; Mobile DNA; Structural organization of eukaryotic chromosomes; DNA Replication. [6 Lectures]

- **Transcriptional Control of Gene Expression**

  Eukaryotic gene control and RNA polymerase; regulatory sequences in protein coding genes; activators and repressors of transcription; mechanism of transcription activation and repression. Processing of eukaryotic pre-mRNA; transport across nuclear envelope; cytoplasmic mechanism of post-transcriptional control; processing of rRNA and tRNA. [9 Lectures]

- **Principles of gene cloning and DNA analysis**

  The early development of genetics leading the invention of tools and techniques for gene cloning. Polymerase chain Reaction. DNA Manipulative Enzymes: Nucleases, ligases, polymerases, DNA modifying enzymes. Enzymes for cutting DNA: restriction endonucleases. The discovery and function of restriction endonucleases. Type II restriction endonucleases. Blunt ends and sticky ends. Ligation: Joining DNA molecules together. The mode of action of DNA ligase sticky ends, blunt ends, linkers and adaptors. [10 Lectures]

- **Vectors for gene cloning: Bacteriophages**

  The phage infection cycle, Lysogenic phages. Gene organization in the $\lambda$ DNA molecule, the linear and circular forms of $\lambda$ DNA. M13—a filamentous phage. Viruses as cloning vectors for other organisms. Introduction of phage DNA into bacterial cells: Transfection, In vitro packaging of $\lambda$ cloning vectors. Introduction of DNA into non-bacterial cells: Transformation of individual cells. Cloning Vectors for E. coli: Cloning vectors based on E. coli plasmids. More sophisticated E. coli plasmid cloning vectors: pUC8—a Lac selection plasmid, pGEM3Z—in vitro transcription of cloned DNA, cloning vectors based on M13 bacteriophage, how to construct a phage cloning vector, hybrid plasmid–M13 vectors. Insertion and replacement vectors. Cloning of long DNA fragments using a cosmid and other high-capacity vectors. Cloning vectors for animals and insects. Viruses as cloning vectors for mammals. Identification methods based on detection of the translation product of the cloned gene. A tutorial will follow this module on Software and online/freeware tools for analyzing restriction sites in DNA sequence. [10 Lectures]

- **Applications of Genetic Engineering in Biotechnology**

  The Applications of Gene Cloning and DNA Analysis in Biotechnology. Production of Protein from Cloned Genes. General problems with the production of recombinant protein in E. coli. Problems resulting from the sequence of the foreign gene. Problems caused by E. coli. Production of recombinant protein by eukaryotic cells. Recombinant protein from Saccharomyces cerevisiae. Using animal cells for recombinant protein production. Protein production in mammalian and insect cells. Gene Cloning and DNA Analysis in Agriculture: The gene addition approach to plant genetic engineering. The $\delta$-endotoxins of Bacillus thuringiensis as an example. Gene Cloning and DNA Analysis in Medicine. Production of recombinant pharmaceuticals. Recombinant insulin: Synthesis and expression of artificial insulin genes. Synthesis of other recombinant human proteins and vaccines. [7 Lectures]

**Text Books and Reference Books**


1. Lodish et al., **Molecular Cell Biology**, 5th Edition or later, W.H. Freeman and Company.

2. Alberts et al., **Molecular Biology of the Cell**, 4th Edition or later, Garland Sciences.

3. Benjamin Lewin, **Genes XIII**, 8th Edition, Pearson Prentice Hall, 2004.

4. Sandy Primrose And Richard Twyman, **Principles of Gene Manipulation and Genomics**, 7th Edition, Wiley-Blackwell, 2006.

## 2.41 BY 516: Introduction to "OMICS" and Systems Analysis

**Course Code: BY 516**
**Course Name: Introduction to "OMICS" and Systems Analysis**

L-T-P-C: 3-0-0-3
Prerequisite: IC136, or consent of faculty
Students intended for: B. Tech. 3rd and 4th year, MS/M. Tech., Ph.D.
Elective or Core: Core for M. Tech. Biotechnology, elective for others
Approval: 9th Senate

**Course contents**

- **Introduction to OMICS**

  i. Genomics
    a. High throughput Next-generation sequencing methods
    b. Quality filtering and reads assembly

  ii. Epigenomics
    a. Bisulfite sequencing
    b. ChIP assays

  iii. Transcriptomics
    a. RNA-seq

  iv. Metagenomics and metatranscriptomics
    a. Phylo-typing
    b. Binning [12 Lectures]

- **Methods in Systems Analysis**

  Basic concepts in systems biology, introduction to Gene Ontology, KEGG and Eco-Cyc database; Reconstruction of biochemical networks including metabolic networks, transcriptional regulatory networks, and signaling networks; Genome scale modelling, from networks to constraint based models, mathematical representation of reconstructed networks, basic features of Stoichiometric matrix and topological properties analysis; Application of systems analysis to Microbial organisms, analysis of Pathways, Metabolic network properties, Metabolic control analysis, Simulation of cellular activities, Gene dispensability in metabolism. [30 Lectures]

**Text Books and Reference Books**

1. Bernhard O. Palsson, **Systems Biology: Properties of Reconstructed Networks**, Cambridge University Press, 2006.

2. Victor Kunin et al., **A Bioinformatician's Guide to Metagenomics**, MICROBIOLOGY AND MOLECULAR BIOLOGY REVIEWS, Dec. 2008, p. 557–578.

3. Next-generation sequencing data interpretation: enhancing reproducibility and accessibility, **Anton Nekrutenko & James Taylor Nature Reviews Genetics**, September 2012 Volume 13, No 9, 667.

4. SOberhardt MA et al., Applications of genome-scale metabolic reconstructions, **Mol Syst Biol**, 5:320, 2009.

5. Francke C et. al., Reconstructing the metabolic network of a bacterium from its genome, **Trends Microbiol**, 13:550-8, 2005.

## 2.42 BY 517: Proteomics

**Course Code: BY 517**
**Course Name: Proteomics**

L-T-P-C : 3 – 0 – 0 – 3
Prerequisite : IC136, or consent of faculty
Students intended for : B. Tech. 3rd and 4th year, MS/M. Tech., Ph.D.
Elective or Core : Core for M. Tech. Biotechnology, elective for others

Approval: 10th Senate

**Course contents**

- **An introduction to proteomics**

  Basics of protein structure and function, An overview of systems biology, Evolution from protein chemistry to proteomics; [6 Lectures]

- **Abundance-based proteomics**

  Sample preparation and prefractionation steps, Gel-based proteomics - two-dimensional gel electrophoresis (2-DE), two-dimensional fluorescence difference in-gel electrophoresis (DIGE), Staining techniques. [6 Lectures]

- **Central role of mass spectrometry**

  ionization sources, mass analyzers, different types of mass spectrometers [6 Lectures]

- **Module-IV**

  Quantitative proteomics - stable isotope labeling by amino acids in cell culture (SILAC), isotope-coded affinity tag (ICAT), isobaric tagging for relative and absolute quantitation (iTRAQ); [6 Lectures]

- **Functional proteomics**

  Recombinational cloning, Interactomics - techniques to study protein-protein interactions, yeast two-hybrid, immunoprecipitation, protein microarrays, Nucleic Acid Programmable Protein Array (NAPPA), Label-free nanotechnologies in proteomics, Surface Plasmon Resonance (SPR); Modificomics: understanding post-translational modifications; [6 Lectures]

- **Module VI**

  Structural proteomics; [6 Lectures]

- **Module VII**

  Bioinformatics in proteomics; Challenges and future prospects of proteomics research. [6 Lectures]

**Text Books and Reference Books**

1. D.C. Liebler, **Introduction to Proteomics: Tools for the New Biology**, Humana Press, 2002.

2. R.M. Twyman, **Principles of Proteomics**, Bios Scientific Pub., 2004.

3. T.D. Veenstra, J.R. Yates III, **Proteomics for Biological Discovery**, John-Wiley & Sons, 2006.

4. R. Hubert, **Protein Biochemistry and Proteomics (The Experimenter Series)**, Academic Press, 2006.

5. R. Westermeier, T. Naven, H-R. Hapker, **Proteomics: A Cold Spring Harbor Laboratory Course Manual**, Cold Spring Harbor Laboratory Press, 2009.

6. Latest research articles will be advised related to the topic being taught.

## 2.43 BY 517 : Introduction to Proteomics

**Course Code: BY 517**

**Course Name : Introduction to Proteomics**

L-T-P-C : 3-0-0-3
**Intended for :** Core for Dual Degree Bio Engg. students; Elective for other B.Tech and M.Tech students.
**Prerequisite :** IC 136 - Understanding Biotechnology & its Applications
**Students intended for:** B. Tech. 3rd and 4th year, MS/MSc. /M.Tech., Ph.D.
**Mutual Exclusion :** None
Approval: 24th Senate

**Course Contents:**

- **An introduction to proteomics:** Basics of protein structure and function, An overview of systems biology, Evolution from protein chemistry to proteomics. (6 hours)

- **Abundance-based proteomics:** Sample preparation and prefractionation steps, Gel- based proteomics - two-dimensional gel electrophoresis (2-DE), Two-dimensional fluorescence difference in-gel electrophoresis (DIGE), Principles of Blue Native-PAGE, Staining techniques, Fundamentals of liquid-chromatography (LC) based protein and peptide separation methods. (6 hours)

- **Central role of mass spectrometry:** Different types of mass spectrometers with respect to source ionization and design, Different kinds of mass analyzers, Different mode of data acquisition; Concepts of top-down vs bottom-up approaches and targeted vs untargeted approaches in proteomics. (6 hours)

- **Quantitative proteomics:** stable isotope labeling by amino acids in cell culture (SILAC), Isotope-coded affinity tag (ICAT), Isobaric tagging based methods for quantitative proteome analyses (iTRAQ/TMT), Label free quantitation (LFQ) (MS based, data-independent acquisition-DIA etc.), Targeted approaches (SRM,MRM). Challenges in performing proteomics in biofluids such as plasma, serum etc. (clinical proteomics). (6 hours)

- **Functional proteomics:** Recombinational cloning, Protein-protein interaction techniques by yeast two-hybrid, immunoprecipitation, protein microarrays, Nucleic Acid Programmable Protein Array (NAPPA), Surface Plasmon Resonance (SPR); Understanding post-translational modifications (PTMs) mainly phosphorylation and glycosylation. (6 hours)
- **Module VI:** Structural proteomics; Protein cross-link detection methods using mass spectrometry. (6 hours)
- **Module VII:** Bioinformatics in proteomics; Manual interpretation of typical mass spectra, Mass spectrometry big data analyses using open-source software suits; Challenges and future prospects of proteomics research. (6 hours)

**Textbook**

1. J. Lovric, **Introducing Proteomics: From Concepts to Sample Separation, Mass Spectrometry and Data Analysis**, John-Wiley & Sons, 2011.
2. David L. Nelson, Michael M. Cox., **Lehninger Principles of Biochemistry**, 7th Edition, Macmillan learning, 2017.

**Reference Books:**

1. D.C. Liebler, **Introduction to Proteomics: Tools for the New Biology**, Humana Press, 2002.
2. T.D. Veenstra, J.R. Yates III, **Proteomics for Biological Discovery**, John-Wiley & Sons, 2006.
3. A.J. Link and J. LaBaer, **Proteomics: A Cold Spring Harbor Laboratory Course Manual**, Cold Spring.
4. **Harbor Laboratory Press**, 2009.
5. N.C. Mishra, **Introduction to Proteomics: Principles and Applications**, John-Wiley & Sons, 2010.
6. R. Matthiesen, **Mass Spectrometry Data Analysis in Proteomics**, Humana Press, 2020.
7. Recent research articles will be advised accordingly.

## 2.44 BY 518: Disease Biology

**Course Code: BY 518**
**Course Name: Disease Biology**

L-T-P-C: 3-0-0-3
Prerequisite: IC136, or consent of faculty

Students intended for: B. Tech. 3rd and 4th year, MS/M. Tech., Ph.D.
Elective or Core: Core for M. Tech. Biotechnology, elective for others
Approval: 9th Senate

**Course contents**

- **Infectious diseases**

  Bacterial: Tuberculosis, Urinary tract infection (E. coli), Pneumonia (S. aureus), Typhoid, Gut infection (H. Pylori); Viral diseases: Cough and cold (influenza), Hepatitis, Measles, Mumps, Japanese encephalitis, Polio, HIV; Parasitic diseases: E. histolytica, Leishmaniasis, Malaria, Ascaris, Giardiasis, Filariasis, Cysticercosis [10 Lectures]

- **Autoimmune diseases**

  Arthritis, Lupus, Atherosclerosis, Alzheimer [8 Lectures]

- **Metabolic diseases**

  Diabetes, Obesity, Cancer [12 Lectures]

- **Genetic diseases**

  Haemophilia, Down syndrome, Angelman syndrome, Colour blindness [12 Lectures]

**Text Books and Reference Books**

1. Nicholas Sperelaki, **Cell Physiology Source Book: A Molecular Approach**, 4th Edition.

2. Jonathan Phillips, Paul G. Murray, Paul Kirk (Editors), **The Biology of Disease**, 3rd edition. Wily Publications.

3. Strachan, Tom, and Andrew P. Read, **Human Molecular Genetics**, 2nd Edition, John-Wiley & Sons.

4. Dennis J. Selkoe, Eckhard Mandelkow, David M. Holtzman, **he Biology of Alzheimer Disease**, ISBN 978-1-936113-44-6.

5. Additional handouts and references from peer reviewed publications will be provided.

## 2.45 BY 519: Protein Sciences in Therapeutics

**Course Code: BY 519**
**Course Name: Protein Sciences in Therapeutics**

L-T-P-C: 3-0-0-3
Prerequisite: IC136, or consent of faculty
Students intended for: B. Tech. 3rd and 4th year, MS/M. Tech., Ph.D.
Elective or Core: Core for M. Tech. Biotechnology, elective for others
Approval: 9th Senate

**Course contents**

- **Introduction**

  Introduction and basic concepts of proteins. Protein structure and function. [2 Lectures]

- **Intrinsically Disordered Proteins**

  Sequence composition of IDPs, distribution of IDPs in nature and their physiological roles, intrinsically disordered regions, fuzzy complexes, designed linkers, folding and binding mechanisms of IDPs. Protein disorder in signaling and disease in human and plants. [6 Lectures]

- **Thermodynamics for therapeutics**

  A brief introduction and thermodynamic principles. Gibbs free energy, thermochemistry and calorimetry. Protein folding theories and structural transitions in polypeptides. Thermodynamic characterization of therapeutic proteins for highest stability and activities. Thermodynamic basis of protein-protein interaction inhibition. [12 Lectures]

- **Protein Engineering – Basic Principles and Rationale**

  Identification of putative enzymes in sequence databases. Enzymes, catalysis and kinetics, factors influencing the speed of enzymatic reaction. Enzyme applications, targets of protein engineering, protein engineering approaches, advantages and limitations. Successful stories of application of protein engineering to improve enzyme catalytic efficiency, enzyme stability and folding. [8 Lectures]

- **Module V**

  Therapeutic potentials of proteins with specific examples including insulin, anticoagulants, blood substitutes and vaccines. Sequence composition and heteromorphic pairs of proteins. [6 Lectures]

- **Module VI**

  Protein misfolding and amyloid diseases: Alzheimer's disease, Parkinson's disease. Signalling involved in misfolding diseases. Transthyretin as amyloid diseases. [8 Lectures]

**Text Books and Reference Books**


1. Donald Voet, Charlotte W. Pratt, Judith G. Voet, **Principles of Biochemistry**, 4th Edition, Wiley, 2012.

2. David L Nelson, Michael M Cox, Albert L Lehninger, **Lehninger Principles of Biochemistry**, 6th edition, W.H. Freeman, 2013.

3. Strachan, Tom, and Andrew P. ReadIrwin H. Segel, **Biochemical calculations: how to solve mathematical problems in general biochemistry**, 2nd Edition, Wiley, 1976.

4. T Palmer, P L Bonner, **Enzymes, Biochemistry, Biotechnology, Clinical Chemistry**, 2nd edition, Woodhead Publishing, 2007.

5. Peter Tompa, Alan Fersht, **Structure and Function of Intrinsically Disordered Proteins**, CRC Press, 2009.

6. David Sheehan, **Physical Biochemistry: Principles and Applications**, 2nd Edition, Wiley, 2009.

7. Several recent papers from peer reviewed journals like Nature, Science, Molecular Therapy, PNAS, Biochemistry, JBC etc.

**Specialisation Laboratory courses**

The experiments proposed are listed against each theme of specialization electives. Each student will perform experiments from either "Systems Biology (ML1)" theme or "Medical and Nano-biotechnology (ML2)" theme. The proposed practicals will be finalized based on standardization and infrastructure development. Efforts are made to match the laboratory exercises with the special elective course components.

## 2.46 BY 520P: : Cell Biology and Physiology Lab

**Course Code: BY 520P**
**Course Name: Cell Biology and Physiology Lab**

L-T-P-C: 0-0-2-1
Prerequisite: None
Students intended for: M. Tech. Biotechnology
Elective or Core: Core Lab for M. Tech. Biotechnology
Approval: 9th Senate

**Course contents**

- Subcellular fractionation and isolation of organelles
- Sub cellular localization of proteins
- Techniques for the propagation of eukaryotic and prokaryotic cells
- Cells lines-generation, characterization and maintenance
- Immunohistochemistry
- Cell proliferation and apoptosis monitoring
- Experiments to study active and passive transports across cell membranes
- Experiments to study cell migration, directionality and speed under shear pressure or across chemotactic gradient
- Experiments to study role of adhesion molecules in cell movements and cell-pathogens interaction

## 2.47 BY 521P: Computational Biology and Cellular Bioprocess Technology Lab

**Course Code: BY 521P**
**Course Name: Computational Biology and Cellular Bioprocess Technology Lab**

L-T-P-C: 0-0-2-1
Prerequisite: None
Students intended for: M. Tech. Biotechnology
Elective or Core: Core Lab for M. Tech. Biotechnology
Approval: 9th Senate

**Course contents**

- Statistical analysis using biological data using statistical software (R or excel)
- Basic scripting – Perl
- Biological databases and sequence file formats
- Local alignment + global alignment exercise
- Prokaryotic gene prediction methods
- Eukaryotic gene prediction methods
- phylogenetic analysis
- Computational Proteomics: Protein visualization tools
- Growth kinetics of industrial strains-includes media design and parameter controls
- Fermentation experiments including product analysis and downstream processing
- Batch and/or chemostat experimental design and implementation
- Bioprocessing of microbial and/or plant (including algal) systems in the context of Biofuels, bioplastics, enzymes and/or other chemicals.
- Field visit and/or miniproject -local bioprocessing unit, Bioreactor design (lab scale vs hungate tube)

## 2.48 BY 522P: Analytical and Molecular Biotechnology Lab

**Course Code: BY 522P**
**Course Name: Analytical and Molecular Biotechnology Lab**

L-T-P-C: 0-0-2-1
Prerequisite: None
Students intended for: M. Tech. Biotechnology
Elective or Core: Core Lab for M. Tech. Biotechnology
Approval: 9th Senate

**Course contents**

- Experiments on the application of different spectroscopic techniques
- Experiments on the application of chromatographic and blotting techniques
- Experiments on the application of different microscopic techniques
- Experiments on the application of Flow Cytometry, ELISA based techniques and/or Real Time PCR
- DNA extraction – genomic and plasmid
- Restriction digestion and mapping of DNA
- Gene cloning
- PCR
- Protein expression optimization using IPTG and auto-induction methods
- Protein purification using affinity column chromatography

## 2.49 BY 523P: Systems Biology Lab

**Course Code: BY 523P**
**Course Name: Systems Biology Lab**

L-T-P-C: 0-0-2-1
Prerequisite: None
Students intended for: M. Tech. Biotechnology
Elective or Core: Core Lab for M. Tech. Biotechnology
Approval: 9th Senate

**Course contents**

Lab sessions for **Introduction to "OMICS" and Systems Analysis** course:

- Basic Insilico analysis of NGS data of genomes/Metagenomes
- Differential gene expression analysis of transciptome data
- 16S rRNA based phylogenetic profiling
- Introduction to Gene Ontology, KEGG, EcoCyc databases
- Automated pathway mapping and annotation of proteins
- Extraction of reaction and metabolite information
- Metabolic network reconstruction
- Genome scale model analysis
- Insilico Gene dispensability analysis

Lab sessions for **Metagenomics, and Next Generation Sequencing Technologies** course:

- Next Generation Sequencing application for Amplicon sequencing
- Next Generation Sequencing application for Transcriptome sequencing
- Next Generation Sequencing application for Metagenomic sequencing
- Basic Insilico analysis of NGS data of genomes/Metagenomes
- Differential gene expression analysis of transciptome data
- 16S rRNA based phylogenetic profiling

Lab sessions for **Metabolic Systems Biology** course:

- Metabolite profiling experiment – NMR/MS based
- Metabolomics experiment untargeted/targeted
- Statistical analysis of the metabolomics data generated
- Measuring major biomass components (for constraints) of a typical cell – I
- Measuring major biomass components (for constraints) of a typical cell – II
- Isotopomer measurements using Mass spectroscopy and their analysis
- 13C based/constraint based flux analysis of central metabolic network-I
- 13C based/constraint based flux analysis of central metabolic network-II
- Making sense of the generated flux map.

Lab sessions for **Proteomics** course:

- Proteomics experiments

## 2.50 BY 524P: Medical and NanoBiotechnology Lab

**Course Code: BY 524P**
**Course Name: Medical and NanoBiotechnology Lab**

L-T-P-C: 0-0-2-1
Prerequisite: M.Tech. Biotechnology Students who enrolled for Medical and NanoBiotechnology specialization
Students intended for: M. Tech. Biotechnology
Elective or Core: Core Lab for M. Tech. Biotechnology
Approval: 9th Senate

**Course contents**

**Cellular Fuel and Cellular Communication**

- Glucose production assay from hepatocytes cells
- Determine the effect of fasting and feeding in glucose output from hepatocytes cells
- Hormonal regulation of gluconeogenic key regulators at their transcripts (real time PCR) and protein (Western blotting) levels
- Determine the effect of Insulin and Glucagon in regulating various second messengers (cAMP, $Ca2+$) level and their downstream effector molecules from hepatocytes cells

**Disease Biology:**

- Culture and Gram's staining of Gram positive and negative bacteria,
- Isolation and characterization of some common pathogenic bacteria from human samples.
- ELISA for viral diseases (hepatitis and measles) and/or smRNP
- EITB for parasitic disease (cysticercosis) diagnosis.
- Immunofluorescence for lupus diagnosis
- Enzyme assay for insulin activity from hepatocyte cell line.

**NanoBiotechnology:**

- Synthesis and characterisation of gold nanoparticles.
- Synthesis and characterization of silver nanoparticle.
- Synthesis and characterization of quantum dots.
- Understanding the analyte specific aggregation of nanoparticle for biosensing application.
- Studying the antibacterial property of silver nanoparticles.
- Synthesis and characterization of polymeric nanoparticles as a drug delivery vehicle.
- Fabrication of nanoparticle impregnated antibacterial polymeric films.

**Protein Sciences in Therapeutics:**

- Site-directed mutagenesis
- Protein structure modification
- Visualization of proteins for engineering purpose
- Obtaining highest purity of Proteins using gel filtration

- Ion Exchange methods to purify proteins
- Biophysical characterization of proteins.
- Protein folding in-vitro
- pH and salt dependent studies of proteins.
- Protein aggregation

## 2.51 BY 527: Gene silencing and genome editing: principles and applications

**Course Code: BY 527**
**Course Name: Gene silencing and genome editing: principles and applications**

L-T-P-C: 3-0-0-3
Prerequisite: IC136, or consent of faculty
Students intended for: B. Tech. IDD 4th year, MS/M. Tech., Ph.D.
Elective or Core: Core for M. Tech. Biotechnology, elective for others
Approval: 36th BoA

**Course contents**

- **Introduction to gene structure and regulation**

  Basic principles of genome organizations, gene structure, chromatin structure, gene silencing by histone modifications, gene silencing by DNA methylation (epigenetics and genome imprinting). Eukaryotic gene structure, eukaryotic transcription, transcriptional gene silencing. [6 Lectures]

- **RNA biology**

  Post-transcriptional gene silencing. Introduction to RNAi (brief history and endogenous roles). Discovery of siRNAs and microRNAs. Molecular mechanisms RNAi. Genetic manipulations and RNAi in C. elegans, Drosophila, mammalian systems and plants. [6 Lectures]

- **Small silencing RNAs**

  Classification, biogenesis and gene-regulatory mechanisms of small RNAs. Cellular functions of small RNAs. Functions of small RNAs in developmental biology, diseases and agriculture. RNAi screens (reverse genetic screens) in cell culture and model organisms. [6 Lectures]

- **Applications of RNAi**

  RNAi-induced innate immunity and antiviral siRNAs. RNA-based therapeutics, vaccines and delivery of siRNAs. Examples of candidate RNAi drugs (Givosiran, Patisiran etc) [3 Lectures]

- **Genome editing methods-1**

  Transgenesis, site-specific chromosomal integration by Cre-LoxP, phiC31-integrase, and Mos1-transposon. [6 Lectures]

- **Genome editing methods-2**

  Genome engineering with TALENs and ZFNs. Discovery and mechanisms of CRISPR-Cas9 meditated genome editing. Different CRISPR systems and their uses in genome editing. [6 Lectures]

- **Module VII**

  Designing of sgRNAs and repair templates. Next generation cloning technologies. Genome engineering methods for model organism. Construction of transgenics and knockouts using C. elegans model organism. [3 Lectures]

- **Applications of CRISPR mediated genome editing**

  Cas9 for gene regulation: CRISPR interference (CRISPRi), CRISPR activation (CRISPRa) and CRISPRon. Genome-wide CRISPR knockout screens. Applications in agriculture, food and fuel industry. Ethical concerns of genome editing by CRISPR. [6 Lectures]

**Text Books**

1. Vijai Singh, Pawan K. Dhar, (Editors), **Genome Engineering via CRISPR-Cas9 System**, Academic Press, 2020.

2. Gregory J. Hannon (Editor), **RNAi: A Guide to Gene Silencing**, Cold Spring Harbor Laboratory Press, 2003.

**Reference Books**

1. Ute Schepers (Editor), **RNA Interference in Practice: Principles, Basics, and Methods for Gene Silencing in C. elegans, Drosophila, and Mammals**, Wiley-VCH Verlag GmbH, 2005.

2. Krishnarao Appasani, **MicroRNAs: From Basic Science to Disease Biology**, Cambridge University Press, 2008.

3. Rajesh K. Gaur, John J. Rossi, (Editors) **Regulation of Gene Expression by Small RNAs**, CRC Press, 2009.

4. Krishnarao Appasani (Editor), **Genome Editing and Engineering: From TALENs, ZFNs and CRISPRs to Molecular Surgery**, Cambridge University Press, 2008.

5. Jennifer Doudna (Editor), **CRISPR-Cas: A Laboratory Manual**, Cold Spring Harbor Laboratory Press, 2016.

6. Relevant research articles/reviews will be advised related to the topic being taught.

## 2.52 BY 528 : Sensory Biology

**Course Code : BY 528**

**Course Name : Sensory Biology**

L-T-P-C : 3-0-0-3

Intended for : Elective for B.Tech, M.Tech and Ph.D.
Prerequisite : IC136 - Understanding Biotechnology & its Applications or Consent of faculty member
Mutual Exclusion:
Approval: 54th BoA

**Course Contents**

- **Introduction to the Sensory System**: Overview of sensory systems in living organisms. Types of sensory stimuli (e.g., light, sound, touch, taste, smell) in humans amd non-human organisms (eg. plants, insects, fishes, bacteria, fungi etc.). (xx hrs)
- **Anatomy of the Sensory System**: Human brain anatomy with focus on sensory lobes. Structure and function of the major sensory organs (e.g. eyes, ears, skin, tongue, nose). Cells and tissues involved in sensory system and their properties. Neural pathways for transmitting sensory information to the brain. (xx hrs)
- **Neuron and Action potential**: Basic cell biology of neuron. The process of converting sensory stimuli into electrical signals. Sensory receptor cells and their properties. Molecular mechanisms of sensory transduction. Sensory adaptation and plasticity. (xx hrs)
- **Functional Significance of the Sensory System**: Evolutionary origins and adaptive significance of sensory systems, sensory ecology and behavior, sensory system disorders and diseases. (xx hrs)
- **Research and Applications of Sensory Biology**: Tools for studying and modulation of sensory systems. (xx hrs)
- **Electronic equivalent of human senses**: Bioinspired electronics for artificial sensory systems. (xx hrs)

**Textbooks:**

1. Liqun Luo, **Principles of Neurobiology**, Garland Science. https://web.math.princeton.edu/∼ss
of-Neurobiology.pdf

**References:**

1. Eric Kandel, James Schwartz, and Thomas Jessell, **Principles of Neural Science**.
2. https://openstax.org/books/biology/pages/36-introduction
3. Related journal articles.

## 2.53 BY 529 : Mechanobiology of the Cell (MBoC)

**Course Code : BY 529**

**Course Name : Mechanobiology of the Cell (MBoC)**

L-T-P-C : 3-0-0-3

Intended for : B.Tech.-M.Tech. Integrated Dual Degree in Bio-Engineering, M. Tech Biotechnology and PhD candidates
Prerequisite : BE201 Cell Biology or Consent of Faculty Member
Mutual Exclusion : NA
Approval: 23rd BoA

**Course Contents**

- **Introduction to Mechanobiology**: Why study mechanobiology, pioneering experiments in mechanobiology.(2 Lectures)
- **Molecular Mechanisms of Mechanotransduction**: Mechanosensory molecules in focal adhesions, cell-cell junctions, cytoskeleton, and nucleus. (6 Lectures)
- **Mechanobiology of cell behavior**: Rigidity sensing and mechanotransduction in adhesion, migration, gene expression, and tissue development. (8 Lectures)
- **Mechanobiology of organ systems**: Cardiovascular, Bone, Cartilage, Liver, Nervous system. (8 Lectures)
- **Mechanobiology of disease**: Muscular dystrophy, cancer, laminopathy. (6 Lectures)
- **Technology innovation for mechanobiology**: Optical microscopy, nanofabrication, microfluidics, organoids, organ-on-chip. (6 Lectures)
- **Mechanobiology in medical diagnostics and therapeutics**: Cell therapy, Cancer diagnostics, Immune profiling. (6 Lectures)

**Textbooks:**

1. Christopher R. Jacobs, Hayden Huang, and Ronal Y. Kwon, **Introduction to Cell Mechanics and Mechanobiology**, Taylor & Francis Group, 2012.
2. Michael Sheetz and Hanry Yu, **The Cell as a Machine**, Cambridge University Press, 2018

**References:**

1. Ronen Zaidel-Bar, **Mechanobiology: Methods and Protocols**, Humana Press, Springer Protocols, Methods in Molecular Biology 2023
2. Stefaan W. Verbruggen, **Mechanobiology in Health and Disease**, Academic Press, 2018.
3. MBInfo (https://www.mbi.nus.edu.sg/mbinfo/) This is a wiki-style repository of mechanobiology with the aim to inform and educate the wider scientific community about mechanobiology and how physics and mechanics impact biological processes.

## 2.54 BY 530 : Advanced Cell and Molecular Biology

**Course Code : BY 530**

**Course Name : Advanced Cell and Molecular Biology**

L-T-P-C : 3-0-0-3

Intended for : Core for M.Tech Biotechnology and elective for B.Tech, M.Sc/M.Tech and PhD candidates

Prerequisite : IC136 - Understanding Biotechnology & its Applications or Consent of faculty member

Mutual Exclusion:

Approval: 54th BoA

**Course Contents**

- **INTRODUCTION**: A tour to Cell: Exploring Eukaryotic, animal and plant cells; cell compartments, their structure and function. Introduction to DNA, RNA and Proteins. Replication and hereditary. Epigenetics, transcription, and translation and their regulatory mechanisms. (6 hours)
- **CELL CYCLE**: Eukaryotic cell cycle: Biochemical and genetics studies on cell cycle; mechanisms regulating mitotic events; meiosis - a special type of cell division; cell birth, lineage and death: Asymmetrical cell division, patterns of stem cell division; Biological description of apoptosis; Molecular basis of cancer, oncogenes and tumor suppressor genes. (4 hours)
- **CELL SIGNALLING, MEMBRANE TRANSPORT and TRAFFICKING**: Membrane structure, function and models; evolution of different membrane lipids, Membrane proteins and their functions, Membrane carbohydrates and their roles in cell-cell recognition; The permeability of the bi-layers: transport proteins; Passive, active and co transport by antiporters and symporters, transporter proteins in plant vacuoles exocytosis and endocytosis Cell signalling and transport across cell membranes: Signalling molecules and cell surface receptors; intracellular signal transduction; G protein coupled receptors; plant growth factors and hormones-auxins, gibberlines, cytokines and others passive and active transport; transport into prokaryotic cells; endocytosis, exocytosis; entry of viruses and toxins into cells. Membrane trafficking: Translocation of secretory proteins across the ER membrane; protein modifications, folding and quality control in the ER; export and sorting of proteins to mitochondria, chloroplast and peroxisomes. (12 hours)
- **GENE MANIPULATION AND ITS APPLICATIONS**: A tutorial on Software and online/freeware tools for analyzing DNA sequence and virtual cloning. PCR and variations of PCR. DNA manipulative enzymes (polymerases, DNA modifying enzymes, nucleases, ligases, etc.) and their molecular biology applications. Different kinds of cloning vectors, cloning and expression vectors, (bacterial, plant and animal vectors, viral vectors etc.). Cloning techniques: Traditional (restriction digestion/ligation) cloning and its variations with use of linkers and adaptors. PCR cloning, multi fragment cloning techniques (Golden gate assembly, infusion cloning, Gibson assembly, etc.). Techniques for selection and screening of clones. Methods for gene and genome manipulation (eg. RNAi, CRISPR etc) Applications

of Genetic Engineering in Biotechnology (Therapeutic hormones/proteins, protein and RNA vaccines, Synthetic food, GM plants etc.). (12 hours)

- **MOLECULAR TECHNIQUES FOR GENE EXPRESSION ANALYSIS**: Introduction to chromatin organization and regulation. Techniques to study replication and transcription (eg. replication labeling, NGS, ChIP, ATACseq, 3D chromatin techniques, etc.), and translation (eg. reporter assays, Gel shift/EMSA, ribosome profiling etc.). (8 hours)

**Textbooks:**

1. Lodish et al., **Molecular Cell Biology**, 5th Edition or Recent, W.H. Freeman and Company.

2. Alberts et al., **Molecular Biology of the Cell**, 4th Edition or Later, Garland Sciences.

**References:**

1. NA

## 2.55 BY 531 : Quantitative Biology and Data Analytics

**Course Code : BY 531**

**Course Name : Quantitative Biology and Data Analytics**

L-T-P-C : 3-0-0-3
Intended for : Core for M.Tech Biotechnology and elective for B.Tech, M.Sc/M.Tech and PhD candidates
Prerequisite : IC136 - Understanding Biotechnology & its Applications or Consent of faculty member
Mutual Exclusion:
Approval: 54th BoA

**Course Contents**

- **Module 1**: Introduction to statistics and probability theory (distributions, mean, standard deviations, variance, etc.), basic principles of statistical inference, statistical models, linear models, basic bayesian methods, confidence interval estimation and hypothesis testing, including P-values, significance level, power, sample size, and two types of errors. (4 hours)

- **Module 2**: Linear algebra and matrices, inference for high dimensional data, distance and dimension reduction, PCA, t-SNE, etc., machine learning, and batch effects. (8 hours)

- **Module 3**: Data visualization, exploratory data analysis, and robust summaries. (4 hours)

- **Module 4**: Mathematical models for biological processes, basic calculus, logistic regression, bifurcation and steady state analysis in population growth models, epidemic models, and predator-prey models. (6 hours)
- **Module 5**: Image processing in MATLAB: types of image - binary, grayscale, & color; image thresholding and segmentation; particle tracking, and z-stack projections. (8 hours)

**Textbooks:**

1. Brian Munsky et. al., **Quantitative Biology: Theory, Computational Methods, and Models**.
2. Whitlock, Michael C.; Schluter, Dolph., **The Analysis of Biological Data**, 2nd Edition, Freeman, W. H. & Company, 2014

**References:**

1. Data Science for Biology, Emily Ren et. al., Online materials, etc.

## 2.56 BY 532 : Immunotechnology

**Course Code : BY 532**

**Course Name : Immunotechnology**

L-T-P-C : 3-0-0-3
Intended for : Elective for B.Tech, M.Tech and Ph.D.
Prerequisite : IC136 - Understanding Biotechnology & its Applications or Consent of faculty member
Mutual Exclusion:
Approval: 54th BoA

**Course Contents**

- **Module 1**: Introduction to immunology Cells of Immune system, Organs of immune system, Organization of immune system, Innate and adaptive components, Clonal selection hypothesis, B and T-cell maturation, Antibody, structure, diversity and function, Complement system, Cytokines, chemokines and biological functions.). (8 hours)
- **Module 2**: Immunology of the diseases Tuberculosis, Malaria, HIV, Arthritis, Diabetes, Lupus, Cancer. (6 hours)
- **Module 3**: Immune diagnosis Agglutination assays, ELISA: principles and procedures, In-house ELISA development and procedure (uses, type), Enzyme Electro immune transfer bot (EITB): principles and procedures, Lateral flow devices, Immuno fluorescence diagnostic tools: Principles and uses, ELISPOT, Flow cytometer: Principles and uses. (14 hours)
- **Module 4**: Immunoinformatics Principles, tools and uses of AI and informatics in immunology. (3 hours)

- **Module 5**: Vaccines and therapeutics Introduction to Vaccinology, Peptide Vaccine designing, Chimeric, Multi-epitope, RNA based Vaccine designing, Immune therapeutics, Mabs in therapeutics, Therapeutic peptides. (11 hours)

**Textbooks:**

1. Punt, Stranford, Jones, Owen, **Kuby Immunology**.

**References:**

1. Roitt, **Essential Immunology**, 12th Edition.
2. Nicholas Sperelaki, **Cell Physiology Source Book: A Molecular Approach**.
3. Bruce Alberts, Julian Lewis, Alexander Johnson, **Molecular Biology of the Cell**.
4. Editor: Samuel Baron, **Medical Microbiology**, 4th Edition.
5. Strachan, Tom, and Andrew P. Read, **Human Molecular Genetics**, 2nd Edition, John Wiley & Sons Inc., 1999.

## 2.57 BY 533P : Advanced Cell and Molecular Biology Lab

**Course Code : BY 533P**

**Course Name : Advanced Cell and Molecular Biology Lab**

L-T-P-C : 0-0-2-1
Intended for : M. Tech Biotechnology
Prerequisite :
Mutual Exclusion:
Approval: 54th BoA

**Course Contents**

- NA

**List of experiments (28 total hours)**

- Handling cell culture
- Isolation and analysis of cell organelles
- Nucleic acids isolation, estimation, visualization.
- PCR •Gene cloning
- Protein expression and purification
- SDS-PAGE and Westernblot

**Textbooks:**

1. Relevant references will be provided by the instructor

**References:**

1. NA

## 2.58 BY 534P : Cellular Bioprocess Technology Lab

**Course Code : BY 534P**

**Course Name : Cellular Bioprocess Technology Lab**

L-T-P-C : 0-0-2-1
Intended for : M. Tech Biotechnology
Prerequisite :
Mutual Exclusion:
Approval: 54th BoA

**Course Contents**

- NA

**List of experiments (28 total hours)**

- Manual and automatic controls of bioprocessing parameters in different bioreactors
- Media design and Growth analysis of selected industrial microbes under
  - Different media components: Rich and Minimal media
  - Different reactors: Tube and Stirred tank bioreactor as batch cultivation
  - Different physiological parameters: pH/Temp/O2 levels
- Analysis and yield estimation of downstream products using various analytical platforms

**Textbooks:**

1. Relevant references will be provided by the instructor

**References:**

1. NA

## 2.59 BY 535P : Analytical Biotechniques Lab

**Course Code : BY 535P**

**Course Name : Analytical Biotechniques Lab**

L-T-P-C : 0-0-2-1
Intended for : M. Tech Biotechnology
Prerequisite :
Mutual Exclusion:
Approval: 54th BoA

**Course Contents**

- NA

**List of experiments (28 total hours)**

- Experiments on the application of different spectroscopic techniques (UV Visible Spectroscopy/ Fluorescence spectroscopy/ IR spectroscopy/ CD spectroscopy)
- Experiments on the application of chromatographic techniques (Gel Filtration/Ion exchange)
- Experiments on the application of microscopic techniques (Fluorescence microscopy/ Confocal Microscopy/ Electron microscopy)
- Experiments on the application of Flow Cytometry/ELISA based techniques/Real Time PCR

**Textbooks:**

1. Joseph R. Lakowicz, **Principles of Fluorescence Spectroscopy**, Springer, 2006
2. David Plummer, **An Introduction to Practical Biochemistry**, Third Edition, 1998
3. Articles from the Journal of Chemical Education, ACS

**References:**

1. NA

## 2.60 BY 536P : Immunotechnology Lab

**Course Code : BY 536P**

**Course Name : Immunotechnology Lab**

L-T-P-C : 0-0-2-1
Intended for : M. Tech Biotechnology
Prerequisite :
Mutual Exclusion:
Approval: 54th BoA

**Course Contents**

- NA

**List of experiments (28 total hours)**

- Isolation of primary cells from blood
- Immunohistochemistry principle and uses
- Isolation and characterization of some common bacteria from human samples.
- In house ELISA for bacterial diseases
- EITB/WB for diagnosis
- qPCR for quantification of viral load
- Immunofluorescence staining technique

**Textbooks:**

1. NA

**References:**

1. NA

## 2.61 BY 537 : Computational Biology-1

**Course Code : BY 537**

**Course Name : Computational Biology-1**

L-T-P-C : 3-0-2-4

Intended for : Core for M.Tech Biotechnology and elective for B.Tech, M.Sc/M.Tech and PhD candidates

Prerequisite : IC136 - Understanding Biotechnology & its Applications or Consent of faculty member

Mutual Exclusion:

Approval: 54th BoA

**Course Contents**

- **Module-1**: Introduction to Basic Programming Introduction to basic scripting and programming routinely used in computational biology. (xx hours)
- **Module-2**: Biological Databases and Sequence File Formats Introduction to different biological databases, their classification schemes, and biological database retrieval systems. (xx hours)
- **Module-3**: Sequence Alignments Introduction to concept of alignment, Scoring matrices, Alignment algorithms for pairs of sequences, Multiple sequence alignment. (xx hours)
- **Module-4**: Gene Prediction Methods What is gene prediction? Computational methods of gene prediction-prokaryotic & eukaryotic. (xx hours)

- **Module-5**: Molecular Phylogeny Introduction to phenotypic and molecular phylogeny. Representation of phylogeny, Molecular clocks, Methods of phylogenetic construction, statistical evaluation of the obtained phylogenetic trees. (xx hours)

- **Module-6**: Introduction to systems biology Different Omics, Metabolic pathways and networks. (xx hours)

**Textbooks:**


1. Dekking, F.M., Kraaikamp, C., Lopuhaa, H.P., Meester, L.E., **A Modern Introduction to Probability and Statistics - Understanding Why and How**, Springer.

2. S.C. Rastogi, N. Mendiratta, P. Rastogi, **Bioinformatics: Methods and Applications Genomics, Proteomics, and Drug Discovery**, 3rd Edition, PHI Learning Private Limited, 2011.

3. Z. Ghosh and B. Mallick, **Bioinformatics Principles and Applications**, Oxford University Press.

4. Arthur M. Lesk, **Introduction to Bioinformatics**, 3rd Edition, Oxford University Press.

5. Latest research articles will be advised related to the topic being taught.

6. Norman Bailey, **Statistical methods in Biology**, latest edition.


**References:**


1. NA


## 2.62 BY 600 : Research Methodology

**Course Code : BY 600**

**Course Name : Research Methodology**

L-T-P-C : 1-0-0-1
Intended for : Masters and PhD candidates
Prerequisite : NA
Mutual Exclusion : NA
Approval: 53rd BoA

**Course Contents**

- What is research The concept and objectives of research, types of research, research hypothesis.

- Research planning or experimental design Necessity to define research problem, research gap, working hypothesis, planning process, research design.

- Lab and biosafety Safe laboratory practices, biosafety levels, biological hazard information, labels, signs and storage of chemical and biological reagents, Classes and types of biosafety cabinets, inactivation and disposal of biological products, waste management, and incident response, report and risk management.

- Data collection and analysis Basics of statistics, data processing and analysis strategies and tools, hypothesis testing, interpretation of data.

- Literature search, collection, storage and citation Importance of literature review in defining a problem, literature review, online tools.

- Writing research reports Types of reports (articles, reviews, progress reports and thesis), formats, planning of report writing. Figure preparation and manipulation. Effective use of English language in scientific papers.

- Science journals and the peer-review process Types of journals, publication process, peer-review process, meaning of impact factor, Hindex, etc.

- Presentation skills Preparation of slides for talks, preparation of posters. Presentation types and skills.

- Research ethics Ethical issues, citation and acknowledgement, plagiarism, reproducibility and accountability.

- IPR Intellectual property rights and patent law, commercialization, copy right, trademarks, royalty, trade related aspects of intellectual property rights and a few case studies.

- Science popularization and outreach Media coverage, lectures in public forums, circulation of scientific ideas and provoking thoughts, and the pros abs cons of these activities.

**References:**


1. Wyne C. Booth, Colomb, William, **The Craft of Research**, 4th Edition, University of Chicago Press.

2. Judith Bell, Stephen Waters, **Doing Your Research Project: A Guide for First-time Researchers**, McGraw-Hill Education, 2014.

3. Ranjit Kumar, **Research Methodology: A Step-By-Step Guide For Beginners**, Sage South Asia, 2011.

4. C. R Kothari, **Research Methodology: Methods and Techniques**, New Age International, 2004.

5. Laura Hyatt, Carol Roberts, **The Dissertation Journey**, Corwin, 2023.

6. Jari Saramaki, **How to Write a Scientific Paper: An Academic Self-Help Guide for PhD Students**, 2018.

7. WIPO Intellectual Property Handbook (Web resources).

8. The WHO Laboratory Biosafety Manual (LBM), 4th edition (online).

## 2.63 BY 606 and BY 606P: Bioinformatics Applications for Systems Analysis

**Course Code: BY 606 and BY 606P**
**Course Name: Bioinformatics Applications for Systems Analysis**

L-T-P-C: 2-0-2-3
Prerequisite: Knowledge of pattern recognition and artificial intelligence
Students intended for: 3rd and 4th year UG and PG (MS/MTech, PhD)
Elective or Core: Elective
Approval: 6th Senate

**Course contents**

- **Part I: Basic Bioinformatics**

  Introduction to Bioinformatics: What is Bioinformatics? What are the applications of Bioinformatics?

  Introduction to Basic Biology: Introduction to basic biological processes to which bioinformatics methods will be mainly applied in this course.

  Introduction to Basic Programming: Introduction to basic scripting in Linux/Unix environment and programming (Perl Language) routinely used for bioinformatics analysis.

  Sequence and Molecular File formats: Introduction to different file formats used for biological data including GenBank, FASTA, EMBL, Clustal, Phylip, SwissProt. Sequence and molecular file conversion tools (ReadSeq, SeqVerter, etc.).

  Databases in Bioinformatics: Introduction to different biological databases (NCBI, EMBL, DDBJ, PIR, SwissProt, etc.), their classification schemes, and biological database retrieval systems.[5 Lectures]

- **Part II: Bio-algorithms and Tools** Sequence Alignments: Introduction to concept of alignment, Scoring matrices (BLOSUM, PAM), Alignment algorithms for pairs of sequences (Dot Matrix method, Global vs. Local alignment, Dynamic Programming algorithm, Needleman-Wunsch algorithm, Smith Waterman algorithm), Heuristic methods (FASTA, BLAST) Multiple sequence alignment (DPA, Heuristic methods, Genetic Algorithm, Simulated annealing, Profile HMMs). Gene Prediction Methods: What is gene prediction? Computational methods of gene prediction. Extrinsic vs. Intrinsic methods, Prokaryotic and Eukaryotic gene prediction methods and tools. Molecular Phylogeny: Introduction to phenotypic and molecular phylogeny. Representation of phylogeny, Molecular clocks, Methods of phylogenetic construction, Evolutionary models (Jukes-Cantor one-parameter model, Kimura two-parameter model), Maximum Parsimony method, Maximum Likelihood method, Distance methods, UPGMA, Neighbor-Joining Method, Fitch-Margoliash method, Minimum Evolution, statistical evaluation of the obtained phylogenetic trees (bootstrapping, Jackknifing), software for phylogenetic analyses (PHYLIP, PAML, PAUP), Tree viewing. Pathways and Systems Biology: Introduction to pathways and systems biology, Analysis of Pathways, Metabolic network properties, Metabolic control analysis, Simulation of cellular activities. [23 Lectures]

The lab BY606P will expose the students to basic tools and methods used to perform the above bioinformatics analysis on real biological data. The studetns will learn the effect of parameters and thresholds used for some of the analysis on the results obtained.

**Text Books:**

1. S.C. Rastogi, N. Mendiratta, P. Rastogi , **Bioinformatics: Methods and Applications Genomics, Proteomics, and Drug Discovery**, 3rd edition, PHI Learning Private Limited.
2. Z. Ghosh and B. Mallick, **Bioinformatics Principles and Applications**, Oxford University Press.

**Reference Books**

1. Arthur M. Lesk, **Introduction to Bioinformatics**, 3rd Edition, Oxford University Press.
2. Benjamin Lewin, **Genes IX**, 9th Edition.

**Articles**

Latest research articles will be advised related to the topic being taught.

## 2.64 BY 613: Metagenomics, and Next Generation Sequencing Technologies

**Course Code: BY 613**
**Course Name: Metagenomics, and Next Generation Sequencing Technologies**

L-T-P-C: 3-0-0-3
Prerequisite: BY 606 or consent from the faculty
Students intended for: B. Tech. M. Tech., Ph.D.
Elective or Core: Core for M. Tech. Biotechnology, elective for others
Approval: 11th Senate

**Course contents**

- **Next-generation sequencing technologies**

  Introduction to different sequencing technologies including Capillary based (Sanger), pyrosequencing (454), Illumina, Solid, and others. Differences in data generated by these methods such as read length, throughput, read qualities, etc. Tools and resources that are available to analyze the generated data from different sequencing methods. Types of sequencing data that can be produced from different sequencing methods, such as genomic, metagenomic, amplicon, exome, transcriptome, targeted sequencing, CHIP-seq, 16S, etc.[22 Lectures]

- **Metagenomics**

  Topics are Metagenomics-specific issues like calling taxa, functional annotation, metagenome assembly and comparative metagenomics. This course will help participants answering questions like:[20 Lectures]

- What are possible approaches of metagenomics?
- How to monitor and predict environmental conditions and change?
- Biological insights, phylogenetic diversity.
- Examining genes/operons for enzyme and natural products.

Many hurdles arise in the analysis and assembly of environmental genomics records, among which short sequence reads, high species complexity in samples and the availability of specialized software for microbial genomics analysis.

Among the many topics in metagenomics addressed in this course are: experimental approaches; sequencing technologies; platforms and platform specific issues; methodologies; Sample preparation; QC-reports & quality controls; mapping sequence reads; taxonomic annotation; functional annotation & function determination; unknown gene prediction; comparative metagenomics; amplicon sequencing; shotgun metatranscriptomics; calling taxa; metagenome assembly; evaluation; visualization and reporting of results; tools & algorithms; 16S profiling; databases; mapability; k-mer profiling; cross assembly; QIIME; MG-RAST; iPath.

**Reference Books**

1. Victor Kunin et al, A Bioinformatician's Guide to Metagenomics, **MICROBIOLOGY AND MOLECULAR BIOLOGY REVIEWS**, Dec. 2008, p. 557–578.

2. Next-generation sequencing data interpretation: enhancing reproducibility and accessibility, **Anton Nekrutenko & James Taylor Nature Reviews Genetics**, Volume 13, No 9, 667, September 2012 .

**Articles**

Other Latest research articles will be advised related to the topic being taught from time to time.

# 3 Civil Engineering Courses

## 3.1 CE 101 Engineering Graphics

**Course Code: CE-101**

**Course Name: Engineering Graphics**

L-T-P-C: 2-0-4-4
Pre-requisite: NIL
Approval: Roorkee Course
Equivalent Course: IC 140

**Course Contents:**

- Types of Projection, Reference Planes and Quadrants. Projection of point keeping it in different quadrants; Auxiliary planes, projection of points on auxiliary planes; Projection of lines; Oblique planes – determination of VTH when inclination are given and vice versa, conversion; Projection of plane figures; Plane figure in OP and one edge inclined to HP or VP; Types of solids and their projections in their initial positions; Section of solid and development;

- **General**: Sheet Layout, Line Symbols, Line Groups, Preferred Scales, Theory of Orthographic Projection, Technical Sketching;

- **Shape Description (External)**: Multiplaner Representation Systems of Projection, Sketching of Orthographic Views from Pictorial Views, Conventional Practices, Precedence of Views, Precedence of Lines;

- **Uniplaner Representation**: Sketching of Pictorial Views(Isometric and Oblique) from Multiplaner Orthographic Views;

- **Shape Description (Internal)**: Sectioning as an Aid to understand internal features, Principles of Sectioning, Types of Sections, Section Lines, Cutting Plane Lines and Conventional Practices;

- **Size Description**: Dimensioning, Tools of Dimensioning, Size and position Dimensions, Unidirectional and Aligned Systems, Principle and Practices, of Dimensioning, Tolerance Dimensioning;

- **Conventional Representation**: Representation and Identification of Common Machine Elements and Features

- **Practicals**: Projection of Points; Projection of lines; Oblique planes; Projection of Plane Figures; Projection of Solids; Section and Development; Sketching of Orthographic; Views from Pictorial Views; Sketching of Pictorial Views (isometric and Oblique) from Multiplaner Orthographic Views; Missing Lines Exercise; Missing View Exercise; Sectioning Exercise; Dimensioning Exercise; Identification Exercise.

**References:**

1. Giesecke, Mitchell, Spencer, Hill, Dygdon and Novak, **Technical Drawing**, Macmillan Publishing Company

2. French T. E., Vierck C. J. and Foster R. J., **Engineering Drawing and Graphics Technology**, McGraw-Hill Inc

3. Luzadder W. J., Warren J. and Duff J. M., **Fundamentals of Engineering Drawing**, Prentice Hall international Editions

4. Sp 46:1988 **Engineering Drawing Practice for Schools and Colleges**, Bureau of Indian Standards

5. Chandra A. M. and Chandra S., **Engineering Graphics**, Narosa Publishing House.

## 3.2 CE 102 Environmental Studies

**Course Code: CE 102**

**Course Name: Environmental Studies**

L-T-P-C: 2-0-0-2
Pre-requisite: NIL
Sem. Both
Approval: Roorkee Course
Equivalent Course: IC 230

**Course Contents:**

Introduction and scope; Earth's natural environment, human population and Ecosystems; Environmental Pollution Air pollution- sources, effects and control, Distribution of pollutants in atmosphere, Air quality standards Water pollution-sources, effects and control, Distribution of pollutants in water, Water quality standards; Land pollution – sources, effects and control; Thermal and noise pollution; Basic principles of waste management, including industrial wastes; Hazardous wastes and risk management; Environmental impact assessment; Life cycle assessment; Sustainable development; Conservation of natural resources; Trade, environment and development; Environmental management systems and ISO certification; Control policies, legislations and acts

**References:**

1. Davis M. L. and Cornwell D. A., **Introduction to Environmental Engineering**, 3rd Edition, McGraw Hill.

2. Masters G. M., **Introduction to Environmental Engineering and Science**, 2nd Edition, Prentice Hall of India.

3. Peavy H. S., Rowe D. R. and Tchobanoglous G., **Environmental Engineering**, McGraw Hill

## 3.3 CE 201: Surveying: Traditional and Digital

**Course Code: CE 201**

**Course Name: Surveying: Traditional and Digital**

L-T-P-C: 2-0-2-3
Prerequisite: None
Students intended for: UG
Elective or Core: Discipline Core
Approval: 9th Senate

**Course Contents**

- **Introduction to surveying:**

  Understanding and need, Reconnaissance survey, compass survey, linear measurements. [2 Lectures]

- **Module II**

  Type of maps, scales and uses, coordinate and map projection, plotting accuracy, toposheet numbering. [4 Lectures]

- **Module III**

  Surveying equipment, levels, compass, theodolites, tachometer, EDM, total Stations and other instruments. [16 Lectures]

  - Levelling and contouring: types of instruments and their classifications, types and application of different methods, cross sections and gradient calculations.
  - Theodolites: Types and classification of different theodolites, applications
  - Total Station: Types, classification & applications
  - GPS & DGPS

- **Module IV**

  Measurement of Distance, Direction and Elevation. [3 Lectures]

- **Module V**

  Theory of error, adjustment of triangulation nets and level nets. Tachometry, Triangulation. [3 Lectures]

**Laboratory**

1. Chain & tape Surveying: Distance measurements
2. Measurements of area using chain and tape.
3. Leveling: Profiling using Theodolite.
4. Leveling: Trigonometric using Theodolite.
5. Measurement of Area using Theodolite

6. Error estimation and calculations.
7. Total Station: Basic and Settings
8. Measurement of Area using Total Station
9. Profiling using Total Station.
10. GPS and DGPS survey and its basics and settings
11. Measurement of area and profiling using DGPS

**Survey Camp**: Reconnaissance and establishing the stations; Base line measurements, Triangulation readings on various stations; computation and preparation of triangulation map; contouring; preparation of map; preparation of report.

**Geology Camp**: Reconnaissance of the area; Elementary geological field mapping of rock formations and structural details; Geomorphic processes Preparation of report.

**Text Books**

1. B. C. Punmia, A.K. Jain and A.K. Jain, **Surveying, Vol-I and Vol-II**, Laxmi Publication Pvt., 1996.
2. G. W. Schofield, **Engineering Surveying**, Butterworth, Heinemann, New Delhi, 6th Ed., 2007.
3. Arora, K.R., **Surveying, Vol. I, II and III**, Standard Book House, 1995.
4. T. P. Kanetkar and S. V. Kulkarni, **Surveying and Levelling, Vol-I and Vol-II**, Pune Vidyarthi Griha Prakshan, 1972.
5. Leick, A., **GPS Satellite Surveying**, John Wiley, 2004.

**Reference Books**

1. R.N. Colwell (Editor-in-Chief), **Manual of Remote Sensing, Vol. I & II**, American Society of Photogrammetry, Falls Church, Virginia, 1983.
2. Anderson, J.M. and Mikhail, E.M., **Surveying: Theory and Practice**, McGraw Hill, 1998.
3. Kaplan, E.D. and Hegarty, C.J., **Understanding GPS: Principles and Applications**, Artech House, 2006.
4. Ahmed El-Rabbany, **Introduction to GPS: The Global Positioning System**, Artec House, London, 2002.
5. Jay Farrell, **Aided Navigation: GPS with High Rate Sensors: GPS with High Rate Sensors**, McGraw Hill, New York, 2008.

## 3.4 CE 202 : Introduction to Civil Engineering

**Course Code: CE 202**

**Course Name: Introduction to Civil Engineering**

L-T-P-C: 1-0-0-1
Intended for: UG Core
Prerequisite: None
Mutual Exclusion: None
Approval: 52nd BoA

**Course Contents**

- **Module 1:** A brief history of civil engineering, a brief introduction to different subbranches of civil engineering, mega structure documentary show, a brief overview of the role and responsibilities of a civil engineer and the types of projects they work on. A brief discussion on civil engineering ethics. [2 Lectures]
- **Module 2:** In this module, one faculty (based on the internal discussion) from each of the following domain will come and talk on past, present, and future of research, industry and technological innovations in their domain (one hour each): (i) Structural Engineering, (ii) Geotechnical Engineering, (iii) Transportation Engineering, (iv) Geoinformatics and Survey, (v) Earth Sciences, (vi) Water and Hydrology Engineering, (vii) Environmental. Engineering. [7 hrs]
- **Module 3:** A visit to all the existing civil engineering laboratories of liT Mandi including the construction activities going on in liT Mandi. A discussion on recent advancement in Civil Engineering and role of AI/ ML and lOT etc. in Modem Civil Engineering. [3 hrs]
- **Module 4:** A field visit or an external expert talk as per the availability. A panel discussion on various career opportunities for Civil Engineering graduates. [2 hrs]

**Text book:**

NA

**References:**

NA

## 3.5 CE 203: Civil Engineering Materials

**Course Code: CE 203**

**Course Name: Civil Engineering Materials**

L-T-P-C: 3-0-0-3
Intended for: B.Tech. (CE)
Prerequisite:None
Mutual Exclusion:None
Approval: 53nd BoA

**Course Contents**

- **Fundamentals:** Atomic bonding and molecular structure of materials; Organic. inorganic and metallic construction materials; Alloys and Phase diagrams; MechanicaL physical and thermal properties of materials; Preliminarics of viscoelasticity and rheology; Environmental impact indices for construction materials. (6 Lectures)

- **Ferrous and Non-ferrous metals:** Classification of ferrous alloys; Production process, microstructure and properties of steel: Effects of alloy clements. work hardening and heat treatment on mechanical properties and we:ldability of steel; Corrosion of steel and its prevention: Structural steel products: Aluminum. Copper and their alloys. production process. properties and uses: Quality and test standards; Sustainability of metals. (6 Lectures)

- **Cement Concrete and Asphalt:** Ingredients of cement concrete and their properties; Concrete mix design and production; Major types of concrete and their characteristics in fresh and hardened states; Durability issues; Cement mortar and its applications; Asphalt binders and their properties: Asphalt mixture formulations: Effects of moisture. temperature and aging on asphalt: Quality and test standards; Sustainability of cement concrete and asphalt. (6 Lectures)

- **Stones, Bricks, Blocks and Tiles:** Composition of good brick earth: Brick manufacturing; Classification of bricks; Classification of rocks: Rock forming minerals: Stone quarrying, seasoning and dressing: Qualities of good building stone and brick: Deterioration and preservation of masonry; Fly ash and concrete masonry units: Sustainability of bricks and blocks: Commonly used tiles for 1loor, wall and roof; Choosing a floor tile; Quality and test standards. (6 Lectures)

- **Glass Composition of glass:** Production and treatment processes; Physical and mechanical properties: Types and uses: Quality and test standards. (4 Lectures)

- **Wood and Wood products:** Structure of wood. defects and non-uniformities; Physical and mechanical properties; Durability and preservation; Wood-based composites; Quality and test standards; Sustainability of wood. (4 Lectures)

- **Polymers and Plastics:** Classification and properties of polymers; Fabrication methods, additives and fillers used for plastics: Common plastics and their uses; Environmental etiects of plastics. (4 Lectures)

- **Paints:** Composition and classification of paints; Production process; Choosing a paint; Defects in painting; FfTcct of paints on indoor air quality. (3 Lectures)

- **Special topics:** Soil as a construction material; Geosynthetics; Materials for sound and thermal insulation. waterproofing and fire protection: Bamboo; Smart materials; Preliminaries of 3D printing. (3 Lectures)

**Textbooks:**

1. Duggal, S.K ., **Building Materials**, 4th Edition, New Age International, 2012.

2. Varghese, P.C., **Building Materials**, 2nd Edition, PHI Learning, 2015 .

**References:**

1. Young, J.F., Mindess, S., Gray, R., and Bentur, A ., **The science and technology of civil engineering materials**, Prentice Hall, 1998.

2. Goncalves. M. C. and Margarido, F., **Materials for Construction and Civil Engineering -- Science: Processing and Design**, Springer Cham, 2015.

3. Subramanian. N., **Building Materials --Testing and Sustainability**, Oxford University Press, India, 2019.

## 3.6 CE 203P: Building Materials Lab

**Course Code: CE 203P**

**Course Name: Building Materials Lab**

L-T-P-C: 0-0-2-1
Intended for: B.Tech. (CE)
Prerequisite:None
Mutual Exclusion:None
Approval: 52nd BoA

**Course Contents:**

1. Static tension test of mild steel, cast iron and aluminum.

2. Static compression test of fired clay brick, concrete blocks, cubes, cores and cylinders.

3. Measurement of the flexural strength of tiles and concrete.

4. Measurement of the wear/abrasion resistance of tiles and concrete.

5. Water absorption tests for fired clay brick and concrete.

6. Measurement of thermal properties of concrete using hot wire method.

7. Measurement of thermal conductivity of common insulation materials and ghiss using Lees' Disc apparatus.

8. Particle shape and size analyses of aggregates.

9. Specific gravity and water absorption tests for aggregates.

10. Crushing and Impact value tests for coarse aggregates.

11. Fineness and specific gravity tests for cement.

12. Standard consistency and setting time tests for cement.

13. Le Chatelier's and autoclave soundness tests for cement.

14. Use of moisture meter, ultrasonic pulse velocity and rebound hammer tests for the non-destructive assessment of concrete quality .

**Text books:**

1. Relevant BIS and ASTM standards

**References:**

1. Bahurudeen A., and Moorthi, P.V.P., **Testing of Construction Materials**, CRC Press, 2021.

## 3.7 CE 251: Hydraulics Engineering

**Course Code: CE 251**

**Course Name: Hydraulics Engineering**

L-T-P-C: 3-0-0-3
prerequisite: None
Students intended for: UG
Elective or Core: Discipline Core
Approval: 9th Senate

**Course contents**

- **Introduction**

  definition of fluid, liquids and gases, continuum hypothesis, Newtonian and non-Newtonian fluids [6 Lectures]

- **Fluid Statics**

  Pascal's law, Manometry, Buoyancy, metacentric height, rigid body motion. [6 Lectures]

- **Fluid Kinematics**

  Lagrangian and Eulerian fluid motion, vorticity and circulation, rotational and irrotational flows. [6 Lectures]

- **Fluid Dynamics:**

  Reynolds transport theorem, Equation of mass momentum and inertia, Integral formulation of governing equations, Euler's equation, Bernoulli's equation, Navier-Stokes equation. [8 Lectures]

- **Internal Flows**

  Couette Flow, Hagen-Poiseuille flow, flow through pipe, channels, Venturi, Orifice, head loss calculations, Moody's chart. [8 Lectures]

- **Dimensional Analysis**

  scaling and similarity, Buckingham $\pi -$ theorem, model testing. [4 Lectures]

- **External Flows**

  Boundary layer flows, laminar and turbulent flows, flow separation, lift and drag, Stokes Law, displacement and momentum thickness. [4 Lectures]

- **Flow in open channel**

  Discharge measurements in open channel, Concept of Specific Energy, Critical flow and depth computation, application of specific energy. [2 Lectures]

- **Introduction to hydrology**

  Meteorological cycle, rainfall and runoff calculation. [1 Lecture]

**Text Books**


1. Hunter Rouse, **Elementary Mechanics of Fluids**, John Wiley & Sons, 2011.
2. V.L. Streeter and E.B. Wylie, **Fluid Mechanics**, McGraw Hill Book Co., 1962.
3. P.N. Modi and S.M. Seth, **Hydraulics & Mechanics**, Standard Book House, 2002.
4. B. S. Massey, **Mechanics of Fluids**, Van Nostrand Reinhold Co., 1979.
5. J. Frabzini, **Fluid Mechanics with Engineering Applications**, McGraw Hill, 1997.
6. J.H. Spurk, **Fluid Mechanics – Problems and Solutions**, Springer, 2003.
7. Wilson, E. M., **Engineering hydrology (Vol. 4)**, Macmillan, 1990.
8. Subramanya, K., **Engineering hydrology**, Tata McGraw-Hill Education, 1994.


**Reference Books**


1. Lewitt, Ernest H., **Hydraulics and Fluid Mechanics: A Text-book Covering the Syllabuses of the B. Sc.(Eng.), ICE and I. Mech. E. Examinations in this Subject**, Pitman, 1958.
2. Dixon, S. L., and Hall, C., **Fluid mechanics and thermodynamics of turbomachinery**, Butterworth-Heinemann, 2013.


## 3.8 CE 252: Geology and Geomorphology

**Course Code: CE 252**

**Course Name: Geology and Geomorphology**

L-T-P-C: 2-0-2-3
Prerequisite: None
Students intended for: UG
Elective or Core: Elective
Approval: 16th Senate

**Course content**

- **Module I**

  Introduction, importance and significance of Earth Science, General characteristics and origin of the Universe, Solar System and its planets. [4 Lectures]

- **Module II**

  Rock cycle, types and characteristics: Igneous, Sedimentary and Metamorphic rocks and their origin, texture, mineral composition, structure and classification. Rock properties. [5 Lectures]

- **Module III**

  Plate tectonic theories, Physiographic sub divisions of India with focus on Himalayas. [4 Lectures]

- **Structural Geology**

  Dip, strike, faults, folds, joints, emphasizing on Himalayan terrain. [6 Lectures]

- **Module V**

  Basic concepts of Geomorphology, Cycle of erosion, Mountains and relief, river basin, drainage network, drainage types. [5 Lectures]

- **Module VI**

  Geomorphic landforms, erosional & depositional: Fluvial, Glacial landforms. [4 Lectures]

**Laboratory**

1. Identifying physical properties of rocks using visual interpretations. (4 hours)
2. Estimation of Hardness of rock using Mohr's Scale test. (2 hours)
3. Mineral identification using several properties. (2 hours)
4. Dip/ Strike measurements using brunton compass in and around campus. (4 hours)
5. Geological map reading and interpretations. (4 hours)
6. Geomorphological mapping and interpretation of maps. (4 hours)
7. Geological field mapping around the campus. (8 hours)

**Text Books**

1. Lutgens & Tarbuck, **Essentials of Geology (with CD)** Pearson Education, 2012.
2. P. Singh, **Engineering and General Geology**, S. K. Kataria and Sons, 2009.

**Reference Books**

1. A L. Bloom, **Geomorphology: A systematic Analysis of Late Cenozoic Landforms**, 3rd Ed.', Pearson Education, Inc., USA, 2004.

2. Peter MacLaren Donald Duff, Donald Duff, **Holme's Principles of physical geology**, Chapman & Hall, 1992.

3. F. G. Bell, **Engineering Geology**, Elsevier, 2007.

4. V S. Kale, and A. Gupta, **Introduction to Geomorphology**, Orient Longman Ltd., 2001.

## 3.9 CE 301: Strength of Materials and Structures

**Course Code: CE 301**

**Course Name: Strength of Materials and Structures**

L-T-P-C: 3-0-2-4
Prerequisite: IC 240 - Mechanics of Rigid Bodies
Students intended for: UG
Elective or Core: Discipline Core
Approval: 9th Senate

**Course contents**

- **Types of structures**

  Free body diagram, conditions of equilibrium, statically determinate and indeterminate trusses, beams and frames. [2 Lectures]

- **Mechanics of small deformation**

  Concepts of stress and strain, stress-strain characteristics of ductile and brittle materials, elastic constants and their relationships, thermal stresses. [12 Lectures]

- **Members subjected to flexural loads**

  Shear force and bending moment in determinate beams. Calculation of deflection by double integration, moment-area and unit load methods. [12 Lectures]

- **Columns**

  Euler's theory, Critical load for different end conditions, eccentric loading, columns with small initial curvature. [4 Lectures]

- **Influence lines for statically determinate structures**

  Moving loads on beams and trusses; Maximum shear force and bending moment due to moving loads. [3 Lectures]

- **Analysis of indeterminate structures by slope-deflection method**

  Statically indeterminate beams subjected to loads and uneven settlement of supports, Analysis of rigid frames with and without side sway. [9 Lectures]

**Laboratory Experiments**

1. Study of reactions in beams with different support conditions.
2. Study of variation of bending moment and shearing force in a beam subjected to various loading conditions.
3. Study of load-deflection characteristics of determinate and indeterminate trusses.
4. Study of load-deflection characteristics of rectangular portal frames with uniform and non-uniform sections.
5. Study of stress and strains in the members of pin jointed frames.
6. Study of plastic bending of portal frames.
7. Load-deflection study of pinned and fixed arches.
8. Study of buckling characteristics of struts.
9. Study of horizontal and vertical deflections of asymmetric sections at various angles and loads.
10. Study of behavior of circular section under torsion.

**Text Books**


1. C. T. F. Ross, J. Case and L. Chivler, **Strength of Materials and Structures**, 4th edition, Butterworth Heinemann, 1999.
2. C.S.Reddy, **Basic Structural Analysis**, Tata McGraw Hill, 2001.
3. C.K. Wang, **Intermediate Structural Analysis**, Tata McGraw Hill, 2010.
4. R.C. Hibbeler, **Structural Analysis**, Pearson Education, 6th edition, New Delhi, 2008.
5. C.H. Norris, J.B. Wilbur, S.Utku, **Elementary Structural Analysis**, Tata McGraw Hill, 1991.
6. L. S. Negi and R. S. Jangjid, **Structural Analysis**, Tata Mc Graw Hill, 1997.


**Reference Books**


1. B. Onouye and K. Kane, **Statics and strength of materials for architecture and building construction**, 4th edition, Prentice Hall, USA, 2013.
2. G. Ranzi and I.B. Raymond, **Structural analysis: principles, methods and modelling**, CRC press, 2014.
3. A. Williams, **Structural analysis: in theory and practice**, Butterworth-Heinemann, UK and USA, 2009.
4. T.H.G. Megson, **Structural and stress analysis**, Butterworth-Heinemann, UK and USA, 2014.

## 3.10 CE 302: Geotechnical Engineering

### Course Code: CE 302

### Course Name: Geotechnical Engineering

L-T-P-C: 3-0-2-4
Prerequisite: None
Students intended for: UG
Elective or Core: Discipline Core
Approval: 9th Senate

### Course contents

- **Stress Distribution in Soils**

  Effective stress concept, water table, seepage and capillarity effects and failure of structures by piping. Boussinesq theory-pressure distribution diagram on a horizontal and vertical plane, pressure bulb. [5 Lectures]

- **Shear Strength of Soil**

  Stress strain curve, stress at a point-Mohr circle of stress, Mohr-coulomb failure criteria, pore pressure, total and effective stress. Peak and residual shear strength. Factors affecting shear strength, Laboratory measurement of shear strength by box shear, unconfined, Vane shear test and triaxial tests under different drainage conditions. Shear strength characteristics of sands and clays. [7 Lectures]

- **Subsoil Exploration**

  Methods of subsoil exploration Direct, semi direct and indirect methods, Soundings by Standard, Dynamic cone and static cone penetration tests, Types of Boring, Types of samples, Criteria for undisturbed samples, Transport and preservation of samples, Borelogs, planning of exploration programmes, report writing. [6 Lectures]

- **Earth Pressure**

  Types of Earth pressure. Rankines and Coulomb's Active and passive earth pressure in soils. [4 Lectures]

- **Module V**

  **Bearing Capacity** Safe bearing capacity and allowable bearing pressure, General and local shear failure conditions, Terzaghi's bearing capacity equations its modifications for square, rectangular and circular foundation, Factors affecting bearing capacity of Soil.

  **Shallow Foundations**: Factors effecting locations of foundation and design considerations of shallow foundations, choice of type of foundations, Foundations on expansive soils. [9 Lectures]

- **ettlement analysis**

  Causes of settlement, Computation of settlement, allowable settlement. Measures to reduce settlement. [3 Lectures]

- **Pile Foundations**

  Types, Construction, load carrying capacity of single pile – Dynamic Formula, Static formula, Pile load tests, Load carrying capacity of pile groups, settlement of pile groups, Negative skin friction. [8 Lectures]

**Laboratory Experiments**

1. Determination of Specific Gravity
2. Grain Size Analysis
   A. Sieve Analysis
   B. Hydrometer Analysis
3. Determination of Consistency Limits
4. Permeability Test
   A. Constant Head Method
   B. Falling Head Method
5. Proctor Light And Heavy Compaction Test
6. Direct Shear Test
7. Unconfined Compression Test
8. Unconsolidated and Undrained Triaxial Test
9. Vane Shear Test
10. CBR Test
11. Field Density Test
12. Free swell and consolidation test

**Text Books**

1. Shamsher Prakash, Gopal Ranjan and Swami Saran, **Analysis, Design of foundations and Earth retaining structures**, IBH Publishers, 1979.
2. Braja M. Das, **Principles of Foundation Engineering**, Cengage Learning, 2015.
3. V.N.S. Murty, **Geotechnical Engineering**, Book World Enterprises, 2002.

**Reference Books**

1. W.C Teng, **Foundation Design**, Prentice Hall Publishers, 1962.
2. J. E. Bowles, **Foundation Analysis and Design**, TataMc-Graw Hill Publishers, 1997.

## 3.11 CE 303: Water Resources Engineering

**Course Code: CE 303**

**Course Name: Water Resources Engineering**

L-T-P-C: 3-0-0-3
Prerequisite: CE 251 - Hydraulics Engineering
Students intended for: UG & PG
Elective or Core: Discipline Core
Approval: 9th Senate

**Course contents**

- **Introduction**

  Hydrology, Open channel flow, Groundwater flow. [6 Lectures]

- **Descriptive Hydrology**

  Hydrology, Meteorology, Rainfall measurements, Runoff, Stream flow, Hydrographs, Factors affecting runoff and its calculation pertaining to Himalayan terrain, Infiltration. [8 Lectures]

- **Storm Hydrology**

  Hydrographs, unit hydrograph theory, S-curve, Mass and flow duration curve, depth area duration curve, runoff estimation. [8 Lectures]

- **Floods**

  Flood estimation, Forecasting systems, Flash flood studies, Hydrologic and reservoir routing, Return period and Probability analysis. [8 Lectures]

- **Watershed Management in Hilly region** introduction and management [4 Lectures]

- **Introduction to ground water systems**

  Types of Aquifer and characteristics, Application of Darcy Law, Groundwater flow equations, well hydraulics. [6 Lectures]

**Text Books**


1. K. Subramaniya, **Engineering Hydrology**, Tata MacGraw Hill, 2013.

2. H.M. Raghunath, **Hydrology – Principles, Analysis and Design**, Wiley Eastern Ltd., 2006.

3. D.K. Todd, **Groundwater Hydrology**, John Wiley & Sons, 2006.

4. V.T. Chow, D.R. Maidment, and L.W. Mays, **Applied Hydrology**, McGraw Hill, 1988.

**Reference Books**


1. R.K. Linsley, J. B. Franzini, D. L. Freyberg and G. Tchobanoglous, **Water Resource Engineering**, 4th Edition, McGraw Hill Book Co., 1992.

2. V.P. Singh, **Elementary Hydrology**, Prentice Hall, 1993.

3. S.K. Garg, **Irrigation Engineering and Hydraulic Structures**, Khanna Publishers, 1992.


## 3.12 CE 303_53: Water Resources Engineering

**Course Code: CE 303_53**

**Course Name: Water Resources Engineering**

L-T-P-C: 3-0-0-3
Intended for: B.Tech. (Civil Engineering)
Prerequisite: CE 251 - Hydraulic Engineering
Mutual Exclusion :None
Approval: 53rd BoA

**Course Conents**

- **Introduction:** Hydrological Cycle, Water budget equation, Reynold Transport Theory, Principle of mass, momentum, and energy balance in Hydrology. (6 Lectures)

- **Precipitation:** Atmospheric Circulation, Water vapor, Precipitation measurement, rain gauge network, Mean Precipitation, Maximum Intensity/Depth Duration Curve, Rainfall patterns in India and Himachal Pradesh. (8 Lectures)

- **Abstractions from Precipitation:** Evaporation and its estimation, Evapotranspiration, Estimation of Evapotranspiration, Potential Evapotranspiration, Interception, Infiltration. (6 Lectures)

- **Hydrometry:** Measurement of Stage, Velocity, Area Velocity Method, Dilution Technique, Electromagnetic method, Ultrasonic Method, Indirect method, Rating Curve. (6 Lectures)

- **Storm Hydrology:** Hydrographs, unit hydrograph theory, S-curve, Mass and flow duration curve, depth area duration curve, runoff estimation. (8 Lectures)

- **Floods and Droughts:** Flood estimation, Frequency analysis, Risk and Reliability, Hydrologic and Hydraulic routing,Clark's and Nash's model. (6 Lectures)

- **Groundwater Hydrology**: Types of Aquifer and charac::tedstics, Application of Darcy Law, Groundwater flow equations; well hydraulics. (2 Lectures)

**Textbooks:**

1. Subramanya, K., **Engineering Hydrology**, Tata Mcgraw Hill, 2013.
2. V. T. Chow, D. R. Maidment,and L. W. Mays, **Applied Hydrology**, Mcgraw Hill, 1988.

**Reference Books:**

1. H. M. Raghunath, **Hydrology - Principles, Analysis and Design**, Wiley Eastern, 2006.
2. V. P. Singh, **Elementary Hydrology**, Printice Hall, 1993.
3. R. K. Linsley, J. B. Franzini, D. L. Freyberg, and G. Tchobanoglous, **Water Resource Engineering**, 4th Edition, Mcgraw Hill, 1992.

## 3.13 CE 304P: Hydraulics Engineering Lab

**Course Code: CE 304P**

**Course Name: Hydraulics Engineering Lab**

L-T-P-C: 0-0-2-1
Prerequisite: CE 251 - Hydraulics Engineering
Students intended for: UG & PG
Elective or Core: Discipline Core
Approval: 9th Senate

**List of Experiments**

- Bernoulli's Theory
- Impacts of jets
- Energy losses in pipes
- Guleph Permeameter
- Hydraulics Jump
- Pipe Surges and water hammer
- Centrifugal pump characteristics
- Flow over weirs
- Flow measurements in open channel

## 3.14 CE 305P: Environment and Earth Science Lab

**Course Code: CE 305P**

**Course Name: Environment and Earth Science Lab**

L-T-P-C:0-0-2-1
Prerequisite: None
Students intended for: UG
Elective or Core: Discipline Core
Approval: 9th Senate

**Modules**

**Environment**

- Determination of B.O.D. & C.O.D. of Wastewater Sample
- Analysis of major cations and anions
- Jar Test for Determining Optimum Coagulant Dosage
- Tests for Coliforms, Fecal, Total Coliforms
- Analysis of Metal and heavy metal in water and waste water
- Soil contamination studies
- Air Quality: Ambient Air quality (High Volume Sampler), PM10, PM2.5

**Earth Science**

- Rock and mineral identification,
- Dip/ Strike, fold, fault, fracture measurements in rocks
- Strength characterization of rocks
- Chemical analysis of rocks and soils
- Field visit

**Text Books**

1. Sawyer, N.C. and McCarty, P.L.,, **Chemistry for Environmental Engineering**, 5th Edition, McGraw Hill, 2003.
2. APHA, **Standard Methods Examination of Water and Wastewater**, American Public Health Association, 1998.

## 3.15 CE 306P: Environmental Engineering Lab

**Course Code: CE 306P**

**Course Name: Environmental Engineering Lab**

L-T-P-C: 0-0-2-1
Intended for: UG
Prerequisite: None
Mutual Exclusion: None
Approval: 52nd BoA

**Course Contents**

**Experiments:**

- Determination of solids
- Jar Test for determining optimum coagulant dosage
- Determination of acidity
- Determination of alkalinity
- Determination ofhardness
- Determination of Dissolved Oxygen
- Determination of B.O.D. of wastewater sample
- Determination of C.O.D. of wastewater sample
- Tests for Colifonns, Fecal, Total Coliforms
- Soil contamination (adsorption) studies
- Introduction to advanced analytical instruments
- Determination of bulk and size-segregated PM2.5
- Determination ofionic species in PM2.5
- Determination ofheavy metals in PM2.5

**Laboratory/practical/tutorial Modules:**

The course is entirely laboratory-based.

**Textbooks:**

1. Sawyer, N.C. and McCarty, P.L., **Chemistry for Environmental Engineering**, 5th Edition, McGraw- Hill Book Co., 2003.
2. APHA, **Standard Methods Examination of Water and Wastewater**, American Public Health Association, 1998.

**References:**

None.

## 3.16 CE 310: Strength of Materials and Structures

**Course Code: CE 310**

**Course Name: Strength of Materials and Structures**

L-T-P-C: 3-0-0-3
Intended for: UG
Prerequisite : IC240: Mechanics of Rigid Bodies
Mutual Exclusion: None
Approval: 52nd BoA

**Course Contents**

- **Module 1:** Introduction to loads, structural materials, and support conditions, Overview of internal and external stability, Definition of determinate structures. (3 Lectures)
- **Module 2:** Mechanics of small deformation: Free Body Diagram, Concepts of stress and strain - types and definition, stress-strain characteristics of ductile and brittle materials, elastic constants and their relationships, Axially loaded members, Concept of Torsion and Torsional behaviour of circular shafts. (8 Lectures)
- **Module 3:** Transformation of stresses and strains, principal stresses and strains, Mohr's circle, and Failure theories. (5 Lectures)
- **Module 4:** Detennination of external and internal forces in Trusses, Cables, Arches, and Beams, Concept of shear force, and bending moment diagrams of determinate beams and frames. (10 Lectures)
- **Module 5:** Flexural and shear stresses in beams, deflections of beams using double integration, introduction to moment area, unit load, and conjugate beam methods. (8 Lectures)
- **Module 6:** Influence lines for statically determinate structures; Moving loads onbeams and trusses; Maximum shear force and bending moment due to moving loads. (4 Lectures)
- **Module 7:** Columns: Euler's theory, Critical load for different end conditions, eccentric loading, columns with small initial curvatures. (4 Lectures)

**Textbooks:**

1. Hibbeler, RC, **Structural Analysis**, 9th Edition, Pearson Education, 2017.
2. Hibbeler. RC, **Mechanics of Materials**, Pearson Education, l0th Edition, 2016.

**References:**

1. Timoshenko, S.P., and Young, D.H., **Elements of Strength of Materials**, 5th Edition, 2003.

2. Beer, F.P., Johnston, E.R., DeWalt, J., and Mazurek, D.F.,

3. Egor P. Popov, **Engineering Mechanics of Solids,** 2nd Edition Pearson Education Inc, 2009

4. Gere and Timoshenko, **Mechanics of Materials**, 2nd Edition, CBS Publishers, 2004.

5. Reddy, CS, **Basic Structural Analysis**, Tata McGraw Hill, 2001.

6. Menon, D., **Structural Analysis**, Narosa Publishing House, 2008.

7. Ross, C.T.F, Case, J, and Chivler, L, **Strength of Materials and Structures**, 4th edition, Butterworth Heinemann, 1999.

8. Megson, THG, **Structural and Stress Analysis**, Butterworth-Heinemann, 2014.

## 3.17 CE 310P: Strength of Materials and Structures Lab

**Course Code: CE 310P**

**Course Name: Strength of Materials and Structures Lab**

L-T-P-C: 3-0-0-3
Intended for: UG
Prerequisite : CE310: Strength of Materials and Structures / Equivalent
Mutual Exclusion: None
Approval: 52nd BoA

**Course Contents**

The curriculum is split into eleven experiments encompassing different structural engineering analysis and strength testing problems typically encountered in the field practices. Validation of the concept through computer programming will also be made as part of this course. The duration of each lab session shall be 3 Lectures

1. Study of stress-strain characteristics of civil engineering materials.

2. Study of reactions in beams with different support conditions.

3. Study ofvariation of bending moment and shearing force in a beam subjected to various loading conditions.

4. Study ofload-deflection characteristics of trusses.

5. Study ofload-deflection characteristics of rectangular portal frames with uniform and nonunifonn sections.

6. Study of stress and strains in the members ofpinjointed frames.

7. Study of plastic bending of portal frames.
8. Load-deflection study of pinned arches.
9. Study of buckling characteristics of struts.
10. Study ofhorizontal and vertical deflections of asymmetric sections at various angles and loads.
11. Study of behaviour of circular section under torsion.

**Textbooks:**

1. Hibbeler, RC, **Structural Analysis**, 9th Edition, Pearson Education, 2017.
2. Hibbeler. RC, **Mechanics of Materials**, Pearson Education, l0th Edition, 2016.

**References:**

1. Timoshenko, S.P., and Young, D.H., **Elements of Strength of Materials**, 5th Edition, 2003.
2. Beer, F.P., Johnston, E.R., DeWalt, J., and Mazurek, D.F.,
3. Egor P. Popov, **Engineering Mechanics of Solids**, 2nd Edition Pearson Education Inc, 2009
4. Gere and Timoshenko, **Mechanics of Materials**, 2nd Edition, CBS Publishers, 2004.
5. Reddy, CS, **Basic Structural Analysis**, Tata McGraw Hill, 2001.
6. Menon, D., **Structural Analysis**, Narosa Publishing House, 2008.
7. Ross, C.T.F, Case, J, and Chivler, L, **Strength of Materials and Structures**, 4th edition, Butterworth Heinemann, 1999.
8. Megson, THG, **Structural and Stress Analysis**, Butterworth-Heinemann, 2014.

## 3.18 CE 311: Geotechnical Engineering I

**Course Code: CE 311**

**Course Name: Geotechnical Engineering I**

L-T-P-C: 3-0-0-3
Intended for: UG students (B.Tech. 3rd Year)
Prerequisite : None
Mutual Exclusion: None
Approval: 52nd BoA

**Course Contents**

- **Introduction:** Origin, Formation, Importance of geotechnical engineering, Idealization of soil matrix, three phase diagram, Mass-weight-volume relationships, applications (8 Lectures)
- **Properties of soil:** Pru1icle size distribution, Index properties, Atterberg Limits, plasticity chart, Soil Classification (4 Lectures)
- **Soil Compaction:** Soil density-water relationship, Proctor tests, field tests and applicability (3 Lectures)
- **Permeability in soils:** One-dimensional flow, Darcy's Law, Laboratory and field method of determination of permeability. concept of seepage (6 Lectures)
- **Stresses in soils:** Stresses in soil mass, capillarity phenomena, concept of effective stress, Stresses from elastic theory, Boussinesq and WesterGaard's theory, pressure distribution diagram, pressure bulb, shapes of loading area (7 Lectures)
- **Consolidation:** ID laboratory test, preconsolidation pressure, concept of normally consolidated and over consolidated soil, One-dimensional equation and solution, determination of consolidation settlement (5 Lectures)
- **Shear Strength of Soil:** Mohr circle, Mohr-coulomb failure criteria, shear strength of sand and clays, pore pressure, factors affecting shear strength, laboratory measurement of shear strength. (8 Lectures)

**Text Books:**

1. Robert D Holtz, William D. Kovacs and Thomas C. Sheahan, **Introduction to Geotechnical Engineering**, 2nd Edition, Pearson, 2021.
2. V. N. S. Murty, **Geotechnical Engineering**, Book World Enterprises, 2005.

**Reference Books:**

1. R.F. Craig, **Soil Mechanics**, ELBS and Van Nostrand Reinhold Co. Ltd., 2004.
2. Braja M. Das, **Principles of Geotechnical Engineering**, 7th Edition and above, Cengage Learning.
3. G. Ranjan and A.S.R. Rao, **Basic and Applied Soil Mechanics**, New Age International Publishers, 2007.

## 3.19 CE 311P: Geotechnical Engineering Laboratory

**Course Code: CE 311P**

**Course Name: Geotechnical Engineering Laboratory**

L-T-P-C: 0-0-2-1
Intended for: UG students (B.Tech. 3rd Year)
Prerequisite : None

Mutual Exclusion: None
Approval: 52nd BoA

**Course Contents**

**Laboratory Modules:**

1. Determination of Specific Gravity
2. Grain Size Analysis (a) Sieve analysis (b) Hydrometer Analysis
3. Determination of Consistency Limits
4. Permeability Test (a) Constant Head Testing (b) Falling Head testing
5. Proctor Test
6. Direct Shear Test
7. Unconfined Compression Test
8. Vane Shear Test
9. Field Density Test
10. Free swell and consolidation test
11. Triaxial Testing

**Text Books:**


1. V. N. S. Murty, **Geotechnical Engineering**, Book World Enterprises, 2005.
2. Braja M. Das, **Principles of Geotechnical Engineering**, 7th edition and above, Cengage Learning


**Reference books:**


1. **Indian standards using Geotechnical Testing**


## 3.20 CE 351: Design of Reinforced Concrete Structures

**Course Code: CE 351**

**Course Name: Design of Reinforced Concrete Structures**

L-T-P-C: 2-1-0-3
Prerequisite: CE 301 - Strength of Materials and Structures
Students intended for: UG
Elective or Core: Discipline Core
Approval: 9th Senate

**Course content**

- **Design of beams**

  Singly and doubly reinforced. [6 Lectures]

- **Design of columns**

  Short and slender columns. [6 Lectures]

- **Design of slabs**

  One way, two way and flat slabs. [6 Lectures]

- **Module IV**

  Design for bond and anchorage of reinforcement. [6 Lectures]

- **Module V** Reinforcement detailing at beam-column and column-foundation junctions. [6 Lectures]

- **Module VI**

  Design of Staircase, Isolated and combined footings. [6 Lectures]

- **Introduction to pre-stressed concrete design**

  Basics of seismic analysis and detailing. [6 Lectures]

**Text Books**

1. Pillai, S.U. and Menon, D,, **Reinforced concrete design**, Tata MacGraw Hill, 2009.

2. Subramanian, N, **Design of reinforced concrete structures**, xford University Press, 2014.

3. Sinha, S.N., **Reinforced concrete design**, Tata McGraw-Hill, 2002.

4. Raju, N.K. and Pranesh, R.N., **Reinforced concrete design: principles and practice**, New Age International, 2007.

5. Raju, N.K., **Prestressed concrete**, Tata MacGraw Hill, 2006.

**Reference Books**

1. Nawy, E.G., **Reinforced concrete: a fundamental approach**, Prentice Hall, 2009.

2. Wright, J.K. and MacGregor, J.G., **Reinforced concrete: mechanics and design**, Prentice Hall, 2015.

3. Hewson, N.R., **Prestressed concrete bridges: design and construction**, Thomas Telford, 2003.

4. Varghese, P.C., **Advanced reinforced concrete design**, Prentice Hall of India, 2009.

## 3.21 CE 352: Transportation Engineering

**Course Code: CE 352**

**Course Name: Transportation Engineering**

L-T-P-C: 3-0-0-3
Prerequisite: None
Students intended for: UG
Elective or Core: Discipline Core
Approval: 9th Senate, 52nd BoA

**Course contents**

- **Introduction to transportation engineering**

  various methods of transportation and their importance, PMGSY, Golden quadrilateral and other road development plans of GOI. [6 Lectures]

- **Module II**

  SGeometrical design, camber, super elevation cross-sectional elements, sight distances, horizontal and vertical alignments, transition curves. [12 Lectures]

- **Highway Engineering**

  Pavement material and characterization, aspects of analysis and design of flexible and rigid pavements. [7 Lectures]

- **Highway Planning & Maintenance**

  types of failure, evaluation and remedial measures. [7 Lectures]

- **Traffic Engineering** Vehicle and driver characteristics, Traffic design studies. [5 Lectures]

- **Module VI**

  Introduction to rail and air transport system, intelligent transport system. [5 Lectures]

**Text Books**

1. S.K. Khanna and C.E.G. Justo, **Highway Engineering**, Nem Chand Bros., 2002.

2. Kadiyali L.R., **Principles and Practice of highway Engineering**, Khanna Publishers, 1992.

3. Khistry, C.J. and B. K. Lall, **Transportation Engineering – An Introduction**, Prentice Hall of India Ltd., 2003.

**Reference Books**


1. Garber, N.J., Hoel, L.A., **Traffic and Highway Engineering**, West Publishing Company, 2014.

2. P. Chakroborty and A. Das, **Principles of Transportation Engineering**, Prentice Hall India, 2003.

3. S.C. Saxena and S.P. Arora, **A text book of Railway engineering**, Dhanpat Rai, 2001.


## 3.22 CE 352_44 : Transportation Engineering

**Course Code: CE 352**

**Course Name : Transportation Engineering**

L-T-P-C : 3-0-0-3
Intended for : UG
Prerequisite : None
Mutual Exclusion : None
Approval: 44th BoA

**Course Contents:**

- **Introduction to transportation engineering**: various methods of transportation and their importance, PMGSY, Golden quadrilateral and other road development plans of GOI. Planning of universal accessibility for public transport. (6 hours)

- **Module II**: Geometrical design, camber, super elevation cross-sectional elements, sight distances, horizontal and vertical alignments, transition curves. (12 hours)

- **Highway Engineering**: Pavement material and characterization, aspects of analysis and design of flexible and rigid pavements. (7 hours)

- **Module IV**: Highway Planning &maintenance, types of failure, evaluation and remedial measures. (7 hours)

- **Traffic Engineering**: Vehicle and driver characteristics, Traffic design studies. (5 hours)

- **Module VI**: Introduction to rail and air transport system, intelligent transport system. (5 hours)

**Text Books:**


1. S.K. Khanna and C.E.G. Justo, **Highway Engineering**, Nem Chand Bros., 2002.

2. Kadiyali L.R., **Principles and Practice of highway Engineering**, Khanna Publishers, 1992.

**Reference Books:**

1. Khistry, C.J. and B. K. Lall, **Transportation Engineering – An Introduction**, Prentice Hall of India Ltd., 2003

2. Garber, N.J., Hoel, L.A., **Traffic and Highway Engineering**, West Publishing Company, 2014.

3. P. Chakroborty and A. Das, **Principles of Transportation Engineering**, Prentice Hall India, 2003.

4. S.C. Saxena and S.P. Arora, **A text book of Railway engineering**, Dhanpat Rai, 2001.

## 3.23 CE 352P: Transportation Engineering Laboratory

**Course Code: CE 352P**

**Course Name: Transportation Engineering Laboratory**

L-T-P-C: 0-0-2-1
Intended for: UG Civil Engineeering
Prerequisite : None
Mutual Exclusion: None
Approval: 52nd BoA

**Course Contents**

**Laboratory Modules:**

1. Los Angles Abrasion Test of Bitumen

2. Devel's abrasion Test of Bitumen

3. CBR Test

4. Marshall Stability of Bitumen

5. Penetration Test of Bitumen

6. Softening Point of Bitumen

7. Flash and Fire point of Bitumen

8. Ductility of Bitumen

9. Viscosity of Bitumen

10. Banklmen's Beam Test

11. Road Survey- Cross section, Super-Elevation Camber, Gradient

12. Measuring Spot Speed/Flow/Density/Vehicle Count

**Text Books:**

1. S.K. Khanna, C.E.G. Justo and A. Veeraraghavan, **Highway Engineering**, 10th Edition, Nem Chand Bros., 2018.

2. Kadiyali L.R., **Principles and Practice of highway Engineering**, Khanna Publishers, 1992.

**References:**

1. **IS Standards for each test**

2. Paul H. Wright and Norman J. Ashford, **Transportation Engineering: Planning and Design**

3. Nicholas J. Garber and Lester A. Hoel, **Traffic and Highway Engineering**

## 3.24 CE 352P_57 : Transportation Engineering Laboratory

**Course Code : CE 352P_57**

**Course Name : Transportation Engineering Laboratory**

L-P-T-C: 0-0-2-1
Intended for: UG Civil Engineering
Prerequisites: None
Mutual Exclusion:
Approval : 52nd BoA, 57th BoA

**Course Contents**

1. Experiments Abrasion Test (Los Angeles, Devel abrasion, etc.)

2. California Bearing Ratio Test for Subgrade (including proctor density)

3. Tests on Bitumen: Penetration

4. Tests on Bitumen: Softening Point

5. Tests on Bitumen: Ductility

6. Tests on Bitumen: Viscosity

7. Tests on Bitumen: Flash and Fire point

8. Tests on Bitumen: Specific Gravity and Water Content

9. Marshal Stability Tests (including rotary evaporator)

10. Banklmen's Beam Test and MERLIN Test

11. Road Survey- Cross section, Super elevation camber, gradient

12. Measuring spot speed/ Flow/ Density/ vehicle count

**Text books:**

1. S.K. Khanna, C.E.G. Justo and A. Veeraraghavan, **Highway Engineering**, 10th Edition, Nem Chand Bros., 2018.

2. Kadiyali L.R., **Principles and Practice of highway Engineering**, Khanna Publishers, Delhi, 1992.

**References:**

1. IS Standards for each test

2. Paul H. Wright and Norman J. Ashford, **Transportation Engineering: Planning and Design**.

3. Nicholas J. Garber and Lester A. Hoel, **Traffic and Highway Engineering**

## 3.25 CE 353P: Civil Engineering Drawing

**Course Code: CE 353P**

**Course Name: Civil Engineering Drawing**

L-T-P-C: 0-0-2-1
Prerequisite: IC 140 - Graphics for Design
Students intended for: UG
Elective or Core: Discipline Core
Approval: 9th Senate

**Modules**

**Environment**

- Course policies, signs and symbols, planning residential building. (2 contact hours)

- Site planning. (4 contact hours)

- Building components: foundations, brick, RC, stone, windows, doors, arches, staircase. (10 contact hours)

- Residential building: announcement of project. (2 contact hours)

- Detailing of RC elements: sections of beams, columns, footings and portal frames. (6 contact hours)

- Detailing of steel connection: rivets, welding, nuts and bolts. (4 contact hours)

**Text Books**

1.

2. **Building Drawing and Detailing**,Spades publishers, Calicut, 1987.

3. M.G.Shah, C.M. Kale, and S.Y. Patki, **Building drawing with an integrated approach to built environment**, 4th Edition, Tata McGraw Hill, 2002.

## 3.26 CE 353P_44 : Civil Engineering Drawing

**Course Code: CE 353P**

**Course Name : Civil Engineering Drawing**

L-T-P-C : 0-0-2-1
Intended for : UG
Prerequisite : None
Mutual Exclusion : None
Approval: 44th BoA

**Course Contents:**

- Course policies, signs and symbols, planning residential building. Consideration of universal accessibility for buildings. (3 Hours)
- Site planning. (3 Hours)
- Building components: foundations, brick, RC, stone, windows, doors, arches, staircase. (10 Hours)
- Residential building: announcement of project. (2 Hours)
- Detailing of RC elements: sections of beams, columns, footings and portal frames. (6 Hours)
- Detailing of steel connection: rivets, welding, nuts and bolts. (4 Hours)

**Text Books:**

1. Balagopal T.S. Prabhu, K. Vincent Paul, and C. Vijayan, **Building Drawing and Detailing**, Spades publishers, Calicut, 1987.
2. M.G.Shah, C.M. Kale, and S.Y. Patki, **Building drawing with an integrated approach to built environment**, 4th Edition, Tata McGraw Hill, 2002.

## 3.27 CE 354P: Building and Pavement Materials Laboratory

**Course Code: CE 354P**

**Course Name: Building and Pavement Materials Laboratory**

L-T-P-C:0-0-2-1
Prerequisite: IC 140 - Graphics for Design
Students intended for: UG
Elective or Core: Discipline Core
Approval: 9th Senate

**List of Experiments**

**Environment**

- Determination of specific gravity, fineness and soundness of different cements.
- The study of setting and hardening characteristics of different cements.
- Determination of specific gravity, moisture content, bulking and water absorption of aggregates.
- The study of abrasion, attrition, hardness, shape, grading and packing characteristics of aggregates.
- The study of water absorption, sorptivity and permeability characteristics of concrete and brick samples.
- Assessing the presence of organic impurities and fines in aggregates.
- Assessment of surface hardness, flexural strength, compressive strength and stress-stain characteristics of cement paste, mortar, concrete and clay & fly-ash bricks.
- Testing of filling ability and passing ability of self compacting concrete.
- The study of stress-strain characteristics of reinforcement bars, other metals and alloys.
- The study of consistency and ductility of bitumen samples.
- Determination of flash and fire points of bitumen samples.
- Determination of softening point of bitumen samples.
- Determination of viscosity of bitumen samples.
- To determine the optimum binder content for a bituminous mix by Marshall's method.

## 3.28 CE 355: Hydrology

**Course Code: CE 355**

**Course Name: Hydrology**

L-T-P-C: 3-0-0-3
Prerequisite: CE 251 - Hydraulics Engineering
Students intended for: UG
Elective or Core: Discipline Core
Approval: 9th Senate

**Course content**

- **Introduction**

  Water management, essence of water, hydrologic cycle, climate data, rain fall occurrence. [2 Lectures]

- **Precipitation**

  Measurement of rainfall, rain gauge, layout of rain gauge, correction of rainfall data, Analysis of rainfall data. [6 Lectures]

- **Runoff calculation**

  infiltration, evaporation and evapotranspiration estimation, base flow separation, stream gauging, stage and discharge, method of runoff estimation, empirical relation for determination of runoff. [10 Lectures]

- **Frequency Analysis**

  Frequency analysis, frequency distribution model, rainfall intensity. [8 Lectures]

- **Hydrograph** Base flow separation, reservoir routing, unit hydrograph, distribution hydrograph, synthetic unit hydrographs. [10 Lectures]

- **Advance hydrology**

  Flood routing, time series analysis, models of hydrographs [6 Lectures]

**Text Books**

1. Not Available

**Reference Books**

1. Not Available

## 3.29 CE 356: Reverse Engineering

**Course Code : CE 356**

**Course Name : Reverse Engineering**

L-T-P-C :1-0-0-1
Intended for : MS/MTech(R)/ PhD
Prerequisite :
Mutual Exclusion:
Approval: 54th BoA

**Course Contents (14 Hours)**

- This course curriculum encompasses a diverse range of topics, including the overview of civil engineering case studies; reading and decoding construction drawings; study of site investigation reports, material testing reports; examination of civil infrastructure failures and the implementation of remediation measures; study of environmental impact assessment reports for existing large infrastructural projects; study of performance assessment of existing road facilities; and study of topographical and survey maps.

- Some of the examples that students will be learning through this course include:
  - Case studies on structural design aspects of infrastructural facilities or geotechnical challenges and solutions or case studies on water resources management and infrastructure or environmental engineering case studies such as pollution remediation and sustainability or case studies on surveying, remote sensing, and GIS or case studies on transportation infrastructure.

**Textbooks:**

1. Raja and Fernandes, **Reverse Engineering: An Industrial Perspective**, Springer-Verlag, 2008.
2. W.F. Chen, J.Y. Richard Liew, **The Civil Engineering Handbook**, CRC Press, 2003.

**References:**

1. NA

## 3.30 CE 401: Design of Steel Structures

**Course Code: CE 401**

**Course Name: Design of Steel Structures**

L-T-P-C: 2-1-0-3
Prerequisite: CE 301- Strength of Materials and Structures
Students intended for: UG
Elective or Core: Discipline Core
Approval: 9th Senate

**Course contents**

- **Design of connections**

  Rivet, bolt and welding [5 Lectures]

- **Tension and Compression member**

  load calculation and design [5 Lectures]

- **Module III**

  Design of members subjected to Unsymmetrical Bending [5 Lectures]

- **Module IV**

  Design of Plate Girder. [5 Lectures]

- **Module V** Design of Base-plate and Anchor [5 Lectures]

- **Module VI**

  Design of Composite beams and Slabs [5 Lectures]

- **Module VII**

  Plastic analysis and design of continuous beam and simple frame . [5 Lectures]

- **Module VIII**

  Design of a multi-storey building and industrial shed. [5 Lectures]

- **Module IX**

  An overview of design for fatigue. [5 Lectures]

**Text Books**

1. N. Subramanian **Design of steel structures**, Oxford University Press, 2008.
2. S. K. Duggal, **Limit state design of steel structures**, McGraw Hill Education, 2014.

**Reference Books**

1. C.G. Salmon, J.E. Johnson, and F.A. Malhas, **Steel structures: design and behavior: emphasizing load and resistance factor design**, 5th Edition, Pearson, 2008.
2. Trahair, N.S., M. A. Bradford, D. Nethercot and L. Gardner., **The behavior and design of steel structures to EC3**, Taylor and Francis, 2008.
3. A. Nussbaumer, L. , Borges and L. Davaine, **Fatigue Design of Steel and Composite Structures**, John Wiley & Sons, 2011.

## 3.31 CE 402: Geotechnical Engineering II

**Course Code: CE 402**

**Course Name: Geotechnical Engineering II**

L-T-P-C: 2-1-0-3
Prerequisite: CE302: Geotechnical Engineering – I or equivalent
Students intended for: B. Tech 3rd or 4th Year
Elective or Core: Discipline Elective
Approval: 15th Senate

**Course content**

- **Subsoil Exploration**

  Methods of subsoil exploration Direct, semi direct and indirect methods, Soundings by Standard, Dynamic cone and static cone penetration tests, Types of boring, Types of sample; Criteria for undistributed samples, Transport and preservation of sample, planning of exploration programmes, report writing. [8 Lectures]

- **Earth Pressure**

  Types of Earth pressure, Rankines and Coulumb's Active and Passive earth pressure in soils, concedpts for slope stability and soil retaining wall design. [6 Lectures]

- **Bearing Capacity**

  Safe bearing capacity and allowable bearing pressure, General and local shear failure conditions, Terzaghi's bearing capacity equations its modifications for square, rectrangular and circular foundation, Factors affecting bearing capacity of soil. [6 Lectures]

- **Design of Shallow Foundations**

  Factors effecting locationxs of foundation and design considerations of shallow foundations, choice of type of foundations, Foundations of expansive soils. [6 Lectures]

- **Settlement Analysis**

  Causes of settlement, computation of settlement, immediate and consolidation settlement,m allowable settlements, Measures to reduce settlement. [4 Lectures]

- **Pile Foundations**

  Types, Construction, load carrying capacity of single pile – Dynamic formu,a, Static formula, Pile load tests, Load carrying capacity of pile groups, settlement of pile groups, Native skin friction. [12 Lectures]

**Text Books**


1. Braja M. Das, **Principles of Foundation Engineering**, Cengage Learning, 2015.
2. V. N. S. Murty, **Geotechnical Engineering**, Book World Enterprises, 2008.


**Reference Books**


1. W. C. Teng, **Foundation Design**, Printice Hall Publishers, 1962.
2. J. E. Bowles, **Foundation Analysis and Design**, Tata McGrawhill Publishers, 1997.
3. Shamsher Prakash, Gopal Ranjan and Swami Saran, **Analysis, Design of Foundations and Earth retaining structures**, IBH Publishers, 1979.


## 3.32 CE 403: Wastewater Engineering

**Course Code: CE 403**

**Course Name: Wastewater Engineering**

L-T-P-C: 3-0-0-3
Prerequisite: IC 230

Approval: 36th BoA

**Course contents**

- **Planning and hydraulic design of sewerage system**

  Population forecasting of town, equivalent sewage flow estimation, onsite, decentralized and centralized systems, Sewer pipelines and the materials, sewers hydraulics, Storm drainage, Storm runoff estimation, sewer appurtenances, corrosion in sewers its prevention and control, sewage pumping, drainage in buildings, plumbing systems for drainage, wastewater Collection System, Instrumentation and automation techniques. [8 Lectures]

- **Primary treatment Processes**

  Unit Operations and Processes, Selection of treatment processes, Onsite sanitation, Septic tank, Grey water harvesting ,Primary treatment ,Principles, functions and design of sewage treatment units ,screens ,grit chamber, primary sedimentation tanks ,Construction, Operation and Maintenance aspects. [8 Lectures]

- **Secondary treatment Processes**

  Selection of Treatment Methods, Hydraulic Principles, Functions Activated Sludge Process and Extended aeration systems, Trickling filters and their design, Sequencing Batch Reactor(SBR), Membrane Bioreactor (MBR), Waste Stabilization Ponds, Reclamation and Reuse of sewage, Recent Advances in Sewage Treatment ,Construction, Operation and Maintenance aspects. [10 Lectures]

- **Sewage Disposal, Recycle and Reuse**

  Standards for Disposal Methods, dilution, Mass balance principle, Selfpurification of river, Oxygen sag curve, deoxygenation and reaeration, Dissolved oxygen Modelling, Land disposal, Agriculture uses of treated Sewage, Cycle of emerging organic contaminant and their effects on human health, sodium hazards, Soil dispersion system. [10 Lectures]

- **Sludge and Solid Waste Management**

  Sludge characterization, Thickening, Design of gravity thickener, Sludge digestion, Standard rate and High rate digester design, Biogas recovery, Sludge Conditioning and Dewatering, Sludge drying beds, ultimate residue disposal. [6 Lectures]

**Text Books**

1. Metcalf, L., Eddy, H. P., and Tchobanoglous, G., **Wastewater engineering: treatment, disposal, and reuse (Vol. 4)**, McGraw-Hill, 1979.

2. Karia, G. L., and Christian, R. A., **Wastewater treatment: Concepts and design approach**, PHI Learning Pvt. Ltd., 2013.

3. Duggal K.N., **Elements of Environmental Engineering**, S. Chand and Co. Ltd., 2014.

4. Mackenzie L. Davis, **Water and Wastewater Engineering: Design Principles and Practice**, McGraw-Hill Education, 2010.

**Reference Books**


1. Metcalf, Leonard, Harrison P. Eddy, and Georg Tchobanoglous, **Waste water engineering: treatment, disposal, and reuse**, McGraw-Hill, 1979.

2. Garg, S.K, **Environmental Engineering Vol. II**, Publishers, 2015.

3. **Journal of Water Processing Engineering-Elsevier**

4. **Journal of Environmental Engineering-ASCE**


## 3.33 CE 404: Analysis of Structures

**Course Code: CE 404**

**Course Name: Analysis of Structures**

L-T-P-C: 3-0-0-3
Intended for: UG Civil Engineeering
Prerequisite : CE 301: Strength of Materials and Structures/Equivalent
Mutual Exclusion: None
Approval: 52nd BoA

**Course Contents**

- **Introduction:** Statically determinate vs statically indeterminate structures, Degrees of static and kinematic indeterminacy, Review on the methods of analysis of determinate structures. (3 Lectures)

- **Energy methods of structural analysis:** Basic concept, Energy relations with structural theory, Virtual work and its application, Energy principles based on displacement and force fields. (5 Lectures)

- **Analysis using force method:** Analysis of indeterminate beams and frames, Law of reciprocal deflections, Theorem of least work, Reactions due to yielding of supports, Analysis of indeterminate trusses using force method. (6 Lectures)

- **Analysis using the displacement method:** Slope-deflection method: Analysis of continuous beams, analysis of rigid frames with and without side sway; Moment distribution method: Analysis of indeterminate beams subjected to loads and uneven settlement of supports, analysis of rigid frames with and without side sway. (8 Lectures)

- **Three-moment theorem:** Derivation and application for analysis of continuous beams subjected to loads and supports settlement. (4 Lectures)

- **Arches:** Introduction, Basic mechanics, Three hinged arch, Two hinged arch, Tied arch and bowstring girder, Analysis of cables and suspension bridges. (5 Lectures)

- **Approximate analysis of statically indeterminate structures:** Analysis of trusses, Gravity loaded building frames, Portal and cantilever methods for laterally loaded building frames. (4 Lectures)

- **Moving load and Influence lines:** Introduction to the methodology and application to indeterminate structures. (2 Lectures)
- **Advanced concepts:** Brief introduction to matrix stifTness method of structural analysis and exposure to relevant software's, Basic introduction to plastic analysis: plastic hinge, shape factor, collapse mechanism, Methods of analysis: static and kinematic. (5 Lectures)

**Text books:**

1. Hibbeler, RC, **Structural Analysis**, 9th edition, Pearson Education, 2017.
2. Reddy, C.S., **Basic Structural Analysis**, Tata McGraw Hill, 2001.

**References:**

1. Wang, C.K., **Intermediate Stmctural Analysis**, Tata McGraw Hill, New Delhi, 20 l 0.
2. Ghali, A., and Neville, A.M., **Structural Analysis: A Unitied Classical and Matrix Approach**, 7th Edition, CRC Press, 2017.
3. Negi, LS,and Jangid, R.S., **Structural Analysis**, Tata Mc Graw Hill, 1997.
4. Gupta, S. P., Gupta, R, and Pandit, GS, **Theory of Structures**, Tata McGraw-Hill, 1999.
5. Menon, D, **Advanced Structural Analysis**, Narosa Publishing House, 2015.
6. Kassimali, A., **Structural Analysis**, 6th Edition, Cengage Learning, 2018.

## 3.34 CE 405: Water and Wastewater Engineering

**Course Code: CE 405**

**Course Name: Water and Wastewater Engineering**

L-T-P-C: 3-0-0-3
Intended for: UG / M. Tech. /MS
Prerequisite : Environmental Science (IC 230) or equivalent
Mutual Exclusion: None
Approval: 52nd BoA

**Course Contents**

- **Planning and hydraulic design of water and sewerage system**: Population forecasting, equivalent sewage flow estimation, sewer pipelines and materials, sewer hydraulics, stormwater drainage, storm runoff estimation, sewer appurtenances, sewage ptm1ping. (12 Lectures)
- **Water treatment processes**: Theory and application of water treatment process - aeration, coagulation, flocculation, sedimentation, filtratiori, and disinfection. (6 Lectures)

- **Wastewater treatment processes**: Unit operations and processes, selection of treatment processes, onsite sanitation, septic tank, grey water harvesting, primary treatment, screens, grit chamber, primary sedimentation tanks, construction, operation andmaintenance aspects. (8 Lectures)
- **Secondary treatment processes**: Selection of treatment methods, hydraulic principles, activated sludge process and extended aeration systems, trickling filters and their design, sequencing batch reactor (SBR), membrane bioreactor (MBR), waste stabilization ponds, construction, operation and maintenance aspects. (10 Lectures)
- **Sewage Disposal and sludge management:** Standards for disposal methods, dilution, mass balance principle, self-purification of river, oxygen sag curve, deoxygenation and reaeration, dissolved oxygen modelling, reclamation and reuse of sewage, land disposal. agricultural uses of treated sewage, sludge characterization and sludge disposal methods. (6 Lectures)

**Text Books:**

1. Mackenzie L. Davis, **Water and Wastewater Engineering: Design Principles and Practice**, McGraw-Hill Education, 2010.
2. Peavy, H.S., Rowe, D.R., Tchobanoglous, G., **Environmental Engineering**, McGraw-Hill Education, 2013

**References:**

1. Metcalf, L., Eddy, H. P., & Tchobanoglous, G., **Wastewater engineering: treatment, disposal, and reuse** (Vol. 4 ), McGraw-Hill, 1979.
2. Karia. G. L., Christian, R. A., **Wastewater treatment: Concepts and design approach**, PHI Learning Pvt. Ltd., 2013.

## 3.35 CE 451 : Irrigation Engineering and Hydraulic Structures

**Course Code : CE 451**

**Course Name : Irrigation Engineering and Hydraulic Structures**

L-T-P-C : 3-0-0-3
Intended for : B.Tech. (Civil Engineering)
Prerequisite : CE 303
Mutual Exclusion: None
Approval: 52nd BoA

**Course Contents**

1. **Crop water requirement:** Scope of irrigation engineering, Irrigation requirements in India, Soil moisture and plant growth, Crop water requirement, Evapotranspiration, Duty, Delta, irrigation scheduling, methods and efficiency, irrigation water quality. (6 Lectures)

2. **Design of Irrigation:** Channel Alignment; canal capacity; losses; FSL of the canal; design of canal in alluvial soil and nonalluvial soils; Kennedy's silt theory; Lacey's regime theory; balancing depth; use of Garrets diagrams and Lacey's Regime diagrams; the lining of irrigation channels; design of lined canal drainage behind lining; Water logging: Causes, Measures: surface and sub-surface drains, land reclamation. (8 Lectures)

3. **Diversion head works:** Introduction; the layout of diversion headwork and its component; Selection of site, Khosla's theory and concept of flow net; safe exit gradient; hydraulic design of weir on Bligh's theory; and design of modern barrage on Khosla's theory; Necessity & ftmctioning of silt excluder & silt extractor. (8 Lectures)

4. **Cross drainage structures:** Types; selection of the suitable type of Cross drainage works; aqueduct and Syphon aqueduct; determination of maximum flood discharge and waterway for drain, fluming of the canal; uplift pressure on the underside of barrel roof and at the floor of the culvert; design of bank connections. (6 Lectures)

5. **Reservoir and planning of dam reservoirs:** Types of dams; selection of the type of dam; capacity elevation and area elevation curves; design of reservoir capacity; Rule curves and operating tables; sedimentation of the reservoir; Gravity dams: modes of failure, stability analysis, construction, joints; Earthen dams: types, modes of failure, design criteria, seepage analysis, and control. (8 Lectures)

6. **Spillway energy dissipators and Spillway gates:** Location of a Spillway; design criteria; controlled and uncontrolled Spillways; Ogee, Chute, Side Channel, Shaft, Syphon Spillways; Energy dissipation; Stilling + basins; Crest gates. (6 Lectures)

**Text Books:**


1. S.K. Garg, **Irrigation Engineering and Hydraulic Structures**, Khanna Publications.

2. B.C. Punmia, **Irrigation and Water Power Engineering**, Laxmi Publication.


**References:**


1. Viessmen, Jr. & Lewis, **Introduction to Hydrology**, PHI Learning Private Ltd.

2. Larry W. Mays, **Water Resources Engineering**, Wiley Publications.


## 3.36 CE 501: Remote Sensing

**Course Code: CE 501**

**Course Name: Remote Sensing**

L-T-P-C: 2-0-2-3
Prerequisite: –
Students intended for: UG 4th year/PG
Elective or Core: Elective

Approval: 8th Senate

**Course content**

- **Module I**

  Introduction, principles and types of remote sensing Energy source and radiation principle.

  Interaction of EMR (electromagnetic radiation) with atmosphere- absorption, scattering, Atmospheric windows, Interaction of EMR with Earth Surface-Spectral reflectance curves[5 Lectures]

- **Module II**

  Platforms and Sensors: Geostationary and sun-synchronous orbits, Active and passive sensors, Spectral, spatial, temporal and radiometric resolutions.

  Salient features of LANDSAT, SPOT, IRS satellites. [5 Lectures]

- **Module III**

  Elements of Image interpretation, Visual analysis of data in VNIR (Visible and Infra-red).

  Image formats, data histogram and image info. [4 Lectures]

- **Module IV**

  Digital Image processing: atmospheric, radiometric & geometric corrections.

  Image enhancement, contrast stretching-linear and non-linear, filtering, image ratios or indices, image transformations- PCA (principal component analysis) [6 Lectures]

- **Module V**

  Classification: Supervised and Unsupervised Classification

  Accuracy assessment and Kappa statistics [5 Lectures]

- **Module VI**

  Application of digital image processing to various problems. [3 Lectures]

**Text/Reference Books**


1. J. R. Jensen, **Remote Sensing of the Environment an Earth Resource Perspective**, Pearson Education, 2003.

2. T.M. Lillesand and R.W. Kiefer, **Remote Sensing and Image Interpretation**, 6th Edition, John Wiley & Sons, 1994.

3. J.B. Campbell, **Introduction to Remote Sensing**, Taylor & Francis, London, 1996.

4. F.F. Sabins, **Remote Sensing: Principles and Interpretation**, W.H. Freeman and Company, 1997.

5. J. R. Jensen, **Introductory Digital Image Processing**, 3rd Edition, Prentice Hall, 2006.

6. G. Joseph, **Fundamentals of Remote Sensing**, Universities Press, 2003.

7. A.K. Keshari, **Satellite Remote Sensing**, Wiley, 2015.

## 3.37 CE 502: Groundwater Flow and Contaminant Transport

**Course Code: CE 502**

**Course Name: Groundwater Flow and Contaminant Transport**

L-T-P-C: 3-0-0-3
Prerequisite: Water Resources Engineering, Programming knowledge, Faculty Approval
Students intended for: UG/PG
Elective or Core: Elective
Approval: 9th Senate

**Course content**

- **Introduction**

  Hydrologic cycle, Subsurface flow and basics, Darcy's law, emphasizing the role of groundwater in the hydrologic cycle, different types of aquifer and flow properties, types and sources of contamination. [2 Lectures]

- **Flow through Porous Medium**

  Flow through filters and soil columns, fractured rock and stratified porous medium, Well Hydraulics. [2 Lectures]

- **Groundwater Flow**

  Hydraulic Potential, the Steady-state Groundwater flow equation, derivations of flow equations for homogeneous and heterogeneous porous medium, application of Darcy's law, Flow Modelling. [4 Lectures]

- **Contaminant Transport**

  Groundwater Pollution, Advection and Dispersion, Sorption and Diffusive Mass Transfer, Aquifer Remediation, contaminant transport model in homogeneous and heterogeneous porous medium, Flow parameters identification and estimation. [6 Lectures]

- **Groundwater Flow and Transport modeling**

  Analytical and Numerical methods, solution of flow equation and ADE, MIM, MPNE. [6 Lectures]

- **Field application of Transport equations**

  Use of numerical model for simulation experimental data and prediction spreading of contaminant at field scale. [6 Lectures]

**Groundwater Lab**

1. Experiments for reactive and nonreactive solute transport through porous media
2. Estimation of equilibrium sorption coefficients of various reactive solutes using linear and nonlinear isotherms
3. Inverse problem for source identification
4. Rainfall runoff simulation for surface and groundwater interaction

**Text Books**

1. Zheng, Chunmiao, and Gordon D. Bennett, **Applied contaminant transport modeling**, Vol. 2, Wiley-Interscience, 2002.
2. Yong, Raymond Nen, Abdel-Mohsen Onsy Mohamed, and Benno P. Warkentin, **Principles of contaminant transport in soils**, Elsevier Science Publishers, 1992.
3. odd, David K., and Larry W. Mays, **Groundwater hydrology edition**, Wiley, New Jersey, 2005.
4. Freeze, R. Allan, John ARA Cherry, and Cherry JA, **Groundwater**, No. 556.3 FRE. 1979.

**Reference Books:**

1. Bear, Jacob, Chin-Fu Tsang, and Ghislain De Marsily, **Flow and contaminant transport in fractured rock**, Academic Press, 2012.
2. Grathwohl, Peter, **Diffusion in natural porous media**, Academic Press, 2012Kluwer, 2002.
3. Dagan, Gedeon, **Flow and transport in porous formations**, Springer-Verlag GmbH & Co. KG., 1989.

## 3.38 CE 503: Fundamentals of Project Management

**Course Code: CE 503**

**Course Name: Fundamentals of Project Management**

L-T-P-C: 3-0-0-3
Prerequisite: None
Students intended for: UG/PG
Elective or Core: Elective
Approval: 9th Senate

**Course content**

- **Introduction**

  Project definition, Constraints and Scope triangle, Project environment, Classification of projects, Conception, Selection, Life cycle, Project management – necessity and processes, Systems approach, Project manager – knowledge areas and role, Project team, Planning – principles, objectives, steps and advantages, Work breakdown structure, Scheduling - Bar charts, Milestone charts, Networks. Project control and evaluation. [8 Lectures]

- **Scheduling by network analysis**

  (i) Programme Evaluation and Review Technique (PERT): Time estimates for activities, Computation of event times, Network analysis – Slack and critical path. (ii) Critical Path Method (CPM): Computation of event and activity times, Network analysis – Float and critical path. [6 Lectures]

- **Time-Cost optimization**

  Crashing a network. Updating a project: Data required and implementation. Resource allocation: Resource usage profiles, Smoothing and Levelling of resources. [4 Lectures]

- **Quality management**

  Policy, Assurance, Management systems, Control, Plan, Audit, Reviews, Statistical methods for quality control – Shewhart, Cusum and EWMA control charts, Process capability analysis, Factorial experiments and Acceptance sampling. [10 Lectures]

- **Management science techniques**

  Linear and integer programming, Distribution and network models – transportation, assignment, transshipment and shortest route problems. Non-linear optimization, Time series analysis and forecasting. [14 Lectures]

**Text Books**

1. B.C.Punmia and K.K.Khandelwal, **Project planning and control with PERT and CPM**, Laxmi Publications, 2006.

2. E. L. Grant and R. S. Leavenworth, **Statistical quality control**, 7th Edition, TMH, 2000.

3. D. R. Anderson, D. J. Sweeney, T. A. Williams, J. D. Camm and Kipp Martin, **An introduction to management science**, 13th Edition, South-Western, 2012.

4. Hamdy A. Taha, **Operations Research – an introduction**, Pearson. 2014.

5. J. M. Nicholas and Herman Steyn, **Project management for engineering, buisness and technology**, 4th Edition, Routledge, 2012.

**Reference Books:**

1. James P. Lewis, **Fundamentals of project management**, 3rd Edition, AMACOM, 2007.

2. Albert Lester, **Project management, planning and control**, Elsevier, 2014.

3. D. C. Montgomery, **Introduction to statistical quality control**, 6th Edition, Wiley, 2009.

4. J. A. Lawrence, Jr. and B. A. Pasternack, **Applied management science**, Wiley, 2002.

5. J. D. West and F. K. Levy, **A management guide to PERT/CPM with GERT/PDM/DCPM**, 1979.

## 3.39 CE 504: Slope Stability and Retaining Structures

**Course Code: CE 504**

**Course Name: Slope Stability and Retaining Structures**

L-T-P-C: 2-1-0-3
Prerequisite: CE 302 - Geotechnical Engineering
Students intended for: UG/PG
Elective or Core: Elective
Approval: 9th Senate

**Course content**

- **Module I**

  Earth pressure, Rankine and Coloumb Earth Pressure theory, stresses and pressures for different conditions, [7 Lectures]

- **Module II**

  Slope stability, types of slopes, theories of slope stability, seepage effects, theory of infinite slope stability, stabilisation methods. [12 Lectures]

- **Module III**

  Design of retaining structures: gravity, cantilever, semi-gravity. [8 Lectures]

- **Module IV**

  Soil reinforcement, earth retaining structures, design and analysis. [8 Lectures]

- **Module V**

  Lateral earth pressure in braced cuts, Design of various components, Stability of braced cuts, base heave and stability, yielding and settlement of ground surrounding excavation. Diaphragm walls, slurry support; Soil Nailing. [7 Lectures]

**Text Books**

1. B. M. Das, **Principles of Foundation Engineering**, Cengage learning, 2011.
2. J. E. Bowles, **Foundation Analysis & Design**, 7McGraw-Hill Higher Education, 2001.
3. V. N. S. Murty, **Geotechnical Engineering**, CRC press, 2002.

**Reference Books:**

1. S Hansbo, **Geotechnical Engineering**, Elsevier, 1994.
2. Hsai-Yang Fang, **Foundation engineering handbook**, Springer Science, 1991.

## 3.40 CE 505: Engineering of Ground Modification

**Course Code: CE 505**

**Course Name: Engineering of Ground Modification**

L-T-P-C: 3-0-0-3
Prerequisite: CE 302 - Geotechnical Engineering
Students intended for: UG/PG
Elective or Core: Discipline Core
Approval: 9th Senate

**Course contents**

- **Introduction to Engineering Ground Modification**

  Need and objectives, Identification of soil types, In-situ and laboratory tests to characterize problematic soils; Mechanical, Hydraulic, Physico-chemical, Electrical, Thermal methods and their applications. [8 Lectures]

- **Module II**

  Mechanical Modification – Principles of soil densification – Properties of Compacted soil, Compaction control tests, Specification of compaction requirements, Blasting Vibrocompaction, Dynamic Tamping and Compaction piles. [8 Lectures]

  Hydraulic Modification – Objectives and techniques, traditional dewatering methods and their choice, Design of dewatering system, Electro-osmosis, Filtration, Drainage and seepage control with Geosynthetics, Preloading and vertical drains, Electro-kinetic dewatering. [8 Lectures]

- **Module III**

  Physical and Chemical Modification – Modification by admixtures, Shotcreting and GunitingTechnology, Modification at depth by grouting, Crack Grouting and compaction grouting, Jet grouting, Thermal Modification, Ground freezing. [9 Lectures]

- **Module IV**

  Modification by Inclusions and Confinement - Soil reinforcement, underpinning, Insitu ground reinforcement, ground anchors, rock bolting and soil nailing, sand bags, crib walls, bin walls, gabion walls. [7 Lectures]

- **Module V**

  Introduction to geosynthetics – Applications. [3 Lectures]

**Text Books**

1. Peter G. Nicholson, **Soil Imprvement and ground modifications methods**, Elsevier, 2015.
2. P. Purushothama Raj, **Ground improvement Techniques**, Laxmi Publications, 2005.
3. Hausmann, M. R., **Engineering Principles of Ground Modifications**, McGraw Hill publications, 1990.

**Reference Books:**

1. John A. Hudson, **Ground Improvement Case Histories**, Elsevier, 2005.
2. C. A. Raison, **Ground and Soil Improvement**,ICE publications, 2004.

## 3.41 CE 506: Analysis of Indeterminate Structures

**Course Code: CE 506**

**Course Name: Analysis of Indeterminate Structures**

L-T-P-C: 3-0-0-3
Prerequisite: CE 301 - Strength of Materials and Structures
Students intended for: UG
Elective or Core: Elective
Approval: 9th Senate

**Course contents**

- **Introduction**

  Statically determinate vs. statically indeterminate structures, Determining degrees of static and kinematic indeterminacy, Methods of analysis. [3 Lectures]

- **Moment distribution method**

  Analysis of indeterminate beams subjected to loads and uneven settlement of supports, analysis of rigid frames with and without side sway. [6 Lectures]

- **Three-moment theorem**

  Derivation and application for analysis of continuous beams subjected to loads and uneven settlement of supports. [6 Lectures]

- **Module IV**

  Kani's method and column analogy method for frames with and without sway. [6 Lectures]

- **Analysis using Force methods**

  Analysis of indeterminate beams and frames, law of reciprocal deflections, theorem of least work, Analysis of indeterminate trusses considering reactions and/or member forces as redundant, reactions due to yielding of supports. [6 Lectures]

- **Approximate analysis of statically indeterminate structures**

  Analysis of trusses, vertically loaded building frames, Portal and Cantilever methods for laterally loaded building frames. [6 Lectures]

- **Introduction to matrix methods for structural analysis**

  Flexibility and stiffness matrices, analysis of continuous beams, rigid and pin jointed frames. [9 Lectures]

**Text Books**


1. C.S.Reddy, **Basic Structural Analysis**, Tata McGraw Hill, New Delhi, 2001.

2. C.K. Wang, **Intermediate Structural Analysis**, Tata McGraw Hill, New Delhi, 2010.

3. DR.C. Hibbeler, **Structural Analysis**, 6th Edition, Pearson Education, 2009.

4. Ghali, A., Neville, A.M. and Brown, T.G., **Structural analysis: a unified classical and matrix approach**, Spon press, USA and Canada, 2003.

5. C.H. Norris, J.B. Wilbur, S.Utku, **Elementary Structural Analysis**, Tata McGraw Hill, 2003.

6. L. S. Negi and R. S. Jangjid, **Structural Analysis**, Tata Mc. Graw, New Delhi, 1997.

7. Pandit G S and Gupta S P, **Structural Analysis: a matrix approach**, Tata McGraw Hill, New Delhi, 2001.

8. Natrajan, C. and Revathi, P, **Matrix methods of Structural Analysis: Theory and Problems**, PHI, New Delhi, 2014.


**Reference Books:**


1. Mau, S.T., **Introduction to structural analysis: Displacement and force methods**, CRC press, FL, 2012.

2. AWeaver, W. Jr. and Gere, J.M., **Matrix analysis of framed structures**, Springer, 2012.

3. Ranzi, G. and Raymond, I.B., **Structural analysis: principles, methods and modelling**, CRC press, FL, 2014.

## 3.42 CE 507: Advanced Concrete Science

### Course Code: CE 507

### Course Name: Advanced Concrete Science

L-T-P-C: 3-0-0-3
Prerequisite: CE 552 - Concrete Technology
Students intended for: UG/PG
Elective or Core: Elective
Approval: 9th Senate

### Course contents

- **Module I**

  Mix design methods for ordinary and high performance concretes [6 Lectures]

- **Module II**

  Performance in fresh and hardened states – Rheology, Stress-Strain characteristics, Creep and Shrinkage. [6 Lectures]

- **Pore structure of cement based materials**

  Types and genesis of pores, Methods of measurement. [4 Lectures]

- **Transport processes in concrete**

  Mechanisms of Water, Gas and Salt transport; Transport models; Tests for the assessment of transport characteristics. [6 Lectures]

- **Degradation mechanisms**

  Carbonation, Sulphate attack, Freeze-Thaw, Alkali-Silica reaction. [6 Lectures]

- **Reinforcement corrosion**

  Mechanisms of initiation and propagation, Electrochemical aspects, Monitoring, controlling and prevention, service-life prediction. [6 Lectures]

- **Design for Durability**

  Service-life, Prescriptive, Performance and Model-based approaches. [6 Lectures]

### Text Books

1. Aligizaki, K. K., **Pore structure of cement-based materials: testing, interpretation and requirements**, Taylor & Francis, New York, 2005.

2. Richardson, M., **Fundamentals of durable reinforced concrete**, Spon Press, London and New York, 2003.

3. Hall, C. and Hoff, W.D., **Water transport in brick, stone and concrete**, CRC Press, Florida, 2011.

**Reference Books:**


1. Sarja, A. and Vesikari, E., **Durability design of concrete structures-Report of RILEM technical committee 130-CSL**, E&FN Spon, London, 2004.

2. Cerny, R. and Rovnanikova, P., **Transport processes in concrete**, Spon Press, USA and Canada, 2002.

3. Claisse, P.A., **Transport properties of concrete: measurement and applications**, Woodhead Publishing, UK, 2014.

4. Bertolini, L., Elsener, B., Pedeferri, P., Redaelli, E. and Polder, R.B., **Corrosion of steel in concrete: prevention, diagnosis, repair**, Wiley-VCH Verlag GmbH & Co. KGaA, Germany, 2013.

5. J. D. West and F. K. Levy, **A management guide to PERT/CPM with GERT/PDM/DCPM**, 1979.


## 3.43 CE 508: Photogeology and Photogrammetry

**Course Code: CE 508**

**Course Name: Photogeology and Photogrammetry**

L-T-P-C: 2-0-2-3
Prerequisite: None
Students intended for: B.Tech. 3rd year/M.S./M.Tech./Ph.D.
Elective or Core: Elective
Approval: 9th Senate

**Course content**

- **Module I**

  Basic concepts of Geomorphology, Overview of landscape evolution models, Cycle of erosion, Mountains and relief, river basin, drainage network & types [4 Lectures]

- **Geomorphic landforms, erosional & depositional**

  Fluvial, Glacial, Aeolian, Coastal and Karst landforms. [6 Lectures]

- **Module III** Overview of Indian geomorphology. [2 Lectures]

- **Module IV**

  Photogrammetry introduction, types of aerial photograph, Geometry, Scale and resolution its applications. [5 Lectures]

- **Module V**

  Principles of stereoscopy, lens and mirror stereoscopes, image parallax, relief displacement, vertical exaggeration, distortion. Measurement of relief displacement and estimation of height of an object. [10 Lectures]

- **Airphoto interpretation & mapping**

  Identification of various rock types and landforms. Delineation and mapping of various geomorphic features (Fluvial, Glacial, Aeolian, Coastal), rock types (Igneous, Sedimentary and Unconsolidated sediments) and structural features (Fold, Faults, Joints, Lineaments, Synclines & Anticlines). [12 Lectures]

- **Module VII**

  Introduction to satellite image processing, geoinformatics, DEM. [3 Lectures]

**Text Books**


1. A L. Bloom, **Geomorphology: A, systematic Analysis of Late Cenozoic Landforms**, 3rd Edition, Pearson Education, Inc., USA, 2004.

2. V S. Kale, and A. Gupta, **Introduction to Geomorphology**, Orient Longman Ltd., India, 2001.

3. Victor, C. Miller, **Photogeology**, McGraw Hill Book Co., New York, 1961.

4. P R. Wolf and B A. Dewitt, **Elements of Photogrammetry: With Applications in GIS**, McGraw Hill Science, New York, 2014.

5. T.M. Lillesand and R.W. Kiefer, **Remote Sensing and Image Interpretation**, 6th Edition, John Wiley & Sons, New York, 2007.


**Reference Books:**


1. J R. Jensen, **Remote Sensing of the Environment an Earth Resource Perspective**, Pearson Education. Delhi, 2003.

2. Julien, P.Y., **River Mechanics**, Cambridge University Press, USA, 2002.

3. G R Davis, SR Reynolds, CF Kluth, **Structural Geology of Rocks and Region**, 3rd Edition, John Wiley, USA, 2012.

4. M P. Billings, **Structural Geology**, 4th Edition, Prentice-Hall, New York, 1987.


## 3.44 CE 509: Bridge Engineering

### Course Code: CE 509

### Course Name: Bridge Engineering

L-T-P-C: 3-0-0-3
Prerequisite: CE 301 and CE 351
Students intended for: B.Tech. 3rd/4th year/PG
Elective or Core: Elective
Approval: 15th Senate

**Course contents**

- **Introduction**

  Imponan ce of bridges; Historical development and classification of bridge types; Various structural fonns; Materials in bridge construction; Consideration for site selection; Detennination of design discharge; binear waterways and economical span; High flood level (HFL) and vertical clearance; Traffic projection. [4 Lectures]

- **Design Loads**

  Consideration of various forces and their application as per IRC specifications for loadings on road bridges. [3 Lectures]

- **Structural Behavior and Concepts for Analysis**

  Moving load anal ysis; Grillage analogy; Structural behavior of box-girder bridges, arch bridges, suspension bridges, and cable stayed bridges. [8 Lectures]

- **Design of Bridge Superstmcture**

  Analysis and design of reinforced concrete slab bridge deck; Design considerations for skewed slab decks; Pretensioning and post-tensioning; Analysis and design of pre-stressed concrete slab deck ; Introduction to T-beam bridges; Approximate methods for analysis of T-beam bridges: Courbon's method; Illustrative examples. [17 Lectures]

- **Bridge Bearings and Joints**

  Importance and types of bearin gs; Design of elastomeric bearings: Seismic considerations for bearing design; Provisions for expansion joints. [5 Lectures]

- **Bridge Substructure**

  Components of substructure; Computation of different forces acting on substructure; Introduction to various bridge foundation types. [3 Lectures]

- **Construction and Maintenance**

  Common bridge construction techniques; overview of segmental construction for long span bridges; Primary [2 Lectures]

**Text Books**

1. D.J. Victor, **Essentials of Bridge Engineering**, 6th Edition, Oxford and ffiH Publ ishing, New Delhi, India, 2007

2. N.K. Raju, **Design of Bridges**, 4th Edition, Oxford and TBH Publi shing, New Delhi, 2009.

**Reference Books:**

1. E.C. Hambly, **Bridge Deck Behaviour**, 2nd Edition, CRC Press, Taylor and Francis Group, New York, USA, 1991.

2. IRC-112 (20 II), Code of Practice for Concrete Road Bridges , Indian Roads Congress, New Delhi, India.

3. IRC-6 (20 I 4), Standard Specifications and Code of Practice for Road Bridges, Section: II - Loads and Stresses , Indian Roads Congress, NeĎelhi , India.

4. N. Rajagopalan, **Bridge Superstructure**, Narosa Publi shing House, New Delhi, India, 2013.

5. S. Ponnuswamy, **Bridge Engineering**, 2nd Edition, Tata McGraw-Hill Education, New Delhi, India, 2007.

6. V.K. Raina, **Rainas Concrete Bridge Practice Analysis, Design & Economics**, 4th Edition, Shroff Publishers and Distributors Pvt. Ltd., Mumbai, India, 2014.

## 3.45 CE 510: Modelling and Simulation in Water Resources Engineering

**Course Code: CE 510**

**Course Name: Modelling and Simulation in Water Resources Engineering**

L-T-P-C: 2-0-2-3
Prerequisite: CE 303, Water Resources Engineering
Students intended for: B.Tech. 3rd/4th year/PG
Elective or Core: Elective
Approval: 15th Senate

**Course content**

- **Introduction**

  Principles of simulation, nature and role of simulation in water resources engineering. Systems, models and simulation, Classification of simulation models: discrete and continuous simu lation models, black box models, conceptual models, lump ed and distributed models Steps involved in developing simulation models demonstrated through simple water balance model - model identification, parameter estimation - least square method for hydrologic models, brute force method, calibration and validation. [6 Lectures]

- **Water shed simulation**

  Watershed and delineation; watershed characteristics; Lumped hydrologic model: HyMOD- Model conceptualization, calibration and validation Distributed hydrologic model: Simulation by physically based models - St. Venant equations; HySIM - Model conceptualization, calibration and validation [4 Lectures]

- **Urban run-off models**

  Introduction to urban hydrology; Developing models for deriving IDF curve, runoff calculation and drainage network design; Strom water drainage system simulation using SWMM model including conceptualization, calibration and validation [4 Lectures]

- **Data driven models**

  Black box models in hydrology; Developing artificial neural network based rainfall' runoff models, model calibration and validation [4 Lectures]

- **Reservoir simulation models**

  Reservoir operation policy; Developing models for determination of reservoir storage capacity, reservoir operation- deriving operational rule curves [6 Lectures]

- **Uncertainty analysis**

  Monte Carlo simulation, Perturbation method, bootstrap method, first order uncertainty analysis (FOUA). [4 Lectures]

**Lab Sessions**

- Developing simple water balance model (Calibration- Validation) (4 Hours)
- Calibration of Hymod model parameters (3 Hours)
- Developing models for storm water drainage network (4 Hours)
- Developing ANN models, calibration and validation (4 Hours)
- Developing simulation models to fix reservoir capacity (3 Hours)
- Developing simulation models for deriving rule c urves of rese rvoir (4 Hours)
- Bootstrap methods (3 Hours)
- FOAU and Perturbation methods (3Hours)

**Text Books**


1. Loucks, D.P. and Eelco van Beek , **Water Resources Systems Planning and Management- an introduction to methods, models and applications, Studies and Reports in Hydrology**, UNESCO Pub., 2005.
2. Rajasekaran Pai S, G. A Vijayalakshmi, **Neural Networks, Fuzzy Logic, and Genetic Algorithms: Synthesis and Applications**, PHI Learning, 2004.


**Reference Books:**


1. Yeou-Koung Tung, Ben-Chie Yen, **Reliability and Uncertainty Analyses in Hydraulic Design**, ASCE Publication, 1993.
2. Averill Law, **Simulation modelling and analysis**, 4th Edition, McGraw Hill Education, 2017.
3. The manuals for hydrologic models HySIM, HyMOD and SWMM can be referred and the same will be provided during the tutorial session.
4. Rudra Pradap, **etting Started with Matlab: A Quick Introduction for Scientists and Engineers**, Oxford University Press, 2010.
5. Chow, V.T., Maidment, D.R. and Mays, L.W. **Applied Hydrology**, McGraw Hill International Editions, 1998.

## 3.46 CE 511: Structural Dynamics with Application to Earthquake Engineering

**Course Number : CE 511**

**Course Name: Structural Dynamics with Application to Earthquake Engineering**

L-T-P-C: 3-0-0-3
Prerequisites: Strength of Materials and Structures (CE301) or Equivalent
Intended for: U G (3rd year and 4th year), PG
Distribution: Discipline El ecti ve (UG); Core/Elective (PG)
Approval: 15th Senate

**Course Contents**

- **Introduction**: Overview and importance of structural dynamics; Various types of dynamic loading; Mass excited and base excited systems; Degrees of freedom (DOF); Typical force displacement behavior of stmctural -elements/-systems. [3 Lectures]
- **Single Degree of Freedom (SDOF) Systems**: Dynamic equilibrium equation for SDOF system ; Analysis for undamped free vibration; Damping in structural system; Equation of moti on and analysis for damped SDOF system ; Critically-damped, over-damped and under-damped systems; Estimation of damping by logarithmic decrement method; Classical and non -classical damping; Equivalent viscous damping; Response of undamped and damped SDOF system to harmonic excitation, Half-power band width method for damping evaluation; Response to support motion and force transmission to foundation; Response of SDOF system to periodic, im pulsive, and general dynamic loading; Duhamel's integral. [13 Lectures]
- **Multi Degrees of freedom (MDOF) Systems**: Idea lization of multi-story shear building as MDOF system; Equations of motion for two-story shear building; Natural frequencies of vibration , modes and mode shapes of MDOF system; Orthogonality of modes; Normalization of modes; Classically damped system; Static condensation of DOF for a multi-story building; Dynamic analysis of linear two-DOF system; Dynamic response control of structures, tuned mass damper. [10 Lectures]
- **Systems with Distributed Properties**: Vibration of uniform beam w ith vari ous support conditions; Free vibration analyses; Natural frequencies of vibration and modes; Dynamic response to applied force and support excitation. [4 Lectures]
- **Application to Earthquake Engineering**: Equation of motion wit h ea11hquake excitation; Response quantities of interest and response hi stories; Response spectrum concept; Characteristics of acceleration, velocity and displacement response spectra ; Elastic design spectra; Modal analysis of MDOF systems; Modal superposition method and mode combination rules; Response spectrum analysis of multi-story building; Introduction to response history analysis; Indian Standard code provisions for com putation of and analysis for earthquake loading; Introduction to seismic control of structures; Dynamics ofbase-isolated structures. [12 Lectures]

**Textbooks:**

1. A.K. Chopra, **Dynamics of Structures - Theory and Application to Earthquake Engineering**, 5th Edition, Pearson, 2017.

2. J.L. Humar, **Dynamics of Structures**, 3rd Edition, CRC Press, Taylor and Francis, 2012.

**Reference Books:**

1. E.L. Wilson, **Three-Dimensional Static and Dynamic Analysis of Structures**, 3rd Edition, Computers and Structures, 2002.

2. M. Paz, Leigh W., **Structural Dynamics - Theory and Computation**, 5th Edition, Springer Science+Business Media LLC, 2006.

3. R.W. Clough , J. Penzien, **Dynamics of Structures**, 3rd Edition, Computers and Stmctures, 1995.

4. T.K. Datta, **Seismic Analysis of Structures**, John Wiley & Sons (Asia) Pte Ltd, 2010.

5. IS 1 893 (Part I), **Criteria for Earthquake Resistant Design of Structures: Part I General Provisions and Buildings**, Bureau of Indian Standard, New Delhi , 2016.

## 3.47 CE 512: Advanced Soil Mechanics

**Course Code: CE 512**

**Course Name: Advanced Soil Mechanics**

L-T-P-C: 3-0-0-3
Pre-requisite: CE302 or Equivalent
Intended for: UG and PG
Distribution: Discipline Elective
Approval: 36th BoA

**Course Contents**

- **Steady State Flow through Soil**

  Laplace's Equation of Continuity; Permeability; Flow net, use and method of obtaining flow net; Numerical solution for 2D steady state flow in soil; Examples of 2D and 3D seepage in soil, seepage in anisotropic soil. [8 Hours]

- **Transient Flow in Soil**

  Compressibility and rate of consolidation; Primary, secondary and tertiary consolidation; Consolidation theories: Terzaghi and Biot's formulation, numerical solution of governing consolidation equation; Laboratory consolidation test and its interpretation. [8 Lectures]

- **Strength and Deformation Behavior of Soil**

  Introduction to stress-strain behavior of soils, principal stresses, Mohr diagrams; Shear strength of cohesive and cohesionless soils, various failure criteria, drained and undrained shear strength of soils; Determination of shear strength from various laboratory tests, e.g. direct shear, triaxial, simple shear, true triaxial, hollow cylinder test, interpretation of various triaxial test results, significance of pore pressure parameters; Concept of critical void ratio; Dilation in sands. [11 Lectures]

- **Stress Path Pertaining to Various Loading Conditions**

  Stress path, drained and undrained stress path; Stress path with respect to different initial state of the soil; Stress path for different practical situations. [4 Lectures]

- **Critical State Concept**

  Critical state soil mechanics, concept of soil yielding, critical state parameters; Critical state for normally consolidated and over consolidated soil; Significance of Roscoe and Hvorslev state boundary surface, drained and undrained plane, complete state boundary surface. [11 Lectures]

**Text Books**


1. Muni Budhu, **Soil Mechanics and Foundations**, John Wiley & Sons, 2010.

2. T.W. Lambe and R.V. Whitman, **Soil Mechanics**, John Wiley & Sons, 1991


**Reference Books**


1. Jonathan Knappett and R.F. Craig, **Craig's Soil Mechanics**, CRC Press, 2012.

2. B.M. Das, **Advanced Soil Mechanics**, CRC Press, 2013.

3. James K. Mitchell, Kenichi Soga, **Fundamentals of Soil Behavior**, John Wiley & Sons, 2005.

4. J.H. Atkinson, **The Mechanics of Soils and Foundations**, CRC Press, 2007.

5. Holtz, R. D., and Kovacs, W. D., **An Introduction of Geotechnical Engineering**, Prentice Hall, 1981.

6. Parry, R. H. G., **Mohr Circles, Stress Paths and Geotechnics**, CRC Press, 2004.

7. David Muir Wood, **Soil Behaviour and Critical State Soil Mechanics**, Cambridge University Press, 1991.

8. Andrew Schofield and Peter Wroth, **Critical State Soil Mechanics**, McGraw Hill, 1968.

9. Potts, D.M. and Zdravkovic, L., **Finite Element Analysis in Geotechnical Engineering: Theory**, Thomas Telford, USA, 1999.

## 3.48 CE 513: Advanced Foundation Engineering

### Course Code: CE 513

### Course Name: Advanced Foundation Engineering

L-T-P-C: 3-0-0-3
Pre-requisite: CE402 or Equivalent
Intended for: UG and PG
Distribution: Discipline Elective
Approval: 36th BoA

### Course Contents

- **Bearing Capacity Theories for Shallow Foundation**

  Foundation classification, choice of foundations; Field investigations, soil data and design parameters; Bearing capacity theories, influence of water table, soil compressibility, inclined loading, one-way and two-way eccentricity on the bearing capacity of soil. [4 Hours]

- **Bearing Capacity for Special Cases**

  Bearing capacity for special cases of shallow foundations: foundations resting on layered soil, foundations supported by a soil with rigid base, foundations on sloping ground, closely placed foundations. [4 Lectures]

- **Allowable Bearing Capacity and Settlement of Foundations**

  Vertical stress increase in a soil mass caused by different types of foundation load; Elastic settlement of foundations, settlement of sandy soil: use of strain influence factor and field test data; Consolidation settlement; Allowable bearing capacity from field load test; Rigid and flexible foundations, contact pressure and settlement distribution beneath footings; Construction issues such as dewatering methods and underpinning of shallow foundations; Foundations on difficult soil: collapsible soils, expansive soils, and sanitary landfills. [5 Lectures]

- **Mat Foundations**

  Combined footings, mat/raft foundation; Bearing capacity and settlement of mat foundation; Design of mat foundation: rigid and flexible methods; Buoyancy raft or floating foundation; Skirted foundation. [7 Lectures]

- **Pile Foundations**

  Deep foundations; Load transfer mechanism for pile foundation, estimation of pile capacity, settlement of pile; Small strain and large strain dynamic tests in piles; Pile foundation design subjected to compressive load, uplift, lateral load; Design of pile groups; Pile raft; Concept of negative skin friction; Construction issues related to pile foundation, effect of adjacent constructions on existing pile foundation. [18 Lectures]

- **Other Types of Deep Foundations**

  Well foundations, classification, physical characteristics: shape, size, scour depth, components of well foundations, allowable bearing pressure, forces acting on well foundation and its lateral stability; An introduction to caisson foundation: mechanism, type and construction. [4 Lectures]

**Text Books**

1. B.M. Das, **Principles of Foundation Engineering**, Cengage Learning, 2013.
2. N.N. Som and S.C. Das, **Theory and Practice of Foundation Design**, Prentice-Hall of India Pvt.Ltd, 2004.

**Reference Books**

1. Joseph Bowles, **Foundation Analysis and Design**, McGraw Hill Education, 2017.
2. J.H. Atkinson, **The Mechanics of Soils and Foundations**, CRC Press, 2007.
3. Muni Budhu, **Soil Mechanics and Foundations**, John Wiley & Sons, Inc., 2010.
4. B.M. Das, **Shallow Foundations: Bearing Capacity and Settlement**, CRC Press, 2019.
5. Michael Tomlinson and John Woodward, **Pile Design and Construction Practice**, CRC Press, 2014.

## 3.49 CE 514 : Rock Mechanics

**Course Code: CE 514**

**Course Name : Rock Mechanics**

L-T-P-C : 3-0-0-3
Intended for : UG elective and PG elective
Prerequisite : Geotechnical Engineering (CE 302) or Equivalent
Mutual Exclusion : None
Approval: 45th BoA

**Course Contents:**

- **Module 1:** Introduction to rock engineering, basics of geology for rock engineers, engineering and index properties of intact rocks, demonstration of laboratory techniques, design implication of different properties of intact rocks. [5 hours]
- **Module 2:** Discontinuities in rocks, engineering behaviour and characterization of discontinuities, types and description of discontinuities, orientation and spacing, discontinuity modelling, roughness, aperture, joint stiffness, RQD estimation. [5 hours]
- **Module 3:** Various geological features of rock-mass and their application in rock-mass classification (RMR, RMi, Q, GSI), correlation between different rock-mass classifications, weathering of rock-mass and its classification. [5 hours]

- **Module 4:** Deformability characteristics of jointed rock-mass, different types of moduli, challenges/issues with in-situ deformability measurement, design implications, anisotropy in rock-mass deformability, scale-effect, empirical methods, and equivalent continuum approach. [8 hours]

- **Module 5:** Shear strength characteristics of jointed rock-mass, different rock failure criteria and strength models, anisotropy in strength, scale-effect, empirical methods, equivalent continuum approach. [8 hours]

- **Module 6:** In-situ stresses in rock-mass and their importance in design of underground caverns and tunnels, permeability of rock-mass. [3 hours]

- **Module 7:** Application of rock mechanics to key rock engineering problems such as rock slope failure and stability analysis, foundations on rocks, and application of rock-mass classification in preliminary tunnel support system design. [8 hours]

**Text books:**


1. Aydan, Omer., **Rock Mechanics and Rock Engineering: Volume 1: Fundamentals of Rock Mechanics**, CRC Press, 2019.

2. Bieniawski, Zdzislaw T,. **Design methodology in rock engineering**, CRC Press, 2020.


References:


1. Jaeger, John Conrad, Neville GW Cook, and Robert Zimmerman, **Fundamentals of rock mechanics**, John Wiley & Sons, 2009.

2. Sivakugan, Nagaratnam, Sanjay Kumar Shukla, and Braja M. Das., **Rock mechanics: an introduction**, CRC Press, 2013.

3. Goodman, Richard E., **Introduction to rock mechanics**, Vol. 2., Wiley, 1989.

4. Hudson, John A., and John P. Harrison., **Engineering rock mechanics: an introduction to the principles**, Elsevier, 2000.

5. Ramamurthy, T., ed., **Engineering in rocks for slopes, foundations, and tunnels**, PHI Learning Pvt. Ltd., 2010.

6. Pariseau, William G., **Design analysis in rock mechanics**, CRC Press, 2006.

7. Zhang, Lianyang., **Engineering properties of rocks**, Butterworth-Heinemann, 2016


## 3.50 CE 515: Environmental Impact Assessment

**Course Code : CE 515**

**Course Name : Environmental Impact Assessment**

L-T-P-C : 3-0-0-3
Intended for : UG elective (3rd and 4th Year)/PG elective (M-Tech/PhD)

Prerequisite : NA
Mutual Exclusion : None
Approval: 50th BoA

**Course Contents:**

- **EIA Introduction**: Introduction, definitions and concepts, rationale and historical development of EIA, Evolution of EIA; EIA at project; Regional and policy levels; EIA process in India and other countries (4 hours)
- **EIA Procedure**: Initial environmental examination, environmental impact statement, environmental appraisal, environmental impact factors and areas of consideration, Screening and scoping criteria; Rapid and Comprehensive EIA; Environmental health impact assessment; Baseline collection of data; EIA pertinent environmental factors (8 hours)
- **EIA Methodologies**: Generic steps, descriptive checklists, simple interaction matrix, stepped matrix, Networks, Overlays, uniqueness ratio, habitat evaluation system, EIA models (12 hours)
- **Impact Identification, Management and Reporting**: Impact Identification, Analysis & Prediction, Development of environment management plan; Post project monitoring ; Stakeholders consultation / Public Involvement in EIA, Mitigation, elements of mitigation, structure and element of EIA report, EIA documentation, Review process, EIA Regulations in India, Environmental Management: Preventive policy of environment, waste minimisation, conservation of water and energy, use of renewable, sources, pollution audit, pollution control strategy (10 hours)
- **Case studies**: Principles, problems and strategies and remedial actions, Applications for industrial; Water resources and irrigation projects; ports and harbours, Mining, Transportation and other projects sectors, Prediction & Assessment of Impacts on the Water Environment, Air Environment and Soil Environment (8 hours)

**Text books:**

1. Canter, L. W., **Environmental Impact Assessment**, 2nd Edition, McGraw-Hill, 1997.
2. Glasson J., Therivel Riki, Chadwick Andrew, **Introduction to Environmental Impact Assessment,** 4th Eedition, Oxford Brookes University, 2012.

**References:**

1. Judith, P. and Eduljee,G., **Environmental Impact Assessment for Waste Treatment and Disposal Facilities**, John Wiley & Sons, 1994.
2. Burke,G., Singh, B.R., and Theodore, L., **Handbook of Environmental Management and Technology**, 2nd Edition, John Wiley & Sons, 2000.
3. Eccleston, C.H., **Environment Impact Statements: A Comprehensive Guide to Project and Strategic Planning**, John Wiley & Sons, 2000.

4. Shrivastava A.K., Baxter Nicola, Grimm Jacob, **Environmental Impact Assessment**, APH Publishers, 2003

5. Anjaneyulu Y., Manickam Valli, **Environmental Impact Assessment Methodologies**, CRC Press 2011

6. Welford,R., **Corporate Environmental Management - Systems and Strategies**, Universities Press, 1996.

7. Whitelaw, K. and Butterworth, **ISO 14001: Environmental System Handbook**, 1997

## 3.51 CE 516: Uncertainty Analysis in Civil Engineering

**Course Code : CE 516**

**Course Name : Uncertainty Analysis in Civil Engineering**

L-T-P-C : 3-0-0-3

Intended for : B.Tech. 4th year/ M.S./ M.Tech./ Ph.D.

Prerequisite: Students are suggested to have a background on basicEngineering Mathematics related course at the UG level and the design and testing aspects in Civil Engineering (CE351: Design of Reinforced Concrete Structures or, CE402: Geotechnical Engineering II, or CE401: Design of Steel Structures or, CE354P: Building and Pavement Materials Laboratory, or equivalent)

Mutual Exclusion : 'None'

Approval: 50th BoA

**Course Contents:**

- **The concept of 'Risk and uncertainty' in Civil Engineering**: Difference between deterministic and uncertain parameters, sources of uncertainties in civil engineering, classification and nomenclature of uncertainties (epistemic, aleatory, parametric, etc.), the concept of hazard, vulnerability and risk, Factor of Safety, lower and upper bounds. (3 Hours)

- **Uncertainty Quantification in Civil Engineering**: Understanding the examples of discrete and continuous random variables in civil engineering such as soil data, concrete strength data, other strength and design data, uncertainty quantification of such variables in form of mean, variance, COV, histograms, percentiles, box plots, correlation, skewness, scatter, probability distributions (PDF and PMF), expectations, moments, joint probability distributions, and extreme value theories. (10 Hours)

- **Introduction to Random Process**: Introduction to earthquake ground motions as random processes, and their basic statistical, temporal, and Spatial characterization including variograms, autocorrelation functions, probability density, Interpolation methods (e.g., kriging), stationarity, ergodicity, and return period. (7 Hours)

- **Uncertainty Simulation & Propagation**: Simulating the random variables using the Monte-Carlo approach, Bootstrap method, example case-studies to understand the implications of these random input variables on the desired outcomes (e.g., structural response to random loads, case-studies from construction planning and management), derivation of the probability distributions of output variables, testing their goodness-fit, sensitivity analysis, first order second moment (FOSM) methods, and event tree analysis. (12 Hours)

- **Data interpretation and modelling**: Introduction to typical data from civil engineering experiments that needs to be modeled, identification of dependent and independent variables through example problems, Correlation analysis between the parameters in the model, identifying outliers, Functional form identification (Parametric, non-parametric), Performance evaluation, confidence interval, a brief overview on approaches to handling of missing information, Mixed-effects regression its significance and application. (6 Hours)

- **Advanced and Miscellaneous Topics**: The basics concepts of load, resistance, failure probability, factor of safety, and reliability, point estimate method, error propagation, Hasofer-Lind approach, Conditional probability, Bayes' law, Posterior distribution. (4 Hours)

**Text books:**


1. H-S.Ang & W.H. Tang, **Probability Concepts in Engineering: Emphasis on Applications to Civil and Environmental Engineering**, Wiley, 2006.

2. Benjamin, Jack R., and C. Allin Cornell, **Probability, statistics, and decision for civil engineers**, Courier Corporation, 2014.


**References:**


1. Papoulis, A., **Probability, Random Variables and Stochastic Processes**, 3rd Edition, McGraw-Hill, 1991.

2. Jay L. Devore, **Probability and Statistics for Engineering and the Sciences**, Brooke & Cole, 2009.

3. Montgomery, Douglas C., and George C. Runger, **Applied statistics and probability for engineers**, John Wiley & Sons, 2007.

4. Fellin, W., Lessmann, H., Oberguggenberger, M., & Vieider, R. (Eds.), **Analyzing uncertainty in civil engineering**, Springer, 2005.

5. Ross, S. M., **Introduction to probability and statistics for engineers and scientists**, Elsevier, 2004.

6. Soong, T. T., **Fundamentals of probability and statistics for engineers**, John Wiley & Sons, 2004.


## 3.52 CE 517: Hydroinformatics

**Course Code : CE 517**

**Course Name : Hydroinformatics**

L-T-P-C : 3-1-0-4

Intended for : B.Tech. (4th year), PG and Ph.D. students

Prerequisite : None; however, familiarity with any computer programming language (e.g., Python, R, MATLAB, etc.) will be helpful during the course.

Mutual Exclusion : None

Approval: 50th BoA

**Course Contents:**

1. Introduction: Introduction to Hydroinformatics, hydrology, water resources, Smart water management; Forecasting and Early warning system; Major sources of meteorological, climatic, and hydrologic data. (6 Hours)

2. Databases and Data Models Data life cycle, Data structures, Database management, Data Storage and retrieval, and use data from data models; CSV; NetCDF; Big Data; query aggregate and pivot data using Structured Query language (SQL), Entity Relationship Model; Introduction to Programming and computational tools Python, R, excel, etc. (8 Hours)

3. Data Analysis and Visualization Exploratory data analysis techniques; Introduction to data visualization tools; Basic and Specialized Visualization Tools; Visualization tools for geospatial data; interactive data visualization; Creating data dashboards. (8 Hours)

4. Geospatial Analysis Analysis of vector and raster datasets; Map Scale and projections; Introduction to GDAL; raster and vector conversions; Analysis and visualization of DEM; Watershed analysis and characterization; Watershed assessment and susceptibility/ vulnerability mapping; Raster querying; Stack Mosaic; Introduction to WebGIS, Introduction to Google Earth Engine and Microsoft Planetary Computer. (8 Hours)

5. Modelling and Simulations Time series analysis, Rainfall-runoff modeling; statistical analysis: Regression, probability distributions, interpolation, autocorrelation, hypothesis testing, frequency analysis, and return period estimation; Missing data; Hydrological modeling: Uncertainty and sensitivity analysis; Calibration and validation using Monte Carlo (MC), Markov Chain Monte-Carlo (MCMC), Maximum likelihood estimation (MLE), Shuffled Complex Evolution Algorithm (SCE-UA), Dynamically Dimensioned Search algorithm (DDS); Machine learning techniques in Hydrology. (12 Hours)

**Text books:**

1. Kumar, P., Folk, M., Markus, M., & Alameda, J. C., **Hydroinformatics: data integrative approaches in computation, analysis, and modeling**, CRC Press, 2005.

2. Remesan R., Mathew J., **Hydrological Data Driven Modelling: A Case Study Approach**, Springer, 2015.

**References:**


1. Tomer, S. K., **Python in Hydrology**, Green Tea Press, 2011.

2. Beven, K. J., **Rainfall-runoff modelling: the primer**, John Wiley & Sons, 2011.

3. Lee, T., Singh, V. P., & Cho, K. H., **Deep Learning for Hydrometeorology and Environmental Science**, Springer, 2021.


**Note:** Some research papers, reports and handouts will also be provided as study material during the class.

## 3.53 CE 518: Structural Reliability and Risk Assessment

**Course number : CE 518**

**Course Name : Structural Reliability and Risk Assessment**

L-T-P-C : 3-0-0-3
Intended for : UG/PG elective
Prerequisite : CE 351 – Design of Reinforced Concrete Structures
Mutual Exclusion : None
Approval: 50th BoA

**Course Contents:**

- **Review of Probability and Statistics**: Basic definition of probability, Concept of random variables; Concepts of probability functions - PDF, CDF, and PMF; Types of probability distributions; Correlations, Conditional probability, Bayes theorem [8 hours]

- **Structural Reliability Analysis 1**: Basic concepts, Exact solution, Mean value first-order second-moment (MVFOSM), First-order second-moment (FOSM), First-order reliability method (FORM), Sensitivity analysis. [8 hours]

- **Probabilistic Simulations**: Monte Carlo simulations, Stratified sampling, Importance sampling. [5 hours]

- **Structural Reliability Analysis 2**: Component and System reliability, Second-Order Reliability Method (SORM), Time-varying reliability, Response surface method, Introduction to machine learning tools. [8 hours]

- **Reliability-based design codes**: Introduction, LRFD, Calibration of safety factors. [6 hours]

- **Advanced Topics and Applications**: Risk assessment of civil structure and infrastructure systems under service loads and natural hazards; Reliability-based Optimization Problems; Bayesian Inference Techniques; Application in structural health monitoring - Concept of Value of Information. [7 hours]

**Text book:**

1. Nowak, A.S. & Collins K.R., **Reliability of Structures**, 2nd Edition, CRC Press, 2012.

2. Ranganathan R, **Structural Reliability: Analysis and Design**, Jaico Publishing, 2006.

**References:**

1. Melchers RE, **Structural Reliability Analysis and Prediction**, 2nd ed., Wiley, 1999.

2. Haldar, A & Mahadevan, S, **Probability, Reliability, and Statistical Methods in Engineering Design**, Wiley, 1999.

3. Wang, C., **Structural Reliability and Time-dependent Reliability**, Cham, Switzerland: Springer, 2021.

4. Ditlevsen, O., & Madsen, H. O., **Structural Reliability Methods** (Vol. 178), Wiley, 1996.

5. Chandrasekaran, S, **Reliability and Risk Assessment**, CRC Press, 2016

6. Thoft-Christensen, P., and Murotsu, Y., **Application of Structural Systems Reliability Theory**, Springer Verlag, 1986.

## 3.54 CE 519: Chemistry of Natural Waters

**Course Code : CE 519**

**Course Name : Chemistry of Natural Waters**

Pre-requisites : Environmental Science, Chemistry
Intended for : UG/M.Tech./MS/PhD
Disciplines : Civil and Environmental Engineering, Basic Sciences (Chemistry)
Approval: 50th BoA

**Course Contents:**

- **Hydrologic Cycle**: This chapter will focus on various components of hydrologic cycle. The chapter discusses composition of rainwater, fundamentals of hydrology, non-meteoric types of water, and chemical terminologies used in hydrology. (4 hours)

- **Chemical Thermodynamics:** (4 hours). This chapter introduces chemical concepts applied to hydrology, and includes topics like units and terminologies, equilibrium thermodynamics, activity-concentration relationships and diffusion. (4 hours)

- **Chemical kinetics:** This topic discusses one of the important controls on water chemistry. The topics of discussion include mineral nucleation, dissolution and growth, and uses quantitative examples like dissolution of calcite in seawater, dissolution of silicates etc. (4 hours)

- **Carbonate System and pH Control:** This chapter discusses one of the most important systems relevant to water quality. The topics of discussion include carbonic acid system, alkalinity and titration curves, calcium carbonate solubility, dolomite solubility, high-magnesium calcite solubility, ground and surface water in carbonate terrains, carbonate chemistry in oceans, and acid water chemistry. (4 hours)

- **Organic Compounds in Natural Waters:** This chapter focuses on structure of natural organic solutes, functional groups, humic substances, and dissolved organic carbon in natural environments. (4 hours)

- **Redox Conditions in Natural Waters:** This chapter will introduce fundamental ideas such as standard hydrogen electrode and thermodynamic conversions, measurement of Eh, pe-pH and Eh-pH diagrams construction and interpretation, partial pressure or fugacity diagrams and interpretation. This chapter will also discuss processes controlling redox equilibrium in natural water such as photosynthesis, respiration and decay, redox buffering, and use specific case studies of lakes, oceans, and groundwater chemistry to illustrate the concepts. (4 hours)

- **Ion exchange and Sorption:** This topic focuses on an important phenomenon of ion exchange that occurs naturally especially with clay minerals and widely used in environmental engineering applications for water and wastewater treatment. The topics of discussion include mineralogy and composition of ion exchange material, colloid properties, and retardation of pollutant cations in groundwater. Concepts of adsorption – desorption, adsorption isotherms etc. will be discussed in the context of natural and engineered water chemistry. (4 hours)

- **Weathering and Water Chemistry:** First part of this chapter will focus on fundamental principles such as soil formation, mass balance, thermodynamic, and statistical approaches to study weathering and water chemistry. The second part of this chapter will focus on specific case studies including river and groundwater systems and their evolution in terms of water chemistry due to weathering. (5 hours)

- **Surface and Groundwater Chemistry:** This chapter will overview chemistry of surface waters including rivers, lakes, oceans, role of environmental factors affecting their chemistry, effects of climate change, and combining the ideas learnt earlier to understand and model surface water chemistry. This chapter will also overview chemistry of groundwater in variety of aquifers worldwide and controlling factors. Ideas about the sediment-water interactions will be introduced in this chapter. Various data visualization techniques will be used to interpret groundwater chemistry. (5 hours)

- **Contaminants in Natural Waters:** Many of the trace elements are of human health concern. This chapter will focus on understanding sources of trace elements (metals or metalloids), their speciation (pH and redox dependent), controls on solubility, adsorption and coprecipitation controls important for remediation, and their uptake by organisms important for bioremediation. Other topics such as organic contaminants, emerging contaminants, acid rain and drainage, eutrophication etc. and more will also be discussed in this chapter. (4 hours)

**Textbooks / Reference Books:**

1. Drever, J.I., **The geochemistry of natural waters**, Prentice hall, 1998.

2. Baird, C. and Cann, M., **Environmental Chemistry**, W. H. Freeman and Company, 2012.

3. Masters, G.M., **Introduction to Environmental Engineering and Science**, Prentice-Hall Inc., 1996.

4. Faure, G., **Principles and Applications of Geochemistry**, Prentice-Hall Inc., 1991

5. D. Langmuir, **Aqueous Environmental Geochemistry**.

6. Appelo and Postma, **Geochemistry, Groundwater, and Pollution**.

7. Stummn and Morgan, **Aquatic Chemistry**.

## 3.55 CE 520 : Environmental Reaction Modeling

**Course Code : CE 520**

**Course Name : Environmental Reaction Modeling**

L-P-T-C: 3-0-0-3
Intended for: PG, PhD
Prerequisites: IC230, CE519 or similar
Mutual Exclusion:
Approval : 57th BoA

**Course Contents**

- **Modeling basics**: This chapter introduces fundamentals of environmental modeling. First and the most critical step in developing environmental models is conceptualizing the system or process of interest in a useful manner; introduction to various environmental systems and the processes therein that can be quantitatively modeled; concepts of mass and energy transfer, thermodynamics. Environmental engineers and scientists now use quantitative models to understand sediment determine which contaminants will migrate from mine tailings and toxic waste sites, predict scaling in geothermal wells and the outcome of steam-flooding oil reservoirs, solve kinetic rate equations, manage injection wells, evaluate laboratory experiments, and study acid rain. (8 hours).

- **Equilibrium of natural waters**: Chemistry of natural waters is of extreme importance for environmental scientists and engineers in terms of determining the quality of natural waters as well as for the treatment of contaminated water systems. This section provides insights on several steps in environmental modeling. (14 hours).

  - Equilibrium State. This chapter discusses how can we express the equilibrium state of such a system; a direct approach to write each reaction that could occur among the system's species, minerals, and gases; numerical solution for equilibrium state by determining a set of concentrations that simultaneously satisfy the mass action equation corresponding to each possible reaction.'

  - Solving for equilibrium state. The principal unknowns equations governing the equilibrium state of aqueous and solid environmental systems are the mass of water and concentrations of basic species, and moles of minerals in equilibrium. Many of these equations are often non-linear and hence cannot be solved using linear algebra. This chapter will focus on the special difficulties posed by the nonlinear forms of the governing equations and discuss how the Newton–Raphson method can be used in geochemical modeling to solve the equations rapidly and reliably.
  - Setting up a model. The basis in reaction modeling includes water, each mineral in the equilibrium system, and each gas of known fugacity, and certain aqueous species. The basis servers two main purposes, each chemical reaction in the model is written in terms of members of the basis set. This chapter discusses how an environmental system can be expressed in terms of chemical reactions and quantitative parameters in the model.
  - Equilibrium model of natural waters. This chapter will focus on constructing models of natural waters to predict processes like mineral dissolution, aqueous speciation of chemicals, minerals precipitation, gas dissolution and degassing, and pH of natural waters.
  - Redox disequilibrium. Many chemical reactions in the environment are redox (oxidation-reduction) reactions and are extremely important for contaminant mobilization. In this chapter, modeling of redox sensitive elements in the environment (C, N, S, O, Fe, and other toxic metals) will be discussed. Inclusion of redox disequilibrium in chemical reaction modeling advances our abilities to predict behavior of contaminants in the environment.
  - Sorption and ion exchange. An important consideration in constructing environmental chemical models, especially those applied to environmental problems, is to account for the sorption of aqueous species onto sediment surfaces. Because of their large surface areas and high reactivities, many components of a sediment – especially clay minerals, zeolites, metal oxides and oxyhydroxides, and organic matter – can sorb considerable masses. This chapter will focus on several simple models of ion sorption and exchange that can be applied within the context of a environmental reaction model. These models include distribution coefficients, Freundlich and Langmuir isotherms, and ion exchange theory.
  - Surface complexation. The sorption models presented in the previous chapter are, however, too simplistic to be incorporated into a geochemical model intended for use under general conditions, such as across a range in pH. This chapter discusses a theory of surface complexation to describe hydrolysis and the mineral surface, account for electrical charge there, and provide for mass balance on the sorbing sites. Several surface complexations models will be constructed to predict the chemistry of natural water in equilibrium with minerals with specific reactive surface area.

- **Reaction Processes**: This section overviews specific reaction processes such as mass transfer, polythermal reactions, geochemical buffering, kinetics of mineral dissolution and precipitation, redox kinetics, microbial kinetics, stable isotopes, transport in flowing groundwater, and reactive transport. (12 hours).

  - Mass transfer. In this chapter we consider how to construct reactions paths that account for the effects of simple reactants, a name given to reactants that are added to or removed from a system at constant rates.
  - Polythermal reactions. This chapter will focus on constructing reaction models that varies over temperature. A temperature varies as a function of reaction progress, is numerically modeled, and activity of solutes, stability of minerals, fugacity of gases involved in the system is calculated as a function of temperature.
  - Geochemical buffers. Buffers are reactions that at least temporarily resist change to some aspect of fluid chemistry (e.g., pH buffers). This chapter focuses on constructing models of buffering reactions, both homogenous and heterogenous.
  - Kinetics of dissolution and precipitation. This chapter focuses on modeling environmental reactions to predict how much time it'd take to reach a certain point along the reaction path, calculating relative rates of minerals in rocks, predicting chemistry of waters in equilibrium with certain rocks for a known amount of time, predicting future groundwater quality under known geochemical conditions, by incorporating reaction rate laws from the field of geochemical kinetics.
  - Redox kinetics. The subject of this chapter is modeling the rates at which redox reactions proceed within the aqueous solution, or when catalyzed on a mineral surface or by the action of an enzyme.
  - Microbial kinetics. This chapter focuses on how the microbial community catalyzes redox reactions, perhaps changing in size and composition as it does. The kinetics of such reactions are of special interest, because of the close relationship between geochemical conditions and microbial ecology. The microbes promote reactions that change geochemical conditions, many times significantly, and the geochemistry controls the nature of the microbial community that can exist in a given environment.

- **Applied Reaction Modeling**: This section overviews specific examples of modeling environmental systems such as geothermal fluids, geothermometry, evaporation, sediment diagenesis, kinetics of water rock interaction, weathering, oxidation and reduction, waste injection wells, petroleum reservoirs, acid mine drainage, contamination and remediation, and microbial communities. These models of these (and other) environmental systems will be constructed throughout the duration of course using modeling programs like PHREEQC, Visual MINTEQ and Geochemist's Workbench. The concepts learnt in previous chapters will be utilized in construction of these models. (8 hours).

**Text books:**

1. Bethke, C.M., **Geochemical and biogeochemical reaction modeling**, Cambridge university press, 2022.

2. Parkhurst, D.L., and Appelo, C.A.J., 2013, **Description of input and examples for PHREEQC version 3—A computer program for speciation, batch-reaction, one-dimensional transport, and inverse geochemical calculations**: U.S. Geological Survey Techniques and Methods, book 6, chap. A43, 497 p., https://doi.org/10.3133/tm6A43

**References:**


1. Gustafsson, J.P., **Visual MINTEQ 3.0 user guide**, KTH, Department of Land and Water Resources, Stockholm, 2011.

2. Appelo and Postma, **Geochemistry, Groundwater, and Pollution**.

3. Merkel and Planer-Friedrich, **Groundwater Geochemistry**.

4. **Microsoft Excel**

5. USGS PHREEQC, open source (https://www.usgs.gov/software/phreeqc-version-3)

6. Visual MINTEQ, open source (https://vminteq.lwr.kth.se/)

7. Geochemist's Workbench, commercial (https://www.gwb.com/)

8. GWB Academy: https://academy.gwb.com/academy.php.


## 3.56 CE 521: Ecology and Environment Microbiology

**Course Code : CE 521**

**Course Name : Ecology and Environment Microbiology**

L-T-P-C : 3-0-2-4
Intended for : PG, PhD
Prerequisite : IC230 (completed a similar Course)
Mutual Exclusion :
Approval: 52nd BoA

**Course Contents**

- **Fundamentals of Ecology**: Basic concepts of ecology and ecosystems, level of organization, ecosystem structure, processess, stability, biogeography and life line zone, population, population characterisic and regulation, species interactions, community and keystone species, succession and concept of climax, fundamental of primary and secondary productivity, energy transfer and nutrient cycling, biodiversity and ecological restoration

- **Introduction of Microbiology**: Science of microbiology, microbial cell and properties, impact of microorganism on humans, historical route of discovery of microbiology, Hooke, van Leeuwenhoek, and Cohn concepts of discovery, cell structure and history; prokaryotic, eukaryotic and viruses, DNA arrangement in microbial cell, metabolic diversity of microbes, Types of bacteria; proteobacteria gram positive and gram negative, archaea, cell morphology and size, cytoplasmic membrane;

structure and function, cell wall ofprokaryotes; gram positive and gram negative, cell walls of archaea, flagella and motility. (8 Lectures)

- **Environment Microbiology:** Microorganism in the environment, bacterial nutrition and growth, specific growth rate and doubling time, type of culture media; batch and continuous culture, enzyme and catalyst, energy-rich compounds and storage, microbial metabolism- glycolysis, TCA, and ETC, fermentation, nitrogen fixation, nitrogenase, methanogensis, acetogensis, biodegradation, bioremediation, bioleaching or biomining, biodegradative organism, environmental factors affecting biodegradation, biodegradation of organic pollutants, biofuel, waste water treatment, water borne microbial diseases, maJor industrial products, flavouring agents and food supplement, vitamins and beverages, organic acids, aeromicrobiology. (12 Lectures)
- **Himalayan Environmental Microbiology:** Geography and uniqueness of Himalayan region, life in extreme environment, biogeochemical cycle of elements, high altitude lake microbiology, cryospheric microbiology, extremophile (halophile, thermophile, psychrophile) adaptation metabolic processes under extreme conditions, application of cryospheric microbes. (8 Lectures)
- **Advanced Microbiology Tools and Techniques:** Light microbiology and its principles, compound light microscope, increasing constrast in light microscopy, phase contrast and microfield microscopy, fluorosence microscopy, differential interface contrast microscopy (DIC), atomic force microscopy (AFM), confocal scanning Laser microscopy (CSLM), Electron microscopy, OMIC techniques in microbial remediation processes, genomics, protoemics, and metabolomics in microbial remediation, recent advanes in in silico approaches for the removal of environmental pollution.

**Laboratory / practical / tutorial Modules:**

1. Method of vegetation sampling, quadrat method; shape, size and number, density, relative density, frequency, relative frequency ofvegetation (6 Lectures)
2. Basic instrumentation, safety and disinfection and in microbiology laboratory (2 Lectures)
3. Preparation and sterilization of various growth media for microbial isolation (2 Lectures)
4. Microbial isolation and maintenance through serial dilution, plating, streaking, slant and storage of microbial culture (4 Lectures)
5. Morphological and biochemical characterization: Gram staining, catalase, urease, oxidase, indole, methyl red etc. (6 Lectures)
6. Growth curve, effect of physical parameter such as temperature, pH, carbon and nitr˜gen sources on microbial growth (4 Lectures)
7. Isolation of environmental and industrially important microbes (2 Lectures)
8. Isolation ofhalophile, thermophile, psychrophile from Himalayan sources. (2 Lectures)

**Text Books:**


1. Madigan, M. T., Clark, D.P., Stahl, D., & Martinko, J. M., **Brock biology of microorganisms**, 13th Edition, Benjamin Cummings, 2010.

2. Singh, J. S., Singh, S. P., & Gupta, S. R., **Ecology, environmental science & conservation**, S. Chand Publishing, 2014.


**References:**


1. Dhakar, K and Pandey, A., **Microbial ecology from the Himalayan cryosphere perspective**, microorganisms, 8(2) 257, 2020

2. Liu, Y., Yao, T., Jiao, N., Tian, L., Hu, A., Yu, W., and Li, S., **Microbial diversity in the snow, a moraine lake and a stream in Himalayn Glacia**, Extremophiles, 15, 411-421, 2011.

3. Sati, S. C. and Belwal, M., **Microbes: Dieversity and Biotechnology**, Daya Publishing House.

4. Maier, R. M., Pepper, I., and Gerba, C. P., **Environmental Microbiology A laboratory Manua**, Academic Press.

5. Odum, E. ., and Barett, G. W., **Fundamentals of Ecology**, 5th Edition, Cengage Learning India, 1971.

6. Pepper, I. L., Gerba, C. P., Gentry, T. J., and Maier, R. M. (editors), **Environmental microbiology**, Academic Press, 2011.

7. Giri, A., and Pant, D., **CO2 management using carbonic anhydrase producing microbes from western Indian Himalaya**, Bioresource Technology Reports, 3, 100320.


## 3.57 CE 522: Matrix Methods for Structural Analysis

**Course Code : CE 522**

**Course Name : Matrix Methods for Structural Analysis**

L-T-P-C : 3-0-0-3
Intended for : UG Program (B. Tech 3rd;4th Year Students) and PG Program
Prerequisite : CE 404: Analysis of Structures/Equivalent
Mutual Exclusion :
Approval: 52nd BoA

**Course Contents**

- **Module 1**: Introduction to matrix analysis of structures, elements and structures, degrees of freedom, the principle of superposition, concepts ofmatrix algebra. (3 Lectures)

- **Matrix analysis of structures with axial elements**: plane trusses and space trusses Flexibility method: Introduction to the approach, Deriving the flexibility matrix of truss. Analysis of determinate and indeterminate structures employing the flexibility matrix approach. (5 Lectures)

- **Matrix analysis of beams and grids:** Flexibility method-Deriving the flexibility matrix beams and grids: Analysis of determinate and indeterminate structures employing the flexibility matrix approach. (5 Lectures)

- **Matrix analysis of plane and space frames:** Flexibility method: Deriving the flexibility matrix of plane and space. frames: Analysis of determinate and indeterminate structures employing the flexibility matrix approach. Analysis of prismatic and non-prismatic frames. (5 Lectures)

- **Matrix analysis of structures with axial elements:** plane trusses and space trusses. Stiffness Method: Introduction to the approach, Deriving the stiffness matrix truss. Analysis of determinate and indeterminate structures employing the stiffness matrix approach. (5 Lectures)

- **Matrix analysis of beams and grids: Stiffness method:** Derivation of stiffness matrix beams and grids: Analysis of determinate and indeterminate structures employing the stiffness matrix approach.(5 Lectures)

- **Matrix analysis of plane and space frames: Stiffness method:** Derivation of the stiffness matrix plane and space frames: Analysis of determinate and indetem1inate structures employing the stiffness matrix approach. Analysis of prismatic and nonprismatic frames. (5 Lectures)

- **Module 8**: Comparison between stiffness and flexibility methods, Analysis of truss, beams, and frame structures using direct stiffness approach; Computer application of direct stiffness method. (5 Lectures)

- **Beyond matrix methods:** Introduction to finite element method, element types, basic formulation, and application to 1 D problems. (4 Lectures)

**Text Books:**


1. Weaver, W., and Gere, J. M ., **Matrix analysis framed structures**, Springer science & business media, 2012.

2. Hibbeler, RC, **Structural Analysis**, 9th edition, Pearson Education, 2017.


**References:**


1. G. S. Pandit and S. P. Gupta, **Structural Analysis: A Matrix Approach**, Tata McGrawHill, 2008.

2. Martin, H. C., **Introduction to Matrix Methods of Structural Analysis**, McGraw-Hill, New York, 1996

3. Menon, D, **Advanced Structural Analysis**, Narosa Publishing House, 2015.

## 3.58 CE 523: Building Science

**Course Code : CE 523**

**Course Name : Building Science**

L-T-P-C : 3-0-0-3
Intended for : UG/PG
Prerequisite : Engineering Thermodynamics and Engineering Mathematics
Mutual Exclusion:
Approval: 54th BoA

**Course Contents**

- **Building system** (6 Hours)
  - Introduction: Life phases of a building; Resources utilized by buildings and the need for sustainability; Design goals and approach
  - Outdoor environment: Air temperature and humidity, solar radiation, wind, precipitation and driving rain; Climatic zones, urban climate, site climate
  - Indoor environment: Thermal comfort; Indoor air quality; Visual comfort; Effect of noise on wellness; Dangers associated with a building fire
  - Building envelope: Walls, roofs, openings; Thermal mass, air and water tightness.
- **Moisture** (6 Hours )
  - Psychrometrics: Moist air properties; Psychrometric chart
  - Moisture transport mechanisms: Capillary action, permeation, vapor diffusion
  - Moisture transport in building elements: Glaser method; Overview of transient models and their numerical solution Prevention of moisture uptake: Damp proofing, vapor barrier, role of thermal insulation and ventilation; Moisture meters .
- **Ventilation and Infiltration** (6 Hours)
  - Natural ventilation: Aerodynamics around a building, ventilation due to wind and stack effects, cross-ventilation; Design guidelines for openings
  - Infiltration: Crack flow equation; Calculation of leakages; Energy implications
- **Heat** (6 Hours)
  - Mechanisms and laws of heat transfer: Conduction, Convection and Radiation
  - Heat transfer in building elements: Steady state transfer in solid wall, wall with airspace, window, slab-on-grade, basement wall and floor, thermal bridges; Introduction to the continuous and distributed methods for analyzing transient heat flow
  - Calculation of heating and cooling loads: Instantaneous, cooling load temperature difference/cooling load factor methods; Overview of transfer function, heat balance and radiant time series methods

- Thermal control: Overview of mechanical and structural controls

- **Acoustics** (6 Hours)
  - Fundamentals: Wave nature of sound; Frequency, pressure, power and intensity of sound; Human perception of loudness; Environmental noise; Noise abatement; Sound meters
  - Room acoustics: Direct and diffuse sound fields; Echo, standing wave; Types of sound absorbers; Sound absorption coefficient and Reverberation time
  - Sound transmission and insulation: Resonance and Coincidence frequencies; Calculation of sound reduction index

- **Illumination** (6 Hours)
  - Fundamentals: Human perception of light; Photometric quantities; Optical properties of matter; Light meters
  - Daylight: Components of daylight; Solar altitude and azimuth, sun path diagram; Sky conditions and luminance; Illumination of horizontal and vertical surfaces; Daylight factor
  - Artificial light: Electric light sources; Properties of light sources

- **Fire** (6 Hours)
  - Fundamentals: Combustion process, development phases, fire classes, fire zones, smoke layer thickness, smoke temperature-time curve
  - Fire safety: Response of building materials to fire and related performance classes; Fire resistance classification; Smoke control; General safety requirements

**Textbooks:**


1. Pinteric, M., **Building Physics: From physical principles to international standards**, 2nd edition, Springer, Switzerland, 2022.

2. Medved, S., **Building Physics: Heat, Ventilation, Moisture, Light, Sound, Fire, and Urban Microclimate**, Springer, 2022.


**References:**


1. Zhai, Z., **Energy Efficient Buildings: Fundamentals of Building Science and Thermal Systems**, Wiley, 2023.

2. Koenigsberger O.H., Ingersoll, T.G., Mayhew, A., and Szololay, S.V., **Manual of tropical housing and building**, Springer, 2022.

3. Moss, K.J., **Heat and Mass transfer in Buildings**, 2nd Edition, Taylor & Francis, 2007.

4. **ASHRAE, Handbook of Fundamentals**, American Society of Heating, Refrigerating and Air conditioning Engineers, 2021.

5. **BIS, National Building Code of India**, Bureau of Indian Standards, 2016.

6. **ECBC Code, Energy Conservation Building Code 2017**, Bureau of Energy Efficiency, 2017.

## 3.59 CE 524 : Applied Hydroclimatology

**Course Code : CE 524**

**Course Name : Applied Hydroclimatology**

L-T-P-C : 3-0-0-3

Intended for : PG and Ph.D. students

Prerequisite : None; however, familiarity with any computer programming language (e.g., Python, R, MATLAB, etc.) will be helpful during the course.

Mutual Exclusion: None

Approval: 56th BoA

**Course Contents**

- **Introduction to hydroclimatology Climate change**: causes and impacts, Impact on global hydrologic cycle; Climate feedback, Tipping points, Water management in changing climate; Concept and scope of hydroclimatology. (4 Lectures)

- **Module II**: Observation Types of research data; Qualitative and quantitative data; Measurement of precipitation, temperature, snow, streamflow, snow water equivalent; Missing data handling techniques; Hydroclimatic measurement network in the Himalayan regions. (4 Lectures)

- **Module III**: Modeling Fundamental principles in hydroclimatic modeling; Types of climate models; Simple climate models, Simple energy balance climate models (e.g., zero- dimensional, single-layer, and one-dimensional); General circulation model (GCM); Hydrologic modeling; types of hydrological models; Components of hydrologic models; SWAT model; VIC model; HEC-HMS.

- **Module IV**: Hydroclimatic data processing and analysis Gridding observed data; Reanalysis data: Satellite-derived data; Radar data; Climate data; Paleoclimatology data; Climate indices, Overview of CMIP6; Downscaling and bias correction of climate data; Impact assessment studies. (8 Lectures)

- **Module V**: Impact on hydrology, agriculture, and ecosystem Climate change impact on Dams; Weather and climate metrics for agriculture, Heat stress indices; Impact of climate change on food security in India; Energy limitation versus moisture limitation; Ecosystem services; Himalayan ecosystem and impact of climate change. (6 Lectures)

- **Module VI**: Hydroclimatic extremes: Droughts and Floods Drought definition: meteorological droughts, hydrological droughts, agricultural drought, socioeconomic drought; Drought indicators: Theory of run; Severity; Duration; Intensity; Frequency analysis; Impact of climate change on droughts; (6 Lectures)

- **Module VII**:Flood types; Extreme precipitation indices; Flood analysis; Flood Frequency analysis; Design Flood; Flood hazard and damage; Glacial lake outburst flood (GLOF); Impact of climate change on floods; Flood risk management and floodplain management. (6 Lectures)

**Text Books:**


1. Shelton, M. L. , Hydroclimatology: perspectives and applications. Cambridge University Press, 2009.

2. VenTe, C., Maidment, D. R., & Mays, L. W., Applied hydrology, 1988.


**Reference Books:**


1. Beven, K. J., **Rainfall-runoff modelling: the primer**, John Wiley & Sons, 2011.

2. McGuffie, K., & Henderson-Sellers, A., **The climate modelling primer**, John Wiley & Sons, 2014.


## 3.60 CE 524P : Computational Hydroclimatology Lab

**Course Code : CE 524P**

**Course Name : Computational Hydroclimatology Lab**

L-T-P-C : 0-0-2-1
Intended for : PG and Ph.D. students
Prerequisite : None
Mutual Exclusion:
Approval: 56th BoA

**List of Experiments**

1. **Acquiring the hydroclimatic data**: Acquisition and preprocessing of hydroclimatic data from various sources (2 Hours)

2. **Analysis of Climate Change Trends**: Analyze long-term temperature and precipitation data to identify and quantify climate change trends. (2 hours)

3. **Handling Missing Hydroclimatic Data**: Apply various techniques to handle missing data in hydroclimatic time series and evaluate their effectiveness. (2 hours)

4. **Simple Energy Balance Climate Model**: Implement a zero-dimensional energy balance climate model to simulate global temperature changes under different forcing scenarios. (2 hours)

5. **Hydrologic Modelling with Lumped Models**: Set up and calibrate multiple lumped models to characterize the hydrologic behavior of the watershed.(2 Hours)

6. **Hydrologic Modeling with SWAT**: Set up and run a SWAT model for a small watershed to simulate hydrological processes and assess impacts of land use changes. (2 hours)

7. **Downscaling and Bias Correction of Climate Data**: Apply statistical downscaling and bias correction techniques to GCM outputs for use in local impact studies. (2 hours)

8. **Analysis of Climate Indices**: Calculate and analyze various climate indices to understand large-scale climate patterns and their local impacts. (2 hours)

9. **Drought Analysis using Standardized Precipitation Index (SPI)**: Compute SPI at multiple timescales to analyze historical drought patterns and assess future drought risk. (2 hours)

10. **Flood Frequency Analysis**: Perform flood frequency analysis using annual maximum streamflow data and assess non-stationarity due to climate change. (2 hours)

11. **Climate Change Impact on Crop Yield**: Assess the impact of climate change on crop yield using a simple crop model and climate projections. (2 hours)

12. **Glacier Mass Balance Modeling**: Implement a simple glacier mass balance model to assess climate change impacts on glacier evolution. (2 hours)

**Text Books:**

1. None. Experiment notebooks will be provided during the lab

**Reference Books:**

1. None. Experiment reference material will be provided during the lab

## 3.61 CE 525 : Advance Transportation Engineering

**Course Code : CE 525**

**Course Name : Advance Transportation Engineering**

L-P-T-C: 3-0-1-4
Intended for: B. Tech ( final year); MS (Research); PhD
Prerequisites: NA
Mutual Exclusion: NA
Approval : 57th BoA

**Course Contents**

- Section 1: **Pavement Materials and Design**
  - **Pavement Materials**: Mechanical characteristics for the pavement materials for design sections. Deformation characteristics of unbound layers (CBR, resilient modulus, modulus of subgrade reaction), functional properties (permeability) etc. 14 hrs)
  - **Design of bituminous & Concrete mixe**s: Requirement of bitumen mixes, design of bituminous mixes as per Marshall Stability & flow method, parametric evaluation of bituminous mixes, IRC & MoRTH recommendations for the design mix of various layers of flexible pavements. [IRC 44] [6 hrs)

- **Design of Flexible Pavements**: Stresses in flexible pavements, theories of stress distribution, Boussinesq's Elastic theory, Burmister's theory, considerations for flexible pavement design, IRC method & other countries method for the design of flexible pavements, AASHTO method of Pavement design [IRC: 37 2018] [8 hrs]
- **Design of Rigid Pavement**s: Stresses in rigid pavements, Westergaard method of rigid pavement design, IRC method of rigid pavement design for plain dowel jointed slabs, design of joints and load transfer devices; design oftie bars, joint fillers and sealers, design of continuously reinforced concrete pavements, design of thin & ultra-thin white toppings as overlay. [IRC 58:2015] [8 hrs)

- Section 2: **Highway Planning and Design**
  - **Traffic Planning& control:** Fundamental principles of Traffic Flow, Traffic flow Elements, Flow Density Relationships, Traffic signs, Road markings, traffic signals, type's i.e. simultaneous system, alternate system, simple progressive system and flexible progressive system, general principles of signal design, Roadway delineations, object markers, guard rails, Barriers. [6 hrs]
  - **Highway capacity& Intersection design**: PCU, Level of service concepts, factors affecting capacity, capacity of urban highways, capacity of rotary intersection, Design of intersection, grade separated intersection, Need for rotary intersection, principles of design, design of rotary intersection. [6 hrs]

**Lab Sessions: (8 Hours)**

1. Testing and Characterization of Pavement Materials o Laboratory Work: I. Plate bearing test.
2. Stability and Flow value test of bituminous mix as per Marshall Criteria.
3. Evaluation of pavement by Benkelman beam.
4. Evaluation of pavement roughness by Bump Integrator.
5. Introduction to highway engineering softwares( HEADS, MX Road and HDM4) 6. To conduct Pavement Deterioration tests. o Design and Analysis of Pavement

**Text books:**

1. Khanna S.K. and C.E.G. Justo, **Highway Engineering**, Nemchand Bros, 2002.
2. Kadyali L. R., **Highway Engineering**, Nem Chand & Brothers, 2002.

**References:**

1. Sharma & Sharma, **Principle and Practice of Highway Engineering**, Asia Publishing House, New Delhi (1980).
2. **Road Development plan for India** (1981-2001), IRC, New Delhi, (1984).

3. Rao G. V., **Transportation Engineering**, Tata McGraw Hill Publisher, New Delhi

4. **Highway Materials**, H.M.S.O. (London).

5. Yoder E. J., **Principles of Pavement Design**, John Wiley & Sons, 1975.

6. Haas R.C.G., Hudson W. Ronald., Zaniewski John P., **Modem Pavement Management**, Krieger Publishing Company, 1994.

7. Susan Brown, **Pavement Managaement Systems**, Transportation Research Board, 1993.

## 3.62 CE 526 : Critical Zone Science

**Course Code : CE 526**

**Course Name : Critical Zone Science**

L-P-T-C: 2-1-0-3
Intended for: PG and Ph.D. students
Prerequisites: NA
Mutual Exclusion: NA
Approval : 57th BoA

**Course Contents**

- **Introduction to critical zone science**: Definition of critical zone and its components, critical zone observatory; Role of soil in critical zone; Introduction to system modelling; Critical zone architecture and evolution 6 Hours

- **Methods in critical zone science**: Design of a critical zone observatory; Tool and techniques for critical zone datasets: Land-atmosphere data, vegetation and associated microbiota, soil (vadose zone), saprolite and bedrock (saturated zone), surface water; Analysis of event-based and continuous fluxes across critical zone interfaces; Pre-processing and analysis of various fluxes using data analysis and statistical computing. 6 Hours

- **Land-atmosphere exchange in critical zone**: Energy budget, earth-atmosphere energy, types of energy transfers, energy balance at earth's surface, effective energy and mass transfer; Carbon budget, carbon cycle and components, global carbon cycle; carbon allocations, controls of Net Primary Production (NPP), carbon relationships 4 hours

- **Water transfer through the critical zone**: Introduction to various runoff generation mechanisms, Dunne diagram; Quantify or track the hydrological cycle in the field; Water balance closure analysis across various temporal and spatial scales; Simulation of runoff generation in hydrologic models; 6 Hours Water balance of a Tree; Water balance impacts, analyze the impact of forest fire and drought on water cycle and nutrient fluxes; Humans in the critical zone; Simulation of water, carbon, energy, and nutrient fluxes 6 Hours

**Text books:**

1. Giardino, J. R., & Houser, C., Principles and dynamics of the critical zone, Elsevier, 2015.

2. Beven, K. J., Rainfall-runoff modelling: the primer, John Wiley & Sons, 2011.

3. Dingman, S. L., Physical hydrology, Waveland press, 2015.

**References:**

1. Tarboton, D. G., **Rainfall-runoff processes**, 2003.

2. Banwart, S. A., Nikolaidis, N. P., Zhu, Y. G., Peacock, C. L., & Sparks, D. L., **Soil functions: connecting earth's critical zone**, Annual Review of Earth and Planetary Sciences, 47(1), 333-359, 2019.

3. Relevant research papers will be provided during class.

## 3.63 CE 527 : Advanced Pavement Engineering

**Course Code : CE 527**

**Course Name : Advanced Pavement Engineering**

L-P-T-C: 3-0-2-4
Intended for: UG and PG
Prerequisites: On approval of the course instructor.
Mutual Exclusion: NA
Approval : 57th BoA

**Course Contents**

- **Cement and Concrete Pavement Technology** (18 hours)

  - **Cement and Concrete Pavement Technology**: Cement Production and Cement Chemistry, Effect of mineral and chemical admixtures (including grinding aids). Supplementary cementitious materials and its effect on hydration Properties of hydrated Portland cement Fresh paste structure and properties; Concrete Pavement Fundamentals: Concrete pavement types, Elements (typical) of concrete pavement types, evolution of concrete pavement design, types of loads on concrete pavements, typical response of concrete pavements to load, typical distresses in concrete pavements. (12 hours)
  - **Pavement Design Methods**: Empirical approaches to the design of concrete pavement, Mechanistic - Empirical approaches to design of concrete pavements, Portland Cement Association, IRC:58-2015, Function of joints, Types of joints, Dowel bars vs tie bars. (6 hours)

- **Bituminous Technology and Analysis & Design of Flexible Pavement** (11 hours)

- **Bituminous Technology**: Physical and chemical characterization of bitumen. Aging of bitumen, Binder properties and their relationship to pavement performance. Modification of bitumen, modified binders such as polymers and rubbers. (6 hours)
- **Analysis & Design of Flexible Pavement**: Stresses and Deflections in Homogeneous Masses Elastic Layer Theories - Wheel Load Stresses – VDF. IRC 37: 2018 (5 hours)

- **Pavements Maintenance and Evaluation** (8 hours)
  - **Pavement Surface Condition & Its Evaluation**: Various Aspects of Surface and their Importance; Skid resistance, Pavement Condition Index (PCI), International Roughness Index (IRI), Causes, Factors Affecting, Measurement of skid resistance, Pavement functional and structural evaluation and its importance. (4 hours)
  - **Pavement Overlays & Design**: Pavement Overlays, Design of Flexible Overlay over Flexible Pavement by Benkelman Beam Deflection and other Methods, Flexible Overlays and Rigid Overlays over Rigid Pavements, Use of Geosynthetics in Pavement Overlays. (4 hours)
- **Recent trends in Pavement Technology** (5 Hours)
  - **Guidelines and practices**: Cold mix technologies and warm mix technologies: materials, additives, guidelines and practices. Perpetual Pavement, White topping, roller compacted concrete pavements, interlocking paving blocks, pervious concrete pavements, precast concrete pavements for highways and airfield; industrial pavements; concrete pavements for low volume road. (5 Hours)

**Laboratory Experiments: (Total no of tests: 10)**

1. Pavement Materials Testing,
2. Bitumen Content of RAP,
3. Rotational Viscometer Test,
4. Evaluates the viscoelastic properties of bitumen binder under different stress and temperature conditions,
5. Aging Tests on bitumen,
6. Rapid Chloride Penetration Test (RCPT),
7. Benkelman Beam Deflection test,
8. Heat of Hydration test,
9. Compressive strength test for cube test specimens
10. Flexural strength tests for beam samples

**Text books:**

1. H.F.W. Taylor, **Cement Chemistry**, 2nd Edition, Thomas Telford, 1997
2. Yang H. Huang, **Pavement Analysis and Design**, 2nd Edition, Pearson, 2004

**References:**

1. Shaw, D. J., **Introduction to Colloid and Surface Chemistry**, 4th Edition, Butterworth, 1992.
2. Hewlett, P. C., **Chemistry of Cement and Concrete**, 4th Edition, Elsevier Science & Technology Books, 2004.
3. Delatte, N., **Concrete Pavement: Design, Construction and Performance**, Taylor & Francis, 2008.
4. Riveiro, B., and M. Solla, **Non-Destructive Techniques for the Evaluation of Structures and Infrastructure**, CRC Press, 2016.
5. Odler, I., **Special Inorganic Cements**, E&FN Spon (Taylor & Francis Group), 2000.
6. Relevant AASHTO Guidelines.
7. Relevant ASTM Testing and Methodologies.

## 3.64 CE 528 : Design of Masonry Structures

**Course Code : CE 528**

**Course Name : Design of Masonry Structures**

L-P-T-C: 3-0-0-3
Intended for: UG and PG
Prerequisites: CE 351 – Design of Reinforced Concrete Structures
Mutual Exclusion: NA
Approval : 57th BoA

**Course Contents**

- **Historical Perspective of Masonry Structures**: Different types of masonry structures (Domes, Buildings, Bridges, Arches, etc.); Traditional/Heritage masonry structures; Foundations and site selection; Behavior of masonry structures during past earthquakes: Common modes of failure, effect of unit shapes and mortar type, effect of roof and floor systems, Common deficiencies. [6 hours]
- **Masonry Properties**: Masonry units- stones, brick and concrete blocks, hollow and solid units; Manufacturing process; Mortar, grout and reinforcement; Various tests and standards, Stress-Strain Characteristics [6 hours]
- **Masonry Under Compression**: Prism strength, Failure mechanism, types of construction and bonds; Eccentric loading; Slenderness – effective length and effective height, effect of openings; Code provisions. [8 hours]

- **Masonry Under Lateral Loads**: In-plane and out-of-plane loads, bending parallel and perpendicular to bed joints; Shear and flexure behavior of piers; Test and standards; Analysis of perforated shear walls, lateral force distribution for flexible and rigid diaphragms; Arching action; Combined axial and bending actions; Masonry infills: Effect of masonry infills on seismic behavior of framed buildings, Failure modes, Code provisions. [10 hours]

- **Earthquake Resistant Measures**: Analysis for earthquake forces, role of floor and roof diaphragm; Concept and design of bands, bandages, splints, and ties; Reinforced masonry; Vertical reinforcement at corners and jambs; Measures in random-rubble masonry; Introduction to confined masonry [8 hours]

- **Retrofitting of Masonry Building**: Techniques of repair and retrofitting of masonry buildings; IS: 13935-1993 provision for retrofitting. [4 hours]

**Text books:**


1. MJN Priestley and T Paulay, **Seismic design and assessment of reinforced concrete and masonry buildings**, John Wiley and Sons, 1997.

2. RG Drysdale, AA Hamid, LR Baker, **Masonry Structures: Behaviour and Design**, Prentice Hall, 1994.


**References:**


1. AW Hendry, **Structural Brickwork**, The Macmillan Press Ltd., 1981.

2. R E Klingner, **Masonry structural design**, McGrawHill Companies, Inc., 2010.

3. M Tomazevic, **Earthquake-resistant design of masonry buildings**, Series on Innovation in Structures and Construction, Vol. 1, Imperial College Press, 1999.

4. National Building Code of India 2016 Vol.1, Part 6 Section 4 Structural Design - Masonry

5. IS 1905: 1987, Handbook on Masonry Design and Construction.

6. IS 17848 : 2022: Confined Masonry For Earthquake Resistance Code of Practice


## 3.65 CE 551: Geosynthetics and their applications

**Course Number: CE 551**

**Course Name: Geosynthetics and their applications**

L-T-P-C: 3-0-0-3
Prerequisites: CE 302 - Geotechnical Engineering
Intended for: UG/PG
Distribution: Discipline Core Semester: Odd/Even
Approval: 9th Senate

**Course Contents**

- **An Overview of Geosynthetics**: Description of Geosynthetics, Properties, Functions. [4 Lectures]
- **Properties and tests**: Properties of geosyntthetics, standard testing procedures based on applications. [8 Lectures]
- **Soil Reinforcement**: Mechanism, Reinforced slopes, Embankments on soft ground, Reinforced Embankments, Reinforced soil walls and Slope stabilization. [9 Lectures]
- **Geosynthetics for Highways**: Roadway Reinforcement, Separation, Filtration, Drainage, Reinforcement, Moisture Barrier, Membrane encapsulation. [6 Lectures]
- **Ground Improvement applications**: Drainage, PVDs, French Drains, encapsulated sand tubes, on-shore applications. [7 Lectures]
- **Geoenvironmental Applications**: Geomembranes for landfills and ponds, Geosynthetic clay liners, designing with GCL's, Filtration, Erosion control, Slope protection. [8 Lectures]

**Text books:**

1. R. M. Koerner, **Designing with Geosynthetics**, 6th edition, Xlibris Corporation, 2012.
2. G L Sivakumar Babu, **An Introduction to Soil Reinforcement and Geosynthetics**, Universities Press, 2006.

**Reference Books:**

1. G. V. Rao and G. V. S. S. Raju, **Engineering with Geosynthetics**, McGraw Hill Education India Pvt Ltd., 1998.
2. Sanjay Kumar Shukla, **Geosynthetics and their applications**, Thomas Telford Publications, 2002.

## 3.66 CE 552: Concrete Technology

**Course Number: CE 552**

**Course Name: Concrete Technology**

L-T-P-C: 3-0-0-3
Prerequisites: None
Intended for: UG/PG
Distribution: Discipline Elective
Approval: 9th Senate

**Course Contents**

- **History of Concrete construction** [1 Lecture]
- **Introduction to Special concretes**:
  - High strength/performance concrete: Principle, Ingredient properties, Material selection, Design principles, Production, Curing, Properties in fresh state and hardened states, Durability.
  - Self-consolidating concrete: Benefits and Limitations, Properties in fresh and hardened states, design principles and Quality Control.
  - Fibre reinforced concrete: Types of fibres, Structure of matrix, Fibre-Cement interactions, Cracking mechanics.
  - Light weight concrete: Production and properties of No-fines concrete, Aerated and foamed concrete, Lightweight aggregate concrete.
  - Recycled aggregate concrete: Use of industrial, construction and demolition wastes and their effect on concrete properties. [6 Lectures]
- **Cement**: Manufacture, Types, Aspects of hydration. [5 Lectures]
- **Supplementary cementing materials**: Fly ash, Silica fume, Ground granulated blast furnace slag, Metakaolin, Rice Husk Ash ' Characteristics, Properties of mortar and concrete in fresh and hardened states, Durability of concrete. [5 Lectures]
- **Chemical admixtures**: Water reducing agents, Super-plasticizers, Air entertainers, Accelerators, Damp proofers and Corrosion inhibitors. [4 Lectures]
- **Aggregates** -Types and Properties. [4 Lectures]
- **Principles of mix design**. [3 Lectures]
- **Concrete production, Placement and Curing**: Equipment and practices; Formwork for concrete structures: Economy, Pressures on formwork, Forms for beams, columns, slabs and footings, Slipforms and Failures of formwork. [5 Lectures]
- **Module IX**: Introduction to the testing of fresh, mechanical and durability characteristics of concrete. [5 Lectures]
- **Module X**: Introduction to Prescriptive and Performance specifications. [2 Lectures]
- **Quality control**: Nature of variability, Control charts. [2 Lectures]

**Text Books:**


1. A. M. Neville, **Properties of concrete**, 4th Edition, Pearson Education, 1963.
2. Neville and Brooks, **Concrete technology**, Prentice Hall, 2006.
3. Mehta, P.K. and Monteiro, P.J.M., **Concrete: structure, properties and materials**, Prentice Hall, NJ, 2006.
4. Mindess, S., Young, J.F. and Darwin, D., **Concrete**, Prentice Hall, NJ, 2003.

**Reference Books:**

1. Siddique, P. and Khan, M.I., **Supplementary cementitious materials**, Springer, 2011.

2. Rixom, R. and Mailvaganam, N., **Chemical admixtures for concrete**, E & FN SPON, 2002.

3. Aitcin, P.C., **High performance concrete**, E & FN SPON,2011.

4. Bentur, A. and Mindess, S., **Fibre reinforced cementitious composites**, E & FN SPON, 2006.

5. Brito, J.de and Saikia, N., **Recycled aggregate in concrete: use of industrial, construction and demolition waste**, Springer, 2012.

6. Day, K.W., **Concrete mix design, quality control and specification**, E & FN SPON, 2006.

7. Peurifoy, R. L. and Oberlender, G. D., **Formwork for concrete structures**, McGraw Hill, 1996.

8. Dackzo, J.A., **Self-consolidating concrete**, Spon press, 2012.

## 3.67 CE 554: Prestressed Concrete Structures

**Course Number: CE 554**

**Course Name: Prestressed Concrete Structures**

L-T-P-C: 3-0-0-3
Prerequisites: (i) Strength of Materials and Structures (CE301 or equivalent), (ii) Design of Reinforced Concrete Structures (CE351 or equivalent)
Intended for: UG (4th year), PG
Distribution: Discipline Elective (UG) / Elective (PG)
Approval: 15th Senate

**Course Contents**

- **Introduction**: History of development, material and basic concept of prestressing, System of prestressing, Need and types of prestressing, Codes and Standards. [3 Lectures]

- **Analysis of prestressed members**: Basic assumptions, Analysis procedure, Prestress line and internal resisting couple, Concept of load balancing, Stresses in tendons, De-bonding and draping of prestressing tendons, Camber of prestressed member, Indeterminate prestressed concrete structures, Circular prestressing. [6 Lectures]

- **Losses of prestress**: Nature of losses of prestress, Consideration of allowable losses in design. [3 Lectures]

- **Deflection of prestressed concrete members**: Importance of deflection control, Influencing factors, Short term and long term deflection, Deflection of cracked members. [6 Lectures]
- **Prestressed concrete members under flexure, shear and torsion**: Flexural failure and strength analysis, Strain compatibility, Shear and torsion in prestressed mem bers. [7 Lectures]
- **Module VI**: Stress transfer in pretensioned members, Anchorage zone stress in post-tension members, Bursting/ end-block stresses, Transmission and transfer lengths. [3 Lectures]
- **Design of prestressed concrete section**: Limit state design criteria for prestressed concrete members, Design of section for flexure, Design of section for axial tension, Design of section for compression, Design of section for shear and torsion, Design for bond and bearing. [8 Lectures]
- **Design of members**: Design of pretensioned and post-tensioned flexural member, Design of prestressed beam and slab, Partially prestressed member. [6 Lectures]

**Text books:**

1. N.K. Raju, restressed Concrete, 5th Edition, McGraw Hill Education, 2012.
2. P. Dayaratnam, Prestressed Concrete Structures, 5th Edition, Oxford & IBH Publishing Co. Pvt. Ltd., 2016.

**References:**

1. Michael P. Collins and Denis Mitchell, Prestressed Concrete Structures, Prentice Hall, 1994.
2. N. Rajagopalan, Prestressed Concrete, 2nd Edition, Narosa Publishing House, 1994.
3. T. Y. Lin, N. H. Bums, Design of Prestressed Concrete Structures, 3rd Edition, Wiley India Prvate Limited, 2010.
4. A. E. Naaman, Prestressed Concrete Analysis and Design - Fundamentals, McGraw Hill Education, 2013.
5. E. G. Nawy, Prestressed Concrete - A Fundamental Approach, 5th Edition, Prentice Hall International, 2005.
6. IS 1343, Prestressed Concrete - Code of Practice, Bureau of Indian Standards, 2012.

## 3.68 CE 555: Advanced Design of Structures

**Course Number : CE 555**

**Course Name : Advanced Design of Structures**

L-T-P-C: 3-0-0-3
Prerequisites : (i) Design of Reinforced Concrete Structures (CE351) or Equivalent; (ii)

Design of Steel Structures (CE401) or Equivalent
Intended for : UG, PG (MS, MTech), PhD
Distribution : Specialization Core (MTech in Structural Engineering), Elective (UG, MS, PhD)
Approval: 16th Senate

**Course Contents**

- **Module 1**: Design philosophies; Probability distributions and modeling for loading and material strength; Advanced materials and their characteristics. Numerical examples on sampling and acceptance criteria; Reliability of structures. [8 Lectures]
- **Reinforced Concrete Structures**: P-M, M-$\Phi$ relationships; P-M-V-T interaction; Strut-and-tie model; Design of deep beam and corbel; Design considerations for slab; Yield line theory; Strip theory; Design of shear walls; Compression field theory for shear design; Design against torsion; Durability design concept; Provisions form Indian Standards and international design guidelines. Development of computer code for interaction curves; Numerical examples on analyses and design of RC structural components using the advanced theories covered in the lecture; Computer simulation of behavior of RC structural components. [12 Lectures]
- **Steel Structures**: Stability design; Torsional buckling (pure, flexural and lateral); Design of beam- columns; Provisions form Indian Standards and international design guidelines. Numerical examples on analyses of steel structures and design of components using the advanced theories covered in the lecture. [8 Lectures]

**Text Books:**

1. N. Subramaniam, **Design of Steel Structures**, Oxford University Press, 2008.
2. N. Subramanian, **Design of Reinforced Concrete Structures**, Oxford University Press, 2013.

**References:**

1. J.K. Wight, J.G. MacGregor, **Reinforced Concrete: Mechanics and Design**, 6th Edition, Pearson Education, 2016.
2. C.G. Salmon, J.E. Johnson and F.A. Malhas, **Steel Structures: Design and Behavior Emphasizing Load and Resistance Factor Design**, 5th edition, Pearson Education, 2009.
3. T. Pauley, M.J.N. Priestley, **Seismic Design of Reinforced Concrete and Masonry Buildings**, John-Wiley & Sons, 1992.
4. A.H. Nilson, D. Darwin, C.W. Dolan, **Design of Concrete Structures**, 15th edition, McGraw-Hill Education, 2015.
5. D. Menon, S. Pillai, **Reinforced Concrete Design**, 3rd Edition, McGraw Hill Education, 2009.

## 3.69 CE 556P: Structural Engineering Laboratory

**Course Number : CE 556P**

**Course Name : Structural Engineering Laboratory**

L-T-P-C: 0-0-4-2
Prerequisites : NIL
Intended for : PG (MS, MTech, PhD)
Distribution : Specialization Core (MTech in Structural Engineering), Elective (MS, PhD)
Approval: 16th Senate

**Course Contents**

- **Self-Compacting and High-Strength Concrete**: [12 Hours]
  - Mix-design for self-compacting and high-strength concrete
  - ) Stress-strain characterization of self-compacting and high-strength concrete
- **Behavior of Structural Elements**: [16 Hours]
  - Behavior of Reinforced Concrete (RC) beam under flexure and shear
  - Un-symmetrical bending of steel beam
  - Behavior of slab
- **Non-Destructive Testing and Damage Detection** [8 Hours]
- **Model Testing for Dynamic Characterization**: [20 Hours]
  - Free and forced vibrations of structure and evaluation of dynamic characteristics
  - Dynamic Young's modulus, shear modulus, and Poisson's ratio of materials
  - Behavior of frame and shear wall building models under horizontal excitation
  - Time and frequency-domain study for dynamic response analysis

**Textbook:**


1. H.G. Harris, G. Sabnis, **Structural Modeling and Experimental Techniques**, 2nd Edition, CRC Press, 1999.


**References:**


1. W.F. Sharpe, **Springer Handbook of Experimental Solid Mechanics**, Springer, 2008.
2. V.M. Malhotra, N.J. Carino, **Handbook of Nondestructive Testing of Concrete,** 2nd Edition, CRC Press, 2003.
3. R.E. Coleman, **Experimental Structural Dynamics: An Introduction to Experimental Methods of Characterizing Vibrating Structures**, AuthorHouse, 2004.

### 3.70 CE 557: Solid Mechanics in structural engineering

**Course Number: CE 557**

**Course Name : Solid Mechanics in structural engineering**

L-T-P-C: 3-0-0-3
Prerequisites: Strength of Material and Structures (CE 301) or Mechanics of Solids (ME206) or Equivalent
Intended for: UG (Civil)/ M.S./ M.Tech./ Ph.D.
Distribution: Specialization Core (M.Tech. in Structural Engineering)/Elective (UG, MS, PhD, M.Tech)
Semester: Odd/Even
Approval: 16th Senate

**Course Contents**

- **Theories of Stress and Strain**: Stress at a point, Equilibrium equations, Deformation of a Deformable Body, Strain tensor, Transformation of Stress/Strain, Principal Stress/Strains, Strain Compatibility, Strain ' Displacement relations in Cylindrical coordinates, Equilibrium equations in Cylindrical Coordinates, Strain measurement and Strain Rosettes, Hooke?s Law: Isotropic Elasticity, Elastic constants and their relations, Displacement Equations of Equilibrium. [8 Lectures]

- **Plane Strain and Plane Stress**: Plane Stress, Plane Strain, Airy?s Stress function, Differential equation for the stress function, Polar coordinates in the plane, Bending of Cantilever beam, Thick ' walled Cylinder subjected to Internal and External Pressures - Lame?s Problem. [5 Lectures]

- **Bending of Beams**: Nonsymmetrical bending, deflections of beams subjected to Nonsymmetrical bending, Shear flow in thin Wall beam cross section, Bending of Curved Beams (Winkler ' Bach Formula). [7 Lectures]

- **Torsion**: Torsion of Prismatic Bars, Torsion of Circular, Elliptical, Equilateral Triangular and Rectangular bars, Membrane Analogy, Torsion of Thin ' walled tubes. [6 Lectures]

- **Beams on Elastic Foundations**: Infinite beam subjected to a Concentrated/ Distributed Load, Semi - infinite Beam subjected to end loads, short beams. [5 Lectures]

- **Failure Theories and Introduction to Ideally Plastic solid**: (6 hours) Theories of failure, Factor of Safety in Design, Mohr?s Theory of failure, Ideally Plastic solid, Yield Surfaces of Tresca and Von Mises, Stress-Strain Relations (Plastic Flow), Prandtl- Reuss Equation. [6 Lectures]

- **Three-Dimensional elastic half-space**: Elastic half-space subjected to surface point, and distributed loads (Boussinesq problem), Propagation of waves in elastic half-space (dilatation, distortion and surface waves), Introduction to earthquake induced ground vibration. [5 Lectures]

**Text books:**

1. Srinath L.S, **Advanced Mechanics of Solids**, 3rd Edition, Tata McGraw-Hill, 2008.
2. Timoshenko, S.P. and Goodier, J.N, **Theory of Elasticity**, 3rd Edition, McGraw-Hill, 2010.

**References:**

1. K. F. Graff, **Wave Motion in Elastic Solids**, Dover Publications, 1991.
2. M. H. Sadd, **Elasticity: Theory, application and numerics**, 3rd Edition, Elsevier India, 2014.

## 3.71 CE 558: Air pollution and its mitigation

**Course Number : CE 558**

**Course Name : Air pollution and its mitigation**

L-T-P-C: 3-0-0-3
Prerequisites : IC 230 (Environmental Science) for B.Tech.
Intended for : 3rd and 4th year B.Tech., Post-graduate
Distribution : Elective
Approval: 28th Senate

**Course Contents**

- **The atmospheric system**: Vertical profiles of pressure and temperature; atmospheric structure; hydrostatic equilibrium and scale height; stability and lapse rates; temperature inversions; atmospheric dispersion; general circulation and surface winds; timescales of atmospheric transport. [5 Lectures]
- **Basics of atmospheric chemistry**: Photochemical and radical-assisted reactions; daytime vs nighttime and tropical vs polar chemistry; species lifetimes; atmospheric measurement units. [2 Lectures]
- **Stratospheric processes**: Dynamics of stratospheric transport; formation and distribution (latitudinal, seasonal and vertical) of stratospheric O3; UV shielding and effect on climate; role of HOX, NOX and chlorofluorocarbons in catalyzing O3 depletion ' observational evidence, mitigation measures, recovery and challenges. [5 Lectures]
- **Tropospheric gas-phase species**: Local, regional and global pollutants; the oxidizing capacity of the troposphere; constraints on CO and CH4; the CO-HOX-NOX-VOC-O3 cycle; photochemical smog ' case study of Los Angeles, USA; dry and wet removal of pollutants; acidic deposition ' case study of the Northeastern USA; current scenario in Asia and the Indian perspective; mitigation, challenges and opportunities. [8 Lectures]

- **Aerosols**: Historical perspectives on air pollution; physical properties of aerosols ' formation, growth, aging and size distribution; primary vs secondary and externally-vs internally-mixed aerosol; core-shell theory; major aerosol chemical components and their sources; tracers. [7 Lectures]

- **Effects on climate**: Greenhouse effect and interaction of potential greenhouse gases; solar and terrestrial emission spectra; radiative transfer; planetary energy balance; aerosol-light interaction; radiative forcing and global warming potential. [4 Lectures]

- **Air pollution control technologies**: Mitigation technologies in stationary systems ' fluidized bed combustion, integrated gasification combined cycle, flue gas desulfurization, baghouses, scrubbers, cyclone collectors, and electrostatic precipitators; mitigation technologies in mobile systems ' catalytic converters, diesel particulate filters, fuel modification and blending. [6 Lectures]

- **Risk assessment and policy intervention on air pollution**: Link between air pollution and mortality/morbidity; risk assessment for carcinogenic and non-carcinogenic pollutants; air quality indices ' case study of India; air pollution as an externality; ambient, emission and technology standards; policies for air pollution control. [5 Lectures]

**Textbooks:**

1. John H. Seinfeld and Spyros N. Pandis, **Atmospheric Chemistry and Physics: From Air Pollution to Climate Change**, 3rd Edition, Wiley, 2016.

2. Daniel J. Jacob, **Introduction to Atmospheric Chemistry**, Princeton University Press, 2000.

**References:**

1. Barbara J. Finlayson-Pitts and James N. Pitts Jr, **Chemistry of the Upper and Lower Atmosphere**, 2nd Edition, Academic Press, 2000.

2. Noel De Nevers, **Air Pollution Control Engineering**, 2nd Edition, McGraw-Hill, 2000.

3. C. Bard and M. Cann, **Environmental Chemistry**, 5th Edition,W.H. Freeman and Company, 2012.

4. Research articles will be advised as required.

## 3.72 CE 558_52B: Air pollution and its mitigation

**Course Code : CE 558**

**Course Name : Air pollution and its mitigation**

L-T-P-C : 3-0-0-3
Intended for : 3rd and 4th year B.Tech, Post-graduate
Prerequisite : IC 230 (Environmental Science) for B..Tech.

Mutual Exclusion :
Approval: 52nd BoA

**Course Contents**

- **The atmospheric system:**Vertical profiles of pressure and temperature; atmospheric structure; hydrostatic equilibrium and scale height; stability and lapse rates; temperature inversions; atmospheric dispersion; general circulation and surface winds; timescales of atmospheric transport. [5 Lectures]

- **Basics of atmospheric chemistry:** Photochemical and radical-assisted reactions; daytime vs nighttime and tropical vs polar chemistry; species lifetimes; atmospheric measurement units. [2 Lectures]

- **Stratospheric processes:** Dynamics of stratosphenc transport; formation and distribution (latitudinal, seasonal and vertical) of stratospheric Ol; UV shielding and effect on climate; role of HOx, NOx and chlorofluorocarbons in catalyzing 0 3 depletion- observational evidence, mitigation measures, recovery and challenges. [5 Lectures)

- **Tropospheric gas-phase species:** Local, regional and global pollutants; the oxidizing capacity of the troposphere; constraints on CO and CH4; the CO-HOx.NOx.VOC-03 cycle; photochemical smog- case study of Los Angeles, USA; dry and wet removal of pollutants; acidic deposition - case study of the Northeastern USA; current scenario in As ia and the Indian perspective; mitigation, challenges and opportunities. [8 Lectures]

- **Aerosols:** Historical perspectives on air pollution; physical properties of aerosols - form ation, growth, aging and size distribution; primary vs secondary and externally- vs internally-mixed aerosol; core-sh ell theory; major aerosol chemical components and their sources; tracers. [6 Lectures]

- **Air pollution control technologies:** Basics of air pollution control system design - velocities, flow rate, pressure drop, nature of combustion, acid dew point, particle settling and drag forces, diffusion; mitigation technologies in stationary systems - fluidized bed combustion, integrated gasification combined cycle, flue gas desulfurization, baghouses, scrubbers, cyclone collectors, and electrostatic precipitators; mitigation technologies in mobile systems - crankcase, evaporative and tailpipe emissions from automobiles, catalytic converters, diesel particulate filters, fuel modification and blending. [11 Lectures]

- **Risk assessment and policy intervention on air pollution:** Link between air pollution and mortality/morbidity; risk assessment for carcinogenic and non-carcinogenic pollutants; air quality indices- case study of India; air pollution as an externality; ambient, emission and technology standards; policies for air pollution control. [5 Lectures]

**Textbooks:**

1. John H. Seinfeld and Spyros N. Pandis, **Atmospheric Chemistry and Physics: From Air Pollution to Climate Change**, 3rd Edition, Wiley, 2016.

2. Daniel J. Jacob, **Introduction to Atmospheric Chemistry**, Princeton University Press.

3. Noel De Nevers, **Air Pollution Control Engineering**, 2nd Edition, McGraw-Hill, 2000.

## 3.73 CE 559: Biological Wastewater Treatment

**Course Number: CE 559**

**Course Title: Biological Wastewater Treatment**

L-T-P-C: 3-0-0-3
Prerequisites: None
Intended for: UG/M.Tech./MS/PhD
Distribution: Elective

Approval: 28th Senate

**Course Contents**

- **Introduction**: Need for wastewater treatment, Need for sludge treatment, Benefits of biological wastewater treatment, Overview of wastewater treatment processes. [2 Lectures]

- **Water and wastewater quality parameter**: pH and DO, Solids: total, dissolved, volatile and fixed solids, Organic carbon: BOD, COD and TOC, Nitrogen: Total Kjeldahl Nitrogen (TKN), Ammonia-nitrogen (NH3N), Nitrite-nitrogen (NO2N) and Nitrate- nitrogen (NO3N), Phosphorous, Microbial analysis: Most probable number (MPN). [6 Lectures]

- **Process Analysis**: Rate of reaction, Order of reaction, Effect of temperature on reaction rate, Enzyme Reaction and kinetics, Types of reactors: CSTR and plug flow reactor, Reactor analysis, Residence time. [6 Lectures]

- **Biological Systems**: Overview and application in wastewater treatment, Biological growth and kinetics, Half-life and doubling time, Yield and decay, Monod's kinetics, Estimation of kinetic parameters. [6 Lectures]

- **Aerobic Process**: Suspended growth processes: Ponds and lagoons, Activated sludge process: Process description and its modifications, Substrate utilization and biomass growth, Process design, Hydraulic and Solids residence time, Activated sludge process with and without biomass recirculation, Efficiency and loading criteria, Effect of temperature on process performance, Trouble shooting, Attached growth processes: Rotating biological contactor (RBC), Trickling filter. [10 Lectures]

- **Anaerobic Processes**: Process description, Process design, Startup and operation, High-rate anaerobic processes, Biofilm and biofloc processes, Loading criteria and biogas generation rate, Biogas yield and composition, Biogas cleanup and use, Trouble shooting and maintenance, Sludge digestion. [6 Lectures]

- **Downstream Treatment**: Need for nutrient removal, Nitrogen removal processes, Biological nitrification and denitrification, Phosphorus removal, Disinfection. [6 Lectures]

**Textbooks:**

1. George Tchobanoglous, Franklin Burton, H. David Stensel, **Wastewater Engineering: Treatment and Reuse**, 4th Edition, McGraw-Hill International Edition, 2003.

2. Henze, M., Mark C. M. Van Loosdrecht, George A. Ekema, Damir Brdjanovic, **Biological Wastewater Treatment: Principles, Modelling and Design**, IWA Publishing, 1997.

**Reference Books:**

1. Sawyer, C. N., Parkin, G. F. and McCarty, P. L., **Chemistry for Environmental Engineering**, McGraw-Hill, 2008.

2. Bailey, J. E. and Ollis, D. F., **Biochemical Engineering Fundamentals**, 2nd Edition, McGraw-Hill International, 1987.

## 3.74 CE 560: Soil Dynamics

**Course Number: CE 560**

**Course Name: Soil Dynamics**

L-T-P-C: 3-0-0-3
Prerequisites: Geotechnical Engineering I (CE 302), Geotechnical Engineering II (CE 402) or Equivalent course.
Intended for: UG and PG students
Distribution: Discipline Elective
Approval: 28th Senate

**Course Contents**

- **Introduction to soil dynamics**: Importance of soil dynamics, nature and types of dynamic loading, concept of dynamic loading, Simple harmonic motion, degrees of freedom, types of vibration, free and forced vibration, decay of motion, vibration measuring instruments. [8 Lectures]

- **Wave propagation in elastic half space**: Elastic response of continua, Wave propagation in soil media, Earthquake waves, Seismic travel time curve, Three-circle method of estimation of Earthquake epicentre. [6 Lectures]

- **Dynamic soil properties**: Stresses in soil element, concept of soil stiffness, damping ratio and plasticity properties of soil, techniques for estimation of dynamic soil properties from field (intrusive and non-intrusive testing) and laboratory testing. Correlation for obtaining various geotechnical parameters. [6 Lectures]

- **Site response analysis**: Transfer function, homogeneous and layered un-damped and damped soil resting on rigid block, equivalent and non-linear approach of ground response analysis, convolution and deconvolution of the earthquake wave, site classification. [6 Lectures]

- **Liquefaction and lateral spreading**: Concept of liquefaction (static and cyclic), cyclic mobility, estimation of liquefaction potential of soil from field and laboratory testing data, cyclic stress ratio of soil and its importance, post liquefaction lateral spreading of soil, effect of liquefaction on various geotechnical structures. [6 Lectures]

- **Design of machine foundations**: Types of machine foundation, Mass-spring dashpot model, concept of vibration isolation, Tschebotarioff's reduced natural frequency method; Elastic half space method; Vertical, sliding, torsional (yawing) and rocking (and pitching) modes of oscillations; Design guidelines as per codes; Typical design problems. [10 Lectures]

**Textbooks:**


1. Shamsher Prakash, **Soil Dynamics**, McGraw Hill Book Company, 1981.

2. Steven L. Kramer, **Geotechnical Earthquake Engineering**, Prentice Hall, 2003.


**References:**


1. Robert W. Day, **Geotechnical Earthquake Engineering Handbook**, McGraw Hill, 2002.

2. Kenji Ishihara, **Soil Behaviour in Earthquake Geotechnics**, Oxford University Press, 1996.

3. G.V. Ramanna and B.M. Das, **Principles of Soil Dynamics**, CENGAGE Learning, 2011.

4. Richart, F.E., Woods, R.D. and Hall, J.R., **Vibrations of soils and foundations**, Prentice-Hall, 1970.


**Additional Readings**

1. Journal papers in the area of Soil Dynamics.

## 3.75 CE 561: The science of climate change

**Course Number : CE 561**

**Course Name : The science of climate change**

L-T-P-C: 3-0-0-3
Prerequisites: IC 230 (Environmental Science) or equivalent
Intended for: 3rd and 4th year B.Tech., PG
Distribution :Elective
Approval: 38th BoA

**Course Contents**

- **Earth system concepts and early climate**: State of a system and couplings; negative and positive feedback loops; system response to feedbacks; stable and unstable equilibrium states; application of these concepts to the Daisyworld climate system; formation and composition of the early atmosphere, and the effect of early life; the Great Oxidation Event and the ozone shield; early climate and its evolution over time. [5 Lectures]

- **Basics of global climate**: Components of the climate system, timescales and the parameterization problem; basics of energy balance and radiative forcing; atmospheric and oceanic circulation and their role in energy redistribution; conservation of momentum, equations of state, temperature and continuity equations, moist processes, wave processes; natural climate variability - El Nino Southern Oscillation (ENSO) dynamics, ENSO teleconnection and prediction.[7 Lectures]

- **Long-term climate regulation and proxies**: The Faint Young Sun paradox - a C02 and CH4-rich early atmosphere; geological indicators of paleoclimate; isotopic proxies and temperature reconstruction; long-term glacial record and evidence of past glaciations; low-latitude glaciation and the Snowball Earth; banded-iron formations and cap carbonates; Pleistocene glaciations and the Milankovitch Cycles; climate record from the Dome C and Vostok ice cores - evidence of anthropogenic influence. [6 Lectures]

- **The greenhouse effect and climate feedbacks**: Global energy balance model with a 1-layer atmosphere - IR emissions and temperature; magnitude of the greenhouse effect; global warming potential; climate feedbacks and climate sensitivity - water vapour, snow/ice, cloud, lapse rate and stratospheric cooling feedbacks; climate response time and sensitivity in transient climate change - doubling of C02, ocean warmmg. [5 Lectures]

- **Modern climate and human influence**: Climate change during the Holocene and the industrial era; the carbon, nitrogen and water cycles and their perturbations, carbon emission intensity, estimating emissions from the Kaya Identity, C02-equivalents; radiative forcing of other greenhouse gases (CH4 , N20, halocarbons) and aerosols since industrialization. [7 Lectures]

- **Effects of climate change in the polar regions and the Himalayas**: Effects of climate change on the cryosphere; temperature and precipitation trends in the poles and the Himalayas under a changing climate; aerosol deposition, snow cover change and glacier melting; effects on stream flow and water resources; the National Action Plan on Climate Change and the National Mission for Sustaining the Himalayan Ecosystem; resilience and adaptation of Himalayan communities to climate change. [5 Lectures]

- **Climate projections for the future and adaptation/mitigation strategies**: Emission paths and scenarios; globally-averaged response to warming scenarios; coupled climate models, projections and multi-model ensemble averages; mitigation strategies - climate-smart agriculture, energy efficiency, GHG accounting, renewable energy, sustainable urban systems. [7 Lectures]

**Textbooks:**

1. J. David Neelin, **Climate Change and Climate Modeling**, 4th Edition, Cambridge University Press, 2015.
2. Lee R. Kump, James F. Kasting, Robert G. Crane, **The Earth System**, 3rd Edition, Prentice Hall., 2010

**References:**

1. Eckhart Ehlers, Thomas Krafft, **Earth System Science in the Anthropocene**, Springer, 2005.
2. Barbara J. Finlayson' Pitts and James N. Pitts Jr, **Chemistry of the Upper and Lower Atmosphere**, 2nd Edition, Academic Press, 2000.
3. John Marshall and R. Alan Plumb, **Atmosphere, Ocean and C limate Dynamics**, Academic Press, 2007.
4. Relevant IPCC reports: AR5 Climate Change 2013 - The Physical Science Basis; Global Warming of 1.5 C; The Ocean and Cryosphere in a Changing Climate.
5. Research articles will be advised as required.

## 3.76 CE 586P: Mini Project

**Course Code: CE 586P**

**Course Name: Mini Project**

L-T-P-C: 0-0-6-3
Intended for: PG (M. Tech in Structural Engineering)
Distribution: Discipline Core
Approval: 19th Senate

**Course Contents**

There is no regular lecture hours or practical classes for this course as it will be carried out during winter vacations. The students will have to work on their specific projects on their own in a self-learning mode. The supervisor will given necessary inputs or suggestions throughout the work.

## 3.77 CE 587P: Industrial / Academic Internship

**Course Code: CE 587P**

**Course Name: Industrial / Academic Internship**

L-T-P-C: 0-0-2-1
Prerequisites: Mini project (CE 586P)
Intended for: PG (M. Tech in related specilization)
Distribution: Discipline Core

Approval: 18th Senate

### Course Contents

There are no regular lecture hours or practical classes for this course as it will be carried out during winter/summer vacations. The students will have to work on their specific projects relevant to their M. Tech Specialization on their work in a self-learning mode. The supervisor will give necessary inputs or suggestions throughout the work.

Proposal for a New Course

## 3.78 CE 591: Special Topics in Civil and Mechanical Engineering

**Course Number : CE 591**

**Course Name : Special Topics in Civil and Mechanical Engineering**

L-T-P-C: 3-0-0-3
Prerequisites : Solid Mechanics, Higher Engineering Mathematics
Intended for : UG (4th year Civil and Mechanical Engineering), PG (School of Engineering)
Distribution : Elective

### Course Contents

- **Module I**: Physical problems. Mathematical models. Ordinary and partial differential equations. Elliptic, parabolic and hyperbolic equations. Boundary, initial and boundary-initial value problems. [5 Lectures]
- **Module II**: Some analytical solutions for simple idealized problems. Difficulties in obtaining analytical solutions. Numerical solutions. Finite difference methods for partial differential equations. [13 Lectures]
- **Module III**: History of finite element method for structural problems. Finite element method for non structural problems. Finite element method for partial differential equations. [20 Lectures]
- **Module IV**: Finite element software development for solution of some practical problems. [4 Lectures]

### Textbooks:

1. O.C. Zienkiewicz and K. Morgan, **Finite Elements and Approximation**, Dover Publications, 1983.
2. S.C. Chapra and R.P. Canale, **Numerical Methods for Engineers: With Programming and Software Application**, WCB/McGraw-Hill, 1998.

### References:

1. D.V. Hutton, **Fundamentals of Finite Element Analysis**, McGraw Hill Education, 2017.
2. S.S. Rao, **The Finite Element Method in Engineering**, 5th edition, Elsevier, 2011.

## 3.79 CE 600: Research Methodology for Civil Engineering

**Course Code : CE 600**

**Course Name : Research Methodology for Civil Engineering**

L-T-P-C :1-0-0-1
Intended for : MS/MTech(R)/ PhD
Prerequisite :
Mutual Exclusion:
Approval: 54th BoA

**Course Contents (14 Hours)**

- Introduction to research methodology
- Literature search and review
- Technical and scientific writing
- Data analysis and visualization
- Technical and scientific presentation
- Best practices in experimental research
- Best practices in numerical research
- Ethics in research
- Open sourcing, software, data sources
- IPR and outreach
- Time and stress management
- Writing proposals and grants

**Textbooks:**

1. Creswell, J. W., & Creswell, J.D., **Research design: Qualitative, quantitative, and mixed methods approach**, 2017.
2. Sekaran, U., & Bougie, R., **Research methods for business: A skill-building approach**, 2016.

**References:**

1. Notes and other material shared by the concerned faculty

## 3.80 CE 601: Geo-Informatics

**Course Number: CE 601**

**Course Name: Geo-Informatics**

L-T-P-C: 2-0-2-3
Pre-requisite: CE 508 - Photogeology and Photogrammetry; CE 501 - Remote Sensing
Intended for: B.Tech. 4th year/M.S./M.Tech./Ph.D.
Distribution: Elective
Approval: 9th Senate

**Course Contents**

**Module I**: Introduction, concepts and terminology, GIS packages & components of GIS, difference between image processing system and GIS. [5 Lectures]

**Module II**: Elements of Image interpretation, Image formats, Raster and vector data, Data acquisition through scanners and digitizers, methods of digitization. [5 Lectures]

**Digital Data**: spatial & non-spatial; preprocessing, spatial referencing and positioning, rectification and registration, interpolation. [10 Lectures]

**Database structure**: Hierarchical data, network systems, relational database, and data management in GIS. [3 Lectures]

**Module V**: Data visualization, data manipulation, overlay, buffering, interpolation, query analysis, mathematical operations on data. [9 Lectures]

**Module VI**: Project based application of GIS for various natural resources mapping & monitoring and for engineering applications. [10 Lectures]

**Text Books:**

1. Kang-Tsung Chang, **Introduction to geographic information systems**, 8th Edition, McGraw-Hill Education, 2015.
2. JR Jensen, and RR Jensen, **Geographic information systems : Exercise workbook**, Pearson College Division, 2013.
3. M A. Gomarasca, **Basics of Geomatic**s, Springer, 2009.
4. P A. Longley, M Goodchild, D J. Maguire, D W. Rhind, **Geographic Information Systems and Science**, 3rd Edition, John Wiley, 2010.

**Reference Books:**

1. P.A. Burrough, and R.A., McDonnell, **Principles of Geographic Information for Land Resources Assessment**, Oxford University Press, USA, 1998.
2. M.N., DeMers, **Fundamentals of Geographic Information System**, 3rd Edition, John Wiley, 2008.
3. M. Neteler, and H. Mitasova, **Open source GIS : GRASS GIS approach**, Springer, 2008.
4. R S. Lunetta, J G. Lyon, **Remote Sensing and GIS Accuracy Assessment**, CRC Press, 2005.

## 3.81 CE 602 : Blast Engineering

**Course Code: CE 602**

**Course Name : Blast Engineering**

L-T-P-C : 3-0-0-3
Intended for : UG/PG elective
Prerequisite : Structural Dynamics (CE511) or Soil Dynamics (CE 560) or equivalent
Mutual Exclusion : None
Approval: 45th BoA

**Course Contents:**

- **Module 1:** Risks, Threat, and vulnerability Assessment, different scenarios: accidental or terrorism, chemical, or nuclear, sources of explosion and explosive devices, introduction to different types of problems through case-studies. [5 hours]
- **Module 2:** Basic physics of shock/explosion phenomena, internal and external explosions, nuclear and chemical explosions, characteristics of blast loads, ideal and non-ideal blast waves, penetration (in concrete, rock, soil), fragmentation, ground shocks, shock wave propagation, cratering and ejecta phenomena. [10 hours]
- **Module 3:** Blast load on buried structures, above ground structures, surface-flush and mounded structures, nuclear loads, soil arching, computing pressure-time curves for different structural components, dynamic behavior of materials (concrete, steel, rock, soil), dynamic response of idealized systems to blast loads (SDOF, MDOF, continuous systems, practices in design codes, equivalent SDOF approach, dynamic flexure and shear behavior), brief introduction to advanced computational tools (such as hydrocodes, LS-DYNA, AUTODYN, DYNA-2D) and methods. [12hours]
- **Module 4:** Shock spectra, Pressure-impulse diagrams, their application in design, closed-form solution, energy balance approach, dynamic models (flexure, shear, resistance function, failure modes) and design/construction aspects for protective structures (connections, openings, site-selection, shock isolation, equipment protection, etc.), progressive collapse under blast load. [10 hours]
- **Module 5:** Current design practices, design and safety considerations as per national and international standards challenges, issues & prospects, industrial needs, interaction with industry/field experts. [5 hours]

**Textbooks:**

1. Prasad, BK Raghu, **Structural Dynamics in Earthquake and Blast Resistant Design**, CRC Press, 2020.
2. Hetherington, John, and Peter Smith, **Blast and ballistic loading of structure**s, CRC Press, 2014.

**References:**


1. Ramamurthi, K., **Explosions and Explosion-Safety**, Tata McGraw-Hill Education, 2010.

2. Dusenberry, Donald O., ed. **Handbook for blast resistant design of buildings**, John Wiley & Sons, 2010.

3. Mays, Geoffrey, Peter Desmond Smith, and Peter David Smith, eds., **Blast effects on buildings: Design of buildings to optimize resistance to blast loading**. Thomas Telford, 1995.

4. Baker, Wilfred Edmund, P. A. Cox, J. J. Kulesz, R. A. Strehlow, and P. S. Westine, **Explosion hazards and evaluation**, Elsevier, 2012.

5. Krauthammer, T., **Modern protective structures**, CRC Press, 2008.

6. Bangash, Mohammad Yusaf Hassan., **Shock, impact and explosion: Structural Analysis and Design**, Springer Berlin Heidelberg, 2009.

7. UFC (Unified Facilities Criteria). 2008. Structures to resist the effects of accidental explosions. Rep. No. UFC 3-340-02. Washington, DC: US Army Corps of Engineers, Naval Facilities Engineering Command, Air Force Civil Engineer Support Agency.

8. ASCE. 1985. Design of structures to resist nuclear weapons effects. Manual of Practice 42. Reston, VA: ASCE

9. IS 4991: 1968 (reaffirmed 2003): Criteria for Blast Resistant Design of Structures for Explosions Above Ground.


## 3.82 CE 604 : Theory of Plasticity

**Course Code : CE 604**

**Course Name : Theory of Plasticity**

L-T-P-C : 2-1-0-3

Intended for : P.G. (M.Tech Structure, Design, etc., M.Tech by Research, and Ph.D.)

Prerequisite : Strength of Materials and Structures, Structural Analysis, Theory of elasticity, advanced solid mechanics

Mutual Exclusion :

Approval: 52nd BoA

**Course Contents**

- **Introduction:** Fundamental principles ofplasticity, Basic laws of plasticity, Index notations. (4 Lectures)

- **Criteria of yielding:** Maximum stress theory, Maximum strain theory, maximum shear theory, maximum strain energy theory, Distortion energy theory, Mohr's theory of yielding, Yielding surfaces. (6 Lectures)

- **Plastic stress strain relations**: Strain relations, Distinction between Elastic and Plastic Stress- Strain Relations, Plastic work, Derivation ofPlastic Stress- strain relations. (6 Lectures)
- **Elastoplastic Problems of Spheres and Cylinders:** General relations, thick hollow sphere with internal pressure and thermal loading, Hollow sphere- Spread of Plastic Zone, Residual Stresses and Strain hardening material. (8 Lectures)
- **Plane problems in plasticity:** Beltrami- Michell equation, Plastic Bending of Plates, Deflection of Circular Plates, Plane Strain Analogy for Plate Bending, Yield Line theory for Plates, Axis symmetric case, General theorems of plasticity, Drucker's postulates, Integration of Plasticity Equation. (8 Lectures)
- **The Torsion problem:** Torsion of Prismatic Bar, General relations, elasticity solutions, perfect plasticity, elastoplastic torsion with strain hardening, bar with rectangular cross-section, bar with circular cross-section. (6 Lectures)
- **Module VII:** Slip-Line Field and limit analysis. (4 Lectures)

**Textbooks:**

1. J. Chakrabarty, **Applied Plasticity**, 2nd Edition, Springe.
2. Alexander Mendelson, **PLASTICITY: Theory and Application**, The Macmillan Company, New York.
3. Jacob Lubliner, **Plasticity Theory**, Courier Corporation, 2008.

**Reference Books:**

1. R. M. Jones, **Deformation theory of plasticity**, Bull Ridge Publishing.
2. Akhatar S khan Sujain Huang, **Continuum Theory of Plasticty**, John Wiley and sons.
3. L.M. Kachanov, **Fundamentals Theory of Plasticty**, Dover Publication.
4. Jacob Lubliner, **Plasticity theory**, Dover Publications.

## 3.83 CE 605: Engineering Seismology and Seismic Hazard Assessment

**Course Number: CE 605**

**Course Name: Engineering Seismology and Seismic Hazard Assessment**

L-T-P-C: 3-0-0-3
Credits Prerequisites: Structural Dynamics with Application to Earthquake Engineering (CE 511) or equivalent course
Intended for B.Tech. 4th year / M.S./ M.Tech./ Ph.D.
Distribution: Discipline Elective (UG, 4th year); Discipline Elective (PG)
Approval: 15th Senate

**Course Contents**

- **Introduction**: Internal Structure of the Earth; Plate tectonics and boundaries; Faults; Focal mechanisms; Location of Earthquakes; Size of Earthquakes; Major Earthquakes in the world; Important Indian Earthquakes. [5 Lectures]

- **Wave Propagation in Elastic Medium**: Waves in Infin ite Medium; longitudinal and Shear waves; Waves in Semi - infinite medium; Reflection and refraction of waves; Rayleigh waves and Love waves; Response of an elastic Half - Space due to surface and buried forces. Seismic moment tensor. Time dependence. [11 Lectures]

- **Strong Ground Motion and Parameters**: Strong - Motion measurement; International and Local strong motion networks; Synthetic strong ground motions; Stoch asticseis mological models; Empirical Green's Function method; One - Dimensional Ground response analysis; Ground motion parameters. [12 Lectures]

- **Seismic Hazard Analysis**: Definitions - seismic hazard, disaster and risk; Deterministic seismic hazard analysis; Probability; Earthquake occurrence models; Estimation of maximum magnitude, maximum credible earthquake, design basis earthquake; Ground motion prediction equations; Return periods and strong motion exceedance rates; seismic Hazard curves; Deaggregation. Seismic microzonation, Case studies/Project on estimating the seismic haza rd of important Himalayan Cities. [14 Lectures]

**Text books:**


1. S. L. Kramer, Geotechnical Earthquake Engineering, 2nd Edition, Person Education, 2004.

2. K. F. Graff, Wave Motion in Elastic Solids, Dover Publications, 1991.


**References**


1. D. M. Boore, Simulation of Ground Motion Using the Stochastic Method, Pure and Applied Geophysics, 160, 635 - 676, 2003.

2. Keiiti AKI and Paul G Rich ards, Quantitative Seism ology, 2nd Edition, University Science Books, 2002.

3. A. Udias, Principles of Seismology, Cambridge University Press, 1999.

4. NOMA, Development of probabilistic seismic hazard map of India, Technical Report, Working Committee of Experts (WCE), National Disaster Managem ent Authority (NOMA), 2011

5. NPTEL course on **Geotechnical Earthquake Engineering** (online resources).

## 3.84 CE 606: Constitutive Modeling of Fri ctional Material

**Course Number: CE 606**

**Course Name: Constitutive Modeling of Frictional Material**

L-T-P-C: 3-0-0-3
Prerequisites: Geotechnical Engineering I (CE302) or Equi valent/ Mechanics of Solids (ME206) or Equi valent
Intended for: B.Tech. 4th year/ M.S./ M.Tech./ Ph.D.
Distribution: Open Elective
Approval: 15th Senate

**Course Contents**

- **Mathematical Background**: Overview and importance of constitutive modeling; Preliminaries on tensor; Stress, strai n and invariants; Principal stress space: triaxia land octahedral plane; Stiffness tensor; Voigt notation. [6 Lectures]

- **Constitutive Behavior of Gcomaterials**: Different laboratory tests and various modeling aspects pertinent to the stress-strain behaviour of geomaterials subjected to shearing and volumetric compression, e.g., void ratio, pressure and stress path dependency, an isotropy and rate/time effects etc. [3 Lectures]

- **Elasticity**: Linear, nonlinear and anisotropic elastic models; Calibration of model parameters. [6 Lectures]

- **Plasticity**: Internal variable, yield criteria, flow rule, plastic potential, Drucker's stabilit y postulate, convexity and normality rules, hardening/ softening, isotropic and kinematic hardening; Different failure criteria for yielding: Tresca, von Mises, Mohr-Coulomb, Drucker-Prager, Hoek and Brown etc. [7 Lectures]

- **Critical State Models**: Critical state concept; Stress-dilatancy theory; Strain hardening and/or work hardening plasticity models for sand: formulation, calibration and implementation to simulate drained and undrained triaxial test. [6 Lectures]

- **Cam-Clay Models**: Cam-Clay models: formulation and calibration ; Implementati on of Cam-Clay model to simulate single element tests: consolidation, drain ed and undrain ed triaxial test, Application of elasto-plastic models. [10 Lectures]

- **Special topics**: Other advanced constitutive models for frictional materials (e.g., damage plasticity/ v isco plasticity/ unsaturated soil model / disturbed state model etc.) [4 Lectures]

**Text Books:**


1. David Muir Wood, **Soil Behaviour and Critical State Soil Mechanics**, Cambridge University Press, 1991.

2. Alexander Puzrin, **Constirutive Modelling in Gcomcchanics**, Springer, 2012.

**References:**


1. David Muir Wood, **Geotechnical Modelling**, CRC Press Taylor and Francis Group, 2004.
2. W.F. Chen and E. Mizuno, **Nonlinear analysis in soil mechanics: theory and implementation**, Elsevier Science Ltd, 1990.
3. Hai-Sui Yu, **Plasticity and Geotechnics**, Springer, 2006.
4. W.F. Chen and G.Y. Baladi, **Soil Plasticity: Theory and Implementation**, El sevier Science Ltd, 1985.
5. C.S. Desai, **Mechanics of Materials and Interfaces: The Disturbed State Concept**, CRC Press, 2000.
6. N.S. Ottosen and M. Ristinmaa, **The Mechanics of Constitutive Modeling**, Elsevier Science, 2005.
7. J.C. Simo and T.J.R. Hughes, **Computational Inelasticity**, Springer, 2000.
8. E.A. de Souza Neto, D. Peric and D.R.J. Owen , **Computational Methods for Plasticity: Theory and Applications**, Wiley, 2008.
9. Allan F. Bower, **Applied Mechanics of Solids**, CRC Press, 2009.


## 3.85 CE 610: Analysis and Design for Earthquake Resistant Structures

**Course Number: CE 610**

**Course Name : Analysis and Design for Earthquake Resistant Structures**

L-T-P-C: 3-0-0-3
Prerequisites : Structural Dynamics with Application to Earthquake Engineering (CE 511) or Equivalent
Intended for: M.Tcch. (Structural Engineering); UG (4th year), PG (M.S., Ph.D.)
Distribution : Elective (UG/PG)/ Specialization Elective (M.Tech. - Structural Engineering)
Approval: 19th Senate

**Course Contents**

- **Basic Concepts**: Behavior of structurs and struc.rural components under earthquake loading; Introduc tion to cisrnology; Seismic inputs to structures; Exampl es or earthquake resistant structures and their behavior during actual earthquakes. [4 Lectures]
- **Seismic Design Philosophy**: Ilistorical development of earthquake resistant design philosophy; Concept of strength) overstrength und ductility; Concept of equal displacement and equal energy principles, c.apacity design. [4 Lectures]

- **Modeling and Analysis of Buildings**: Equivalent static analysis; Response spectrum analysis; Mode superposition method; Time history analysis; Non-linear analysis consideration; Pushover analysis; Modeling concept of reinforce-d concrete building; Consideration of irregularities in seismic design of buildings; Introduction to modeling and analysis of reinforced masonry buildings; Simulation of structures using soflware for seismic analysis. [12 Lectures]

- **Seismic Design of Building Components**: Earthquake resistant properties of reinforced concrete; Seismic behavior and design of linear reinforced c.oncrete elements; Seismic behavior of planar reinforced concrete elements; Codal provisions; Detailing for ductility; Design guidelines specific for reinrorced masonry building; Earthquake resistant design considerations for steel structmes. Consideration for computer aide.d sei smic design using software simulation. [14 Lectures]

- **Advanced Topics in Earthquake Resistant Design**: Performance based earthquake engineering; Introduct ion to eanhquake resistam design for special structures; Retrofitting and trengthening of structures; Concept of base isolat ion technique and other seismic vibration control. [8 Lectures]

**Textbooks:**

1. Pauley T. and Priestley M.J.N., **Seismic Design or Reinlorced Concrete and Masonry Buildings**, John-Wiley & Sons, 1992.

2. Datta T.K., **Seismic Anal ysis of Structures**, John Wiley & Sons (Asia) Pte Ltd, 2010.

**References:**

1. Chopra A.K., **Dynamics of Structures- Theory and Application to Earthquake engineering**, 5th Edilion, Pearson Education I ndia, 2017.

2. Shrikhande M., Agrawal P., **Earthquake Resistant Design of Structures**, Prentice Hall India Learning Private Limited, 2006.

3. Taly N., **Design of Reinforced Masonry Structures**, 2nd Edition, McGraw-Hill Education, 2010.

4. Rai D.C. (2005), **IITK-GSDMA Guidelines for Structural use of Reinforced Masonry - Provisions with Commentary and Explanatory Examples**, IIT Kanpur, Gujrat State Disaster Mitigation Authority.

5. ATC-40, **Seismic Evaluation and Retrofit of Concrete Building** - Vol. I &II, Applied Technology Council, 1996.

6. AISC 341-10, **Seismic Provisions for Structural Steel Buildings**, American Institute ofSteel Construction, 2010.

7. Naeim F., Kelly J.M., **Design of Seismic Isolated Structures: From Theory to Practice**, John Wiley & Sons, 1999.

8. IS 189J (Part I ), **Criteria for Earthquake Resistant Design of Stntctures: Part I General Provisions and Buildings**, Bureau of lndian Standard, 2016.

9. IS 13920, **Ductile Dcsign and Detailing of Reinforced Concrete Structures Subjected to Seismic Forces-Code of Practice**, Bureau oflndian Standard, 2016.


## 3.86 CE 611: Structural Health Monitoring

**Course Code: CE 611**

**Course Name: Structural Health Monitoring**

L-T-P-C: 3-0-0-3
Prerequisites: Strength of Materials and Structures – CE 301 and Structural Dynamics with Application to Earthquake Engineering – CE 511 or equivalent
Intended for: UG and PG
Distribution: Discipline Elective (UG and PG)
Approval: 19th Senate

**Course Contents**

- **Module I**: Introduction to SHM, brief history structural rehabilitation, Condition monitoring, Infrastructure management, Components of SHM, Sensors and Instrumentation, Measurement noise and precision. [4 Lectures]
- **Module II**: Non-destructive evaluation based methods: Acoustic emission based, Ultrasonic testing, Eddy current based method, Radiographic imaging based. [4 Lectures]
- **Module III**: Vibration based methods, basic procedures (Operational evaluation, data acquisition fusion and cleansing), feature extraction, feature discrimination, Modal information based approaches: Model independent methods, frequency based (forward and inverse), Mode shape and modal curvature based methods, Modal information based approaches: Model dependent methods, Direct matrix update, Parameter optimization, soil computing based methods. [15 Lectures]
- **Module IV**: [4 Lectures]

## 3.87 CE 612: Theory of Plates and Shells

**Course Number: CE 612**

**Course Name: Theory of Plates and Shells**

L-T-P-C: 3-0-0-3
Prerequisites: Theory of Elasticity, Advance Solid Mechanics (CE 557, ME 606)
Intended for: M.Tech./M.S./Ph.D./ B. Tech (3rd and 4th Year)
Distribution: Elective
Approval: 24th Senate

**Course Contents**

- Introduction to classical plate theory and governing equations, stress resultants, boundary conditions. [6 Lectures]
- Solution of bending of rectangular plates using Navier and Levy methods. [6 Lectures]
- Bending of circular plates. [6 Lectures]
- Vibration and buckling of rectangular and circular plates. [6 Lectures]
- Introduction to surfaces, Strain displacement relations in curvilinear coordinates, Classification of shells. [6 Lectures]
- Membrane theory of shells and governing equations, stress resultants, boundary conditions. [6 Lectures]
- Analysis of axisymmetric shells. [6 Lectures]
- Bending, buckling and vibration of circular cylindrical shells. [6 Lectures]

**Textbooks:**

1. S.P. Timoshenko and S. Woinwosky-Kriegger, **Theory of Plates and Shells**, 2nd Edition, McGraw Hill, 2010.
2. W. Soedel, **Vibrations of Shells and Plates**, Marcel Dekker, 2004.
3. D.O. Brush and B.O. Almorth, Buckling of Bars, Plates and Shells, McGraw Hill, 1975.

**References:**

1. H. Kraus, **Thin Elastic Shells**, John Wiley and Son, 1967.
2. E. Ventsel and T. Krauthammer, **Thin Plates and Shells Theory, Analysis, and Applications**, Marcel Dekker, 2001.
3. K. Chandrashekhara, **Theory of Plates**, Universities Press, 2001.
4. J.N. Reddy, **Theory and Analysis of Elastic Plates and Shells**, CRC Press, 2006.

## 3.88 CE 613: Mechanics of Unsaturated Soils

**Course Code : CE 613**

**Course Name : Mechanics of Unsaturated Soils**

L-T-P-C: 3-0-0-3
Intended for : UG and PG students
Prerequisite : Geotechnical Engineering I (CE302), Geotechnical Engineering II (CE 402) or equivalent course.
Mutual Exclusion : None
Approval: 50th BoA

**Course Contents:**

- **Introduction to Unsaturated Soil Mechanics**: Role of climatic conditions, Need and application areas of unsaturated soil mechanics, Typical profile of unsaturated soils (2 Hours)
- **Phase Properties and Stress state variables**: Properties of individual phases, Interaction of air and water, Volume-mass relations, Effective stress for unsaturated soils, Stress state variables, Limiting stress state conditions and experimental testing of stress state variables (8 Hours)
- **Measurement of soil suction**: Theory of soil suction, Capillarity, Measurement of Total suction, Matric suction, and Osmatic suction (8 Hours)
- **Flow behaviour in unsaturated soils**: Flow of water, Driving potential for water phase, Darcy's law, coefficient of permeability with respect to water phase, steady state flow (8 Hours)
- **Shear strength of unsaturated soils**: Failure envelope for unsaturated soils, Triaxial and direct shear tests on unsaturated soils (8 Hours)
- **Stress-deformation analysis for unsaturated soils**: Swelling pressure determination, 1-D Heave estimation, Foundation design in expansive soil (6 Hours)

**Textbooks:**

1. Fredlund, D.G., Rahardjo, H., and Fredlund, M.D., **Unsaturated Soil Mechanics in Engineering Practice**, 2nd Edition, John Wiley & Sons, Inc., 2012.
2. Lu, N., and Likos, W.J., **Unsaturated Soil Mechanics**, 1st Edition, John Wiley & Sons, Inc., 2004.

**References:**

1. Ng, Charles, W.W., and Menzies, B., **Advanced Unsaturated Soil Mechanics and Engineering**, Taylor and Francis, 2007.
2. Blight, G.E., **Unsaturated Soil Mechanics in Geotechnical Practice**, Taylor and Francis, 2013
3. Refereed publications in the field of unsaturated soil mechanics

## 3.89 CE 688P: Post Graduate Project - 1

**Course Code: CE 688P**

**Course Name: Post Graduate Project - 1**

L-T-P-C: 0-0-28-14
Intended for: M. Tech in Structural Engineering Specialization
Distribution: Discipline Core

Approval: 55th BoA

**Revision**: Original Credit Structure was: 0-0-24-12, approved in 28th Senate. Revised to 0-0-28-14 in 55th BoA.

### Course Contents

A the beginning of the semester the students have to present their project topics and planned to work to be carried in next few months. At the end of the semester they may have to submit a report and must give presentation based on their complete work and future plans.

### Reference Books:

1. As suggested by Supervisor
2. As the students find necessary during working on their research project.

## 3.90 CE 689P: Post Graduate Project - II

### Course Code: CE 689P

### Course Name: Post Graduate Project - II

L-T-P-C: 0-0-30-15
Intended for: M. Tech in Structural Engineering Specialization
Prerequisites: Post Graduate Project - I
Distribution: Discipline Core
Approval: 55th BoA
**Revision**: Original Credit Structure was: 0-0-34-17, approved in 28th Senate. Revised to 0-0-30-15 in 55th BoA.

### Course Contents

At the end of the semester the students have to submit a detailed technical report and must give a presentation based on their completed work. A committee shall be formed to evaluate the students' performance during the entire period through their report and seminars. Reference Books: As suggested by Supervisor As the students find necessary during working on their research project.

### Reference Books:

1. As suggested by Supervisor
2. As the students find necessary durin

# 4 Computer Science and Engineering Coureses

## 4.1 CS 201: Computer Organization

### Course Code: CS 201

### Course Name: Computer Organization

L-T-P-C: 3-0-0-3
Prerequisites: None
Intended for: UG
Distribution: Institute Core
Semester: V
Approval: 9th Senate

### Course Contents

- **Digital Logic and Data Representation** Introduction to digital logic (logic gates, flip-flops, circuits); Logic expressions and Boolean functions; adder, subtractor, Design of arithmetic and logic unit (ALU)., Representation of numeric data, signed and unsigned arithmetic; Range, precision and errors in floating-point arithmetic; Representation of text, audio and images.

- **Computer Architecture and Organization** History of the digital computer; Introduction to instruction set architecture, micro architecture and system architecture; Instruction sequencing, flow-of-control , subroutine call and return mechanisms; Structure of machine-level programs; Low-level architectural support for high- level languages.

- **Interfacing and I/O strategies** I/O fundamentals: handshaking and buffering; Interrupt mechanisms; vector and prioritized, interrupt acknowledgement; Buses: protocols, arbitration, direct memory access(DMA); Examples of modern buses: e.g. PCIe, USB, Hyper transport.

- **Memory Architecture** Storage systems and their technology, Storage standards (CD-ROM,DVD); Memory hierarchy, latency and throughput; Cache memories-operating principles, replacement policies, multilevel cache, virtual memory system: page table and TLB, cache coherency

- **Functional Organization** Review of register transfer language to describe internal operations in a computer; CISC vs RISC Designs simple implementation schemes datapath design, control unit Micro architectures- hardwired and micro programmed realizations; Instruction pipelining and instruction-level parallelism (ILP); Overview of superscalar architectures; Processor and system performance; Performance their measures and their limitations.

### CO Lab:

1. The assignment will be designed to assist the theory covered in the class:

2. Some examples are given as follows:

3. Design adder, subtractor in breadboard
4. Designing ALU (Arithmetic and Logical Unit) in breadboard
5. Programming in assembly language and perform some basic operations addition, subtraction, sorting

**Text books:**

1. C.Hamacher, Z.Vranesic and S.Zaky, **Computer Organization**, 5th Edition, McGraw-Hill, 2002.
2. J.P.Hayes, **Computer Architecture and Organization**, 3rd Edition.
3. D. A. Patterson and J.L.Hennessy, **Computer Organization and Design - The Hardware/Software Interface**
4. William Stallings, **Computer Organization & Architecture designing for performance**, 7th Edition.

## 4.2 CS 201P: Computer Organization Laboratory

**Course Code: CS 201P**

**Course Name: Computer Organization Laboratory**

L-T-P-C: 0-0-2-1
Prerequisites: None
Intended for: UG
Distribution: Discipline Core
Semester: V
Approval: 9th Senate

**Course Contents**

Lab assignments (listed below) require 3 hours in the lab, preceded by at least 3 hours at home. The weekly assignments would be targeted at understanding the concepts covered in the theory course. Some examples of the structure of assignment is as follows:

- Week 1 Getting familiarity in the Verilog/VHDL programming.
- Week 2-3 Design and simulation of simple combinational and sequential circuits (flip flops) using Verilog/VHDL programming.
- Week 4 Design and similation of 16-bit signed and unsigned integer adder-subtractor circuit.
- Week 5 Design and similation of 16-bit signed and unsigned integer multiplication circuit using carry save addition.
- Week 6 Design and similation of 16-bit signed and unsigned integer combinational division circuit using non-restoring procedure.

- Week 7 Design and similation of 16-bit signed and unsigned arithmatiac and logic unit (ALU) as a single unit by combining all the circuits simulated from week 2-7.
- Week 8-13 Programming in assembly language, e.g., assembly language in IA32 architecture

**Text books**

1. Sivarama P. Dandamudi, **Guide to Assembly Languag Programming in Linux**, Springer, 2005.

## 4.3 CS 202 (4) Advanced Data Structure and Algorithms

Senate: 8th
Approval: 9th Senate
Equivalent Course / Modified to: CS 202 Data Structure and Algorithms

**Course Outline:**

After the students have gone through a course on discrete structures, where they learn the formal and abstract representations of data and its manipulation, a course on data structures and algorithms should teach the students concrete implementations and manipulation of such discrete structures and their use in design and analysis of non-trivial algorithms for a given computational task. On completion of such a course, students should be able to ‘ analyse the asymptotic performance of algorithms - demonstrate their familiarity with major data structures, rule to manipulate those, and their canonical applications - construct efficient algorithms for some common computer engineering design problems Further, as programming is an integral part of the CS education, in this course students should implement the data structures and algorithms they learn, compute the corresponding achievable performance (computation time, memory requirement, etc), and if possible compare the achievable performance with alternative designs.

## 4.4 CS 202: Data Structures and Algorithms

**Course Code: CS 202**

**Course Name: Data Structures and Algorithms**

L-T-P-C: 3-1-0-4
Prerequisites: IC-250 Programming and Data Structure Practicum
Intended for: UG
Distribution: Compulsory for CSE; CS elective for EE and ME
Semester: 4th
Approval: 5th, 9th, 12th Senates

**Coruse Contents**

- **Complexity Analysis** Time and Space complexity of algorithms, asymptotic analysis, average and worst case analysis, asymptotic notation, importance of efficient algorithms, program performance measurement, data structures and algorithms. [2 Lectures]

- **Stacks and Queues** Abstract data types, sequential and linked implementations, representative applications such as towers of Hanoi, parenthesis matching, finding path in a maze. [4 Lectures]

- **Lists** Abstract data type, sequential and linked representations, comparison of insertion, deletion and search operations for sequential and linked lists, list and chain classes, doubly linked lists, circular lists, skip lists, applications of lists in bin sort, radix sort, sparse tables. [6 Lectures]

- **Dictionary** Abstract data type, array and tree based implementations. [1 Lecture]

- **Hashing** Search efficiency in lists and skip lists, hashing as a search structure, hash table, collision resolution, universal hashing, linear open addressing, chains, hash tables in data- compression, LZW algorithm. [4 Lectures]

- **Trees** Abstract data type, sequential and linked implementations, tree traversal methods and algorithms, Binary trees and their properties, threaded binary trees - differentiation, leftist trees, tournament trees, use of winner trees in mergesort as an external sorting algorithm, bin packing. [8 Lectures]

- **Search Trees** Binary search trees, search efficiency, insertion and deletion operations, importance of balancing, AVL trees, searching, insertion and deletions in AVL trees, Tries, 2-3 tree, B-tree. [4 Lectures]

- **Heaps** Heaps as priority queues, heap implementation, insertion and deletion operations, binary heaps, binomial and Fibonacci heaps, heapsort, heaps in Huffman coding. [3 Lectures]

- **Graphs** Definition, terminology, directed and undirected graphs, properties, implementation adjacency matrix and linked adjacency chains, connectivity in graphs, graph traversal breadth first and depth first, spanning trees. [4 Lectures]

- **Basic algorithmic techniques** Greedy algorithms, divide & conquer, dynamic programming. Search techniques - backtracking, Sorting algorithms with analysis, integer sorting, selection sort. Graph algorithms: DFS and BFS with applications, MST and shortest paths. [6 Lectures]

**Reference Books:**

1. S. Sahni, **Data Structures, Algorithms, and Applications in C++**, 2nd Edition, Silicon Press, 2005.

2. T. H. Cormen, C. E. Leiserson, R. L. Rivest, and C. Stein, **Introduction to Algorithms,** 3rd Edition, MIT Press, 2009.

3. A. M. Tenenbaum, Y. Langsam, and M. J. Augenstein, **Data Structures Using C and C++**, 2nd Edition, Prentice Hall, 1995.

## 4.5 CS 203: Discrete Structures

**Course Code: CS 203**

**Course Name: Discrete Structures**

L-T-P-C: 3-0-0-3
Students intended for 2nd year B. Tech. CSE
Elective or Compulsory: Compulsory
Prerequisites: None

Approval: 3rd Senate

**Course Contents**

- Logics and Proofs: Propositional Logic, Applications of Propositional Logic, Propositional Equivalences, Predicates and Quantifiers, Nested Quantifiers, Rules of Inference, Introduction to Proofs, Proof Methods and Strategies.
- Sets, Functions, Sequences, Sum, and Matrices: Sets, Set operators, Functions, Sequences and Summations, Cardinality of Sets, Matrices
- Counting and Discrete Probability: Basics of Counting, Pigeonhole Principle, Permutations and Combinations, Introduction to Discrete Probability, Probability Theory, Bayes Theorem, Expected Value and Variance
- Relations: Relations and Their Properties, n-ary Relations and Their Applications, Representing Relations, Closures of Relations, Equivalence Relations, Partial Orderings
- Graphs: Graphs and Graph Models, Representing Graphs and Graph Isomorphism, Connectivity, Euler and Hamilton Paths, Shortest-Path Problems, Planar Graphs, Graph Coloring
- Trees: Introduction to Trees, Application of Trees, Tree Traversal, Spanning Trees, Minimum Spanning Trees
- Boolean Algebra and Modeling Computation: Boolean Algebra, Representing Boolean Functions, Logic Gates, Minimization of Circuits, Language and Grammars, Finite-State Machines, Language Recognition, Turing Machines

**Readings (including but not restricted to the following):**


1. Kenneth Rosen [KR], **Discrete mathematics and its applications**, 6th Edition, McGraw-Hill Science/Engineering/Math, 2006.


**Reference Books:**


1. C. Liu, D. Mohapatra[CM], **Elements of Discrete Mathematics**, Tata McGraw-Hill, 2008.
2. T.Koshy [TK], **Discrete mathematics with applications**, Academic Press, 2003

3. J. Hein [JH], **Discrete structures, logic and computability**, Jones & Bartlett Publishers, 2009.

## 4.6 CS 204: Introduction to Database

**Course Code: CS 204**

**Course Name: Introduction to Database**

L-T-P-C: 3-0-0-3
Category:
Prerequisites: None
Approval: 5th Senate

**Course Contents**

- Introduction, ER model, Relational model & algebra, Relational calculus, SQL, File organisation&indexing, Dependencies & normalization, Database tuning, Transactions, concurrencyand recovery, Case studies and Advanced topics

**Text books:**

1. R. Elmasri & S.B. Navathe, **Fundamentals of Database Systems**, 5th Edition, Pearson, 2008.
2. P. Sreenivasa Kumar, **NPTEL lecture notes on databases**.
3. Baron Schwartz et al., **High Performance MySQL: Optimization, Backups, Replication, and More**, 2nd Edition, O'Reilly Associates, 2008.

## 4.7 CS 205: Paradigms of Programming

**Course Code: CS 205**

**Course Name: Paradigms of Programming**

L-T-P-C: 3-0-0-3
Category:
Prerequisites: None
Approval: 5th Senate

**Course Contents**

- Introduction (talking about different paradigms), First order logic and logic programming (with Prolog). Lambda calculus and functional programming (with Haskell) A couple of lectures on Object Oriented Programming.

**Text books:**

1. Ehud Shapiro, Leon Sterling, **The Art of PROLOG: Advanced Programming Techniques**.

2. William F. Clocksin, Christopher S. Mellish, **Programming in Prolog**.

3. Bryan O'Sullivan, Don Stewart, and John Goerzen, **Real World Haskell**.

## 4.8 CS 206: Computer Networks

**Course Code: CS 206**

**Course Name: Computer Networks**

L-T-P-C: 3-0-0-3
Prerequisites: None
Approval: 5th Senate

**Course Contents**

- **Part 1**: Building a network; Goals; Requirements; layered network architecture; Physical media - electrical, optical, wireless; Encoding; Framing; Network adapter; Error Detection; Reliable transmission
- **Part 2**: Topology: Ethernet, Rings; Packet Switching; Forwarding; Bridges and LAN switches; Wifi
- **Part 3**: Routing; Algorithms (Distance Vector; Link State); Addressing; IPv4 and IPv6; Internet; Multicast; [8 Lectures]
- **Part 4**: Transport protocols UDP, TCP; Network resource allocation Flow and Congestion Control; Quality of Service [8 Lectures]
- **Part 5**: Application layer - Web, Email, DNS; Network security; Network management; Advanced topics: Wireless networks; Optical communications [8 Lectures]

Note: Architectures, protocols, implementation and performance to be covered in all parts.

**Textbooks:**

1. Peterson & Davie, **Computer Networks: A Systems Approach**
2. A.S. Tanenbaum, **Computer Networks**.

## 4.9 CS 207: Applied Databases Practicum

**Course Code: CS 207**

**Course Name: Applied Databases Practicum**

L-T-P-C: 0-0-3-2
Prerequisites: IC 150 Computation for Engineers
Intended for: UG
Distribution: Compulsory for CSE; CS elective for EE and ME
Semester: 3rd
Approval: 6th, 9th, 11th Senates

**Course Contents**

A few lab lectures (8 hours spread over the semester):

- Architectures of DB applications: Client-server; UI-Business logic-DBMS; Browser UI-Web server-Business logic-DBMS.
- Introduction to SQL
- Introduction to E-R modelling and MVC
- Transactions what, how and when?
- Introduction to a scripting language, eg PHP, Python
- Introduction to HTML and especially HTML5
- Introduction to Javascript and Ajax/Comet
- Introduction to NoSQL

Lab assignments (listed below) require 3 hours in the lab, preceded by at least 3 hours at home. The weekly assignments are stage-wise demonstrations of the evolution of a mini-project stages are as follows:

- Week 1-2 Choice of mini-project a useful web-based tool.
- Week 3-4 Designing the data model and table schemas, testing the tables manually.
- Week 5-6 Design the UI flow the user view.
- Week 7 Creating the GUI forms and reports.
- Week 8-9 Putting together the Web UI flow with the appropriate data access.
- Week 10 Basic tool ready with full functionality
- Week 11 Improving UI using javascript and HTML5 features.
- Week 12 Using AJAX for better user-interaction.
- Week 13 Substituting portions of the data model using NoSQL databases

**Textbooks:**

- This course will use web-resources to cover course topics.

## 4.10 CS 208: Mathematical Foundations of Computer Science

**Course Code: CS 208**

**Course Name: Mathematical Foundations of Computer Science**

L-T-P-C: 3-1-0-4
Prerequisites: IC 150 Computation for Engineers
Intended for: UG
Distribution: Compulsory for CSE; CS elective for EE and ME
Semester: 3rd
Approval: 9th Senate

**Course Contents**

- **Fundamental structures**:
  - Functions - surjections, injections, inverses, composition. (2 contact hours) Relations - reflexivity, symmetry, transitivity, equivalence relations. [2 Lectures]
  - Sets - Venn diagrams, complements, Cartesian products, power sets, finite and infinite sets, introduction to lattices. [4 Lectures]
  - Abstract orders: quasi-order, partial order, well-order, (Advanced, optional topics: Zorn's lemma, Koenig's theorem.) [2 Lectures]
- **Combinatorics**
  - Counting arguments/techniques; pigeonhole principle; cardinality and countability, the inclusion-exclusion principle, recurrence relations, generating functions. [5 Lectures]
  - Basics of graph theory: graph as a discrete structure, graph coloring and connectivity, traversal problems, and spanning trees. [5 Lectures]
  - Advanced, optional topic: Probabilistic method in combinatorics.
- **Logic**
  - Propositional and predicate logic: syntax, semantics, soundeness, completeness, unification, inferencing, resolution principle, proof system. [6 Lectures]
  - Proof techniques (negation, contradiction, contraposition, mathematical induction) and the structure of formal proofs; efficiency of proof-systems. [4 Lectures]
- **State machines**
  - Introduction, minimization, grammars, languages. [4 Lectures]
- **Algebra**
  - Motivation for algebraic structures, the theory of some algebras such as monoids, groups (finite, cyclic, permutation, matrix), cosets, subgroups, Lagrange's theorem, discrete logarithm. [8 Lectures]
- **Optional topic**
- **Number Theory**
  - Elementary number theory, fundamental theorem of arithmetic, gcd, unique factorization, Euler's function, modular arithmetic, Fermat's little theorem, Chinese remainder theorem, modular exponentiation, RSA public key encryption.

**Suggested Reference Books:**

1. E. Lehman, F. T. Leighton, and A. R. Meyer, **Mathematics for Computer Science**, 2013. Available online at: http://courses.csail.mit.edu/6.042/spring13/mcs.pdf
2. R. L. Graham, D. E. Knuth, and O. Patashnik, **Concrete Mathematics**, Pearson, 1994. Also, available online at: www.maths.ed.ac.uk/∼aar/papers/knuthore.pdf?
3. A. Aho and J. Ullman, **Foundations of Computer Science**, W. H. Freeman, 1992. Available online at: http://infolab.stanford.edu/∼ullman/focs.html
4. I. N. Herstein, **Topics in Algebra**, 2nd Edition, Wiley, 1975.
5. A. Tucker, **Applied Combinatorics**, 6th Edition, Wiley, 2012.
6. C. Liu and D. P. Mohapatra, **Elements of Discrete Mathematics**, 3rd Edition, Tata-McGraw Hill, 2008.
7. T. Koshy, **Discrete Mathematics with Applications**, Academic Press, 2003.
8. J. Hein, **Discrete Structures, Logic, and Computability**, 3rd Edition, Jones and Barlett, 2009.

## 4.11 CS 211P: Network and Database Practicum

**Course Code: CS 211P**

**Course Name: Network and Database Practicum**

L-T-P-C: 0-0-3-2
Category:
Prerequisites: None

Approval: 5th Senate

**Course Contents**

- Basic C Programming + Unix; notion of safety and importance of return values infunction calls in C. Exposure to Unix command line and file system organization.
- Basic Unix System Calls.
- Unix sockets, ports, TCP/UDP end-to-end argument in networks; transport model inTCP and
- UDP; basic flow of server/client; TCP/UDP servers and clients.
- Basic Echo Server + File Server Design and implementation of a simple echo serverusing TCP and UDP; Chat program.
- Configuring a LAN, gateway sub netting; configuring multiple logical networks inthe same physical network; basic commands like ping, ifconfig etc.

- Basics of Routing, IP Address Configuration, Subnetting - separation of logicalnetworks using gateways; commands for configuring routing tables.
- Tcp dump, Wire shark; Observing network activity, tracing a connection; groupingconnections by types/protocols/source/destination; writing filters; introduction to libpcap.
- Configuring and maintaining web server/DNS server.
- IPTables, Configuration, Setup notion of firewall; rule management; setting up andtesting a simple firewall.
- Basics of Wireless Networks, setting up a real network, performance measurement.

## 4.12 CS 212 : Design and Analysis of Algorithms

**Course Code : CS 212**

**Course Name : Design and Analysis of Algorithms**

L-T-P-C : 3-0-2-4
Intended for : BTech (Semester 3 or 4)
Prerequisite : IC253: Programming and Data Structures, or equivalent for UG students
Mutual Exclusion:
Approval: 54th BoA

**Course Contents**

- Review of Data Structures from IC course: Asymptotic Notations and recurrence relations, Insertion Sort, Merge Sort, QuickSort and Randomization (5 H)
- Sorting Lower Bounds and Non-Comparison Sorting algorithms like Counting Sort and Radix Sort (2 H)
- Order Statistics: Minima and Maxima, Quickselect, Median of Medians (3 H)
- Applying sorting techniques to Computational Geometry : Closest pair problem, Convex Hull of points in a plane (3 H)
- Advanced topics in Sorting and Searching:- Binary Search Trees, Red-Black Trees, Augmentation of Binary Search Trees (8 H)
- Graph Algorithms: Basics of Graphs, BFS and DFS, Topological Sorting, MST(using Kruskal and Prim's), Union-Find Data structure, Single-Source Shortest Path Dijkstra's Algorithm and Bellman-Ford /Maximum Flow (Ford Fulkerson) (8 H)
- Dynamic Programming: Longest Common Subsequence, Matrix Multiplication (2 H)
- Amortized analysis: aggregate analysis, accounting, potential method (3 H)
- Advanced Data Structures: B-Trees, Binomial and Fibonacci/Quake Heaps (3 H)

- Computational complexity: Problem classes: P, NP, NP-complete, NP-hard. Reductions and Examples of NP-complete problems. (3 H)
- Dealing with NP-hard problems:- Approx/Randomized Algorithms, Parameterized Complexity (2 H)
- Coding Lab which covers topics discussed in this course (28 H)

**Textbooks:**


1. T. H. Cormen, C. E. Leiserson, R. L. Rivest, and C. Stein, Introduction to Algorithms, MIT Press, 3/e, 2009.
2. J. Kleinberg and E. Tardos, Algorithm Design, Pearson, 2006.


**References:**


1. S. Dasgupta, C. H. Papadimitriou, U. V. Vazirani, Algorithms, McGraw-Hill, 2006.
2. S. S. Skiena, The Algorithm Design Manual, Springer, 2/e, 2008


## 4.13 CS 241: Introduction to Cryptography

**Course Code: CS 241**

**Course Name: Introduction to Cryptography**

L-T-P-C: 3-0-0-3
Category:
Prerequisites: None
Approval: 5th Senate

**Course Contents**

- **Overview of Cryptography**
- Introduction, Information Security and Cryptography, Background on Functions, Basic Terminology and Concepts, Symmetric Key Encryption, Digital Signatures, Authentication and Identification, Public Key Cryptography, Hash Functions, Protocols and Mechanisms, Classes of Attacks and Security Models
- **Classical Cryptography**
  - Introduction to Some Simple Cryptosystems, The Shift Cipher, The Substitution Cipher, The Affine Cipher ,The Vigenere Cipher, The Hill Cipher, The Permutation Cipher, Stream Ciphers
  - Cryptanalysis, Cryptanalysis of the Affine Cipher, Cryptanalysis of the Substitution Cipher, Cryptanalysis of the Vigenere Cipher, A Known Plaintext Attack on the Hill Cipher

- Public Key Cryptography, Introduction to public key cryptography, Number theory, Algebra, RSA, DHP and Discrete Log assumptions, Diffie Hellman key exchange, RSA public key system, ElGamal encryption, Pseudo-random bit generators
- Digital Signatures, Digital signatures: definitions and applications, How to sign using RSA, Overview of signatures based on discrete-log

- **Basic Symmetric Key Encryption**
  - One time pad and stream ciphers, Shannons Theory, Block Ciphers, Case studies: Feistel networks, DES, 3DES, and AES, Basic modes of operation: CBC and counter mode
  - Attacks on Block Ciphers, exhaustive search, time-space tradeoffs, differential & linear cryptanalysis, meet in the middle, side channels
  - Message Integrity, Message integrity: definition and applications, Collision resistant hashing, Merkle-Damgard and Davies-Meyer. MACs from collision resistance, Case studies: SHA and HMAC

**Text Books:**


1. Abhijit Das and C. E. VeniMadhavan, **Public-Key Cryptography: Theory and Practice**, Pearson Education
2. Ivan Niven, Herbert S. Zuckerman and Hugh L. Montgomery, **An Introduction to the Theory of Numbers**,Wiley-India
3. I. N. Herstein, To**pics in Algebra**, 2nd Edition, Wiley India.


## 4.14 CS 302: Paradigms of Programming

**Course Code: CS 302**

**Course Name: Paradigms of Programming**

L-T-P-C: 3-0-2-4
Prerequisites: IC 150 Computation for Engineers
Intended for: UG
Distribution: Compulsory for CSE; CS elective for EE and ME
Semester: 5th
Approval: 12th Senate (Wrong Credits: 0-0-3-2 were approved in 9th Senate)
L-T-P-C: 3-0-2-4
Approval: 12th Senate

**Course Contents**

- **Module I** Lambda Calculus - Syntax, Conversion, Reduction and Normal Order, Church-Rosser Theorem, Order of Evaluation, Currying, Integers, Booleans and Recursion.

- **Module II** Functional Programming - Scheme/Lisp syntax - expressions and functions/procedures, evaluation - naming, environment and the substitution model of function application, Higher-order functions and higher-order programming, Data abstraction.
- **Module III** Object-oriented Programming - Mutable data, modularity and state, Objects, Closures - data structures encapsulated into functions.
- **Module IV** Delayed Evaluation, Laziness and Infinite Data-structures - Stream Programming, Infinite streams, Streams as lazy Lists.
- **Module V** Logic Programming - Deductive Information retrieval, declarative programming - facts and rules, Search trees and Backtracking, Non-deterministic programming, Continuations and back-tracking, Prolog - arithmetic, recursion, cuts and negation, Real-life applications of Prolog. Prolog implementation in Scheme/Lisp - use of continuations and macros.

## 4.15 CS 303: Software Engineering

**Course Code : CS 303**

**Course Name: Software Engineering**

L-T-P-C: 2-0-2-3
Prerequisites : None
Intended for : 3rd, 4th year B. Tech.
Distribution : Discipline-elective for CSE B.Tech; Free elective for other B. Tech. students
Approval: 4th Senate

**Course Contents**

- **Software Qualities and Cooperation in Global Software Development**: How different qualities impact the development approach and process: usability, performance, and safety and reliability. The basis for the project establishment, the choice of communication channels, tools for sharing documents, and the collaboration protocol. Lab: Project begins; Project groups are formed and case studies are assigned. [6 Lectures]
- **Software Development Models**: Organize software engineering work in a systematic manner. A number of development models are discussed: waterfall, V, RAD, Spiral, Incremental, and Agile (Scrum and XP). Lab: The project teams are expected to produce an overview of the development models and select one for their case study. [6 Lectures]
- **Project Management**: Estimation, reporting and re-planning, stakeholders, organisation of the software development team, and different roles. Lab:The project teams are expected to produce a project plan involving different software engineering activities corresponding to their development model. Also, they need to assign roles to different activities in their plan. [6 Lectures]

- **Requirements Engineering and Risk Management**: Understand a complex use situation through rich pictures and UML class diagrams as means to analyze the problem domain. Discuss the documentation of requirements, their handling throughout the development, and their analysis with an emphasis on legal aspects of software.Managing software project risks, software risk management, elements of risk management, risk program strategy.Lab:The project teams are expected to make rich pictures, UML class diagrams, and gather and write their requirement specifications. Also, they need to identify the product and process risks and discuss mitigation strategy. [6 Lectures]

- **Software Quality-in-Use and Configuration Management**: Participatory design, future workshops, scenarios and mock-up based design and show how they feed into and expand object-oriented analysis and design methods. Also, discuss document conventions and draft a configuration management plan.Lab: Project teams make scenarios and mock-up based design. Also, they figure out how these methods help in object-oriented analysis and design methods. As part of this weeks lab, the teams also create a configuration management plan and a document convention. [6 Lectures]

- **Static and Dynamic Test**: Introduces quality assurance and static test techniques, especially peer reviews. Also, introduces into planning, processes, and techniques for dynamic testing. Lab: Project teams write test cases, send their documents for peer-review, and also create a quality assurance plan. [6 Lectures]

- **Software Architecture, Design, and Process Qualities**: Use architectural design as a start for the software design and implementation. Software process quality and why it is important. Discuss the Capability - Maturity - Model and software process improvement. Lab: Project teams write software architecture on their projects and prepare portfolio for final submission. [6 Lectures]

**Textbooks:**

1. Pankaj Jalote, **An Integrated Approach to Software Engineering**, 2nd Edition or Higher, Narosa Publishing House. [JAL]

2. Ian Sommerville, **Software Engineering**, 9th Edition, Pearson. [SOM]

**Articles:**

1. Articles from IEEE. Instructor will either hand out photocopies or send them via email during the semester.

## 4.16 CS 304: Formal Languages and Automata Theory

**Course Code: CS 304**

**Course Name: Formal Languages and Automata Theory**

L-T-P-C: 3-0-0-3
Prerequisites: CS 202, CS 208 or instructors consent
Intended for: B.Tech.

Distribution: Discipline elective for CS; CS elective for EE, ME, and Civil
Semester: 5th
Approval: 5th, 6th, 10th Senates

**Course Contents**

- **Regular languages** DFA, NFA, Subset construction, Regular, Pumping Lemma, DFA state minimization, Myhill-Nerode relations and theorem. [12 Lectures]
- **Grammars** Production systems, Right linear grammar and Finite state automata, Context free grammars, Normal forms, Pumping Lemma for CFLs, Subfamilies of CFL, Derivation trees and ambiguity. [10 Lectures]
- **Pushdown automata** Acceptance by final state and empty stack, Equivalence between push- down automata and context-free grammars, Closure properties of CFL, Deterministic push- down automata, the CKY algorithm. [10 Lectures]
- Advanced topics: the Chomsky-Schtzenberger theorem, Parikhs theorem.
- **Turing machines** Techniques for Turing machine construction, Generalized and restricted versions equivalent to the basic model, Universal Turing machine, Recursively enumerable sets and recursive sets. [10 Lectures]
- **Decidability** Decidable and undecidable problems, Reduction, Post's correspondence problem, Rice's theorem, decidability of membership, emptiness and equivalence problems of languages. [10 Lectures]
- **Advanced topics** Gdels incompleteness theorem, Gdels proof.

**Reference Books:**

1. D. C. Kozen, **Automata and Computability**, Springer, 1997.
2. J. E. Hopcroft, R. Motwani and J. D. Ullman, **Introduction to automata theory, languages and computation**, 3rd Edition, Pearson, 2006.
3. E. A. Rich, Automata, **Computability and Complexity: Theory and Applications**, Pearson, 2007.
4. M. Sipser, **Introduction to the Theory of Computation**, 3rd Edition, Cengage Learning, 2012.
5. Peter Linz, **An introduction to formal language and automata**, 3rd Edition, Narosa publishing house, 2002.

## 4.17 CS 305: Artificial Intelligence

### Course Code: CS 305

### Course Name: Artificial Intelligence

L-T-P-C: 3-0-0-3
Students intended for: 3rd year B. Tech. CSE/EE/ME students

Elective or Core: Elective
Prerequisite: Consent of the faculty member
Approval: 3rd Senate

**Course Contents**

- **Introduction** Overview and Historical Perspective; Turing test, Physical Symbol Systems and the scope of Symbolic AI; Agents.
- **Weak Methods** Search Methods, Heuristic Search, Goal Trees; Optimization, Probabilistic Methods; Game Trees; Planning and Constraint Satisfaction Problems - Waltz Algorithm.
- **Knowledge representation** Logic, Conceptual Dependency Theory, and Frames; Theorem Proving, Forward Reasoning and Rete Networks; Backward Reasoning, Resolution Method and Logic Programming; Semantic Networks, Inheritance and Aggregation Hierarchies; Case Based Reasoning and Learning; Truth maintenance systems, Default and Probabilistic Reasoning, Dempster-Shafer Theory.

**Text Books:**

1. Russell, S., and Norvig, P., **Artificial Intelligence: A Modern Approach**, Prentice Hall, 1995.
2. Winston, P. H., **Artificial Intelligence**, Addison-Wesley, 1992.
3. Patterson, D.H., **Introduction to Artificial Intelligence and Expert Systems**, Prentice Hall of India, 2001.
4. Charniak, E., and McDermott, D., **Introduction to Artificial Intelligence**, Addison-Wesley, Re 1984.
5. Rich, E., and Knight, K., **Artificial Intelligence**, Tata McGraw Hill, 1991.

## 4.18 CS 305 : Artificial Intelligence

**Course Code : CS 305**

**Course Name : Artificial Intelligence**

L-T-P-C : 3-0-0-3
Intended for : 3rd and 4th year B. Tech. students
Prerequisite : CS 212 Design of Algorithms or an equivalent course
Mutual Exclusion:
Approval: 54th BoA

**Course Contents**

- **Introduction to AI**: Overview, historical perspective, Turing test, agents. (3 Hours)

- **Search Methods and Optimization**: Problem representation, State Space Search, A* Algorithm, AO* search, Minimax and alpha-beta pruning, AI in games. (8 Hours)
- **Logic and Automated Reasoning**: Propositional Logic, Predicate Calculus, Resolution Refutation, Formal Systems, Soundness, Consistency, Completeness. (7 Hours)
- **Planning and Constraint Satisfaction**: Blocks World, STRIPS, Constraint Satisfaction Problems, Basics of Probabilistic Planning, Waltz Algorithm. (6 Hours)
- **Knowledge Representation and Reasoning**: Semantic Net, Frames, Scripts, Conceptual Dependency, Ontologies, Basics of Semantic Web, Intelligent Question Answering. (7 Hours)
- **Learning and Uncertainty**: Learning from Examples, Decision Trees, Neural Nets, Bayesian Theory, Fuzzy Logic, Non-monotonic Logic, Default Reasoning, Case-based Reasoning. (6 Hours)
- **Advanced Topics in AI**: Introduction to Computer Vision, Expert Systems, Natural Language Processing, Robotics, Hidden Markov Models, Reinforcement Learning. (5 Hours)

**Textbooks:**

1. Russell, S., & Norvig, P., **Artificial Intelligence: A Modern Approach**, 4th Edition, Pearson Education, 2020.
2. Poole, D., & Mackworth, A., **Artificial Intelligence: Foundations of Computational Agents**, 2nd Edition, Cambridge University Press, 2017.

**References:**

1. Murphy, K. P., **Machine Learning: A Probabilistic Perspective**, MIT Press, 2012.
2. Luger, G. F., **Artificial Intelligence: Structures and Strategies for Complex Problem Solving**, 6th Edition, Pearson Education, 2008.

## 4.19 CS 306: Operating Systems

**Course Code: CS 306**

**Course Name: Operating Systems**

L-T-P-C: 3-0-0-3
Category:
Prerequisites:
Approval: 5th Senate

**Course Contents**

- **Introduction**: Review of Computer Organization and Architecture, OS Concepts, Structure and Operations - Process Mgmt, Memory Mgmt. and Storage Mgmt.
- **Process Management**: Processes - Concept, Scheduling - different scheduling algorithms, Need for synchronization, Process Synchronization - Critical Section, Mutexes, Semaphores, Mailboxes, Monitors, Inter-process Communication, Deadlock and its prevention.
- **Memory Management**: Physical memory vs Virtual memory, Swapping, Paging and Page tables, Segmentation, Address translation and MMU, Caches, Page misses and TLB, Handling page miss and Page replacement.
- **File Systems and I/O Management**: Concept of File and File System, Structure of FS, Allocation and management of Free space, brief review of mass storage structure and its relation to FS implementation. Generic I/O interface presented by OS for FS, Network - Device handling.
- **Module V**: Protection and Security as applicable to Process, Memory and File Management. Virtualization. Case study of an OS (including details of data structures and algorithms at the kernel level).

## 4.20 CS 307: Systems Practicum

**Course Code: CS 307**

**Course Name: Systems Practicum**

L-T-P-C: 0-0-3-2
Prerequisites: IC150 Computation for Engineers , CS207 Applied Databases Practicum
Intended for: UG
Distribution: Compulsory for CSE; CS elective for EE and ME
Semester: 5th
Approval: 9th Senate

**Course Contents**

A few introductory lab lectures (6-8 hours spread over the semester):

- Architecture and functions of an OS, layered network architecture
- Processes and threads
- Concept of name, address, location IP addresses and DNS; well-known services
- Inter-process communication: files, shared memory, pipes, sockets Synchronisation: lock files, semaphores
- Packet-switching: packet formats, hop-by-hop routing, routing tables
- Files, devices, filesystems
- Installation and boot procedures of an OS; virtualisation

Lab assignments (9-10 weekly assignments 3 hours in the lab, preceded by at least 3 hours at home plus a mini-project for 4 weeks). Assignment problems are designed to expose the students to the following sequence of concepts, skills and tools:

- Create and synchronise processes and threads. Utilities: ps, vmstat, /proc
- Bulk data transfer using various forms of IPC.
- Use of networking utilities: ping, traceroute, netstat, tcpdump, /proc
- Socket programming in C: applications such as file transfer, simple chat, ping, etc using UDP or TCP. Use of socket options.
- Socket programming in C (continued)
- Program access to i-nodes and directory nodes; Use of rsync.
- Virtualisation using eg. VirtualBox; installation of at least 2 different OS'es on virtual machines. Network connections between these OS'es.
- Configuration of DNS, NAT, NFS, syslogd.
- I/O to serial or parallel port. Use of ioctl().

Measurement of performance integral to most of the lab exercises: design of experiments, measurement techniques, confidence intervals, analysis of results, presentation in graphs and tables.

Mini-projects involving one or more of the following (4 weeks): Email, RMI, PKI, DNS, LDAP/single-sign on, configuring IP routing, Iptables, backup/restore of filesystems, Apache, Squid, Linux user administration, system logging using syslog, NFS, automounting, etc.

**Textbooks:**

- Wikipedia, man pages and online documentation on assorted utilities, tools, components and platforms
- Bautts, Dawson & Purdy, **Linux Network Administrator's Guide**, 3rd Edition, O' Reilly, 2005
- Adelstein & Lubanovic, **Linux System Administration**, O' Reilly, 2007

**References:**


1. A.S. Tanenbaum, **Modern Operating Systems**, 3rd Edition, Pearson Ed. Inc., 2008
2. B. Davie & L. Peterson, **Computer networks**, 4th Edition, Morgan and Kauffman, 2011.
3. R. Jain, **The Art of Computer Systems Performance Evaluation**, Wiley, 2008.
4. R.L. Schwartz, T. Phoenix & b.d. foy, **Learning Perl**, 5th Edition, O' Reilly, 2008.

5. L. Wall, T. Christiansen & J. Orwant, **Programming Perl**, 3rd Edition, O' Reilly, 2000

## 4.21 CS 307: Systems Practicum

Course Name: Systems Practicum
Course Number: 307
Credits: 0-0-3-2 ,
Prerequisites. IC150, CS 207
Intended for: B. Tech
Distribution: Compulsoryfor CSE; CS elective for EE and ME
Senate: 8th
Approval: 9th Senate

**Obiective:**

This course calls for a sequence of 3 Practicum co'urses for CSE viz. CS 207 Applied Databases Practicum CS 307 Systems Practicum and CS 308 Large Applications Practicum. The erstwhile CS 211 Networks and Database Practicum included both networks and databases tools and programming. Now, the networks material is shifted to CS 307 andCS 207 focuses only on database applications.

**Course Outline:**

Understanding of architecture and working of networks and 08 through use of system cails monitoring tools (ps, vmstat, netstat, tcpdump. ping, traceroute..), 'simple socket programming in C. Building multi-process, distributed applications using scripting or other languages. Setting up' and configuring various network and OS services such as web, DNS, email, LDAP, etc. Installing Linux—master boot record, boot loader, disk partitioning,virtualisation (Virtual Box). 08 and network security, Techniques for performance measurement.' data analysis and presentation.

**Syllabus:**

- Architecture and functions of an OS. layered network architecture.
- Processes and threads.
- Concept of name, address, location —IP addresses and DNS; well-known services
- Inter-process communication: files, shared memory, pipes, sockets Synchronisation: lock files, semaphores.
- Packet-switching: packet formats, hop-by-h'op routing, routing tables.
- Files, devices file systems.
- Installation and boot procedures Ofan OS; virtualisation

**Lab assignments(9-10 weekly assignments—3 hours in the lab, preceded by at least 3 hours at home— plus a mini-p-roject for 4 Weeks).**

Assignment problems are ‘ designed to expose the students to the following sequence of concepts, skillsand tools:

- Create and synchronize processes and threads. Utilities: ps, vmstat, /proc. Bulk data transfer using various forms of IPC. ‘ Use of networking utilities. ping, traceroute, netstat, tcpdump, /proc
- Socket programming in C: applications such as file transfer, simple chat ping, etc using UDP or TCP. Use of socket options.
- Socket programming in C (continued).
- Program accessto i-nodesand directory nodes; Use of sync.
- VirtualiSation using eg. VirtualBox; installation of at least 2 different OS‘es on virtual machines. Network connections between these 03'es.
- Configuration of DNS NAT NFS, syslogd l/O to serial or parallel port. Use of Ioctlo -Measurement of performance integral to most of the lab exercises: design of experiments measurement techniques Confidence intervats analysis of results, presentation in graphs and tables.
- Mini-projects involving one or more of the following (4 weeks): Email, RMI, PKI, DNS, LDAP/single-sign on, configuringIP routing,_—ptables backup/restore of file. systems, Apache, Squid Linux user administration, system logging using syslog, NFS automounting, etc.

**Suggested Reference Books:**


1. Wikipedia, man pages and online documentation on assorted utilities, tools, components and platforms
2. Ba'utt's, Dawson & Purdy, **Linux Network Administrator's Guide**, 3 rd Edition, O'Reilly, 2005.
3. Adelstein & Lubanovic, **Linux System Administration**, O'Reilly, 2007, Kaufmann, Elsevier 2011. (Reference)
4. A.S. Tanenbaum, **Modern Operating Systems**, 3 rd Edition, Pearson Ed. Inc., 2008
5. B. Davie & L. Peterson, **Computer networks**, 4th Edition, Morgan and Kauffman, 2011.
6. R. Jain, **The Art of Computer Systems Performance Evaluation**, Wiley, 2008.
7. R.L. Schwartz, T. Phoenix & b.d. foy, **Learning Perl**, 5th Edition O'Reilly, 2008.
8. L. Wall, T. Christiansen & J. Orwant, **Programming Perl**, 3 rd Edition, O'Reilly, 2000.

## 4.22 CS 308 (2) Large Application Practicum

Senate: 8th

**Course Outline:**

The students will learn the mechanics of building large sofiware applications using object—orient languages. Topics covered 1n this course include: Writing Makefiles and use of Make to compile large programs; source code revision control; documentation generation from code; systematic and organized approaches to software testing; and. introduction to software testing tools. Also, this course covers certain software utilities that help write very fast parsers for almost arbitrary file formats. Flex and Bison. Furthennore, this course exposes students to use of UML notation for object-oriented design. The course concludes with an assignment on reverse ‘ engineering of a large open-source software application.

## 4.23 CS 308: Large Applications Practicum

**Course Code: CS 308**

**Course Name: Large Applications Practicum**

L-T-P-C: 0-0-3-2
Prerequisites: IC 150
Intended for: UG
Distribution: Compulsory for CSE; CS elective for EE and ME
Semester: 6th
Approval: 9th Senate

**Course Contents**

A few lab lectures (8 hours spread over the semester):

- Overview of the Make utility (Makefiles, writing rules, use of variables, Conditionals, Functions, running make)
- Source code revision control (version control basics, introduction to some basic version control systems like CVS, SVN, and Git)
- Introduction to document generation from annotated source code (with specific focus on Doxygen, TwinText, and Natural Docs)
- Software testing (introduction, need for software testing, types of tests, test case design)
- Software testing tools (introduction to some basic testing tools for object-oriented languages e.g., Jester for JUnit)
- Introduction to conventions of fast parsers for context-free grammars: Flex and Bison
- Overview of diagrams in the UML notation (also, how UML translates to programming structures in certain object-oriented languages like C++/Java)

- Introduction to software reverse engineering

Lab assignments (listed below) require 3 hours in the lab, preceded by at least 3 hours at home. The weekly assignments would be targeted at mastering the concepts covered weekly in the course:

- Week 1-2 Use of Make and Makefiles for object-oriented programming languages.
- Week 3-4 Use of a versioning system (e.g., Git, SVN).
- Week 5-6 Document generation from annotated source code using one of the open-source software (e.g., Doxygen, Natural Docs).
- Week 7 8 Software testing and test-case design; use of open-source software testing tools to test object-oriented code (e.g., Jester).
- Week 9-10 Use of parsers for parsing context-free grammars (using Flex/Bison)
- Week 11-12 Application of UML notation and diagrams for object-oriented design.
- Week 13 Reverse engineering of an existing open-source application (using certain reverse engineering tools)

**References:**


1. GNU 'make' pages (http://www.gnu.org/software/make/manual/make.html)
2. Boston University's Make Tutorial (http://www.cs.bu.edu/teaching/cpp/writing-makefiles/)
3. Emory University's Make Tutorial (http://www.mathcs.emory.edu/∼cheung/Courses/255/Syllabu C-intro/make.html)
4. Introduction to CVS, SVN, and Git (http://www.linuxdevcenter.com/pub/a/linux/2002/01/03/cv http://subversion.apache.org/; http://git-scm.com/)
5. Manual pages for Doxygen and Natural Docs (http://www.stack.nl/∼dimitri/doxygen/; http://www.naturaldocs.org/)
6. Paul Ammann and Jeff Offutt, Course code: CS 546, Cambridge University Press, 2008.
7. Carnegie Mellon University resources on Software Testing Tools (https://www.ece.cmu.edu/$sim$k http://mcahelpline.com/tutorials/testing/testing.pdf)
8. Andreas Spillner, Tilo Linz, Hans Schaefer, **Software Testing Foundations: A Study Guide for the Certified Tester Exam** (Rockynook Computing), Rocky Nook, 2011.
9. Flex & Bison, **Text Processing Tools**, John Levine, O'Reilly Media, 2009.
10. GNU resources on Flex and Bison (http://www.gnu.org/software/bison/; http://flex.sourceforge.n
11. UML and object-oriented design (http://www.agiledata.org/essays/objectOrientation101.html)
12. Jesse Liberty, Vishwajit Aklecha, **C++ Unleashed**, 1998.
13. Eldad Eilam, **Reversing: Secrets of Reverse Engineering**, Wiley, 2005.

## 4.24 CS 309: Information and Database Systems

### Course Code: CS 309

### Course Name: Information and Database Systems

L-T-P-C: 3-0-2-4
Prerequisites: CS 207 Applied Databases Practicum
Intended for: UG
Distribution: Compulsory for CSE; CS elective for EE and ME
Semester: 6th
Approval: 9th Senate

### Course Contents

- **Introduction** [6 Lectures]
  - Information Modeling: background, approaches, information system lifecycle.
  - Four information levels: conceptual, logical, physical, external
  - Conceptual Schema Design Procedure : facts, constraints, roles, value, set comparison, final checks
- **Relational Database Design** [6 Lectures]
  - Overview of ER, Barker notation, mapping from ORM to ER
  - Overview of UML, mapping from ORM to UML
  - Relational schemas, functional dependencies, Normal forms
- **Data Manipulation with SQL** [9 Lectures]
  - Relational Algebra
  - SQL : Basic operations, Joins, Nested and correlated queries, views, Triggers
  - Embedded SQL and database application development
- **Transactions** [9 Lectures]
  - ACID properties
  - Concurrency Control Techniques
  - Recovery Techniques
- **Principles of query processing** [3 Lectures]
  - Indexes
  - Query plans and operators
  - Cost-based query optimization
- **Data storage** [3 Lectures]
  - Databases Vs. FileSystems (Google FileSystem, Hadoop Distributed FileSystem)

- **Scalable data processing** [6 Lectures]
  - MapReduce and introduction to systems based on MapReduce (Hadoop)
  - Introduction to Scalable key-value stores (Amazon Dynamo, Google BigTable, HBase)

**Textbooks:**

1. Terry Halpin and Tony Morgan, **Information Modeling and Relational Databases**, 2nd Edition ((The Morgan Kaufmann Series in Data Management Systems) by

**References:**

1. Elmasri, Ramez and Navathe, **Fundamentals of Database Systems**, 6th Edition, Shamkant
2. Raghu Ramakrishnan and Johannes Gehrke, **Database Management Systems**, 3rd Edition, McGraw- Hill
3. Assorted Readings from web resources like Yahoos Hadoop Tutorial, Googles Big Table etc.

## 4.25 CS 310: Introduction to Communicating Distributed Processes

**Course Code: CS 310**

**Course Name: Introduction to Communicating Distributed Processes**

L-T-P-C: 3-0-0-3
Prerequisites: CS 307 Systems Practicum
Intended for: UG
Distribution: Discipline core for CSE Semester: 6th semester

**Course Contents**

- **Introduction**: Operating systems, Network Architecture
- **Process management** Scheduling, Inter-process communication
- **Network architecture**: Socket address, layering, encapsulation
- **Packet Switching**: Routing, switching, addressing
- **Process coordination**: Scheduling, Synchronization, deadlocks
- **Network reliability**: Protocols, TCP/UDP, Flow Control, Congestion Control
- **Network and distributed operating systems**: Synchronization, mutual exclusion, concurrency

**Textbooks:**

1. A. Silberschatz et al, **Operating System Concepts**
2. A.S. Tanenbaum, **Computer Networks**

**References:**

1. A.S. Tanenbaum, **Modern Operating Systems**, 3rd Edition, Pearson Ed., 2008
2. B. Davie & L. Peterson, **Computer networks**, 4th Edition, Morgan and Kauffman, 2011.
3. B. Forouzan, **Introduction to Data Communications and Networking**

## 4.26 CS 310 Introduction to Communicating Distributed Processes

Course Number: CS310
Course Name: Introduction to Communicating Distributed Processes (CDP)
Credits: 3-1-0-4
Prerequisites: CS 307 (Systems Practicum)
Intended for: B. Tech.
Distribution: Core for CS

**Preamble:**

Objective of the course. is to give students an 'understanding of theoretical and practical aspects of processess that are communicating in distributed environment. The discussion about both operating system and computer networking based communicating system will be carried on.

On completion of the course students should be able to understand various challenges that are required to be addressed for processess that are communicating in distributed environment via available computer networks. They should understand what are the issues what are the solutions and what are the their pros and cons. So . that later they must understand how to device solutions that can fulfill the system requirement.

**Course Outline**

- **Introduction**: Operating systems, Network Architecture [3 Hours] Computer system organisation and its architecture, Basic responsibilities of operating system, Data Communication components, Hierarchical/layer protocol, Various layers and their responsibilities, Multiplexing and Demultiplexing, Encapsulation and Decapsulation, Various inter-networking devices.
- **Process and Thread Management** [5 Hours] Process model. states and its structure, Process creation and termination, Thread models and issues, User/Kernel level threads. Inter process communication, Race Condition, Critical section, Mutual exclusion, Semaphore, Mutex.

- **Network architecture: IP layer protocol** [10 Hours] Packet switching, Circuit switching, Virtual circuit and Datagram approach, MAC and IP addressing, lP packet header and structure, Shortest path algorithms (Warshal, Dikstra and Bellman-Ford algo), Routing Algorithms (Flooding and selective, Distance vector, Link state, Hierarchical, Broadcast, Multicast).
- **Process coordination** [9 Hours] Process synchronization, Critical section via Peterson and Dekker algorithms, Classical problems: Bounded buffer, Readers-writers and Dining philosophers problem, Atomic transactions. Deadlock introduction and characterization, Resource modelling, Deadlock prevention, Avoidance (Bankers algorithm), Detection and Recovery
- **Network reliability**: Transport Layer Protocol [10 Hours] Connection oriented and Connection less services, Three way handshake based connection establishment, Flow control (Simplest, Stop and Wait, Stop and Wait ARQ, Go Back N ARQ, Selective Repeat ARQ), Congestion control via open loop, Closed loop (back pressure, choke packet) and Traffic shaping (Leaky bucket and token bucket).
- **Memory Management** [5 Hours] Physical and logical memory organisation Memory partitioning (fixed and dynamic) Paging, Segmentation, Virtual memory management, Locality of reference, Page table and Inverted page table, Translation look aside buffer (TLB), Page replacement (FIFO NRU, LFU, LRU, Clock page replacement)

**Suggested Reference Books:**


1. William Stallings, **Operating System**, 8th Edition, Pearson 2010. (Textbook)
2. Silberschatz, Glavin, Gagne, **Operating System Concepts**, 8th Edition, Pearson 2008. (Reference)
3. Andrew S. Tanenbaum, **Modern Operating System**, 5th Edition, Pearson 2010 ,(Reference)
4. Andrews. Tanenbaum and David J. Wetherall., **Computer Networks**, 5th Edition. Prentice Hall 2010/11 (Reference)
5. Behrouz A. Forouzan, **Data Communications and Networking**, 5th Edition, McGraw Hill 2013. (Textbook)
6. William Stallings, **Data and Computer Communications**, 9th Edition, Pearson 2010. (Reference)
7. Larry L. Peterson & Bruce S. Davie, **Computer Networks A Systems Approach**, 5th Edition, Morgan Kaufmann Elsevier 2011. (Reference)


## 4.27 CS 312 : Operating System

**Course Code : CS 312**

**Course Name : Operating System**

L-T-P-C : 3-0-2-4

Intended for : B.tech (CSE) 3rd Year, Electives for others
Prerequisite :
Mutual Exclusion:
Approval: 54th BoA

**Course Contents**

- **Introduction to Operating Systems (OS)**: What OS do, OS Structure, OS Operations, OS Services, User and OS Interface, System Calls, Types of System Calls, System Programs, OS Design and Implementation, OS Debugging and OS Generations. (5 Hours)

- **Process Management**: Process Concept, Scheduling, Interprocess Communication, Multi-core and Multithreading Programming Models, Thread Libraries, Threading Issues, The Critical-Section Problem, Mutex Locks, Semaphores, CPU Scheduling, Scheduling Algorithms, Thread Scheduling, Deadlocks Characterization, Detection, Prevention and A voidance. (9 Hours)

- **Memory Management**: Main Memory Background, Swapping, Contiguous Memory Allocation, Segmentation, Virtual Memory Concept, Demand Paging, Page Table Structure, Page Replacement, Copy-on-Write, Thrashing. (8 Hours)

- **Storage Management**: Storage Structure Overview, Disk Management and Scheduling, RAID Structure, File System Interface, Directory and Disk Structure, File Sharing, File-System Structure and Allocation Methods, Directory Implementation, I/0 Hardware, I/0 Interface, Kernel 110 Subsystem. (8 Hours)

- **Protection and Security**: Goals, Principle and Domain of Protection, Access Matrix. Access Control, Access Rights Revocation, Security Problem, Program Threats, User Authentication, Implementing Security Defenses, Firewalls. (7 Hours)

- **Advance Topics**: Virtual Machines, Virtualization and OS Component, Distributed System, Network-based OS, Communication Protocols, Case Studies related to different OS like XV6, Linux, Windows, etc. (5 Hours)

**Textbooks:**

1. Abraham Silberschatz, Peter B. Galvin, Greg Gagne, **Operating System Concepts**, 8th Edition, John Wiley, 2008.

2. AS Tanenbaum, **Modem Operating Systems**, 3rd Edition, Pearson, 2009

**References:**

1. William Stallings, **Operating Systems: Internals and Design Principles**, Prentice-Hall, 6th Edition, 2008.

2. AS Tanenbaum, AS Woodhull, **Operating Systems Design and Implementation**, 3rd Edition, Prentice Hall, 2006.

3. M. J. Bach, **Design of the Unix Operating System**, Prentice Hall of India, 1986.

4. Remzi Arpaci-Dusseau, Andrea Arpaci-Dusseau, **Operating Systems: Three Easy Pieces**, Version 1.1.0.

## 4.28 CS 313 : Computer Networks

**Course Code : CS 313**

**Course Name : Computer Networks**

L-T-P-C : 3-0-2-4
Intended for : BTech CSE (Third year)
Prerequisite :
Mutual Exclusion:
Approval: 54th BoA

**Course Contents**

- **Introduction** (4 Hours):
  - What is the Internet? Services and protocols.
  - Core and Edge Network, Packet-switched and circuit-switched networks
  - Layered architecture, Data Encapsulation, the end-to-end argument, history of the Internet.
  - [Lab] Networking tools in Linux: ping, traceroute, etc. Introduction packet analyzers such as tcpdump, Wireshark.
- **Application Layer** (4 Hours):
  - Services of the application layer, network applications, where is the application layer?
  - Application layer protocols, Hypertext Transfer Protocol, Email and Simple Mail Transfer Protocol (SMTP), Secure Shell (SSH), Domain Name System (DNS), File Transfer Protocol (FTP).
  - [Lab] Socket programming.
- **Transport Layer** (7 Hours):
  - Transport layer services and overview, Principles of reliable data transfer, UDP and TCP, Flow control and congestion control.
  - TCP congestion control, TCP implementation: Slow start, congestion avoidance, fast retransmit and fast recovery, Evolution ofTCP, legacy TCP and latest variants.
  - [Lab] Introduction to network simulators: ns2/ns3. Simulation-based study of TCP and UDP.
- **Network Layer** (9 Hours):
  - Network layer services and overview, architecture of a router, Switching and Forwarding, Datagram Approach (connectionless Service), Virtual Circuit Approach (connection- oriented Service).

- The Internet Protocol, Addressing and NAT, 1Pv4, IPv6 and Dynamic Host Configuration Protocol (DHCP).
- Unicast and multicast routing, Routing algorithms: Link-state routing and Distance-vector routing.
- Interaction of transport and network layer. Role of network layer in congestion control.
- Software-Defined Networking (SDN) and its evolution, Network management and associated protocols. [Lab] Study of routing algorithms using ns2/ns3 or network emulation using Mininet.

- **Link Layer** (8 Hours):
  - Link layer services, overview, link layer addressing, Address Resolution Protocol (ARP).
  - Error detection and correction, Cyclic Redundancy Check (CRC) and Checksum.
  - Multiple access protocols: channel partitioning, random access (ALOHA, CSMA and its variants), taking turns. Link-layer addressing, Ethernet and its evolution, Switches and VLANS.
  - [Lab] Virtual networking in Linux.

- **Wireless and next-gen networks** (4 Hours):
  - WiFi and 802.11 standard.
  - Cellular Internet Access, Routing and handoffs in mobile networks.
  - Edge computing, architecture for cloud networking and loT. [Lab] Simulation-/measurement-based study ofwireless networks.

- **Advanced topics** (6 Hours):
  - Firewalls, Proxy, VoiP, protocols for video streaming, network economics, Content Delivery Networks.

**Textbooks:**

1. JF. Kurose and KW. Ross, **Computer Networking: A top-down approach**, 8th Edition, Pearson, 2022.

**References:**

1. L. Peterson and B. Davie, **Computer Networks: A Systems Approach**, 6th Edition, Morgan Kaufmann Publishers.

2. BA. Forouzan, **Data Communications and Networking**, 5th Edition, McGraw Hill.

3. MJ. Donahoo and KL. Calvert, **TCP/IP Sockets inC: Practical Guide for Programmers**, Morgan Kaufmann Publishers.

### 4.29 CS 347 : Software Engineering

**Course Code : CS 347**

**Course Name : Software Engineering**

L-T-P-C : 3-0-2-4

Intended for : B.Tech. Electrical Engineering, allied B.Tech programmes

Prerequisite : IC161 – Applied Electronics, EE261 - Electrical Systems around us, EE260 – Signals and Systems.

Mutual Exclusion:

Approval: 56th BoA

**Course Contents**

- **Introduction**: software engineering principles, software life-cycle models, software requirements specification, formal requirements specification and verification - axiomatic and algebraic specifications (9 Lectures)
- **Software Architecture and Design**: Function-Oriented Software design, Object Oriented Design, UML, design patterns, user interface design, computer-aided software engineering (CASE), software reuse, component-based software development, extreme programming. (12 Lectures)
- **Software Testing and Verification**: Coding and Unit testing, Integration and System testing, debugging techniques, Software Quality: SEI CMM and ISO-9001,Software Reliability and fault tolerance. (8 Lectures)
- **Software Management**: Evolution, Project Management and Risk Analysis, Software Quality Management, Configuration Mangement, Software Metrics, Cost Analysis and Estimation, Manpower Management and Organization and Management of large software projects. (11 Lectures)

**Laboratory/practical/tutorial Modules:**

Lab(s)/Assignment(s) related to different aspect of software development, testing and verification using CASE tool and workbenches.

**Text Books:**

1. Pressman, **Software Engineering: A Practitioner's Approach**, 7th edition, McGraw Hill Education.

**Reference Books:**


1. 1. I. Sommerville, **Software Engineering**, 5th Edition, Addison-Wesley, 2000.
2. T. C. Lethbridge and Robert Laganire, **Object Oriented Software Engineering**, Tata McGraw Hill, 2004.
3. Bennett, S. McRobb, R. Farmer, **Object Oriented Systems Analysis and Design using UML**, McGraw-Hill, 4th edition, 2010.

## 4.30 CS 350: Computer Graphics

**Course Code: CS 350**

**Course Name: Computer Graphics**

L-T-P-C: 3-0-0-3
Category:
Prerequisites:
Approval: 5th Senate

**Course Contents**

Raster Graphics; line and circle drawing algorithms; Windowing and 2D/3D clipping. Cohen and Sutherland line clipping, Cyrus Beck clipping method; 2D and 3D Geometrical Transformations: scaling, translation, rotation, reflection; Viewing Transformations: parallel and perspective projection; Curves and Surfaces: cubic splines, Bezier curves, B-splines, Parametric surfaces. Surface of revolution Sweep surfaces, Fractal curves and surfaces; Hidden line/surface removal methods; illuminations model; shading, Introduction to Ray-tracing; Animation; Programming practices with standard graphics libraries like openGL.

**Text and Reference Books**

1. Edward Angel, **Interactive Computer Graphics: A top-down approach using OpenGL**, 5th Edition, Pearson Education.
2. Hearn and Baker, **Computer Graphics using OpenGL**, 3rd Editoin, Pearson Education.
3. Foley, Dam, Feiner and Hughes, **Computer Graphics: Principles and Practice in C**, Pearson Education.
4. Hill, **Computer Graphics using OpenGL**, PHI.

## 4.31 CS 362 : Artificial Intelligence

**Course Code : CS 362**

**Course Name : Artificial Intelligence**

L-T-P-C : 3-0-0-3
Intended for : 3rd and 4th year B.Tech. students
Prerequisite : CS 212 or an equivalent course
Mutual Exclusion:
Approval: 54th BoA

**Course Contents**

- **Introduction to AI**: (3 Hours) Overview, historical perspective, Turing test, agents.

- **Search Methods and Optimization**: Problem representation, State Space Search, A* Algorithm, AO* search, Minimax and alphabeta pruning, AI in games. (8 Hours)

- **Logic and Automated Reasoning**: Propositional Logic, Predicate Calculus, Resolution Refutation, Formal Systems, Soundness, Consistency, Completeness. (7 Hours)

- **Planning and Constraint Satisfaction**: Blocks World, STRIPS, Constraint Satisfaction Problems, Basics of Probabilistic Planning, Waltz Algorithm. (6 Hours)

- **Knowledge Representation and Reasoning**: Semantic Net, Frames, Scripts, Conceptual Dependency, Ontologies, Basics of Semantic Web, Intelligent Question Answering. (7 Hours)

- **Learning and Uncertainty**: Learning from Examples, Decision Trees, Neural Nets, Bayesian Theory, Fuzzy Logic, Nonmonotonic Logic, Default Reasoning, Case-based Reasoning. (6 Hours)

- **Advanced Topics in AI**: Introduction to Computer Vision, Expert Systems, Natural Language Processing, Robotics, Hidden Markov Models, Reinforcement Learning. (5 Hours)

**Textbooks:**

1. Russell, S., & Norvig, P., **Artificial Intelligence: A Modern Approach**, 4th Edition, Pearson Education, 2020.

2. Poole, D., & Mackworth, A., **Artificial Intelligence: Foundations of Computational Agents**, 2nd Edition, Cambridge University Press, 2017.

**References:**

1. Murphy, K. P., **Machine Learning: A Probabilistic Perspective**, MIT Press, 2012.

2. Luger, G. F., **Artificial Intelligence: Structures and Strategies for Complex Problem Solving**, 6th Edition, Pearson Education, 2008.

## 4.32 CS 401: Architecture of High Performance Computers

**Course No. : CS 401**

**Course Name : Architecture of High Performance Computers**

L-T-P-Cs :3-0-2-4
Prerequisites :Computer Architecture; Operating Systems.
Approval: Not Approved; OTA Course

**Course Contents**

- Classification of parallel computing structures, instruction level parallelism - static and dynamic pipelining, improving branch performance, superscalar and VLIW processors; High performance memory system; Shared memory multiprocessors and cache coherence; Multiprocessor interconnection networks; Performance modeling; issues in programming multiprocessors; Data parallel architectures.

## 4.33 CS 402 (3) Compilers

Senate: 8th
Approval: OTA Course; 5th Senate

**Course Outline:**

This course aims to provide the students with a thorough understanding of compilation technology. Assignments/Mini-project will provide the students with a practical knewledge of building compiler components using the open source LLVM fi'amework. Towa'r'dsthe end, an overview of compiling functional languages will provide glimpses and illustrations of advanced programming language and compilation technology.

## 4.34 CS 402: Compiler Technology

**Course Code : CS 402**

**Course Name : Compiler Technology**

L-T-P-C : 0-0-3-2
Prerequisites : None
Intended for : B.Tech.
Distribution : Compulsory for CSE; CS elective for EE and ME
Pre-requisites: Algorithms and Data Structures; Formal Languages and Automata Theory; Paradigms of Programming
Approval: 4th Senate

**Course Contents**

- **Moduel I** Introduction to compilers, Lexical Analysis, Syntax Analysis, Parsing Top down, Bottom up and advanced, Syntax directed translation, Intermediate Code Generation type checking and control flow.
- **Moduel II** Run time environments Stack allocation, Heap management, Garbage Collection, Code generation and Optimization machine independent, machine dependent, parallelism, data flow analysis and locality.
- **Moduel III** LLVM - Introduction, Illustration with examples, Mini-project.
- **Moduel IV** Compiling Functional Languages Review of Lambda Calculus, Translating functional programs into lambda calculus, Program representation and Graph reduction of lambda expressions, Supercombinators and lambda lifting, Advanced Graph Reduction the G-Machine and Optimizations.

- **Moduel V** (Optional time permitting) Compiling with Continuations Review of Continuations and CPS, Conversion to CPS, Optimization of CPS, Closure Conversion and Machine code generation.

**Textbooks:**

1. A. Appel, **Modern Compiler Implementation in C (Java, ML)**, Cambridge Univ. Press.

2. Simon Peyton-Jones, **Implementation of Functional Languages**, Prenctice-Hall.

3. A. Appel, **Compiling with Continuations**, Cambridge University Press.

**References:**

1. Aho, Lam, Sethi and Ullman, **Compilers Principles, Techniques, Tools**, 2nd Edition, Pearson/Addison-Wesley.

## 4.35 CS 403: Algorithm Design and Analysis I

**Course Number: CS 403**

**Course Name: Algorithm Design and Analysis I**

Credits: 3-0-1-4 .
Prerequisites: CS 492 (ADSA) or equivalent, and the instructors consent
Intended for: B.Tech.
Distribution: Elective for CS and EE
Approval:

**Objective:**

After the students have gone through a course on discrete structUres, where they learn-formal and abstract representations of data and its manipulation and another course on data ; A structures, where they learn concrete implementations and usage of such discrete structures, a first course on algorithm design and analysis shOuld teach the students how to design an efficient algorithm for a given computational task using one or more of such data ' structures, analyze performance of a given algorithm, and provide performance guarantees:

On completion of such a course, students should be able to

- analyze the asymptotic performance of algorithms and write formal correctness proof for algorithms

- demonstrate their familiarity with major algorithm design paradigms and methods of analysis

- demonstrate their knowledge of major algorithms and data-structures corresponding to each algorithm

- design paradigm construct efficient algorithms for common computer engineering design problems
- classify a problem as computationally tractable or intractable, and discuss strategies to address in-tractability.

Further, as programming is an integral part of the CS education, 'in this course students v should implement the algorithms they learn and compare the corresponding achievable performance (computation time. memory requirement. etc.) with the corresponding asymptotic performance bounds they learn to compute in this course.

**Syllabus:**

- **Review of Data Structures** (3 hours)
- **Program Performance**: Time and space complekity, average and worst case analysis, asymptotic,,notation, recurrence equations and their solution (3 hours)
- **Algorithmic Techniques**: Search techniques. Sorting algorithms - lower bound, sorting in linear time, Greedy algorithms (Huffman coding, knapsack). Divide and conquer - Master theorem, Dynamic programming (0/1 knapsack, Traveling salesman problem. matrix multiplication, all-pairs shortest paths), Randomization, Randomized data structures: Skip Lists, Universal and perfect Hash functions, Back-tracking, Branch and bound (15 hours)
- For each algorithm technique the following is expected: Description of a technique, explanation when an algorithm design situation requires it examples of algorithms based on this technique, analysis of performance these algorithms. .
- **Graph Algorithms**: DFS and BFS, biconnectivity, spanning trees; Minimum cost spanning trees: Kruskals, Prime. and Sollins algorithms; Path finding and shortest path algorithms; Topological sort-ing; Matching, Network Flows; Bipartite graphs (6 hours)
- **Computational complexity**: Problem classes. P, NP, NP—complete NP-hard Reduction Cooks theorem. Examples of NP—complete problems (6 hours)
- **Competitive analysis** (3 hours)
- **Amortized analysis**: aggregate analysis, accounting, potential method. (3 hours)
- **Other topics**: Number theoretic algorithms (GCD. modulo arithmetic, Chinese remainder theorem). string matching algorithms (Rabin Karp algorithm, string matching with Finite State ' Automata, KMP (Knuth-Morris—Pratt) algorithm, Boyer-Moore algorithm), Strassens matrix multiplication, FFT, integer and polynomial arithmetic (3 hours)
- **Advanced topics**: Lower-bound techniques: adversary arguments, information-theoretic bounds

**Reference Books:**

1. T. H. Cormen, C. E. Leiserson R. L. Rivest. and C. Stein, **Introduction to Algorithms**, 3rd Edition, MIT Press, 2009.

2. J. Kleinberg and E Tardos, **Algorithm Design**, Pearson, 2006.

3. S: Dasgupta, C H. Papadimitriou, U. V. Vazirani, **Algorithms**, McGraw-Hill, 2006.

4. S. S. Skiena, **The Algorithm Design Manual**, 2nd Edition, Springer, 2008.

5. G. Brassad, P. Bratley, **Fundamentals Of Algorithmics**, Prentice-Hall India.

## 4.36 CS 403: Algorithm Design and Analysis

**Course Code : CS 403**

**Course Name : Algorithm Design and Analysis**

L-T-P-C : 3-0-2-4
Prerequisites : CS-3xx (ADSA) or equivalent, or the instructors consent
Intended for : UG
Distribution : Discipline elective for CS and EE
Semester : 5th or 6th
Approval: 6th Senate

**Course Contents**

- **Review of Data Structures**. [3 Lectures]
- **Program Performance**: Time and space complexity, average and worst case analysis, asymptotic notation, recurrence equations and their solution. [3 Lectures]
- **Algorithmic Techniques**: Search techniques (backtracking and bounding), Sorting algorithms - lower bound, sorting in linear time, Greedy algorithms (Huffman coding, knapsack), Divide and conquer - Master theorem, Dynamic programming (0/1 knapsack, Traveling salesman problem, matrix multiplication, all-pairs shortest paths), Randomization, Randomized data structures: Skip Lists, Universal and perfect Hash functions, Backtracking, Branch and bound. [15 Lectures]
  - For each algorithm technique the following is expected: Description of the technique, explanation when an algorithm design situation requires it, examples of algorithms based on this technique, analysis of performance these algorithms.
- **Graph Algorithms**: DFS and BFS, biconnectivity, spanning trees; Minimum cost spanning trees: Kruskals, Prims, and Sollins algorithms; Path finding and shortest path algorithms; Topological sorting; Matching, Network Flows; Bipartite graphs. [6 Lectures]
- **Computational complexity**: Problem classes: P, NP, NP-complete, NP-hard. Reduction. Cooks theorem. Examples of NP-complete problems. [6 Lectures]
- Competitive analysis [3 Lectures]

- **Amortized analysis**: aggregate analysis, accounting, potential method. [3 Lectures]
- **Other topics**: Number theoretic algorithms (GCD, modulo arithmetic, Chinese remainder theorem), string matching algorithms (Rabin Karp algorithm, string matching with Finite State Automata, KMP (Knuth-Morris-Pratt) algorithm, Boyer-Moore algorithm), Strassens matrix multiplication, FFT, integer and polynomial arithmetic. [3 Lectures]
- **Adanced topics**: Lower-bound techniques: adversary arguments, information-theoretic bounds.

**Reference Books:**


1. T. H. Cormen, C. E. Leiserson, R. L. Rivest, and C. Stein, **Introduction to Algorithms**, 3rd Edition, MIT Press, 2009.
2. J. Kleinberg and E. Tardos, **Algorithm Design**, Pearson, 2006.
3. S. Dasgupta, C. H. Papadimitriou, U. V. Vazirani, **Algorithms**, McGraw-Hill, 2006.
4. S. S. Skiena, **The Algorithm Design Manual**, 2nd Edition, Springer, 2008.


## 4.37 CS 405: Verification of Reactive Systems

**Course Code: CS 405**

**Course Name: Verification of Reactive Systems**

L-T-P-C: 3-0-0-3
Prerequisites: MFCS, FLAT (recommended)
Intended for: BTech, MTech, MSc, MS/PhD in the area.
Elective/Core: Discipline elective for BTech CSE and EE, free elective for others
Approval: OTA Course; 11th Senate

**Course Contents**

- Introduction (1 week)
  - o Introduction and overview of the course
  - o Revision of predicate logic, undecidable problems, proof systems.
  - o Basic approaches to verification: property and equivalence verification, correctness by design
- Modelling of Systems (2 weeks)
  - Formal models for non-terminating reactive systems (hardware/software) : Buechi Automata, Transition Systems, Process Algebras, Petri Nets
  - Dimensions of behavior descriptions :
    - interleaving vs truly concurrent

    * linear vs branching time
    * quantitative vs qualitative descriptions
  - Property classification: regularity, safety, liveness, fairness
  - Equivalence notions:
    * trace equivalence
    * testing equivalence
    * observation equivalence
  - Case studies - equivalence checking

- Property Verification of Reactive Systems (4 weeks)
  - Verification of regular properties
  - Temporal and modal logics for property specification: LTL, CTL, CTL*, HML
  - Verifying properties: principles of model checking, complexity and limits
  - Case studies with model checker SPIN

- Property Verification of Time-Critical and Hybrid Systems (3 weeks)
  - Timed automata (theory, reachability analysis)
  - Case study with model checker UPPAAL

- Correctness by Design (2 week)
  - Stepwise refinement
  - Case study with proof assistant RODIN

- (Remaining week will be used as buffer and for doubt clearing.)

**Textbooks:**

1. Christel Baier and Joost-Pieter Katoen, **Principles of Model Checking**, MIT Press, 2008.

**References:**


1. Luca Aceto, Anna Ingolfsdottir, Kim G. Larsen and Jiri Srba, **Reactive Systems - Modelling, Specification and Verification**, Cambridge textbooks, 2007
2. M. Ben-Ari, **Principles of the SPIN Model Checker**, MIT Press, 2008
3. Wan Fokking, **Modelling Distributed Systems**, Springer Verlag, 2007
4. Michael Huth and Mark Ryan, **Logic in Computer Science Modelling and Reasoning about Systems**, Cambridge University Press, 2004
5. Gerald Holzmann, **The SPIN Model Checker - Primer and Reference Manual**, Addison Wesley, 2003
6. Doron Peled, **Software Reliability Methods**, Springer Verlag, 2001

## 4.38 CS 406: Computer Networks

### Course Code: CS 406

### Course Name: Computer Networks

L-T-P-C: 3-1-0-4
Prerequisites: CS-304 - Communicating Distributed Processes or the instructor's consent
Intended for: UG
Distribution: Elective for CS and EE
Semester: 7th or 8th
Approval: 9th Senate

### Course Contents

- **Introduction to Networking and Physical layer** [4 Lectures]
  - Signals and Data Basic Properties, Fourier Transform, Transmission (noise, attenuation, distortion), Effective Bandwidth.
  - Digital to Digital Transmission Line coding, Block coding and Scrambling.
  - Multiplexing - Frequency-Division Multiplexing (FDM), Wavelength-Division Multiplexing (WDM), Time-division Multiplexing (TDM).
  - Types of Switching Circuit Switching, Packet Switching, Message Switching, QoS for Circuit Switching.
- **2. Data Link Layer** [7 Lectures]
  - Link-Layer Addressing Types of addresses, Address Resolution Protocol (ARP).
  - Error Detection and Correction Block Coding, Cyclic Codes (Cyclic Redundancy Check, Polynomials, GF2) and Checksum.
  - Logical Link Control (LLC) Sublayer: LLC Services Framing, Flow and Error Control. Protocols Stop-and-Wait, Piggybacking, High-Level Data Link Control (HDLC), Point-to-Point Protocol (PPP).
  - Media Access Control (MAC) Sublayer: Random Access ALOHA, Carrier Sense Multiple Access (CSMA), Collision Detection (CSMA/CD), Collision Avoidance (CSMA/CA).
- **Network Layer** [10 Lectures]
  - Network Layer Services Packeting, Routing, and Forwarding.
  - Packet Switching Datagram Approach (connectionless Service), Virtual Circuit Approach (connection- oriented Service).
  - QoS of Packet Switching Delay, Throughput, Packet Loss, and Congestion Control.
  - IP Addressing IPv4 and IPv6, Dynamic Host Configuration Protocol (DHCP), Network Address Translation (NAT).
  - Routing Algorithms:

    * UNICAST Routing: Max Flow-Min Cut theorem and Ford Fulkerson Algorithm, Bellman Ford and Dijkstra's Algorithms, Shortest Path Routing, Distance-Vector Routing, Link -State Routing and Path Vector Routing, Hierarchical Routing, Routing Information Protocol (RIP), Open Shortest Path First (OSPF).
    * MULTICAST Routing: Flooding, Multicast Distance Vector (DVMRP), Protocol Independent Multicast (PIM) and Multicast Link State (MOSPF).

- **Transport Layer** [10 Lectures]
  - Protocols Stop-and-Wait, Go-Back-N, Selective-Repeat, User Datagram Protocol (UDP): services and applications, Transmission Control Protocol (TCP): services, flow, and congestion control.
  - TCP implementation techniques Slow start, congestion avoidance, fast retransmit and fast recovery.
  - Optional Topics: TCP Variants: TCP Tahoe, TCP Reno, TCP Vegas, TCP SACK and TCP Westwood, STCP.
- **Application Layer** [6 Lectures]
  - Services and Protocols Application protocols, such as Hypertext Transfer Protocol (HTTP), Simple Mail Transfer Protocol (SMTP), File Transfer Protocol (FTP), Internet Mail Access Protocol (IMAP), Post Office Protocol (POP), Simple Network Management Protocol (SNMP).
  - Optional Topics: Secure Shell (SSH), Domain Name System (DNS), Lightweight Directory Access Protocol (LDAP), Network Time Protocol (NTP), Remote Procedure Call (RPC) and Secure Socket Layer (SSL).
- **Advanced Topics** [5 Lectures]
  - Service Models Resource Reservation Protocol (RSVP), Integrated and Differentiated.
  - Flow Control Scheduling, Traffic Modellers, Multi Protocol Label Switching (MPLS).
  - Peer to Peer Paradigm Distributed Hash Table (DHT), CHORD, PASTRY, KADEMILA.

**Textbooks:**

1. 1. B. A. Forouzan, **Data Communications and Networking**, 5th Edition, McGraw Hill, 2013.

**Suggested Reference Books:**

1. A. S. Tanenbaum and D. J. Wetherall, **Computer Networks**, 5th Edition, Prentice Hall, 2011.

2. D. P. Bertsekas and R. G. Gallager, **Data Networks**, 2nd Edition, Prentice Hall, 1992.

3. S. Keshav, **An Engineering Approach to Computer Networking: ATM Networks, the Internet, and the telephone network**, Addison Wesley Longman, 1997.

4. R. Perlman, **Interconnections: Bridges, Routers, Switches and Internetworking Protocols**, 2nd Edition, Addison Wesley, 1999.

5. L. L. Peterson and B. S. Davie, **Computer Networks: A Systems Approach**, 5th Edition, Morgan Kaufmann, Elsevier, 2011.

6. W. Stallings, **Data and Computer Communications**, 10th Edition Pearson, 2013.

7. G. B. White, E. A. Fisch, and U. W. Pooch, **Computer System and Network Security**, CRC Press, 1995.

## 4.39 CS 451: Computer Graphics and Game Design

**Course Code: CS 451**

**Course Name: Computer Graphics and Game Design**

L-T-P-C: 2-0-2-3
Prerequisites: Experience in writing computer-code.
Intended for: B.Tech. (all branches) II/III/IV year
Distribution: Elective for B.Tech. II/III/IV year
Approval: 28th Senate

**Course Contents**

- **Introduction:** Motivation; Types of games, Different aspects of game design; Different components in a game; Game engines; Geometric primitives, 2D and 3D linear transforms, Homogeneous matrices; Examples of games. [5 Lectures]

- **Sprites and animation:** Different image formats; Polygon file formats; Creating sprites; Rigging; Animations using sprite-sheets; Animations using keyframes; Animation controllers. [6 Lectures]

- **Level design:** Scenes; Tiles, visual continuity in tiles; Adding objects to scene; Prefabs; Lighting, RGB space, transparency, texture mapping; Collectibles; Navigation and pathfinding. [6 Lectures]

- **World interaction:** Physics engines; Gravity simulation; Rigid body interaction; Collisions. [6 Lectures]

- **User interface:** Layout; Menu system; Visual components; Event system; Skins. [3 Lectures]

- **Audio:** Audio assets; Different audio formats; Audio mixing. [2 Lectures]

**Lab Exercises**

Lab to be conducted on a 2-hour slot, in tandem with the theory course so the topics for problems given in the lab are already initiated in the theory class. The topics taught in the theory course shall be appropriately sequenced for synchronization with the laboratory. The students will progressively design and write a 2D video game as part of the lab.

- Lab1-2: Installation of a game engine, e.g., Unity, familiarization of the GUI. Conceptualize the theme for a 2D game.
- Lab3-4: Character design, sprites, movement and character control.
- Lab5-7: Level design: design of the world in form of tiles along with interactive and collectible objects.
- Lab8-9: Design of interaction between the player and the world, optionally using the physics engine.
- Lab9-11: Design of menus and user interaction in mobile platform.
- Lab12: Insert audio.

**Textbooks:**

1. Nystrom Robert, **Game Programming Patterns**, 3rd Edition, Genever Benning, 2014

**Reference Books:**

1. Paris Buttfield-Addison et al., **Unity Game Development Cookbook: Essentials for Every Game**, O'Reilly Media, 2019.

## 4.40 CS 456: Distributed Databases

**Course Code : CS 456**

**Course Name : Distributed Databases**

L-T-P-C : 3-0-0-3
Students intended for: Third Year and Fourth Year CS students
Elective or Compulsory: Elective
Semester : Odd or Even
Prerequisites :CS204 and CS206
Approval: 4th Senate

**Course Contents**

(if possible, separated in to approximate units each corresponding to 10 Lectures):

- **Introduction**
  - a. Distributed Data Processing
  - b. Concepts of Distributed Database Systems

- **Distributed DBMS Architecture**
  - Transparency Issues
  - Architectural Models
  - Distributed Database Design
- **Distributed Database Design Issues**
  - a. A Fragmentation b. Allocation
  - c. Integrity Constraints
- **Query Processing**
  - Objectives of Query Processing
  - Layers of Query Processing
  - Query Decomposition and Data Localization
- **Optimization of Distributed Queries**
  - Centralized Query Optimization
  - Join Ordering
  - Distributed Query Optimization Algorithms
- **Advanced Topics**
  - Distributed Transaction Management and Concurrency Control , Distributed DBMS
  - Reliability and Replication Techniques, Multidatabase Systems

**Suggested Reading:**


1. M.TamerOzsu, Patrick Valduriez, **Principles of Distributed database systems**, 2nd Edition, Pearson Education.

2. Stefano Ceri, Giuseppe Pelagatti, **Distributed Databases: Principles & Systems**, McGraw- Hill.


## 4.41 CS 501: Access Networks

**Course Code: CS 501**

**Course Name: Access Networks**

L-T-P-C: 3-0-0-3
Prerequisites:5th Senate
Approval:

**Course Contents**

- Overview of Analog and Digital communications
- PDH/SDH/SONET
- XDSL (ADSL, HDSL and VDSL)
- Overview of Fiber Optics/Optical Sources and detectors
- PON basics and GPON in detail
- Multiple access schemes: FDMA, TDMA, CDMA
- Wireless systems and standards (1G/2G/3G systems)

## 4.42 CS 502: Compiler Design

**Course Code : CS 502**

**Course Name : Compiler Design**

L-T-P-C : 3-0-2-4
Prerequisites : CS 202: Data Structures and Algorithms; CS304: Formal Languages and Automata Theory
Intended for : BTech third and final year CSE and MS/PhD
Distribution : Elective for third and final year BTech CSE/EE, MS, PhD
Approval: 24th Senate

**Course Contents**

- **Introduction and lexical analysis** Introduction to language translators. Stages of compilation. Lexical analyzers: token specification and recognition. [4 Lectures]
- **Parsing** Overview of context-free grammars. Parse trees and derivations. Left recursion and left factoring. Top-down and bottom-up parsing. [8 Lectures]
- **Semantic analysis** Syntax-directed translation. Various intermediate representations. Intermediate code generation. Type checking. [9 Lectures]
- **Runtime environments**: Activation records. Heap management. Garbage collection. [4 Lectures]
- **Code generation and optimization**: Register allocation. Instruction selection and scheduling. Control-flow graphs. Data-flow analysis. Peephole optimizations. [9 Lectures]
- **Advanced topics**: Loop optimizations. Call-graph construction. Machine learning in compiler design. Just-in- time compilers. [8 Lectures]

**Labs**

Learning the art of compiler design involves a nice mix of theory and practice. The course consists of at least four programming assignments from the following set (assignments will be rotated in every offering to contain plagiarism):

- Learning to use a lexer/parser generator such as Flex/Bison/JavaCC
- Intermediate code generation
- Type checking
- One forward/backward dataflow analysis
- Register allocation
- Assembly code generation

**Textbooks:**

1. Alfred V. Aho, Monica Lam, Ravi Sethi and Jeffrey D. Ullman, **Compilers: Principles, Techniques, and Tools**, 2nd Edition, Pearson Education, 2007.
2. Andrew W. Appel, Jens Palsberg, **Modern Compiler Implementation in Java**, 2nd Edition, Cambridge University Press, 2002.

**Reference books:**

1. Keith D. Cooper and Linda Torczon, **Engineering a Compiler**, 2nd Edition, Morgan Kaufmann, 2011.
2. Y. N. Srikant and Priti Shankar, **The Compiler Design Handbook**,2nd Edition, CRC Press, 2007.

## 4.43 CS 502P: Basic Data Science Practicum

**Course Code: CS 502P**

**Course Title: Basic Data Science Practicum**

L-T-P-C: 1-0-3-3
Prerequisites: Consent of Teacher
Intended for: MSc/PhD in Chemistry, Biology, Physics, MA in HSS. Not open to B.Tech.
Elective or Core: Free elective
Approval: 22nd Senate

**Course Contents**

- Introduction to Data Science; model of computation; program = data structures + algorithms
- Expressions: scalar variables, operators, precedence, data types
- Decisions: if-else; nested decisions; flow-charts

- Top-down and bottom-up program design; iterations – definite and indefinite; arrays
- Functions and modules; stats, rand, matplotlib modules; Review of statistics; Visualisation of data
- Collections: list, set, dict, Numpy array; File I/O; exceptions
- CSV file format; Pandas dataframe; Regression and interpolation; measures of goodness of fit; visual inspection – boxplots
- Data collection; cleansing; formats; units
- Case studies from experimental chemistry, biology and allied areas

**Lab**

- The Python programming environment (OS and IDE); "Hello world" in Python
- Python as a calculator; input/output of numbers; type conversion
- Classification using if-else; debugging using print, breakpoints, execution of selected statements
- Trying it out using the console; flow-charts to code; initiallising an array; filling an array with input numbers; printing an array
- Filling an array with random numbers; distributions; Computing statistics of an array of numbers; Plotting line, scatter, bar, histograms using matplotlib
- Use of list, set and dict; Reading data from a file into a Numpy array
- Reading .csv into a Pandas dataframe; Fitting curves to given datasets
- Gridding of datasets; conversion of file from one format to another

**Text books**

1. Michael Dawson, **Python Programming for the Absolute Beginner**, 3rd Edition, Premier Press, 2003 (Chapter 1-7)
2. Jake Vanderplas, **Python Data Science Handbook**, O' Reilly, 2016 (Chapters 1-4)

**References**

1. Montgomery & Runger, **Applied Statistics and Probability for Engineers**, 3rd Edition, Wiley, 2003
2. Jose Unpingco, **Python for probability, statistics and machine learning**, Springer.
3. Ben Stephenson, **The Python Workbook: A Brief Introduction with Exercises and Solutions**, Springer, 2014

The course is a subset of IC152. IC152 is intended for BTech students and assumes a strong background in mathematics and familiarity with computers. CS502P is not open to BTechs, it assumes no knowledge of computers and only 10th standard mathematics.

## 4.44 CS 506: Cognitive Modeling

**Course Code: CS 506**

**Course Name: Cognitive Modeling**

L-T-P-C: 2-0-2-3
Students intended for: 3rd, 4th year B. Tech. CSE/M.S. SCEE/Ph.D. SCEE, HSS
Elective or Compulsory: Elective
Semester: Odd or Even
Prerequisites: None
Approval: 3rd Senate

**Course Contents**

- **Introduction to Cognitive Modeling**: What are cognitive models? Advantages of cognitive models, Practical uses of cognitive models, The steps involved in cognitive modeling
- **Lab**: Install and becoming familiar with cognitive modeling software tools (Excel and/or Matlab) on your computer
- **Qualitative Model Comparisons**: Category learning experiment, Two models of category learning, Qualitative comparisons of Models
- **Lab**: Simulate qualitative model comparison using the Exemplar model in Matlab or Excel
- **Basic Parameter Estimation Techniques**: Linear and Nonlinear parameter estimation, Retention Experiment and Model, Aggregate modeling versus individual modeling, Objective function and searching for optimal parameters
- Application to Choice and Response Time Measures (Signal detection task; Dynamic signal detection model; parameter estimation; goodness of fit; lack of fit tests)
- **Lab**: Simulate parameter estimation using the Retention model in Matlab or Excel. Also, simulate parameter estimation using the Wiener Diffusion Model in Matlab or Excel
- **Quantitative model comparisons**: Maximum likelihood estimation, Becharas Simulated Gambling Task (BSGT), Three Cognitive Models on BSGT, Parameter estimation, Quantitative model comparisons using AIC and BIC, Cross-validation and Generalization
- **Lab**: Create models on BSGT in Matlab or Excel; Simulate parameter estimation on BSGT in Matlab or Excel

- Connectionist versus Rational Approaches: (Rational) Instance-based Learning (Instances; K- nearest neighbor learning; Case-based reasoning; Similarity; Activation), (Connectionist) Neural Networks(neural networks, Rescorla-wagner/delta rule, Multi-layer feed forward networks, Discuss the relative theoretical merits of either approach

- **Lab**: Create and simulate a cognitive model for each ofthe connectionist and the rational approaches.

**Textbooks:**

1. J. Busemeyer & A. Diederich, **Cognitive Modeling**, Sage Publications, 2009. [BD]

2. S. Farrel & S. Stephan Lewandowsky, **Computational Modeling in Cognition: Principles and Practice**, Sage Publications, 2010. [FL]

**Reference Books:**

1. R. Sun, **Cognition and Multi-Agent Interaction**, Cambridge University Press, 2006. [RS]

2. Konar, **Artificial Intelligence and Soft Computing: Behavioral and Cognitive Modeling of the Human Brain**, CRC Press, 1999. [AK]

3. T. Mitchell, **Machine Learning**, McGraw-Hill Science, 1997.[TM]

4. B. Hahn, **Essential Matlab for Engineers and Scientists**, 4th Edition, Academic Press, 2009. [BH]

**Articles**

1. Certain articles from JSTOR: I will hand out photocopies during the semester.

**Software**

- Matlab and Palisade Decisions Tools (the instructor will provide the CD for these software tools)

## 4.45 CS 507: Computer Architecture

**Course Code : CS 507**

**Course Name : Computer Architecture**

L-T-P-C : 3-0-2-4
Pre-requisite : CS201 Computer Organization or Equivalent
Intended for :BTech Computer Science Engineering (CSE) and Electrical Engineering(EE), MS, M. Tech. & PhD.
Distribution : Elective for Third and Final year B. Tech (CSE/EE), MS, M. Tech. in VLSI/Signal Processing and Communication & PhD
Approval: 14th Senate

**Course Contents**

- **Introduction:** Defining Computer Architecture, Flynns Classification of Computers, Metrics for Performance Measurement [4 Lectures]
- **Memory Hierarchy:** Introduction, Advanced Optimizations of Cache Performance, Memory Technology and Optimizations, Virtual Memory and Virtual Machines, The Design of Memory Hierarchy, Introduction to Pin Instrumentation and Cachegrind, Case Study: Memory Hierarchies in Intel Core i7 and ARM Cortex-A8. [8 Lectures]
- **Instruction Level Parallelism**: Instruction-level Parallelism: Concepts and Challenges, Basic Compiler Techniques for Exposing ILP, Reducing Branch Costs with Advanced Branch Prediction, Dynamic Scheduling, Advanced Techniques for Instruction Delivery and Speculation, Limitations of ILP, Multithreading: Exploiting Thread-Level Parallelism to Improve Uniprocessor Throughput, Modeling Branch Predictors using Pin Tool, Case Study: Dynamic Scheduling in Intel Core i7 and ARM Cortex-A8. [10 Lectures]
- **Thread Level Parallelism:** Introduction, Shared-Memory Multicore Systems, Performance Metrics for Shared-Memory Multicore Systems, Cache Coherence Protocols, Synchronization, Memory Consistency, Multithreaded Programming using OpenMP, Case Study: Intel Skylake and IBM Power. [10 Lectures]
- **Data Level Parallelism:** Introduction, Vector Architecture, SIMD Instruction Set Extensions for Multimedia, Graphics Processing Units, GPU Memory Hierarchy, Detecting and Enhancing Loop-Level Parallelism, CUDA Programming, Case Study: Nvidia Maxwell. [10 Lectures]

**Computer Architecture Lab:**

- The lab experiments (assignments) will be designed to assist the theory covered in the class.

**Text Books:**


1. J.L. Hennessy and D.A. Patterson. **Computer Architecture: A Quantitative Approach**, 5 th Edition, Morgan Kauffmann Publishers, 2012.


**References:**


1. J.P. Shen and M.H. Lipasti, **Modern Processor Design: Fundamentals of Superscalar Processors**, McGraw-Hill Publishers, 2005.
2. D.B. Kirk and W.W. Hwu, **Programming Massively Parallel Processors**, 2nd Edition, Morgan Kauffmann Publishers, 2012.
3. Pin - A Dynamic Binary Instrumentation Tool. https://software.intel.com/en-us/articles/pin-a-dynamic-binary-instrumentation-tool
4. Cachegrind: A Cache and Branch-Prediction Profiler. http://valgrind.org/docs/manual/cg-manual.html

5. OpenMP. www.openmp.org
6. CUDA. https://developer.nvidia.com/cuda-zone

**Course Code: CS 507 (Old)**

**Course Name: Advanced Data Structure and Algorithms**

L-T-P-C: 3-0-0-3
Prerequisites:

**Course Contents**

- Introduction to runtime analysis of algorithms, recap of sorting etc from course Basic Datastructures. RAM model, abstract runtime of algorithms. Growth of functions, upper, lower, exact bounds, working with asymptotic runtime behaviour.
- Recap of linear data structures. Dictionnaries as an interface, comparing linked lists with arrays. Dynamic arrays a first example in amortized analysis. Skip lists.
- Search trees. Balanced search trees: AVL trees, Splay trees, 2-3 trees, Red-black-trees. Search trees for block devices (disk et al.): B-trees, B+-trees.
- Intro to multidimensional search trees: k-d-trees, R-Trees, [depending on time: reducing dimension space filling curve (Hilbert curve)]
- Hashing: basic algorithms, specific applications: consistent hashing, Distributed hash tables, Bloom filters, [Merkle trees]
- [Tries: data structures for information retrieval ]
- Graphs: DFS/BFS, Shortest path, minmal spanning tree.

**Literature:**

1. Cormen et al, **Introduction to Algorithms**, MIT press,
2. Skiena, **Algorithm Design handbook**, Springer Verlag
3. Weiss, **Data Structures and Problem Solving (Java or C++)**, Pearcon / Addison Wesley

**Project:**

You are supposed to implement dictionnaries( insert(), find() delete() ) in six different ways: Binary search tree, AVL tree, Splay tree, 2-4 (also: 2-3-4)trees, Redblack trees, Hashing.

Furthermore a test bed which allows to compare them, is needed. You should devise a comparison methodology and write a report on that.

## 4.46 CS 507 (3) Advanced Computer Architecture

Senate: 8th
Approval: OTA 5th and 11th Senate

**Course Outline:**

Advanced processor desi91: CPU pipelining, Datapath and Control Design, Data and Control Hazards. Instruction level parallelism, Dynamic scheduling of instructions, Branch Prediction and Speculation —From reference book and papers- VLIW, Multithreading, and Network processor architectures —Front papers- Basic multiprocessor design: Shared memory and message passing; Network topologies.

## 4.47 CS 508: Introduction to Network Security

**Course Code : CS 508**

**Course Name : Introduction to Network Security**

L-T-P-C : 3-0-0-3
Prerequisites : CIntroduction to Computer Networks
Intended for : M.S./Ph.D. or senior UG
Distribution : Elective in CS and EE
Semester : 5th or 6th
Approval: 6th Senate

**Preamble**

Individual course as of now. Meant to serve as pre-requisite to future courses

**Course Outline:**

This course focuses on basic concepts in network security. It aims to introduce students to the fundamental techniques used in implementing secure network communications, and to give them an understanding of common threats and attacks, as well as some practical experience in attacking and defending networked systems. This is not a course in cryptography, nor a comprehensive course in systems security.

**Course Contents:**

- **Introduction**: Motivating examples; Basic concepts: confidentiality, integrity, availability, security policies, security mechanisms, assurance
- **Basic Cryptography**: Historical background; Transposition/Substitution, Caesar Cipher; Introduction to Symmetric crypto primitives, Asymmetric cryptography primitives
- **Secret Key Cryptography**: Applications; Data Encryption Standard (DES); Encrypting large messages (ECB, CBC, OFB, CFB, CTR); Multiple Encryption DES (EDE); Advanced Encryption Standard (AES)
- **Message Digests**: Applications; Strong and weak collision resistance; Hash functions; The Birthday Paradox; MD5, SHA-1 • Public Key Cryptography: Applications; Theory: Euclidean algorithm, Euler Theorem, Fermat Theorem, Totent functions, multiplicative and additive inverse; RSA, Selection of public and private keys

- **Authentication**: Security Handshake pitfalls; Online vs. offline password guessing; Reflection attacks; Per-session keys and authentication tickets; Key distribution centers and certificate authorities
- **Trusted Intermediaries**: Public Key infrastructures; Certification authorities and key distribution centers; Kerberos
- **Real-time Communication Security**: Introduction to TCP/IP protocol stack; Implementation layers for security protocols and implications; IPsec: AH and ESP; IPsec: IKE; SSL/TLS
- **Electronic Mail Security**: Distribution lists; Establishing keys; Privacy, source authentication, message integrity, non-repudiation, proof of submission, proof of delivery, message flow confidentiality, anonymity; Pretty Good Privacy (PGP)
- **Firewalls and Web Security**: DoS and Phishing attacks; Packet filters; Application level gateways; Encrypted tunnels; Cookies; Web security problems; Intrusion Detection systems; DNS Security

**Textbooks:**

1. Charlie Kaufman, Radia Perlman, and Mike Speciner, **Network Security: PRIVATE Communication in a PUBLIC World**, Prentice Hall.
2. William Stallings, **Network Security Essentials: Applications and Standards**, Prentice Hall.

**References:**

1. Behrouz Forouzan, Debdeep Mukhopadhyay, **Cryptography and Network Security**, Tata McGraw-Hill.

## 4.48 CS 508: Introduction to Heterogeneous Computing

**Course Code: CS 508**

**Course Name: Introduction to Heterogeneous Computing**

L-T-P-C: 2-0-0-2
Prerequisites: Introductory Programming skill
Students intended for: MS/MTech/PhD/I-PhD/4th year BTech
Elective or Compulsory: Elective

Approval: 10th Senate

**Course Contents**

- **Review of programming concepts:** C/C++: Algorithm design, Expressions, Decisive statements, Iteration loops, Functional calls, Recursion, Arrays, Pointers, Addresses, I/O file handling, Error handling [6 Lectures]

- **Introduction to HPC:** Introduction to uni-processor and multiprocessor architecture, types of parallelism, Data parallelism, Loop unrolling, communication and synchronization needs,Parallel programs using openMP/ MPI, Introduction to cluster hardware, software, and network [8 Lectures]

- **Understanding parallelism with GPUs**: CUDA C: GPU architectures, Grids, Blocks and Threads in CUDA, Memory Handling with CUDA, Concepts of tiling and warps for CUDA[12 Lectures]

- **Application case studies:** Problem statements, designing an algorithm, writing program, verifying the output profiling the performance, optimization of the program [8 Lectures]

**Text Books:**


1. Cook S., **CUDA Programming**,

2. Morgan Kaufmann, **nVIDIA GPU Teaching Kit**.

3. Kirk D.B. and Hwu W-M.W,. **Programming Massively Parallel Processors**.


## 4.49 CS 511: Applied Probability

**Course Code : CS 511**

**Course Name : Applied Probability**

L-T-P-C 2-0-0-2
Intended for : MTech (CSE), MS, PhD
Distribution :
Prerequisite : None
Mutual Exclusion : EE534, MA524
Approval: 44th BoA

**Course Contents**

- **Module I**: Sigma field. Review of axiomatic probability, conditional probability, and independence, Bayes rule and applications. [3 Lectures]

- **Module II**: Recap of random variables, discrete and continuous random variables, and functions of random variables. [2 Lectures]

- **Module III**: Joint, marginal, and conditional distribution, Covariance and correlation, Multinomial, Multivariate Normal, Conditional Expectations. [2 Lectures]

- **Module IV**: Probability generating function, moment generating function and characteristic functions properties and applications. [3 Lectures]

- **Module V**: Markov chains, classification of states and chains, stationary distribution and limit theorem, Poisson process. Application of Markov Chain in Page Rank, text summarization etc. [4 Lectures]

- **Module VI**: The convergence of random variables basic results, inequalities (Markov and Chebyshev), the law of large numbers (weak and strong), central limit theorem, hypothesis testing. [5 Lectures]
- **Module VII**: Concentration inequalities Chernoffs bound, Hoeffdings inequality and their applications in parameter estimation and confidence interval of parameters. [3 Lectures]
- **Module VIII**: Random vectors and covariance matrix. Random processes. Autocorrelation, cross correlation, power spectral density. Basic notion of ergodicity. [6 Lectures]

Text books:

1. Grimmett and Stirzaker, Probability and Random Processes, 4th Edition, Oxford University Press, 2020.
2. Papoulis and Pillai, Probability, Random variables and Stochastic processes, 4th Edition, McGrawHill Europe, 2002.

**References:**


1. Erhan Cinlar, **Introduction to Stochastic Processes**, Dover Books on Mathematics, 2013.
2. R. G. Gallager, **Stochastic Processes: Theory for applications**, Cambridge University Press, 2014.
3. S. M. Ross, **Stochastic processes**, 2nd Edition, John Wiley, New York, 1996.
4. J. R. Norris, **Markov chains**, Cambridge University Press, Cambridge, 1999.
5. Joseph K. Blitzstein and Jessica Hwang, **Introduction to Probability**, CRC Press.com
6. Kishor S Trivedi, **Probability & Statistics with Reliability, Queuing, and Computer Science Applications**, Prentice Hall.


It is a subset of the existing course EE534 with topics relevant for MTech CSE. The 2 credit structure for this course is already approved in the senate document for CSE MTech.

## 4.50 CS 512: Matrix Theory

**Course Code : CS 512**

**Course Name : Matrix Theory**

L-T-P-C : 2-0-0-2
Intended for : MTech (CSE), MS, PhD
Prerequisite : None
Mutual Exclusion : MA512, EE522

Approval: 44th BoA

**Course Contents**

- **Background and review**: Linear system of equations, and their solutions, Linear transformation, Matrices, Determinant, Rank, Linear Vector spaces, Basis, Dimensions, Subspaces, Inner product, and orthogonality, Range space and null space, Eigenvalues and eigenvectors. Application: Examples of linear transformation such as rotation, translation, scaling, and eigen analysis. [5 Lectures]
- **Norms for vectors and matrices**: Vector norms and their properties, Matrix norms, Error analysis in linear systems, Application: Examples of neural network optimization/regularizations. [4 Lectures]
- **Eigenvalue Problems**: Condition numbers, and their application, Generalized Eigenvalue problems, Rayleigh Quotient. Application: Physical significance of eigenvalues and vectors and its relationship with PCA and Face recognition. [4 Lectures]
- **Matrix factorization and Least square problems**: Singular value decomposition, generalized pseudoinverses, QR factorization, PCA, Least square problems. Application: Examples from dimensionality reduction and Clustering. [5 Lectures]
- **Sparse matrices, their analysis, and algorithms**: Graphs and matrices, Sparse Gaussian elimination, Sparse eigenvalue, and singular value problems. Application: Relationship of sparse matrices with graph-based spectral clustering OR graph CNNs. [4 Lectures]
- **Different types and matrices, their properties, and analysis**: Symmetric, stochastic, Random Matrices, Properties of positive definite matrices, Toeplitz, and Circulant matrices. Application: Toeplitz's relationship with convolution and deconvolution networks OR DSM based graph clustering. [6 Lectures]

**Text books:**


1. Roger A. Horn and Charles R. Johnson, **Matrix Analysis**, Cambridge university press, 2012.
2. Gene H. Golub and Charles F. Van Loan, **Matrix computations**, 3ed Edition, John Hopkins University Press, 2012.


**References:**


1. T. A. Davis, **Direct Methods for Sparse Linear Systems**, SIAM, 2006
2. Joel Tropp, **An Introduction to Matrix Concentration Inequalities**, 2015
3. Terence Tao, **Topics in Random Matrix Theory**, AMS, 2012
4. Lloyd N. Trefethen and David Bau III, **Numerical linear algebra**, Siam, 1997.
5. Alan J. Laub, **Matrix analysis for scientists and engineers**, Siam, 2005.
6. Harry Dym, **Linear algebra in action**, American Mathematical Soc., 2013.

7. Gilbert Strang, **Linear Algebra and its application**, 4th Edition, Cengage Learning

8. Rajendra Bhatia, **Matrix Analysis**, Springer 1997.

9. David Lewis, **Matrix Theory**, 3rd Edition, Allied Publishers, 2014.

It is a subset of the existing course EE522 with topics relevant for MTech CSE. The 2 credit structure for this course is already approved in the senate document for CSE MTech.

## 4.51 CS 513: Discrete Mathematics

**Course Code : CS 513**

**Course Name : Discrete Mathematics**

L-T-P-C: 3-1-0-4
Intended for : MTech CSE
Prerequisite : none
Mutual Exclusion: CS208 and CS511.
Approval: 44th BoA

**Course Contents**

- **Logic:** Propositional logic syntax and semantics (revision); proof system and deduction; soundness and completeness; principle of resolution; (ordered) binary decision diagrams; first order logic syntax and semantics; structures, models, satisfaction and validity; resolution; unification; proof systems; axiomatization, soundness, completeness and incompleteness theorems; undecidability of validity problem. [8 Lectures]

- **Infinite and Structured Sets**: [12 Lectures]
  - Countable and uncountable sets, Cantor's diagonalization. Turing machines, Church- Turing Thesis. undecidability of the halting problem. consequences to the program verification problem.
  - **Abstract Algebra**: Homomorphism, Fundamental Theorem of homomorphisms, posets and lattices, formal contexts, monoids, semigroups, groupoids and groups, subgroups, cosets, Lagrange' theorem, rings, fields.

- **Combinatorics & Graph Theory**: [12 Lectures]
  - Counting arguments, recurrence relations, generating functions (Mnage problem), formal power series (ring).
  - Basics of graph theory (revision), planar graphs (Kuratowski's theorem), minor graphs (Wagners theorem, Robertson-Seymour theorem) matching and covering (Hall's theorem, Tuttle's theorem, Gallai/Milgram's theorem, connectivity and network flows, coloring (Brooks' theorem, Vizing's theorem), intersection and perfect graphs, sparse and dense graphs.

- **Probability Theory**: Recap of basic probability theory: axiomatic definition, discrete and continuous random variables, functions of random variables; joint, marginal, conditional distributions, Expectation and variance, Moment generating function and characteristic functions. Moments and deviations (Stable marriage problem, the coupon collectors problem), Concentration inequalities (Chernoff and Hoeffding bounds), Markov Chains and random walks (Expanders). Monte Carlo method. [10 Lectures]

**Laboratory/practical/tutorial Modules:**

Tutorials on each of the above course modules (14 hours)

**Text books:**

1. K. H. Rosen, **Discrete Mathematics and Its Applications**, 8th Edition, McGraw Hill, 2019.
2. D. S. Dummit and R. M. Foote, **Abstract Algebra**, 3rd Edition, Wiley, 2004.
3. M. Mitzenmacher and E. Upfal, **Probability and Computing**, 2nd Edition, Cambridge Univ. Press, 2017.

**References:**

- Dirk van Daalen, **Logic & Structure**, Springer, 2008.
- Uwe Schoening, **Logic for Computer Scientists**, Springer, 2008
- Michael Huth, Mark Ryan, **Logic in Computer Science: Modelling and Reasoning about Systems**, Cambridge University Press 2004.
- B. Ganter, R. Wille, **Formal Concept Analysis**, Springer, 1996.
- P. M. Cohn, **Universal Algebra**, Springer, 1981.
- W. Wechler, **Universal Algebra for Computer Scientists**, Springer, 1992.
- Reinhard Diestel, **Graph Theory**, 5th Edition, Springer, 2017.
- Bela Bollobas, **Modern Graph Theory**, Springer, 1998.

## 4.52 CS 514: Data Structures and Algorithms-II

**Course Code : CS 514**

**Course name : Data Structures and Algorithms-II**

L-T-P-C : 3-0-2-4
Prerequisites : CS-202 (DSA) or equivalent for UG students, None for PG students
Intended for : BTech (Semester 5 or 6) who have not taken CS403, MTech (CSE), MS, PhD
Distribution : Discipline Core for MTech CSE, Elective for UG CSE/DS, MS/PhD

Approval: 40th BoA

**Course Contents**

- **Review of Data Structures from CS 202**: Asymptotic Notations, Solving recurrences, Insertion Sort, Merge Sort, QuickSort. [3 Lectures]
- **Advanced topics in Sorting and Searching**: Randomized Data Structures Treaps, Hashing, AVL Trees, Bucket Sort. [6 Lectures]
- **Dynamic Programming**. [3 Lectures]
- **Amortized analysis**: aggregate analysis, accounting, potential method. [3 Lectures]
- **Graph Algorithms**: Single-Source Shortest Paths Bellman Ford, All-Pairs Shortest Paths using Floyd Warshall, Maximum Flow (Ford Fulkerson). [6 Lectures]
- **Advanced Data Structures**: Quake heaps, van Emde BoasTrees, Union Find Data structures. [6 Lectures]
- **Computational complexity**: Problem classes: P, NP, NP-complete, NP-hard. Reduction. Cooks theorem. Examples of NP-complete problems. [6 Lectures]
- **Approximation Algorithms**: Greedy and Local Search algorithms, DP Algorithms. [3 Lectures]
- **Parameterized Complexity**: Introduction to FPT, Bounded Search Trees, Kernels
- **Additional Topics**: Streaming Algorithms:- Misra Gries, Countmin sketch, LSH, lossy count algorithm. [3 Lectures]
- **Comp. Geometry**: Convex Hull, Line segment intersection, Voronoi Diagrams. [3 Lectures]
- **Coding Lab** which covers topics discussed in this course [28 Hours]

**Textbooks**

1. T. H. Cormen, C. E. Leiserson, R. L. Rivest, and C. Stein, **Introduction to Algorithms**, 3rd Edition, MIT Press, 2009.
2. J. Kleinberg and E. Tardos, **Algorithm Design**, Pearson, 2006.

**Reference books**

1. S. Dasgupta, C. H. Papadimitriou, U. V. Vazirani, **Algorithms**, McGraw Hill, 2006.
2. S. S. Skiena, **The Algorithm Design Manual**, 2nd Edition, Springer, 2008.

This course is proposed as a core course for MTech (CSE) and BTech students shall also be allowed to credit the same. The overwhelming overlap of contents (with CS403) is deliberate because we intend to discontinue offering CS403 starting from the winter session of 2021. Some parts of CS403 have either been covered in CS202 or are not relevant to the currently trending research areas. We compensate for these topics by adding new topics which we feel are best suited for the students and this upgrade in coursework also makes this course suitable for M.S., M.Tech and Ph.D. candidates.

## 4.53 CS 515: Advanced Computer Science Practicum

**Course Code: CS 515**

**Course name : Advanced Computer Science Practicum**

L-T-P-C : 2-0-2-3
Prerequisites : UG level courses on Computer Networks, Operating Systems, Databases, Computer Organization and Compilers
Intended for : MTech (CSE), MS, PhD
Distribution : Discipline Core for MTech CSE, Elective for others
Approval: 40th BoA

**Course Contents**

- **Databases**: Assignment on implementing an end-to-end system involving database backend, front-end web-based visualization and using database queries, joins, procedures, triggers, views, cursors, and transactions. Possible problems include: [8 Lectures]
  - Create a backend database application with a front-end web-based visualization that plots dependent variables of interest.
  - Create a front-end website with the ability to register and authenticate users with respect to usernames and passwords; write a trigger on a table in a database that allows us to back-up the deleted entries in the table; write other complex queries involving joins on multiple tables.
- **Operating Systems**: Assignments on understanding practical aspects of synchronization and implementing kernel modules in Linux. Modules allow extending the function of the kernel without rebooting the system. This assignment will introduce the students to implementing simple modules, their compilation and also tools for debugging kernels. [8 Lectures]
- **Computer Networks**: Assignments that involve socket programming, and protocol analysis by using network simulators. [8 Lectures]
- **Compilers and Architecture**: Assignments that involve understanding the mapping of a high-level program down to a machine. The idea would be to familiarize students with the nuances of the connection between translating a high-level program and the machine on which it is executed. The assignments could be a subset of: [16 Lectures]
  - Writing a translator for converting programs written in a small programming language to an intermediate representation.
  - Writing an interpreter for evaluating expressions/statements in a (small) programming language.

- Writing a register allocator for a given reference architecture.
  - Writing an assembler that translates programs in an intermediate representation to the assembly for a given architecture.

- Mini-project on designing scalable systems for different applications. This project will follow software engineering principles of project management, will emphasize scalable design principles, and involve performance analysis. [16 hours]

**Reference books**

1. Jonathan Corbet, Alessandro Rubini, and Greg Kroah-Hartman, **Linux Device Drivers**, 3rd Edition, OReilly Media, 2005.

2. Remzi H. Arpaci-Dusseau and Andrea C. Arpaci-Dusseau, **Operating Systems: Three Easy Pieces** by Arpaci-Dusseau Books,2018.

3. Kurose and Ross, **Computer Networking: A Top-Down Approach**, 6th Edition, Pearson 2013.

4. Andrew W. Appel and Jens Palsberg, **Modern Compiler Implementation in Java**, 2nd Edition, Cambridge University Press, 2002.

5. Elmasri, R., & Navathe, S. B., **Fundamentals of Database Systems**, 7th Edition, Pearson Education, UK, 2015.

This course is proposed as a core course for MTech (CSE) and BTech stuclems will not be allowed to credit the same. The overlapping contents are essentially with vorious BTech core courses, and thus the intended audience is completely different.

## 4.54 CS 516P: Exploratory Project

Course Name : CS 516P
Course number : Exploratory Project
Credit Distribution : 0-0-6-3 (L-T-P-C)
Intended for : M.Tech.Computer Science and Engineering (CSE)
Distribution : Core for M.Tech in CSE
Semester : Winter Session of Year I
Prerequisite : None
Mutual Exclusion : None
Approval: 50th BoA

**Course Contents:**

It is advisable that the projects should be related to the courses M.Tech.(CSE) students may credit or the specializations that this program offers. Therefore, students can opt for any project in Theoretical Computer Science or Computer Systems or Artificial Intelligence/Machine Learning (AI/ML). Additionally, they are allowed to select a project from other areas, e.g., Human Computer Interaction, Signal Processing and Communications, or Applied Mathematics, as long as the project has 30% or more overlap with any of the three specializations of M.Tech. (CSE) curriculum.

**Deliverables:** A student must declare the deliverables of her/his project in the initial project proposal after consulting with the respective mentor(s). While the initial project proposal and the final report carry some marks, a significant portion of the marks, 70% or more, is allotted to the deliverables to emphasize their importance.

**Contact hours:** On average, a student should work 40 hours per week on her/his project. The students are supposed to meet their respective mentors at least once a week to report their progress.

**Evaluation:** There will be two evaluations, one in the beginning of the winter vacation and the other one in the beginning of the forthcoming semester. In the first evaluation, the students will be evaluated based on the initial project proposals they have submitted. During the second evaluation, they will be evaluated based on their progress with respect to the promised deliverables, their project reports, and the understanding they have gained from their respective projects.

**Text books:**

1. Related literature.

**References:**

1. N/A

## 4.55 CS 510 : Randomized Algorithms

**Course Code : CS 510**

**Course Name : Randomized Algorithms**

L-P-T-C: 4-0-0-4
Intended for: M.Tech/Ph.D./B.Tech 3rd/4th year
Prerequisites: Data Structures and Algorithms, Basic Discrete Probability
Mutual Exclusion:
Approval : 57th BoA

**Course Contents**

- **Introduction**: review of discrete probability, Introduction to randomized algorithms, basic examples: Polynomial Identity Testing, matrix product verification (Frievald's algorithm), Karger's randomized min-cut algorithm, randomized quicksort. [8 hours]

- **Concentration inequalities**: Markov's and Chebychev's inequalities, randomized selection, two-point sampling, stable marriage problem, coupon collector's problem, birthday paradox, balls and bins, Chernoff bound, application to error reduction and network routing. [8 hours]

- **Markov chains and random walks**: randomized algorithm for 2SAT, Markov chains, random walks on graphs, graph connectivity, expander graphs and randomly mixing random walks, probability amplification using random walks on expander graphs. [9 hours]

- **Randomized data structures**: random treaps, skip lists, hash tables, universal family of hash functions, perfect hashing. [8 hours]
- **Randomized computational geometry**: randomized incremental construction, convex hull construction, geometric duality, half space intersections, Delaunay triangulation, trapezoidal decomposition, random sampling, linear programming. [8 hours]
- **Randomized graph algorithms**: all pairs shortest paths, minimum-cut, minimum spanning trees. [7 hours]
- **Online algorithms**: adversary models, paging against oblivious and adaptive adversaries, the k-server problem. [6 hours]
- **Randomized Complexity classes**: RP, co-RP, ZPP, BPP. [2 hours]

**Text books:**

1. R. Motwani and P. Raghavan, **Randomized Algorithms**, Cambridge University Press, 1995.
2. M. Mitzenmacher and E. Upfal, **Probability and Computing: Randomization and probabilistic techniques in algorithms and data analysis**, 2nd Edition, Cambridge University Press, 2017.
3. S. P. Vadhan, **Pseudorandomness**, Now Publishers, 2012.

**References:**

1. D. P. Dubhashi and A. Panconesi, **Concentration of Measure for the Analysis of Randomized Algorithms**, Cambridge University Press, 2009.

## 4.56 CS 520 : Introduction to Quantum Computing

**Course Code : CS 520**

**Course Name : Introduction to Quantum Computing**

L-P-T-C: 2-0-1-3
Intended for: M.Tech/Ph.D./B.Tech 3rd/4th year.
Prerequisites: Basic Linear Algebra and Probability
Mutual Exclusion: Other Research Methodology Courses
Approval : 57th BoA

**Course Contents**

- **Introduction** : Review of Linear Algebra, Probability, Qubits, Interference, Superposition, Entanglement, Young double slit, Mach-Zehnder Experiment, Dirac Notation, Postulates of Quantum Mechanics. [8 hours]
- **Quantum Computation** : Universal Quantum gates, CNOT gate, Tofoli gate, Fredkin gate, No-cloning theorem, Basic Deutsch's algorithm, Quantum Teleportation, BB84, Bell States, Quantum Circuits [8 hours]

- **Quantum Algorithms** : Quantum parallelism, Deutsch's algorithm, Deutsch-Jozsa algorithm, Quantum Search algorithms, Grover's search, Shor's algorithm, Speeding up the solutions of NP-complete problems, Quantum Supremacy [8 hours]
- **Quantum Cryptography** : Quantum key distribution, Simon's algorithm, and Cryptanalysis.[4 hours]

**Text books:**

1. M A Nielsen and I L Chuang, **Quantum Computation and Quantum Information**.
2. P Ka , R Laflamme and M Mosca, **An Introduction to Quantum Computing**.

**References:**

1. https://www.cse.iitk.ac.in/users/rmittal/course_s24.php
2. http://books.google.ca/books?id=qYHTvHPvmG8C

## 4.57 CS 522: Distributed Algorithms

**Course Code : CS 522**

**Course Name : Distributed Algorithms**

L-T-P-C : 3-0-0-3
Prerequisites : CS 202 Data Structures & Algorithms, CS 208 Mathematical Foundations of Computer Science or Equivalent or COT
Intended for : UG/PG
Distribution : Discipline Elective for BTech CSE, Free Electives for others
Approval: 12th Senate

**Course Contents**

- **Module I**: Introduction (algorithmic challenges of distributed algorithms). [1 Lecture]
- **Module II**: Basic definitions (System models, distributed computation, local/global states, consistency, complexity measures). [6 Lectures]
- **Module III**: Time in distributed computing (logical clocks, vector clocks, virtual time). [3 Lectures]
- **Module IV**: Distributed graph algorithms (Spanning trees, broadcast & converge cast, shortest path). [6 Lectures]
- **Module V**: Distributed mutual exclusion algorithms. [4 Lectures]
- **Module VI**: Global state and snapshot recording algorithms (Chandy/Lamport , Lai/Yang, Mattern, Venkatesan Algorithm). [4 Lectures]

- **Module VII**: Monitoring global states (Necessary & sufficient conditions for consistent global states, zig-zag paths). [3 Lectures]
- **Module VIII**: Termination Detection (Based on snapshots computations, weight throwing, spanning trees). [3 Lectures]
- **Module IX**: Deadlock detection. [2 Lectures]
- **Module X**: Global predicate detection. [2 Lectures]
- **Module XI**: Checkpointing and rollback recovery (Coordinated, communication induced, ...). [4 Lectures]
- **Module XII**: Consensus and agreement algorithms. [4 Lectures]

**Text books:**


1. A. Kshenkalyani, M.Singhal, **Distributed Computing**, Cambridge University Press, 2008


**References:**


1. Wan Fokkink, **Distributed Algorithms: an Intuitive Approach**, MIT Press, 2013
2. David Peled, **Distributed Computing: a Locality Sensitive Approach**, SIAM Monograph, 2000
3. Nancy Lynch, **Distributed Algorithms**, Morgan Kaufmann, 1996
4. M. Raynals, **Distributed Algorithms for Message-Passing Systems**, Springer, 2013


**Course Code: CS 523**

**Course Name: Verification of Reactive Systems**

L-T-P-C: 3-0-0-3
Prerequisites: CS 208 or equivalent
Intended for: BTech, MTech, MSc, MS/PhD in the area.
Elective/Core: Discipline elective for BTech CSE and EE, free elective for others

**Course Contents**

- **Introduction** [3 Lectures]
  - Introduction and overview of the course
  - Revision of predicate logic, undecidable problems, proof systems.
  - Basic approaches to verification: property and equivalence verification, correctness by design
- **Verifying Sequential Terminating Systems** [3 Lectures]

  - Hoare Logic, small case studies

- **Modelling of Reactive Nonterminating Systems** [6 Lectures]
  - Formal models for non-terminating reactive systems (hardware/software) : Buechi Automata, Transition Systems, Process Algebras, Petri Nets
  - Dimensions of behavior descriptions :
    * interleaving vs truly concurrent
    * linear vs branching time
    * quantitative vs qualitative descriptions
  - Property classification: regularity, safety, liveness, fairness
  - Equivalence notions:
    * trace equivalence
    * testing equivalence
    * observation equivalence
  - Case studies - equivalence checking

- **Property Verification of Reactive Systems** [12 Lectures]
  - Verification of regular properties
  - Temporal and modal logics for property specification: LTL, CTL, CTL*, HML
  - Verifying properties: principles of model checking, complexity and limits
  - Case studies with model checker SPIN

- **Property Verification of Time-Critical and Hybrid Systems** [9 Lectures]
  - Timed automata (theory, reachability analysis)
  - Case study with model checker UPPAAL

- **Correctness by Design** [9 Lectures]
  - Stepwise refinement
  - Case study with proof assistant RODIN
  - Student Projects

**Textbooks:**

1. Christel Baier and Joost-Pieter Katoen, **Principles of Model Checking**, MIT Press, 2008.

**References:**

1. Luca Aceto, Anna Ingolfsdottir, Kim G. Larsen and Jiri Srba, **Reactive Systems - Modelling, Specification and Verification**, Cambridge textbooks, 2007
2. M. Ben-Ari, **Principles of the SPIN Model Checker**, MIT Press, 2008
3. Wan Fokking, **Modelling Distributed Systems**, Springer Verlag, 2007

4. Michael Huth and Mark Ryan, **Logic in Computer Science Modelling and Reasoning about Systems**, Cambridge University Press, 2004

5. Gerald Holzmann, **The SPIN Model Checker - Primer and Reference Manual**, Addison Wesley, 2003

6. Doron Peled, **Software Reliability Methods**, Springer Verlag, 2001

## 4.58 CS 541P: IoT systems and the Cloud

**Course Code : CS 541P**

**Course Name : IoT systems and the Cloud**

L-T-P-C: 1-0-3-3
Prerequisites: IC161- Applied Electronics or equivalent, IC250 - Programming and Data Structure Practicum or equivalent with Consent of Instructor
Intended for : B.Tech. (EE. & CSE) /MS/MTech/PhD
Distribution Semester:Elective for B.Tech. TII/IV year, MS, M.Tech., Ph.D.
Approval: 15th Senate

**Course Contents**

- Module 1: **Hardware components of loT systems**: Introduction to microcontrollers including PIC, Arduino, Raspberry Pi; imerfacing sensors and actuators with microcontrollers, building breadboa rd circuits, using loT C AD tools; performance cha racteristics, drift, measurement techn iques, packaging. [4 Lectures + 12 lab hours]

- Module 2: **Networking of devices**: Device-to-device comm unication; networking protocols and architectures; scheduling a nd routing; wired and wireless (Bluetooth, Zigbee, NFC) sensor networks; communication technologies like LoRA, SigFox, Cellular loT; edge a nalytics and sensor control in networks. [3 Lectures + 9 lab hours]

- Module 3: **Getting Data Ready for Analytics in the Cloud**: Introdu ction to cloud service models, pre processing input strea ms of loT data , storage in the cloud - m essage queues, distributed file systems and distributed databases. [3 Lectures + 9 lab hours]

- Module 4: **Data Analytics in the Cloud**: Com puting paradigms - map-reduce and its extensions to resilient distributed datasets, concepts in complex event processing (CEP), algori thms for mining data strea ms, Lambda Architecture. [4 Lectures + 12 lab hours]

**Text books:**

1. Donald Norris, **The Internet of Things**, McGraw Hill Ed u calion, 2015.

2. Na than Marz and James Warren, **Big Data: Principles and best praccices of scala ble realtime data systems**, Manning Publications, 2015.

**Reference Books:**


1. Upton and Halfacree, **Raspberry Pi User Guide**, Wil ey, 2014.

2. Robert Faludi, **Building Wireless Sensor Networks**, O'Reilly Media, 20ll.

3. Jure Leskovec, Anand Rajaraman and Jeffrey D. Ullman, **Mining of Massive Datasets**, v2.1 online edition, 2015.

4. Research papers on Resilient Distributed Datasets, Kafka, HBase, etc.


## 4.59 CS 542 : Design Patterns for Scalable Systems

**Course Code: CS 542**

**Course Name : Design Patterns for Scalable Systems**

L-T-P-C : 3-0-0-3
Intended for : B. Tech./Masters/Ph.D.
Prerequisite : CS 310 and CS 309 or equivalent courses covering basics of computer networks, databases and operating system
Mutual Exclusion : None
Approval: 45th BoA

**Course Contents:**

- **Introduction to design patterns and reactive systems:** Software design: functional and non-functional requirements, design patterns, changing landscape: web-scale responsive applications, design approach: monolithic vs microservices, horizontal vs vertical scaling, walk-through of the reactive manifesto. (5 hours)

- **Review of concurrency in practice:** Threads in OS, notions of parallelism: tasks, functions, and loops, synchronization and data flow concepts, consistency protocols, transition from parallel to distributed systems: distributed memory architectures, CAP theorem, distributed state: sharding and conflict free replicated data types. (6 hours)

- **Review of functional programming concepts:** Immutability, pattern matching, partial functions, collections, futures (5 hours)

- **Actor model:** Asynchronous programming, Actor model, message processing semantics, designing and testing Actor models (7 hours)

- **Design patterns for high availability:** Fault-tolerance and recovery patterns, replication patterns, resource management patterns, state management and persistence patterns (14 hours)

- **Design patterns for effective communication:** Message flow patterns, flow control patterns (5 hours)

**Laboratory/practical/tutorial Modules:**

None

**Text books:**

1. Roland Kuhn, Brian Hanafee and Jamie Allen, **Reactive Design Patterns**, Manning Publications Co., 2017.
2. Erich Gamma, Richard Helm, Ralph Johnson and John Vlissides, **Design Patterns: Elements of Reusable Object-Oriented Software**, Addison-Wesley, 1995.

**References:**

1. Clement Escoffier and Ken Finnigan, **Reactive Systems in Java**, 1st Edition, O'Reilly, 2021.
2. Martin Kleppmann, **Designing Data-Intensive Applications**, 17th Release, O'Reilly, 2021.
3. Chris Richardson, **Microservices Patterns with examples in Java**, Manning Publications Co., 2018.
4. onas Boner, **Reactive Microsystems: The Evolution of Microservices at Scale**, 1st Edition, O'Reilly, 2017.
5. Thomas Anderson and Dahlin, **Operating Systems: Principles and Practice**, 2nd Edition, Recursive books, 2011.

## 4.60 CS 544: Formal Concept Analysis: Theory and Practice

**Course Code : CS 544**

**Course Name : Formal Concept Analysis: Theory and Practice**

L-T-P-C : 3-0-0-3
Prerequisites : CS208 Mathematical Foundations of Computer Science or equivalent; IC250 Programming and Data Structure Practicum or equivalent
Intended for : B.Tech. (EE. & CSE) /MS/MTech/PhD
Distribution : Elective for B.Tech. III/IV year, MS, M.Tech., Ph.D.
Approval: 16th Senate

**Course Contents**

- **Formal contexts, formal concepts and concept lattice**: Formal context; conceptual scaling of many valued contexts; concept forming operators; basic mathematical structures behind FCA: Galois connections and closure operators; algebra of concepts - partial order and lattices; basic theorem; concept lattice diagrams. [8 Lectures]
- **Centralized and distributed algorithms for concept lattice construction**: Clarification and reduction of formal concepts; basic algorithms for computing concept lattice next closure algorithm, linear time closed item-set miner; distributed implementation of the algorithms for concept lattice construction naive approach,

map-reduce based close-by-one, distributed closed item-set miner, trade-offs between breadth-first search and depth-first search based approaches; concept interestingness measures support, cue-validity, stability, lift and separation; incremental algorithms for constructing concept lattice. [12 Lectures]

- **The canonical basis**: Attribute implications, computing closure under implications, learning implications with membership and equivalence queries; pseudo-closed sets and canonical basis of implications, finding pseudo-closed sets; attribute exploration algorithm and its variations; concept exploration with partial lattice. [10 Lectures]
- **Applications of FCA**: Case-studies of concept exploration exploring faulty data, exploration in a fuzzy setting, triadic data; analysis of social networks social networks as formal contexts, individuality of social networks, knowledge communities; FCA in databases: learning functional dependencies, extensions to knowledge graphs; neural network architecture based on concept lattice. [12 Lectures]

**Text books:**

1. Bernhard-Ganter and Sergei Obeidkov, **Conceptual Exploration**, Springer 2016.
2. Rokia Missaoui, Sergei O. Kuznetsov and Sergei Obiedkov, **Formal Concept Analysis of Social Networks**, Lecture Notes in Social Networks, Springer 2017.

Reference Books:

1. Research papers on FCA
2. Open source softwares:
   (a) https://github.com/fcatools/
   (b) http://www.upriss.org.uk/fca/fcasoftware.html
3. Radim Belhohlavek, **Introduction to Formal Concept Analysis**, Olomouc 2008.
4. Bernhard Ganter and Rudolf Wille, **Formal Concept Analysis: Mathematical Foundations**, Springer 1999.

## 4.61 CS 545: Software Design Patterns

**Course Code : CS 545**

**Course Name : Software Design Patterns**

L-T-P-C : 3-0-0-3
Prerequisites: UML and OO Programming
Intended for : UG & PG
Distribution:Elective for B.Tech. Electrical Engg.& Computer Sc. &Engg., MS/M.Tech., Ph.D.
Approval: 11th Senate

**Course Contents**

- Review of UML and concepts of OO programming languages. [3 Lectures]
- Use Case and System Sequence Diagram. [2 Lectures]
- Design Methodology : Responsibility assignment. [3 Lectures]
- Design patterns classification and template. [3 Lectures]
- Creational Patterns. [6 Lectures]
- Structural Patterns. [6 Lectures]
- Behavioral Patterns. [6 Lectures]
- Architectural Patterns. [3 Lectures]
- Evaluative Patterns. [2 Lectures]
- Advance Topics such as Concurrency Patterns, Pattern Lang. [6 Lectures]

**Reference Books:**

List is suggestive only, not mandatory

1. Craig Larman, **Applying UMLand Patterns An Introduction to Object-Oriented Analysis and Deisgn**, 3rd Edition.
2. Erich Gamma, Richard Helm, Ralph Johnson, John Vlissides, **Design Patterns Elements of Reusable Object-Oriented Software**, 2015(Paper back)
3. John Vlissides, **Pattern Hatching: Design Patterns Applied**
4. Martin Fowler, **Patterns of Enterprise Application Architecture**
5. **The Architecture of Open Source Applications**, Vol. 1 & 2

## 4.62 CS 546: Design of Concurrent Software

**Course code: CS 546**

**Course Name: Design of Concurrent Software**

L-T-P-C: 3-0-0-3
Prerequisites: programming & data structures; basics of operating systems, basics of networks.
Intended for: BTech, MTech, MSc, MS/PhD in the area.
Elective/Core: Discipline elective for BTech CSE and EE, free elective for others
Approval: 10th Senate

**Course Contents**

- **Introduction**: Need for concurrent programs; the critical section problem; parallel and distributed architectures.
- **Programming models**: levels of parallelism; data distribution for arrays; shared variables and message-passing; processes and threads.
- **Performance evaluation**: metrics for parallel programs; design of experiments, measurement techniques, confidence levels.
- **Parallel programming**: the MPI message-passing model; point-to-point and collective communication modes; process groups; MPI and Pthreads; testing for correctness and for performance; debugging. Optionally: CUDA/OpenCL for GPU programming.
- **Concurrency in Java**: Java memory model; threads; RMI; locking; scalability; selected concurrency design patterns.
- **Big Data Processing**: the Map Reduce programming model; Map Reduce architecture and implementations; Map Reduce algorithm design; limitations of the Map Reduce model, extensions to solve these.

**Textbooks:**

1. T. Rauber & G. Rnger, **Parallel Programming for Multicore and Cluster Systems**, Springer, 2007.
2. B. Goetz et al., **Java Concurrency in Practice**, Pearson, 2006.
3. J. Lin & C. Dyer, **Data-Intensive Text Processing with Map Reduce**, Morgan & Claypool, 2010

**References:**

1. E.D. Lazowska et al., **Quantitative System Performance**, Prentice-Hall, 1984.
2. K.S. Trivedi, **Probability and Statistics with Reliability, Queueing and Computer Science Applications**, Prentice-Hall, 1982.
3. Doug Lea, **Concurrent Programming in Java: Design Principles and Patterns**, 2nd Edition, Pearson, 2000.
4. M. Subramanian, **Network Management: Principles and Practice**, 2nd Edition, Pearson, 2009. (Chap 9.4)
5. D. Kirk and W. Hwu, **Programming Massively Parallel Processors: A Hands-on Approach**, 2nd Edition, Morgan Kaufmann, 2012.

## 4.63 CS 547: Network Management Systems

**Course Code: CS 547**

**Course Name: Network Management Systems**

L-T-P-C: 3-0-0-3
Prerequisites: Basic knowledge of computer networks, statistics and probability. CS211P; or CS206 or EE304 concurrently; or COT

Approval: 5th Senate

**Course Contents**

- **Introduction**: Review of computer networks; models of network management
- **SNMP**: the SNMP model; MIBs; SNMP protocol; security
- **Other management protocols**: TMN, Web-based management, desktop management
- **Case studies**: management of wireless networks, broadband networks, clusters, clouds, etc.
- **Advanced topics**: Proxy agents; distributed NMS; design of NMS software

**References:**


1. Mani Subramaniam, **Network Management: Principles and Practice**, 2nd Edition, Pearson, 2009
2. W. Stallings, **SNMP, SNMPv2, SNMPv3, and RMON 1 and 2: Practical Network Management**, 3rd Edition, Addison-Wesley, 1999.
3. L.G. Raman, **Fundamentals of Telecommunications Network Management**, IEEE Press Series on Network Management, Prentice-Hall India, 1999


## 4.64 CS 548: Cloud Networking

**Course Code: CS 548**

**Course Name: Cloud Networking**

L-T-P-C: 3-0-0-3
Prerequisites: CS 406 Computer Networks, CS 310 Introduction to Computing Distributed Processes, CS5 47 Network Management Systems, or the instructor's consent
Intended for: UG/PG
Elective/Core: Elective
Approval: 9th Senate

**Course Contents**

- **Module 1**: Cloud Networking Introduction. [3 Lectures]
- **Module 2**: [7 Lectures]
  - Application and traffic patterns - how web search works, data center traffic , implication on networking
  - Physical network structure - Big Switch Approach, FAT tree network etc
- **Module 3**: [12 Lectures]
  - Routing and traffic engineering - STP( spanning tree), link stat protocol, Transparent Interconnection of Lots of Links, OSPF over IP, Border Gateway Protocol in the Data Center, distributed congestion aware load balancing for data centers.
  - Host virtualization - Server Virtualization, networking VMs, Improving networking performance, packet processing on CPUs, Open vSwitch.
  - Congestion control - Feedback control loop, Basic Congestion control Loop, Problems with TCP, Data Center TCP, Explicit Congestion Notification.
- **Module 4**: [8 Lectures]
  - Introduction to SDN architecture - Software-defined Networks, evaluation of SDN, flexible data planes, logically centralized control.
  - Network virtualization - Network virtualization in VL2, Network virtualization in VMware NSX (VL2 Physical topology, Routing in VL2, Routing Implementation, end-end example).
- **Module 5**: [10 Lectures]
  - Inter-data center networking- Large online services work, Traditional WAN approach and problems.
  - Content Distributed Networks
  - Application layer techniques
- **Module 6**: Green Cloud Networking. Energy efficient Optimization Technology, Nano Data Center. [3 Lectures]

**Textbooks:**


1. G Varghese, **Network Algorithmics**, 1st Edition An Interdisciplinary Approach to Designing Fast Networked Devices, 2014
2. Lee Chao, **Cloud Computing Networking: Theory, Practice, and Development**, CRC Press, August 2015.
3. William Stallings, **Foundations of Modern Networking: SDN, NFV, QoE, IoT, and Cloud**, Addison Wesley, Oct 2015.
4. Ken Gray, Thomas Nadeau, **SDN - Software Defined Networks**, O'Reilly Media, August, 2013.

**References:**

There will be a selection of readings and resources available to you for this course. Some of these will be required, while others will be optional for you to explore further.


1. Use of BGP for Routing in Large-Scale Data Centers, online https://www.ietf.org/id/draft-ietf-rtgwg-bgp-routing-large-dc-07.txt

2. RFC, TCP Congestion Control (This is an RFC, i.e., Request for Comments.). (online) https://www.ietf.org/id/draft-ietf-rtgwg-bgp-routing-large-dc-07.txt, https://tools.ietf.org/h

3. Mohammad Alizadeh et. al., **CONGA: Distributed Congestion-Aware Load Balancing for Datacenters**, SIGCOMM14, August 17-22, 2014, Chicago, IL, USA.

4. Ben Pfaff et. al., **The Design and Implementation of Open vSwitch**, 12th USENIX Symposium on Networked Systems Design and Implementation (NSDI 15).May 4-6, 2015, Oakland, CA, USA

5. Ankit Singla et.al, **Towards a Speed of Light Internet**, ACM Hotnets, Oct. 2014, LA, USA 2014

6. Ilya Grigorik, **Latency: The New Web Performance Bottleneck**, 2012.


## 4.65 CS 549: Performance Analysis of Computer Networks

**Course Code : CS 549**

**Course name : Performance Analysis of Computer Networks**

L-T-P-C : 3-0-0-3
Prerequisites : IC 210 Probability, statistics and random variables or equivalent, CS 310 Introduction to Communicating and Distributed Processes or consent of the instructor.
Intended for : BTech CSE & EE, MTech/MS/PhD in the area.
Elective/Core : Discipline elective for BTech CSE and EE, free elective for others
Approval: 24th Senate

**Course Contents**

- **Introduction to computer networks**: A brief history and introduction to the Internet, Review of networking and layering. [3 Lectures]

- **Multiaccess communication and its analysis**: Slotted multi-access and the ALOHA system, Carrier sensing multiple access slotted ALOHA, Local Area Networks: Carrier Sense Multiple Access with Collision Detection (CSMA/CD) and Ethernet: Slotted CSMA/CD, unslotted CSMA/CD and IEEE 802 standards, Link scheduling and Network capacity. [9 Lectures]

- **Routing algorithms and their analysis**: Algorithms for shortest path routing - Dijkstra's Algorithm, Bellman-Ford Algorithm and Generalized Dijkstras Algorithm, Optimal routing. [8 Lectures]

- **Queueing theory**: Brief review of Random processes, Introduction to Markov chains and queueing theory, traffic models, deterministic and stochastic analysis; Delay modeling using queueing theory Littles law, M/M/1, M/M/m, M/M/m/m, M/G/1 queueing systems, priority queueing. [10 Lectures]
- **Measurement techniques and experiment design**: Workloads, Monitors, Experiment design - 2k, 2kr factorial designs. [6 Lectures]
- **Advanced topics**: Network economics, Mobile IP, Multimedia streaming, VoIP, Content Distribution Networks, Software-defined networking and network function virtualization. [4 Lectures]

**Textbooks:**

1. D. Bertsekas and R.G. Gallager, **Data networks**, Prentice-hall, 1992.
2. Anurag Kumar, D. Manjunath and Joy Kuri, **Communication networking: an analytical approach**, Elsevier 2004.
3. J.F. Kurose and K.F. Ross, **Computer networking: a top-down approach**, Pearson, 2010.

**Additional References:**

1. R. Jain, **The art of computer systems performance analysis**, Wiley India, 2013.
2. K.S. Trivedi, **Probability and Statistics with Reliability, Queueing, and Computer Science Applications**, John Wiley and Sons Ltd, 2016.
3. G. Varghese, **Network algorithms: an interdisciplinary approach to designing fast networked devices**, Morgan Kaufmann, 2004.
4. B. Hajek, **Notes for ECE 567 Communication network analysis**, University of Illinois, 2006. http://www.ifp.illinois.edu/∼hajek/Papers/networkanalysis.html

## 4.66 CS 549: Computer Networks Analysis

**Course Code: CS 549**

**Course Name : Computer Networks Analysis**

L-T-P-C : 3-0-0-3

**Intended for :** BTech CSE & EE, MTech/MS/PhD in the area.

**Prerequisite :** IC 210 Probability, statistics and random variables or equivalent, CS 310 Introduction to Communicating and Dist1ibuted Processes, MA 651 Optimization Techniques or the consent of the instructor.

**Mutual Exclusion :** None

Approval: 12th Senate

**Course Contents:**

1. Introduction to computer networks: A brief history and introduction to Internet, Review of networking and layering. (2 Lectures)

2. Delay models in computer network: Brief review of Random processes, Introduction to Markov chains and Queueing theory, Traffic models, deterministic and stochastic analysis; Delay modeling using Queuing theory: Little's Jaw, M/M/l M/M/m, M/M/m/m, M/G/1 queuing systems, priority queuing. (10 Lectures)

3. Routing algorithms aud their analysis: Algorithms for shortest path routingDijkstra's Algorithm, Bellman-Ford Algorithm and Generalized Dijkstra's Algorithm, Optimal routing. (10 Lectures)

4. Multiaccess communication and its Analysis: Slotted multi-access and the ALOHA system, Canier sensing multiple access slotted ALOHA, Local Area Networks: Currier Sense Multiple access with Collision Detection (CSMA/CD) and Ethemet: Slotted CSMA/CD, unslotted CSMA/CD and IEEE 802 standards, Link scheduling and Network capacity. (10 Lectures)

5. Nctwork economics: Economic models for ISPs, price for QoS, Usage-based prices, Congestion prices, Market Dynamics, revenue Maximization. (6 Lcctures)

6. Advanced topics:Mobile IP, Multimedia streaming, VoIP, Content Distribution Networks, Software-defined networking and network function virtualization. (4 Lectures)

**Textbooks:**


1. D. Bertsekas, and, R. G. Gallager, **Data networks**, Prentice-hall, 1992.

2. Anurag Kumar, D. lvlanjunath, and Joy Kuri, **Communication networking: an analytical approach**, Elsevier, 2004.


**Additional References:**


1. Walrand, and P. P. Varaiya, **High performance Communication network**, 2nd Revised Edition, Morgan Kaufinann Publishers, 1999.

2. F. Kelly, and E. Yudovina, **Stochastic Networks**, Cambridge University press, 2014.

3. G. Varghese, **Network algorirhmics: an interdisciplinary approach to designing fast networked devices**, Morgan Kaufmann, 2004.

4. B. Hajek, **Notes for ECE 567 Conununication network analysis**, University of Illinois, 2006, www.ifp.illinois.edu/∼hajek/Papers/networkanalysis.html

5. J. F. Kurose, and K. F. Ross, **Computer networking: a top-down approach**, Pearson, 2010.

6. P. Whittle, **Networks**, Cambridge University press, 2004.

7. S. Meyn, **Control techniques for complex networks**, Cambridge University press, 2010.

## 4.67 CS 550: Computer Graphics and Geometric Design

### Course Code: CS 550

### Course Name: Computer Graphics and Geometric Design

L-T-P-C: 2-0-2-3
Prerequisites: IC 111 Linear Algebra or similar course, IC250 Data Structure and Algorithms or similar course.
Intended for: B.Tech. (CSE, EE and ME) II/III/IV year/ MS/M.Tech /PhD (any branch)
Distribution:Elective for B.Tech. II/III/IV year/ MS/M.Tech/PhD
Approval: 37th BoA

### Course Contents

- **Introduction**: Motivation; Use of computer graphics in different domains; Digital display technologies; Color; Graphics processing pipeline; OpenGL. [2 Lectures]
- **Geometry representation**: Lines, triangles, polygons, meshes, point-clouds, polynomials, B-splines; Parametric v/s. implicit representation, boundary representation, volumetric representation. [2 Lectures]
- **Rasterization**: World and camera transformations; Orthogonal and perspective projections; Hidden-surface removal, Z-buffering; Bresenham's line drawing algorithm; Triangle drawing primitive; Flood-fill algorithm. [6 Lectures]
- **Lighting, shaders and texture mapping**: Radiometric concepts such as BRDF, BTDF, BSSRDF; Types of light sources such as point, spot, parallel; Texture mapping; Shading schemes such as Flat, Gouraud, Phong; Flattening of 3D surfaces; Bump maps, Normal maps, Displacement maps. [6 Lectures]
- **Ray tracing and ray casting**: Mechanism of tracing the path of light in order to generate realistic images from 3D scenes. [3 Lectures]
- **Modeling with curves**: Differential geometry of planar and space curves; Definition and basic properties of Bezier and B-spline curves; Weierstrass approximation theorem. [5 Lectures]
- **Modeling with surfaces**: Differential geometry of surfaces; Definition and basic properties of tensor-product Bezier surfaces. [4 Lectures]

### Lab exercises:

Lab to be conducted on a 2-hour slot. It will be conducted in tandem with the theory course so the topics for problems given in the lab are already initiated in the theory class. The topics taught in the theory course shall be appropriately sequenced for synchronization with the laboratory.

- Lab l: Installation of Blender, familiarization of the GUI, simple exercises involving creation of primitive shapes. Installation ofOpenGL, writing a 'Hello World' application. Draw a few parametric as well as implicitly defined curves.

- Lab 2-4: Implementation of Bresenham's line drawing algorithm. Implementation of flood fill algorithm.
- Lab5-7: Create a 3D scene in Blender and apply various models of light-interaction such as BRDF, BTDF, BSSRDF. Insert different types of light sources into the scene. Apply textures to 3D objects. Lighting and shading in OpenGL, Raytracing
- Lab8-10: Implementation of ray-tracing.
- Lab11-12: Installation of Open Cascade. Construct and plot Bezier curves. Plot the tangents and osculating circles at a few points. Plot the Frenet frame at a few sampled points. Construct and plot B-spline curves.
- Lab13-14: Construct and plot tensor-product Bezier surfaces. Plot tangent-plane and curvature at sampled points. Extract iso-curves.

**Textbooks:**


1. Donald D. Hearn et al., **Computer Graphics with OpenGL**, 3rd Edition, Pearson, 2013


**Reference Books:**


1. Steve Marschner et al., **Fundamentals of Computer Graphics**, 4th Edition, A K Peters/CRC Press, 2015
2. Gerald Farin, **Curves and Surfaces for CAGD**, 5th Edition, 2001
3. Dave Shreiner, **OpenGL Programming Guide: The Official Guide to Learning OpenGL**, Versions 3.0 and 3.1 (7th Edition)


## 4.68 CS 551: Human Computer Interaction

**Course Code : CS 551**

**Course Name : Human Computer Interaction**

L-T-P-C : 3-0-0-3
Intended for : B. Tech./Masters/Ph.D.
Prerequisite : A programming course at the undergraduate level involving the use of Python, C#, HTML, or JavaScript for interface design.
Mutual Exclusion : None
Approval: 44th BoA

**Course Contents**

- **Introduction to HCI**: Course overview; goals in HCI; importance of design for usability; usability goals and metrics; historical perspective: machinery, computers, PCs and GUIs, and the Internet; different types of users; usability guidelines, principles, and theories of attention, perception, memory, and decision making. [8 Lectures]

- **User experience and design**: Different methods and frameworks of design; tools, practices, and patterns of design; social impact analysis; task decomposition; cognitive walkthroughs; expert reviews and heuristics; heuristic evaluation; guidelines of usability; active use evaluation; motion and time studies; GOMS keystroke-level models; human-study methodologies and techniques; survey and interview instruments; metaphors; storyboards; acceptance tests; ethical issues; design cases. [12 Lectures]

- **Interaction Design**: Direct manipulation; 2D devices and 3D interfaces; teleoperation and presence; augmented and virtual augmented reality; certain design patterns; fluid navigation; speech recognition and production; human language technology; traditional command languages; models of collaboration and contexts; deciding the appropriate interaction design. [10 Lectures]

- **Design choices**: Choices for user experience (animation, color, error handling, etc.); timing of user experience (system response time influence); help menus; information search; data types and data visualizations; grand challenges and future interfaces. [12 Lectures]

**Text books:**

1. Ben Shneiderman, Catherine Plaisant, Maxine Cohen, Steven Jacobs, Niklas Elmqvist, and Nicholas Diakopoulos, **Designing the User Interface: Strategies for Effective Human- Computer Interaction**, 6th Edition, Pearson, 2016

2. Dan R. Olsen Jr., **Building Interactive Systems: Principles for Human-Computer Interaction**, Cengage, 2010.

**References:**

1. Jeff Johnson, **Designing with the Mind in Mind: Simple Guide to Understanding User Interface Design Guidelines**, 3rd edition, Morgan Kaufmann, 2020.

2. Jenifer Tidwell, Charles Brewer, Aynne Valencia, **Designing Interfaces: Patterns for Effective Interaction Design**, 3rd Edition, O'Reilly Media, 2020

3. Materials from other online sources [http://www.cs.utep.edu/nigel/hci/videos.html], [https://www.inf.ed.ac.uk/teaching/courses/hci/1718/], and [http://pages.cpsc.ucalgary.ca/∼sau

## 4.69 CS 560: Text Retrieval and Mining

**Course Code: CS 560**

**Course Name: Text Retrieval and Mining**

L-T-P-C: 3-0-0-3
Prerequisites: CS309 Information and Database Systems
Intended for: B Tech, MS and PhD
Distribution: Elective for CS
Approval: 7th Senate

**Course Contents**

- **Introduction to IR**: What IR means, what its goals are, what entities it attempts to retrieve, the criteria by which IR systems are evaluated. Web search engine as a case study. [3 Lectures]
- **Introduction to TM**: Structured vs Unstructured Data, Document Classi?cation and Information Retrieval, Clustering and Organizing Documents, Textual Information to Numerical Vectors, Tokenization, Lemmatization, Stemming, Vector generation, Sentence boundary determination, Part of speech tagging, Parsing, Feature generation [8 Lectures]
- **Text Mining Techniques**: Similarity and nearest neighbor methods, Decision rules, Decision Trees, Linear Scoring methods, Key word search, Document matching, Inverted list, Clustering- K-means, Centroid clustering, Hierarchical clustering [8 Lectures]
- **Looking for Information in Documents**: Finding Patterns and entities, Coreference resolution, Relationship Extraction, Template filling and database construction [6 Lectures]
- **Case Studies**: Assigning topics to News Articles, Filtering email (Enron example) [3 Lectures]
- Hands on experience and mini projects

Software R with text mining package will be used for text mining the following datasets:

- Twitter dataset
- Titanic survivor dataset
- Blogging dataset
- Spam training dataset

Projects will be based on the real world applications like (not an exhaustive list)

- Spam filtering
- Fraud detection by investigating notification of claims
- Automatic labeling of documents in business libraries
- Creating suggestion and recommendations (like amazon)
- Monitoring public opinions (for example in blogs or review sites)
- Measuring customer preferences by analyzing qualitative interviews
- Fighting cyberbullying or cybercrime in IM and IRC chat

**Reference Books/Material:**


1. C. Manning, P. Raghavan, and H. Schtze, **Introduction to Information Retrieval**, Cambridge University Press, 2008.

2. Sholom M. Weiss, Nitin Indurkhya, Tong Zhang, Editors David Gries Fred B. Schneider, **Fundamentals of Predictive Text Mining**, Springer

3. W. Fan, L. Wallace, S. Rich, Z. Zhang, **Tapping the power of text mining**, Communications of ACM, 49(9), 76-82, 2006.

4. The Journal of Statistical Software article **Text Mining Infrastructure in R**

5. Ingo Feinerer, **Introduction to the tm Package: Text Mining in R**, 2014. (http://cran.r-project.org/web/packages/tm/vignettes/tm.pdf)


## 4.70 CS 561: Map Reduce and Big Data

**Course Code: CS 561**

**Course Name: Map Reduce and Big Data**

L-T-P-C: 3-0-0-3
Prerequisites:
Intended for:UG/PG
Distribution:Elective
Approval: 9th Senate, 11th Senate

**Course Contents**

Modules:

- **Unit 1**: Introduction to Big Data, the MapReduce paradigm and programming model. The MapReduce framework and its benefits. Cloud computing and MapReduce. Open source MapReduce frameworks Hadoop, Shark, Mrjob etc. - comparison and benefits of each such framework. [3 Lectures]

- **Unit 2**: Thinking in the MapReduce way via simple problems that serve as a building block for larger problems Matrix-Vector multiplication, Matrix multiplication, Relational algebra selections, projections, union, intersection, difference, natural join, grouping and aggregation. Complexity analysis of MapReduce algorithms. [3 Lectures]

- **Applying MapReduce to different Big Data contemporary problem areas**: [36 Lectures]
  - Similarity computations
  - Clustering algorithms K-means, CURE, ...
  - Web crawling and indexing
  - Web-scale graph algorithms PageRank, HITS, ...
  - Recommendation Systems content-based filtering, collaborative filtering, dimensionality reduction.

- Text advertising on the web AdWords.
- Social networks and their analysis.
- Large-scale Machine Learning Perceptrons and Support Vector machines.
- Statistical Machine Translation.
- Market Basket analysis.
- ? Mining Data Streams.

**Textbooks:**

1. Jimmy Lin and Chris Dyer, **Data-Intensive Text Processing with Map Reduce**, Morgan and Claypool.
2. Rajaraman and Ullman, **Mining of massive Datasets**, Cambridge University Press

## 4.71 CS 562: Artificial Intelligence

**Course Code : CS 562**

**Course Name : Artificial Intelligence**

L-T-P-C : 3-0-0-3
Pre-requisite : IC250 - Programming and Data Structure Practicum or Equivalent, CS202 Data Structure and Algorithm or Equivalent, CS403 - Algorithm Design and Analysis or Equivalent, COT
Intended for :B. Tech, MS, M. Tech. & PhD.
Distribution : Elective for Third and Final year B. Tech (All branches), MS, M. Tech. & PhD
Approval: 14th Senate

**Course Contents**

- **Introduction**: Overview and Historical Perspective, Turing Test, Physical Symbol Systems and the scope of Symbolic AI, Agents. [3 Lectures]
- **State Space Search**: Depth First Search, Breadth First Search, DFID. [3 Lectures]
- **Heuristic Search**: Best First Search, Hill Climbing, Beam Search. [3 Lectures]
- Traveling Salesman Problem, Tabu Search, Simulated Annealing. [3 Lectures]
- **Population Based Search**: Genetic Algorithms, Ant Colony Optimization. [3 Lectures]
- Branch & Bound, Algorithm A*, Admissibility of A*. [3 Lectures]
- Monotone Condition, IDA*, RBFS, Pruning OPEN and CLOSED in A* [3 Lectures]
- Problem Decomposition, Algorithm AO*, Game Playing. [3 Lectures]

- **Game Playing**: Algorithms Minimax, AlphaBeta, SSS*. [3 Lectures]
- Rule Based Expert Systems, Inference Engine, Rete Algorithm. [3 Lectures]
- **Planning**: Forward/Backward Search, Goal Stack Planning, Sussmans Anomaly. [3 Lectures]
- Plan Space Planning, Algorithm Graph plan. [3 Lectures]
- Constraint Satisfaction Problems, Algorithm AC-1, Knowledge Based Systems. [3 Lectures]
- Propositional Logic, Resolution Refutation Method. [3 Lectures]

**Text Books:**

1. Deepak Khemani, **A First Course in Artificial Intelligence**, McGraw Hill Education, 2013.

**References:**


1. John Haugeland, **Artificial Intelligence: The Very Idea**, A Bradford Book, The MIT Press, 1985.
2. Pamela McCorduck, **Machines Who Think: A Personal Inquiry into the History and Prospects of Artificial Intelligence**, 2nd Edition, A K Peters/CRC Press;2004.
3. Eugene Charniak and Drew McDermott, **Introduction to Artificial Intelligence**, Addison Wesley, 1985.
4. ZbigniewMichalewicz and David B. Fogel, **How to Solve It: Modern Heuristics**, 2nd Edition, Springer, 2004.
5. Judea Pearl, **Heuristics: Intelligent Search Strategies for Computer Problem Solving**, Addison-Wesley, 1984.
6. Elaine Rich and Kevin Knight, **Artificial Intelligence**, Tata McGraw Hill, 1991.
7. Stuart Russell and Peter Norvig, **Artificial Intelligence: A Modern Approach**, 3rd Edition, Prentice Hall, 2009.
8. Patrick Henry Winston, **Artificial Intelligence**, Addison-Wesley, 1992.
9. Stefan Edelkamp and Stefan Schroedl, **Heuristic Search: Theory and Applications**, Morgan Kaufmann, 2011.

## 4.72 CS 563: Scalable Data Science

**Course Code : CS 563**

**Course Name: Scalable Data Science**

L-T-P-C: 3-1-0-4

Prerequisite: Data Structures and Algorithms (CS202), Probability, Statistics and Random Processes (IC210), Algorithm Design and Analysis (CS403).

Students intended for: B.Tech.(3rd/4th year)/M.S./Ph.D.

Approval: 32nd Senate, 41st BoA

**Course Contents:**

- **Dimensionality reduction algorithms**: Johnson-Lindenstrauss Lemma; Random Projections; Spectral Projection, and their applications [5]. (4 Lectures)
- **Sketching algorithms for large data stream**: Reservoir sampling; Frequent element detection – Misra Gries algorithm; probabilistic counting – Flajolet and Martin Sketch; Set membership problem – Bloom filters and Cuckoo filters; Frequency estimation– Count Min- Sketching [8, 5]. (7 Lectures)
- **Algorithm for large scale search**: Introduction to Locality Sensitive Hashing (LSH) and its variants: LSH for Jaccard Similarity – Minwise Independent Permutations (MinHash) [6] and its recent advancements (b-bit MinHash [14], One Permutation Hashing [15]); LSH for Cosine Similarity – Signed Random Projections (SimHash) [7]; LSH for Euclidean Distance [12]; LSH for Hamming distance [10]. (8 Lectures)
- **Application of LSH**: Faster duplicate detection, clustering the web, large scale itemset mining, model compression. (3 hours)
- **Mining massive graphs and applications**: Algorithms for page rank; community detection; finding overlapping communities and connected components; partitioning of graphs; counting triangles. Learning embedding of nodes with applications in link prediction, node classification. (7 Lectures)
- **Clustering algorithms for large data**: Sampling algorithms for k- means clustering – kmeans++ [1], scalable k-means++ [2]; spherical k-means clustering [9]; k-mode clustering [11]; spectral clustering [5]. (6 Lectures)
- **Miscellaneous Topics**: Learning representation of text – word2vec [16, 13] and images – spectral hashing [17, 5] and its connection with Matrix Factorization; Topic modelling and Topic labelling [4, 3]; Building Recommendation System – a) Collaborative Filtering, b) Content based recommendation. (7 Lectures)

**Text Books**


1. Anand Rajaraman, Jure Leskovec, and Jeffrey D. Ullman, **Mining Massive Datasets**, 2014.
2. A. Blum, J. Hopcroft and R. Kannan, **Foundations of Data Science**, Cambridge University Press, 2020.

## References


1. David Arthur and Sergei Vassilvitskii. k-means++: the advantages of careful seeding. In Proceedings of the Eighteenth Annual ACM- SIAM Symposium on Discrete Algorithms, SODA 2007, New Orleans, Louisiana, USA, January 7-9, 2007, pages 1027–1035, 2007.

2. Bahman Bahmani, Benjamin Moseley, Andrea Vattani, Ravi Kumar, and Sergei Vassilvitskii. Scalable k-means++. PVLDB, 5(7):622–633, 2012.

3. Shraey Bhatia, Jey Han Lau, and Timothy Baldwin. Automatic labeling of topics with neural embeddings. In COLING 2016, 26th International Conference on Computational Linguistics, Proceedings of the Conference: Technical Papers, December 11-16, 2016, Osaka, Japan, pages 953–963, 2016.

4. D.M. Blei, A.Y. Ng, and M.I. Jordan. Latent Dirichlet allocation. the Journal of Machine Learning research, 3:993–1022, 2003.

5. Avrim Blum, John Hopcroft, and Ravindran Kannan, **Foundations of data science**, 2015.

6. Andrei Z. Broder, Moses Charikar, Alan M. Frieze, and Michael Mitzenmacher. Min-wise independent permutations (extended abstract). In Proceedings of the Thirtieth Annual ACM Symposium on the Theory of Computing, Dallas, Texas, USA, May 23-26, 1998, pages 327– 336, 1998.

7. Moses Charikar. Similarity estimation techniques from rounding algorithms. In Proceedings on 34th Annual ACM Symposium on Theory of Computing, May 19-21, 2002, Montréal, Québec, Canada, pages 380– 388, 2002.

8. Graham Cormode. Sketch techniques for approximate query processing. In Synopses for Approximate Query Processing: Samples, Histograms, Wavelets and Sketches, Foundations and Trends in Databases. NOW publishers, 2011.

9. Inderjit S. Dhillon and Dharmendra S. Modha. Concept decompositions for large sparse text data using clustering. Machine Learning, 42(1/2):143–175, 2001.

10. Aristides Gionis, Piotr Indyk, and Rajeev Motwani. Similarity search in high dimensions via hashing. In VLDB'99, Proceedings of 25th International Conference on Very Large Data Bases, September 7-10, 1999, Edinburgh, Scotland, UK, pages 518–529, 1999.

11. Zhexue Huang. Extensions to the k-means algorithm for clustering large data sets with categorical values. Data Mining and Knowledge Discovery, 2(3):283–304, Sep 1998.

12. Piotr Indyk and Rajeev Motwani. Approximate nearest neighbors: Towards removing the curse of dimensionality. In Proceedings of the Thirtieth Annual ACM Symposium on the Theory of Computing, Dallas, Texas, USA, May 23-26, 1998, pages 604–613, 1998.

13. Omer Levy and Yoav Goldberg. Neural word embedding as implicit matrix factorization. In Advances in Neural Information Processing Systems 27: Annual Conference on Neural Information Processing Systems 2014, December 8-13 2014, Montreal, Quebec, Canada, pages 2177–2185, 2014.

14. Ping Li and Arnd Christian König. b-bit minwise hashing. In Proceedings of the 19th International Conference on World Wide Web, WWW 2010, Raleigh, North Carolina, USA, April 26-30, 2010, pages 671–680, 2010.

15. Ping Li, Art B. Owen, and Cun-Hui Zhang. One permutation hashing. In Advances in Neural Information Processing Systems 25: 26th Annual Conference on Neural Information Processing Systems 2012. Proceedings of a meeting held December 3-6, 2012, Lake Tahoe, Nevada, United States, pages 3122–3130, 2012.

16. Tomas Mikolov, Ilya Sutskever, Kai Chen, Gregory S. Corrado, and Jeffrey Dean. Distributed representations of words and phrases and their compositionality. In Advances in Neural Information Processing Systems 26: 27th Annual Conference on Neural Information Processing Systems 2013. Proceedings of a meeting held December 5-8, 2013, Lake Tahoe, Nevada, United States, pages 3111–3119, 2013.

17. Yair Weiss, Antonio Torralba, and Rob Fergus. Spectral hashing. In D. Koller, D. Schuurmans, Y. Bengio, and L. Bottou, editors, Advances in Neural Information Processing Systems 21, pages 1753–1760. Curran Associates, Inc., 2009.

## 4.73 CS 571: Programming Practicum

**Course Code: CS 571**

**Course Name: Programming Practicum**

L-T-P-C: 1-0-3-3
Prerequisites: Programming experience in any language (C/C++/Matlab/Python etc.)
Students intended for: MTech./M.S./Ph.D.
Elective or Core: Core for M.Tech. CSP, Elective for M.S./Ph.D.
Approval: 22nd Senate

**Course Contents**

1 lecture per week, followed by 3 hours of lab.

- **Review of general programming constructs**: Loops, conditionals, recursion, file i/o, data structures: strings, tuples, lists, dictionaries. [4 Lectures]
- **Introduction to scientific computing**: Numerical precision in programs, IEEE 754 floating point representation, introduction to NumPy and Scipy. [1 Lecture]
- **Data manipulation**: Pandas, handling large data files. [1 Lecture]
- **Data visualization**: Various types of plots: histograms, scatter plots, box plots etc. Datasets can be provided and plots can be created from them. [1 Lecture]
- **Object oriented programming**: Classes and objects, inheritance. [1 Lecture]

- **Implementing well known programs**: Matrix factorizations, solving large order linear systems of equations, least squares approximations, simulating binary channels, signal denoising, K-means clustering, classification using Bayes rule etc. [4 Lectures]
- **Introduction to parallelization**: Cuda programming (conceptual level only). [1 Lecture]
- **Program analysis**: Performance tuning, profiling of programs, identifying performance bottlenecks. [1 Lecture]

**Text Books:**

1. Jake Vanderplas, **Python Data Science Handbook**, O Reilly, 2017

**Reference Books:**

1. Michael Dawson, **Python Programming for the Absolute Beginner**, Third Edition
2. Allen Downey, Jeffrey Elkner, Chris Meyers, **How to Think Like a Computer Scientist: Learning with Python**, Green Tea Press, 2016
3. Muller and Guido, **Introduction to machine learning with Python**, O Reilly, 2017

## 4.74 CS 580 Advanced Data Structures and Algorithms

Course Number: CS 580
Course Name: Advanced Data Structures and Algorithms
Credits: 3-0-1-4
Prerequisites: IC 250, CS 208
Intended for: B.Tech.
Distribution: Compulsory for CS; CS elective for EE and ME
Approval: OTA; 8th Senate (3rd Convocation)

**Preamble:**

The proposed new curriculum for CS includes six discipline core courses.

1. Mathematical Foundations of Computer Science
2. Advanced Data Structures and Algorithms
3. Paradigms of Programming
4. Computer Organization
5. Information Systems
6. Communicating Distributed Processes

The proposed course follows the new CS curriculum design approach that strives to .cover in the above-mentioned six core courses all the fundamental concepts that a CS undergraduate student must know of.

The course proposal attempts to include the fundamental topics in data structures and algorithms. The topics from the essential core of this course that must be . covered comprehensively, with lots of examples. practice exercises. and weekly programming labs. In the proposed contents. there are some topics that are marked advanced. These topics can be introduced depending on background and interests of the class and if the time permits. These and some other advanced topics should be covered in greater detail in advanced discipline electives.

**Obiective:**

After the students have gone throdgh a Course on discietÃ© structureshwhe'‘re they - learn the formal and abstract representations of data and its manipulation, a course on data structures and algorithms should teach the students concrete implementations and manipulations of such discrete structures and their use in design and analysis of non-trivial algorithms for a given computational task. On completion of such a course the students should be able to

- analyze the asymptotic performance of algorithm
- demonstrate their familiarity with major data structures rules to manipulate those, and their canonical applications
- construct efficient algorithms for some common computer engineering design problems Further, as programming is an integral part of the CS education, in this course the students should implement the data structures and algorithms they learn, compute the corresponding achievable performance (computation time, memory requirement, etc), and if possible compare the achievable performance among alternative designs and implementations.

**Syllabus:**

- **Complexity Analysis**: (2 hours) Time and Space complexity of algorithms asymptotic analysis, average and worst , case analysis asymptotic notation, importance of efficient algorithms program performance measurement. data structures and algorithms.
- **Stacks and Queues**: (4 hours) ADT, sequential and linked implementations, representative applications. towers of Hanoi parenthesis matching, finding path In a maze.
- **Lists**: (6 hours) ADT, sequential and linked representations, comparison of insertion, deletion and search operations for sequential and linked lists, list and chain classes, doubly Iinked lists, circular lists applications of lists In bin sort radix sort sparse tables. Advanced topic(s): Skip lists
- **Dictionary**: (1 hour) ADT. array and tree based implementations.

- **Hashing**: (4 hours) Search efficiencyency in lists and skip lists, hashing as a search structure, hash table, collision resolution, linear open addressing, chains hash tables _In data-compression, LZW algorithm Advanced topic(s): Universal hashing

- **Heaps**: (3 hours) Heaps as priority queues, heap implementation, insertion and deletion operations binary heaps, heapsort, heaps m Huffman coding. Advanced topic(s) Binomial, Fibonacci and Leftist heaps

- **Trees**: (8 hours) ADT, sequential and linked implementations tree traversal methods and algorithms: Binary trees and their properties, tournament trees use of winner trees In mergesort bin packing. Advanced topic(s): Threaded binary trees—differentiation

- **Search Trees**: (3 hours) Binary search trees search efficiency, insertion and deletion operations importance of- balancing, Tries, 2-3tree, B-tree Advanced topic(s): AVL trees, searching, insertion and deletionsI'n AVL trees

- **Graphs**: Definition, terminology, directed and undirected graphs, prOperties, implementation — adjacency matrix and linked adjacency chains, connectivity in? graphs, graph traversal — breadth first and depth first. spanning trees.

- **Basic algorithmic techniques**: (7 hours) Greedy algorithms, divide & conquer, dynamic programming. Search techniques - backtracking, Sorting algorithms with analysis, integer sorting, selection sort. Graph algorithms: DFS and BFS with applications, MST and shortest paths.

**Reference Books:**


1. A. Am and J. Ullman, **Foundations of Computer Science**, W. H. Freeman, 1992. Available online at: http://infolab stanford. edu/∼ul—man/focs.html

2. A. V Aho, J. D. Ullman, and J. E. Hopcroft, **Data Structures and Algorithms**, Addison-Wesley, 1983

3. A. M Tenenbaum, Y Langsam, and M. J. Augenstein, **Data Structures Using C and C++**, 2nd Edition, Prentice Hall, 1995.

4. S. Sahni, **Data Structures Algorithms, and Applications m C++**, 2nd Edition, Silicon Press, 2005

5. E. Horowitz S. Sahni, and D. Mehta, **Fundamentals of Data Structures in C++**, 2nd Edition, Silicon Press, 2006.

6. M. A. Weiss, **Data Structures and Algorithm Analysis in C++**, 4th Edition, Prentice Hall, 2013

7. T. H. Cormen, C. E. Leiserson. R. L. Rivest, and C. Stein, **Introduction to Algorithms**, 3rd Edition, MIT Press, 2009.

## 4.75 CS 580 Advanced Data Structure and Algorithm

**Course Code: CS 580**

**Course Name: Advanced Data Structure and Algorithm**

L-T-P-C: 3-0-2-4
Prerequisites:
Students Intended for:
Core or Elective:

**Course Contents:**

- **Review of Basic Concepts**: Abstract data types, Data structures, Algorithms, Big Oh, Small Oh, Omega and Theta notations, Solving recurrence equations, Master theorems, Generating function techniques, Constructive induction
- **Advanced Search Structures for Dictionary ADT**: Splay trees, Amortized analysis, 2-3 trees, 2-3-4 trees, Red-black trees, Randomized structures, Skip lists, Treaps, Universal hash functions
- **Advanced Structures for Priority Review of Basic Concepts**: Abstract data types, Data structures, Algorithms, Big Oh, Small Oh, Omega and Theta notations, Solving recurrence equations, Master theorems, Generating function techniques, Constructive induction
- **Advanced Search Structures for Dictionary ADT**: Splay trees, Amortized analysis, 2-3 trees, 2-3-4 trees, Red-black trees, Randomized structures, Skip lists, Treaps, Universal hash functions
- **Advanced Structures for Priority Queues and Their Extensions**: Binomial heaps, Leftist heaps, Skewed heaps, Fibonacci heaps and its amortized analysis, Applications to minimum spanning tree algorithms
- **Data Structures for Partition ADT**: Weighted union and path compression, Applications to linite state automata minimization, Code optimization
- **Graph Algorithms**: DFS, BFS, Blconnected components, Cut vertices, Matching, Network flow
- **Computational Geometry**: Geometric data structures, Plane sweep paradigm
- **Lower Bound Theory**: Adversary arguments, information theory bounds **Queues and Their Extensions**: Binomial heaps, Leftist heaps, Skewed heaps, Fibonacci heaps and its amortized analysis, Applications to minimum spanning tree algorithms
- **Data Structures for Partition ADT**: Weighted union and path compression, Applications to linite state automata minimization, Code optimization
- **Graph Algorithms**: DFS, BFS, Blconnected components, Cut vertices, Matching, Network flow
- **Computational Geometry**: Geometric data structures, Plane sweep paradigm

- **Lower Bound Theory**: Adversary arguments, information theory bounds

## 4.76 CS 591 series: Special topics in Knowledge Discovery and Data Mining

**Course Code: CS 591 series**

**Course Name: Special topics in Knowledge Discovery and Data Mining**

L-T-P-C: 1-0-0-1
Prerequisites: Data mining for decision making [CS660] or Pattern recognition [CS669]
Intended for: B.Tech and M.Tech
Distribution:

**Course Contents**

- Entity Analytics and Integration Tools and Techniques. [3 Lectures]
- Social Data Analytics and Text Mining. [2 Lectures]
- Knowledge Graph Platforms. [2 Lectures]
- Knowledge Graph Applications. [2 Lectures]
- Image Analytics, Visual Search Applications & Deep Learning. [1 Lecture]
- Project Assignment and Discussions. [2 Lectures]
- Student Research Paper presentation and discussion. [2 Lectures]

**Suggested Reference Books:**

- Mostly recent VLDB/SIGMOD Papers
- Documentations available on web

## 4.77 CS 591 Series: Selected topics in machine learning for computer vision

**Course Code: CS 591 Series**

**Course Title: Selected topics in machine learning for computer vision**

L-T-P-C: 1-0-0-1
Prerequisites:
Students intended for: UG/PG

**Course Contents**

- Machine Learning Basics: [1 Lecture]
- Clustering: KMeans, Agglomerative, Normalized Cuts. [2 Lectures]
- Bag of Words. [1 Lecture]
- Haar Cascade. [1 Lecture]
- Graphical Models: Modelling, Inference. [4 Lectures]
- Neural Networks: Shallow, Deep, CNN, Auto-encoders. [5 Lectures]

## 4.78 CS 591 Series: Data Visualization

**Course Code: CS 591 Series**

**Course Title: Data Visualization**

Pre-requisites: Some exposure to programming.

**References:**

- Edward Tufte, The Visual Display of Quantitative Information
- Edward Tufte, Envisioning Information
- Ben Fry, Visualizing Data

Session Details

- Session 1: The Value of Visualization
- Sessions 2 & 3: Effective Use of Form and Space Fundamentals of Graphs
  - Readings:
    * Graph Selection Matrix
    * Seven Common quantitative relationships in Graphs and how to display them
    * Save the Pies for Dessert
    * Constructing Correlation Bar And Paired Bar Graphs With Microsoft Excel
    * Ref: perceptualedge.com
- Session 4: Integrity in Visualization
  - Reading : Chapter 2 of The Visual Display of Quantitative Information by Edward Tufte
- Session 5: Visual Perception and Quantitative Communication
  - Reading : Chapter 5 of Envisioning Information by Edward Tufte

- Sessions 6 & 7: Effective Use of Form and Space Detailed Design of Tables and Graphs
  - Readings: Summary at a Glance: Table Design
  - Summary at a Glance: Graph Design
- Session 8: Additional Constructs and Multivariate Analysis
  - Readings : Chapters 4 and 5 of The Visual Display of Quantitative Information by Edward Tufte
  - Reference: http://tech.fortune.cnn.com/2011/08/15/put-on-your-5-d-glasses/
- Session 9 : Escaping 2 Dimensions: Animated Scatter-Plots
  - Readings: Instructions for creating Motion Charts in Excel
  - References: GapMinder and Google Motion Charts (www.gapminder.org)
- Sessions 10 & 11: Introduction to Information Design
  - Reading: http://adaptivepath.com/ideas/ben-frys-computational-information-design
  - Reference: Processing Software - tutorial (http://processing.org/learning)
- Session 12 & 13 : Interactive Data Visualization
  - Reference: http://www.tableausoftware.com/public
- Session 14 : Recap of course and Wrap-up

## 4.79 CS 591_1: Selected Topics in Computer Graphics: Curves in Computer Geometric Modelling

**Course Code: CS 591_1**

**Course Name: Selected Topics in Computer Graphics: Curves in Computer Geometric Modelling**

Pre-requisite: linear algebra, basic calculus, data structures.
Audience: It should be accessible to UG students of 2nd year onwards and all PG students.

- **Module 1:** Motivation: Design of machines, automobiles, aircrafts, ships, buildings and structures. Basics of polynomials, Different bases serve different purposes. Interpolation vs approximation, Bernstein-Weierstrass theorem. [3 lectures]
- **Module 2:** Bernstein base and its properties, Bezier curves and their properties. DeCasteljau algorithm, Algorithms for degree elevation, subdivision etc. [4 lectures]
- **Module 3:** Curve operations: closet point computations, intersection computations: curves vs lines, curves vs planes, curves vs curves. A multi-dimensional Newton-Raphson framework, Curve-to-curve contact conditions etc. [4 lectures]
- **Module 4:** Curve constructions: projection of curves, curvature basics, offset curves, self-intersection issues. [3 lectures]

## 4.80 CS 592: Selected Topics in Artificial Intelligence

### Course code : CS 592

### Course Name: Selected Topics in Artificial Intelligence

L-T-P-C :0-0-4-2
Pre-requisites: Some exposure to various programming paradigms. Permission of the instructor is required before allotment
Intended for: B. Tech
Elective/Core: Discipline elective for B. Tech CSE, free electives for others Course Outline Students can work individually or in small groups. Assignment of project topics will be based on interests and discussion and interview with the instructor.

### Course Outline

Themes for each project will be one of the following: Algorithms in Linear Programming, Graph Theory, Linear Algebra etc. Parallelization based on OpenMP, MPI e-content creation for Algorithms Source to source language translation

As a by-product, students can learn python or Fortran or Latex .

## 4.81 CS 592: Reactive Design Patterns

### Course Code: CS 592

### Course Name: Reactive Design Patterns

L-T-P-C : 2-0-0-2
Prerequisites : Instructor's permission
Intended for : UG and PG
Distribution : Elective for BTech CSE, MS, PhD

### Course Contents

- Review of Multicore processor, cache & memory hierarchy and cache coherency. [2 Lectures]
- Review of Process & thread. [1 Lecture]
- hread Pool & their scheduling & User Mode scheduling. [3 Lectures]
- Event and message communication & their context & handling. [1 Lecture]
- Asynchronous Communication, Promise & Future. [2 Lectures]
- Method execution as an independent thread & Green Threads. [2 Lectures]
- Message Flow Patterns: Request-Response & Ask. [4 Lectures]
- Flow Control Patterns: Pull, Managed Queue, Drop. [3 Lectures]
- Replication Patterns: Active-Reactive, Active-Active. [4 Lectures]

- Resource Management Patterns: Resource Pool & Complex Command Pattern. [3 Lectures]
- Mutability & Synchronization primitives. [2 Lectures]
- Software Transactional Memory. [4 Lectures]

## 4.82 CS 601: Probability and Random Processes

**Course Code: CS 601**

**Course Name: Probability and Random Processes**

L-T-P-C: 3-1-0-4
Students intended for: High-level B.Tech / MS / Ph.D.
Prerequisites: N/A
Elective or Compulsory: Elective
Approval: 10th Senate

**Course Contents**

- **Set theory and Basic probability**: Set operations, Axioms, Properties, Finite sample space, Combinatorics, Union of events, Conditional Probability, Independence of events, Bayes formula. [6 Lectures]
- **Introduction to measure theory (Definitions, examples, some theorems)**: Set sequences and their limits, Borel fields, Sigma fields, Measure space, Additive set functions, Measure, Probability space and probability measure, Random variable. [5 Lectures]
- **Random Variables**: Basic definitions and examples, PDF, CDF, Examples and properties of some standard continuous and discrete random variables. [7 Lectures]
- **Functions of Random variables**: Functions of one random variable, Transformation of Random Variables, Expectations, Moments, Moment generating functions, Some inequalities (Chebyshevs, Schwarz, Markov, etc.), Functions of two random variables, Joint distributions, Marginal distributions, Joint moments, Covariance, Correlation, Independence, Central limit theorem, Example applications. [9 Lectures]
- **Random vectors and random processes**: Joint pdf, Multivariate distributions, Expectation vector, Covariance matrix, Diagonalization, Principal components Analysis, Generalization of random vectors to random process, Examples of Random Processes, Auto-and Cross Correlation, Auto- and Cross Covariance, Stationarity, WSS, Random process through a LTI system, Power spectral density, White noise, Example applications. [10 Lectures]
- **Overview of some applications (with examples)**: ML and MAP estimation, Bayesian belief networks. [5 Lectures]

**Text Books:**

1. H. Stark, J Woods, **Probability and Random Processes with Applications to Signal Processing**, 3rd Edition, Prentice Hall, 2002

2. A. Papoulis, U. Pillai, **Probability Random Variables and Stochastic Processes**, 4th Edition, McGraw-Hill, 2002.

3. Sheldon M. Ross, **Introduction to Probability Models**, Academic Press, 2009.

## 4.83 CS 603: Managerial Decision Making

**Course Code : CS 603**

**Course Name : Managerial Decision Making**

L-T-P-C: 3-0-0-3
Prerequisites : IC 210 Probability, Statistics and Random Processes; or, with instructors permission
Intended for: 3rd, 4th year B. Tech./M.S./Ph.D.
Distribution : Discipline-elective for CSE B. Tech. students; Free elective for other B. Tech./M.S./Ph.D. students
Approval: 4th Senate

**Course Contents**

- **Introduction to decision making**: Orientation, introduction to decision making, Introduction to decision analysis, framing decisions, applications of decisions framing to marketing and management. [6 Lectures]

- **Valuation and choice in certain and uncertain decision situations**: Valuing and choosing among certain outcomes, valuing and choosing among uncertain outcomes, applications of decision trees to decision making. [6 Lectures]

- **Use of heuristics and biases**: Introduction to different heuristics and biases, endowment effect, loss aversion, status quo bias, inter- temporal biases, other common biases in decision making under risk and uncertainty. [10 Lectures]

- **Real-world managerial decision making**: Decisions under uncertainty in the real world, managerial perspectives on risk and risk taking, regression analysis, improper linear models in decision making, when to trust your gut instincts, theory of thin slices. [8 Lectures]

- **More biases and heuristics under risk and uncertainty**: Availability, representativeness, anchoring-and-adjustment, illusion of control, confirmation bias. [6 Lectures]

- **Decision making in groups**: Decision making in groups and organizations, cognitive repairs, nudges, conclusions. [6 Lectures]

**Textbooks:**

1. J. Edward Russo & Paul Schoemaker, **Winning Decisions: Getting it Right the First Time**, Doubleday, 2002. [RS]

2. John S. Hammond, Ralph L. Keeney, & Howard Raiffa, **Smart Choices: A Practical Guide to Making Better Decisions**, Harvard Business School Press, 1999. [HKR]

**Articles:**

1. JSTOR: Articles are available from www.jstor.org (accessible through any IIT computer).

2. HBS-online: Cases, articles, and teaching notes from Harvard Business School Press are available from http://harvardbusinessonline.hbsp.harvard.edu.

## 4.84 CS 606_Old - Cognitive Modeling

Course Name and contents are different in the website. New Course Name:**Computational Modeling of Social Systems**[1]

## 4.85 CS 606: Computational Modeling of Social Systems

**Course Code : CS 606**

**Course Name : Computational Modeling of Social Systems**

L-T-P-C : 3-0-0-3
Prerequisites : IC 110 Engineering Mathematics and IC 150 Computation for Engineers; or, after instructors permission
Intended for : 3rd, 4th year B. Tech./M.S./Ph.D.
Distribution : Discipline-elective for CSE B. Tech. students; Free elective for other B. Tech. students
Approval: 4th Senate

**Course Contents**

- **Learning in Complex Systems**: Policy Resistance, Counterintuitive Behavior of Social Systems; Learning and feedback process; Barriers in Learning; Requirements for Learning in Complex Systems; Virtues and Pitfalls of Virtual Worlds; Importance of simulation. [4 Lectures]

- **The Modeling Process**: Purpose of Modeling; Steps in the Modeling Process; Problem Articulation; Formulating a Dynamic Hypothesis; Formulating a Simulation Model; Testing; Policy Design and Evaluation; Causal Loop Diagrams; Fundamental Modes of Dynamic Behavior; Dynamics of Stocks and Flows: First-order Systems, Positive Feedback and Exponential Growth, Multiple-Loop Systems, Nonlinear First-Order Systems. [8 Lectures]

[1] Approved in 3rd Senate

- **Applications of Modeling Process**: Modeling S-Shaped Growth; Modeling Epidemics (e.g., Modeling the HIV/AIDS Epidemic); Modeling Innovation Diffusion: Modeling New Ideas and New Products (The Bass Diffusion Model). [6 Lectures]
- **Feedback Delays**: Duration and Dynamics of Delays; Defining Delays; Material Delays: Structure and Behavior; Information Delays: Structure and Behavior; Response to Variable Delay Times; Estimating the Duration and Distribution of Delays; Examples: Forecasting Semiconductor Demand. [8 Lectures]
- **Modeling Decision Making**: Principles for Modeling Decision Making; Formulating Rate Equations; Common Pitfalls; Human Decision Making: Bounded Rationality or Rational Expectations; Cognitive Limitations; Individual and Organizational Responses to Bounded Rationality; Intended Rationality; Case Study: Modeling High-Tech Growth Firms. [8 Lectures]
- **Validation and Model Testing**: Difficulties in Validation and Verification; Questions Model Users Should Ask: Types of Data, Documentation, Replicability, Protective versus Reflective Modeling; Model Testing in Practice (Boundary Adequacy Tests, Structure Assessment Tests, Dimensional Consistency, Parameter Assessment, Extreme Condition Tests). [8 Lectures]

**Text Books:**

1. John D Sterman, **Business Dynamics: Systems Thinking and Modeling for a Complex World**, McGraw-Hill, 2000

**Reference Books:**

1. Donella H. Meadows, **Thinking in Systems: A Primer** (Paperback), Chelsea Green Publishing.2008.
2. John Morecroft, **Strategic Modelling and Business Dynamics: A Feedback Systems Approach**, John Wiley & Sons, 2007.

## 4.86 CS 609_Old : Speech processing

**Course Code: CS 609_Old**

**Course Name: Speech processing**

L-T-P-C: 3-0-0-3
Prerequisites: Signal Processing.
Students intended for : Masters/PhD
Elective or Compulsory: Elective
Approval: 2nd Senate

**Course Outline:**

Fundamental of speech recognition, The speech signal: Production,Perception and acoustic-phonetic characterization, Signal processing methods for speech recognition, Pattern-comparison techniques, Speech recognition system design and implementation issues, Speech recognition using? vocabulary continuous speech recognition

**Text & Reference Books:**

1. L. R. Rabiner, B. H. Juang, and B. Yegnenarayana, **Fundametntals of Speech Recognition**, Pearson, 2009.

## 4.87 CS 609: Speech Processing

**Course Code: CS 609**

**Course Name: Speech Processing**

L-T-P-C: 3-0-2-4
Prerequisites: Signals and Systems (IC260), or Digital Signal Processing (EE305) or COT
Students intended for: BTech./MTech./M.S./Ph.D.
Elective or Core: Elective
Approval: 10th Senate

**Course Contents**

- **Introduction** [1 Lecture]
- **Review of digital signal processing**: Discrete-time signals and systems, transform representation of signals and systems, fundamentals of digital filters, sampling. [3 Lectures]
- **Fundamentals of human speech production, acoustic theory of speech production**: Speech production, short-time Fourier transform, acoustic phonetics. [3 Lectures]
- **Hearing and speech perception, auditory models**: Anatomy and functions of the ear, the perception of sound, auditory models, lossless tube models. [3 Lectures]
- **Time-domain methods**: Short-time analysis (energy, magnitude, zero-crossing rate, autocorrelation). [5 Lectures]
- **Frequency-domain methods**: Discrete-time Fourier analysis, short-time Fourier analysis, spectrograms, Overlap-add method of synthesis, filter-bank summation method of synthesis. [7 Lectures]
- **Cepstrum and homomorphic speech processing**: Homomorphic analysis, computing the short-time cepstrum and the complex cepstrum, cepstrum analysis of all-pole models, cepstrum distance measures. [5 Lectures]
- **Linear predictive analysis of speech**: Basic ideas, gain computation, frequency-domain interpretation, solving LPC equations, the prediction error signal, representations of LP parameters. [6 Lectures]
- **Algorithms for estimating speech parameters**: Median smoothing, speech-background discrimination, pitch period estimation, formant estimation. [5 Lectures]

- **Digital coding of speech signals**: Sampling speech signals, statistical models for speech signals, quantization (instantaneous, adaptive), quantising speech model parameters, delta modulation, DPCM, ADPCM. [3 Lectures]

- **Applications**: **speech recognition, speech enhancement, speaker recognition**: Hidden Markov models for speech recognition, statistical methods for speech enhancement, factor analysis for speaker recognition. [4 Lectures]

**Text Books:**


1. L.R. Rabiner, R. W. Schafer, **Theory and applications of digital speech processing**, Prentice Hall

2. L.R. Rabiner, R. W. Schafer, **Digital Processing of Speech Signals**, Pearson

3. Douglas O'Shaughnessy, **Speech Communications: Human and Machine**, Wiley India

4. Ben Gold and Nelson Morgan, **Speech and Audio Signal Processing: Processing and Perception of Speech and Music**, Wiley


**Reference Books:**


1. J. R. Deller, J. H. L. Hansen, J. G Proakis, **Discrete-time processing of speech signals**, Wiley.

2. A. V. Oppenheim, R. W. Schafer, R. Buck, **Discrete-time signal processing**, Pearson


## 4.88 CS 611: Program Analysis

**Course Code: CS 611**

**Course name: Program Analysis**

L-T-P-C: 3-1-0-4
Prerequisites: CS202: Data Structures and Algorithms or equivalent; CS208: Mathematical Foundations of Computer Science or equivalent; CS304: Formal Languages and Automata Theory or equivalent
Intended for: B.Tech., M.Tech., MS, PhD
Distribution: Discipline Elective for BTech CSE, Elective for others
Approval: 32nd Senate, 37th BoA

**Course Contents**

- **Introduction to static analysis**: Concrete versus abstract semantics. Abstract interpretation. Galois connection. Symbolic execution. Control-flow graphs. Iterative da taflow analysis. Lattices and monotonicity. Analysis dimensions. [10 Lectures]

- **Heap analysis. Heap modeling**: Points-to information. Andersen's and Steensgard's pointer analyses. Variations: alias analysis, null-check analysis, escape analysis. [9 Lectures]

- **Interprocedural analysis**: Call-graph construction. Context sensitivity: functional and call-string approaches. Various context abstractions: value and lsrv contexts, object and type sensitivity. Heap cloning. [10 Lectures]
- **Strategies for efficiency**: Demand-driven anal ysis. Program slicing. Analysis staging. Partial analysis. Efficient data structures. Heuristics and machine learning. [9 Lectures]
- **Language features and challenges**: Lexical and dynamic scoping. Eager and lazy evaluation. Call-backs and reflection. Concurrency and synchronization: may-happen-in-parallel analysis. Speculative optimizati ons and deoptimization. Dynamic analysis. [10 Lectures]
- **Sneak peek into applications**: Type checking. Bug detection. Program correctness. Program synthesis and repair. Software refactoring. [8 Lectures]

**Tutorials and assignments**

This course involves hands-on practice with writing different program analyses, implementing the techniques for efficiency, and learning various associated tools and language features. The classes wi ll teach the theory, and tutorials would train the students on the various skill-sets required to finish take home programming assignments.

lt may be noted that as the coure covers several recent topics related to designing analyses that are precise-yet-efficient, the classes will use one or two important analyses as running examples (examples being alias analysis and pointer analysis for resolving virtual calls). Hence, another aim of the tutorial hours would be to help students imbibe the concepts learnt by making them write specifications of different analyses and optimization strategies.

The take-home assignments will be based on implementing and understanding (a) intra- and inter procedural analyses; (b) strategies for imparting efficiency; (c) examples of handli ng tricky language features; and (d) non-trivial applications such as parallelization, refactorinp and security.

**References:**

1. Flemming Nielson, Hanne Riis Nielson and Chris Hankin, **Principles of Program Analysis**, Corrected Edition, Springer, 1999.
2. Uday P. Khedker, Amitabha Sanyal and Bageshri Karkare, **Data Flow Anal ysis: Theory and Practice**, CRC Press, 2009.
3. Y. N. Srikant and Priti Shankar, **The Compiler Design Handbook**, 2nd Edition, CRC Press, 2007.
4. Various research papers related to the course content.

## 4.89 CS 630: Speech Technology

### Course Code: CS 630

### Course Name: Speech Technology

L-T-P-C: 3-0-2-4
Students intended for: B.Tech
Elective or Core: Elective
Approval: 3rd Senate

### Course Contents

- **Overview of Speech Technology**: What is Speech Technology? Why is it important? Its applications and issues.
- **Speech Production**: Mechanism of speech production; Categories of sounds; Sound units in indian languages.
- **Nature of Speech Signal**: Source-system characteristics; Segmental and suprasegmental features; Temporal and spectral parameters for sound units in indian languages.
- **Basics of Digital Signal Processing**: Signals and systems; Discrete fourier transform; Digital filtering; Stochastic processes.
- **Speech Signal Processing Methods**: Short-time spectrum analysis; Spectrograms; Linear prediction analysis; Cepstrum analysis.
- **Speech Recognition**: Isolated word recognition; Connected word recognition Continuous
- **Speech Recognition**: Speech recognition problem; Hidden markov models.
- **Other Applications**: Word spotting; Speaker recognition; Speech enhancement; Speech synthesis; Practical issues in speech technology.

### Text Books:

1. L R Rabiner and R W Schafer, **Theory and Application of Digital Speech Processing**, Pearson, 2011.
2. L R Rabiner, B-H Juang and B Yegnanarayana, **Fundamentals of Speech Recognition**, Pearson, 2009.
3. Xuedong Huang, Alex Acero, Hsiao-wuen Hon, **Spoken Language Processing: A guide to Theory, Algorithm, and System Development**, Prentice Hall, 2001.

**References:**


1. Oppenheim and Schafer, **Discrete-Time Signal Processing**, PHI, 2001.

2. T W Parsons, **Voice and Speech Processing**, McGraw Hill, 1986.

3. Thomas Quatieri, **Discrete-time Speech Processing: Principles and Practice**, PH, 2001.

4. Rabiner and Schafer, **Digital Processing of Speech Signals**, Pearson Education, 1993.

5. Douglas O Shaughnessy, **Speech Communications**, University Press, 2001.


## 4.90 CS 660: Data Mining for Decision Making

**Course Code: CS 660**

**Course Name: Data Mining for Decision Making**

L-T-P-C: 3-0-1-4
Prerequisites: IC 210: Probability, Statistics and Random Processes; IC 250: Data Structure and Algorithms
Intended for: UG/PG
Distribution: Discipline elective for CSE; CS elective for EE and ME
Approval: 8th Senate

**Course Contents**

The course is divided into weekly modules, where a new topic is covered in each week. The details of the topics covered in each week are provided below:

- Week 1: **Introduction to Data mining**: What is Data Mining? What is the Data Mining Process? Basic Data Mining Tasks, Problem Identification, Data Mining Metrics, Data Cleaning (pre-processing, feature selection, data reduction, feature encoding, noise and missing values, etc.), Key Issues, Opportunities for Data Mining. [3 Lectures]

- Week 2: **Nave Bayes classifier**: Two-class classifiers, Training and Test sets, Maximum-Likelihood estimation, Bayesian estimation, Classification of Test sets. [3 Lectures]

- Week 3: **Decision Trees**: Classification and Regression Trees, Building and Selecting Decision Trees (concept of Information Gain), Obtaining Production Rules from Decision Trees, Handling missing values in Decision Trees. [3 Lectures]

- Week 4: **Neural Networks**: Introduction to Artificial Neural Networks, Single-layer Networks, Multi-layer Networks, Backward Propagation Algorithm, Annealing the learning rate (Step decay, Adagrad, and RMSprop), Over-fitting and choice of Epochs. [3 Lectures]

- Week 5: **Instance-Based Learning**: Instances, Activations, Recency, Frequency, Retrieval from Memory, Blending of instances. [3 Lectures]

- Week 6: **Clustering**: Introduction to Cluster Analysis, Clustering Algorithms, Hierarchical Methods (Nearest neighbor, Farthest neighbor, Group average), Similarity Measures. [3 Lectures]
- Week 7: **Logistic Regression**: Introduction to Logistic Regression, Logistic function, odds ratio, logit, Logistic Regression with more than two classes. [3 Lectures]
- Week 8: **Multiple-Linear Regression**: Introduction to Multiple-Linear Regression, Assumption made in a linear regression model, regression process, dropping irrelevant variables. [3 Lectures]
- Week 9: **Principal Components Analysis**: Introduction to principal components analysis, dimensionality reduction, principal components and orthogonal least squares. [3 Lectures]
- Week 10: **Discriminant Analysis**: Introduction to discriminant analysis, applications to two-classes, extension to more than 2- classes, canonical variate loadings, extension to unequal covariance structures. [3 Lectures]
- Week 11: **Association Rules**: Introduction to association rules, support, confidence, Apriori Algorithm. [3 Lectures]
- Week 13: **Implementation Issues**: Metrics for Model selection - MDL, BIC, AIC, Ethics, Legality, and Privacy; Staffing and Implementation [3 Lectures]
- Week 14: **The Future of Data Mining, Unstructured Data Mining, and conclusions**: [3 Lectures]
- **If time permits**: Topics in graph mining: Definition of Graphs, Subgraphs, Frequent Subgraphs and subgraphs, Detection Algorithms: Apriori-Based Approach, Pattern Growth Approach (gSpan), Graph Classification, and Graph Compression.

**Textbooks:**

1. Hand David, Mannila Heikki, and Smyth Padhraic, **Principles of Data Mining**, MIT, 2004.,

**References:**


1. Han, J., Kamber, M. & Pei, J., **Data mining concepts and techniques**, 3rd Edition Morgan Kaufmann Publishers, 2012.
2. Berry and Linoff, **Mastering Data Mining**, Wiley, 2000.
3. Delmater and Hancock, **Data Mining Explained**, Digital Press, 2001.
4. T. Mitchell, **Machine Learning**, McGraw-Hill, 1997.
5. M. H. Dunham, **Data Mining: Introductory and Advanced Topics**, Pearson Education, 2001.
6. Samatova, N. F., Hendrix, W., Jenkins, J., Padmanabhan, K., & Chakraborty, A. (Eds.), **Practical Graph Mining with R**, CRC Press, 2013.

7. Wang, H., **Managing and mining graph data** (Vol. 40), C. C. Aggarwal (Ed.), Springer, 2010.

## 4.91 CS 661: Knowledge Representation and Reasoning

**Course code : CS 661**

**Course Name : Knowledge Representation and Reasoning**

L-T-P-C : 3-0-0-3
Prerequisites : CS202-Data Structures & Algorithms, CS208-Mathematical Foundations of Computer Science or Equivalent or COT
Intended for : UG/PG
Elective/Core : Discipline Elective for BTech CSE, Free Elective for others
Approval: 12th Senate

**Course Contents**

- **Module I**: Introduction, Propositional Logic, Proof Systems. [2 Lectures]
- **Module II**: Tableau Method, Resolution Method, First Order Logic (FOL). [3 Lectures]
- **Module III**: FOL Semantics, Unification, Forward Chaining with the Rete Algorithm. [4 Lectures]
- **Module IV**: Rete example, Reification, Event Calculus, Conceptual Dependency (CD) Theory. [4 Lectures]
- **Module V**: Conceptual Dependency Theory, Mapping from Natural Language, Goal Trees. [4 Lectures]
- **Module VI**: Logic Programming with Prolog, Resolution Refutation in FOL. [4 Lectures]
- **Module VII**: SLD Resolution, Frames, Scripts. [4 Lectures]
- **Module VIII**: Goals and Plans, Description Logic (DL), Structure Matching. [4 Lectures]
- **Module IX**: Classification in DL, A-Box Reasoning, Extensions of DL, ALC. [4 Lectures]
- **Module X**: Inheritance Networks, Default Reasoning, Circumscription. [4 Lectures]
- **Module XI**: Event Calculus, Default Logic, Auto-epistemic Logic. [3 Lectures]
- **Module XII**: Epistemic Reasoning. [2 Lectures]

**Textbooks:**

1. Ronald J. Brachman, Hector J. Levesque, **Knowledge Representation and Reasoning**, Morgan Kaufmann, 2004.

2. Deepak Khemani, **A First Course in Artificial Intelligence**, McGraw Hill Education (India), 2013.

**References:**

1. Schank, Roger C., Robert P. Abelson, **Scripts, Plans, Goals, and Understanding: An Inquiry into Human Knowledge Structures**, Lawrence Erlbaum, 1977.

2. R. C. Schank and C. K. Riesbeck, **Inside Computer Understanding: Five Programs Plus Miniatures**, Lawrence Erlbaum, 1981.

3. Murray Shanahan, **A Circumscriptive Calculus of Events**, Artif. Intell. 77(2), pp. 249-284, 1995.

4. John F. Sowa, **Conceptual Structures: Information Processing in Mind and Machine**, Addison Wesley Publishing Company, 1984.

5. John F. Sowa, **Knowledge Representation: Logical, Philosophical, and Computational Foundations**, Thomson Learning, 2000.

6. Ronald Fagin, Joseph Y. Halpern, Yoram Moses, Moshe Y. Vardi, **Reasoning About Knowledge**, MIT Press, 1995.

## 4.92 CS 662: Mobile Virtual Reality and Artificial Intelligence

**Course Code : CS 662**

**Course Name: Mobile Virtual Reality and Artificial Intelligence**

L-T-P-C: 3-0-0-3
Prerequisites: CS 660, CS 669, or an equivalent course in AI/ML area
Intended for: B. Tech./M. Tech ./M.S./Ph.D. students
Approval: 37th BoA

**Course Contents**

- **Introduction to VR an VR programming** [12 Lectures]

- **Building the first AI simulation** :Developing a Pathfinding Game, How to Set Up a Project, Node, String Map, A* A lgor.ithm Setup, A* Algorithm Loop, Auxi liary Methods, Finishing the A lgorithm, Importing 2D Assets, Building a Level, From Console to Visual, Adding Tanks, Identifying Nodes, Moving the Tank, Visually Moving Tank, Smooth Movement, Smooth Rotation, Ordering Tank to Move, Speeding up Player, Spawning Logic, Crate Visuals, Adding Crates to Valid Positions, Collecting Crates, Score Counting, Game Interface, Starting the Game, Game Over Screen, Scoring, Sounds. [6 Lectures]

- **Introduction to Virtual Reality and Blending:** VR Introduction, Camera Changing Position, Triggering Events Interface, Blending and Introduction & Customizing Settings, Controlling Blender Camera, Emulate Numpad Camera, Manipulating Objects, Common Tools, Mirroring l Side of Object. Case Study: Flappy bird game in VR, First person shooter VR game, Kart VR game. [8 Lectures]

- **Introduction to ML in VR:** Introduction to Machine Learning, the need for ML in VR, different kinds of learn ings, Neural Networks (NNs), Training a NN, Optimizer, Convolutional layers, Transfer learning, Imitation learning. Case study: Training the karin kart game via IL and testing the kart drive.

- **Reinforcement Learning**: Introduction to Reinforcement Learning, Initial state, Training a policy, The PPO algorithm, Evoluti onal Strategies, Reward. Case study: Training a kart in the kart game with RL, Tensorboard analysis, Testing results. [10 Lectures]

**Textbooks:**

1. Butttield-Addison, P., Manning, J., Nugent, T., **Unity Game Development Cookbook: Essentials for Every Game**, O'Reilly Media, 2019.

**Reference books:**

1. Linowes, J., & Schoen, M, **Cardboard VR Projects for Android**, Packt Publishing, 2016.

2. Lanham, M., **Hands-On Deep Learning for Games: Leverage the power of neural networks and reinforcement to build intellegent games**, Packt Publishing Ltd, 2019.

## 4.93 CS 669: Pattern Recognition

**Course Code: CS 669**

**Course Name: Pattern Recognition**

L-T-P-C: 3-1-0-4
Prerequisites: IC
Students intended for: MS/Mtech/PhD/3rd and 4th year B Tech
Elective or Compulsory: Elective
Approval: 10th Senate
Note: Credits changed from 3-0-0-3 to 3-1-0-4 in 10th Senate

**Course Contents**

- **Basics of Probability, Random Processes and Linear Algebra** (recap) [8 Lectures]
    - Probability: independence of events, conditional and joint probability, Bayes theorem

  - Random Processes: Stationary and nonstationary processes, Expectation, Autocorrelation, Cross-Correlation, spectra.
  - Linear Algebra: Inner product, outer product, inverses, eigen values, eigen vectors, singular values, singular vectors.
  - Programming Assignment 1

- 2. **Bayes Decision Theory** [8 Lectures]
  - Minimum-error-rate classification
  - Classifiers, Discriminant functions, Decision surfaces
  - Normal density and discriminant functions
  - Discrete features

- 3. **Parameter Estimation Methods** [12 Lectures]
  - Maximum-Likelihood estimation: Gaussian case
  - Maximum a Posteriori estimation
  - Bayesian estimation: Gaussian case
  - Unsupervised learning and clustering
    * Criterion functions for clustering
    * Algorithms for clustering: K-Means, Hierarchical and other methods
    * Cluster validation
  - Gaussian mixture models
  - Expectation-Maximization method for parameter estimation
  - Maximum entropy estimation
  - Programming Assignment 2

- **Sequential Pattern Recognition** [4 Lectures]
  - Discreat Time Warping (DTW)
  - Hidden Markov Models (HMMs)
  - Discrete HMMs
  - Continuous HMMs
  - Programming Assignment 3

- **Nonparametric techniques for density estimation** [4 Lectures]
  - Parzen-window method
  - K-Nearest Neighbour method

- **Dimensionality reduction** [4 Lectures]
  - Principal component analysis it relationship to eigen analysis
  - Fisher discriminant analysis Generalised eigen analysis
  - Eigen vectors/Singular vectors as dictionaries.

- **Linear discriminant functions** [8 Lectures]
  - Gradient descent procedures
  - Perceptron
  - Support vector machines
- **Non-metric methods for pattern classification** [4 Lectures]
  - Non-numeric data or nominal data
  - Decision trees: Classification and Regression Trees (CART).
  - Programming Assignment 4/Project

**Text Books:**

1. R.O.Duda, P.E.Hart and D.G.Stork, **Pattern Classification**, John Wiley, 2001
2. S.Theodoridis and K.Koutroumbas, **Pattern Recognition**, 4th Edition, Academic Press, 2009.
3. C.M.Bishop, **Pattern Recognition and Machine Learning**, Springer, 2006.

**References:**

1. Some relevant papers/notes will be put up on the website from time-to-time.
2. Simon Haykin, **Neural Networks: A Comprehensive foundation to Neural Networks or Neural Net-works and Learning Machines**, any edition will do.

## 4.94 CS 670: Kernal Methods for Pattern Recognition

**Course Code: CS 670**

**Course Name: Kernal Methods for Pattern Recognition**

L-T-P-C: 4-0-0-4
Intended for: B. Tech students who have completed CS 669, Masters Students
Approval: 11th and 17th Senates; OTA Course

**Course Outline:**

The course kernel methods for pattern analysis (KMPA) deals with the advanced topics in the area of pattern analysis. Pattern analysis mainly involves pattern classification, regression and pattern clustering. The course C8669: Pattern Recognition introduces various techniques'in pattern classification and clustering. The KMPA course is a continuation of pattern recognition course and introduces advanced pattern classification, clustering and regression techniques. In this course vie˜mainly focus on an advanced concept in pattern analysis called kernel methods. This course aims at expertizing the students in the theory as well as in the practical usage of various pattern analysis techniques.

The course Kernel methods for pattern analysis is currently offered through NKN. This course is taught by Professor C. Chandra sekhar, Department of Computer Science and Engineering, IIT Madras. This is an approved course in the Department of CSE, IIT Madras offered as CSÃ©Oll: Kernel Methods for Pattern Analysis.

This course is targeted to II and IV year BTech students who have successfully completed the course CS 669: Pattern Recognition and MS & PhD Scholars who have successfully completed the course CS 669: Pattern Recognition or have exposure to the pattern analysis techniques.

## 4.95 CS 671: Deep Learning and Applications

**Course Code: CS 671**

**Course Name: Deep Learning and Applications**

L-T-P-C: 3-1-0-4
Prerequisites: Probability and Random Processes, Linear Algebra
Intended for: B.Tech, MS/PhD in the area.
Elective/Core: Discipline elective for B.Tech CSE and EE, free elective for others
Approval: 12th Senate

**Course Contents**

- **Basics of artificial neural networks (ANN)**: Artificial neurons, Computational models of neurons, Structure of neural networks, Functional units of ANN for pattern recognition tasks. [4 Lectures]

- **Feedforward neural networks**: Pattern classification using perceprton, Multilayer feedforward neural networks (MLFFNNs), Backpropagation learning, Empirical risk minimization, Regularization, Autoencoders. [6 Lectures]

- **Deep neural networks (DNNs)**: Difficulty of training DNNs, Greedy layerwise training, Optimization for training DNNs, Newer optimization methods for neural networks (AdaGrad, RMSProp, Adam), Second order methods for training, Regularization methods (dropout, drop connect, batch normalization). [12 Lectures]

- **Convolution neural networks (CNNs)**: Introduction to CNNs convolution, pooling, Deep CNNs, Different deep CNN architectures LeNet, AlexNet, VGG, PlacesNet, Training a CNNs: weights initialization, batch normalization, hyperparameter optimization, Understanding and visualizing CNNs. [12 Lectures]

- **Recurrent neural networks (RNNs)**: Sequence modeling using RNNs, Back propagation through time, Long Short Term Memory (LSTM), Bidirectional LSTMs, Bidirectional RNNs, Gated RNN Architecture. [8 Lectures]

- **Generative models**: Restrictive Boltzmann Machines (RBMs), Stacking RBMs, Belief nets, Learning sigmoid belief nets, Deep belief nets. [8 Lectures]

- **Applications**: Applications in vision, speech and natural language processing. [6 Lectures]

**Textbooks:**

1. Ian Goodfellow, Yoshua Bengio and Aaron Courville, **Deep learning**, In preparation for MIT Press, Available online: http://www.deeplearningbook.org, 2016

**References:**

1. S. Haykin, **Neural Networks and Learning Machines**, Prentice Hall of India, 2010

2. Satish Kumar, **Neural Networks - A Class Room Approach**, 2nd Edition, Tata McGraw-Hill, 2013

3. B. Yegnanarayana, **Artificial Neural Networks**, Prentice- Hall of India, 1999

4. C.M. Bishop, **Pattern Recognition and Machine Learning**, Springer, 2006

## 4.96 CS 672: Advanced Topics in Deep Learning

**Course Code: CS 672**

**Course Name: Advanced Topics in Deep Learning**

L-T-P-C: 3-0-2-4
Prerequisites: CS 671: Deep Learning and its Applications.
Distribution: Discipline Elective for fmal year BTech CSE, DSE and EE, Elective for other final year B.Tech disciplines, MS, M.Tech, and Ph.D. students.
Approval: 38th BoA

**Course Contents**

- **GAN series**: Deep Convolutional GAN (DCGAN), Conditional GAN (eGAN), Wasserstein GAN (WGAN), Stacked GAN (StackGAN), Attention GAN, Picture to Picture GAN (Pi x2Pix), Cyclic GAN (Cycle GAN), Discover Cross-Domain R-elations (DiscoGAN), Super Resolution GAN (SRGAN), Texture GAN, Self Attention GAN (SAGAN). [8 Lectures]

- **Transformer Networks**: Drawbacks of Recurrent Neural Networks, Self Attention, Transformers, Bidirectional Encoder Representation from Transformer (BERT), Generative pre-trained Transformer (GPT). [6 Lectures]

- **Deep Reinforcement Learning**: Basic of reinforcement learning, Markov decision process, Value and Q-val ue functions, Deep Q-learning, Deep Policy Gradient iteration (Reinforce Algo). [10 Lectures]

- **Graph-based Deep Learning**: Basics of Graph Convolutional Neural Network (GCN), Graph Embeddings, Spectral and Spatial GCNs, Graph Autoencoders. [5 Lectures]

- **Some latest miscellaneous deep learning paradigms and concepts**: [10 Lectures]

  – Capsule Network

- Teacher-student network
- Attention and Self-attention mechanism
- Multi-task learning
- Novel loss functions
- Model compression/Network Pruning: redundant filter removal, filter ranking, and filter attention.
- Explainable AI

- **Advance deep learning application** (optional/cover in above topics/related to projects): [3 Lectures]
  - CV related: Object detection, Tracking with Re-id, Flow networks,
  - NLP related: Summarization, text generation,
  - Mise: Domain Adaptation etc.

**Reference Material:**

1. Most of the material will be covered from the recently published research papers at prestigious venues like NIPS, CVPR, ECCV, ICCV, ICLR, etc. [Lecture Material]
2. Aston Zhang et.al., **Dive into Deep Learning**, (Book website: ms://d21.aiL) (Book PDF: https://d2l.ai/d2l-en.ruti)
3. Ian Goodfellow and Yoshua Bengio and Aaron Courville, **Deep Learning**, (Book website: htms://www.deeglearningbook.org/) [Reference Books]
4. [Few Reference Courses]
   (a) [CS23l n, DL Stanford course]
   (b) [CS224n, NLP Stanford course]
   (c) [DeepMind RL course by David Silver]

## 4.97 CS 673 : Advanced Computer Vision

**Course Code : CS 673**

**Course Name : Advanced Computer Vision**

L-T-P-C : 3-0-2-4

Intended for : B.tech (Yd and 4111 Year), CSE, DSE and EE Students

Prerequisite : EE511 Computer Vision or CS671 Deep Learning or EE608 Digital Image Processing or CS669 Pattern Recognition, or similar

Mutual Exclusion:

Approval: 54th BoA

**Course Contents**

- **Introduction to Computer Vision**: Get a conceptual overview of image classification, object localization, object detection, and image segmentation. Also be able to describe multi-label classification and distinguish between semantic segmentation and instance segmentation. In the rest of this course, you will apply PyTorch to build object detection and image segmentation models. (6 Hours)
- **Vision Models Classification**: Convolutional Neural Networks: Architectures, Convolution I Pooling Layers, spatial arrangement, layer patterns, layer sizing patterns, AlexNet/ZFNet/VGGNet/EfficentNet case studies, computational considerations, Transfer learning for Representation, domain adaptation, domain Generalization, open set, open world, cuTTiculum learning (6 Hours)
- **Vision Models Object Detection and Tracking**: Overview of some popular object detection models, such as regional-CNN and ResNet-50. Use of object detection models in PyTorch, Transfer Learning for object detection: download your own models and configure them for training and build your own models for object detection. Using transfer learning, you will train a model to detect and localize. Model compression and real-time inference on Edge-devices. (9 Hours)
- **Vision Models Segmentation**: Types of semantic segmentation, instance-based models, Disadvantages of search window methods, RCNN-family models, Unet, DeepLab, Transformer based segmentation. (6 Hours)
- **Graphs and XAI for Vision**: Graph Representation/formulation for visual tasks, Deep Learning Models for Graphs, GradCam, GradCam++, Graph Model Explanation, LIME, GraphLIME (6 Hours)
- **Vision & Language Models**: Visual to Text: Recent methods for Text embeddings, Scene/Video Captioning, OCR, VQA, Video Description using RNNs, LSTMs. Transformers. Text to Visual: Text to image/video generation using V AEs, GANs, Transformers. (9 Hours)

**Textbooks:**

1. Richard Szeliski, **Computer Vision: Algorithms and Applications**.
2. David Forsyth and Jean Ponce, **Computer Vision: A Modern Approach**, 2nd Edition.

**References:**

1. Ian Goodfellow, **Deep Learning**.
2. Trevor Hastie, Robert Tibshirani, and Jerome Friedman, **Elements of Statistical Learning**.
3. Richard Hartley and Andrew Zisserman, **Multiple View Geometry in Computer Vision, 2nd Edition**.

## 4.98 CS 677: Soft Computing

**Course Code : CS 677**

**Course Name : Soft Computing**

L-T-P-C : 2-0.5-0.5-3
Students intended for: M.S./Ph.D
Prerequisites : Knowledge of Probability, Statistics and Optimization, C/C++/MATLAB.
Elective or Compulsory: Elective
Approval: 4th Senate

**Course Description**

Introduction to soft computing and its applications. Biological neural network, artificial neural networks and applications, mathematical foundations and learning mechanisms, perceptron learning, radial basis function networks, feed forward neural network,competitive learning,self organizing neural network, support vector machine, Application of to Financial Markets, weather prediction. Fuzzy systems and applications: Introduction to fuzzy sets and fuzzy logic systems, fuzzy sets, fuzzy reasoning, fuzzy inference systems, fuzzy clustering, applications of fuzzy systems, neuro-fuzzy modeling and control.

**Text Books:**

1. Simon Haykin, **Neural Networks**, Prentice Hall, 1998.
2. Timothy J Ross, **Fuzzy Logic with Engineering Applications**, Wiley, 2009.
3. J.S.R. Jang, C.T. Sun, E. Mizutani, **Neuro-Fuzzy and Soft Computing: A Computational Approach to Learning and Machine Intelligence**, Prentice Hall, 1996

**Reference Books:**

1. Mohamad H. Hassoun, **Fundamentals of Artificial Neural Networks**, MIT Press, 1995.
2. Bart Kosko, **Neural Networks and Fuzzy Systems**, Prentice Hall of India Learning, 2009.
3. M. Friedman and Abraham Kandal, **Introduction to Pattern Recognition-Statistical, Structural, Neural and Fuzzy Logic Approaches**, World Scientific, 2005.

## 4.99 CS 683 : Generative AI

**Course Code : CS 683**

**Course Name : Generative AI**

L-T-P-C : 3-0-1-4

Intended for : Elective for B. Tech. Data Science and Engineering, Discipline elective for B. Tech. Computer Science and Engineering, Electrical Engineering, Free elective for other B. Tech. disciplines, Elective for M.Tech (CSP/Intelligent Systems/CSE) and PhD

Prerequisite : CS 671 - Deep Learning and It's Applications

Mutual Exclusion:

Approval: 54th BoA

**Course Contents**

- **Introduction**: Introduction to Generative Models- GenAl, Basics of Deep Learning ,Convolutional Neural Networks, Convolutional Neural Networks -II, Recurrent Neural Networks & LSTM. (4 Hours)
- **Variational Autoencoders**: Deep Dive Into Variational AutoEncoder, Variants of Variational AutoEncoders. (3 Hours)
- **Generative Adversarial Networks**: Theory ofGAN, Variants ofGAN, GAN architectures, Various GAN losses and Convergence analysis ofGAN, Conditional GANS:pix2pix, cycleGAN, Domain adaptation frameworks. (7 Hours)
- **Flow Based Generative Models**: Normalizing Flow Basics, Variational Normalizing Flow and Sampling Basics. (2 Hours)
- **Diffusion Models**: Introduction to Diffusion Models, Deepdive into Diffusion Models -1, Score Based Diffusion Models, Discrete Latent Variable Models, Diffusion Models for Discrete Data. (7 Hours)
- **Hybrid Generative Models**: V AE-GAN, Diffusion guided Style GAN. (2 Hours)
- **Evaluation of Generative Models**: Discussion ofthe scores like FID, Inception Score. (1 Hour)
- **Transformer Based Generative Models**: Introduction to Transformers, Variants of Transformers, BERT Models, GPT Models, Chat GPT, Video and Image generation via. Transformers: VIT, VVIT, CLIP, GLIDE, DALE, Text Generation, Text to Text and Text to Image, Text to Video. (8 Hours)
- **Deep Graph Generative Models**: Graph Neural Networks- Model, Design, Deep Generative Models for Graph Generation and Graph Transformers. (8 Hours)

**Laboratory/practical/tutorial Modules:**

- Lab to be conducted on a 2-hour slot every week. It will be conducted in tandem with the theory course so the topics for problems given in the lab are already initiated in the theory class.
- Programming Assignments to Implementing state of art Diffusion Models, GANs,Transformers and Graph Neural Networks.
- Tools- Pytorch or Tensorflow

**Textbooks:**

1. Alger fraley, **The Artificial Intelligence and Generative AI Bible**: [5 in 1] The Most Updated and Complete Guide I From Understanding the Basics to Delving into GANs, NLP, Prompts, Deep Learning, and Ethics of AI, 2024
2. David Foster, **Generative Deep Learning**, 2nd Edition, O'Reilly Media, Inc.

**References:**

1. Jakub M. Tomczak, **Deep Generative Modeling**.
2. Keita Broadwater and Namid Stillman, **Graph Neural Networks in Action**.

## 4.100 CS 685 : Natural Language Processing

**Course Code : CS 685**

**Course Name : Natural Language Processing**

L-T-P-C : 3-0-0-3
Intended for : BTech 3rd/4th year; MTech; MSc; Ph.D.
Prerequisite : Introductory course in machine-learning/ AI; Programming in Python
Mutual Exclusion:
Approval: 54th BoA

**Course Contents**

- **Introduction to NLP and FSTs**: (6 Hours)
  - History ofNLP and its Evolution
  - Challenges and Applications of NLP
  - Text Preprocessing: Tokenization, Stop words removal, Stemming, Lemmatization, and Normalization
  - Parsing Algorithms
  - Regular Languages and Finite State Transducers
- **Language Modeling**: (6 Hours)
  - Language modeling with Markov chains
  - Introduction to probability and information theory in NLP
  - Concept of Perplexity
  - Supervised learning: Feature extraction, Naive Bayes and Support Vector Machines for text classification
- **Word Embeddings and HMM**: (6 Hours)
  - Word2Vec, CBOW and Skip-gram
  - FastText
  - GloVe: Global Vectors for Word Representation

  - HMM and Viterbi

- **Named Entity Recognition (NER) and Part-of-Speech Tagging (POS)**: (9 Hours)
  - Introduction to NER
  - Sequence labeling for NER
  - CRF-based NER models
  - Deep learning approaches to NER
  - Introduction to POS tagging
  - Rule-based POS tagging
  - Hidden Markov Models for POS tagging
  - Neural network-based POS tagging
- **Text Post Processing and Sentiment Analysis:** (8 Hours)
  - Adaptive Text Post Processing using plugin classifiers
  - Understanding sentiment analysis and Lexicon-based approaches
  - Machine learning-based sentiment analysis
- **Text Generation**: (10 Hours)
  - Using pre-trained word embeddings for specific applications
  - Sentence Embeddings
  - Introduction to text generation
  - Sequence-to-Sequence Models, Attention Mechanism and Transformers
  - Recurrent Neural Networks (RNNs) for text generation
  - Large Language Models • BERT for NER
  - Language generation with GPT-3 and similar models
  - Ethical considerations, future trends and research directions in NLP

**Laboratory/practical/tutorial Modules:**

- In addition to the lecture modules, this course will include a take home assignment where students will apply their knowledge to develop and fine-tune LLM applications using Python and platforms such as Hugging Face Transformers.

**Textbooks:**

1. Yoav Goldberg, **Neural Network Methods for Natural Language Processing**, Morgan and Claypool, 2017.
2. Dan Jurafsky and James Martin, **Speech and Language Processing**, 3rd Edition.

**References:**

1. Allen, James, **Natural Language Understanding**, 2nd Edition, Benjamin/Cumming, 1995.
2. Charniack, Eugene, **Statistical Language Learning**, MIT Press, 1993.
3. Jurafsky, Dan and Martin, James, **Speech and Language Processing**, 2nd Edition, Prentice Hall, 2008.
4. Manning, Christopher and Heinrich, Schutze, **Foundations of Statistical Natural Language Processing**, MIT Press, 1999.

## 4.101 CS 685_56 : Natural Language Processing

**Course Code : CS 685**

**Course Name : Natural Language Processing**

L-T-P-C : 3-0-0-3
Intended for : BTech 3rd/4th year; MTech; MSc; Ph.D.
Prerequisite : Introductory course in machine-learning/AI; Programming in Python;
Mutual Exclusion:
Approval: 56th BoA

**Course Contents**

- Introduction to NLP and FSTs (6 Hours)
  - History of NLP and its Evolution
  - Challenges and Applications of NLP
  - Text Preprocessing: Tokenization, Stop words removal, Stemming, Lemmatization, and Normalization
  - Parsing Algorithms
  - Regular Languages and Finite State Transducers
- Language Modeling, Word Embeddings and HMM (12 Hours)
  - Language modeling with Markov chains
  - Introduction to probability and information theory in NLP
  - Concept of Perplexity
  - Text Classification: Classification Layers, Low-Rank Adaptation (LoRA)
  - Word2Vec, CBOW, Skip-gram, and FastText
  - GloVe: Global Vectors for Word Representation
  - HMM and Viterbi
- Text Generation (10 Hours)
  - Using pre-trained word embeddings for specific applications

  - Sentence Embeddings
  - Introduction to text generation
  - Sequence-to-Sequence Models, Attention Mechanism and Transformers
  - Recurrent Neural Networks (RNNs) for text generation Large Language Models
  - Language generation with GPT-3 and similar models
  - Ethical considerations, future trends and research directions in NLP

- Named Entity Recognition (NER) and Part-of-Speech Tagging (POS) (9 Hours)
  - Introduction to NER
  - Sequence labeling for NER
  - CRF-based NER models
  - Deep learning approaches to NER
  - Introduction to POS tagging
  - Rule-based POS tagging
  - Hidden Markov Models for POS tagging
  - Neural network-based POS tagging

- Text Post Processing and Sentiment Analysis (8 Hours)
  - Coreference resolution and coherence
  - Adaptive Text Post Processing using plugin classifiers
  - Understanding sentiment analysis and Lexicon-based approaches
  - Machine learning-based sentiment analysis

**Laboratory/practical/tutorial Modules:**

In addition to the lecture modules, this course will include a take home assignment where students will apply their knowledge to develop and fine-tune LLM applications using Python and platforms such as Hugging Face Transformers.

**Text Books:**

1. Yoav Goldberg, **Neural Network Methods for Natural Language Processing**, Morgan and Claypool, 2017.
2. Dan Jurafsky and James, **Martin Speech and Language Processing**, 3nd Edition.

**Reference Books:**


1. Allen, James, **Natural Language Understanding**, 2nd Edition, Benjamin/Cumming, 1995.

2. Charniack, Eugene, **Statistical Language Learning**, MIT Press, 1993.

3. Jurafsky, Dan and Martin, James, **Speech and Language Processing**, 2nd Edition, Prentice Hall, 2008.

4. Manning, Christopher and Heinrich, Schutze, **Foundations of Statistical Natural Language Processing**, MIT Press, 1999.


## 4.102 CS 686_56 : Large Language Models: Core Concepts to Custom Applications

**Course Code : CS 686**

**Course Name : Large Language Models: Core Concepts to Custom Applications**

L-T-P-C : 3-0-2-4
Intended for : BTech 3rd/4th year; MTech; MSc; Ph.D
Prerequisite : Introductory course in machine-learning/AI; Programming in Python;
Mutual Exclusion:
Approval: 56th BoA

**Course Contents**

- Introduction to NLP and LLMs (9 Hours)
  - Fundamentals of NLP and its Evolution
  - Language Model Basics: n-grams to Neural Networks
  - Word embeddings
  - Introduction to Transformer Architectures and Attention Mechanisms
  - Introduction to Generative AI
  - Overview of Prominent LLMs (GPT, BERT, Llama, Mistral, etc.) and their Impact
- Deep Dive into LLM Architectures (12 Hours)
  - Selecting the right model and Generative AI responsibility
  - Comprehensive Study of Transformer Mechanism
  - Scaling Laws: Understanding computational demands and data efficiency
  - Hallucinations and Citations
  - Architectural Variants and Innovations in LLMs, including parameter-efficient fine-tuning models like LoRA, QLoRA
- Practical Applications and Customization of LLMs (15 Hours)

- Text data cleaning, normalization, and tokenization
- LLMs in Text Generation, Translation, and Summarization
- Best Prompt Engineering Techniques
- Fine-Tuning Strategies for Task-Specific Applications
- Overview of Instruction Fine Tuning and Reinforcement Learning from Human Feedback (RLHF)
- Model alignment techniques including Decision Process Optimization (DPO), Knowledge Transfer Optimization (KTO)
- Retrieval-Augmented Generation (RAG)
- Practical Session: Building LLM-based Applications
- Building Chat Applications
- Embeddings based Search Applications
- Speech based LLMs

- Ethical Considerations and Societal Impacts (4.5 Hours)
  - Addressing Bias and Fairness in LLM Outputs
  - Ethical Use and Misuse of Generative AI
  - Future Societal Challenges and Opportunities
- Advanced Topics and Research Directions in LLMs (4.5 Hours)
  - Emerging Trends in LLM Research
  - Novel Applications and Future Technologies
  - Open Problems and Discussion

**Laboratory/practical/tutorial Modules:**

In addition to the lecture modules, this course will include take home assignment where students will apply their knowledge to develop and fine-tune LLM applications using Python and platforms such as Hugging Face Transformers.

**Text Books:**

1. Yoav Goldberg, **Neural Network Methods for Natural Language Processing**, Morgan and Claypool, 2017.
2. Dan Jurafsky and James Martin, **Speech and Language Processing**, 3nd Edition.

**Reference Books:**

1. Ian Goodfellow, Yoshua Bengio, Aaron Courville, **Deep Learning**, MIT Press, USA, 2016.

2. A collection of the latest research papers, technical blogs, and articles from top journals and conferences to stay updated with the advancements and debates in the domain of LLMs.

3. **Large Language Models in Practice** - This is a placeholder for a current and comprehensive resource focused on the practical and theoretical aspects of LLMs. Due to the rapidly evolving nature of this field, the latest resource available at the time of course launch should be selected.

4. Generative AI for beginners by, Microsoft, https://learn.microsoft.com/en-gb/collections/zpy7c8z 105485-koreyst

## 4.103 CS 686 : Large Language Models: Core Concepts to Custom Applications

**Course Code : CS 686**

**Course Name : Large Language Models: Core Concepts to Custom Applications**

L-T-P-C : 3-0-2-4
Intended for : BTech 3rd;4th year; MTech; MSc; Ph.D.
Prerequisite : Introductory course in machine-learning/AI; Programming in Python
Mutual Exclusion:
Approval: 54th BoA

**Course Contents**

- **Introduction to NLP and LLMs** (9 Hours)
  - Fundamentals ofNLP and its Evolution
  - Language Model Basics: n-grams to Neural Networks
  - Word embeddings
  - Introduction to Transformer Architectures and Attention Mechanisms
  - Introduction to Generative AI
  - Overview of Prominent LLMs (GPT, BERT, Llama, Mistral, etc.) and their Impact
- **Deep Dive into LLM Architectures** (12 Hours)
  - Selecting the right model and Generative AI responsibility
  - Comprehensive Study of Transformer Mechanism
  - Scaling Challenges: Computational Demands, Data Efficiency
  - Hallucinations and Citations
  - Architectural Variants and Innovations in LLMs
- **Practical Applications and Customization of LLMs** (15 Hours)
  - Text data cleaning, normalization, and tokenization

  - LLMs in Text Generation, Translation, and Summarization
  - Best Prompt Engineering Techniques
  - Fine-Tuning Strategies for Task-Specific Applications
  - Overview ofInstruction Fine Tuning and Reinforcement Learning from Human Feedback (RLHF)
  - Retrieval-Augmented Generation (RAG)
  - Practical Session: Building LLM-based Applications Building Chat Applications
  - Embeddings based Search Applications
  - Speech based LLMs
- **Ethical Considerations and Societal Impacts** (4.5 Hours)
  - Addressing Bias and Fairness in LLM Outputs
  - Ethical Use and Misuse of Generative AI
  - Future Societal Challenges and Opportunities
- **Advanced Topics and Research Directions in LLMs** (4.5 Hours)
  - Emerging Trends in LLM Research
  - Novel Applications and Future Technologies
  - Open Problems and Discussion

**Laboratory/practical/tutorial Modules:**

- In addition to the lecture modules, this course will include take home assignment where students will apply their knowledge to develop and fine-tune LLM applications using Python and platforms such as Hugging Face Transformers.

**Textbooks:**

1. Auffarth, B, **Generative AI with LangChain: Build large language model (LLM) apps with Python, ChatGPT and other LLMs**, Packt Publishing, 2023.

2. Jacob Eisenstein, **Introduction to Natural Language Processing**, MIT Press, 2019.

**References:**

1. Ian Goodfellow, Yoshua Bengio, Aaron Courville, **Deep Learning**, MIT Press, 2016.

2. A collection of the latest research papers, technical blogs, and articles from top journals and conferences to stay updated with the advancements and debates in the domain ofLLMs.

3. Title: Large Language Models in Practice- This is a placeholder for a current and comprehensive resource focused on the practical and theoretical aspects ofLLMs. Due to the rapidly evolving nature of this field, the latest resource available at the time of course launch should be selected.

4. Generative AI for beginners by Microsoft http://learn.microsoft.com/en-gb/collections/zpy7c8zmc
id=academic-105485-koreyst

## 4.104 CS 693: Compressed Sensing and its applications

**Course Code: CS 693**

**Course Name: Compressed Sensing and its applications**

L-T-P-C: 3-0-0-3
Prerequisites: Signal Processing
Students intended for: Masters/PhD
Elective or Core: Elective Semester: Odd/Even: Even
Approval: 2nd Senate

**Course Outline**

Sparse and Redundant Representations Theoretical and Numerical Foundations , Uniqueness and Uncertainty, Pursuit Algorithms Practice , From Exact to Approximate Solutions, Iterative-Shrinkage Algorithms, The Dantzig-Selector Algorithm, Sparsity-Seeking Methods in Signal Processing, The Quest for a Dictionary, MAP versus MMSE Estimation, Case study: Image Deblurring, Image Denoising and face recognition.

**Text & Reference Books:**

1. Michael Elad, **Sparse and Redundant Representations : From Theory to Applications in Signal and Image Processing**, Springer, 2010.

2. Research articles from IEEE

# 5 Chemistry Courses

## 5.1 CY 001 Preparatory Chemistry - 1

**Course Code:** CY 001
**Course Name:** Preparatory Chemistry - 1
L-T-P-C: 3-1-0-4
**Students Intended for:** Preparatory Students
**Core or Elective:** Core
Approval: 52nd BoA

**Course Contents:**

**Physical Chemistry:**

- **Kinetic Theory:** Idea of distribution function, properties of gamma functions; transformation properties for Cartesian to polar coordinates. Maxwell's speed and energy Distributions (derivations for 1, 2 and 3 dimensions); distribution curves; different types of speeds and their significance, frequency of collisions against a surface; frequency of collisions against a surface; frequency of binary collisions; mean free path

- **Thermodynamics**: System and Surroundings, walls; reversible and irreversible processes; isothermal, adiabatic and other processes; work, partial and total derivatives; exact differntials and state functions, definitions of thermodynamic functions: Zeroth Law (T), First law (U) and second law (S); other functions like H, A, and G. Carnot's cycle and theorems; changes of thermodynamic functions in irreversibility and entropy, importance of H in thermo-chemistry, Maxwell's relations.

- **Chemical Kinetics:** Order and molecularity of reactions, first and second order reactions, average life period, concept of Arrhenius activation energy

**Inorganic Chemistry:**

- **Inorganic Chemistry:** Periodicity, general trends, blocks of periodic table, s-block, p-block, and introduction to f-block, VSEPR, valence band theory, electron deficient bonding, thermodynamics of reduction processes.

**Organic Chemistry:**

- **Organic Chemistry:** Classification and nomenclature of organic compounds, hybridization, dipole moment and bond energy, factors influencing electron availability: inductive effect, electromeric effect, resonance, mesomeric effect or conjugative effect, hyperconjugative effect, steric effect, H-bonding foirce etc, concept of organic acid and base, substitution and elimination reactions.

**Text Books:**

1. J. D. Lee, **Concise Inorganic Chemistry**, 5th Edition, ELBS, 1996.

2. R. T. Morrison and R.N. Boyd, **Organic Chemistry**, 5th Edition, Printice Hall of India Pvt. Ltd. 1990.
3. G. Solomons and C. Fryhle, **Organic Chemistry**, John Wiley and Sons (Asia) Pte Ltd.
4. D. A. McQuarrie, and J. D. Simons, **Physical Chemistry,** Viva Books, 1998.
5. Irving M. Klotz and Robert M. Rosenberg, **Chemical Thermodynamics: Basic Concepts and Methods,** Wiley, 2008.

## 5.2 CY 002 Preparatory Chemistry - 2

**Course Code:** CY 002
**Course Name:** Preparatory Chemistry - 2
L-T-P-C: 3-1-0-4
**Students Intended for:** Preparatory Students
**Core or Elective:** Core
Approval: 52nd BoA

**Course Contents:**

**Physical Chemistry:**

- **Quantum Mechanics:** Construction of Hamiltonian operator; solution of HΨ=EΨ for particle in a 1-d box; normalization and orthogonolity of Ψ, nodes in excited states, and calculation of average values like ¡x¿, ¡x2¿, ¡p¿ and ¡p2¿, demonstration of the uncertainty product inequality, $\Delta x \Delta p \geq h/4\Pi$, discussion on uncertainty principle.
- **The H atom problem:** Hamiltonian in Cartesian and Polar Coordinates; separation of radial and angular parts; emergence of magnetic quantum number; mathematical forms of orbital functions (ns and np) and degeneracy, shapes of orbitals (s,p).
- **Spectroscopy and Photochemistry:** Einstein's Law, primary photophysical processes; potential energy diagram; Frank-Condon Principle; fluorescence and phosphorescence; photochemical reactions, quantum yield; photosensitisation; photochemical equilibrium; dimerization of anthracene.
- **Alkali-Metal Spectra (S, P, D, F series):** its origin, multiplicity of spectral lines, idea of spin quantum number; physical idea of spin-orbit coupling, rotational (rigid rotator model) and vibrational (harmonic oscillator model) spectra of diatomics; frequency expressions, applications to estimate molecular parameters, idea of $n \rightarrow \Pi*$ and $\Pi \rightarrow \Pi*$ electronic spectra; conjugated polyenes and 1-d box model.
- **Dipole moment and Intermolecular Forces:** Induced and orientation polarisation; Debye and Clausius Mossotti equations (with derivations), dipole-dipole, dipole-induced dipole and van der Walls ibnteractions in molecules, realistic intermolecular potential energy diagrams.

**Inorganic Chemistry:**

- **Inorganic Chemistry:** Chemistry of d-block elements, crystal field theory, magnetism in transition metal compounds, valence bond theory for prediction of molecular geometry, magnetic properties, metal-carbonyl chemistry, important elements of catalysis by transition mnetal compounds, chemistry of f-block elements.

**Organic Chemistry:**

- **Organic Chemistry:** Functional group inter-conversions, concept of stereochemistry concept of aromaticity, aromatic electrophilic and nucleophilic substitution reactions.

**Text Books:**


1. J. D. Lee, Concise **Inorganic Chemistry**, 5th Edition, ELBS, 1996.
2. R. T. Morrison and R.N. Boyd, **Organic Chemistry**, 5th Edition, Printice Hall of India Pvt. Ltd. 1990.
3. G. Solomons and C. Fryhle, **Organic Chemistry**, John Wiley and Sons (Asia) Pte Ltd.
4. P. W. Atkins, **Molecular Quantum Mechanics**, Oxford University Press, 1999.


## 5.3 CY 101: Chemistry

**Course Code: CY 101**

**Course Name: Chemistry**

L-T-P-C: 3-1-2-5
Category: Core
Prerequisites: Nil

Approval: 5th Senate

**Course contents**

- **Quantum Mechanics**

  Postulates, Schrödinger wave equation, Interpretation of wave function, particle in a box, implication of the concepts, H atom, radial and angular wave functions, and shapes of orbital.

- **Thermodynamics**

  Statistical concept of entropy, free energy, and chemical equilibria, chemical potential.

- **Kinetics and Catalysis**

  Theories of chemical reactions, homogeneous and heterogeneous catalysis.

- **Electrochemcial Cells**

  Electrochemical corrosion and fuel cells.

- **Stereoisomerism**

  Overview of concepts, configuration, Fischer and Newman projections. Optical isomerism of simple cyclic systems and of compounds without asymmetric carbon atom (allenes, spirocompounds, etc.); chirality involving atoms other than carbon.

- **Reaction Mechanism and Stereochemistry in Organic Synthesis**

  Synthesis:(a)Addition of KMnO4, OsO4, and peracidoncis-, and trans alkenes(b)Diels-Alder reaction: (4+2) cyclo addition MO treatment(c)Aromatic Nucleophilic substitution mechanism (SNAr, SN1, Arynes) reactivity and reactions;

- **Novel Polymers** Stereo chemical control of synthesis, Ziegler- Natta catalyst, Polyurethanes, conducting polymers

- **Spectroscopic Techniques**

  Introductory ideas of molecular spectroscopy and applications of UV visible and IR to simple compounds/coordination complexes.

- **Coordination Compounds**

  Crystal field theory of octahedral and tetrahedral complexes, colour and magnetic properties, Jahn-Teller distortion with specific reference to d9 case.

- **Organometallics**

  (i)Metal carbonyls: synthesis, structure and bonding(ii)Metal alkene complexes: bonding in metal alkene complexes, role of metal alkene complexes in hydrogenation and hydroformylation.

- **Metal ions in Biological Systems**

  Role of trace metals in biological systems with special reference to transition metals(Cu,Fe,Zn), toxic effects of Cd and Hg.

**Experiments:**

1. Determination of iron in iron ore using potassium dichromate (Internal indicator method);
2. Determination of sodium carbonate in baking/washing soda;
3. Determination of hardness of water by EDTA- complexometry titrations;
4. Heat of neutralization of a strong base by a strong acid;
5. Equivalent weight of an acid;
6. Viscosity of mixtures of liquids;
7. Surfaceexcessof1-butanolinaqueous solution;
8. Order of reaction;

9. Percentage of ammonia in an ammonium salt;
10. Identification of functional groups in organic compounds;
11. Blue Printing
12. pH metry / potentiometry titrations; a)Strong acid – strong base; b) Strong acid – weak base; c) Weak acid – strong base; d) Redox titration: Fe2+ or Mn2+;
13. Spectro photometry: Determination of Fe(III) by colorimetry;
14. Determination of water of crystallization by microwave irradiation;
15. Preparation of acetanilide or aspirin and determination of melting point, and matching with known sample;
16. Determination of chloride of As or Cr in Water.

**References:**


1. LeeJ.D., **Concise Inorganic Chemistry**, 5th Edition, Chapman &Hall.
2. Malik T. and Madan, **Selected Topics in InorganicChemistry**, 5th Edition, S.Chand & Company.
3. PeterS., **A guide book to Mechanism in Organic Chemistry**, 6th Edition, Orient Longman.
4. Morrison R.T.and Boyd R.N., **Organic Chemistry**, 6th Edition, Printice Hall of India.
5. Mahan B.H., **University Chemistry**, 3rd Edition, Narosa Publishing House.
6. Atkins P.W., **Physical Chemistry**, 5th Edition, ELBS, Oxford University Press.


## 5.4 CY 201P : Physical Chemistry Laboratory

**Course Code : CY 201P**

**Course Name : Physical Chemistry Laboratory**

L-T-P-C : 0-0-4-2
Intended for : BS Chemical Sciences
Prerequisite : None
Mutual Exclusion: None
Approval: 42nd Senate

**Course Contents**

- Module I: **Data Analysis and Programming**

  1. Determination of distribution, mean, variance, standard deviation, confidence interval from sample data obtained for the space variables of diffusive particles at a finite-time.
  2. Determination of correlations, auto-correlations and spectral density of sample data obtained for the space and momentum variables of diffusive particle at a given time.
  3. Linear and non-linear curve fitting (regression analysis) of given spectroscopic data (Abs. coefficient. vs. T/Fl. Decay) and determination of physical properties from fitting.
  4. Writing a Fortran/C++ program for matrix multiplication, diagonalization, and calculation of roots of a Secular determinant.

- Module II: **Physical Properties**

  1. Determining a given solution's viscosity coefficient with Ostwald's viscometer considering aqueous solutions of glycerol, ethanol, etc.
  2. Determination of surface tension of a given solution by drop weight method using a stalagmometer, considering aqueous solutions of NaCl, acetic acid, ethanol, etc., as systems.

- Module III: **Chemical Kinetics**

  1. Study of kinetics of saponification of ester by using the conductometric method.
  2. Study of the kinetics of the reaction I– + S2O82– by colorimetric method.
  3. Acid hydrolysis of methyl acetate at different temperatures at a given concentration of [H+] ions.

- Module IV: **Spectroscopy**

  1. Verification of Beer-Lambert law using colorimetry.
  2. Absorption spectrum of a conjugated dye, polymethine, interpretation of the spectra using the "free-electron" model.
  3. Determination of quantum yield.

- Module V: **Electrochemistry**

  1. Determination of emf of an electrochemical cell and measurement of thermodynamic parameters from the temperature dependence of emf.
  2. Determination of E0 of Fe3+/Fe2+ couple in the hydrogen scale by potentiometric titration of ferrous ammonium sulfate solution using KMnO4, or K2Cr2O7 as standard.

**Textbooks:**

1. D. P. Shoemaker, C. W. Garland, and J. W. Nibler, **Experimental Physical Chemistry**, 8th Edition, McGraw Hill, 2009.
2. G. Peter Matthews, **Experimental Physical Chemistry**, Oxford University Press, 1986.

**References:**

1. Frederick A. Bettelheim, **Experimental physical chemistry**, Saunders, 1971.
2. A. Ghosal, B. Mahapartra, A. K. Nad, **An Advanced Course in Practical Chemistry**, New Central Book Agency Pvt Ltd, 2000.

## 5.5 CY 202P : Physical Chemistry Laboratory

**Course Code : CY 202P**

**Course Name : Physical Chemistry Laboratory**

L-T-P-C : 0-0-4-2
Intended for : BS Chemical Sciences
Prerequisite : None
Mutual Exclusion: None
Approval: 42nd Senate

**Course Contents**

- Module I: **Basic Lab Techniques**
  1. To determine type and detection of extra elements (N, S, Cl, Br, I) in organic compounds
  2. Thin layer chromatography (TLC) and calculation of Rf values
  3. Separation of 2 organic compounds by paper chromatography
  4. Purification of organic compounds by crystallization.
- Module II: **Organic Qualitative Analysis**
  1. Separation of two components from the binary mixture of organic compounds (Solid-Solid, Solid-Liquid).
- Module III: **Organic Preparations** (any 6)
  1. Preparation of paracetamol
  2. Preparation of aspirin
  3. Preparation of phthalimide form phthalic anhydride
  4. Preparation of 2:4-DNP derivative of aldehyde or ketone
  5. Preparation 4-chloro benzyl alcohol from 4-chloro benzaldehyde
  6. Base catalyzed Aldol condensation

7. Preparation 4-iodonitrobenzene from 4-nitroaniline by Sandmeyer Reaction
8. Preparation of Glucosazone derivative of Glucose
9. Preparation of quinone from hydroquinone
10. Preparation of Oxime derivative of Ketones.

**Textbooks:**

1. **Vogel's book of Practical Organic Chemistry**, 5th Edition, Longman Scientific & Technical, 2006.
2. Pavia, Lampman, Kriz & Engel, **Organic Chemistry A Lab Manual**, Cengage Learning, 2009.

**References:**

1. Frederick A. Bettelheim, **Experimental physical chemistry**, Saunders, 1971.
2. A. Ghosal, B. Mahapartra, A. K. Nad, **An Advanced Course in Practical Chemistry**, New Central Book Agency Pvt Ltd, 2000.

## 5.6 CY 203P : Physical Chemistry Laboratory

**Course Code : CY 203P**

**Course Name : Physical Chemistry Laboratory**

L-T-P-C : 0-0-4-2
Intended for : BS Chemical Sciences
Prerequisite : None
Mutual Exclusion: None
Approval: 42nd Senate

**Course Contents**

1. General introduction to inorganic laboratory
2. Basic concepts of quantitative analysis
3. Errors in chemical analysis data
4. Qualitative analysis: Inorganic semi micro qualitative analysis with four radicals
5. Quantitative analysis:
   (a) Volumetric Analysis:
      i. Acid-base titrations relevant to the neutralizing power of antacids
      ii. Complexometric and spectroscopic estimation of metal ions b) Gravimetric Analysis: • Estimation of barium/sulphate as barium sulphate
      iii. Estimation of iron as ferric oxide etc.
6. Synthesis:

(a) Preparation of potash alum from scrap aluminum
(b) Preparation of hexamine Ni(II) chloride
(c) Preparation of tetramine Cu(II) sulphate

**Textbooks:**

1. A.J. Elias, **A Collection of Interesting General Chemistry Experiments**, Revised edition, Universities Press Pvt. Ltd., 2007.

**References:**

1. **Vogel's Textbook of Quantitative Chemical Analysis**, 5th Edition, Orient Longman, 1989.
2. **Vogel's Textbook of Macro and Semimicro Qualitative Inorganic Analysis**, 5th Edition, Orient Longman, 1982.
3. Robert J. Angelici, **Synthesis and Technique in Inorganic Chemistry**, 2nd Edition, University Science Books, 1991.
4. Lab Manual and Instrument Manuals

## 5.7 CY 241: Nano-scale Science and Technology

**Course Code: CY 241**

**Course Name: Nano-scale Science and Technology**

L-T-P-C: 3-0-0-3
Students intended for: B. Tech. 2nd Year onward
Elective or Core: Elective
Approval: 1st Senate

**Course contents**

- **Properties**

  Properties of materials with nanoscale dimensions. [4 Lectures]

- **Nanostructures**

  Zero, one, two and three–dimensional nanomaterials. [2 Lectures]

- **General methods of synthesis**

  General methods of synthesis of nanomaterials and nanostructures [5 Lectures].

- **Characterisation techniques**

  Optical spectroscopy and microscopy, scanning probe microscopy, scanning electron microscopy, transmission electron microscopy and X-ray diffraction. [8 Lectures]

- **Inorganic nanomaterials**

  Metallic nanocrystals with special emphasis on coinage metals, semiconductor nanocrystals, quantum dots, magnetic materials. [6 Lectures]

- **Carbon nanostructures**

  Carbon nantubes, graphene and fullerenes. [4 Lectures]

- **Organic and biological nanostructures** [4 Lectures]

- **Applications**

  Catalysts, sensors, actuators, display systems, molecular devices and nanobiotechology. [7 Lectures]

- Quizzes [2 hours]

**Text Books**

1. C. P. Poole (Jr.) and F. J. Owens, **Introduction to Nanotechnology**, Wiley Interscience, John Wiley and Sons, Hoboken, New Jersey.
2. G. A. Ozin and A. C. Arsenault, **Nanochemistry: A Chemical Approach to Nanomaterials**, RSC Publishing, Royal Society of Chemistry, U.K.
3. M.D. Ventra, S. Evoy, J.R. Heflin Jr. (Eds.), **Introduction to Nanoscale Science and Technology**, Kluwer Academic Publishers, Boston.
4. G. Cao, **Nanostructures & Nanomaterials: Synthesis, Properties & Applications**, Imperial College Press, 2004.

**Reference Books:**

1. L. M. Liz-Marsan and P. V. Kamat, **Nanoscale Materials**, Kluwer Academic Publishers, Boston, USA.
2. D. A. Bonnel, **Scanning Probe Microscopy and Spectroscopy: Theory, Techniques and Applications**, 2nd Edition. New York, Wiley-VCH.
3. S. Amelinckx , **Electron Microscopy: Principles and Fundamentals**, Weinheim, VCH.

## 5.8 CY 242: Introduction to Molecular Spectroscopy

**Course Code: CY 242**

**Course Name: Introduction to Molecular Spectroscopy**

L-T-P-C: 3-0-0-3
Prerequisite: Chemistry or Physics common course
Students intended for: B. Tech. 3rd Year
Elective or Core: Elective
Approval: 2nd Senate

**Course contents**

- **Quantum Mechanics**

  Wave-particle duality, Schrdinger wave equation, Operators, Probability density, Matrix elements of operators and expectation values, One-dimensional problems in quantum mechanics - particle in a box, potential well, potential barrier and tunnelling. [12 Lectures]

- **Structure and bonding**

  Hydrogen atom, Helium atom, Hydrogen molecule, Structure and Bonding, Nature of the chemical bond, Donor-Acceptor complexes, Charge transfer, Energy transfer, Conductance through DNA, Molecular electronic circuits, Single molecule transistors, Single molecule logic gates. [16 Lectures]

- **Spectroscopic Techniques**

  Born-Oppenheimer Approximation, Molecular spectroscopy, Selection Rules, Vibrational and Rotational motion, Electronic Absorption and Emission Spectroscopy, Raman Spectroscopy. [14 Lectures].

**Text and Reference Books**


1. Jeanne L. McHale, **Molecular Spectroscopy**, Prentice Hall, 1998.
2. R. L. Liboff, **Introductory Quantum Mechanics**, Addison-Wesley, 2002.
3. Attila Szabo, **Modern Quantum Chemistry**, Dover, 2000.


## 5.9 CY 243: Engineering Chemistry

**Course Code: CY 243**

**Course Name: Engineering Chemistry**

L-T-P-C: 3-0-0-3
Prerequisite: Consent of the faculty member
Students intended for: B. Tech.
Elective or Core: Elective
Approval: 1st Senate

**Course contents**

Fats, oils, soaps and detergents, explosives and propellants, lubricants, synthetic dyes, cements, insulators, paints, composite materials, natural and synthetic rubbers, liquid crystals, ionic liquid, polymers, petroleum and petrochemicals, plastics, corrosion and its control, water treatment, fuel and combustion, environmental chemistry, adhesives, ceramics, organic electronics.

**TextBooks**

1. P.C. Jain & Monika Jain, **Engineering Chemistry**
2. Shashi Chawla, **A Text Book of Engineering** Chemistry
3. P.Y. Bruice, **Organic Chemistry**

**Reference Books:**

1. J.C. Kuriacose & J.Rajaram, **Chemistry in Engineering and Technology**
2. O.G. Palanna, **Engineering Chemistry**

## 5.10 CY 247: Introduction to Molecular Thermodynamics

**Course Code: CY 247**

**Course Name: Introduction to Molecular Thermodynamics**

L-T-P-C: 3-0-0-3
Prerequisite: Consent of the faculty member
Students intended for: B. Tech. 2nd year
Approval: 2nd Senate

**Course contents**

- **Probability, Distributions, and Equilibrium**

  Distributions, Relative Probability and Fluctuations, Equilibrium, Most Probable Distribution, Le Chateliers Principle, Equilibrium Amounts and Equilibrium Constants. [6 Lectures]

- **Energy Levels in Real Chemical Systems**

  Real Chemical Reactions, The Quantized Nature of Energy, Distributions of Energy Quanta in Small Systems, Probability of a Particular Distribution of Energy, Most Probable Distribution, Energy Level Separation, Fraction of reactive Particles. [6 Lectures]

- **First Law of thermodynamics, - bonding and internal energy**

  Internal Energy, Chemical Bond, Mean Bond Dissociation Energies and Internal Energy, Using Bond Dissociation Energies to Understand Chemical Reactions, The High-Energy Phosphate Bond and Other Anomalies, Beyond Covalent bond, Modern View of Bonding. [8 Lectures]

- **Entropy and the second law**

  Energy Does Not Rule, Entropy Comparisons Are Informative, Standard Change in Entropy for a Chemical. [4 Lectures]

- **Enthalpy and the surroundings**

  Enthalpy vs. Internal Energy, High Temperature Breaks Bonds. [2 Lectures]

- **Gibbs Energy and Equilibrium Constant** The Second Law - Again, Concept of equilibrium, The Low Enthalpy/High Entropy Rule, Quantitative Look at Melting Points,Vapor Pressure, Barometric Pressure, and Boiling, Isomerization Reactions, Experimental Data Can Reveal Energy Level Information, Application to Real Chemical Reactions. [8 Lectures]

- **Applications of Gibbs Energy - Phase Changes** Evaporation, Boiling, Sublimation, Vapor Deposition, Solubility, Impure Liquids. [2 Lectures]

- **Applications of Gibbs Energy – Electrochemistry** Electrical Work Is Limited by the Gibbs Energy, Gibbs Energy and Cell Potential, Actual Cell Voltages and the Nernst Equation. [6 Lectures]

**Text & Reference Books**

1. R. M. Hanson and S. Green, **Introduction to Molecular Thermodynamics**, University Science Books, 2008.

2. D. A. Mcquarrie and J. D. Simon, **Molecular Thermodynamics**, University Science Books, 1999.

3. Richard E. Dickerson, **Molecular Thermodynamics**, W. A. Benjamin, 1969.

4. , James W. Whalen, **Molecular Thermodynamics: A Statistical Approach**, 1991.

## 5.11 CY 248: Molecular Physical Chemistry for Engineers

**Course Code : CY 248**

**Course Name : Molecular Physical Chemistry for Engineers**

L-T-P-C : 3-0-0-3
Prerequisites : None.
Students intended for : B. Tech. 2nd year
Elective or Compulsory : Elective
Approval: 6th Senate

**Course Contents**

- **Brief Review of Elementary Thermodynamics**

  Introduction, Application of Gibbs free energy, Calculation of an Equilibrium Constant that cannot be Measured Conveniently. [4 Lectures]

- **Introduction to Quantum Theory & Applications**

  Introduction, one dimensional problems, Observing Vibrations and Rotations of Molecules by Spectroscopy, Infrared Spectroscopy, Electronic Excitations in Molecules. [10 Lectures]

- **Statistical Mechanics Fundamental Ideas and Applications**

  Introduction, Statistical Occupation of Energy Levels, Boltzmann Distribution Function, Ensembles, Molecular Partition Function, Connecting the Molecular Partition Function to the Internal Energy and Entropy, Boltzmann Law on entropy, Applications of the Partition Function to Chemical Thermodynamics Problems. [12 Lectures]

- **Chemical Reactions**

  Introduction, Collision Theory, Reactive Hard-Sphere Molecules, Transition State Theory of Chemical Reaction Rates, Connection of Transition State Theory to Collision Theory, unimolecular reactions, RRKM theory. [16 Lectures]

**Text Books:**

1. John T. Yates and J. Karl Johnson, **Molecular Physical Chemistry for Engineers**.

**References:**

1. K. A. McLauchlan, **Molecular Physical Chemistry - A Concise Introduction**
2. D. Mcquarrie and J. Simon, **Physical Chemistry: A Molecular Approach**.
3. P. M. S. Monk, **Physical Chemistry: Understanding our Chemical World**.
4. S. Warren, **The Physical Basis of Chemistry**.
5. R. J. Silbey, R. A. Alberty, M. G. Bawendi, **Physical Chemistry**
6. P. Atkins and J. de Paula, **Physical Chemistry**.

## 5.12 CY 301 : Principles and Theories of Physical Chemistry

**Course Code : CY 301**

**Course Name : Principles and Theories of Physical Chemistry**

L-T-P-C : 3-0-0-3
Intended for : BS Chemical Sciences
Prerequisite : None
Mutual Exclusion: None
Approval: 42nd Senate

**Course Contents**

- **Gaseous State and Fluids**: Gas laws, distribution of molecular speeds, kinetic energy distribution, molar heat capacity of gases, virial expressions, collision of gas molecules and mean free path. Viscosity of fluids, viscosity coefficient, temperature dependence of viscosity, surface tension of liquids, capillary rise, measurement of surface tension, temperature dependence of surface tension. (12 Hours)

- **Concepts of Thermodynamics**: Equilibrium and concept of temperature, the zeroth-law of thermodynamics, first law of thermodynamics, state and path functions, extensive and intensive properties, equation of state, work, heat, internal energy, heat capacity and concept of enthalpy, second law of thermodynamics, reversible and irreversible process, heat engines, Carnot cycle, concept of entropy, free energy, criteria for equilibrium and stability, third law of thermodynamics, concept of the absolute zero temperature and Nernst heat theorem. (12 Hours)

- **Chemical Kinetics and Photochemistry**: Rate laws and rate constants, order and molecularity of reactions, determination of order, kinetics of zero-, first- and second-order reactions, parallel, reversible and consecutive reactions, rate-determining and steady-state approximation, temperature dependence of rate constant, potential energy surface, Frank-Condon principle, decay of excited states, fluorescence and phosphorescence, Jablonsky diagram, laws of photochemistry, quantum yield. (12 Hours)

- **Conductance and Electrochemistry**: Mechanism of electrolysis and Faraday's law, strong and weak electrolytes, conductance, electrolytic conductance, ionic conductance, conductometric titration, estimation of solubility product. Types of electrochemical cells, cell reactions, EMF and change thermodynamics properties, Nernst equation, standard cells, half-cells/electrodes. (6 Hours)

**Textbooks:**

1. Peter Atkins, Julio de Paula, James Keeler, **Physical Chemistry**, Oxford University Press, 2018.

2. Donald A. McQuarrie & John D. Simons, **Physical Chemistry: A molecular approach**, Indian Reprint, Viva books, 2019.

**References:**

1. Ira N. Levine, **Physical Chemistry**, McGraw Hill Book Co., 2008.

2. G. W. Castellan, **Physical Chemistry**, Narosa Publications, 2004.

## 5.13 CY 302 : Principles of Organic Chemistry

**Course Code : CY 302**

**Course Name : Principles of Organic Chemistry**

L-T-P-C : 3-0-0-3
Intended for : BS Chemical Sciences
Prerequisite : None
Mutual Exclusion: None
Approval: 42nd Senate

**Course Contents**

- **Bonding & Aromaticity**: Atomic orbitals and their overlaps, bonding of different types – s-bond, p-bond, Bond dissociation energy, Bond order and multiplicity, Hybridization, VSEPR theory, Bent's rule, Dipole moment, Molecular orbital (MO) theory, Electronic effects: inductive & field effects, Mesomeric effects, Hyperconjugation, Resonance. Aromaticity, antiaromaticity, and homoaromaticity; Hückel's rule, aromatic ring currents; examples of nonbenzenoid aromatic and antiaromatic compounds. (10 Hours)

- **Reaction Kinetics and Reactive Intermediates**: Energetics of a chemical reaction, Transition state, Hammond's postulate, Hammett equation, Arrhenius equation, Effect of a catalyst, Kinetic Isotope Effect (primary and secondary), Isotope scrambling, Structure, stability and reactivity of carbocations, carbanions, free radicals, carbenes, and nitrenes. (8 Hours)

- **Acid-Base Theory**: Acidity, basicity, and pKa, Brønsted & Lowry concept, Lewis concept, The definition of pKa, Basicity, Factors that influence the acidity and basicity, HSAB Principle, Keto-enol tautomerism. (4 Hours)

- **Principles of Stereochemistry**: Baeyer's strain theory, Pitzer strain (torsional strain) and conformational analysis (up to cyclohexane), geometrical isomerism (E/Z), optical isomerism, projections, CIP rules (R/S nomenclature of acyclic and cyclic molecules); nomenclature – threo and erythro, syn and anti, endo and exo, and meso and d/l; Introduction to chirality and its origin. (10 Hours)

- **Organic Reactions**: Carbon-carbon bond forming reactions, Olefination reactions, Reduction & oxidation reactions, aromatic substitution reactions (electrophilic, nucleophilic, etc.), chemistry of carbonyl compounds, alkenes and alkynes. (10 Hours)

**Textbooks:**

1. Clayden, J., Greeves, N., Warren, S., Wothers, S., **Organic Chemistry**, Oxford University Press, 2001.

2. Eliel, E. L., Wilen, S. H., Doyle, M. P., **Basic Organic Stereochemistry**, John Wiley and Sons, 2001.

3. Smith, M. B. and March, J., **Advanced Organic Chemistry**, Wiley Interscience, 2007.

4. D. Nasipuri, **Stereochemistry of Organic Compounds-Principle and Applications**, 4 Revised Edition, New Academic Science, 2012.

5. P. Sykes, **A Guidebook to Mechanism in Organic Chemistry**, 7th Edition, Addison- Wesley, 2003.

**References:**

1. H. O. House, **Modern Synthetic Reactions**, W.A. Benjamin Inc., 1972.

2. A. Jacobs, **Understanding Organic Reaction Mechanism**, Cambridge 1998.

## 5.14 CY 303 : Fundamentals of Inorganic Chemistry

**Course Code : CY 303**

**Course Name : Fundamentals of Inorganic Chemistry**

L-T-P-C : 3-0-0-3
Intended for : BS Chemical Sciences
Prerequisite : None
Mutual Exclusion: None
Approval: 42nd Senate

**Course Contents**

- **Periodic properties**: Atomic Structure, electronic configuration, Chemical periodicity and periodic anomalies, Size of atoms and ions, Effective nuclear charge, Screening effect, Ionization energy, Electronegativity, Electron affinity, Lanthanide contraction, Fajan's rules. (8 Hours)
- **Concepts of acids and bases**: Theories of acids and bases, Bronsted and Lewis acids and bases, Gas phase versus solution acidity, leveling effects of solvents, Concepts of pH, pKa, pKb, Hardness and softness, surface acidity. (8 Hours)
- **Principles of electrochemistry**: Oxidation and reduction, Redox potential and stability, Electrode potentials, Nernst equation, Frost, Latimer and Pourbaix diagrams. (6 Hours)
- **s & p block elements**: Structure and properties of s and p block elements, and their compounds like hydrides, oxides, and halides, biological functions of inorganic elements in organisms. (8 Hours)
- **Transition elements**: Coordination complexes, Isomerism, Theories of metal-ligand bonding and their limitations, Valence bond theory, Spectrochemical series of ligands, Crystal field theory, Splitting of d orbitals in octahedral, tetrahedral and square planar complexes, Low-spin and high-spin complexes, Brief introduction to color and magnetism. (8 Hours)
- **Introduction to nuclear chemistry**: Nuclear reactions, fission and fusion, radio analytical techniques. (4 Hours)

**Textbooks:**

1. Ajai Kumar, **Basic Inorganic Chemistry**, 2nd Edition, Aaryush Education, 2019.
2. J. E. Huheey, E. A. Keiter and R. L. Keiter, **Inorganic Chemistry: Principles of Structure and Reactivity**, 4th edition, Pearson Education Inc., 2000.

**References:**

1. . F. A. Cotton, G. Wilkinson, C. A. Murillo and M. Bochmann, **Advanced Inorganic Chemistry**, 6th edition, Wiley, 2007.

2. B. Douglas, D. McDaniel and J. Alexander, **Concepts and Models of Inorganic Chemistry**, 3rd edition, Wiley, 2006.

3. J. D. Lee, **Concise Inorganic Chemistry**, 5th edition, Wiley, 2010.

4. P. Atkins et al, **Shriver & Atkins' Inorganic Chemistry**, 5th edition, W. H. Freeman and Company, 2010.

## 5.15 CY 304 : Fundamental Analytical Chemistry

**Course Code : CY 304**

**Course Name : Fundamental Analytical Chemistry**

L-T-P-C : 3-0-0-3
Intended for : BS Chemical Sciences
Prerequisite : None
Mutual Exclusion: None
Approval: 42nd Senate

**Course Contents**

- **Basic Tools of Analytical Chemistry**: Measurements in Analytical Chemistry, Units of Measurement, Uncertainty in Measurements, Concentration, Molarity and Formality, Normality, Molality, Weight, Volume, and Weight-to-Volume Percent, Parts Per Million and Parts Per Billion, Converting Between Concentration Units, Stoichiometric Calculations, Types of errors in Chemical Analyses, Accuracy, Precision, Sensitivity, Specificity and Selectivity, Sampling, Standardization and Calibration, Least square fit, Limit of detection and quantification, Statistical Data Treatment and Evaluation, Basic Equipment, Signal and noise in instrumental measurement, Equipment for Measuring Mass and Volume, Equipment for Drying Samples, Spreadsheets and Computational Software . (10 Hours)

- **Classical Methods of Analysis**: Preparing Solutions, Preparing Stock Solutions, Preparing Solutions by Dilution, Gravimetric Methods of Analysis, Titrations in Analytical Chemistry, Principles of Neutralization Titrations, Complex Acid/Base Systems, Applications of Neutralization Titrations, Complexation and Precipitation Reactions and Titrations, Titration Curves, Calculation of the pH of Solutions. (10 Hours)

- **Chemical Equilibria**: Reversible Reactions and Chemical Equilibria, Thermodynamics and Equilibrium Chemistry, Equilibrium Constants for Chemical Reactions, Precipitation Reactions, Acid– Base Reactions, Complexation Reactions, Oxidation–Reduction (Redox) Reactions, Le Châtelier's Principle, Buffer Solutions. (8 Hours)

- **Analytical Electrochemistry**: Potentiometry-General principles, Calomel Electrodes, Ag-AgCl electrodes, Membrane electrodes-ion selective electrodes, glass electrodes, biosensors. Coulometry: Basic principles, constant current and constant potential coulometry. Voltammetry: different waveforms – linear scan, square scan and triangular scan, cyclic voltammetry. (8 Hours)

- **Separation Techniques**: Principles and applications of TLC, General Theory of Column Chromatography, Gas chromatography (GC), High Performance Liquid Chromatography (HPLC), FPLC, Ion chromatography (IC), Supercritical Fluid Chromatography, Capillary Electrophoresis. (6 Hours)

**Textbooks:**

1. D. A. Skoog, D. M. West, F. J. Holler, S. R. Crouch, **Fundamentals of Analytical Chemistry**, 9th Edition, Thomson, 2013.
2. D. Harvey, **Analytical chemistry 2.1**, McGraw-Hill, 2016.
3. G.D. Christian, P.K. Dasgupta and K.A. Schug, **Analytical Chemistry**, 7th edition, Wiley
4. H. H. Willard, L. L. Merritt Jr.,J. A. Dean, f. A. Settle Jr., **Instrumental Methods of Analysis**, CBS Publishers, 1986.
5. J. C. Miller, J. N. Miller, **Statistics for Analytical Chemistry**, 2nd Edition, Wiley, 1998.
6. D. C. Harris, **Quantitative Chemical Analysis**, 7th Edition, W. H. Freeman, 2006.

**References:**

1. NA

## 5.16 CY 342: Understanding Small Systems

**Course Code: CY 342**

**Course Name: Understanding Small Systems**

L-T-P-C: 3-0-0-3
Elective or Core: Elective
Prerequisite: Consent of the faculty member
Students intended for: B. Tech. 3rd Year
Semester: Odd/Even: Even
Approval: 2nd Senate

**Course contents**

- **Big picture and principles of the small world.** [6 Lectures]
- **Why the smaller, the better?** [3 Lectures]
- **Introduction to Nanoscale physics, Nanomaterials.** [12 Lectures]
- **Nanomechanics, Nanoelectronics, Nanophotonics.** [9 Lectures]
- **Nanoscale Fluid Mechanics, Nanoscale Heat transfer.** [6 Lectures]
- **Nanobiology, Molecular motors, future Nanoscience.** [6 Lectures]

**Text & Reference Books:**

1. Masaru Kuno, **Introductory Nanoscience**, Garland Science, 2011.
2. A. N. Clealand, **Foundations of Nanomechanics**, Springer, 2003.
3. Vladimir V. Mitin, Dimitry I. Sementsov & Nizami Z. Vagidov, **Quantum Mechanics for Nanostructures**, Cambridge, 2010.
4. Edward L. Wolf, **Nanophysics and Nanotechnology: An introduction to the modern concepts in Nanoscience**, Wiley-VCH, 2011.

## 5.17 CY 344: Food Chemistry: Processing, Preservation and Storage

**Course Code: CY 344**

**Course Name: Food Chemistry: Processing, Preservation and Storage**

L-T-P-C: 3-0-0-3
Prerequisite: Consent of the faculty member
Students intended for: B. Tech.
Elective or Core: Elective
Approval: 2nd Senate

**Course contents**

- **Water** Water microstructure, Availability in Foods, Water activity, Food Stability, Moisture sorption, State diagrams and freezing, Molecular mobility and the glass transition, Example: Candy manufacturing, Emulsions and foams.
- **Proteins** Amino Acids / Basic Building Blocks, Peptides and Proteins, Protein denaturation, Protein functionality, Emulsification, Nutritional Properties, Protein Modification, Processing and Storage, Browning reactions in foods.
- **Carbohydrates** Monosaccharides, Disaccharides and Oligosaccharides, Polysaccharides, related reactions, dietary carbohydrates and their sources, functional properties of dietry carbohydrates.
- **Lipids** Fatty acids, Glycerides, fat and oil processing, fatty acids in foods, rancidity and reversion of oils, enrobing fats.
- **Enzymes** Specificity, Catalysis and Regulation, Temperature and pH, Water Activity, Electrolytes, endogenous enzymes in food, enzymes as food processing aids.
- **Vitamins and Minerals** Fat and water soluble vitamins, vitamins as food ingredients, major and trace minerals, minerals and canned food.
- **Flavor** Taste, odor, description of food flavors.
- **Texture** Its importance in food industries.
- **Color, additives and contaminants** A brief introduction

- **Food spoilage** Causes and remedies
- **Various techniques for food processing and preservations**
  A brief introduction on food laws.

**Text & Reference Books:**

1. John M. Deman, **Principles of Food Chemistry**.
2. Srinivasan Damodaran, Kirk Parkin, Owen R. Fennema, **Fennistrema'S Food Chemistry**, 4th Edition
3. David E. Newton, **Food Chemistry**
4. Tom P. Coultate, **Foy bod: The Chemistry Of Its Components**
5. Meenakshi Paul, **Experimental Food Chemistry**.
6. Shalini Saxena, **Food Chemistry**.
7. Meenakshi Paul, **Effects Of Food Processing On Bioactive Compounds**
8. B. Sivasankar, **Food processing and preservation**.
9. R. Chaudhary, **Basics Of Food Chemistry**.
10. Frank A. Lee, **Basic Food Chemistry**
11. D. W.S.Wang, **Mechanism and theory in food chemistry**
12. J. Kaur, **Fundamentals of food chemistry**

## 5.18 CY 401 : Introduction to Quantum Chemistry & Molecular Spectroscopy

**Course Code : CY 401**

**Course Name : Introduction to Quantum Chemistry & Molecular Spectroscopy**

L-T-P-C : 3-0-0-3
Intended for : BS Chemical Sciences
Prerequisite : None
Mutual Exclusion: None
Approval: 42nd Senate

**Course Contents**

- **Module I:** Introduction to Schrödinger equation, Bohr's atom, De Broglie's Wave, wave-particle duality, Light-atom/molecule interaction, Introduction to optical spectroscopy, time- independent Schrodinger equation, Particle in a box, Quantum Mechanics of Hydrogen Atom. (20 Hours)
- **Module II:** Heisenberg's Uncertainty Relation, Operators, Commutators, Eigenvalues and Eigenvectors, absorption and emission spectra, Boltzmann Energy distribution, Principle of equipartition of energy Einstein's Semiclassical model, Born Oppenheimer Approximation, Beer-Lambert Law. (14 Hours)
- **Module III:** Diatomic Vibrational Spectra: Harmonic Model, Morse Oscillator Model, Molecular Vibrations in Polyatomic Molecules, Diatomic rotational spectra, rotation of polyatomic molecules, electronic absorption, and emission spectra. (8 Hours)

**Textbooks:**

1. Peter Atkins, Julio de Paula, James Keeler, **Physical Chemistry**, Oxford University Press, 2018.

**References:**

1. Thomas Engel, **Quantum Chemistry & Spectroscopy**, 3rd Edition, Pearson, 2015.
2. Donald A. McQuarrie & John D. Simons, **Physical Chemistry: A molecular approach**, Indian Reprint, Viva books, 2019.

## 5.19 CY 402 : Applied Materials Chemistry

**Course Code : CY 402**

**Course Name : Applied Materials Chemistry**

L-T-P-C : 3-0-0-3
Intended for : BS Chemical Sciences
Prerequisite : None
Mutual Exclusion: None
Approval: 42nd Senate

**Course Contents**

- **Introduction to Materials chemistry**: Concepts of materials chemistry, Different types of materials, Sources and characteristics of traditional materials, Uses of materials, Approaches to producing new materials with new properties, Atomic level growth of solid material (crystalline and amorphous), Types of bonding in solids, Crystal structures. (6 Hours)

- **Polymers and Polymer based Materials**: Introduction to polymers, History and recent developments, Classification and nomenclature of polymers, Thermoplastics, Thermosets, Elastomers, Molecular weight, Polymer synthesis, Techniques of polymerization Conducting polymers. (9 Hours)

- **Nanomaterials**: Fundamentals of nanotechnology, Classification of nanomaterials, Synthesis of nanomaterials, Top down and bottom-up approach, Discovery and synthesis of quantum dots, Particle surface functionalization: electrostatic, steric and electrosteric stabilization, Toxicity. (9 Hours)

- **Biomaterials**: Introduction to biomaterials and its history, Classification, Properties of Biomaterials, biocompatibility and biodegradability, biopolymers, hydrogels, sealants and adhesives, Chemistry of dental materials . (9 Hours)

- **Functional materials, properties, and their applications**: Smart materials, Carbon materials, Energy materials, Optoelectronic materials, Catalysis, Environment, Agriculture, Biomedicine, Emerging materials, Thin films, Chemical vapour deposition (CVD), Atomic Layer deposition (ALD). (9 Hours)

**Textbooks:**


1. Harry R. Allcock, **Introduction to Materials Chemistry**, 2nd Edition, Wiley, 2019.

2. V. R. Gowarikar, N. V. Viswanathan, J. Sreedhar, **Polymer Science**, 3rd Edition, New Age International,. Wiley, 2019.

3. Bikramjit Basu, **Biomaterials Science and Tissue Engineering: Principles and Methods**, Cambridge University Press, 2017.

4. M.D. Ventra, S. Evoy, J.R. Heflin Jr. (Eds.), **Introduction to Nanoscale Science and Technology**, Kluwer Academic Publishers.

5. Charles Stanley Gibson, **The Chemistry of Dental Materials**, Classic Reprint, 2018.


**References:**


1. R. J. Young and P. A. Lovell, **Introduction to Polymers**, CRC Press.

2. C. E. Carraher, **Polymer Chemistry**, CRC Press.

3. L. M. Liz-Marsan and P. V. Kamat, **Nanoscale Materials**, Kluwer Academic Publishers.

4. **Advanced Biomaterials: Fundamentals, Processing and Applications,** John Wiley & Sons, Inc. 2009.

5. Related journal articles

6. Alan J. Heeger, **Semiconducting and Metallic Polymers: The Fourth Generation of Polymeric Materials**, J. Phys. Chem. B, Vol. 105, No. 36, 2001

7. T. A. Skotheim (Editor), **Handbook of Conducting Polymers**, Dekker, 1986, vol. 1–2.

8. Bing Zhou, Scott Han, Robert Raja, and Gabor A. Somorjai, (Editors), **Nanotechnology in catalysis**, vol.3, Springer 2007

9. Charles P. Poole Jr and Frank J. Owens, **Introduction to Nanotechnology**, Wiley India student Edition, 2008

10. K.J. Klabunde and Ryan M. Richard, **Nanoscale Materials in chemistry**.

11. Guozhong Cao, **Nanostructured Materials**, Imperial College Press, 2004

## 5.20 CY 403 : Numerical methods and Data Analysis in Chemistry

**Course Code : CY 403**

**Course Name : Numerical methods and Data Analysis in Chemistry**

L-T-P-C : 3-0-0-3
Intended for : BS Chemical Sciences
Prerequisite : Computing and Data Science IC 152
Mutual Exclusion: None
Approval: 42nd Senate

**Course Contents**

- **Theories of Numerical Methods**: (12 Hours)
  - Methods of solution of sets of linear equations: Gauss elimination, Gauss-Jordan elimination, Gauss-Seidel method, QR decomposition method
  - Solution of nonlinear algebraic equations: Bisection method, Newton-Raphson method, Secant method
  - Interpolation and extrapolation: Polynomial interpolation and extrapolation, Rational function interpolation and extrapolation, Cubic spline interpolation
  - Numerical differentiation: Finite-difference method, Higher-order methods
  - Numerical integration: Newton-Cotes quadrature – Rectangle rule, Trapezoidal rule, Simpson's 1/3rd and 3/8th rule, Romberg's method; Gaussian quadrature
  - Solution of differential equations: Euler method, Predictor-corrector method - Improved and Modified Euler method, Runge-Kutta method; Finite-difference method
  - Fourier analysis: Fourier transform of discretely sampled data, Fast Fourier transform
- **Significance and application of the numerical methods in Chemistry**: Application of the solution of the sets of linear equations in Quantum Mechanics, Application of the solution of the nonlinear algebraic equations to get the optimum

of the energy landscapes and minimum of the error function, Application of interpolation and extrapolation techniques in Chemistry; to predict data related to chemical experiments at a given condition, Application of the numerical differentiation techniques to solve diffusion equation, Brief introduction to the Molecular Dynamics; Störmer-Verlet, Verlet, Velocity – Verlet methods, Importance of Fourier analysis in spectroscopy. (8 Hours)

- **Data Analysis**: Determining the distribution of a set of data, Moments of a distribution – its mean, variance, skewness etc., Correlation of data – linear correlation, auto-correlation, least square fit method, Importance of data analysis in Chemistry. (4 Hours)

- **Introduction to the Langevin Dynamics Simulations and Monte Carlo Techniques**: Idea of the random numbers, Langevin Dynamics Simulations, Monte Carlo algorithm, Metropolis algorithm, Gillespie algorithm; their significance in Chemistry. (6 Hours)

  - Introduction to time-series analysis and machine learning and their connection to chemistry (12 Hours)Time-series analysis: Trend, stationarity, seasonality and correlations; Moving average (MA), Autoregressive (AR), Autoregressive moving average (ARMA), Autoregressive integrated moving average (ARIMA) models; Forecasting with ARIMA model; Spectral density function and Spectral analysis.
  - Machine learning: Supervised learning and linear regression, Logistic regression, Decision tree and Random forest, Unsupervised learning, Time-series modelling, Deep learning
  - Significance in Chemistry: Illustration of the applicability of time-series analysis and machine learning in important problems related to chemistry; such as calculating bond orders and determining normal modes, forecasting reaction pathways, proposing the designing techniques of new molecules and materials etc.

**Textbooks:**

1. H. W. Press, S. A. Teukolsky, W. T. Vettering, and B. P. Flannery, **Numerical Recipes - The Art of Scientific Computing**, Cambridge Univ. Press, 1992.

2. F. Jensen, **Introduction to Computational Chemistry**, Second Edition, Wiley, 2006.

3. T. Hastie, R. Tibshirani and J. Friedman, **The Elements of Statistical Learning**, Springer, 2009.

4. R. H. Shumway and D. S. Stoffer, **Time series analysis and its application**, Springer, 2011.

**References:**

1. H. W. Press, S. A. Teukolsky, W. T. Vettering, and B. P. Flannery, **Numerical Recipes in Fortran**, Cambridge Univ. Press, 1992.

2. W.H. Press, B.P. Flannery, S.A. Teukolsky, and W.T. Vetterling, **Numerical Recipes in C**, Cambridge Univ. Press, 1990.

3. J. M. Zelle, **Python Programming: An Introduction to Computer Science**, Beedle & Associates, Inc., 2004.

4. Carleo et al., **Machine learning and the physical sciences**, Reviews of Modern Physics, 91, 045002, 2019.

## 5.21 CY 404 : Fundamentals of Soft Matter Science and Applications

**Course Code : CY 404**

**Course Name : Fundamentals of Soft Matter Science and Applications**

L-T-P-C : 3-0-0-3
Intended for : BS
Prerequisite :
Mutual Exclusion:
Approval: 54th BoA

**Course Contents**

- **Introduction to Soft Matter**: Definition and examples of soft matter, Self-assembly, and structures in soft matter, Intermolecular forces, and properties. (7 hours)

- **Liquid Crystals: Chemical and Physical Aspects**: Introduction and historical development of liquid crystals, Physical and structural properties, Anisotropy, Order parameter, Birefringence, Defect textures (demonstration of textures using polarizing microscopy), Alignment in liquid crystals, Classification of liquid crystals, Chirality in liquid crystals, Photoswitchable liquid crystals, Brief introduction to liquid crystal gels, colloids, nanoparticles, polymers and elastomers, Liquid crystals in biology. (15 hours)

- **Surfactants and Amphiphiles**: Micelles (cationic, anionic, and neutral, CMC determination and applications), Vesicles, Bilayers, Cylinders, Micro-emulsions, Ionic liquids, Lyotropic liquid crystals, Membranes, Self-assembly and their phase behavior. (7 hours)

- **Instrumentation and Characterization Techniques**: Polarized optical microscopy, X-ray scattering (XS): Small-angle (SAXS), Wide-angle (WAXS), Grazing incidence (GI-SAXS/WAXS), Differential Scanning Calorimetry (DSC), Rheology, Dynamic light scattering (DLS), Langmuir-Blodgett technique, Microfluidics. (6 hours)

- **Applications in Technology and Beyond**: Liquid crystals in displays, photonics, drug delivery, biological and chemical sensors, discotic LCs in organic optoelectronics. (7 hours)

**Textbooks:**

1. L. S. Hirst, **Fundamentals of soft matter science**, CRC press (2019).
2. J. W. Goodby, P. J. Collings, T. Kato, C. Tschierske, H. Gleeson, P. Raynes and V. Vill, **Handbook of liquid crystals**, (Vol. 1), John Wiley & Sons (2014).
3. P. J. Collings and J. W. Goodby, **Introduction to liquid crystals: chemistry and physics**, CRC Press (2019).
4. B. Bahadur, **Liquid crystal-applications and uses** (Volume 1), World scientific (1990).
5. R. Borsali and R. Pecora, **Soft-matter characterization**, Springer Science & Business Media (2008).

**References:**

1. I. W. Hamley, **Introduction to soft matter: synthetic and biological self-assembling materials**, John Wiley & Sons (2007).
2. S. Kumar, **Chemistry of discotic liquid crystals: from monomers to polymers**, CRC press (2014).
3. A. A. Collyer, **Liquid crystal polymers: from structures to applications** (Vol. 1), Springer Science & Business Media (2012).
4. H. K. Bisoyi, and Q. Li, **Liquid crystals: versatile self-organized smart soft materials**, Chemical reviews, 2021, 122, 4887-4926.
5. S. W. Ula, N. A. Traugutt, R. H. Volpe, R. R. Patel, K. Yu, and C. M. Yakacki, **Liquid crystal elastomers: an introduction and review of emerging technologies**, Liquid Crystals Reviews, 2018, 6, 78-107.
6. A. M. Lowe, N. L. Abbott, **Liquid crystalline materials for biological applications**, Chemistry of Materials, 2012, 24, 746-58.
7. B. R. Kaafarani, **Discotic liquid crystals for opto-electronic applications**, Chemistry of Materials, 2011, 23, 378–396.
8. S. Setia, S. Sidiq, J. De, I. Pani and S. K. Pal, **Applications of liquid crystals in biosensing and organic light-emitting devices: future aspects**, Liquid Crystals, 2016, 43, 2009-2050.

## 5.22 CY 501:Organic Reactions & Mechanism

**Course Code: CY 501**

**Course Name: Organic Reactions & Mechanism**

L-T-P-C: 3-1-0-4
Prerequisites: B.Sc. (with Chemistry) or Teachers consent
Intended for: UG/PG
Distribution: Core Semester: Odd/Even
Approval: 8th Senate

**Course Contents**

- **Nucleophilic Substitution Reaction**

  Aliphatic Nucleophilic Substitution Reaction: The SN2, SN1, borderline of SN1 and SN2 mechanisms involving ion pairs and single electron transfer (SET) mechanisms. Relationship between stereochemistry and reaction mechanism. Neighbouring Group Participation, anchimeric assistance. Classical and nonclassical carbocations, phenonium ions, norbornyl system, common carbocation rearrangements. The SNi mechanism. Nucleophilic substitution at an allylic, aliphatic trigonal and a vinyl carbon. Reactivity effects of substrate structure, attaching nucleophile, leaving group and reaction medium. [14 Lectures]

- **Aromatic Nucleophile Substitution**

  The SNAr, SN1, benzyne and SRN1 mechanisms. Reactivity; effect of substrate structure, leaving group and attacking nucleophile.

- **Electrophilic Substitution Reaction**

  Aliphatic electrophilic substitution reaction: SE1, SE2 and SEi. The SE1 mechanism, electrophilic substitution accompanied by double bond shifts. Effect of substrates, leaving group and the solvent polarity on the reactivity.

- **Aromatic electrophilic substitution reaction**

  The arenium ion mechanism, orientation and reactivity, energy profile diagrams. The ortho/para ratio, ipso attack, orientation in other ring systems. Quantitative treatment of reactivity in substrates and electrophiles. [10 Lectures]

- **Elimination Reactions**

  The E2, E1 and E1cB mechanisms and their spectrum. Regiochemistry of eleimination reactions and stereochemistry of E2 elimination reactions. Reactivity; effects of substrate structures, attaching base, the leaving group and the medium. Concerted pyrolytic eliminations. [5 Lectures]

- **Free Radical Reactions**

  Types of free radical reactions, free radical substitution mechanism, mechanism at an aromatic substrate, neighbouring group assistance. Reactivity for aliphatic and aromatic substrates at a bridgehead. Reactivity in the attaching radicals. The effect of solvents on reactivity. Addition to Carbon-Carbon Multiple Bonds: Free radical mediated cyclization reactions Baldwin rules. [6 Lectures]

- **Mechanistic and stereochemical aspects of other reactions**

  Addition reactions involving electrophiles, nucleophiles and free radicals, regio- and chemo- selectivity, orientation and reactivity. Addition to cyclopropane ring. Hydroboration. Addition to Carbon-Hetero Multiple Bonds: Mechanism of metal hydride reduction of saturated and unsaturated carbonyl compounds, acids, esters and nitriles. Addition of Grignard reagents, organozinc and organolithium reagents to carbonyl and unsaturated carbonyl compounds. [7 Lectures]

**Text Books:**

1. F. A. Carey and R. A. Sundberg, **Advanced Organic Chemistry, Part A: Structure and Mechanisms**, 5th edition, Springer, New York, 2007
2. Reinhard Bruckner, **Advanced Organic Chemsitry Reaction mechanism**, Academic Press, 2002.
3. Jonathan Clayden, Nick Geeves, Stuart Warren, **Organic Chemistry**, Oxford University Press, 2001
4. J. March, **Advanced Organic Chemistry**, John Wiley & Sons, 1992
5. S. H. Pine, **Organic Chemistry**, McGraw Hill, 1987.

**References:**

1. H. O. House, **Modern Synthetic Reactions**, W.A. Benjamin, 1972.
2. A. Jacobs, **Understanding Organic Reaction Mechanism**, Cambridge 1998.
3. J. M. Hornback, **Organic Chemistry**, Books Coley, 1998.
4. P.Y. Bruice, **Organic Chemistry**, Prentice Hall, 1998.
5. P.S. Kalsi, **Organic Reaction and their Mechanism**, New Age, 1996.
6. Goutam Brahmachari, **Organic Chemistry Through Solved problems**, Narosa Publishing House, 2014.

## 5.23 CY 501P: Organic Chemistry Laboratory

**Course Code: CY 501P**

**Course Name: Organic Chemistry Laboratory**

L-T-P-C: 4-0-0-4
Prerequisites: Core course
Intended for: M.Sc in Chemistry
Distribution: Core course
Approval: 9th Senate

**Course Contents**

- Techniques [3 Lectures]
- Learning structure elucidation of organic molecules & determination of following functional groups using IR and NMR spectroscopy-: (a) Amines (b) Imines (c) Esters (d) Amides (e) Carboxylic acid (f) Alcohol (g) Ethers (h) Aldehydes/Ketones [3 Lectures]
- Extraction of Organic compounds & their characterization using IR, NMR and Mass spectroscopy-: (a) Extraction of caffeine from tea leaves. (i) Extraction of piperene from black pepper powder. [6 Lectures]

- Quantitative Estimations-: Estimation of carbonyl group-: (i) Standardization of glucose solution by Fehlings Method. (ii) Determination of percentage purity of given sample of glucose. [3 Lectures]
- Organic Synthesis-: Synthesis of organic molecules & their characterization using IR, NMR and Mass spectroscopy. (a) One step synthesis-: Synthesis of Bezpinacol (b) Multistep Synthesis-: Synthesis of Benzilic Acid; Benzaldehyde Benzoin Benzil Benzilic acid [6 Lectures]
- Synthesis of a fluorogenic molecule and evaluation of its quantum yield. [4 Lectures]

  (a) Introduction to c-c couplings. (b) Significance of c-c couplings in pharmaceutical industry. (c) Performing Sonogashira coupling at laboratory scale. [8 Lectures]
- Synthesis of organic reagent, use of reagent in organic reaction & determination of its optical activity. (a) Synthesis of N-Bromosuccinamide (organic reagent, involves highly toxic and fuming Br2 for synthesis). (b) Use of NBS in synthesis of halo-hydrin (Electrophilic Addition Reaction). (c) Determination of optical activity of generated product using polarimeter. [7 Lectures]
- Use of Computer - Chem Draw, Draw the structure of simple aliphatic, aromatic, heterocyclic compounds with different subsistent. Get the correct IUPAC name and predict the 1HNMR signals. [1 Lectures]
- Practical demonstration of instruments (a) HPLC (b) NMR [1 Lectures]

  NOTE- Alternate practical may be offered subject to conditions and availability of chemicals.

**Books Recommended**


1. **Vogels textbook of practical organic chemistry**, John Wiley and Sons.
2. **Vogels elementary quantitative organic analysis**, John Wiley and Sons.
3. Robert, Gilbert & Rodewald, **An Introduction to Modern Experimental Organic Chemistry**, Saunderss Publication.
4. Skoog, West and Holler, **Fundamentals of Analytical Chemistry**, Saunderss College publishing.
5. Field, Sternhell & Kalman, **Organic structures from Spectra**, John Wiley and Sons.


## 5.24 CY 502: Photochemistry and pericyclic reactions

**Course Code: CY 502**

**Course Name: Photochemistry and pericyclic reactions**

L-T-P-C: 3-1-0-4
Prerequisites: Organic Chemistry I
Intended for: M.Sc
Distribution: Core
Approval: 10th Senate

**Course Contents**

- **Pericyclic Reactions** Molecular orbitals and their symmetry Molecular orbitals and their symmetry properties, Frontier orbitals of ethylene, 1,3-butadiene, 1,3,5-hexatriene and allyl systems. [5 Lectures].
- **Woodward-Hoffmann**

  Frontier Molecular Orbital method and Orbital symmetry correlation method. [5 Lectures].
- **Various type of pericyclic reactions**

  Electrocyclic reaction; conrotatory and disrotatory motions 4n, 4n+2 and allyl systems. Cycloaddition; antrafacial and suprafacial addition, 4n and 4n+2 systems, 2+2 addition of ketenes, Diels-Alder reaction, stereochemical aspects and synthetic applications. 1,3 dipolar cycloadditions and cheleotropic reactions. Sigmatropic Rearrangements; suprafacial and antrafacial shifts of H, sigmatropic shifts involving carbon moieties, 3,3- and 5,5- sigmatropic rearrangements, Claisen, Cope and Aza-Cope rearrangements. Ene reaction. [15 Lectures].
- **Photochemistry**

  Quantum yields, intersystem crossing, photosensitization and energy transfer reactions. Photochemistry of olefins and carbonyl compounds, photo oxygenation and photo fragmentation, Photochemistry of aromatic compounds: isomerisation, additions and substitutions. Singlet molecular oxygen reactions. Patterno-Buchi reaction, Di-pi-methane rearrangement, Bartons reaction and Photo-Fries rearrangement. [17 Lectures].

**Text Books:**

1. Charles H. DePuy, **Molecular Reactions and Photochemistry**, Orville Lamar Chapman
2. I. Fleming, **Frontier Orbital and Organic Chemical Reactions**, John Wiley, 1976.
3. W. Carruthers, **Some modern Methods of Organic Synthesis**, Cambridge University Press, 1990.
4. T.W. Greene, **Protective Groups in Organic Synthesis**, Wiley-VCH, 1999.

**References:**

1. T. L. GilcLecturesist and R. C. Storr, Organic Reactions and Orbital Symmetry, 2nd Edition, CUP.
2. L. A. Paquette, Modern Heterocyclic Chemistry, W.A. Benjamin, Inc.,1968.
3. Ian Fleming, Pericylic reactions, Oxford University Press, 1999.
4. S. Sankararaman, Pericyclic Reactions: A Textbook, Wiley-VCH, 2005
5. N. J. Turro, V. Ramamurthy, J. C. Scaiano, Modern Molecular photochemistry of organic molecules, University Science books, 2010

## 5.25 CY 504: Heterocyclic Chemistry

### Course Code: CY 504

### Course Name: Heterocyclic Chemistry

L-T-P-C: 2-0-0-2
Prerequisites: CY501
Intended for: UG/PG
Distribution: Core course for M.Sc Chemistry
Approval: 9th Senate

### Course Contents

- **Module I**

  Nomenclature, Classification of heterocycles; Common synthesis strategies for aromatic heterocycles; Furan, Pyrrole and Thiophene (five membered heterocycles with one heteroatom) general methods and strategies for their synthesis; their properties, structure and reactivity; their electrophilic substitution and metalation. [7 Lectures].

- **Module II**

  Five membered heterocycles with two heteroatoms- Pyrazole, Imidazoles, Thiazole, Isothaizole; Isoxazole and Oxazole - Brief introduction, synthetic approaches and chemical reactions. [5 Lectures.

- **Module III**

  Six membered heterocycles with one heteroatom. Pyridines general properties, structure, synthesis strategies, electrophilic and nucleophilic substitution reactions in pyridines, metalation of pyridines; Pyridine derivatives such as oxy-pyridines, alkyl pyridines, pyridinium salts, and pyridine N- oxides [5 Lectures]

- **Module IV**

  Fused heterocyclic systems. Indole - electronic structure and reactivity of indoles, Fisher and Bischler indole syntheses, reaction of indole with electrophiles, Mannich reaction of Indoles; Quinoline and Isoquinoline - General properties and reactivity, synthesis strategies, electrophilic and nucleophilic substitution reactions in quinolones and Isoquinolines. [7 Lectures].

  Brief on the modern methods and applications.

- **Module 5**

  Six membered heterocycles with two heteroatoms. Pyridazine, Pyrimidine, Pryazine, and Oxazines brief introduction, synthesis strategies and reactions. [4 Lectures]

### Text Books:

1. J. A. Joule, K. Mills and G. F. Smith, **Heterocyclic Chemistry**, 3rd Edition.

2. T. L. Gilchrist, **Heterocyclic Chemistry**, 2nd Edition.

**Reference Books:**

1. D. T. Davies, **Aromatic Heterocyclic Chemistry**
2. T. Eicher and S. Hauptmann, **The Chemistry of Heterocyles**.
3. Lee A. Paquette, **Principles of Modern Heterocyclic Chemistry**
4. P-de-Mayo, **Molecular Rearrangement**.

## 5.26 CY 506: Chemistry of Transition Elements

**Course Code: CY 506**

**Course Name: Chemistry of Transition Elements**

L-T-P-C: 3-1-0-4
Prerequisites: B.Sc. (with Chemistry) or Teachers consent
Intended for: UG/PG
Distribution: Core Semester: Odd/Even
Approval: 8th Senate

**Course Contents**

- **Structure, bonding and properties of transition metal complexes**

  Theories of metal-ligand bonding and their limitations; CFT, d-orbital splitting; CFSE; low-spin and high-spin complexes and magnetic properties; LFT and Molecular Orbital (MO) theory of selected octahedral and tetrahedral complexes. [12 Lectures]

- **Spectral and magnetic properties of coordination compounds**

  Term symbols and splitting of free ion terms in cubic and square planar fields - crystal field configurations and term diagrams - Orgel and Tanabe-Sugano diagrams - selection rules for electronic transitions electronic spectra of simple ions and calculation of B and $\beta$ – magnetic properties of metal complexes. [8 Lectures]

- **Reaction mechanisms**

  Substitution reactions in octahedral and square planar complexes, trans effect and its influence, water exchange, anation, acid and base hydrolysis, stereochemistry, inner and outer sphere electron-transfer mechanisms. [8 Lectures]

- **Principles of electrochemistry**

  Oxidation and reduction, use of redox potential data. Analysis of redox cycles,redox stability in water, disproportionation, Frost, Latimer and Pourbaix diagrams. [7 Lectures]

- **Inner transition elements**

  Spectral and magnetic properties, complex formation, important oxides and complex oxides, analytical applications. [10 Lectures]

- **Nuclear chemistry**

  Nuclear reactions, fission and fusion, radio analytical techniques and activation analysis. [11 Lectures]

**Reference Books:**


1. F. A. Cotton, G. Wilkinson, C. A. Murillo and M. Bochmann, **Advanced Inorganic Chemistry**, 6th Edition, Wiley, 2007.
2. J. E. Huheey, E. A. Keiter and R. L. Keiter, **Inorganic Chemistry: Principles of Structure and Reactivity**, 4th edition, Pearson Education Inc., 2000.
3. B. Douglas, D. McDaniel and J. Alexander, **Concepts and Models of Inorganic Chemistry**, 3rd Edition, Wiley, 2006.
4. J. D. Lee, **Concise Inorganic Chemistry**, 5th Edition, Wiley, 2010.
5. P. Atkins et al, **Shriver & Atkins Inorganic Chemistry**, 5th Edition, W. H. Freeman and Company, New York, 2010.
6. B.C. Harvey, Introduction to Nuclear Chemistry, Prentice-Hall, 1969.
7. G. Friedlander, J.W. Kennedy, E.S. Marcus & J.M. Miller **Nuclear & Radiochemistry**, John-Wiley & Sons, 1981.
8. H. J. Arnikar, **Essentials of Nuclear Chemistry**, 4th Edition, New Age International Publishers, 2010.


## 5.27 CY 506P: Inorganic Chemistry Lab

**Course Code: CY 506P**

**Course Name: Inorganic Chemistry Lab**

L-T-P-C: 4 Credits
Prerequisites: B.Sc. (with Chemistry) or Teachers Consent
Intended for: UG/PG
Distribution: Core for M.Sc. and Elective for UG
Approval:

**Course Contents**

- Quantitative Analysis: Acid-base, Redox and complexometric titrations and their practical applications - Spectrophotometric analysis of metal ions.
- Quantitative separation of metal ions from binary mixtures.
- Qualitative Analysis: Reactions of some less common metal ions in a mixture of two.
- Synthesis of inorganic complexes/organometallic compounds such as transition metal and main group acetylacetonate complexes, ferrocene derivatives etc. Their characterization using various analytical and spectroscopic techniques like IR, UV-vis, LECTURES-MS, NMR, Magnetic susceptibility, and X-ray diffraction.

**Reference Books:**

1. **Vogel's Textbook of Quantitative Chemical Analysis**, 5th Edition, Orient Longman, 1989.
2. **Vogel's Textbook of Macro and Semimicro Qualitative Inorganic Analysis**, 5th Edition, Orient Longman, 1982.
3. Robert J. Angelici, **Synthesis and Technique in Inorganic Chemistry**, 2nd Edition, University Science Books, 1991.
4. Lab Manual and Instrument Manuals

## 5.28 CY 507: Chemistry of Main Group Elements

**Course Code: CY 507**

**Course Name: Chemistry of Main Group Elements**

L-T-P-C: 3-1-0-4
Prerequisites: B.Sc. (with Chemistry) or Teachers consent
Intended for: UG/PG
Distribution: Core
Approval: 8th Senate

**Course Contents**

- **Module I**

  Chemical periodicity and periodic anomalies. [5 Lectures]

- **Module II**

  Structure and bonding in homo- and heteronuclear molecules, shapes of small molecules. [10 Lectures]

- **Module III**

  Concepts of acids and bases: Bronsted and Lewis acids and bases -Gas phase versus solution acidity - leveling effects of solvents - hardness and softness - surface acidity. [10 Lectures]

- **Module IV**

  Pre-transition (alkali and alkaline earth) metals, their solutions in liquid ammonia. Noble gas compounds, structure and reactivity. Hydrogen and its compounds, H-bond and its influence on the structure and properties of crystals. [10 Lectures]

- **Module V**

  Chemistry of main group elements and their compounds: Borides, borates, boron halides, boranes, carboranes and metallocarboranes. BN compounds - a brief survey of Al, Ga and In chemistry. Allotropes of carbon - intercalation compounds carbides - C-oxides - pure silicon – silica and silicates - silicones low coordinated silicon compounds a brief survey of Ge, Sn chemistry. P(III) and P(V) compounds, P-N, P-O and P-S compounds including cyclophosphazenes a brief survey of heavier elements - nitrogen and phosphorus ligands - Sulfur-nitrogen compounds. Charge-transfer complexes of halogens Inter-halogen compounds - halogen oxides and xygen fluorides - pseudohalogens. [20 Lectures]

**Text and Reference Books:**


1. F. A. Cotton, G. Wilkinson, C. A. Murillo and M. Bochmann,**Advanced Inorganic Chemistry**, 6th Edition, Wiley2007.
2. J. E. Huheey, E. A. Keiter and R. L. Keiter, **Inorganic Chemistry: Principles of Structure and Reactivity**, 4th Edition, Pearson Education Inc., 2000.
3. B. Douglas, D. McDaniel and J. Alexander, **Concepts and Models of Inorganic Chemistry**, 3rd Edition, Wiley, 2006.
4. K. F. Purcell and J. C. Kotz, **Inorganic Chemistry**, Cengage Learning, 2010.
5. A. G. Sharpe, **Inorganic Chemistry**, 3rd Edition, Pearson, 2011.
6. P. Atkins et al, **Shriver & Atkins Inorganic Chemistry**, 5th Edition, W. H. Freeman and Company, 2010.


## 5.29 CY 508: Organometallic Chemistry

**Course Code: CY 508**

**Course Name: Organometallic Chemistry**

L-T-P-C: 2-0-0-2
Prerequisites: CY 506 and CY 507
Intended for: M.Sc Chemistry (2nd year)
Distribution: core
Approval: 9th Senate

**Course Contents**

- **Module-I** [6 Lectures] Introduction to organometallics: Brief history of organometallic chemistry,Werner Complexes, Types of Ligand, Soft Versus Hard Ligands, The Crystal Field, The Ligand Field, Back Bonding, Electroneutrality, Oxidation State, Coordination Number and Geometry, Effects of Complexation, Differences between Metals, Outer-Sphere Coordination, Kepert Model, VBT, MOT,The Trans Effect and its theory

  General Properties of Organometallic Complexes: The 18-Electron Rule, Limitations of the 18- Electron Rule, Electron Counting in Reactions

  Metal Alkyls, Aryls, and Hydrides and Related ?-Bonded Ligands Transition Metal Alkyls and Aryls, Related $\sigma$-Bonded Ligands, Metal Hydride Complexes, $\sigma$ Complexes, Bond Strengths for Classical $\sigma$-Bonding Ligands

  Carbonyls, Phosphine Complexes, and Ligand Substitution ReactionsMetal Complexes of CO, RNC,CS and NO, phosphines and related ligands

- **Module-II** [10 Lectures]

  Oxidative Addition and Reductive Elimination Concerted Additions, SN2 Reactions, Reductive Elimination, Oxidative Coupling and Reductive Cleavage, Dissociative Substitution, Associative Mechanism, Redox Effects, the I Mechanism, and Rearrangements in Substitution, Photochemical Substitution, Steric and Solvent Effects in Substitution, Insertion and Elimination Reactions Involving CO, Insertions Involving Alkenes

  Nucleophilic and Electrophilic Addition and Abstraction Nucleophilic Addition to CO, Electrophilic Addition, Electrophilic Abstraction of Alkyl Groups, Single-Electron Transfer Pathways

- **Module-III** [6 Lectures]

  Homogeneous Catalysis Alkene Isomerization, Alkene Hydrogenation, Alkene Hydroformylation, Hydrocyanation of Butadiene, Alkene Hydrosilation and Hydroboration, Coupling Reactions, Surface and Supported Organometallic Catalysis, Grubbs and ScLecturesock catalysts

  Clusters and the MetalMetal Bond Structures, The Isolobal Analogy, Synthesis, Reactions, Giant Clusters and Nanoparticles, Giant Molecules, Borane,carborane,metalocarborane, bimetallic and clusters complexes structure and application in catalysis

  Applications of Organometallic Chemistry Alkene Metathesis, Dimerization, Oligomerization, and Polymerization of Alkenes, Activation of CO and CO2, CH Activation, Organometallic Materials and Polymers, $\sigma$-Bond Metathesis

- **Module-IV** [6 Lectures]

  Introduction to Bio-organometallic Chemistry : Organometallic enzymes and coenzymes, Vitamin B12 coenzyme, B12 model compounds, Organometallic compounds as drugs, Organometallic compounds as radiopharmaceuticals, tracers, ionophores and sensors

  Introduction to metallocenes

  Important Reactions :Beta hydride elimination, Olefin Metathesis and Cross Coupling Reactions, reaction with metals and transmetallation, hydrometallation, Heck reaction, Suzuki-Miyaura coupling, Sonogashira coupling, Stille coupling and Negishi coupling, industrial applications of cross coupling reactions.

**Text books:**


1. Robert H. Crabtree, **The Organometallic Chemistry of the Transition Metals**, 5th Edition, Wiley-Blackwell; 2009.

2. B D Gupta & A J Elias, Basic Organometallic Chemistry Univ. Press.

3. Christoph Elschenbroich, **Organometallics**

4. Dirk Steinborn, **Fundamentals of Organometallic**

**Reference Books:**

1. R. C. Mehrota, **Organometallic Chemistry: A Unified Approach**, 2nd Edition New Age International Publishers, 2009

2. Whyman Robin, **Applied Organometallic Chemistry And Catalysis**, Oxford University Press, 2012.

## 5.30 CY 511: Group Theory and Spectroscopy

**Course Code: CY 511**

**Course Name: Group Theory and Spectroscopy**

L-T-P-C: 3-0-0-3
Prerequisites: B.Sc. (with Chemistry) or Teachers Consent
Intended for: UG/PG
Distribution: Core
Approval: 8th Senate

**Course Contents**

- **Molecular symmetry and group theory**

  Definition of a group and basic theorems, Group multiplication table, elements of a symmetry group, symmetry group classification. The Great Orthogonality theorem Direct products, similarity transformation, Characters of representation, Character table, irreducible representation, symmetry adopted linear combination, bonding in diatomics, group theory and molecular electronic states. [16 Lectures]

- **Interaction of light with matter**

  Transition moments and transition probabilities, Einsteins coefficients, oscillator strength, Beer- Lambert law, polarizabilities, oscillator strength, relationship between Einsteins coefficients and total absorbance. orr- Oppenheimer approximation, Frank Condon Principles, [4 Lectures]

- **Rotational and Vibrational Spectroscopy**

  Moment of inertia, The Rotational energy levels, Rotational spectra of diatomic molecules, Rotational Raman spectra, Rotational spectra of polyatomic molecules, Molecular vibrations, Selection rules, vibrational spectra of diatomic molecules, simple harmonic oscillator and rigid rotor model, anharmonic corrections, Vibrational-Rotational Spectra, vibrational Raman spectra of diatomic molecules. Infrared absorption spectra of polyatomic molecules, symmetric and asymmetric top molecules, normal modes of vibration and their classification by group theory, coupling between rotational and vibrational degrees of freedom. Symmetry and normal modes of vibrations. Symmetry and selection rules for allowed transitions among rotational, vibrational level. Determining the symmetry of molecular motions. Group theory and molecular electronic transitions. Symmetry and selection rules, spin and parity forbidden transitions, vibronic interaction. [16 Lectures]

- **Electronic spectroscopy**

  Electronic angular momentum and magnetic moment, atomic spectroscopy, spectra of hydrogen atom, many electron atoms, spectra and structure of diatomic molecule, electronic spectra of polyatomic molecules. [6 Lectures]

**Text Books:**


1. Donald A. McQuarrie and John D. Simon, **Physical Chemistry: A Molecular Approach**, Viva Books, 1998.

2. Peter Atkins and Julio de Paula, **Physical Chemistry**, 7th Edition, Oxford University Press, 2002.

3. J. M. Hollas, **Modern Spectroscopy**, 4th Edition, John Wiley, 2004.

4. F. A. Cotton, **Chemical Applications of Group Theory**, 3rd Edition, John Wiley, 2003.


**Reference Books:**


1. Ira N. Levine, **Quantum Chemistry**, Prentice-Hall: Englewood Cliffs, NJ, USA (1991).

2. Alan Vincent, **Molecular Symmetry and Group Theory**, 2nd Edition, Wiley, 2000.

3. Robert L. Carter, **Molecular Symmetry and Group Theory**, John Wiley & Sons, 1997.

4. K. Verra Reddy, **Symmetry and Spectroscopy of Molecules**, 2nd Edition, New Age International Limited Publishers, 2009.


## 5.31 CY 511 P: Physical Chemistry Laboratory

**Course Code: CY 511 P**

**Course Name: Physical Chemistry Laboratory**

L-T-P-C: 0-0-8-4
Prerequisites: Undergraduate level Physical Chemistry Laboratory
Intended for: M.Sc
Distribution: Core
Approval: 10th Senate

**Course Contents**

- **Module –I**

  Calibration of volumetric apparatus.

  Spectroscopy

  Analysis of the vibrational spectra of HCl, CCl4, small organic molecules.

Simultaneous Determination of cLecturesomium and manganese in a mixture by visible light spectroscopy

Physical Property and Surface chemistry

Determination of critical miceller concentration.

Determination of pKa of an amino acid by pHmeter

Distribution Law

Distribution coefficient of I2 between two immiscible solvents.

Determination of the equilibrium constant of the reaction KI+I2=KI3 using the result from the previous experiment.

- **Module –II**

  Electro-analytical Method

  8. The potentiometric titration of an acid mixture

  9. Conductometric titrations of strong acid HCl using strong base NaOH

  10. Conductometric titrations of weak acid CH3COOH using strong base NaOH

  11. Conductometric titration of a triple mixture of HCl, NH4Cl and KCl by NaOH and AgNO3.

- **Module -III Phase Equilibria**

  12. Determination of phase diagram of a simple eutectic system (Naphthalene Biphenyl, Naphthalene-Diphenyl amine)

  13. Determination of phase diagram of a binary solid system forming a compound (e.g., Naphthalene m-dinitrobenzene)

  Photochemistry

  14. Interaction of Interaction of protein- fluorescence of protein complex, Kinetic study of protein activity of p-nitro phenol acetate to p-nitrophenol conversion, Fluorescence spectrum and stern-volmer quenching constant.

  Nanomaterials

  15. Synthesis of gold nanoparticles and characterization by UV-VIS, DLS techniques etc

  16. Size Effect of Gold Nanoparticles in Catalytic Reduction of p-Nitrophenol with NaBH4

**Reference Books:**

1. F. A. Bettelheim, **Experimental physical chemistry**

2. G. P. Matthews, **Experimental physical chemistry**

3. Alex Findlay, **Practical physical chemistry**.

4. D. P. Shoemaker, C. W. Garland, and J. W. Nibler, **Experimental Physical Chemistry**.

5. B. Viswanathan & R.S. Raghavan, **Practical Physical Chemistry**, Viva Books, 2009.

6. A. Ghosal, B. Mahapartra, A. K. Nad, **An Advanced Course in Practical Chemistry**, New Central Book Agency Pvt Ltd., 2000.

## 5.32 CY 512: Advanced Quantum Chemistry

**Course Code: CY 512**

**Course Name: Advanced Quantum Chemistry**

L-T-P-C: 3-0-0-3
Prerequisites: B.Sc. (with Chemistry) or Teachers Consent
Intended for: UG/PG
Distribution: Core
Approval: 8th Senate

**Course Contents**

- **Module I**

  Review, Basic concepts and postulates of quantum mechanics of quantum mechanics: ScLecturesdinger wave equation, Eigenfunction, eigenvalues and operators, Interpretation of wavefunctions. [6 Lectures]

- **Module II**

  Free particle, Particle-in-a-box, Rigid rotor, Harmonic oscillator, Hydrogen atom. [6 Lectures]

- **Module III**

  Introduction to Self Consistent Field Theories; Valence Bond and Molecular Orbital theories; Introduction to Molecular spectroscopy: absorption, emission and resonance. [10 Lectures]

- **Module IV**

  Approximate methods of quantum chemistry: variational principle; LCAO approximation; Huckel Theory; Time-independent perturbation theory. Many electron atoms: Orbital approximation, Slater determinant; Hartree-Fockselfconsistent field theory; Slater type orbitals. [6 Lectures]

- **Module V**

  Angular momentum of many-particle systems. Spin orbital interaction; LS and JJ coupling. Spectroscopic term symbols for atoms. Molecules and Chemical bonding: Born-Oppenheimer approximation, MO and VB theories illustrated with H2-molecule[8 Lectures]

- **Module VI**

  Spectroscopic term symbols for diatomics; Directed valence & hybridization in simple polyatomic molecules. Elementary treatments of scattering and density functional theories [6 Lectures]

**Text Books:**

1. Donald A. McQuarrie and John D. Simon, **Physical Chemistry: A Molecular Approach**, Viva Books, 1998.

2. Peter Atkins and Julio de Paula, **Physical Chemistry**, Oxford University Press, 7th Edition, 2002.

**Reference Books:**

1. Ira N. Levine, **Quantum Chemistry**, Prentice-Hall, 1991.

2. Alberty and Silbey, **Physical Chemistry**, 4th Edition, Wiley, 2005.

3. Thomas Engel and Philip Reid, **Quantum Chemistry and Spectroscopy**, Pearson Education 2005.

## 5.33 CY 513: Reaction Dynamics, Kinetics and Catalysis

**Course Code: CY 513**

**Course Name: Reaction Dynamics, Kinetics and Catalysis**

L-T-P-C: 3-0-0-3
Prerequisites: B.Sc. (with Chemistry) or Teachers Consent
Intended for: UG/PG
Distribution: Core
Approval: 8th Senate

**Course Contents**

- **Module I**

  Introduction Review of kinetic theory of gases, the kinetic model of gases, collisions with walls and surfaces, the rate of effusions, transport properties of a perfect gas, atomic and molecular collisions, collisional theory, diffusion controlled reactions, thermodynamics properties of diffusion, potential energy surface, generation, interpretation and correlation with reaction energetics; elementary ideas on conical intersection. [12 Lectures]

- **Module II**

  The rates of a chemical reactions Rate theories Transition state theory and RRKM theory, scattering - classical and quantum. Reactive Collisions Potential energy surfaces, atom-diatom reactions, polyatomic reactions, state-selective, molecular beams, reaction rates and cross sections. [12 Lectures]

- **Module III**

  Catalytic Reactions, homogeneous catalysis, energetics, homogeneous active sites, activation and deactivation, auto catalysis and its mechanism. [6 Lectures]

- **Module IV**

  Synthesis and reaction of polymers; thermodynamics and kinetics of polymerization; Chemical structure andmorphology, Kinetics and mechanism of chain growth and step growthpolymerisation. Fibre forming polymers, ring-opening polymerization; water-soluble polymers, gels and hydrogels; chemical aspects to polymer processing, polymer surface and its modification; introduction to industrial polymers; application of polymers in medicine, nanotechnology, electronics; eco-friendly polymers: biodegradable, bio-sourced polymers, polymers from renewable resources. [10 Lecture]

**Text Books:**

1. R. D. Levine, **Molecular Reaction Dynamics**, Cambridge University Press, 2005.

2. Henriksen & Hansen, **Theories of Molecular Reaction Dynamics**, Oxford University Press, 2008.

**Reference Books:**

1. Donald A. McQuarrie and John D. Simon, **Physical Chemistry: A Molecular Approach**, Viva Books, 1998.

2. Peter Atkins and Julio de Paula, **Physical Chemistry**, 7th Edition, Oxford University Press, 2002.

3. R. Schinke, **Photo dissociation Dynamics**, Cambridge University Press, 1993.

4. G. Odian, **Principles of Polymerization**, 4th Edition, John Wiley and Sons, 2004.

5. L. H. Sperling, **Introduction to Physical Polymer Science**, 4th Edition, Wiley, 2006.

## 5.34 CY 514: Chemical Thermodynamics and Electrochemistry

**Course Code: CY 514**

**Course Name: Chemical Thermodynamics and Electrochemistry**

L-T-P-C: 3-0-0-3
Prerequisites: B.Sc. (with Chemistry) or Teachers Consent
Intended for: UG/PG
Distribution: Core
Approval: 8th Senate

**Course Contents**

- **Unit I**

- **The Laws of Thermodynamics**

  Zeroth law of Thermodynamics, Equilibrium, State Functions, Probability and distribution, Chemical Systems and Surroundings, temperature, equations of state First Law of thermodynamics : Internal energy, heat capacity, enthalpy, Isothermal, Adiabatic and Isobaric Processes , Energy, Enthalpy and Exact Differentials, Heat Capacities, Joule Thompson Effect, Heat Engines and Heat Pumps Second Law of thermodynamics: Entropy, Carnot cycles, heat engines, spontaneous changes, enthalpy and surrounding, Gibbs energy and application of Gibbs Energy Third Law of Thermodynamics: Concept of the absolute zero temperature. [10 Lectures]

- **Statistical Thermodynamics**

  Kinetic theory of gases, Probability and Maxwell Boltzmann distribution, Molecular Partition Functions, Thermodynamics from partition Functions, Equilibrium Constants, canonical ensemble ;ideal monoatomic, diatomic and polyatomic gases, quantum statistics Electronic, Vibrational, Rotational Partition Functions, Translational Partition Function, Heat Capacities, Heat Capacities of Solids, Debye and Einstein Models. [8 Lectures]

- **Unit II**

- **Equilibrium and Nonequilibrium Thermodynamics** [10 Lectures]

  Equilibrium: Free Energy and Equilibria, Application of Gibbs energy for Phase change, Helmoltz Free Energies, Gibbs Helmoltz Equation, Free Energies of Formation, phase rule, Clapeyron equation, phase diagram, Ideal and non-ideal solutions, gases, liquids and solutions, equation of states, Fugacities and their determination,Entropy and Free Energy of Mixing, Partial Molal Quantities and the Chemical Potential, Activities and Activity Coefficients, Debye Huckel Theory and Extensions, the Nernst equation, colligative properties, multicomponent phase diagram, Determination of Activity Coefficients [2 Lectures]

  Nonequilibrium Thermodynamics: Postulates and significance of nonequilibrium thermodynamics, Entropy Production for heat transfer, chemical reactions and diffusion, Onsagers formulation and limitations, Onsagers reciprocity relation verification using chemical reactions, electrokinetic and thermoelectric effects-I, Onsagers reciprocity relation verification using chemical reactions, electrokinetic and thermoelectric effects-II, Conductance of electrolytes using Onsagers approach.

- **Unit-III**

- **Electrochemistry and Kinetics of Electrode reactions** [6 Lectures]

- **Electrochemistry: Introduction and over view of electrochemical processes** [4 Lectures]

  Electrochemical cell and reactions, Faradic and nonfaradiac processes, electrochemical Experiments and variables in electrochemical cells, Basic electrochemical thermodynamics, free energy and cell EMF, half reaction and reduction potentials, formal potentials , reference electrodes , measurements of potential differences, Electrochemical potentials, liquid junction potential.

- **Kinetics of Electrode reactions** [8 Lectures]

  Essentials of electrode reactions, Butler Volmmer Model for electrode kinetics, One step, one electron process tLecturesough potential energy diagram, standard rate constants and transfer coefficients, equilibrium condition and exchange current,

**Text Books:**

1. Donald A Mcquarrie and Simon, **Molecular Thermodynamics**, Viva Books Private Limited, 2010.
2. J.O.M Bokris and A.K.N, Reddy, **Modern Electrochemistry**, Volume 1 and 2, Plenum Press, 1970.
3. A.J. Bard and L.R. Faulkner, **Electrochemical Methods**, 2nd Edition, John Wiley and Sons, 2001.

**Reference Books:**

1. Glasstone, Chemical Thermodynamics, Lightning Source, 2007.
2. Thomas Engel and Philips Reid, Physical Chemistry, 3rd Edition, Pearson Education, 2013.
3. Berry Rice and Ross, Physical Chemistry books, 2nd Edition, OUP, 2000.

## 5.35 CY 515 : Advanced Inorganic Spectroscopy

**Course Code: CY 515**

**Course Name : Advanced Inorganic Spectroscopy**

L-T-P-C : 3-0-0-3
Intended for : PG and PhD level
Prerequisite : Basic understanding of physical chemistry and preliminary knowledge of quantum mechanics, or with instructor's approval.
Mutual Exclusion : None
Approval: 45th BoA

**Course Contents:**

- **Electron Paramagnetic Resonance Spectroscopy:** Origin of EPR signals, g-factor, Presentation of the EPR spectrum, Hyperfine splitting: from protons and from Nuclei I ¿ 1/2, Origin of hyperfine interaction, Contributions to the hyperfine interactions in isotropic systems, Anisotropic Effects: Anisotropy in the g value, EPR of triplet states, nuclear quadrupole interaction, line widths, Experimental considerations and application of EPR. (10 hours)
- **Magnetic Circular Dichroism Spectroscopy:** Differences with CD, Theoretical Framework: Definition of MCD Terms, Measurement of MCD Spectra, The Interpretation of MCD Spectra, Case Studies; Diamagnetic Systems (A and B terms) and Paramagnetic Systems (C Terms) Magnetic Vibrational Circular Dichroism (MVCD) and X-Ray magnetic Circular Dichroism (XMCD), Application. (6 hours)

- **Nuclear Quadrupole Resonance Spectroscopy:** Nuclear quadrupole moment, Energies of nuclear quadrupole transitions, Effect of magnetic field on the spectra, Relationship between electric field gradient and molecular structure, Applications, Interpretations of structural information from NQR spectra. (6 hours)

- **Mossbauer Spectroscopy:** The Mossbauer effect, Line width, Recoil energy, Mössbauer active nuclei, Isomer shift, Quadrupole splitting, Magnetic hyperfine interactions, Mossbauer spectroscopy vs. Chemical bond, Structure determination and Analytical applications. (7 hours)

- **Photoelectron Spectroscopy:** Auger electron spectroscopy, Photoionization process, Spin-orbit Coupling, X-ray Photoelectron spectroscopy, Electron Energy Loss Spectroscopy (EELS). (6 hours)

- **X-ray Absorption and Emission Spectroscopy:** Introduction of X-ray absorption spectroscopy (XAS), X-ray emission spectrum (XES), X-ray Absorption spectrum, Theory of X-Ray Absorption Near Edge Structure (XANES) and Extended X-ray Absorption Fine Structure (EXAFS), Application. (7 hours)

**Laboratory/practical/tutorial Modules:**

None

**Text books:**


1. D. N. Sathyanarayana., **Handbook of Molecular Spectroscopy: From Radio waves to gamma rays**, I. K. International Publishing House Pvt. Ltd. 2019.

2. Russell S. Drago, **Physical Methods in Inorganic Chemistry**,Van Nostrand Reinhold, 2016.


**References:**


1. Jack D. Graybeal, **Molecular Spectroscopy**, McGraw Hill Education Private Limited, 1988.

2. G. Aruldhas, **Molecular Structure and Spectroscopy**, PHI Learning Private Limited, Delhi, 2019.

3. ditor(s): Jeroen A. Van Bokhoven, Carlo Lamberti, **X-Ray Absorption and X-Ray Emission Spectroscopy: Theory and Applications**, John Wiley & Sons, Ltd, 2016.

4. Editors: Edward I. Solomon, A. B. P. Lever, **Inorganic Electronic Structure and Spectroscopy, Volume I: Methodology and Volume II: Application and Case Studies**, John Wiley & Sons, Inc., 2006.

5. Skoog, West and Holler, **Fundamentals of Analytical Chemistry**, Saunders's College publishing, 2013.

6. W. Roy Mason, **A Practical Guide to Magnetic Circular Dichroism Spectroscopy**, Wiley-Interscience, 2007.

## 5.36 CY 521: Mathematics for Chemist

### Course Code: CY 521

### Course Name: Mathematics for Chemist

L-T-P-C: 3-0-0-3
Prerequisites: None
Intended for: UG/PG
Distribution: Elective
Approval: 8th Senate

### Course Contents

- **Linear Algebra** [14 Lectures]

  Scalars and Vectors: vector, a summary of vectors and representation of 3-D coordinates, Vector Products, Vector Spaces, orthonormal basis set, vector functions, differentiation and integration of vector functions, gradient, divergence and Curl, line integral, Surface integral, volume integrals, Linear independence, basis, curvilinear coordinates, Laplacian, Greens theorem, Stokes theorem, Tensors

  Matrix Algebra: Matrix and determinants, Rank, Matrix Algebra, diagonalization, Matrix property, Matrix functions, Eigen values, Eigen vectors,

  Applications: Visualization in quantum chemistry, Symmetry and group theory, Spectroscopy

- **Calculus** [14 Lectures]

  Functions, Variables, Bessel functions, basic rules of differentiation, maxima and minima, exact and inexact differential, partial differentiation (limits), rules of integration, definite and indefinite integrals, first and second order differential equations, linear homogeneous/inhomogeneous equations, general solution and particular solution, polynomials, Taylor and McLaurin series, Fourier series and Fourier transforms, power series method

  Calculus of Several Variables: Functions of More Than One Variable, An Introduction to Partial Derivatives, Differentiability and the Gradient, The Chain Rule, Derivatives of Integrals, The Total Differential, the method of Lagrange Multipliers, multiple integrals

  Applications: Kinetics, Quantum Chemistry, thermodynamics

  Special Functions: integral functions, interpolation, delta function

- **Analytical geometry and Data Analysis** [14 Lectures]

  Analytical geometry: Properties of different graphs and plotting of them, understanding of any kind of scientific equation- plotting of them and interpreting the physical significance of the plot. Relevant especially for thermodynamic, kinetic and radioactive study, general application in all fields of chemistry

  Data Analysis: Data Plotting, least square fitting, concept of floating points, interpolation, asymptotic analysis, error analysis, random numbers, correlations.

**Text books:**

1. R.G.Mortimer, **Mathematics for Physical Chemists**, Academic Press, 2005.
2. Charles L. Perrin, **Mathematics for Chemists**, Wiley-Inter science, 1970.
3. Donald A. McQuarrie, **Mathematical Methods for Scientists and Engineers**, University Science Books, 2003.

**References Books:**

1. E. Steiner, **The Chemical Maths Book**, 2nd Edition, Oxford University Press, 2008.
2. Martin C. R. Cockett and Graham Doggett, **Maths for Chemists**, Volumes 1 and 2, Royal Society of Chemistry, Cambridge Press, 2003.

## 5.37 CY 522: Computational Chemistry

**Course Code: CY 522**

**Course Name: Computational Chemistry**

L-T-P-C: 3-0-0-3
Prerequisites: CY 521 Mathematics for Chemistry & CY 512 Advanced Quantum Chemistry
Intended for: UG/PG
Distribution: Core
Approval: 9th Senate
Note: Course ran with CY 502; Course Code changed from CY 502 to CY 522 in 9th Senate

**Course Contents**

- **Introduction to Computational Chemistry**

  Scope of computational chemistry, Numerical Methods (algorithms), Molecular Mechanics / Force Field Methods, molecular dynamics, Born-Oppenheimer approximation, potential energy surfaces, local and global minima, transition states. [16 Lectures]

- **Basics of Approximate methods**

  Variational method, Hartree-Fock method. Molecular orbital theory, Slater determinants, anti- symmetry principle, restricted and unrestricted references, self-consistent-field (SCF) procedure. [6 Lectures]

- **Use of Approximate methods**

  Basis sets, Hartree-Fock algorithm, Electronic spin degeneracy, evaluating the spin of Slater determinants, computational simplification using Group Theory, Semi-empirical methods, Geometry optimization. [6 Lectures]

- **Thermodynamic Properties**

  Intrinsic reaction coordinate (IRC) analysis, Introduction to analytic gradient theory, Transition state theory, statistical mechanics, and thermodynamic properties. [8 Lectures]

- **Advanced Methods**

  Electron correlation, Configuration interaction, Many-body perturbation theory. Comparing the performance of electronic structure theories. [6 Lectures]

  Unit 6:

- **Hands on experience**

  Hands on experience on the use of computational chemistry packages & understanding of experiments done in Laboratory courses. [0 Lecture]

**Textbooks:**


1. F. Jensen, **Introduction to Computational Chemistry**, 2nd Edition, John Wiley & Sons, 2007.
2. A. Szabo and N. S. Ostlund, **Modern Quantum Chemistry**, 2nd Edition, McGraw-Hill, 1989.


**Reference Books:**


1. D. A. McQuarrie, **Quantum Chemistry**, Viva Books, 2011.
2. Ira N. Levine, **Quantum Chemistry**, Prentice-Hall, 1991.
3. F. A. Cotton, **Chemical Applications of Group Theory**, 3rd Edition, Wiley-Interscience, 1990.
4. C. J. Cramer, **Essentials of Computational Chemistry**, 2nd Edition, John Wiley & Sons, 2004.
5. A. R. Leach, **Molecular Modelling: Principle and Applications**, Prentice-Hall, 2001.
6. D. Young, **Computational Chemistry**, John Wiley & Sons, New York, 2001.
7. E. G. Lewar, **Computational Chemistry: Introduction to the Theory and Applications of Molecular and Quantum Mechanics**, Springer, 2003.


## 5.38 CY 523 : Colloids and Interface Science and Technology

**Course Code: CY 523**

**Course Name : Colloids and Interface Science and Technology**

L-T-P-C : 3-0-0-3
Intended for : PG
Prerequisite : B.Sc./B.Tech. with Chemistry as a subject or consent of the instructor
Mutual Exclusion : None
Approval: 46th BoA

**Course Contents:**

- **Introduction to Colloids:** Introduction: applications and importance of colloid chemistry, definition, classification and physical properties of colloids, colloids in nature, stability of colloids, electrostatic, steric and electrosteric stabilization, synthesis of colloids, self-assembly, micelles, reverse micelles, critical micellar concentration and its determination, interfaces, commonly observed interfacial phenomena, applications, phase diagram, structure and rheology of surfactant solutions. (8 Hours)

- **Interactions in Colloids:** Origin of van der Waals interactions, van der Waals interactions between particles, Hamaker constant, effect of medium on van der Waals interactions, van der Waals forces in nature. (6 Hours)

- **Colloid Polymer Interactions:** Colloid-polymer mixtures, phase diagram, polymer-solvent interaction, effect of polymer addition on colloidal dispersion, factors affecting phase behavior, depletion interactions, steric interactions. (4 Hours)

- **Electrical Double Layer :** Surface charge origin, electrical double layer, Helmholtz model, Gouy Chapman model, Debye Huckel approximation, structure of double layer, DLVO theory. (6 Hours)

- **Electrokinetics and Particles at Interfaces:** Electrokinetic phenomenon, electrophoretic mobility, zeta potential, Schultz-Hardy rule, colloidal particles at interface, contact angle, HLB. (4 Hours)

- **Characterization of Colloids:** Dynamic and static light scattering – Light scattering by objects, Scattering by small and large particles, experimental aspects of light scattering, dynamic light scattering, particle size, particle shape, particle surface functionalization, response to stimuli, particle density, surface area, surface charge, viscosity. (6 Hours)

- **Advanced Functional Colloids and Interfaces:** Applications of colloids and interface science in superhydrophobic surface, functional coatings, nanocomposites, detergents, personal-care products, pharmaceuticals, food, textile, paint and petroleum industries, Particle adsorption to interfaces, energy of attachment, wetting, interaction forces, microstructure and rheology of particle laden interfaces, emulsions and foams. (8 Hours)

**Laboratory/practical/tutorial Modules:**

NA

**Textbooks:**

1. P. C. Hiemenz and R. Rajagopalan, **Principles of Colloid and Surface Chemistry**, 3rd Edition Revised and Expanded, CRC Press, 1997.

2. J. C. Berg, **An Introduction to Interfaces and Colloids: The Bridge to Nanoscience**, World Scientific, 2010.

**References:**


1. J. Israelachvili, **Intermolecular and Surface Forces**, 3rd Edition, Academic Press (Elsevier), 2011.

2. Paul C. Hiemenz, **Principles of Colloid and Surface Chemistry**, Marcel Dekker, any edition starting with the 2nd edition, 1986.

3. Carel J. van Oss, **Interfacial Forces in Aqueous Media**, Marcel dekker or Taylor & Francis, 1994.

4. R. J. Hunter, **Foundations of Colloid Science**, Oxford University Press, 2005.

5. Related journal articles


## 5.39 CY 524: Basic and Applied Electrochemistry

Course number : CY 524
Course Name : Basic and Applied Electrochemistry
Credit : 3-0-0-3 Distribution : L-T-P-C
Intended for : M.Sc Chemistry, MTech, PhD
Prerequisite : Undergraduate level Physical Chemistry courses
Mutual Exclusion :
Approval: 50th BoA

**Course Contents:**

- **Interfacial Electrochemistry**: Introduction and over view of electrochemical processes, Basic electrochemical thermodynamics, free energy, Nernst Equation, half reaction and electrochemical potentials, formal potentials, liquid junction potential, Faradic and non-Faradaic processes, electrode-electrolyte interface, electrical double layer, polarizable and non-polarizable interfaces, Pourbaix diagram, thermodynamics of batteries. (8 Hours)

- **Kinetics of Electrode reactions and Measurements**: Essentials of electrode reactions, Butler Volmmer Model for electrode kinetics, one step-one electron process through potential energy diagram, standard rate constants, symmetry factor and transfer coefficients, Tafel slops, equilibrium condition and exchange current, mechanistic criteria; diffusion, activation phenomena, electron transfer theories, Marcus Theory, electrochemical transport process. (8 Hours)

- **Techniques for electrochemical methods**: Current-potential relationship; methods of measurement of kinetic parameters; over potential, electrochemical Experiments and variables in electrochemical cells, reference electrode, three electrode cell, supporting electrolyte, steady state and potential step techniques; polarography; cyclic voltammetry; chronomethods; convective diffusion systems: rotating disc and ring disc electrodes; microelectrodes; impedance techniques - concepts and applications, Equivalent Circuit Dynamics, differential pulse voltammetry, square wave voltammetry, linear sweep voltammetry. (14 Hours)

- **Application of Electrochemistry**: Pourbaix Diagram and relation to electrochemistry Fundamentals of batteries: primary, secondary, reserve batteries; solid state and molten solvent- batteries; heterogeneous catalysis, sensor, fuel cells, photoelectrochemical solar cells and conversion of solar energy, Corrosion – fundamentals and applications. (10 Hours)

- **Laboratory/practical/tutorial Modules**: 0

**Text books:**


1. J.O.M Bokris and A.K.N, Reddy, **Modern Electrochemistry**, Volume 1 and 2, Plenum Press, 1998.

2. A.J. Bard and L.R. Faulkner, **Electrochemical Methods,** 2nd Edition, John Wiley and Son, 2001.


**References:**


1. Scientists A. E.Gileadi, **Electrode Kinetics for Chemists**, Chemical Engineers and Material, VCH 1993.

2. Berry Rice and Ross, **Physical Chemistry published**, 2nd Edition, OUP, 2000.


## 5.40 CY 541: Fundamentals of Organic Chemistry

**Course Code: CY 541**

**Course Name: Fundamentals of Organic Chemistry**

L-T-P-C: 3-0-0-3
Prerequisites: B.Sc. (with Chemistry) or Teachers consent
Intended for: UG/PG
Distribution: Elective

Approval: 8th Senate

**Course Contents**

- **Structure and Bonding**

  Review of basic principles of structure and bonding, application of acid base concepts, HSAB theory, aromaticity and antiaromaticity, Hckels rule, anti-aromaticity, y-aromaticity, homo- aromaticity n-annulenes, heteroannulene, fullerenes, C-60, cryptates, Bonds weaker than covalent; addition compounds, inclusion compounds, crown ethers, cyclodextrins, catenanes and rotaxanes. [10 Lectures]

- **Stereochemistry**

  Conformational analysis of alkanes and cycloalkanes, effect of conformation on reactivity. Elements of symmetry, chirality, molecules with more than one chiral center, projection formulae (i) Fischer (ii) Sawhorse (iii) Newman (iv) Flying Wedge;

tLectureseo and erytLectureso isomers, methods of resolution, optical purity, enantiotopic and diastereotopic atoms, groups and faces, stereospecific and stereoselective synthesis, Asymmetric synthesis. Optical activity in the absence of chiral carbon. Axis and planar chirality. Absolute configuration of chiral centers. [12 Lectures]

- **Reaction mechanism**

  Structure and Reactivity: Types of mechanisms, types of reactions, thermodynamic and kinetic requirements, Hammond postulate, Curtin-Hammett principle, transition states and intermediates, methods of determining mechanisms, isotopic effects. Generation, structure, stability and reactivity of carbocations, carbanions, free radicals, carbenes and nitrenes. Effect of structure on reactivity.The Hammett equation and linear free energy relationship (sigma-rho) relationship, Taftequation. [12 Lectures]

- **Oxidation, Reduction and Rearrangements** [8 Lectures]

  Oxidation: Different oxidative processes. Hydrocarbons, carbonyl compounds, amines, hydrazines and sulphides.

  Reduction: Different reductive processes. Hydrocarbons, carbonyl compounds, nitro, nitroso, azo and oxime groups. Hydrogenolysis.

  Rearrangements: General mechanistic considerations, nature of migration, migratory aptitude, nucleophilic, electrophilic and free radical rearragnement. A detailed study of various arrangements reactions.

**Text Books:**


1. F. A. Carey and R. A. Sundberg, **Advanced Organic Chemistry, Part A: Structure and Mechanisms**, 5th edition, Springer, 2007.

2. D. Nasipuri, **Stereochemistry of Organic Compounds**, Wiley, 1994.

3. E. J. Eliel, **Stereochemistry of Carbon Compounds**, McGraw Hill


**References:**


1. D. G. Morris, **Stereochemistry**, RSC Tutorial Chemistry Text 1, 2001.

2. S. H. Pine, **Organic Chemistry**, McGraw Hill, 1987.

3. J. March, **Advanced Organic Chemistry**, John Wiley & Sons, 1992.


## 5.41 CY 547: Chemical Crystallography

**Course Code : CY 547**

**Course Name : Chemical Crystallography**

L-T-P-C : 2-0-2-3
Prerequisites : Consent of Teacher
Students intended for : M.Sc., Ph.D.
Elective or Compulsory : Elective

Approval: 5th Senate

**Course Contents**

- **Unit 1** Crystallography overview, X-ray generation, properties of X-rays, crystal lattices, the unit cell and crystal systems, Bravais lattices, lattice planes and hkl indices, Braggs law, reciprocal lattice, structure factors and phase problem. [3Lectures]

- **Unit 2**

  Crystal symmetry, symmetry elements, space groups, asymmetric unit, Laue groups, systematic absences. [4Lectures]

- **Unit 3**

  Experimental methods, crystal growth, crystal mounting, four circle diffractometer, area detectors, data reduction, absorption correction. [4Lectures]

- **Unit 4**

  Structure solution and refinement, Patterson methods and Direct methods, least squares refinement, crystallographic R-values, refinement techniques. [6 Lectures]

- **Unit 5**

  Anomalous dispersion and Absolute Structure, chiral and polar space groups, disorders, twinning, space group errors. [5 Lectures]

- **Unit 6**

  Interpretation and presentation of results, crystallographic information file, checkcif, bond lengths and angles, torsion angles, Ortep plots, crystallographic literature and data bases. [6 Lectures]

- **Topics to be covered in practical sessions** [28 Lectures]

  Using appropriate sample crystals, practical training will be given on the following topics: crystal selection and mounting, unit cell determination and setting up data collection strategy, data reduction and absorption correction using the software package provided, structure solution and refinement using SHELX/ provided package, preparation of cif file, checkcif and preparation of ortep diagram and other publication data of the structure. Brief training will be given in structure refinement of special cases like those with twinning, disorders etc. using standard structural data available on internet resources. Data base search.

**Text Books:**


1. Werner Massa, **Crystal Structure Determination**, 4th Edition, Springer, 2010.


**References:**


1. J. P. Glusker, M. Lewis M. Rossi, **Crystal Structure Analysis for Chemists and Biologist**, VCH, 1994.

2. M. M. Woolfson, **An Introduction to X-ray Crystallography**, 2nd Edition,Cambridge University Press, 1997.

3. M. F. C. Ladd, R. A. Palmer, **Structure Determination by X-ray Crystallography: Analysis by X-rays and Neutrons**, 5th Edition, Springer, 2012.

4. The SHELX-97 Software Manual.

## 5.42 CY 550: Bioinspired Materials

**Course Code : CY 550**

**Course Name : Bioinspired Materials**

L-T-P-C : 3-0-0-3
Prerequisites : IC 130 and IC 241 /or permission from instructor

Students intended for: B.Tech. (all branches), M.Sc., M.Tech., M.S. and Ph.D.

Elective or Compulsory: Elective
Approval: Not Approved; Approved one time 8th Senate

**Course Contents**

- **Fundamental Principles**

  Biomimicry introduction; design concepts; typical examples; intelligent life; multiscale hierarchical structures; heterogeneous interfaces; high strength materials; biomimetic strategies and materials processing [8 Lectures]

- **Concepts and Processes**

  Bioinspired synthesis of nanostructures; supramolecular chemistry; self-assembly; controlled assembly; biomineralization; stimuli-responsive behavior; self-replication; self-healing; self-cleaning; anti-reflection; anti-fouling; wettability; adhesion; scaffolds; multi-functionality; sensing; transduction; camouflage; swam intelligence; fabrication and replication of biological systems [12 Lectures]

- **Technological Applications**

  Artificial photosynthesis; renewable energy; biofuels; photovoltaics; catalysis; ion channels; medical diagnostics; drug delivery; tissue engineering; prosthetics; electronics; photonics; optics; fog harvesting; water filtration; defense; robotics; aeronautics; other new technological applications; review of current research. [12 Lectures]

- **Investigation Tools** [10 Lectures]

  High resolution optical microscopy; scanning electron microscopy; transmission electron microscopy; scanning probe microscopies; x-ray absorption spectroscopy; x-ray tomography; x-ray scattering; x-ray photoelectron spectroscopy; time-of flight secondary ion mass spectrometry; neutron scattering; single molecule probes; theoretical modeling and computer simulations

**Text books:**

1. L. Jiang, L. Feng, **Bioinspired Intelligent Nanostructured Interfacial Materials**, World Scientific Publishing Company, 2010.

2. S. Mann (Ed.), **Biomimetic Materials Chemistry**, Wiley-VCH, 1995.

**Further readings:**

1. Y. Zhou, **Bio-Inspired Nanomaterials and Nanotechnology**, Nova Science Publishers, 2009.

2. C. S. S. R. Kumar (Ed.), **Biomimetic and Bioinspired Nanomaterials**, Wiley-VCH, 2010.

3. Y. Bar-Cohen, **Biomimetics: Biologically Inspired Technologies**, CRC Press, 2005.

4. Youtube Channel: `http://www.youtube.com/functionalsurfaces`

## 5.43 CY 552: Hydrogen Generation and Storage

**Course Code: CY 552**

**Course Name: Hydrogen Generation and Storage**

L-T-P-C:3-0-0-3
Prerequisites:None
Intended for:UG/PG.
Distribution: Elective for B. Tech (3rd year), M. Tech. (Energy Materials), M.Sc Chemistry and Ph. D. students
Approval: 9th Senate

**Course Contents**

- **Production of Hydrogen**

  Different methods of hydrogen production, Renewable electrolysis, Steam Methane Reforming, Gasification of coal and other hydrocarbon, partial oxidation of hydrocarbon, Hydrogen from biomass, hydrogen generation from wind energy, water electrolysis, Thermonuclear/other methods and solar energy for hydrogen generation. The course will include at least few Lectures of elaborate study and description about each of the method of hydrogen production. [12 Lectures]

- **Hydrogen Handling and transport**

  Major issues regarding the handling of hydrogen and safety requirement .Materials issues : hydrogen embrittlement, Hydrogen leakage and monitoring, hydrogen sensors, Liquid hydrogen: liquefaction costs and low temperature, Pipelines for hydrogen transport-main issue. Few Lectures will be given on these above issues with detailed discussion. Emphasis will be given on the role of materials science in the improvement of the handling of hydrogen. [12 Lectures]

- **Hydrogen Storage**

  Hydrogen storage requirements: what is crucial? Metal Hydride requirements for hydrogen storage for mobile application, Onboard hydrogen storage system for light-duty vehicles,Hydrogen storage: materials point of view, Storage tLecturesough surface adsorption: nanocarbon, metal organic framework, Conventional metal hydrides, Light metal hydrides, ClatLecturesates for hydrogen storage. Material Scientists point of view: scope of research on the materials for hydrogen storage, their stability under loading and unloading of hydrogen. [12 Lectures]

- **Hydrogen R & D Opportunities**

  Safe handling and safe storage of hydrogen for long term usage, Evaluation of the technique for hydrogen generation, Codes and safety: hydrogen technology standards

**Text books:**

1. Ram B Gupta (Editor), **Hydrogen Fuel Production, Transport and Storage**, CRC, 2008.

**Reference Books:**

1. A.J. Bard and L.R. Faulkner, **Electrochemical Methods**, 2nd Edition, John Wiley and Son, 2001.
2. Marc Koper, Andrzej Wieckowski, (Editors), **Fuel Cell Catalysis: A Surface Science Approach**, Wiley-Interscience, 2009.
3. Marie-Ccile Pera (Editor), Daniel Hissel (Editor), Hamid Gualous (Editor), Christophe Turpin (Editor), **Electrochemical Components** (Electrical Engineering), Wiley-ISTE, 2013

## 5.44 CY 553: Organic Inorganic Spectroscopy

**Course Code: CY 553**

**Course Name: Organic Inorganic Spectroscopy**

L-T-P-C: 3-0-0-3
Prerequisites: B.Sc in Sciences with Chemistry as main subject
Intended for: PG
Distribution: Elective for Masters in Chemistry
Approval: 9th Senate

**Course Contents**

- **Recapitulation of UV, IR, NMR and Mass spectroscopy** (In this module the elaborated syllabus has been included for a better idea of the topics to be covered)

  UV includes: Color and light absorption, the cLecturesomophore concept. Theory of electronic spectroscopy, orbitals involved and electronic transitions, effect of solvent and conjugation on max. Woodward Fieser rules e.t.c.

IR includes: Molecular vibrations and modes of vibrations. Factors influencing vibrational frequencies vibrational coupling, hydrogen bonding, conjugation, inductive, mesomeric (resonance), field effects and bond angles, application to identify functional groups.

NMR includes: Nuclear spins resonance, chemical shift and its measurement. Relaxation processes, factors influencing chemical shift. Shielding, deshielding and anisotropic effects. Effect of restricted rotation, concentration temperature and hydrogen bonding. Spin coupling (simple and complex), mechanism of coupling.

Mass includes: Introduction, Mass spectrum and Metastable ion peak, Determination of molecular formula and recognition of molecular ion peak and the Nitrogen rule, Molecular formula and index of Hydrogen deficiency, General rules of fragmentation and the McLafferty rearrangement, Fragmentations associated with functional groups.

Structure elucidation of organic compounds by joint applications of IR, NMR and Mass spectroscopy. [12 Lectures]

- **Circular DicLecturesoism** (This is a new module introduced on the suggestions of reviewers)

  Theory of polarized light, optical activity and optically active molecules, Cotton effects, CD, Octet Rule, Experimental Techniques, Applications. [6 Lectures]

- **Nuclear Quadrupole Resonance Spectroscopy**

  Introduction, energies of quardrupole transitions, effect of magnetic field on the spectra, relationship between electric field gradient and molecular structure, applications, interpretations of structural information from NQR spectra. [7 Lectures]

- **Mossbauer Spectroscopy**

  The Mossbauer effect, the Mossbauer active nuclei.. The chemical isomer shift. The quadrupole splitting, magnetic hyperfine interactions. Mossbauer spectroscopy applied to study nature of chemical bond, structural determination and analytical applications. [8 Lectures]

- **Electron Paramagnetic Resonance Spectroscopy**

  Introduction, Principles, Presentation of the spectrum, hyperfine splitting in isotropic systems involving more than one nucleus, Contributions to the hyperfine coupling constant in isotropic systems. Anisotropic Effects: Anisotropy in the g value, EPR of triplet states, nuclear quadrupole interaction, line widths, EPR applications. [9 Lectures]

**Text and Reference Books:**


1. R. V. Parish, **NMR, NQR, EPR and Mossbauer Spectroscopy In Inorganic Chemistry**, Elis Horwood Limited.

2. Robert M. Silverstein, Francis X. Webster, David J. Kiemle, David L. Bryce, **Spectrometric Identification of Organic Compound**, John Wiley and Sons.

3. William Kemp, **Organic Spectroscopy**, Macmillan.

4. Russell S. Drago, **Physical Methods in Inorganic Chemistry**, Van Nostrand Reinhold.

5. Skoog, West and Holler, **Fundamentals of Analytical Chemistry**, Saunderss College publishing.

6. Field, Sternhell & Kalman, **Organic structures from Spectra**, John Wiley and Sons.

## 5.45 CY 554: Science and Technology of Nanomaterials

**Course Code: CY 554**

**Course Name: Science and Technology of Nanomaterials**

L-T-P-C: 3-0-0-3
Prerequisites: None
Intended for: UG/PG
Distribution: Elective for B.Tech (all Branches), M.Sc. (Chemistry) & Ph.D.
Approval: 9th Senate

**Course Contents**

- **Module I**

  Fundamentals of nanoscience, surface and volume, surface energy, classification of Nanostructures [10 Lectures]

- **Module II**

  Synthesis of nanomaterials, Top down, bottom up, particle stabilization in colloids, thin film deposition technologies; CVD, PVD, PLD, ALD [7 Lectures]

- **Module III**

  Advanced Characterisation techniques: scanning probe microscopy, scanning electron microscopy, transmission electron microscopy [7 Lectures]

- **Module IV**

  Interesting nanomaterials: metals, semiconductors, metal oxides, Fullerenes, Carbon nantubes, graphene6Applications: Energy materials, Catalysts, sensors, display systems, nanobiotechology, Biomimetics.[8 Lectures]

- **Module V**

  Societal implications of nanotechnology: Ethical aspects, Nanotoxicology [2 Lectrues]

- **Quiz I & Quiz II [2 Lectures]**

**Text Books:**

1. C. P. Poole (Jr.) and F. J. Owens, **Introduction to Nanotechnology**, Wiley Interscience.
2. M.D. Ventra, S. Evoy, J.R. Heflin Jr. (Eds.), **Introduction to Nanoscale Science and Technology**, Kluwer Academic Publishers.

**Reference Books:**

1. L. M. Liz-Marsan and P. V. Kamat, **Nanoscale Materials**, Kluwer Academic Publishers.
2. G. L. Hornyak , H.F. Tibbals, J. Dutta and J. J. Moore, **Introduction to Nanoscience and Nanotechnology**, CRC Press.
3. G. Cao, **Nanostructures & Nanomaterials: Synthesis, Properties & Applications**, Imperial College Press, 2004.
4. D. A. Bonnel, **Scanning Probe Microscopy and Spectroscopy: Theory, Techniques and Applications**, 2nd Edition, Wiley-VCH.
5. D. B. Williams & C. B. Carter, **Transmission Electron Microscopy: A Textbook for Materials Science**, 2nd Edition, Springer 2009.

## 5.46 CY 555: Introduction to Polymer Science & Technology

**Course Code: CY 555**

**Course Name: Introduction to Polymer Science & Technology**

L-T-P-C: 3-0-0-3
Prerequisites: IC 130 for B.Tech students
Intended for: UG/PG
Distribution: Elective for B.Tech. (all Branches), M.Tech./M.Sc. (Chemistry & all branches), & Ph.D. students
Approval: 24th Senate

**Course Contents**

- **Introduction to polymers**

  History and recent developments, monomers, oligomers, polymers and their characteristics, classification and nomenclature of polymers, physical state of polymers, Tg, Tc, molecular weight and MWD, natural polymers [6 Lectures]

- **Radical polymerization** Mechanism, kinetics, chain transfer, autoacceleration, gel effect, copolymerization, reactivity ratios, composition of copolymers, living radical polymerization: ATRP and RAFT. [6 Lectures]

- **Ionic polymerization** Mechanism and kinetics of cationic and anionic polymerization[5 Lectures]

- **Stereospecific polymerization** Stereoisomerism, complex catalyst polymerization [2 Lectures]
- **Step growth polymerization**

  Kinetics, step copolymerization, detailed methods for the preparation of polyesters, polyamides, polycarbonates etc., high performance polymers [6 Lectures]
- **Techniques of polymerization** Bulk, solution, emulsion, suspension, melt polycondensation, solution polycondensation, interfacial and gas phase. [3 Lectures]
- **Polymer characterization** Molecular weight by GPC, light scattering, osmotic pressure etc., IR, UV, NMR, TGA, DSC, radiation scattering: SAXS, WAXS, DLS. [8 Lectures]
- **Processing, testing and applications of polymer materials**

  Extrusion, molding, tensile, impact, flexural testing, adhesives, foam, polymer fibers, catalysis, environment care, medicine etc. [6 Lectures]

**Text Books:**

1. V. R. Gowarikar, N. V. Viswanathan, J. Sreedhar, **Polymer Science**, 3rd Edition, New Age International. Wiley, 2019.
2. F. W. Billmeyer, **Textbook of Polymer Science**, 3rd Edition, Wiley, 2007.

**Reference Books:**

1. G. Odian, **Principles of polymerization**, 4th Edition, Wiley, 2004.
2. P. C. Heimenz, T. P. Lodge, **Polymer Chemistry**, 2nd Edition, CRC press, 2007.
3. C. E. Carraher, **Seymour/Carraher's Polymer Chemistry**, 6th Edition, Marcel Dekker, 2003.
4. J. M. G. Cowie, **Polymers: Chemistry and Physics of Modern Materials**, 3rd Edition, CRC Press, 2007.
5. H. F. Mark, **Encyclopedia of Polymer Science and Technology**, 3rd Edition, Wiley, 2004.

## 5.47 CY 556: Organic Spectroscopy

**Course Code: CY 556**

**Course Title : Organic Spectroscopy**

L-T-P-C : 3-0-0-3
Prerequisites : Intended for : MSc Chemistry and PhD (any discipline)
Distribution : Elective Course
Approval: 43rd BoA

**Course Contents**

- **UV Spectroscopy**

  Introduction, Principle of UV spectroscopy, Concept of cLecturesomophore, Solvent effect, Fluorescence and phosphorescence, Characteristic absorption of organic compounds, Woodward-Fieser rules for dienes and enones, Substituent effects, Model compound studies. [4 Lectures]

- **Infra-red (IR) Spectroscopy** Introduction, Molecular vibrations, factors influencing molecular frequencies, Infrared spectrometer, application of IR spectroscopy for identification of functional groups. [4 Lectures]

- **Mass Spectroscopy**

  Basic principle, Ionization methods, Determination of molecular weight and molecular formula, Molecular ion and its recognition, Fragmentation and rearrangements, Examples of organic compounds from different classes such as hydrocarbon, hydroxyl compounds, ketones, aldehydes, carboxylic acids and esters, lactones, amines and amides, nitro compounds, nitriles and heteroaromatic compounds. [4 Lectures]

- **1H NMR Spectroscopy**

  The NMR Phenomenon, Theory of nuclear magnetic resonance, Chemical shift and factors affecting chemical shift, integral and integration in proton NMR, Chemical equivalence and magnetic equivalence, First order and second order spectra, Spin-spin coupling, Pascals triangle, Coupling constant, Factors influencing coupling constant, A2, AB, and AX spin systems, AMX, ABX and ABC spin system with tLecturesee coupling constants, D2O exchange, Shift reagents, Effect of chiral center, 19F and 31P NMR, Structure elucidation of organic compound using 1H NMR. [12 Lectures]

- **13C NMR Spectroscopy and 2-D NMR spectroscopy**

  Introduction, Correlation chart for 13C chemical shift, Proton-coupled 13C spectra, Proton-decoupled 13C spectra, carbon-deuterium coupling, NOE effects, Structural applications of 13C NMR, Fundamentals and applications of DEPT technique in NMR spectroscopy, Application of 2-D NMR spectroscopic techniques such as 1H-1H COSY, 1H-13C COSY, HMBC and HSQC for structure determination of complex organic compounds. [10 Lectures]

- **Structural Elucidation of Organic Compounds**

  Interpretation of spectroscopic data of unknown compounds, Application of UV-Vis, MS, IR and NMR spectroscopic techniques for solving structure of organic molecules [8 Lectures]

**Textbooks:**

1. Harald Gunther, **NMR Spectroscopy**, 2nd Edition, Wiley Publishers.

2. Jeremy K.M. Sanders, Edwin C. Constable, Brian K. Hunter and Clive M. Pearce, **Modern NMR Spectroscopy: A workbook of Chemical Problems**, 2nd Edition, Oxford University Press.

3. Jeffrey H. Simpson, **Organic Structure Determination, using 2-D NMR Spectroscopy, a problem- based approac**.

**References:**


1. Erno Pretsch, Philippe Buhlmann, Martin Badertscher, **Structure Determination of Organic Compounds**, Tables of Spectral Data, Springer.
2. Robert M. Silverstein, Francis X. Webster, David Kiemle, **Spectrometric Identification of Organic Compounds**, 7th Edition, John Wiley & Sons.
3. William Kemp, **Organic Spectroscopy**, 3rd Edition, Palgrave Publishers Ltd.


**Course Code: CY641**

**Course Name: Polymer Synthesis**

L-T-P-C: 3-0-0-3 Prerequisite: Consent of the faculty member
Students Intended for: B.Tech/MS/PhD
Elective or Core: Elective

**Course Contents**

- **Introduction**

  Definition, types of polymers, polymer mechanisms, polymer properties. [3 Lectures]

- **Step Growth Polymerization**

  General Theory. Types of step growth polymerization reactions. Gelation [3 Lectures]

- **Carbonyl Addition-Elimination Reactions**

  Polyesters, polyamides, polyimides etc. [6 Lectures]

- **Nucleophilic Substitution Reactions Epoxy Resins Multiple Bond Addition Reactions**

  Polyurethanes, Diels Alder reactions. [3 Lectures]

- **Free Radical Polymerization**

  Chemistry of free radicals. Initiation, propagation, termination mechanisms and kinetics, MWD, Free radical coupling reactions, Living free radical polymerizations [3 Lectures]

- **Ionic Polymerization**

  Cationicandanionic. Ionic polymerization contd. Addition polymerization by radiation. Group transfer polymerization. [6 Lectures]

- **Copolymers** Free radical copolymerization, Block copolymers, Telechelic polymers, IPN/SIPN, Ring Opening Polymerization [3 Lectures]

- **Coordination Polymerization** Ziegler-Natta catalysts; stereo regular polymers; olefin metathesis; metallocene catalysts. Polyacetylenes. [3 Lectures]

**Text and Reference Books:**

1. George Odian, **Principles of Polymerization**, 4th Edition, Wiley, 2004
2. Malcolm P. Stevens, **Polymer Chemistry: An Introduction**, 3rd Edition, Oxford, 2011.

**Journals**

- Macromolecules
- Biomacromolecules
- J.Am. Chem. Soc.
- MacroLetters
- NanoLetters
- Chemistryof Materials

## 5.48 CY 558 : Inorganic Chemistry for Sustainability

**Course Code : CY 558**

**Course Name : Inorganic Chemistry for Sustainability**

L-P-T-C: 3-0-0-3
Intended for: PG and PhD Level
Prerequisites: None
Mutual Exclusion: None
Approval : 57th BoA

**Course Contents**

- Introduction: Introduction to sustainability, life cycle sustainability assessments, social dimensions of sustainability, life cycle costing in sustainability assessment-a case study of remanufactured alternators, valorization, greenhouse gases and greenhouse effect, greenhouse gas emission associated with primary metal production, recycling, downcycling and upcycling of metals, modern trends in inorganic analysis. (5 hours)
- Solvent systems for sustainability: Bio-derived solvents, water as a solvent, liquid N2, supercritical CO2, CO2 expanded liquids, CO2 switchable solvents. (5 hours)
- Inorganic waste treatment: Recovery of gold from sewage sludge, recovery of gold carbon-based materials, carbon in pulp method: a case study from Japan, earth recycling from neodymium-iron-boron permanent magnets, development of recycling technology for rare earth metals by Hitachi: case study, adsorption methods for metal removal. (6 hours)

- Sustainable water remediation: Reasons and problems related to wastewater, bioremediation, zeolites as treatment agents for wastewater, modified silica gels as chelating sorbents, ionic liquids for water remediation, inorganic hybrid materials for water remediation, adsorption methods for water treatment, water treatment by electrocoagulation. (9 hours)
- Sustainable inorganic catalysts for organic transformations: Inorganic catalyst (Re, Ti, Mn, W) for epoxidation, catalytic epoxidation of oils, fatty derivatives and terpenes, (Al, K and Fe) based catalysts for carbonate synthesis, fluorous catalysts for hydrocarbon oxidation. Metal oxide (CuO, RuO2, WO3, CeO2) supported catalytic transformation involving amination, electrophilic cyclization, C-C coupling and hydrogenation. (7 hours)
- Sustainable synthesis with microwave irradiation: Microwave assisted controlled organic synthesis, microwave assisted polymerization, synthesis of inorganic solids using microwaves, microwave assisted nanoparticle synthesis. (5 hours)

**Text books:**

1. David A. Atwood (Editor), **Sustainable Inorganic Chemistry**, Wiley, 2016.
2. F. Cavani, G. Centi, S. Perathoner, and F. Trifiro, **Sustainable Industrial Chemistry**, Wiley-VCH Verlag, 2009.

**References:**

1. Introduction: Sustainable Chemistry, **Chemical Reviews**, 118, 369−371, 2018.
2. J. J. M Nelson; E. J. Schelter, Sustainable Inorganic Chemistry: Metal Separations for Recycling, **Inorganic Chemistry**, 58, 979−990, 2019.
3. The Materials Science behind Sustainable Metals and Alloys, **Chem. Rev.**, 123, 2436−2608, 2023.
4. New Technology for Gold Recovery, JOGMEC report, Japan Oil, Gas and Metal National Corporation (JOG-MEC), Tokyo, 1995.
5. Insight; http://www.51report.com/research/3051099.html
6. E. M. Schau, M. Traverso, A. Lehmann and M. Finkbeiner, **Sustainability**, 3, 2268, 2011.

## 5.49 CY 600 : Research Methodology for Chemistry

**Course Code : CY 600**

**Course Name : Research Methodology for Chemistry**

L-T-P-C : 1-0-0-1
Intended for : PhD
Prerequisite :
Mutual Exclusion:
Approval: 54th BoA

**Course Contents**

- **Literature Survey**: Literature search via journals and using various search engines. Knowledge of journal abbreviations and parameters, and different publishing platforms. Citation matrices. (3 Hours)
- **Scientific Writing, Communication, and Ethics**: Structure of research paper/article/literature review. Scientific writing and presentation techniques. Ethical conduct in scientific research and knowledge of plagiarism detecting tools. Bioethics in experiments with living organisms. (3 Hours)
- **Chemical Safety**: Safety protocols in the laboratory, first aid, and emergency response procedures. Proper disposal methods for waste chemicals. (2 Hours)
- **Data Analysis and Chemistry Software**: Quantitative and Qualitative data analysis. Knowledge of data analysis software, data reliability, and validity. Exposure to various chemistry software. (5 Hours)
- **Intellectual Property**: Briefing about intellectual property, patents, copyrights, and trademarks. (1 Hour)

**Textbooks:**

1. NA

**References:**

1. Fraenkel F. J. & Warren N. E., **How to Design and Evaluate Research in Education**, 4th Edition, McGraw-Hill, 2002.
2. Dean, J. R., Jones, A. M., Holmes, D., Reed, R., Weyers, J. & Jones, A., **Practical skills in chemistry**, 2nd Edition, Prentice-Hall, 2011.
3. Hibbert, D. B. & Gooding, J. J., **Data analysis for chemistry**, Oxford University Press, 2006.
4. Levie, R. de., **How to use Excel in analytical chemistry and in general scientific data analysis**, Cambridge University Press, 2001.
5. **Chemical safety matters – IUPAC – IPCS**, Cambridge University Press, 1992.
6. Internet resources.

## 5.50 CY 641: Polymer Synthesis

**Course Code: CY 641**
**Course Name: Polymer Synthesis**

L-T-P-C: 3-0-0-3
Prerequisites: Consent of the faculty member
Students intended for: B.Tech/MS/PhD
Elective or Core: Elective
Approval: 2nd Senate

**Course Contents**

- **Introduction**

  Definition, types of polymers, polymer mechanisms, polymer properties [3 Lectures]

- **STEP GROWTH POLYMERIZATION**

  General Theory. Types of step growth polymerization reactions.Gelation [3 Lectures]

- **CARBONYL ADDITION-ELIMINATION REACTIONS**

  Polyesters, polyamides, polyimides etc. [6 Lectures]

- **NUCLEOPHILIC SUBSTITUTION REACTIONS**

  Epoxy resins. MULTIPLE BOND ADDITION REACTIONS: Polyurethanes, Diels Alder reactions. [3 Lectures]

- **FREE RADICAL POLYMERIZATION**

  Chemistry of free radicals. Initiation, propagation, termination mechanisms and kinetics, MWD, Free radical coupling reactions, Living free radical polymerizations [3 Lectures]

- **IONIC POLYMERIZATION**

  Cationicandanionic, Addition polymerization by radiation. Group transfer polymerization. [6 Lectures]

- **COPOLYMERS**

  Free radical copolymerization, Block copolymers, Telechelic polymers, IPN/SIPN, Ring Opening Polymerization. [3 Lectures]

- **COORDINATION POLYMERIZATION**

  Ziegler-Natta catalysts; stereo regular polymers; olefin metathesis; metallo cene catalysts. Polyacetylenes. [3 Lectures]

- **Additional Module**

  biomaterials, nanomaterials etc.

**Text Books:**


1. George Odian, **Principles of Polymerization**, 4th Edition, , Wiley, 2004.

2. Malcolm P. Stevens, **Polymer Chemistry An Introduction**, 3rd Edition, Oxford University Press, 2011.

**Journals:**

1. Macromolecules
2. Biomacromolecules
3. J.Am. Chem. Soc.
4. MacroLetters
5. NanoLetters
6. Chemistryof Materials

## 5.51 CY 642: Molecular- and Bio-electronics

**Course Code: CY 642**

**Course Name: Molecular- and Bio-electronics**

L-T-P-C : 3-0-0-3
Prerequisites : IC 130 and IC 241 /or permission from instructor
Students intended for : B.Tech. (All branches), M.S. and Ph.D.
Elective or Compulsory : Elective
Approval: 5th Senate

**Course Contents**

- **Molecular electronics**

  Moores laws and beyond; metallic atom-size contacts; transport tLecturesough molecular junctions, plastic electronics; liquid crystal devices; single electron devices; logic gates; device fabrication strategies (in detail); tools for molecular electronics. [8 Lectures]

- **Organic electronics**

  Pi-conjugated molecules; electroactive organic compounds; organic semiconductors; structure- electronic property relationships; organic electronic devices (OLED, OPV, OPD, OTFT, OFET); gate dielectrics; flexible polymeric substrates; printed organic electronics; novel processing techniques; device performance and characterization. [8 Lectures]

- **Nanoelectronics**

  Nanowires, nanotubes and nanostructures synthesis, characterization and uses (in brief); nanowire integrated circuitry; nanostructure enabled chemical sensing; supra molecular bioelectronics nanostructures; quantum dot devices; electromechanical actuators. [8 Lectures]

- **Bioelectronics**

  Introduction; electron transfer tLecturesough proteins; biosensors and biofuel cells; enzyme electrodes; electrochemical DNA sensors; biomolecules-semiconductor interfaces for sensing and detection; bio- nano hybrid systems for electronic devices;

DNA- templated electronics; S-layer proteins in bioelectronics; computing with nucleic acids. [10 Lectures]

- **Current research** Review of recent literature tLecturesough high-impact journal articles on relevant topics; guest Lecturers (2-3) by eminent scientists/professors from abroad tLecturesough video conference (using NKN facilities); few simple hands-on experiments will be demonstrated/performed. [8 Lectures]

**Reference Books:**


1. M. C. Petty, **Molecular Electronics: From Principles to Practice**, John Wiley & Sons, 2008.
2. J. C. Cuevas, E. Scheer, **Molecular Electronics: An Introduction to Theory and Experiment**, World Scientific Publishing Company, 2010.
3. H. Klauk, **Organic Electronics: Materials, Manufacturing, and Applications**, Wiley-VCH, 2006.
4. H. Klauk, **Organic Electronics II**, Wiley-VCH, 2006.
5. K. Iniewski, Nanoelectronics: Nanowires, **Molecular Electronics, and Nanodevices**, McGraw-Hill, 2010.
6. I. Willner, E. Katz, **Bioelectronics: From theory to applications**, Wiley-VCH, 2005.


## 5.52 CY 643: Advanced Analytical Techniques

**Course Code: CY 643**

**Course Name: Advanced Analytical Techniques**

L-T-P-C : 3-0-0-3
Students intended for: B.Tech/MSc/PhD
Prerequisites:
Elective or Compulsory: Compulsory
Approval: 1st Senate

**Course Contents**

- **Introduction**

  Role of Analytical Chemistry in Science, Classification of quantitative methods in the science, steps in typical quantitative analysis. [2 Lectures]

- **Surface Analysis by Microscopy**

  Scanning Electron Microscopy (SEM), Atomic Force Microscopy (AFM)-Principle, Instrumentation, Analysis, and Applications. [10 Lectures]

- **Atomic Spectroscopy for Analysis**

  Atomic Absorption and Atomic Emission Spectroscopy - Principle, Instrumentation, Analysis, and Applications and Advances. [8 Lectures]

- **Purification and Isolation techniques**

  An introduction to chromatographic techniques, Gas Liquid chromatography and Liquid chromatography (particularly High Performance Liquid Chromatography) - Principles, Instrumentation, Applications and Advances. [8 Lectures]

- **Miscellaneous Methods of Analysis**

  Thermal Methods- Differential Thermal Analysis, Differential Scanning Calorimetry. Particle Size Determination Dynamic Light Scattering. [14 Lectures]

**Text & Reference Books**

:


1. Skoog, Holler, Crouch, **Instrumental Analysis**.
2. Skoog, West, Holler, **Fundamentals of Analytical Chemistry**


## 5.53 CY 644: Bioinorganic chemistry

**Course Code: CY 644**

**Course Name : Bioinorganic chemistry**

L-T-P-C : 3-0-0-3
Prerequisites : CY 101 or equivalent and basic knowledge in coordination chemistry
Students intended for : B. Tech. & Ph.d.
Elective or Compulsory : Elective
Approval: 4th Senate

**Course Contents**

- **Introduction** Fundamentals of coordination chemistry; Introduction to bioinorganic chemistry; Role of alkali and alkaline earth metal ions; Essential and trace metals; fundamentals of Na-K Pump; Ionophores and crown ethers. [7 Lectures]

- **Module II**

  The role of metal ions in biological functions Their active structure/site and function in: (a) Metal ion transport and storage - Ferritin, Transferrin, metallothioneinetc; (b) Electron Transfer - cytochromes, Fe-S Proteins, copper protein etc. (c) Oxygen activation - cytochrome P450, cytochrome c oxidase. (d) Oxygen transport and storage - hemoglobin, myoglobin, hemerytLecturesin, hemocyanin, their coordination geometry and electronic structure, co-operativity effect, Hill coefficient and BoLectures Effect; characterization of O2 bound species by spectroscopic methods. [12 Lectures]

- **Module III**

  Other enzymes - Peroxidase, alcohol dehydrogenase, carbonic anhydrase, nitrogenase, vitamin B12 coenzyme. [2 Lectures]

- **Module IV**

  The use of metals in medicinal chemistry- The significance of metal-based compounds for medicinal use (cis-platin, radiopharmaceuticals etc); recent developments in the medical field based on inorganic or bioinorganic principles; Metals used in diagnosis; Gd-based MRI and X-ray contrast agents. [8 Lectures]

- **Module V**

  Some related basic tools and techniques - Bioassay, EPR spectroscopy, Single crystal X-ray diffraction, Electrochemistry with cyclic voltammetry, UV-Vis Absorption Spectroscopy, Fluorescence emission spectroscopy and Fluorescence excited state life time measurements. [5 Lectures]

- **Module VI**

  Toxicity of metalsToxic effects of Pb, Cd, Hg and Cr with specific examples. [7 Lectures]

- **Module VII**

  Metal Ions in Plant-Based Systems: The essential role of metal ions in photosynthesis and other processes in plant and fungal systems. Identify the bioinorganic molecules responsible for energy harvesting and electron transfer in biological systems. [4 Lectures]

**Text Books:**

1. Stephen J. Lippard and Jeremy M. Berg, **Principles of Bioinorganic Chemistry**.

**Reference books:**

1. Wolfgang Kaimand, Brigitte Schwederski, **Bioinorganic Chemistry: Inorganic Elements in the Chemistry of Life**.
2. Ivano Bertini, Harry B. Gray, Edward I. Stiefel, Joan Selverstone Valentine, (Editors), **Biological Inorganic Chemistry**.
3. Wolfgang Kaimand, Brigitte Schwederski, **Bioinorganic Chemistry**.
4. Asim K. Das, **Bioinorganic Chemistry**
5. D. F. Shiver, P. W. Atkins, C. H. Langford, **Inorganic Chemistry**, Oxford University Press, 1990.
6. J. E. Huheey, E. A. Keiter, R. L. Keiter, **Inorganic Chemistry, Principles of Structure and Reactivity**, Pearson Education, 2004.

## 5.54 CY 645: Reagents in organic synthesis

### Course Code : CY 645

### Course Name : Reagents in organic synthesis

L-T-P-C : 3-0-0-3
Prerequisites : Basic knowledge in organic reaction and mechanism
Students intended for : PhD
Elective or Compulsory : Elective
Approval: 4th Senate

### Course Contents

- **Introduction**

  Classification of reagents; about air and moisture sensitive reagents; handling, storage and precaution; (3 h) Oxidising and reducing agents Synthesis of various oxidizing and reducing reagents; application in the synthesis of natural products, in organic transformation and in asymmetric synthesis [7 Lectures]

- **Solid supported reagents**

  Advantages and disadvantages; various inorganic supports and their application in organic reaction; effect of support materials on reactivity; organic supports including polymeric resins, their functionalization and application. [7 Lectures]

- **Hypervalent iodine reagents**

  Various types of hypervalent iodine reagents and their preparation; application in organic transformation, selectivity, sensitivity and reactivity [4 Lectrues] Peptide couplingreagents Phosphonium, immonium, imidazolium, carbodiimide, uronium, organophosphorous, chloroformate and acid halogenating reagents; their applications. [5 Lectrues]

- **Functional group protecting agents**

  Different types of protecting/masking agents; protection of chemical functionalities and their deprotection after completion of reaction; their application in chemo- and regioselective reaction (5 h) Copper, palladium, platinum and ruthenium based coupling reagents Preparation of Copper, palladium, platinum and ruthenium based coupling reagents; application in C-C, C-N, C-O and C-S bond forming reactions; their applications in asymmetric synthesis. [5 Lectrues]

- **Lanthanide reagents in organic synthesis**

  Applications in oxidation, reduction, C-C bond forming, cyclopropanation and cycloaddition reactions. [2Lectrues]

- **P, S, Se and Si-based reagents**

  Synthesis and application in organic synthesis. [3 Lectrues]

**Text Books:**

1. Bradford P. Mundy, Michael G., **Reactions and Reagents in Organic Synthesis**.

2. Richard F HeckFavaloro, **Palladium reagents in organic syntheses**.

**Reference Books:**

1. **Encyclopedia of Reagents for Organic Synthesis**

2. **Fieser and Fieser's Reagents for Organic Synthesis**

3. Anthony J. Pearson, William R. Roush, **Handbook of Reagents for Organic Synthesis, Activating Agents and Protecting Groups**.

4. David Crich, **Handbook of Reagents for Organic Synthesis: Reagents for glycoside, nucleotide, and peptide synthesis**.

5. Philip L. Fuchs, **Handbook of Reagents for Organic Synthesis: Reagents for direct functionalization of C-H bonds**.

6. Leo A. Paquette, **Fluorine-Containing Reagents**

7. Peter Wipf, **Handbook of Reagents for Organic Synthesis: Reagents for high-throughput solid-phase and solution-phase organic synthesis**.

8. Theodora W. Greene, Peter G. M. Wuts, **Protective groups in organic synthesis**

9. **Review articles on reagents from leading journals ofvx n1/4 organic chemistry**.

## 5.55 CY 646: Advanced NMR Spectroscopy- A problem based approach

**Course Code: CY 646**

**Course Title: Advanced NMR Spectroscopy- A problem based approach**

L-T-P-C: 3-0-0-3
Prerequisites: BSc (with Chemistry as one of the subject)
Intended for: PG
Distribution: Elective Course
Approval: 8th Senate

**Course Contents**

- **Nuclear Magnetic Resonance Spectroscopy**

  The NMR Phenomenon, The spinning nucleus, the effect of an external magnetic field, Precessional motion, Precessional frequency, Energy transitions. [2 Lectures]

- **Theory of Nuclear Magnetic Resonance**

  Chemical Shift and its Measurement, internal standards, the NMR spectrometer, units used in NMR spectroscopy, Factors Influencing Chemical Shift, Electronegativityshielding and deshielding, anisotropic effects, Correlation Data for Proton NMR Spectra, Use of correlation tables, Influence of restricted rotation. Choice of solvent for proton NMR spectra, Solvent shifts concentration and temperature effectshydrogen bonding, Integrals in Proton NMR Spectra. [3 Lectures]

- **Symmetry and Topicity**

  Homotopicity, Enantiotopicity, Diastereotopicity, Chemical Equivalence, Magnetic Equivalence. [1 Lectures]

- **Through-Bond Effects**

  Spin-Spin (J) Coupling & Origin of J-Coupling Skewing of the Intensity of Multiplets, Prediction of First-Order Multiplets, The Karplus Relationship for Spins Separated by TLecturesee Bonds, The Karplus Relationship for Spins Separated by Two Bonds, Long Range J-Coupling, Decoupling Methods, One-Dimensional Experiments Utilizing J-Couplings, Two-Dimensional Experiments Utilizing J-Couplings, Homonudear. [2 Lectures]

- **Two-Dimensional Experiments utilizing J-Couplings**

  COSY, HMQC, HSQC, HMBC, TOCSY, INADEQUATE, Heteronuclear Two-Dimensional Experiments Utilizing J-Couplings. [4 Lectures]

- **TLecturesough-Space Effects**

  The Nuclear Overhauser Effect (NOE)

  The Dipolar Relaxation Pathway, The Energetics of an Isolated Heteronuclear Two-Spin System, Decoupling One of the Spins in a Heteronudear Two-Spin System, Rapid Relaxation via the Double Quantum Pathway, A One-Dimensional Experiment Utilizing the NOE, Two-Dimensional Experiments Utilizing the NOE, NOESY and ROESY. [4Lectures]

- **Strategies for Assigning Resonance to Atoms within a Molecule**

  Prediction of Chemical Shifts, Prediction of Integrals and Intensities, Prediction of 1H Multiplets, good Bookkeeping Practices, Assigning 1H Resonances on the Basis of Chemical Shifts, Assigning Resonances on the Basis of Multiplicities, Assigning 1H Resonances on the Basis of the gCOSY Spectrum, The Best Way to Read a gCOSY Spectrum, Assigning 13C Resonances on the Basis of Chemical Shifts, Pairing 1H and 13C Shifts by Using the HSQC/HMQC Spectrum, Assignment of Nonprotonated 13C's on the Basis of the HMBC Spectrum, Variable Temperature NMR techniques. 19F and 31P NMR. [4 Lectures]

- **Strategies for Elucidating Unknown Molecular Structures**

  Initial Inspection of the One -Dimensional Spectra Good Accounting Practices, Identification of Entry Points, Completion of Assignments. [1 Lectures]

- **Simple Problems**

  2-Acetylbutyrolacton, a,-Terpinene, (1R)-endo-(+)-Fenchyl Alcohol in CDC13, ()-Bornyl Acetate, N-Acetylhomocysteine Thiolactone, Guaiazulene, 2-Hydroxy-3-Pinanone, (R)-(+)- Perilly1 Alcohol, 7-Methoxy-4-Methylcoumarin, Sucrose and some more interesting molecules from literature if time permits. [8 Lectures]

- **Complex Problems**

  Longifolene, (+) Limonene, l-Cinchodine, (3aR)-(+) Sclareolide, (-)-Epicatechin, (-)- Eburnamonine, trans-Myrtanol, cis-Myrtaol, Naringenin, (-) Ambroxide and some more complex molecules from literature if time permits. [10 Lectures]

**Text Books:**


1. Harald Gunther, **NMR Spectroscopy**, 2nd Edition, Wiley Publishers, 1995.
2. Jeremy K.M. Sanders, Edwin C. Constable, Brian K. Hunter and Clive M. Pearce, **Modern NMR Spectroscopy: A workbook of Chemical Problems**, 2nd Edition, Oxford University Press, 1993.
3. Jeffrey H. Simpson, **Organic Structure Determination, using 2-D NMR Spectroscopy, a problem based approach**, Academic Press, 2012.


**References:**


1. Erno Pretsch, Philippe Buhlmann, Martin Badertscher, **Structure Determination of Organic Compounds, Tables of Spectral Data**, Springer, 2009.
2. Robert M. Silverstein, Francis X. Webster, David Kiemle, **Spectrometric Identification of Organic Compounds**, 7th Edition, John Wiley & Sons, 2005.
3. William Kemp, **Organic Spectroscopy**, 3rd Edition, Palgrave Publishers Ltd.


## 5.56 CY 660: Photocatalysis: Fundamentals and Applications

**Course Code : CY 660**

**Course Name : Photocatalysis: Fundamentals and Applications**

L-T-P-C : 3-0-0-3
Prerequisites : CY 506 and CY 507 or equivalent/ Consent of instructor
Intended for : M.Sc. (Chemistry)and Ph.D.
Distribution : Elective PG and Ph.D
Approval: 14th Senate

**Course Contents**

- **Fundamental Concepts**

  Photocatalyst introduction; light-matter interactions; semiconductor physics; quantum size effects; photoelectrochemistry and redox potentials; type I & II Semiconductors; Z-scheme photocatalytic systems. [8 Lectures]

- **Photochemical Processes**

  Primary processes (homogeneous and heterogeneous) and time scales; natural photosynthesis (PSI & PSII); kinetics and reaction mechanisms; quantum yield and quantum efficiency; photonic yield and photonic efficiency; solar energy conversion efficiency; reactor design; reaction engineering. [8 Lectures]

- **Advanced Photocatalysts**

  Selection of materials; band energy diagrams, band gap and band bending; pure and doped photocatalysts; composite and heterojunctionphotocatalysts; organic photocatalysts; dye- sensitized photocatalysts; strategies for development of efficient photocatalysts; review of current research. [10 Lectures]

- **Investigation Techniques**

  X-ray diffraction; x-ray photoelectron spectroscopy; x-ray absorption spectroscopy; surface area measurements (BET analysis); photophysical measurements (UV-visspectroscopy, KubekkaMunk function for band gap determination, diffuse reflectance spectroscopy, fluorescence spectroscopy); Raman spectroscopy. [6 Lectures]

- **Technological Applications**

  Degradation of organic contaminants in water; removal of metallic and inorganic pollutants; inactivation of microorganisms; artificial photosynthesis (water splitting and carbondioxide reduction); organic transformations; biomass conversion; review of current research. [10 Lectures]

**Text books:**

1. Y. Nosaka, A. Nosaka, **Introduction to Photocatalysis: From Basic Science to Applications**, RSC, 2016.

2. R. Ameta, S. C. Ameta, **Photocatalysis: Principles and Applications**, CRC Press, 2016.

**References:**

1. J. Schneider, D. Bahnemann, J. Ye, G. L. Puma, D. D. Dionysiou (Eds.), **Photocatalysis: Fundamentals and Perspectives**, RSC Energy and Environment Series, 2016.

2. D. Dionysiou, G. L. Puma, J. Ye, J. Schneider, D. Bahnemann (Eds.), **Photocatalysis: Applications**, RSC Energy and Environment Series, 2016.

## 5.57 CY 670: Fluorescence spectroscopy, microscopy and applications

**Course Code: CY 670**

**Course Name: Fluorescence spectroscopy, microscopy and applications**

L-T-P-C: 3-0-0-3
Prerequisites:NA

Intended for : MSc / M. Tech / PhD in Chemistry, Physics, nanotechnology and other discipline relevant to the course content
Distribution :Elective
Approval: 15th Senate

**Course Contents**

- **Introduction to fluorescence spectroscopy**

  Light matter interaction, different processes when light absorbed by matter, light scattering, Fluorescence, Phosphorescence, absorption , Transition moments and t rans ition probabilit i es, Einstein's coefficients, oscillator strength, Beer-Lambert law, polarizabilities, Frank Condon Principles. Steady state fluorescence, Jablonski diagram describing the excited processes, characteristics of fluorescence spectra, Kasha and Vavilov's rule, stokes shift, radiative and nonradiative processes, overview of time and frequency domain measurement, fluorescence lifetime or decay, quantum yield and calculation , time correlated single photon counting (TCSPC), light source and electronics for TCSPC, Instrumentation of steady state and time resolved spectro photometer such as light source, detectors etc. [12 Lectures]

- **Solvent and environment effects**

  Effect of solvent polarity on spectral shift, genera l solvent effect, The Lippart Mataga equation, specific sol vent effect, temperature effect, additional factors affecting the spectra l shift localy excited and internal charge transfer states, excited slate intramolecular proton transfer, dynamics of sol vent effect, time resolved emission spectra (TRES), picosecond spectral relaxation i n solvent, theory for time dependent so l vent relaxation, red edge excitation shift. [4 Lectures]

- **Quenching of fluorescence**

  Reasons of fluorescence quenching, type of quenching, static and dynamic quenching, stem volmer equation , theory of static quenching, mechanism of dynamic quenching, theory of combined quenching, photo- induced electron transfer based quenching, application fo quenching in proteins, DNA dynamics, sensors, molecular beacons based quenching, effect of temperature, viscosity on the quenching. [6 Lectures]

- **Fluorescence resonance Energy Transfer (FRET)**

  Basics of energy transfer, donor acceptor pair, factors affecting the energy transfer, surface energy transfer (SET), difference between FR ET and SET, comparison of quenching and FRET, distance dependent FRET, SET and quenching, metal enhanced fluorescence (M EF), mechanism of MEF, radiative decay engineering in MEF, surface plasmon coupled emission, energy transfer to multiple acceptors in one, two tLecturesee dimentions. [9 Lectures]

- **Fluorescence anisotropy**

  Definition and theory of fluorescence anisotropy, relation of polarization to anisotropy, L and T format for anisotropy, effect of resonance energy transfer on anisotropy, effect of rotational diffusion on fluorescence anisotropy, time dependent anisotropy decay, rotational correlation time, applications of anisotropy on molecular interactions. [4 Lectures]

- **Fluorescence microscopy and single molecule detection**

  Basic principles and applications of wide filed fluorescence microscopy, fluorescence lifetime imaging microscopy (FLIM), confocal microscopy, laser scanning TCSPC FUM, single molecule detection (SMD), optical configuration of SMD, SMD detectors, single molecule based FRET, total internal reflection (TIRF), Fluorescence correlation spectroscopy (FCS), effect of concentration, diffusion coefficient, duel col or fluorescence cross correlation (FCCS), applications of FCS and FCCS. [10 Lectures]

**Text books:**

1. joseph R Lakowicz, **Principles of fluorescence spectroscopy**, 3rd Edition, springer, 2010.

2. Peter Hinterdorfer, Antoine VanOijen, **Handbook of single molecule biophysics**, Springer, 2009.

**References:**

1. R. Riglet, M. Orrit, T Basche, **Single Molecule Spectroscopy: Nobel Conference Lectures**, Springer Series in Chemical Physics, 2012.

2. Yves Engelborghs, Antonie Visser, **Fluorescence Spectroscopy and Microscopy**, springer, 2014.

3. M Valeur and J . C. Brachon, **New Trends in Fluorescence Spectroscopy: Applications to Chemical and Life Sciences**, springer, 2001.

4. Ewa M. Goldys, **Fluorescence Applications in Biotechnology and Life Sciences**, Wiley Blackwell, 2010.

## 5.58 CY 701: Advances Physical Methods in Chemistry Theory and Applications

**Course Code: CY 701**

**Course Name: Advances Physical Methods in Chemistry Theory and Applications**

L-T-P-C: 3-0-0-3
Elective or core: Elective
Students intended for: Ph.D.
Prerequisite: Consent of the faculty member
Approval: 1st Senate

**Course Contents**

- **Quantum Chemistry and molecular symmetry**

  ScLecturesdinger wave equation, Born Oppenheimer Approximation and electronic wave function, particle in a box, potential well, potential barrier and tunneling.

Definition of a group and basic theorems, molecular symmetry groups and classes, symmetry and normal modes of vibrations, determining the symmetry of molecular motions, symmetry and selection rules for allowed transitions among rotational, vibrational level, group theory and molecular electronic transitions. [8 Lectures]

- **Interaction of light with matter**

  Transition moments and transition probabilities, Einsteins coefficients, oscillator strength, Beer-Lambert law, polarizabilities, Frank Condon Principles, Fluorescence and absorption spectroscopy, Quantum yield and its measurements. Donor acceptorcomplexes. Fluorescence quenching (static and dynamic). Stern Volmer analysis. Timescale of molecular processes in solution. Steady state and time-resolved fluorescence. Fluorescence anisotropy. Biochemical fluorophores. New fluorescence technologies: Multiphoton Excitation, Fluorescence correlation Spectroscopy, Single molecule detection. [10 Lectures]

- **Rotational and Vibrational Spectroscopy**

  Moment of inertia, The Rotational energy levels, Rotational spectra of diatomic molecules, Rotational Raman spectra, Molecular vibrations, Selection rules, vibrational spectra of diatomic molecules, simple harmonic oscillator and rigid rotor model,anharmonic corrections, Vibrational-Rotational Spectra, vibrational Raman spectra of diatomic molecules. Infrared absorption spectra of polyatomic molecules, symmetric and asymmetric top molecules, normal modes of vibration and their classification by group theory, coupling between rotational and vibrational degrees of freedom. [7 Lectures]

- **Nuclear Magnetic Resonance Spectroscopy**

  Basic Principles, Chemical shifts, Spinspin interactions. Application of 1H and 13CNMR spectroscopy including COSY, NOESY in the structure determination of bioorganic compounds. Application in conformational analysis. Solid state NMR.Instrumental aspects. Multinuclear NMR of various inorganic and organometalliccompounds. Instrumental aspects. [10 Lectures]

- **Mass spectrometry**

  Basic concepts. Fragmentation and rearrangements (including McLaffertyre arrangement) of different classes of organic molecules. Isotope effect. ESIMS, MALDITOF techniques. [5 Lectures]

**Text Books:**

1. Donald A. McQuarrie and John D. Simon, **Physical Chemistry: A Molecular Approach**, University science books.

2. Peter Atkins and Julio de Paula, **Physical Chemistry**, OUP.

3. K Veera Reddy, **Symmetry and Spectroscopy of molecules** New Age International publishers

4. Joseph R. Lackowicz, **Principles of fluorescence spectroscopy**, Springer.

5. J. M. Hollas, **Modern Spectroscopy**, 4th Edition, John Wiley, 2004.

6. Edmond de Hoffmann and Vincent Stroobant, **Mass Spectrometry: Principles and applications**, 3rd edition John Wiley.

## 5.59 CY 702: Advanced Inorganic Chemistry: Theory and Applications

**Course Code: CY 702**

**Course Name: Advanced Inorganic Chemistry: Theory and Applications**

L-T-P-C: 3-0-0-3
Elective or core: Elective
Students intended for: Ph.D.
Prerequisite: Consent of the faculty member
Approval: 1st Senate

**Course Contents**

- **Structure and Properties of Solids**

  Bonding in metals, Band theory, Density of States, k space and Brillouin Zones; Ionic,covalent and hydrogen bonded solids; electronic properties of solids, conductors, semiconductors, insulators, ferroelectricity, anti-ferroelectricity, piezoelectricity. [10 Lectures]

- **Chemistry of Transition elements and Coordination Chemistry**

  Limitations of VB theory, crystal field theory, crystal field diagrams, ligand field theory,molecular orbital theory; spectrochemical series, nephelauxetic series; structural distortion and lowering of symmetry, electronic, Jahn-Teller effects on energy levels. [10 Lectures]

- **Spectral and Magnetic Properties of Complexes**

  Spectroscopic ground states; Orgel energy level and Tanabe-Sugano diagrams for transition metal complexes; Charge transfer spectra; electronic spectra of octahedral and tetrahedral complexes and calculation of ligand-field parameters. Types of magnetic behaviors- magnetic susceptibility measurements- Gouy method, diamagnetic corrections- spin only value- orbital contribution- spin orbit coupling- ferro and antiferromagnetic coupling- Application of magnetic measurements to structure determinations of transition metal complexes. [8 Lectures]

- **Instrumental Methods for Studying Inorganic Compounds**

  Optical activity in coordination complexes- ORD and CD- cotton effect- applications. Infrared spectroscopy: Nuclear Magnetic Resonance- Mossbauer and Electron Spin Resonance Spectroscopy for structural studies of complexes- Importance of molar conductance studies in coordination chemistry. [6 Lectures]

- **Synthetic Methodologies and Supramolecular Chemistry**

  Ligand design and ligand synthesis: polypyridine, Schiff base, oxime, macrocycle etc.ligands, molecular forces, self-assembly, host / guest chemistry, molecular recognition molecular receptors, supramolecular devices, supramolecular frameworks, molecular machines, molecular/crystal engineering. [6 Lectures]

**Text Books:**

1. A.R. West, **Solid State Chemistry and its Applications**, Wiley India Pvt Ltd (2007)

2. L.V. Azaroff, **Introduction to Solids**, Tata Mgraw Hill (1984)

3. F. A. Cotton, G. Wilkinson, C. M. Murillo and M. Bochmann, **Advanced Inorganic Chemistry**, 6th Edition, Wiley India Pvt Ltd, 2007.

4. J. E. Huheey, E. A. Keiter and R. L. Keiter, **Inorganic Chemistry: Principles of Structure and Reactivity**, 4th Edition, Pearson, 2006.

5. J. D. Lee, **Concise Inorganic Chemistry**, Wiley India Pvt Ltd, 2008.

6. J. W. Steed and J. L. Atwood, **Supramolecular Chemistry**, 2nd Edition, John Wiley and Sons, 2009.

## 5.60 CY 703: Advanced Organic Chemistry

**Course Code: CY 703**

**Course Name: Advanced Organic Chemistry**

L-T-P-C: 3-0-0 - 3
Elective or core: Core
Students intended for: Ph.D.
Prerequisite: M.Sc. Semester: Even/Odd
Approval: 1st Senate

**Course contents**

- **Stereochemistry and Conformational Analysis**

  Enantiomeric relationships, diastereomeric relationships, stereochemistry of reactions, acyclic sp3- sp2 systems, cyclohexane and substituted cyclohexanes, A values, cyclohexene, decalins, anomeric effect, strain. [5 Lectures]

- **Kinetics and thermodynamics of Organic Reactions**

  Free energy relationships, Transition state theory, Intramolecular versus Intermolecular reactions, Kinetic and thermodynamic control, Hammond postulate, principle of microscopic reversibility, isotope effects, isotopes in labeling experiments, characterization of reaction intermediates, catalysis by bronsted acids and bases, catalysis by Lewis acids and bases. [7 Lectures]

- **Reactive Intermediates: Carbanion, carbocation, radical & carbine**

  Carbanions, stability of carbanions, generation of carbanions, SN1 and SN2 mechanisms, carbocations, nucleophilicity and solvent effects, leaving groupe ffects, neighboring group participation, the norbornylcation and other nonclassical carbocations. E1 and E2 mechanisms, regiochemistry of elimination reactions, stereochemistry of E2 elimination reaction, acidity of hydrocarbons, electrophillic aromatic substitution reactions, Structure reactivity relationships, nucleophillic aromatic substitution, generation and characterization of free radicals, characteristics of free radicals, characteristics of reaction mechanisms involving radical intermediates, free radical substitution reactions and free radical addition reactions, generation of carbenes, addition to double bonds, insertion reactions.[12 Lectures]

- **Pericyclic reactions, Photochemistry and Aromaticity**

  Rules governing electrocyclic reactions, sigmatropic rearrangements, cycloaddition reactions, the concept of aromaticity, the annulenes, aromaticity incharged rings, homo aromaticity, fused ring systems, heterocyclic rings, Norrish type I and II reactions and Paterno Buchi reaction, Di-pi-methane rearrangement. [5 Lectures]

- **Strategic applications of named reactions in organic synthesis**

  Alder (ene) reaction, aldol reaction, olefin metathesis, aza Cope rearrangement, Bayer villiger oxidation, Baylis Hillman reaction, Birch reduction, Buchwald-Hartwig reaction, Claisen rearrangement, Cope rearrangement, Dess Martin oxidation, Diels Alder cycloaddition, enyne metathesis, Friedel-Crafts acylation and alkylation, Grignard reaction, Heck reaction, Johnson Claisen rearrangement, Mannich reaction, Mc Murry coupling, Mitsnobu reaction, Nazrov cyclisation, Sharpless asymmetric epoxidation, Shi asymmetric epoxidation,Puasand Khand reaction, Wittig reaction. [6 Lectures]

- **Synthetic Analysis and Design**

  Retrosynthetic analysis, strategic bond analysis, total synthesis of natural products. Assignment on a synthetic target and defend tLecturesough seminar. [5 Lectures]

**Text Books:**


1. F. A. Carey and R. I. Sundberg, **Advanced Organic Chemistry**, Part A, 5th Edition, Springer, 2007.

2. F. A. Carey and R. I. Sundberg, **Advanced Organic Chemistry**, Part B, 5th Edition, Springer, 2007.

3. Michael B. Smith and Jerry March, **Marchs Advanced Organic Chemistry**, 5th Edition, Wiley Interscience, 2001.

4. Jonathan Clayden, Nick Greeves, Stuart Warren and Peter Wrothers, **Organic Chemistry**, Oxford University Press, 2001.

5. Ian Fleming, **Molecular Orbitals and Organic Chemical Reactions: Reference Edition**, John Wiley & Sons, 2010.

6. E. L. Eliel and S. H. Wilen, **Stereochemistry of Organic Compounds**, John Wiley and Sons, 1994.

7. W. Carruthers and Iain Coldham, **Modern Methods of Organic Synthesis**, 4th Edition, Cambridge University Press, 2004.

8. Peter Sykes, **Guidebook to Mechanism in Organic Chemistry**, 6th Edition, Pearson Prentice hall, 1986.

9. Laszlo Kurti and Barbara Czako, **Strategic Applications of Named Reactions in Organic Synthesis**, Academic Press, 2005.

**References:**


1. Goverdhan Mehta, A. Narayana Murthy and D. Siva Kumar Reddy, **A photothermal metathesis approach to perhydro-as-indacenes: rapid construction of the carbocyclic segment of ikarugamycin**, Tetrahedron Letters, 1987, 28, 467-1468.

2. Matthew W. B. Pfeiffer and Andrew J. Phillips, **Total Synthesis of (+) Cyanthiwigin U**, J. Am. Chem. Soc., 2005, 127 (15), pp 5334533.

3. Timothy New house and Phil S.Baran, **Total Synthesis of Psycotrimine**, J. Am. Chem. Soc., 2008, 130 (33), 088610887


## 5.61 CY 704: Introduction to Theoretical Chemistry

**Course Code: CY 704**

**Course Name: Introduction to Theoretical Chemistry**

L-T-P-C: 3-0-0-3
Elective or core: Elective
Students intended for: Ph.D.
Prerequisite: M.Sc. Semester: Odd
Approval: 2nd Senate

**Course contents**

- The Basics of Quantum Mechanics, Model Problems, Exact Solution. [6 Lectures]
- Understanding Energy surfaces, beyond model problems, normal modes, local modes, transition states, symmetry. [6 Lectures]
- An overview of spectroscopy, theoretical chemistry: Structure, bonding, rateof changes, Molecular [6 Lectures]
- Electronic structure: Structure atomic and molecular orbitals, Experimental Probes of Electronic Structure [6 Lectures]
- Statistical Mechanics: Collections of Molecules at or Near Equilibrium,Monte Carlo Evaluation of Properties, Molecular Dynamics Simulations, applications. [10 Lectures]
- Chemical Dynamics: Theoretical Treatment of Chemical Change and Dynamics, Experimental Probes of Reaction Dynamics. [8 Lectures]

**Text & Reference Books:**

1. Jack Simons, **An Introduction to Theoretical Chemistry**, Cambridge University Press, 2003.

2. C. J. Cramer, **Essentials of Computational Chemistry**, Wiley, 2002.

3. R. D. Levine and R. B. Bernstein, **Molecular Reaction Dynamics and Chemical Reactivity**, Oxford University Press, 1997.

4. A. R. Leach, **Molecular Modeling**, 2nd edition, Prentice Hall, 2001.

## 5.62 CY 705: Modern Methods in Organic Synthesis

**Course Code: CY 705**

**Course Name: Modern Methods in Organic Synthesis**

L-T-P-C: 3-0-0-3
Elective or core: Elective
Students intended for: MSc and PhD Students
Prerequisite: Bachelors degree with Chemistry as one of the Subjects
Approval: 2nd Senate

**Course Contents**

- **Asymmetric Synthesis**

  Stereoselective-Directed Aldol Reaction, Diastereofacial selectivity in the Aldol Reaction, Zimmermann-Traxler chair Transition States, Z and E Boron Enolates. Sharpless Asymmetric Dihydroxyltion, AD mix Reagents, Jacobsen catalytic asymmetric epoxide-opening reaction, kinetic resolution of epoxides, Shi Asymmetric epoxidation reaction, Asymmetric Diels Alder Reaction, Nayoris Asymmetric Hydrogenation, Enantioselective addition to C=O bonds, Enantioselective synthesis of Cyclopropanes. [13 Lectures]

- **Reactions involving Organometallics**

  Lithium-Halogen exchange reactions, Magnesium Halogen exchange reactions, Organo Lithiums: production, stability, storage, titrations, additives, and general reactions. Directed orthomettalation reactions, Allyl and Substituted-Allyl Metal Chemistry, Cyclic Closed Transition State, Open Transition State, Cyclic Transition State, Allyl Zincs and Allyl Boron Reagents. Browns Reagent Preparation and uses, Roushs Chiral Borolane Reagent preparation and uses, Allylsilanes, Allylstannanes, Allyl Titanium Reagents. Yamamotos Chiral Silver (I) Complex: Trimethoxy Silanes. [14 Lectures]

- **General Organic Reactions** Suzuki Coupling: Reactions and mechanisms, conditions, catalysts and ligands, synthesis of boronates, sp3- sp3 Suzuki Coupling, strategic application of Suzuki coupling in the synthesis of Discodermolide, Rutamycin B and Epothilone A. Heck Reaction: Reactions and mechanisms, catalyst, regiochemistry, Tandem Heck reactions, enantioselective Heck Reactions. Stille Reaction: Reactions and mechanisms, conditions, synthesis of aryl and vinyl stannanes. Horner-Wadsworth-Emmons Olefination, Petersons Olefination, Oxidations: Oppenaur Oxidation, CLecturesomium (VI) oxidants, IBX, DMP oxidations, N-Oxoammonium mediated oxidation, Oxidation reactions using o-Iodoxybenzoic acid (IBX), Dess-Martin Periodinane (DMP), Rubottom Oxidation. Reductions: Lithium Aluminium Hydride (LAH), Lithium Borohydride, Borane Complexes Luche reduction, Ionic Hydrogenation, Barton Decarboxylation, Radical Dehydrogenation, Diazene-Mediated Deoxygenation. Wolf Kishner Reduction, Clemmensen Reduction. [15 Lectures]

**Text & Reference Books:**


1. Francis Carey and Richard J. Sundberg, **Advanced Organic Chemistry, Part B: Reactions and Synthesis**, V edition, Springer 2007

2. Michael B. Smith and Jerry March. Marchs, **Advanced Organic Chemistry**, 6th Edition, Wiley 2007.

3. J. Clayden, N. Greeves, S. Warren, P. Wothers, **Organic Chemistry**, Oxford, 2006.

4. Laszlo Kurti and Barbara Czako, **Strategic Applications of Named Reactions in Organic Synthesis**, Elsevier Academic Press, 2005.

5. Reinhard Bruckner, **Advanced Organic Chemistry: Reaction Mechanisms**, Elsevier, 2002.


## 5.63 CY 746: Self assembly of surfactants and Polymers in Solution

**Course Code: CY 746**

**Course Name: Self assembly of surfactants and Polymers in Solution**

L-T-P-C: 3-0-0-3
Prerequisites: Consent of the faculty member
Students intended for: Ph.D.
Elective or Core: Elective
Approval: 2nd Senate

**Course Contents**

Classification of surfactants, Basic and applied theories, surface active polymers, properties of surfactants, micelle formation, microemulsions, phase behaviour of surfactant systems, applications in nanomaterial synthesis, emulsion formation and stabilisation, foams, wetting, spreading and adhesion, personal care and cosmetics, pharmaceutical formulations, food industry

**Text & Reference Books:**


1. Milton J. Rosen, **Surfactants and Interfacial Phenomena**, Wiley Interscience.

2. K. Holmberg, B. Jonsson, B. Kronberg, B. Lindman, **Surfactants and Polymers in Aqueous Solution**, John Wiley & Sons Limited.
3. Richard J. Farn, **Chemistry and Technology of Surfactants**, Blackwell Publishing.
4. Tharwat F. Tadors, **Applied Surfactants: Principles and Applications**, Wiley-VCH.
5. John Texter, **Reactions and Synthesis in Surfactant Systems**, Marcel Dekker.

## 5.64 DP 501P: Design Practicum I

**Course Code: DP 501P**

**Course Name : Design Practicum I**

L-T-P-C : 0-0-4-2
Prerequisites : None
Intended for : M.Sc. (Chemistry)
Distribution : Core
Approval: 10th Senate

**Course Description**

This course is offered to the first semester M.Sc. (Chemistry) students in order to give them an exposure to design and research problems right from the start of the program. In this course, each student is assigned to a faculty mentor and performs a detailed study of a particular research problem. The students do extensive literature survey on the assigned research problem and present their works in open seminars.

**Course Evaluation**

Two seminars (mid-term and fmal presentations) of 50% each evaluated by an internal committee.

## 5.65 DP 502P: Design Practicum II

**Course Code: DP 502P**

**Course Name : Design Practicum II**

L-T-P-C : 0-0-4-2
Prerequisites : DP 503P
Intended for : M.Sc. (Chemistry)
Distribution : Core
Approval: 10th Senate

**Course Description**

This course is offered to the second semester M.Sc. (Chemistry) students, wherein each student is assigned to a faculty mentor and performs a short research project under their guidance. The students do literature survey and short research works on the assigned research problem and present their works in open seminars.

**Course Evaluation**

Two seminars (mid-tenn and fmal presentations) of 50% each evaluated by an internal committee.

## 5.66 DP 503P: Basic Mechanical and Electrical Workshop

**Course Code: DP 503P**

**Course Name : Basic Mechanical and Electrical Workshop**

L-T-P-C : 0-0-4-2
Prerequisites : None
Intended for : M.Sc. & Ph.D.
Distribution : Core
Approval: 10th Senate

**Course Contents:**

- **Module 1. Engineering Drawing and Solid Works:**
  - Uses of Engineering Drawing and its importance, Introduction to lines, Scales and surfaces and their uses. Representation of solids using different lines. Dimensioning, unidirectional method and aligned method of dimensioning, symbolic representations of different mechanical and electrical components. Projections: Point, lines, surfaces, solids, and angle projections. Introduction to isometric views and projections.
  - Introduction to CAD modeling techniques and Solid works. Sketching of different two dimensional objects using lines, curves, circle, polygons, arc, etc. Use of extrusion, revolve, extrude cut, revolve cup, linear patterns and others, in order to get three dimensional objects.
- **Module 2. Electronics workshop:**
  - Introduction to CRO (Cathode ray oscilloscope)
  - DSO (Digital storage oscilloscope)
  - Voltage measurement and amplification using Wheat Stone Bridge
  - Temperature measurement (temperature sensor)
  - Binary addition and logic gates (AND, NOR, OR, XOR)
  - Half and full added circuit
  - Introduction to MA TLAB

**Textbooks:**

Not Avaialble

**Reference Books:**

Not Avaialble

## 5.67 DP 504P: Mini Project

**Course Code: DP 504P**

**Course Name : Mini Project**

L-T-P-C : 0-0-8-4
Prerequisites : DP501P & DP502P
Intended for : M.Sc. (Chemistry)
Distribution : Core
Approval: 10th Senate

**Course Description**

This course is offered to the third semester M.Sc. (Chemistry) students, wherein each student is assigned to a faculty mentor and performs a short research project under their guidance. The students, along with the literature survey, start their lab work to get some new results and fmally to present a report at the end of the semester.

**Course Evaluation**

One final presentation of the work done by the student in the current semester. The final presentation has the marks weightage of 60 %. PI contribute 30 % marks seeing on the progress. 1 0 % of the marks for the progress report. All the faculty members will be present in the fmal presentation

## 5.68 DP 505P: Main Project

**Course Code: DP 505P**

**Course Name : Main Project**

L-T-P-C : 0-0-18-9
Prerequisites : DP 503P
Intended for : M.Sc. (Chemistry)
Distribution : Core
Approval: 10th Senate

**Course Description**

This course is offered to the final semester M.Sc. (Chemistry) students, wherein each student is assigned to a faculty mentor and performs a research project under their guidance. The students do extensive research work on a specific research problem and present their fmdings in a fmal seminar.

### Course Evaluation

IIT Mandi ordinance for M.Sc. Chemistry will be strictly followed with regard to evaluation of the main project. In brief, the thesis advisor will have 40% contribution and the evaluation c01mnittee, which may include an extemal examiner, will have 60% contribution to the final marks.

# 6 Data Science and Engineering Courses

## 6.1 DS 201_Old : Data handling and visualization

### Course Number : DS 201

### Course Name : Data handling and visualization

L-T-P-C : 2-0-2-3

Prerequisites : None

Intended for : UG Distribution : Discipline core for B. Tech. Data Science and Engineering, Discipline elective for B. Tech. Computer Science and Engineering, Electrical Engineering, Free elective for other B. Tech. disciplines

### Course Contents

- **Data sources and collection**: This module walks you through the process of data collection. Starting with a review of existing structured and unstructured data sources, we cover data collection techniques using sensors, surveys, and different instruments. This includes data collection and storing for different domains such as IoT, Audio and Video, Web and Social Networks etc. Concepts of Population, Sampling and Experiment Design. [6 Lectures]

- **Data Pre-processing**: Highlight the importance of data correction and discuss some basic features that can affect your data analysis when dealing with sample data. Issues of data access and resources for access are introduced in this module. Issues related to data distribution, outlier detection, data skewing. Descriptive data summarization, data cleaning, normalization, data integration and transformation, data reduction. [7 Lectures]

- **Data representation**: Importance of data representations, Extracting salient features from data, Examples include MFCC from audio signals, histogram representation for text, feature representations for images, encoded representations, Spatial data representation: cartography, GIS paper maps to ArcGIS ArcMap symbolizing, Time-series data representations and curve fitting. Importance of representation in latency of retrieval, storage efficiency, computation, classification / regression performance etc. [9 Lectures]

- **Basic charting and data visualization**: Basic charting, examples with real world weather data, extract and manipulate the data to display the maximum information, various types of graphs like pie chart, bar graphs, 3-D plots using Matlab and R. Examples with Mapbox and GoogleMap APIs. Procedure of composite charts by overlaying a scatter plot of record breaking data for a given year, Visualization of high dimensional data e.g. TSNE plot, histogram etc. Also, data representations and visualization of data using tools such as D3.j, PowerBI, Tableau. [6 Lectures]

### Lab Exercises

Lab to be conducted on a 2-hour slot. It will be conducted in tandem with the theory course so the topics for problems given in the lab are already initiated in the theory class. The topics taught in the theory course should be appropriately be sequenced for synchronization with the laboratory.

**Textbooks:**

1. Yau, Nathan, **Visualize this: the Flowing Data guide to design, visualization, and statistics**, John Wiley & Sons, 2011.
2. 2. Tufte, Edward R., **The visual display of quantitative information**, Vol. 2, CT: Graphics press, 2001.

**Reference books:**

1. Janert, Philipp K., **Data analysis with open source tools: a hands-on guide for programmers and data scientists**, O'Reilly Media, 2010.
2. Zhu, Xuan., **GIS for environmental applications: a practical approach**, Routledge, 2016.

## 6.2 DS 201 : Data Handling and Visualization

**Course Code : DS 201**

**Course Name : Data Handling and Visualization**

L-T-P-C : 2-0-2-3

Intended for : Discipline core for B. Tech. Data Science and Engineering, Discipline elective for B. Tech. Computer Science and Engineering, Electrical Engineering, Free elective for other B. Tech. disciplines

Prerequisite :

Mutual Exclusion:

Approval: 55th BoA

**Course Contents**

- **Data sources and collection**: This module walks you through the process of data collection. Starting with a review of existing structured and unstructured data sources, we cover data collection techniques using sensors, surveys, and different instruments. This includes data collection and storing for different domains such as IoT, Audio and Video, Web and Social Networks etc. (6 Lectures)
- **Data Pre-processing**: Highlight the importance of data correction and discuss some basic features that can affect your data analysis when dealing with sample data. Issues of data access and resources for access are introduced in this module. Descriptive data summarization, data cleaning, normalization, data integration and transformation, data reduction. (7 Lectures)
- **Data representation**: Importance of data representations, Extracting salient features from data, Examples include MFCC from audio signals, histogram representation for text, feature representations for images, encoded representations, Spatial data representation: cartography, GIS paper maps to ArcGIS ArcMap symbolizing, Time-series data representations and curve fitting. (9 Lctures)

- **Basic charting and data visualization**: Basic charting, examples with real world weather data, extract and manipulate the data to display the maximum information, various types of graphs like pie chart, bar graphs, 3-D plots using Matlab and R. Procedure of composite charts by overlaying a scatter plot of record breaking data for a given year, Visualization of high dimensional data e.g. TSNE plot, histogram etc. Also, dynamic data representations and visualization of data using D3. (6 Lectures)

**Lab Exercises:**

Lab to be conducted on a 2-hour slot. It will be conducted in tandem with the theory course so the topics for problems given in the lab are already initiated in the theory class. The topics taught in the theory course should be appropriately be sequenced for synchronization with the laboratory.

**Textbooks:**

1. Yau, Nathan., **Visualize this: the Flowing Data guide to design, visualization, and statistics**, John Wiley & Sons, 2011.

2. Tufte, Edward R., **The visual display of quantitative information**, Vol. 2, Cheshire, CT: Graphics press, 2001.

**References:**

1. Janert, Philipp K., **Data analysis with open source tools: a hands-on guide for programmers and data scientists**, O'Reilly Media, Inc., 2010.

2. Zhu, Xuan., **GIS for environmental applications: a practical approach**, Routledge, 2016.

## 6.3 DS 301 : Mathematical Foundations of Data Science

**Course Code : DS 301**

**Course Name : Mathematical Foundations of Data Science**

L-T-P-C : 3-1-0-4

Intended for : Discipline core for B. Tech. Data Science and Engineering, Discipline elective for B. Tech. Computer Science and Engineering, Electrical Engineering, Free elective for other B. Tech. disciplines

Prerequisite : IC110-Engineering Mathematics, IC111-Linear Algebra

Mutual Exclusion:

Approval: 55th BoA

**Course Contents**

- **Module 1:** Definition of metric spaces, Examples, Open sets, Closed sets, Dense sets, Compact sets, Connectedness, Closure and interior of the sets, Metric subspace. (10 Lectures)

- **Module 2:** Cauchy sequences, Convergent sequences, Complete metric space, , Continuous functions, Continuity of composite functions, Continuity and inverse image of open and closed sets. (10 Lectures)
- **Module 3:** Normed linear spaces, Linear subspaces of normed linear spaces, Banach spaces, Riesz lemma, Continuity of linear maps, Bounded linear maps, Norm equivalence. (10 Lectures)
- **Module 4:** Hilbert spaces, Cauchy -Schwarz inequality, Parallelogram law, Orthogonality, Pythagorean Theorem, Orthogonal projection, orthogonal complement and projection theorem, Orthonormal sets, Orthonormal basis, Gram-Schmidt process, Examples of orthonormal basis. (12 Lectures)

**Textbooks:**

1. Apostol, T., **Mathematical Analysis**, 2nd Edition, Narosa Publishers, 2002.
2. Limaye, B. V., **Functional Analysis**, 2nd Edition, New age international Publishers, 2009.
3. Dan Simovici, **Mathematical Analysis for Machine Learning and Data Mining**, World Scientific, 2018
4. Rudin, W., **Principles of Mathematical Analysis**, 3rd Edition, McGraw-Hill, 2013.

**References:**

1. Stein, E. M. and Shakarchi, M., **Real Analysis**, Princeton Lectures.
2. Tao, T, **Analysis I and II**, Trim, Hindustan book agency.
3. Kreyszig, E., **Introductory Functional Analysis with Applications**, Reprint, 2017
4. Naylor, A. C. and Sell, G. R., **Linear Operator Theory in Engineering and Science**.

## 6.4 DS 301_Old : Mathematical Foundation of Data Science

**Course Number : DS 301**

**Course Name : Mathematical Foundation of Data Science**

Credit s : 3-0-1-4
Prerequisites : IC110, IC111
Students intended for : UG

**Course Contents**

- **Module I**: Definition of metric spaces, Examples, Open sets, Closed sets, Dense sets, Compact sets, Connectedness, Closure and interior of the sets, Metric subspace. [10 Lectures]
- **Module II**: Cauchy sequences, Convergent sequences, Complete metric space, Continuous functions, Continuity of composite functions, Continuity and inverse image of open and closed sets, Banach Contraction mapping theorem, Implicit and Inverse function theorem (statements only). [10 Lectures]
- **Module III**: Normed linear spaces, Linear subspaces of normed linear spaces, Banach spaces, Riesz representation theorem, Continuity of linear maps, Bounded linear maps, Norm equivalence. [10 Lectures]
- **Module IV**: Hilbert spaces, Cauchy -Schwarz inequality, Parallelogram law, Orthogonality, Pythagorean Theorem, Orthogonal projection, orthogonal complement and projection theorem, Orthonormal sets, Orthonormal basis, Gram-Schmidt process, Examples of orthonormal basis. [12 Lectures]

**Text Books:**

1. Apostol, T., **Mathematical Analysis**, 2nd Edition, Narosa Publishers, 2002.
2. Limaye, B. V., **Functional Analysis**, 2nd Edition, New age international Publishers, 2009.
3. Dan Simovici, **Mathematical Analysis for Machine Learning and Data Mining**, World Scientific, 2018
4. Rudin, W., **Principles of Mathematical Analysis**, 3rd Edition, McGraw-Hill, 2013.

**Reference Books:**

1. Stein, E. M. and Shakarchi, M., **Real Analysis**, Princeton Lectures.
2. Tao, T, **Analysis** I and II, Trim, Hindustan book agency.
3. Kreyszig, E., **Introductory Functional Analysis with Applications**, Reprint 2017
4. Naylor, A. C. and Sell, G. R., **Linear Operator Theory in Engineering and Science**.

## 6.5 DS 302_Old : Computing Systems for Data Processing

**Course Number : DS 302**

**Course Name : Computing Systems for Data Processing**

L-T-P-C : 2-0-2-3
Prerequisites : None Intended for : UG

Distribution : Discipline core for B. Tech. Data Science and Engineering, Not allowed to B.Tech. CSE, Discipline elective for B. Tech. Electrical Engineering, Free elective for other B. Tech. disciplines.

**Course Contents**

- **Basics of Computer Organization**: Data representation, machine code, computer arithmetic, code compilation, memory organization and management, memory and run time performance optimization. [8 Lectures]
- **Introduction to Operating Systems**: Responsibilities of OS; process & thread management: process model, states and its structure, process creation and termination, thread models and issues, User/Kernel level threads; inter-process communication, process synchronization, and process scheduling; file systems. [8 Lectures]
- **Introduction to Databases**: Information modeling, ACID properties and Transactions, Trade-offs between Relational Databases and NoSQL, Data Manipulation Language SQL. [8 Lectures]
- **Scalable data processing using MapReduce**: Hadoop Distributed File System, MapReduce programming model. [4 Lectures]

**Text books:**

1. Stallings, William., **Computer Organization and Architecture**, Pearson Education Limited, 2015.
2. Silberschatz, Abraham, Greg Gagne, and Peter B. Galvin., **Operating system concepts**, Wiley, 2018.
3. Elmasri, Ramez, and Sham Navathe, **Fundamentals of database systems**, Pearson, 2017.

**Reference Books:**

1. Forouzan, Behrouz, Catherine Coombs, and Sophia Chung Fegan, **Introduction to data communications and networking**, McGraw-Hill, Inc., 1997.
2. Ramakrishnan, Raghu, and Johannes Gehrke, **Database management systems**, McGraw Hill, 2000.
3. Carl Hamacher, V., Zvonko G. Vranesic, and Safwat G. Zaky, **Computer organization**, 2004.

## 6.6 DS 302 : Computing Systems for Data Processing

**Course Code : DS 302**

**Course Name : Computing Systems for Data Processing**

L-T-P-C : 2-0-2-3

Intended for : Discipline core for B. Tech. Data Science and Engineering, Not allowed to B.Tech. CSE, Discipline elective for B. Tech. Electrical Engineering, Free elective for other B. Tech. disciplines.

Prerequisite : None

Mutual Exclusion:

Approval: 55th BoA

**Course Contents**

- **Basics of Computer Organization**: Data representation, machine code, computer arithmetic, code compilation, memory organization and management, memory and run time performance optimization. (8 Lectures)
- **Introduction to Operating Systems**: Responsibilities of OS; process & thread management: process model, states and its structure, process creation and termination, thread models and issues, User/Kernel level threads; inter-process communication, process synchronization, and process scheduling; file systems. (8 Lectures)
- **Introduction to Databases**: Information modeling, ACID properties and Transactions, Trade-offs between Relational Databases and NoSQL, Data Manipulation Language SQL. (8 Lectures)
- **Scalable data processing using MapReduce**: Hadoop Distributed File System, MapReduce programming model. (4 Lectures)

**Textbooks:**

1. Stallings, William., **Computer Organization and Architecture**, Global Edition, Pearson Education Limited, 2015.
2. Silberschatz, Abraham, Greg Gagne, and Peter B. Galvin., **Operating system concepts**, Wiley, 2018.
3. Elmasri, Ramez, and Sham Navathe, **Fundamentals of database systems**, Pearson, 2017.

**References:**

1. Forouzan, Behrouz, Catherine Coombs, and Sophia Chung Fegan., **Introduction to data communications and networking**, McGraw-Hill, 1997.
2. Ramakrishnan, Raghu, and Johannes Gehrke, **Database management systems**, McGraw Hill, 2000.
3. Carl Hamacher, V., Zvonko G. Vranesic, and Safwat G. Zaky., **Computer organization**, 2004.

## 6.7 DS 303 : Statistical Foundations of Data Science

**Course Code : DS 303**

**Course Name : Statistical Foundations of Data Science**

L-T-P-C : 3-0-0-3

Intended for : Discipline core for B. Tech. Data Science and Engineering, Discipline elective for B. Tech. Computer Science and Engineering, Electrical Engineering, Free elective for other B. Tech. disciplines

Prerequisite : IC110-Engineering Mathematics, IC252-Data Science 2

Mutual Exclusion:

Approval: 55th BoA

**Course Contents**

- **Module I:** Sample space, Sigma field, axiomatic definition of probability, conditional probability and independence, Bayes Rule. (2 lectures)
- **Review**: Random variables – discrete and continuous, probability mass function, probability density function, some standard (important) pdfs, independence, expectation, variance, conditional distribution, conditional expectation, covariance and correlation, Functions of random variables. (7 lectures)
- **Module III**: Probability generating function, moment generating function and characteristic functions – properties and applications. (3 lectures)
- **Module IV**: Convergence of random variables – basic results, inequalities (Markov and Chebyshev), law of large numbers (weak and strong), central limit theorem. (5 lectures)
- **Module V**: Random vectors and covariance and correlation matrix, Random processes – stationarity, WSS, Autocorrelation, cross correlation, power spectral density, Ergodicity. Wiener processes, Markov processes, Poisson Process. (8 lectures)
- **Sampling methods**: Inverse transforms sampling, Rejection sampling, adaptive rejection sampling, importance sampling, Markov chains and MCMC (8 lectures)
- **Graphical models**: ML and MAP estimation, directed and undirected models, Bayesian networks, CRF, Learning and Inference method (ML, MAP, Sampling) (9 lectures)

**Textbooks:**

1. Grimmett, Geoffrey, and David Stirzaker, **Probability and random processes**, Oxford university press, 2001.
2. Bishop, Christopher M., **Pattern recognition and machine learning**, Springer, 2006.

**References:**


1. Ross, Sheldon., **A first course in probability**, Pearson, 2014.

2. Stark, Henry, and John William Woods, **Probability, statistics, and random processes for engineers**, Pearson, 2012.

3. Papoulis, Athanasios, and S. Unnikrishna Pillai, **Probability, random variables, and stochastic processes**, Tata McGraw-Hill Education, 2002.


## 6.8 DS 303_Old : Statistical Foundations of Data Science

**Course Number : DS 303**

**Course Name : Statistical Foundations of Data Science**

L-T-P-C : 3-0-0-3

Prerequisites : IC110-Engineering Mathematics, IC252-Data Science 2

Intended for : UG Distribution : Discipline core for B. Tech. Data Science and Engineering, Discipline elective for B. Tech. Computer Science and Engineering, Electrical Engineering, Free elective for other B. Tech. disciplines

**Course Contents**

- **Module I**: Sample space, Sigma field, axiomatic definition of probability, conditional probability and independence, Bayes Rule. [2 Lectures]

- **Module II**: Review: Random variables – discrete and continuous, probability mass function, probability density function, some standard (important) pdfs, independence, expectation, variance, conditional distribution, conditional expectation, covariance and correlation, Functions of random variables. [7 Lectures]

- **Module III**: Probability generating function, moment generating function and characteristic functions – properties and applications. [3 Lectures]

- **Module VI**: Convergence of random variables – basic results, inequalities (Markov and Chebyshev), law of large numbers (weak and strong), central limit theorem. [5 Lectures]

- **Module V**: Random vectors and covariance and correlation matrix, Random processes – stationarity, WSS, Autocorrelation, cross correlation, power spectral density, Ergodicity. Wiener processes, Markov processes, Poisson Process. (8 lectures)

- **Sampling methods**: Inverse transforms sampling, Rejection sampling, adaptive rejection sampling, importance sampling, Markov chains and MCMC. [8 Lectures]

- **Graphical models**: ML and MAP estimation, directed and undirected models, Bayesian networks, CRF, Learning and Inference method (ML, MAP, Sampling). [9 Lectures]

**Textbooks:**

1. Grimmett, Geoffrey, and David Stirzaker, **Probability and random processes**, Oxford university press, 2001.
2. Bishop, Christopher M, **Pattern recognition and machine learning**, Springer, 2006.

**References:**

1. Ross, Sheldon, **A first course in probability**, Pearson, 2014.
2. Stark, Henry, and John William Woods, **Probability, statistics, and random processes for engineers**, Pearson, 2012.
3. Papoulis, Athanasios, and S. Unnikrishna Pillai, **Probability, random variables, and stochastic processes**, Tata McGraw-Hill Education, 2002.

## 6.9 DS 313_Old : Statistical Foundations of Data Science

**Course Code : DS 313**

**Course Name : Statistical Foundations of Data Science**

L-T-P-C : 3-1-0-4

Intended for : Discipline core for B. Tech. Data Science and Engineering, Discipline elective for B. Tech. Computer Science and Engineering, Electrical Engineering, Free elective for other B. Tech. disciplines

Prerequisite : IC 110 - Engineering Mathematics, IC252 - Data Science 2

Mutual Exclusion: Applied Probability (CS511), Probability and Random Processes (EE532/EE534), Probability & statistics (MA524), Probability and Statistics for Data Science and AI (MB-510)

Approval: 54th BoA

**Course Contents**

- **Module 1**: Sample space, Sigma field, axiomatic definition of probability, conditional probability and independence, Bayes Rule. (2 Hours)
- **Module 2**: Review: Random variables – discrete and continuous, probability mass function, probability density function, some standard (important) pdfs, independence, expectation, variance, conditional distribution, conditional expectation, covariance and correlation, Functions of random variables. (7 Hours)
- **Module 3**: Probability generating function, moment generating function and characteristic functions – properties and applications. (3 Hours)
- **Module 4**: Convergence of random variables – basic results, inequalities (Markov and Chebyshev), law of large numbers (weak and strong), central limit theorem. (5 Hours)

- **Module 5**: Random vectors and covariance and correlation matrix, Random processes – stationarity, WSS, Autocorrelation, cross correlation, power spectral density, Ergodicity. Wiener processes, Markov processes, Poisson Process. (8 Hours)
- **Module 6**: Sampling methods: Inverse transforms sampling, Rejection sampling, adaptive rejection sampling, importance sampling, Markov chains and MCMC. (8 Hours)
- **Module 7**: Graphical models: ML and MAP estimation, directed and undirected models, Bayesian networks, CRF, Learning and Inference method (ML, MAP, Sampling) (9 Hours)

**Tutorial Modules:**

- Same as the course modules. Selected practice problems will be discussed in tutorial sessions.

**Textbooks:**

1. Papoulis, Athanasios, and S. Unnikrishna Pillai, **Probability, random variables, and stochastic processes**, Tata McGraw-Hill Education, 2002.
2. Grimmett, Geoffrey, and David Stirzaker, **Probability and random processes**, Oxford university press, 2001.

**References:**

1. Bishop, Christopher M, **Pattern recognition and machine learning**, Springer, 2006.
2. Ross, Sheldon, **A first course in probability**, Pearson, 2014.
3. Hajek, B., **Random Processes for Engineers**, Cambridge University Press, 2015.

## 6.10 DS 313 : Statistical Foundations of Data Science

**Course Code : DS 313**

**Course Name : Statistical Foundations of Data Science**

L-T-P-C : 3-1-0-4

Intended for : Discipline core for B. Tech. Data Science and Engineering, Discipline elective for B. Tech. Computer Science and Engineering, Electrical Engineering, Free elective for other B. Tech. disciplines; From 2022 UG Batches

Prerequisite : IC110-Engineering Mathematics, IC252-Data Science 2

Mutual Exclusion:

Approval: 55th BoA

**Course Contents**

- **Moeule I**: Sample space, Sigma field, axiomatic definition of probability, conditional probability and independence, Bayes Rule. (2 lectures)
- **Review:** Random variables – discrete and continuous, probability mass function, probability density function, some standard (important) pdfs, independence, expectation, variance, conditional distribution, conditional expectation, covariance and correlation, Functions of random variables. (7 lectures)
- **Module III**: Probability generating function, moment generating function and characteristic functions – properties and applications. (3 lectures)
- **Module IV**: Convergence of random variables – basic results, inequalities (Markov and Chebyshev), law of large numbers (weak and strong), central limit theorem. (5 lectures)
- **Module V**: Random vectors and covariance and correlation matrix, Random processes – stationarity, WSS, Autocorrelation, cross correlation, power spectral density, Ergodicity. Wiener processes, Markov processes, Poisson Process. (8 lectures)
- **Sampling methods**: Inverse transforms sampling, Rejection sampling, adaptive rejection sampling, importance sampling, Markov chains and MCMC (8 lectures)
- **Graphical models**: ML and MAP estimation, directed and undirected models, Bayesian networks, CRF, Learning and Inference method (ML, MAP, Sampling) (9 lectures)

**Textbooks:**


1. Grimmett, Geoffrey, and David Stirzaker, **Probability and random processes**, Oxford university press, 2001.
2. Bishop, Christopher M., **Pattern recognition and machine learning**, Springer, 2006.


**References:**


1. Ross, Sheldon., **A first course in probability**, Pearson, 2014.
2. Stark, Henry, and John William Woods, **Probability, statistics, and random processes for engineers**, Pearson, 2012.
3. Papoulis, Athanasios, and S. Unnikrishna Pillai, **Probability, random variables, and stochastic processes**, Tata McGraw-Hill Education, 2002.


## 6.11 DS 401_Old : Optimization for data science

**Course Number : DS 401**

**Course Name : Optimization for data science**

L-T-P-C : 3-0-0-3

Prerequisites : Linear algebra (IC 111), Engineering Mathematics (IC110), Mathematical Foundations of Data Science – I (DSE-301)

Intended for : UG

Distribution : Discipline core for B. Tech. Data Science and Engineering, Discipline elective for B. Tech. Computer Science and Engineering, Electrical Engineering, Free elective for other B. Tech. disciplines

**Course Contents**

- **Module I**: Affine sets, convex sets, cone, examples – hyperplanes, halfspaces, polyhedra, simplexes, positive semidefinite cones. Operations that preserve convexity. Separating and supporting hyperplanes. Dual cones. [6 Lectures]
- **Module II**: Convex function, first and second order conditions, epigraph, operations that preserve convexity, conjugate function. [5 Lectures]
- **Module III**: Convex optimization – Linear, quadratic, geometric, conic. Formulation of - unconstrained, equality constrained, inequality constrained and both – problems. [5 Lectures]
- **Module IV**: Duality – Lagrange dual function, bounds on the optimal value. Lagrange dual problem, weak and strong duality, optimality conditions. [8 Lectures]
- **Module V**: Gradient methods – Gradient descent, conjugate gradient, accelerated gradient descent, Newton methods, proximal and projected gradient descent, conditional gradient and Frank-Wolfe algorithm, barrier and interior point methods, Dual gradient ascent, ADMM, Stochastic gradient method. [18 Lectures]

**Textbooks:**

1. Boyd, Stephen, and Lieven Vandenberghe, **Convex optimization**, Cambridge university press, 2004.

**Reference books:**

1. Yurii, Nesterov, **Introductory lectures on convex optimization: a basic course**, Kluwer Academic Publishers, 2004.
2. Bertsekas, Dimitri P., **Nonlinear programming**, Journal of the Operational Research Society 48.3 (1997): 334-334.
3. Luenberger, D. G., and Y. Ye, **Linear and nonlinear programming**, Springer, 2008.
4. Nocedal, Jorge, and Stephen Wright, **Numerical optimization**, Springer Science & Business Media, 2006.

## 6.12 DS 401 : Optimization for Data Science

**Course Code : DS 401**

**Course Name : Optimization for Data Science**

L-T-P-C : 3-0-0-3

Intended for : Discipline core for B. Tech. Data Science and Engineering, Discipline elective for B. Tech. Computer Science and Engineering, Electrical Engineering, Free elective for other B. Tech. disciplines

Prerequisite : IC111-Linear Algebra, IC110-Engineering Mathematics, DS301- Mathematical Foundations of Data Science I

Mutual Exclusion:

Approval: 55th BoA

**Course Contents**

- **Module I**: Affine sets, convex sets, cone, examples – hyperplanes, halfspaces, polyhedra, simplexes, positive semidefinite cones. Operations that preserve convexity. Separating and supporting hyperplanes. Dual cones. (6 lectures)
- **Module II**: Convex function, first and second order conditions, epigraph, operations that preserve convexity, conjugate function. (6 lectures)
- **Module III**:Convex optimization – linear, quadratic, geometric, conic, semidefinite programming. Formulation of - unconstrained, equality constrained, inequality constrained and both – problems. (7 lectures)
- **Module VI**:Duality – Lagrange dual function, bounds on the optimal value. Lagrange dual problem, weak and strong duality, optimality conditions. (8 lectures)
- **Module V**: Gradient methods – gradient descent, Lipschitz functions, smooth functions, projected gradient descent, Frank-Wolfe algorithm, Chebyhsev iterations, conjugate gradient, Nesterov's accelerated gradient descent. Dual gradient ascent, ADAM. (10 lectures)
- **Module VI**:Nonconvex optimization – alternating minimization and expectation maximization algorithms, convex relaxations. (5 lectures)

**Textbooks:**

1. Boyd, Stephen, and Lieven Vandenberghe, **Convex optimization**, Cambridge university press, 2004.

**References:**

1. Yurii, Nesterov, **Introductory lectures on convex optimization: a basic course**, Kluwer Academic Publishers, 2004.
2. Luenberger, D. G., and Y. Ye, **Linear and nonlinear programming**, Springer, 2008.
3. Nocedal, Jorge, and Stephen Wright, **Numerical optimization**, Springer Science & Business Media, 2006.

## 6.13 DS 402 : Matrix Computations for Data Science

**Course Code : DS 402**

**Course Name : Matrix Computations for Data Science**

L-T-P-C : 2-0-2-3

Intended for : Discipline core for B. Tech. Data Science and Engineering, Discipline elective for B. Tech. Computer Science and Engineering, Electrical Engineering, Free elective for other B. Tech. disciplines

Prerequisite : IC110-Engineering Mathematics, IC111-Linear Algebra

Mutual Exclusion:

Approval: 55th BoA

**Course Contents**

- **Basics**: Errors in numerical computations. Review matrices and transformations, Matrix and Vector Norms. (2 lectures)
- **Matrix factorizations**: Cholesky factorization, QR factorization, Householder reflectors and Givens rotations. LU factorization and Gaussian elimination. Numerical stability Pivoting strategies and solution of triangular and full systems by factorization. (5 lectures)
- **Eigenvalue problem**: Basic theory, Power method, bisection method, QR algorithm. Similarity reduction. (4 lectures)
- **Linear least squares problem**: Singular value decomposition, Moore-Penrose Pseudoinverse. Perturbation theory. Least square and normal equations. SVD and rank deficiency, Principal Component Analysis, Linear Discriminant Analysis. (6 lectures)
- **Iterative methods for linear systems**: Iterative methods for linear systems Iterative methods: Jacobi, Gauss-Seidel and SOR iterations. Kronecker product. Krylov subspace methods, conjugate gradient method, preconditioning. (5 lectures)
- **Sparse and banded linear systems**: Storage schemes for banded and sparse matrices, Sparse matrices and sparse solutions: approximate inverses, eigenvalues, incomplete factorization. Matrix regularization: matrix completion. (6 lectures)

**Lab Exercises:**

Lab would be conducted on a 2-hour weekly slot. Lab sessions would be conducted in tandem with the theory course so the topics for problems given in the lab are already initiated in the theory class.

**Textbooks:**


1. Trefethen, Lloyd N., and David Bau III, **Numerical linear algebra**, Vol. 50, SIAM, 1997.
2. Eldén, Lars., **Matrix methods in data mining and pattern recognition**, Vol. 4, SIAM, 2007.

**References:**

1. Watkins, David S., **Fundamentals of matrix computations**, Vol. 64. John Wiley & Sons, 2004.

2. Demmel, James W., **Applied numerical linear algebra**, Vol. 56. SIAM, 1997.

3. Golub, Gene H., and Charles F. Van Loan., **Matrix computations**, Vol. 3. JHU press, 2012.

4. Cullen, Charles G., **An introduction to numerical linear algebr**a, PWS Publishing Company, 1994.

## 6.14 DS 402_Old : Matrix Computations for Data Science

**Course Number : DS 402**

**Course Name : Matrix Computations for Data Science**

Credits : 2-0-2-3

Prerequisites : IC110-Engineering Mathematics, IC111-Linear Algebra

Intended for : UG

Distribution : Discipline core for B. Tech. Data Science and Engineering, Discipline elective for B. Tech. Computer Science and Engineering, Electrical Engineering, Free elective for other B. Tech. disciplines Semester : odd/even

**Course Contents**

- **Basics**: Errors in numerical computations. Review matrices and transformations, Vector and Matrix Norms. [2 Lectures]

- **Matrix factorizations**: Gaussian elimination and LU factorization , Cholesky factorization, QR factorization, Givens rotations and Householder reflectors. Numerical stability, Pivoting strategies and solution of triangular and full systems by factorization. [5 Lectures]

- **Eigenvalue problem**: Basic theory, Power method, LR and QR algorithms, Given's and Householder's methods for symmetric matrices. [5 Lectures]

- **Linear least squares problem**: Singular value decomposition, SVD and rank deficiency, Moore-Penrose Pseudo inverse. Perturbation theory. Least square and normal equations., Principal Component Analysis, Linear Discriminant Analysis. [6 Lectures]

- **Iterative methods for linear systems**: Iterative methods for linear systems, Iterative methods: Jacobi, Gauss-Seidel and SOR iterations. Krylov subspace methods, conjugate gradient method, preconditioning. [5 Lectures]

- **Sparse and banded linear systems**: Storage schemes for banded and sparse matrices, solutions of Sparse Linear Systems: approximate inverses, eigenvalues, incomplete factorization. Matrix regularization: matrix completion. [5 Lectures]

**Textbooks:**

1. Trefethen, Lloyd N., and David Bau III, **Numerical linear algebra**, Vol. 50. SIAM, 1997.

2. Elden, Lars., **Matrix methods in data mining and pattern recognition**, Vol. 4, SIAM, 2007.

**References**

1. Watkins, David S., **Fundamentals of matrix computations**, Vol. 64, John Wiley & Sons, 2004.

2. Demmel, James W., **Applied numerical linear algebra**, Vol. 56, SIAM, 1997.

3. Golub, Gene H., and Charles F. Van Loan, **Matrix computations**, Vol. 3, JHU press, 2012.

## 6.15 DS 403_Old : Introduction to Statistical Learning

**Course Number : DS 403**

**Course Name : Introduction to Statistical Learning**

L-T-P-C : 2-0-2-3

Prerequisites : IC272 – Data Science-3, DS201 - Data Handling and visualization or equivalent, DS303 – Statistical Foundations of Data Science or equivalent, DS402 – Matrix Computations for Data Science

Intended for : UG

Distribution : Discipline core for B. Tech. Data Science and Engineering, Discipline elective for B. Tech. Computer Science and Engineering, Electrical Engineering, Free elective for other B. Tech. disciplines

**Course Contents**

- **Introduction to learning from data**: Introduction to supervised learning and unsupervised learning. [2 Lectures]

- **Supervised learning**: **Regression**: Linear regression models and least squares, Shrinkage methods: ridge regression and the LASSO. [6 Lectures]

- **Supervised learning: Classification**: Logistic regression, nearest neighbour's method, Bayes classifier with unimodal and multimodal density - maximum likelihood estimation, expectation-maximization (EM) algorithm; decision trees, support vector machines (SVMs), basics of neural networks. [8 Lectures]

- **Model Assessment and Selection**: Bias, variance and model complexity, The Bayesian approach, AIC and BIC, cross-validation, bootstrap methods, hypothesis testing, confidence intervals, significance testing. [6 Lectures]

- **Unsupervised learning**: Introduction to association rules, clustering, and dimension reduction. [6 Lectures]

**Lab Exercises:**

Lab to be conducted on a 2-hour slot. It will be conducted in tandem with the theory course so the topics for problems given in the lab are already initiated in the theory class. The topics taught in the theory course should be appropriately be sequenced for synchronization with the laboratory.

**Textbooks:**

1. Hastie, T., Tibshirani, R. and Friedman, J., The Elements of Statistical Learning: Data Mining, Inference, and Prediction, 2nd Edition, Springer, 2017.

**Reference books:**

1. Duda, R. O., Hart, P. E. and Stork, D. G., **Pattern Classification**, John Wiley, 2001.
2. Bishop, C. M., **Pattern Recognition and Machine Learning**, Springer, 2006.
3. Theodoridis, S. and Koutroumbas, K., **Pattern Recognition**, Academic Press, 2009.

## 6.16 DS 403 : Introduction to Statistical Learning

**Course Code : DS 403**

**Course Name : Introduction to Statistical Learning**

L-T-P-C : 2-0-2-3

Intended for : Discipline core for B. Tech. Data Science and Engineering, Discipline elective for B. Tech. Computer Science and Engineering, Electrical Engineering, Free elective for other B. Tech. disciplines

Prerequisite :DS201 - Data Handling and visualization or equivalent, DS303 – Statistical Foundations of Data Science or equivalent, DS402 – Matrix Computations for Data Science

Mutual Exclusion:

Approval: 55th BoA

**Course Contents**

- Introduction to learning from data: Introduction to supervised learning and unsupervised learning. (2 Lecture)
- Supervised learning: Regression: Linear regression models and least squares, Shrinkage methods: ridge regression and the LASSO. (6 Lectures)
- Supervised learning: Classification: Logistic regression, nearest neighbour's method, Bayes classifier with unimodal and multimodal density - maximum likelihood estimation, expectation-maximization (EM) algorithm; decision trees, support vector machines (SVMs), basics of neural networks(8 Lectures)

- Model Assessment and Selection: Bias, variance and model complexity, The Bayesian approach, AIC and BIC, cross-validation, bootstrap methods, hypothesis testing, confidence intervals, significance testing. (6 Lectures)
- Unsupervised learning: Introduction to association rules, clustering, and dimension reduction. (6 Lectures)

**Lab Exercises:**

Lab to be conducted on a 2-hour slot. It will be conducted in tandem with the theory course so the topics for problems given in the lab are already initiated in the theory class. The topics taught in the theory course should be appropriately be sequenced for synchronization with the laboratory.

**Textbooks:**

1. Hastie, T., Tibshirani, R. and Friedman, J., **The Elements of Statistical Learning: Data Mining, Inference, and Prediction**, 2nd Edition, 12th Reprint, Springer, 2017.

**References:**

1. Duda, R. O., Hart, P. E. and Stork, D. G., **Pattern Classification**, John Wiley, 2001.
2. Bishop, C. M., **Pattern Recognition and Machine Learning**, Springer, 2006.
3. Theodoridis, S. and Koutroumbas, K., **Pattern Recognition**, Academic Press, 2009.

## 6.17 DS 404 : Information Security and Privacy

**Course Code : DS 404**

**Course Name : Information Security and Privacy**

L-T-P-C : 3-0-0-3

Intended for : Discipline core for B. Tech. Data Science and Engineering, Discipline elective for B. Tech. Computer Science and Engineering, Electrical Engineering, Free elective for other B. Tech. disciplines

Prerequisite : DS203-Mathematical Foundations of Data Science I

Mutual Exclusion:

Approval: 55th BoA

**Course Contents**

- **Introduction to information security**: Information security models; attacks, threats, vulnerabilities, and risks. Operations security: Haas' Laws. Identification and authentication: identity verification, falsifying identification, multifactor and mutual authentication, passwords, biometrics, hardware tokens, performance evaluation. Authorization and access control: principle of least privilege, access control lists, and access control methodologies, physical security and access controls.

Auditing and accountability: non-repudiation, deterrence, intrusion detection and prevention, logging, monitoring, assessments. (8 Lectures)

- **Cryptography**: Protocols (key exchange, public key cryptography, secret sharing), techniques (key length, key management, etc), cryptographic algorithms (mathematical background, data encryption standard, block and stream ciphers, public-key, digital signatures). (8 Lectures)
- **Network security**: Protecting networks and network traffic, mobile device security, network security tools. (6 Lectures)
- **Operating system security**: OS hardening, protecting against malware, firewalls and host intrusion detection, OS security tools. (4 Lectures)
- **Application security**: Software development vulnerabilities, web security, database security, and application security tools. (6 Lectures)
- **Information privacy**: Static and dynamic data anonymization and threats to anonymization, privacy in synthetic and test data, privacy regulations. (6 Lectures)
- **Information Ethics**: Ownership, privacy, anonymity, validity, algorithmic fairness, societal consequences, code of ethics, attributions. (4 Lectures)

**Textbooks:**

1. Andress, J. and Winterfeld, S., **The Basics of Information Security**, 2nd Edition, Syngress, 2014.
2. Venkataraman, N. and Shriram, A., **Data Privacy: Principles and Practice**, Chapman and Hall/CRC, 2016.

**References:**

1. Guise, P. D., **Data Protection**, Routledge, 2017.
2. Katz, J. and Lindell, Y., **Introduction to Modern Cryptography**, Chapman and Hall/CRC, 2015.
3. Torra, V., **Data Privacy: Foundations and the Big data Challenge**, Springer, 2017.
4. Weigand, A., **Data for the People**, Basic Books, 2017.

## 6.18 DS 404_Old : Information Security and Privacy

**Course Number : DS 404**

**Course Name : Information Security and Privacy**

Credits : 3-0-0-3
Prerequisites : IC152 or any other programming course
Intended for : B.Tech.

Distribution : Discipline core for B. Tech. Data Science and Engineering, Discipline elective for B. Tech. Computer Science and Engineering, Electrical Engineering, Free elective for other B. Tech. disciplines

**Course Contents**

- **Introduction to information security**:
  - Information security models; attacks, threats, vulnerabilities, and risks. Operations security: Haas' Laws. Identification and authentication: identity verification, falsifying identification, multifactor and mutual authentication, passwords, biometrics, hardware tokens, performance evaluation.
  - Authorization and access control: principle of least privilege, access control lists, and access control methodologies, physical security and access controls. Auditing and accountability: non-repudiation, deterrence, intrusion detection and prevention, logging, monitoring, assessments. [8 Lectures]
- **Cryptography**: Protocols (key exchange, public key cryptography, secret sharing), techniques (key length, key management, etc), cryptographic algorithms (mathematical background, data encryption standard, block and stream ciphers, public-key, digital signatures). [8 Lectures]
- **Network security**: Protecting networks and network traffic, mobile device security, network security tools. [6 Lectures]
- **Operating system security**: OS hardening, protecting against malware, firewalls and host intrusion detection, OS security tools. [4 Lectures]
- **Application security**: Software development vulnerabilities, web security, database security, and application security tools. [6 Lectures]
- **Information privacy**: Static and dynamic data anonymization and threats to anonymization, privacy in synthetic and test data, privacy regulations. [6 Lectures]
- **Information Ethics**: Ownership, privacy, anonymity, validity, algorithmic fairness, societal consequences, code of ethics, attributions. [4 Lectures]

**Text Books:**


1. Andress, J. and Winterfeld, S., **The Basics of Information Security**, 2nd Edition, Syngress, 2014.
2. Venkataraman, N. and Shriram, A., **Data Privacy: Principles and Practice**, Chapman and Hall/CRC, 2016.


**Reference Books:**


1. Guise, P. D., **Data Protection**, Routledge, 2017.
2. Katz, J. and Lindell, Y., **Introduction to Modern Cryptography**, Chapman and Hall/CRC, 2015.

3. Torra, V., **Data Privacy: Foundations and the Big data Challenge**, Springer, 2017.

4. Weigand, A., **Data for the People**, Basic Books, 2017.

5. William Stallings and Lawrie Brown, **Computer Security -- Principles and Practice**, 3rd Edition. Pearson.

## 6.19 DS 411_Old : Optimization for Data Science

**Course Code : DS 411**

**Course Name : Optimization for Data Science**

L-T-P-C : 3-1-0-4
Intended for : UG
Prerequisite : IC111-Linear Algebra, IC110-Engineering Mathematics, DS301- Mathematical Foundations for Data Science
Mutual Exclusion:
Approval: 54th BoA

**Course Contents**

- **Module 1**: Affine sets, convex sets, cone, examples – hyperplanes, half-spaces, polyhedra, simplexes, positive semidefinite cones. Operations that preserve convexity. Separating and supporting hyperplanes. Dual cones. (6 Hours)
- **Module 2**: Convex function, first and second order conditions, epigraph, operations that preserve convexity, conjugate function. (6 Hours)
- **Module 3**: Convex optimization – linear, quadratic, geometric, conic, semidefinite programming. Formulation of - unconstrained, equality constrained, inequality constrained and both – problems. (7 Hours)
- **Module 4**: Duality – Lagrange dual function, bounds on the optimal value. Lagrange dual problem, weak and strong duality, optimality conditions. (8 Hours)
- **Module 5**: Gradient methods – gradient descent, Lipschitz functions, smooth functions, projected gradient descent, Frank-Wolfe algorithm, Chebyhsev iterations, conjugate gradient, Nesterov's accelerated gradient descent. Dual gradient ascent, ADAM. (10 Hours)
- **Module 6**: Nonconvex optimization – alternating minimization and expectation maximization algorithms, convex relaxations. (5 Hours)

**Textbooks:**

1. Boyd, Stephen, and Lieven Vandenberghe, **Convex optimization**, Cambridge university press, 2004.

**References:**

1. Yurii, Nesterov, **Introductory lectures on convex optimization: a basic course**, Kluwer Academic Publishers, 2004.

2. Luenberger, D. G., and Y. Ye, **Linear and nonlinear programming**, Springer, 2008.

3. Nocedal, Jorge, and Stephen Wright, **Numerical optimization**, Springer Science & Business Media, 2006.

## 6.20 DS 411 : Optimization for Data Science

**Course Code : DS 411**

**Course Name : Optimization for Data Science**

L-T-P-C : 3-1-0-4

Intended for : Discipline core for B. Tech. Data Science and Engineering, Discipline elective for B. Tech. Computer Science and Engineering, Electrical Engineering, Free elective for other B. Tech. disciplines

Prerequisite : IC111-Linear Algebra, IC110-Engineering Mathematics, DS301- Mathematical Foundations of Data Science I

Mutual Exclusion:

Approval: 55th BoA

**Course Contents**

- **Module I:** Affine sets, convex sets, cone, examples – hyperplanes, halfspaces, polyhedra, simplexes, positive semidefinite cones. Operations that preserve convexity. Separating and supporting hyperplanes. Dual cones. (6 lectures)

- **Module II:** Convex function, first and second order conditions, epigraph, operations that preserve convexity, conjugate function. (6 lectures)

- **Module III:** Convex optimization – linear, quadratic, geometric, conic, semidefinite programming. Formulation of - unconstrained, equality constrained, inequality constrained and both – problems. (7 lectures)

- **Module VI:** Duality – Lagrange dual function, bounds on the optimal value. Lagrange dual problem, weak and strong duality, optimality conditions. (8 lectures)

- **Module V:** Gradient methods – gradient descent, Lipschitz functions, smooth functions, projected gradient descent, Frank-Wolfe algorithm, Chebyhsev iterations, conjugate gradient, Nesterov's accelerated gradient descent. Dual gradient ascent, ADAM. (10 lectures)

- **Module VI:** Nonconvex optimization – alternating minimization and expectation maximization algorithms, convex relaxations. (5 lectures)

**Textbooks:**

1. Boyd, Stephen, and Lieven Vandenberghe, **Convex optimization**, Cambridge university press, 2004.

**References:**

1. Yurii, Nesterov, **Introductory lectures on convex optimization: a basic course**, Kluwer Academic Publishers, 2004.

2. Luenberger, D. G., and Y. Ye, **Linear and nonlinear programming**, Springer, 2008.

3. Nocedal, Jorge, and Stephen Wright, **Numerical optimization**, Springer Science & Business Media, 2006.

## 6.21 DS 412 : Matrix Computations for Data Science

**Course Code : DS 412**

**Course Name : Matrix Computations for Data Science**

L-T-P-C : 3-0-2-4

Intended for : Discipline core for B. Tech. Data Science and Engineering, Discipline elective for B. Tech. Computer Science and Engineering, Electrical Engineering, Free elective for other B. Tech. disciplines

Prerequisite : IC 110-Engineering Mathematics, IC 111-Linear Algebra; From 2022 UG Batches

Mutual Exclusion:

Approval: 55th BoA

**Course Contents**

- **Basics**: Errors in numerical computations. Review matrices and transformations, Matrix and Vector Norms. (2 lectures)

- **Matrix factorizations**: Cholesky factorization, QR factorization, Householder reflectors and Givens rotations. LU factorization and Gaussian elimination. Numerical stability Pivoting strategies and solution of triangular and full systems by factorization. (5 lectures)

- **Eigenvalue problem**: Basic theory, Power method, bisection method, QR algorithm. Similarity reduction. (4 lectures)

- **Linear least squares problem**: Singular value decomposition, Moore-Penrose Pseudoinverse. Perturbation theory. Least square and normal equations. SVD and rank deficiency, Principal Component Analysis, Linear Discriminant Analysis. (6 lectures)

- **Iterative methods for linear systems** : Iterative methods for linear systems Iterative methods: Jacobi, Gauss-Seidel and SOR iterations. Kronecker product. Krylov subspace methods, conjugate gradient method, preconditioning. (5 lectures)

- **Sparse and banded linear systems**: Storage schemes for banded and sparse matrices, Sparse matrices and sparse solutions: approximate inverses, eigenvalues, incomplete factorization. Matrix regularization: matrix completion. (6 lectures)

**Lab Exercises:**

Lab would be conducted on a 2-hour weekly slot. Lab sessions would be conducted in tandem with the theory course so the topics for problems given in the lab are already initiated in the theory class.

**Textbooks:**


1. Trefethen, Lloyd N., and David Bau III, **Numerical linear algebra**, Vol. 50, SIAM, 1997.

2. Eldén, Lars., **Matrix methods in data mining and pattern recognition**, Vol. 4. SIAM, 2007.


**References:**


1. Watkins, David S., **Fundamentals of matrix computations**, Vol. 64, John Wiley & Sons, 2004.

2. Demmel, James W., **Applied numerical linear algebra**, Vol. 56, SIAM, 1997.

3. Golub, Gene H., and Charles F. Van Loan., **Matrix computations**, Vol. 3, JHU press, 2012.

4. Cullen, Charles G., **An introduction to numerical linear algebra**, PWS Publishing Company, 1994.


## 6.22 DS 412_Old : Matrix Computations for Data Science

**Course Code : DS 412**

**Course Name : Matrix Computations for Data Science**

L-T-P-C : 3-0-2-4
Intended for : UG
Prerequisite : IC111-Linear Algebra, IC110-Engineering Mathematics
Mutual Exclusion:
Approval: 54th BoA

**Course Contents**

- **Basics**: Errors in numerical computations. Review matrices and Block matrix, Linear Transformations: matrices, Projection Transformations, Reflection Transformations, and Rotational Transformations, compositions of Linear Transformations, Matrix and Vector Norms. (10 Hours)

- **Matrix factorizations**: Cholesky factorization, QR factorization, Householder reflectors and Givens rotations. LU factorization and Gaussian elimination. Numerical stability Pivoting strategies and solution of triangular and full systems by factorization. (6 Hours)
- **Eigenvalue problem**: Basic theory, Power method, bisection method, QR algorithm. Similarity reduction. (5 Hours)
- **Linear least squares problem**: Jordan decomposition: Uniqueness and similarities, Existence and computation, Matrix functions, Singular value decomposition, Moore-Penrose Pseudoinverse. Perturbation theory. Least square and normal equations. SVD and rank deficiency, Principal Component Analysis, Linear Discriminant Analysis. (8 Hours)
- **Iterative methods for linear systems**: Iterative methods for linear systems Iterative methods: Jacobi, Gauss-Seidel and SOR iterations. Kronecker product. Krylov subspace methods, conjugate gradient method, preconditioning. (7 Hours)
- **Sparse and banded linear systems**: Storage schemes for banded and sparse matrices, Sparse matrices and sparse solutions: approximate inverses, eigenvalues, incomplete factorization. Matrix regularization: matrix completion. (6 Hours)

**Laboratory/practical/tutorial Modules:**

Lab would be conducted on a 2-hour weekly slot. Lab sessions would be conducted in tandem with the theory course so the topics for problems given in the lab are already initiated in the theory class.

**Textbooks:**


1. Trefethen, Lloyd N., and David Bau III, **Numerical linear algebra**, Vol. 50. SIAM, 1997.
2. Elden, Lars, **Matrix methods in data mining and pattern recognition**, Vol. 4. SIAM, 2007.


**References:**


1. Watkins, David S., **Fundamentals of matrix computation**s, Vol. 64. John Wiley & Sons, 2004.
2. Demmel, James W, **Applied numerical linear algebra**, Vol. 56. SIAM, 1997.
3. Golub, Gene H., and Charles F. Van Loan, **Matrix computations**, Vol. 3. JHU press, 2012.
4. Cullen, Charles G., **An introduction to numerical linear algebra**, PWS Publishing Company, 1994.

## 6.23 DS 413_Old : Introduction to Statistical Learning

**Course Code : DS 413**

**Course Name : Introduction to Statistical Learning**

L-T-P-C : 3-1-0-4
Intended for : UG
Prerequisite :IC 272 – Data Science-3, IC111 – Linear Algebra, IC152 – Computing and Data Science, IC252 - Probability and Statistics (Data Science 2)
Mutual Exclusion:
Approval: 54th BoA

**Course Contents**

- Introduction to learning from data: (4 Hours)
  - Introduction to supervised learning and unsupervised learning.
  - Introduction to statistical learning
  - Statistical Models, Supervised Learning and Function Approximation
- Supervised learning: Regression (7 Hours)
  - Linear regression models and least squares
  - Shrinkage methods: ridge regression
  - The LASSO
  - Logistic regression.
- Supervised learning: Classification (12 Hours)
  - Bayes Decision Theory (Taken from PR)
    * Minimum-error-rate classification
    * Classifiers, Discriminant functions, Decision surfaces
    * Normal density and discriminant functions
    * Discrete features
  - Bayes classifier with unimodal and multimodal density - maximum likelihood estimation and MAP (class density estimation), Expectation-Maximization (EM) algorithm
  - Decision trees: Classification and Regression Trees (CART) (Random Forest)
  - K - nearest neighbour
  - Perceptron
  - Support vector machine (SVM)
- Model Assessment and Selection: (9 Hours)
  - Bias, variance and model complexity
  - The Bayesian approach, AIC and BIC,cross-validation

- Bootstrap methods, hypothesis testing, confidence intervals, significance testing,Ensemble learning

- Unsupervised learning: (10 Hours)
  - Introduction to association rules, clustering, and dimension reduction.
  - Principal component analysis (PCA) – Optimization formulation and kernel PCA
  - Linear discriminant analysis (LDA)

**Laboratory/practical/tutorial Modules:**

Lab would be conducted on a 2-hour weekly slot. Lab sessions would be conducted in tandem with the theory course so the topics for problems given in the lab are already initiated in the theory class.

**Textbooks:**


1. Hastie, T., Tibshirani, R. and Friedman, J., **The Elements of Statistical Learning: Data Mining, Inference, and Prediction**, 2nd Edition, 12th Reprint, Springer, 2017


**References:**


1. Duda, R. O., Hart, P. E. and Stork, D. G., **Pattern Classification**, John Wiley, 2001.
2. Bishop, C. M., **Pattern Recognition and Machine Learning**, Springer, 2006.
3. Theodoridis, S. and Koutroumbas, K., **Pattern Recognition**, Academic Press, 2009.


## 6.24 DS 413 : Introduction to Statistical Learning

**Course Code : DS 413**

**Course Name : Introduction to Statistical Learning**

L-T-P-C : 3-1-0-4

Intended for : Discipline core for B. Tech. Data Science and Engineering, Discipline elective for B. Tech. Computer Science and Engineering, Electrical Engineering, Free elective for other B. Tech. disciplines

Prerequisite : DS201 - Data Handling and visualization or equivalent, DS303 – Statistical Foundations of Data Science or equivalent, DS402 – Matrix Computations for Data Science; From 2022 UG Batches

Mutual Exclusion:

Approval: 55th BoA

**Course Contents**

- **Introduction to learning from data**: Introduction to supervised learning and unsupervised learning. (2 Lectures)
- **Supervised learning: Regression**: Linear regression models and least squares, Shrinkage methods: ridge regression and the LASSO. (6 Lectures)
- **Supervised learning: Classification**: Logistic regression, nearest neighbour's method, Bayes classifier with unimodal and multimodal density - maximum likelihood estimation, expectation-maximization (EM) algorithm; decision trees, support vector machines (SVMs), basics of neural networks. (8 Lectures)
- **Model Assessment and Selection**: Bias, variance and model complexity, The Bayesian approach, AIC and BIC, cross-validation, bootstrap methods, hypothesis testing, confidence intervals, significance testing. (6 Lectures)
- **Unsupervised learning**: Introduction to association rules, clustering, and dimension reduction. (6 Lectures)

**Lab Exercises:**

Lab to be conducted on a 2-hour slot. It will be conducted in tandem with the theory course so the topics for problems given in the lab are already initiated in the theory class. The topics taught in the theory course should be appropriately be sequenced for synchronization with the laboratory.

**Textbooks:**

1. Hastie, T., Tibshirani, R. and Friedman, J., **The Elements of Statistical Learning: Data Mining, Inference, and Prediction**, 2nd Edition, 12th Reprint, Springer, 2017.

**References:**

1. Duda, R. O., Hart, P. E. and Stork, D. G., **Pattern Classification**, John Wiley, 2001.
2. Bishop, C. M., **Pattern Recognition and Machine Learning**, Springer, 2006.
3. Theodoridis, S. and Koutroumbas, K., **Pattern Recognition**, Academic Press, 2009.

# 7 Electrical Engineering Courses

## 7.1 EE 101 Electrical Science

Course Code: EE-101
Course Name: Electrical Science
L-T-P-C:3-1-2-4
Pre-requisite: NIL Sem. Both
Approval: 5th Senate
Equivalent Course: IC 160

**Course Contents:**

- **Network Fundamentals**: Types of Sources and Elements, Kirchoff's Laws, Mesh and Node Analysis of D.C. Networks.
- **Transient Analysis**: RL & RC circuits.
- **Network Theorems**: Thevenin's Theorem, Norton's Theorem, Superposition Theorem, Maxi- mum Power Theorem, Star-Delta Transformation.
- **A.C. Fundamentals**: Concept of Phasor, Impedance and Admittance, Mesh and Node analysis of Single Phase AC Networks, Network Theorems in AC Networks, Active and Reactive Power in AC Circuits, Resonance in Series AC Circuits.
- **Introduction to 3-phase A.C. Circuits**: Analysis of 3-phase balanced start-delta circuits, Power in 3-phase Circuits.
- **Magnetic Circuit Concepts**: Analogy with Electrical Circuits, Calculation for series, parallel and series parallel magnetic circuits, Eddy current and Hysteresis losses.
- **Single Phase Transformer**: Basic constructional features, Operating principle, Phasor diagram, Equivalent Circuit, Voltage regulation, Efficiency, Open circuit and Short Circuit tests.
- **D.C. Machines** : Principle of operation, Basic constructional features, Emf and torques equation, Armature reaction, Types of Excitation and Generator characteristics, Types of D.C. motors, Starting and speed control of D.C. motors.
- **Machines**: Three phase Induction Motor: Operating principle, Constructional features, Equivalent circuits, Torque-speed characteristics, Starting and speed control. Synchronous Generator: Basic principle of operation, Emf equation, Constructional features.
- **Measurement of Electrical Quantities**: Measurement of Voltage, Current, Power and Energy, Moving Iron Instruments, Measurement of 3 phase power, Accuracy class of meters.

**References:**


1. Mukhopadhyaya P., Pant A. K., Kumar V. and Chittore D. S., **Elements of Electrical Science**, M/s Nem Chand & Brothers.

2. Vincent Del Toro, **Electrical Engineering Fundamentals**, Prentice Hall of India.

3. Kothari D. P., Nagrath I. J., **Theory and Problems of Basic Electrical Engineering**, Prentice Hall of India.

4. Hayt W. H., Kemmerly J. E. and Durbin S. M., **Engineering Circuit Analysis**, Tata McGraw–Hill Publishing Company Limited.

5. Chapman S. J., **Electric Machinery Fundamentals**, McGraw Hill Book Company.

6. Hughes E., **Electrical & Electronic Technology**, 8th Edition, Pearson Publishing


## 7.2 EE 201: Electromechanics

**Course Code : EE 201**

**Course Name : Electromechanics**

L-T-P-C : 2.5-0.5-0-3
Prerequisites : IC 160 Electrical System around Us
Students intended for : UG
Elective or Core : Core for EE, Elective for CSE/ME
Approval: 6th Senate

**Course Contents**

- **Circuits**: AC circuits - 1-phase & 3- phase (review); magnetic circuits. [2 Lectures]

- **Transformers**:1-phase and 3-phase, auto-transformers, harmonics, special multiphase transformers and their applications. [8 Lectures]

- **Basic principles of electro mechanical energy conversion and rotating machines** [3 Lectures]

- **Synchronous Machines**: Construction, characteristics, regulation, V-curves, parallel operation and power system interfacing. [10 Lectures]

- **Induction machines**: 3-phase and 1- phase machine construction, characteristics, starting, braking and speed control, induction generators and applications. [10 Lectures]

- **Special machines**: Construction, characteristics and applications of a few special machines, such as, BLDC machine, PM machine, SRM, hysteresis motor, stepper motor, linear induction motor and their applications. [9 Lectures]

**Text Books:**

1. Kosow, I. L., **Electric Machinery & Transformers**, PHI, India
2. Nagrath I. J. and Kothari D. P., **Electrical Machines**, 3rd Edition, Tata McGraw-Hill Publishing Company Limited.
3. Venkatratnam K., **Special Electrical Machines**, University Press, India

**Reference Books:**

1. Fitzgerald A. E., Kingsley C. and Kusko A., **Electric Machinery**, 6th Edition, McGraw-Hill International Book Company.
2. Say M. G., **The Performance and Design of Alternating Current Machines**, CBS Publishers and Distributors.

## 7.3 EE 201 P: Electromechanics Lab.

**Course Code: EE 201 P**

**Course Title: Electromechanics Lab.**

L-T-P-C: 0-0-2-1
Syllabus: Experiments & simulations to supplement the EE 201 Electromechanics Lab.
Approval: 6th Senate

## 7.4 EE 202: Analog Electronics

**Course Code : EE 202**

**Course Title : Analog Electronics**

L-T-P-C : 3-0-0-3
Students intended for : B.Tech.
Approval: 5th Senate

**Course Contents**

**Unit 1:** Review of Transistor Characteristics, DC Biasing, Small Signal Models: Review of working of BJT, MOSFET and their small signal equivalent Circuit; Biasing of BJT and MOSFET circuits, Small Signal Models

Unit 2: **Basic Amplifier stages**: Common Emitter, Common Base and Common Collector BJT amplifier stages; Common Source, Common

Gate and Common Drain MOSFET stages. Differential Amplifiers

Unit 3: **Differential Amplifiers**: Cascode stage and Current mirrors; BJT Differential pair , The MOSFET differential pair, Large and Small signal Analysis of BJT Differential pair and MOSFET differential pair, Common mode rejection, Differential pair with active load

Unit 4: **Frequency response of Amplifiers**: Relationship between Transfer function and frequency response. General expressions for the low- frequency and high frequency responses. Millers theorem. Frequency response of BJT amplifiers and MOSFET amplifiers.

Unit 5: **Operational Amplifier**: General configuration and basic stages of an operational amplifier (Opamp). Analysis of simple BJT and CMOS opamps.Opamp parameters ideal and practical.Examples of commercial BJT and CMOS opamps.Compensated and un-compensated opamps.

Unit 6: **Feedback in analog circuits**: Advantages of negative feedback, Loop gain, feedback factor, Closed-loop gain. Basic feedback topologies: Series- Shunt, Series-Series, Shunt-Shunt and Shunt-Series configurations. Derivation of input resistance, output resistance and closed-loop gain of the above for both the ideal and practical amplifiers. Stability of feedback amplifiers, Gain and Phase-margins. Frequency compensation.

Unit 7: **Amplifier Applications**: Signal generators and waveform shaping circuits; Tuned amplifiers

**Textbooks:**

1. Adel S. Sedra, Kenneth Carless Smith, **Microelectronic Circuits**, Oxford University Press

2. Behzad Razavi, **Fundamentals of Microelectronics**, Wiley

**Other Text Books:**

1. Donald Neamen, **Electronic Circuit Analysis and Design**, McGraw-Hill

2. Roger T. Howe, Charles G. Sodini, **Microelectronics: An Integrated Approach**, Prentice Hall

3. Paul R. Gray, Paul J. Hurst, Robert G. Meyer, Stephen H. Lewis, **Analysis And Design Of Analog Integrated Circuits**, Wiley-India, 2008

## 7.5 EE 202P: Analog Electronics Lab

**Course Code: EE 202P**

**Course Title: Analog Electronics Lab**

L-T-P-C : 0-0-2-1
Prerequisites:
Students intended for : B.Tech.
Elective or Compulsory
Approval: 5th Senate

**Course Contents**

- Lab 1: Introduction to Spice and Winspice

- Lab 2: Construct a spice netlist to study the characteristics of a BJT. Do a dc analysis and sweep the base current and illustrate the dependence of beta on collector current.

- Lab3: Construct spice netlist to analyse the sensitivity of Quiscent current for
  - a) Simple resistor biasing,
  - b) Voltage divider biasing,
  - c) Emitter degeneration biasing
  - d) Self biasing Prepare a report and discuss the biasing schemes based on your sensitivity analysis results.
- Lab 4: The common-emitter shown in the figure must amplify signals in the range of 1 MHz to 100 Mhz.
  - (a) Using the .op command, determine the bias conditions of Q1 and verify that it operates in the active region.
  - (b) Running an ac analysis, choose the value of C1 such that —VP/Vin—˜ 0.99 at 1 MHz. This ensures that C1 acts as a short circuit at all frequencies of interest.
  - (c) Plot —Vout/Vin— as a function of frequency for several values of C2 , e.g., 1 uF, 1 nF, and 1 pF. Determine the value of C2 such that the gain of the circuit at 10 MHz is only 2% below its maximum (i.e., for C2 = 1uF).
  - (d) With the proper value of C2 found in (c), determine the input impedance of the circuit at 10 MHz. (One approach is to insert a resistor in series with Vin and adjust its value until VP/Vin or Vout/Vin drops by a factor of two.)

## 7.6 EE 203: Network Theory

**Course Name: EE 203**

**Course Code: Network Theory**

L-T-P-C: 3-0-0-3
Prerequisites: IC 160 Electrical System Around us
Students intended for: UG
Elective or Compulsory: Core for EE, Elective for other UG branches
Approval: 5th Senate, 8th Senate

**Course Contents**

- **Transient Network Analysis**: Transient and steady state sinusoidal response. Response of RL, RC and RLC networks using Laplace Transforms for unit step, impulse and ramp inputs. [6 Lectures]
- **Two Port Networks and their Characterization**: Open circuit, short circuit, hybrid and transmission parameters; Series, parallel and tandem connections of two-port networks, multi-port networks, multi-terminal networks; Resonant and band pass circuits, magnetically coupled circuits, analysis of coupled circuits. Network transmission criteria; delay and rise time, Elmores and other definitions. [10 lectures]
- **Network Functions:** Concept of complex frequency, Driving point impedances; Transfer functions of networks, Poles and zeros, Stability analysis. [4 Lectures]

- **Network Synthesis**: Positive real functions and their properties, tests for positive real functions, Hurwitz polynomials; Driving-point synthesis of LC, RC and RL networks, Foster forms and Cauer forms. [8 lectures]
- **Network graphs and their applications in network analysis**: [3 lectures]
- **Three-Phase A.C. Circuit Analysis**:Analysis of balanced and unbalanced three-phase networks; Symmetrical components and their application in analysis of unbalanced networks. [3 Lectures]
- **Analysis of A.C. circuits with non-sinusoidal inputs**:Filters: Introduction to filters, various types of filters - LP, HP, BP and BS. Transformation of LP to other types. Butterworth, Chebyshev and Elliptic approximations to LPF. [2 Lectures]
- **Frequency response**: Polar plots, magnitude and phase plots, Bode plot. [6 lectures]

**Text & Reference Books:**

1. Franklin Fa-Kun Kuo, **Network Analysis and Synthesis**, John Wiley & Sons, 1996.
2. Van Valkenburg, **Network Analysis**, PHI Learning, 2014.

## 7.7 EE 205 : Electromagnetics and Wave propagation

**Course Code :EE 205**

**Course Name : Electromagnetics and Wave propagation**

L-T-P-C : 2.5-0.5-0-0
Intended for : Discipline core for 2nd year B. Tech Electrical Engineering, VLSI students
Prerequisite : None
Mutual Exclusion : None/PH 521
Approval: 52nd BoA

**Course Contents**

- **Vector Analysis:** Basic Mathematical operations using vectors, coordinate systems, integrals (line, surface, volume) using vector functions, vector theorems, basics of partial derivatives, Laplacian, Greens functions. (9 Lectures)
- **Electrostatics:** Electrostatic in free space, Coulomb's law, Gauss Law and its applications, Potential and work done, Conductors, Dielectric, capacitance, static fields in matter, static boundary conditions. method of images. (9 Lectures)
- **Magnetostatics:** Magnetostatics in free-space, Magnetostatics force, Vector Magnetic potential, Biot-Savart law, Ampere's law, Inductance and Magnetic materials, Boundary conditions for Magnetostatics. (9 Lectures)

- **Time Varying fields**: Introduction to time varying fields, limitation of Ampere's law, Continuity relations, MaxweJJ's Equations and its applications, Boundary conditions for dynamic fields, use of vector potential for dynamic fields, wave equations and propagation (in isotropic and anisotropic medium). (9 Lectures)

- **Radiation and propagation principle:** Relation between guided wave and free space wave, Concept of dipoles and monopoles, radiated fields from dipoles, Far-fi elds and near fie lds, Concept or group and phase velocity. Introduction to high frequency transmission line. (9 Lectures)

**Laboratory/practical/tutorial Modules:**

- There shall be practical demonstration for certain fundamental laws of physics and its Interpretations shall be derived In mathematical form. This shall be conducted in the form of tutorial sessions to aid thporctical concepts.

**Text Books**


1. Mathcw N.O. Sadiku, **Principles of Elcctromagnetics**, 4th Edition, Oxford Press, 2007.

2. David. K Cheng, **Fields and Wave Elcctromagnetics**, 5th Imprission, Pearson Education, 2007.


**References:**


1. R. K. Shcvgaonkar, **Electromagnetic waves**, McGraw-Hill Education (India) Pvt Limited, 2005.

2. David. J Griffith, **Introduction to Electrodynamics**, Cambridge Unlvenity Press, Republished year: 2017.

3. G. S. N Raju, **Electromagnetic Field Theory and Transmission Lines**, Pearson Education India, 2006.

4. Walter Lewin, **Lectures on Physics**, MIT.

5. J.D. Jackson, **Classical Electrodynamics**, Wiley, 1999.


## 7.8 EE 208: Digital Electronic Circuits

**Course Code: EE 208**

**Course Name: Digital Electronic Circuits**

L-T-P-C : 3-0-0-3
Prerequisites
Students intended for: B.Tech.
Elective or Compulsory
Approval: OTA in 5th and 8th Senates

**Course Contents**

- **Number system:** Binary Numbers, Octal Numbers, Hexadecimal Numbers, Complement, Signed Binary Numbers Addition and Subtraction
- **Logic Gates and Boolean Algebra:** Digital Logic Gates, Basic Theorems and Properties of Boolean algebra, Boolean Functions, Minterms and Maxterms, Sum of Products and Product of Sums
- **Minimization of Logic functions**:
- Karnaugh map method, Simplification of logic expressions, two variable, three variable, four variable etc., Implementation of logic functions
- **Combinational Circuits** : Design of Adders, Subtractor, Multiplier, Encoder & Decoder, Multiplexer & Demultiplexer, and their use in logic synthesis, Arithmetic circuits, Seven-segment and alphanumeric display design.
- **Sequential Circuits**: Latch, RS, JK, Master Slave, D, and T flip flops Finite state machines, State reduction
- **Registers and Counters**: Registers, shift registers, Counters, Asynchronous Counters, Synchronous Counters, Design of counters, design of other sequential circuits.
- **Memory and Programmable Logic devices**
- **Digital Integrated Circuits**

**Textbooks**

1. Mano, M.M. and Ciletti, M.D., **Digital Design**, 4th Edition, Prentice-Hall.
2. Floyd, T.L., **Digital Fundamentals**, 8th Edition, Pearson Education.

**Other Textbooks**

1. Balabanian, N. and Carlson, B., **Digital Logic Design Principles**, John Wiley & Sons.
2. Jain, R.P., **Modern Digital Electronics**, 3rd Ed., Tata McGraw-Hill.
3. John F. Wakerly, **Digital Design Principles and Practices**, Prentice Hall.

## 7.9 EE 208P: Digital Systems Design Practicum

**Course Code: EE 208P**

**Course Name: Digital Systems Design Practicum**

L-T-P-C:1-0-2-2
Prerequisites : Applied Electronics (IC161) or Equivalent
Intended for :UG

Elective / Core :Discipline Core for B. Tech EE (2nd year and above); Elective for B.Tecll in CE, CSE and ME (2nd year and above)

Approval: OTA 5th Senate 8th Senate

**Course Contents**

- **Introduction to digital systems**: Review of logic design, combinaliat1al and sequential digltal system design
- **lntroduction to Microcontrollers**: Introduction to microcontrollcrs, overview of architecture of a typical microcontroller such as AVR microcontroller, addressing, assembly language programming, interfacing with T/0 devices, timer/counter programming, interrupt pocessing, etc.
- **Real world interfacing of microcontrollers**: Interfacing with simple devices such as LCD, keyboard, motor control, sensors, LED 7 segment display, DTMF decoder, etc.
- **Hardware Description Language**: Introduction to hardware description language, overview of structural, behavioral and dataflow modeling of digital systems using hardware description language, notion of f i nite state machines, delay modeling, memory modeling, synthesizable & non-synthcsizable HDL codes for digital system design.
- **Introduction to FPGA**: Jmroduction to complex digital systems design, notion of programmable logic devices, overview of FPGA architectural realization of data path and controller, liming analysis of data-path and controller, synthesis, placement, routing, perfom1ance optimization,
- **FPGA based systems design**: Implementation of simple systems using PPGA exercising the timing closure paths.
- **Physical design automation**: Partitioning, f1onr-p1anning, placement, routing; clock design considerations, timing margins, dock ske\v', clock distribution net,vorks.

**Course lectures:**

The course lectures will comprise of 1 hour of lecture per week covering the fundamentals of the topics.

**Mini project:**

The students will be required to carry out a small project on topics such as but not limited to Electronic locic, Voting machine, Traffic Light controller, Automatic Room Light Controller, etc. The projects are aimed at exposing the studems !oreal Hfe design issues.

**Text books:**

1. Dhananjay Gadre, **Programming and Customizing the AVR microconrroller**, Tata McGraw Hill, 2014.

2. Wayne Wolf, **FPGA based Systems Design**, Pearson Education, 2003.

3. Stephen Brown and Zvonko Vrancsic, **Fundamentals of Digital with VHDL Design**, McGraw Hill, 2008.

4. Volnei A. Pedroni, **Circuit Design with VHDL**, The MIT Press, 2004.

**Reference Books:**

1. St vKilts, **Advanced FPGA Design: Architecture, Implementation and Optimization**, J. Wiley and Sons, 2007.

2. Seetharaman Ramachandran, **Digital VLST Systems Design**, Springer Verlag, 2012.

3. Peter Ashenden, **The designer's guide top VHDL**, Morgan Kaufmann, 2008.

4. Charles H. Roth Jr., **Digilal Systems Design using VHDL**, Cengage Learning, 2014.

## 7.10 EE 210 : Digital System Design

**Course Number: EE 210**

**Course Name: Digital System Design**

L-T-P-C: 3-0-0-3.
Students Intended: B. Tech (EE)
Elective or Core: Core for B. Tech (EE) & Elective for other UG programs.
Pre-requisite: Applied Electronics (IC161) and Applied Electronics Lab (IC161P).
Approval: 24th Senate

**Course Contents:**

- **Combinational Logic Design with MSI Components and Programmable Logic Devices**: 1.1 Binary Adders and Subtractors {Cascading FullAdders, Carry Look-ahead Adder, High-speed Adders using Carry Look-ahead Principles, using MSI Adders as Subtractors, BCD Adder, using MSI adder as code converter}; 1.2 Arithmetic Logic Unit; 1.3 Binary Multipliers; 1.4 Array Multipliers; 1.5 Tristate Buffers; 1.6 Combinational Logic Hazards {Static and Dynamic Hazards}. [4 Lectures]

- **Flip-Flops and Simple Flip-Flop Applications**: 2.1 Basic Bi-stable Element; 2.2 Application of the SR Latch as Switch De-bouncer; 2.3 Gated SR and D Latch; 2.4 Timing Considerations {Propagation Delays, Contamination Delays, Minimum Pulse Width, Setup and Hold Times}; 2.5 Pulse Triggered Master-Slave Flip -Flops {SR & JK Master-Slave Flip-Flops, O's and 1 's Catching}; 2.6 Edge Triggered

Flip-Flops {Positive & Negative Edge Triggered Flip-Flops, Master Slave Flip-flops with Data Lockout}; 2.7 Characteristics Equations; 2.8 Registers; 2.9 Counters; 2.10 Design of Synchronous Counters; 2.11 Self-Correcting Counters. [5 Lectures]

- **Synchronous Sequential Networks and Algorithmic State Machine (ASM)**: 3.1 Introductions to State Equivalence; 3.2 State Reductions {Equivalence Classes and Implication Charts}; 3.3 State Reduction of Incompletely Specified State Table using Merger Graphs; 3.4 State Assignment Techniques {State Assignment Permutations, State Assignment Algorithm, Implication Graph}; 3.5 Algorithm State Machine {ASM Symbols, Elapse Time Measurement as an ASM Design Example}; 3.6 Linked Sequential Machines. [3 Lectures]

- **Asynchronous Sequential Networks**: 4.1 Fundamental and Pulse Mode Asynchronous Sequential Machines; 4.2 Analysis of Asynchronous Sequential Machines; 4.3 Deriving Flow Table; 4.4 State Assignment; 4.5 Asynchronous Design Problems; 4.6 Data Synchronizers; 4.7 Mixed Operating Mode Asynchronous Circuits. [7 Lectures]

- **Programmable Logic and Memory**: 5.1 Introductions to Memory {ROM, PROM and EPROM}; 5.2 Using and EPROM to Realize a Sequential Circuit; 5.3 Programmable Logic Devices {PLA, PAL, GAL}; 5.4 Erasable Programmable Logic Devices; 5.5 PLD Computer-Aided Design {PLD Realization of Combinational Logic, Realization of truth table, flip-flops and state machine using PLD language}. [5 Lectures]

- **Hardware Description Language and Field-Programmable Gate-Array (FPGA)**: 6.1 Introductions to Hardware Description Language (HDL); 6.2 Overview of Structural, Behavioral and Dataflow Modeling of Digital Systems using HDL; 6.3 HDL Realizations of Finite State Machines, Delay Modeling, Memory Modeling; 6.4 Synthesizable & Non-Synthesizable HDL Codes for Digital System Design; 6.5 Overview of FPGA architecture; 6.6 Realization of Data-Path and Controller; 6.7 Timing Analysis of Data-Path and Controller; 6.8 Synthesis, Placement, Routing and Performance Optimization; 6.9 Implementation of Simple Digital Systems using FPGA Exercising the Timing Closure Paths. [7 Lectures]

- **Microcontroller and Real-World Applications**: 7.1 Introduction to microcontrollers; 7.2 Architectural Overview of a Typical Microcontroller such as AVR Microcontroller; 7.3 Addressing; 7.4 Assembly Language Programming; 7.5 Interfacing with 1/0 devices, timer/counter programming, interrupt processing etc; 7.6 Interfacing with Simple Devices such as LCD, Keyboard, Motor Control, Sensors, LED 7 Segment Display, DTMF decoder etc; 7.7 SPI, 12C, Programmable Interrupt Controller, USART etc. [9 Lectures]

**Text books:**


1. Donald D. Givone, **Digital Principles and Design**, Tata McGraw-Hill Edition, 2012.

2. John M. Yarbrough, **Digital Logic (Applications and Design)**, Cengage Learning, 2011.

**Reference books:**

1. Dhananjay Gadre, **Programming and Customizing the A VR microcontroller**, Tata McGraw Hill, 2014.

2. Wayne Wolf, **FPGA based Systems Design**, Pearson Education, 2003.

3. Stephen Brown and Zvonko Vranesic, **Fundamentals of Digital with VHDL Design**, McGraw Hill, 2008.

4. Volnei A. Pedroni, **Circuit Design with VHDL**, The MIT Press, 2004.

5. Steve Kilts, **Advanced FPGA Design: Architecture, Implementation and Optimization**, J. Wiley and Sons, 2007.

6. Seetharaman Ramachandran, **Digital VLSI Systems Design**, Springer Verlag, 2012.

7. Peter J. Ashenden, **The designer's guide top VHDL**, Morgan Kaufmann, 2008.

8. Charles H. Roth Jr., **Digital Systems Design using VHDL**, Cengage Learning, 2014.

## 7.11 EE 210P : Digital System Design

**Course Number: EE 210**

**Course Name: Digital System Design**

L-T-P-C: 0-0-2-1.
Students Intended: B. Tech (EE)
Elective or Core: Core for B. Tech (EE) & Elective for other UG programs.
Pre-requisite: Applied Electronics (IC161) and Applied Electronics Lab (IC161P).
Approval: 24th Senate

**Experimental Modules for EE-210P:**

- Basics understanding of hardware descriptive language (Verilog / VHDL / System Verilog). Netlist synthesis, functional (Behavioral) & post-route simulations, and hardware prototyping on FPGA using latest design suites (like Xilinx ISE or Vivado or Model Sim etc.). [2 hours]

- Design and implementation of basic gates, multiplexers, de-multiplexers, various adders and multipliers in FPGA platform. [1 hours]

- FPGA implementations of flip-flops, registers, counters and circuitry verifying the register delays. [1 hours]

- Design and implementation of Processor ALU on FPGA. [2 hours]

- Design and implementations of random-access memory (RAM) and read only memory (ROM). These experiments must include the reading and writing operations of RAM for various applications. [1 hours]

- Understanding the static timing analysis of simple sequential circuits. It must demonstrate the two major states of any sequential circuits: timing violated and timing met states. [2 hours]
- Embedded experiments on LED and 7 -segment displays. [I hours]
- Embedded experiment on Interfacing the LCD and LDR. [2 hours]
- Embedded experiments on interfacing servo motor with ultrasonic. [2 hours]

**Text books:**


1. Donald D. Givone, **Digital Principles and Design**, Tata McGraw-Hill Edition, 2012.
2. John M. Yarbrough, **Digital Logic (Applications and Design)**, Cengage Learning, 2011.


**Reference books:**


1. Dhananjay Gadre, **Programming and Customizing the A VR microcontroller**, Tata McGraw Hill, 2014.
2. Wayne Wolf, **FPGA based Systems Design**, Pearson Education, 2003.
3. Stephen Brown and Zvonko Vranesic, **Fundamentals of Digital with VHDL Design**, McGraw Hill, 2008.
4. Volnei A. Pedroni, **Circuit Design with VHDL**, The MIT Press, 2004.
5. Steve Kilts, **Advanced FPGA Design: Architecture, Implementation and Optimization**, J. Wiley and Sons, 2007.
6. Seetharaman Ramachandran, **Digital VLSI Systems Design**, Springer Verlag, 2012.
7. Peter J. Ashenden, **The designer's guide top VHDL**, Morgan Kaufmann, 2008.
8. Charles H. Roth Jr., **Digital Systems Design using VHDL**, Cengage Learning, 2014.


## 7.12 EE 211 : Analog Circuit Design

**Course Number: EE 211**

**Course Name: Analog Circuit Design**

L-T-P-C: 2-0-2-3
Students Intended: B. Tech (EE)
Elective or Core: Core for B. Tech (EE) & Elective for other UG programs.
Pre-requisite: Network theory (EE203 ), Applied Electronics (IC 161)
Approval: 24th Senate

**Course Contents:**

- **BJT/MOS single stage amplifiers, cascade and cascodes** [6 hrs]
  - Large signal and small-signal model, biasing, input and output impedance, operating point calculations and design, single ended BIT/CMOS amplifiers, cascade and cascade amplifiers
- **BJT/MOS Current mirrors** [3 hrs]
  - PVT independent normal current mirror, cascade current mirror, regulated current mirror and Wilson current mirror
- **Differential Amplifiers** [3 hrs]
  - MOS/BJT Differential Pair, qualitative large/small signal analyses, differential pairs with active loads and common-mode rejection
- **BJT/MOS Frequency Response**
  - High frequency model of single ended and differential amplifiers, Frequency response: magnitude and phase plot calculations [3 hrs]
- **Feedback theory** [3 hrs]
  - Properties of negative and positive feedback, loop gain calculations, types of amplifiers, voltage controlled current source (VCCS), current controlled current source (CCCS), current controlled voltage source (CCVS), voltage current voltage source (VCVS), stability analyses under negative feedback topology.
- **Output stages and power amplifiers** [3 hrs]
  - Emitter follower as power amplifier, push-pull amplifier, cross-over distortions, large signal considerations, heat dissipation, efficiency, Classes of amplifiers
- **Oscillators and phase locked loop** [4 hrs]
  - Barkhausen criteria of oscillation, bistable, monostable and astable multi vibrators, LC, relaxation, phase shift and Colpit oscillators, phase locked loop concept and its understanding, signal generation and wave shaping circuits.
- **Data converters** [3 hrs]
  - Digital-to-analog converters (DAC): R-2R, current scaling and voltage scaling
  - Analog-to-digital converter (ADC): flash, SAR, single slope, dual slope, pipeline and sigma-delta modulator

**Experiment modules:**

1. Introduction to laboratory: DSO and its advance features, XY-mode (Lissajous pattern), LTspice and required software.
2. Understanding ofI-V characteristics ofBJT/MOS transistor using net-listing in SPICE simulations.
3. Common emitter amplifier design.
4. Understanding ofMOS class-AB pull-pull amplifier using CD4007 IC.
5. Oscillator: design of ring, LC and phase shift oscillators.
6. Operation ofPLL understanding using 565 IC.
7. Operation of SAR understanding using 0808/0809 I C.
8. Project on analog circuit application.

**Textbook:**

1. Behzad Razavi, **Fundamentals of microelectronics**, Wiley, 2013.

**Reference book:**

1. A.S. Sedra and K.C. Smith, **Microelectronic Circuits-Theory & Applications**, 7th Edition, Oxford University Press, 2017.

## 7.13 EE 223P : Reverse Engineering

**Course Code : EE 223P**

**Course Name : Reverse Engineering**

L-T-P-C : 1-0-0-1
Intended for : BTech EE/BTech VLSI
Prerequisite : Faculty approval
Mutual Exclusion : NA
Approval: 53rd BoA

**Course Contents**

- **Topic 1:** Introduction to Reverse Engineering, need of Reverse Engineering, understanding of Reverse Engineering through examples, methodologies for Reverse Engineering, Reverse Engineering vs Forward Engineering, steps for Reverse Engineering (1 hour).
- **Topic 2:** Mechanical components used in joining (screw fasteners, bolts, nut and washers, compression fittings, pop rivets and rivets), and power transmission (belt drives, chain drives, gear drives and couplings), mechanical tools used in mechanical workshop: measuring tool, fastening-wrenches, fasting screwdrivers, fastening-pliers, cutting tools and striking/driving tools, standards of measurement: primary,

secondary, tertiary and working standards, measurement devices: caliper and bevel protector (1 hour).

- **Topic 3:** Top down approach, product information through examples, important electrical/electronics devices: resistor, capacitor, inductor, diode, transistor, operational amplifiers and integrated circuit or microchip, various analysis and quantities, measuring instruments: multi-meter, function generator, oscilloscope, probe and connectors (1 hour).
- **Topic 4:** Introduction to engineering drawing, importance of engineering drawing, engineering drawing projections, detailed drawing, assembly drawing and its classification, exploded assembly drawing, advantages of exploded views (1 hour).
- **Topic 5**: Importance of engineering drawing in Reverse Engineering, engineering drawing of bench wise, engineering drawing standards in dimensioning, sectional view, tolerance, surface finish and welding, standard codes, engineering drawing format, production drawing of bench wise, Bill Of Material (BOM) (1 hour).
- **Topic 6**: Introduction to engineering materials, evolution of engineering materials, classification of engineering materials into metals, non-metals, ceramics and composites, features, identification, examples and applications of different materials, understanding through case studies, introduction to manufacturing processes, classifications of machining and joining process, introduction to casting process, various allowances and types of casting process (1 hour).
- **Topic 7**: Demonstration exercise: Reverse Engineering of Electric Kettle (1 hour).

**Laboratory/practical/tutorial Modules:**

- 4 lab activities will follow the 7 hours indicated above. In the labs, the students will be disassembling and reassembling some day-to-day devices based on the lectured principles, and provide a report that will typically include
- Explanation of the working mechanism,
- Exploded drawing of the product,
- Assembly and disassembly procedure,
- Bill of Materials (BOM),
- Manufacturing processes and scope of materials,
- Discussion and Scope for Improvement.
- The devices used will be (but not limited to) torch, calculator, mouse and DC motor.

**Textbooks:**


1. K. Otto and K. Wood, **Product Design: Techniques in Reverse Engineering and New Product Development**, Prentice Hall, 2001.
2. Raja and Fernandes, **Reverse Engineering: An Industrial Perspective**, Springer-Verlag, 2008.

**References:**

1. Eldad Eilam, **Reversing: Secrets of Reverse Engineering**, Wiley, 2005.

2. Chris Eagle, **The IDA Pro Book: The Unofficial Guide to the World's Most Popular Disassembler**.

## 7.14 EE 231 : Measurement and Instrumentation

**Course Code : EE 231**

**Course Name : Measurement and Instrumentation**

L-T-P-C : 2-0-2-3
Intended for : B.Tech. Electrical Engineering, allied B.Tech programmes
Prerequisite : IC161 – Applied Electronics, EE261 - Electrical Systems around us, EE260 – Signals and Systems.
Mutual Exclusion:
Approval: 56th BoA

**Course Contents**

- **Fundamentals of measurement**: Physical quantities, dimensional analysis, significant figure calculations, errors in measurement, Taguchi method. (2 Lectures)

- **Measurement foundations**: Measurement of resistances – wire and bridge methods; Measurement of impedances – bridge methods; analog and digital meters; the digital storage oscilloscope. (4 Lectures)

- **Sensors and Actuators**: Sensors – Definitions, classification, static and dynamic characteristics, sensor examples, e.g. temperature, pressure, piezoresistive, piezoelectric, capacitative, etc.; Actuators – e.g. piezoelectric actuator, DC motors , servo motor, stepper motor. (8 Lectures)

- **Instrumentation**: Signal conditioning – amplification, filtering, isolation and handling noise; Power supply and regulation essentials; Data acquisition approaches – principles of ADC-based acquisition, use of DAQ cards; Calibration principles and reference to standards; Standard computer interfaces and communication protocols. (8 Lectures)

- **System-level design**: Elements of system-level thinking; introduction to microcontrollers and FPGAs; Integration of sensors, signal conditioning and data acquisition systems; Problem-based learning based on real-world examples – e.g. distance sensors, PID controllers, real-time data acquisition systems, etc.; Troubleshooting strategies. (6 Lectures)

**Laboratory/practical/tutorial Modules:**

1. **Instrumentation fundamentals**: soldering; using power sources, signal generators, oscilloscopes; SCPI programming (2 hours).

2. **The Wheatstone Bridge**: First principles calibration (1 hour).

3. **The Instrumentation amplifier**: Verification of working, amplification of Wheatstone bridge output (1 hour).

4. **The ADC**: use of off-the-shelf ADCs (ADS1115s, or MCP3008) with standard microcontrollers (e.g. Arduino) for data acquisition (1 hour).

5. **System design**: an end-to-end temperature logger using a thermistor. (2 hours)

6. Real-time temperature stabilization of a Peltier element using PID control and the temperature logger (2 hours).

7. Elements of digital signal processing (2 hours).

8. PID control of speed of a DC motor (3 hours).

**Text Books:**


1. A. K. Sawhney, **A course in Electrical and Electronic Measurements and Instrumentation**, Dhanpat Rai and Co.


**Reference Books:**


1. Doeblin, E. O., Manik, D. N., **Measurement Systems**, 6th Edition, Tata McGraw Hill India, 2011.

2. Fraden, Jacob., **Handbook of modern sensors**, Springer Science+Business Media, 2010.


## 7.15 EE 301: Control Systems

**Course code : EE 301**

**Course Name : Control Systems**

L-T-P-C : 2.5-0.5-0-3
Prerequisites :IC 260-Signals and Systems
Intended for :UG
Elctive/Core: Discipline core for BTech in EE, Elective for BTech in CE, CSE and ME
Approval: 5th Senate, 12th Senate

**Course Contents**

- **Basic concepts**: Introduction, basic terminology, objective of subject, some basic examples, Notion of feedback; open- and closed-loop systems.

- **Mathematical Models**: Representation of physical systems and analogous systems, Lapalce transforms, block diagrams, transfer functions for different type of systems, block diagrams reduction techniques; Signal flow graphs and Mason's gain formula.

- **Control hardware and their models**: Potentiometers, synchros, LVDT, DC and AC servo motors, tachogenerators, electro-hydraulic valves, and pneumatic actuators.
- **Time-domain analysis**: Time domain performance criterion, transient response of first order, second order and higher order systems;
- **Steady state errors**: Static and dynamic error constants, system types, steady state errors for unity and non unity feedback systems, performance analysis for P, PI and PID controllers.
- **Frequency-domain analysis**: Bode and polar plots, frequency-domain specifications, correlation between transient response and frequency response.
- **Stability analysis**: Concept of stability by Routh stability criterion, Nyquist stability criterion, gain and phase margins, relative stability, constant M and N circles, Nichol's chart and its application.
- **Root-locus technique**: Nature of root-locus, rules of construction, root-locus analysis of control systems.
- **Compensation**: Types of compensation, Proportional, PI and PID controllers; Lead-lag compensators.
- **State-space concepts**: Eigen values and eigen vectors; Solution of state equations; Controllability; Observability; pole placement result, Minimal representations(if time permits).
- **Non-Linear systems**: Characteristics of non-linear systems, types of non-linearities, phase-plane analysis, limit cycles and describing functions (if time permits).

**References:**


1. Nagrath I. J. and Gopal M., **Control System Engineering**.
2. Kuo B. C., **Automatic Control Systems**.
3. Ogata K., **Modern Control Engineering**.
4. Gopal M., **Control Systems: Principle and Design**.
5. Prof. S. D Agashe**, NPTEL Video Lectures on Control Engg**.
6. Prof. M. Gopal, **NPTEL Lecture Notes on Control Systems**.
7. Dorf R. C. and Bishop R. H., **Modern Control Systems**.
8. Norman S. N., **Control Systems Engineering**.
9. IEEE Transactions on Automatic Control.
10. IEEE Transactions on Control Systems Technology.

## 7.16 EE 301: Control Systems_old

**Course Code: EE 301**

**Course Name: Control Systems_old**

L-T-P-C: 2.5-0.5-0-3
Prerequisites: IC 260- Signals and Systems
Elective / Core: Discipline Core for B. Tech in EE, Elective for B. Tech in CE, CSE and ME
Approval: 5th Senate; Revised in 12th Senate

**Course Contents**

- **Feedback Principles**: Feedback control; Practical examples and some history of control theory [2 Lectures]
- **System Modeling and representation**: Modeling of electrical and mechanical systems; State-space representation and Transfer function representation, block diagram, converting State space to Transfer function and Transferfm1ction to State-space representations; Linearization technique; Methods to obtain Transfer-functions: Block reduction and Signal flow graphs. [15 Lectures]
- **Time response & Error Analysis**: Poles, Zeros, System response, damping of systems, Laplace transform solution of state equation, Time domain solution of state equation, Steady-state error and Static-error constants. [6 Lectures]
- **Stability**: Routh-Hurwitz Criterion; lnternal stability and Input-output stability. [5 Lectures]
- **Frequency Domain Analysis**: Nyquist plots and Bode plots, stability margin; Sensitivity and the Gang of Four; Introduction to fundamental limitations due to RHP poles and Zeros. [7 Lectures]
- **Frequency Domain Design**: Common compensator designs: PID, lead-lag, root locus, Nyquist plot and Bode plots. [10 Lectures]
- **State Feedback**: Introduction to Controllability and Observability, Controller design via state feedback [7 lectures]

**Textbooks:**

1. Norman S. Nise, **Control Systems Engineering**, 4th edition, John Wiley, 2003.

**References:**

1. G. Franklin, J.D. Powell and A. Emami-Naeini, **Feedback Control of Dynamic Systems**, Addison Wesley, 1986.
2. Karl J. A and Richard M. Murray, **Feedback Systems: An Introduction for Scientists and Engineers**, Princeton University Press, 2014.

3. I.J. Nagrath and M. Gopal, **Control System Engineering**, 2nd Edition, Wiley Eastern, 1982.

4. J.C. Doyle; B.A. Francis and A.R. Tannenbaum, **Feedback Control Theory**, Maxwell Macmilan lntemational Edn. 1992.

5. C.L. Phillips and R.D. Harbour, **Feedback Control Systems**, Prentice Hall, 1985.

## 7.17 EE 301P: Control Systems Laboratory

**Course Code: EE 301P**

**Course Name: Control Systems Laboratory**

L-T-P-C: 0-0-2-1
Prerequisites: IC 260 Signal and Systems and, EE 301 taken concurrently
Intended for: UG
Elective /Core: Discipline Core for B. Tech in EE, Elective for B. Tech in CE, CSE, and ME
Approval: 12th Senate

**Laboratory Experiments and Design Project:**

- DC Motor Control
- Vertical take-off Landing Trainer
- Heating Ventilation and Air conditioning Trainer
- Ball and Beam System
- Multi-Tank System

This laboratory course has a five weeks design project component. For Example: Self-balancing of robotic kit: Balanduino

**Tasks**: Modelling, compensator design, implementation and documentation of a project on stabilizing the Balanduinio robot.

## 7.18 EE 301P_Old: Control Systems Lab

**Course Code: EE 301P**

**Course Name: Control Systems Lab**

L-T-P-C: 0-0-4-2
Prerequisites
Students intended for: B.Tech. Elective or Compulsory
Approval: 5th Senate; OTA Course; Revised in 12th Senate

**Course Contents**

Experiments to supplement the Control Systems Theory course EE 301.

## 7.19 EE 303: Power Systems

**Course Code : EE 303**

**Course Name : Power Systems**

L-T-P-C : 3-1-0-4
Prerequisites : EE 201 Electromechanics or Instructors consent
Students intended for : UG
Elective or Compulsory: Compulsory for EE, Elective for CSE/ME
Approval: 6th Senate

**Course Contents**

- **Module I**: Basic Concept of Three-phase circuit and Three-Phase power, Introduction to power systems and its structure: Generation, transmission and distribution, substation arrangements. Energy resources and power generation: An overview of conventional and non-conventional energy sources. [5 lectures]
- **Representation of power system components**: Generator, Transformers, Transmission lines, line parameters, transmission line design, corona, interference of power lines with communication circuits, line insulators, power cables, per unit system. [15 lectures]
- **Load Flow Analysis:** Concepts of PV, PQ and Slack Bus - NR Method [5 Lectures]
- **Fault Analysis**: Symmetrical components, symmetrical and unsymmetrical fault calculations. [8 lectures]
- **Moduel V**: Integrated operation of power systems, economic operation (ELD), stability, swing equation, equal area criterion, reactive power control, HVDC transmission and FACTS devices, load management. [10 lectures]
- **Module V**I: Introduction to protection and switchgear. [6 lectures]
- **Module VI**I: Introduction to restructuring of power systems, power market fundamentals and price discovery, and smart grid. [4 lectures]
- **Module VIII**: Introduction to modelling and simulation to perform of power system studies/analysis through graphical user interface as well as programming based tools. Like, load flow studies, performance analysis of transmission lines, ELD, fault analysis, etc. [3 lectures]

**Text Books:**

1. J. J. Grainger and W. D. Stevenson, **Power System Analysis**, Tata McGraw Hill.
2. Hadi Saadat, **Power System Analysis**, Tata McGraw Hill.
3. D. P. Kothari and I. J. Nagrath, **Modern Power System Analysis**, Tata McGraw Hill.
4. Ravindranath B. and Chander M., **Power System Protection and Switchgear**, New Age International Private Limited.

**References:**

1. S. N. Singh, **Electric Power System Generation**, Transmission and Distribution, PHI.

2. NPTEL Courses

3. Paithankar Y. G. and Bhide S. R., **Fundamentals of Power System Protection**, Prentice Hall of India Private Limited.

4. O. L. Elgerd, **Electric Energy Systems Theory: An Introduction**, Tata McGraw Hill.

## 7.20 EE 303P: Power System Lab

**Course No.: EE 303P**

**Course Name: Power System Lab**

L-T-P-C: 0-0-2-1
Prerequisites
Students intended for: B.Tech.
Elective or Compulsory
Approval:

### Course Contents

Experiments/modeling & simulations to supplement the EE 303 Power Systems course.

## 7.21 EE 303 (3-0-0-3) Power Systems and EE 303P Power Systems Lab. (0-0-2-1).

Approval: 8th Senate; OTA Course

### Course Outline:

The objective of the course is to provide the first detailed treatment of fiindamental understanding and operation of the power systems. Beginning with the basic terms, concepts and power system components representations, the course will present power generation technologies and power delivery systems. Students will be introduced about fault analysis, integrated economic operation of power systems with reliability and stability. Introduction to new developments 1n power system operation and control by restructuring of power systems and smart grid will be discussed.

Introduction to modelling and simulation to perform of power system studies/analysis through graphical user interface as well as programming based tools. Like, load flow studies, performance analysis of transmission lines, ELD, fault analysis, etc.

**Course No.: EE 303P**

**Course Name: Power System Lab**

L-T-P-C: 0-0-2-1
Prerequisites
Students intended for: B.Tech.
Elective or Compulsory

**Course Contents**

Experiments/modeling & simulations to supplement the EE 303 Power Systems course.

## 7.22 EE 304: Communication Theory

**Course Code : EE 304**

**Course Name : Communication Theory**

L-T-P-C : 3-0-1-4
Prerequisites : IC210, IC260
Intended for : B.Tech.
Distribution : Compulsory for EE; EE elective for CSE Semester: 5th
Approval: 4th Senate

**Course Contents**

- **The communication process**: motivation, building blocks of a canonical. [2 Lectures]
- **Representation of Signals and Systems**: Fourier transform, Linear systems, etc [3 Lectures]
- Brief review of Probability and Random Processes, and Linear Algebra [3 Lectures]
- **Analog Communication**: Analog modulation (Amplitude and Angle Modulation), Noise in analog communication (Receiver model, Noise in DSB-SC, SSB, VSB, AM, and FM/PM receivers) [10 Lectures]
- **From Analog to Digital Communication**: sampling, quantization. [6 Lectures]
- Digital modulation (PAM, PPM, PCM and Delta Modulation), Baseband and Passband digital communication (Phase modulation, FSK), Noise in digital communication (optimal detection/optimum receiver design, performance and error-probability analysis of various digital modulation schemes). [12 Lectures]
- **Limits on Communication and achievability**: Introduction to Information Theory and Coding Theory (Interoduction to convolutional and block codes) [6 Lectures]

**Reference Books:**


1. J. G. Proakis and M. Salehi, **Fundamentals of Communication Systems**, Prentice Hall, December 2004.

2. S. Haykin and M. Moher, **An Introduction to Analog and Digital Communications**, 2nd Edition, Wiley,2006.

3. R. G. Gallager, **Principles of Digital Communication**, Cambridge Univ. Press, 2008.

4. B. P. Lathi and Z. Ding, **Modern Digital and Analog Communication Systems**, 4th Edition, Oxford University Press, 2009.

5. A. Lapidoth, **A Foundation in Digital Communication**, Cambridge University Press, August 2009.


## 7.23 EE 304_52B : Communication Systems

**Course Code :EE 304**

**Course Name : Communication Systems**

L-T-P-C : 3-0-2-4
Intended for : BTech EE (core), BTech CSE (elective)
Prerequisite : IC260, IC252
Mutual Exclusion :
Approval: 52nd BoA

**Course Contents**

- **Signals in communication systems and their representation:** Time and frequency domain representations of signals, vector representation of s ignals, Constellation diagram, Baseband and bandpass signals, Amplitude and angle modulated signals (AM, FM, PM, ASK, FSK, PSK, PAM etc.), random processes and their analysis, Energy and Power spectral densities. (15 Lectures)

- **Systems in communication system and their analysis:** Modulators and demodulators (coherent and noncoherent; envelope detectors, PLLs, balanced discriminators etc.), Pre-emphasis and de-emphasis, Sampler, Quantizer, Equalizers, Encoders (PCM), Line coders (On-off, Polar, Bipolar, NRZ, RZ etc.), Pulse shapers, Bandlim ited and distortion-less channels, LTI systems and random processes, Matched fi lter, Correlation receiver. (15 Lectures)

- **Performance analysis of analog and digital communication systems:** Signal-to-Noise Ratio (SNR) calculation for different analog communication systems, SNR analysis for PCM, Bit Error Rate (BER) calculations for different digital communication systems. (8 Lectures)

- **Case studies:** A brief overview of modem communication/broadcast technologies, e .g. Digital Radio Mondiale (DRM), Wifi, Cellular communication etc. (4 Lectures)

**Text Books:**

1. B. P. Lathi and Z. Ding, **Modem Digital and Analog Communication Systems**, 4th Edition, Oxford Univ. Press, January 2009.

2. J. G. Proakis and M. Salehi, **Fundamentals of Communication Systems**, Prentice Hall, December 2004

**References:**

1. S. Haykin and M. Moher, **An Introduction to Analog and Digital Communications**, 2nd Edition,Wiley, January 2006.

2. R. G. Gallager, **Principles of Digital Communication**, Cambridge University Press, March 2008.

3. A. Lapidoth, **A Foundation in Digital Communication**, Cambridge University Press, August 2009.

## 7.24 EE 305(3) Digital Signal Processing

Approval: 8th Senate; OTA

**Course Outline:**

- Introduction to discrete time signals and systems, their properties and representations
- Discretetime signal transfonns:Fourier transform and Z-transform,and their properties
- Sampling, Nyquist theorem, processing continuous and discrete signals, multi—ratesampling
- Introduction to filtering of signals, filter structures, and types of filters
- Discrete Fourier transform (DFT), its analysis and properties, its efficient computation, and analysisof signals using DPT

## 7.25 EE 305: Digital Signal Processing

**Course code : EE 305**

**Course Name : Digital Signal Processing**

L-T-P-C : 3-1-0-4
Prerequisites : IC-260 - Signals and Systems
Elective/Core : Elective
Approval: 6th Senate

**Course Contents**

- **Discrete time signals and systems**: Types of systems, LTI systems and their properties, impulse response and convolution, Difference equations, Eigen-functions of LTI systems [4 Lectures]
- **Discrete time signal transform**: Discrete time Fourier Transform (DTFT) and examples, Properties, Convergence of signals, Z-transform and examples, Properties, Difference equation representation, Inverse Z-transform. [4 Lectures]
- **Sampling**: Time domain and frequency domain representation, Nyquist theorem, Signal reconstruction, Discrete-time processing of continuous-time signals, Continuous-time processing of discrete-time signals, Changing the sampling rate, Multi-rate signal processing, Sub-Nyquist sampling and its applications. [10 Lectures]
- **Filtering and Frequency response of LTI systems**: Discrete-time frequency selective filtering, Phase distortion and delay, Characterization with difference equations, Stability and Causality, Frequency response of rational system functions, All pass and minimum- phase systems, Basics of filter design, Z-transform characterization of IIR filters, Window functions for FIR filters, Filter structures for IIR and FIR filters. [10 Lectures]
- **Discrete Fourier transform (DFT)**: Discrete Fourier series and its properties, Fourier transform of periodic signals, Sampling the Fourier transform, DFT and its properties, Linear and circular convolution, Efficient computation of DFT using the Fast Fourier transform (FFT). [10 Lectures]
- **Fourier analysis of signals using the DFT**: Pipeline for analyzing continuous time signals, Effect of windowing, Effect of spectral sampling. [4 Lectures]

**Text books:**

1. Text for Unit 1 to Unit 6: Alan V. Oppenheim, Ronald W. Schafer, John R. Buck., **Discrete-Time Signal Processing**, 2nd Edition, Pearson, 1999.

**Additional reference:**

1. John G. Proakis, Dimitris G. Manolakis., **Digital Signal Processing Principles, Algorithms, and Applications**, 4th Edition, Pearson 2007.

## 7.26 EE 306 Computer Organization & Microprocessor

**Course Code: EE 306**

**Course Name: Computer Organization & Microprocessor**

L-T-P-C: 3-0-0-3
Prerequisites:
Students Intended for:
Core or Elective:
Approval: OTA Course; 5th Senate

**Course Contents:**

- **Digital Logic and Digital Systems**: Overview and history of computer architecture, combinational vs sequential logic, hardware description languages (VHDL), physical constraints (gate delay, fan-in, fan-out, energy/power).
- **Instruction Set Architecture**: Introduction to instruction set architecture, Basic organization of computing machine: fetch, decode, and execute; Instruction set types, instruction format, addressing modes, subroutine call and return mechanisms; Structure of machine-level programs; Low-level architectural support for high level languages. Performance assessment.
- **Computer Arithmetic**: Representation of numeric data, signed and unsigned arithmetic; Range, precision and errors in floating-point arithmetic; Design of arithmetic and logic unit (ALU).
- **Processor Architecture**: CISC vs RISC Designs, simple implementation schemes, datapath design, control unit: hardwired realization vs micro-programmed realization, multi-cycle implementation. Instruction level parallelism, instruction pipelining, pipeline hazards.
- **Memory Architecture**: Storage systems, introduction to memory hierarchy: importance of temporal and spatial locality; main memory organization, cache memory: address mapping, block size, replacement, and store policies; virtual memory system: page table and TLB.
- **Interfacing and I/O Organization**: External storage; IO fundamentals: handshaking, buffering, programmed IO, interrupt driven IO; Interrupt handling mechanism, Buses: protocols, arbitration, direct memory access (DMA).

**Text Books:**

1. DA Patterson and JL Hennessy, **Computer Organization and Design**, 4th Edition, Morgan Kaufmann Publisher, 2010.

**References:**

1. J.P. Hayes, **Computer Architecture and Organization**, Mc Graw Hill.
2. A.S. Tanenbaum, **Structured Computer Organization**, PHI Publication.
3. W. Stalling, **Computer Organization and Architecture**, PHI Publication.

## 7.27 EE 307: Theory of Measurement

**Course Code: EE 307**

**Course Name: Theory of Measurement**

L-T-P-C: 3-0-0-3

Prerequisites: Basic electrical circuits, Understanding of basic probability and statistics.

Students intended for: B.Tech.
Elective or Compulsory:
Approval: 5th Senate

**Course Contents**

- Module 1: **Characterization of Measurement Systems**: Significance of Measurements, Units and Standards, Instruments and Measurements, Examples of Measurement System, Instrument Characteristics (Accuracy, Range, Linearity, Sensitivity, Calibration), Dynamic Characteristics (Zero, First and Second Order Systems).
- Module 2: **Error and Noise Analysis**: Errors, Classification of Errors, Review of Probability and Statistics, Statistical Treatment of Data, Regression Analysis (Least Squares), Uncertainty Analysis.
- Module 3:**Primary Sensing Elements**: Strain Gauges, Load Cells, Linear Variable Displacement Transformers (LVDT), Potentiometers, Capacitive Transducers, Thermistors, Thermocouple, Pressure Sensors, Flow Sensors, Piezoelectric transducers.
- Module 4:**Signal Conditioning Circuits**: Analog Signal Conditioning: Amplifiers, Voltage Comparator and Filters. Sampling, Quantization, A/D Converter, D/A Converter, Digital Voltmeter, Data Acquisition, Smart Sensors.

**Text Books:**

1. Ernest Doebelin, **Measurement System: Application and Design**, 5th Edition, McGraw.
2. Richard S. Figliola and Donald E. Beasley, **Theory and Design for Mechanical Measurements**, Wiley&Sons.
3. D. Patranabis, **Principal of Industrial Instrumentation**, 3rd Edition, McGraw-Hill.

## 7.28 EE 308 Solid State Devices

**Course Code: EE 308**

**Course Name: Solid State Devices**

L-T-P-C: 3-0-0-3
Prerequisites:
Students Intended for:
Core or Elective:
Approval: OTA Course; 5th Senate

**Course Contents:**

Valence band and Energy band models of intrinsic and extrinsic semiconductors. Thermal equilibrium carrier concentration. Carrier transport by drift, resistivity. Excess carriers, lifetime, carrier transport by diffusion, Continuity equation. Quantitative theory of PN junctions : Steady state I-V characteristics under forward bias, reverse bias and illumination. Dynamic behavior under small and large signals. Qualitative theory of breakdown mechanisms. Quantitative theory of bipolar junction transistors having uniformly doped regions. Static characteristics in active andsaturation regions. Emitter efficiency, transport factor, transit time, (and their calculation as functions of frequency. Charge control description. Theory of Field Effect Transistors : Static characteristics of JFETs. Analysis of MOS structure. Calculation of threshold voltage. Static I-V characteristics of MOSFETs.

**Text Books:**

1. Ben G. Streetman and Sanjay Banerjee, **Solid State Electronic Devices**, Prentice Hall International.

2. S.M.Sze, **Semiconductor Devices Physics and Technology**, John Wiley & Sons.

3. Nandita Das Gupta and Amitava Das Gupta, **Semiconductor Devices Modelling and Technology**, Prentice Hall of India Pvt. Ltd.

**References:**

1. S.M. Sze, **Physics of Semiconductor Devices**, John Wiley and Sons.

2. M.S. Tyagi, **Introduction to Semiconductor Materials and Devices**, John Wiley and Sons.

## 7.29 EE 309: Power Electronics

**Course Code : EE 309**

**Course Name : Power Electronics**

L-T-P-C : EE309: 2.5-0.5-0-3
Pre-requisites : IC-160 & IC-160P
Distribution : Elective
Approval: 5th Senate

**Course Contents**

- **Introduction**: About power electronics; power control through switching; overview of power devices, converters and applications. [2 Lectures]

- **DC to DC power converters**: Buck, boost and buck-boost converters; continuous and discontinuous modes of operation; operation as single-quadrant, two-quadrant and four-quadrant choppers; basics of transformer isolated half-bridge and full-bridge converters. [8 Lectures]

- **Power semiconductor switches**: Desirable switch characteristics; overview of available switches; power diodes / thyristors including GTOs; power MOSFETs / IGBTs; emerging power devices. [8 Lectures]
- **DC to AC inverters**: Background; single phase voltage source inverter; square wave and single pulse PWM (Pulse Width Modulation) operation; selective harmonic elimination; three-phase six-step inverter; simple sine-PWM technique; waveform distortion and harmonics; output filter. [8 Lectures]
- **Engineering aspects**: Drive circuits for power devices; conduction and switching loss calculations; heat sink for power devices; elementary design of magnetic components; basic snubber circuits. [6 Lectures]
- **AC to DC Converters Uncontrolled rectifiers**: Single phase bridge rectifier; centre-tapped rectifier; three phase bridge rectifier. Input side and output side performance; concept of AC input power factor under distorted waveforms. Controlled rectifiers: Some basic concepts regarding AC-DC phase controlled thyristor converters. AC to DC PWM rectifiers: Operation of a PWM bridge DC-AC inverter as an AC to DC PWM rectifier; application in renewable energy systems. [8 Lectures]

**Textbooks:**

1. Mohan, Undeland and Robbins, **Power Electronics: Converters, Applications and Design**, Wiley India, 2007.
2. L. Umanand, **Power Electronics: Essentials & Applications**, Wiley India, 2009.

## 7.30 EE 309P: Power Electronics Lab

**Course Code : EE 309P**

**Course Name : Power Electronics Lab**

L-T-P-C : 0-0-2-1
Pre-requisites : IC-160 & IC-160P
Distribution : Elective; This course runs concurrently with EE 309
Approval: 5th Senate

**Laboratory Work:**

The laboratory will involve a few experiments related to power converters and control of the same.

## 7.31 EE 310: Electromagnetic Fields

**Course Code : EE 310**

**Course Name : Electromagnetic Fields**

L-T-P-C :3-0-0-3
Prerequisites :
Approval: OTA Course; 5th Senate

**Course Contents**

Review: Electrostatics, Magnetostatics, Amperes Law, Faradays Law, Electromagnetic Energy. (Topics covered in PH 102) - Solution Techniques Laplace/Poissons equation with Dirchlet/ Neumann boundary conditions. Method of images, separation of variables, finite difference schemes Time varying fields Maxwells equations, wave equation, Poynting theorem, phasor notation - Plane Waves: Solution of the wave equation in vacuum. Wave velocity and impedence. Normal and Oblique incidence at interfaces. Penetration into conducting surfaces - skin effect. Reflection off dielectric layers - Introduction to waveguides: Guided waves. Interpretation as superposition of obliquely travelling plane waves. Modes and their cutoffs. The TEM wave and the transmission line limit - Transmission Lines: The high-frequency circuit. Time domain reflectometry. LCR ladder model for transmission lines. The transmission line equation. Analogy with wave equation. Solution for lossless lines. Wave velocity and wave impedence. Reflection and Transmission coeffcients at junctions. VSWR. Introduction to Smith Chart - Antennas: The free space antenna. The half-wave dipole antenna. Radiation patterns. Antenna gain and directivity - Case studies: Semiconductors, bio-electromagnetics, data storage, RF circuits, optics, telecommunications.

**Textbooks:**

1. Nannapaneni Narayana Rao, **Elements of Engineering Electromagnetics**, Prentice Hall of India.

2. Hayt, **Engineering Electro-magnetics**, McGraw-Hill.

**References:**

1. Kraus and Fleisch, **Electromagnetics with applications**, McGraw-Hill.

2. Ramo, Whinnery and Van Duzer, **Fields and Waves in Communication Electronics**, John Wiley and Sons

## 7.32 EE 311: Device Electronics for Integrated Circuits

**Course Code: EE 311**

**Course Name: Device Electronics for Integrated Circuits**

L-T-P-C: 3-0-0-3
Semester: Odd
Prerequisites: IC121 (Mechanics of Particles and Waves)
Intended for: 2nd and 3rd year UG
Elective or Core: Core for 2nd Yr. and 3rd Yr. Electrical Engineering
Approval: 10th Senate

**Course Contents**

- **SEMICONDUCTOR ELECTRONICS** [6 Lectures]
  - i. Physics of Semiconductor Materials

- ii. Band Model of Solids
- iii. Carrier distribution functions
- iv. Free Carriers in Semiconductors, Concept of electrons and holes,
- v. Concept of equilibrium and non-equilibrium in semiconductor device vi. Current Conduction mechanisms in semiconductors

- **P-N JUNCTIONS** [12 Lectures]
  - i. Fundamentals of p-n junction
  - ii. p-n junction under thermal equilibrium
  - iii. Operation of p-n junction under forward and reverse bias
  - iv. Different type of junctions including step junction, linearly graded junction and heterojunctions,
  - v. Junction Breakdown: Physics of avalanche and Zener breakdown mechanisms vi. Generation and Recombination in a p-n junction
  - vii. Current-Voltage Characteristics of p-n junctions
  - viii. Devices based on p-n junction, Solar cells, LED and photodetectors
- **METAL-SEMICONDUCTOR CONTACTS** [3 Lectures]
  - i. Idealized Metal-Semiconductor junctions
  - ii. Physics of Schottky and Ohmic contacts
  - iii. Effect of surface states on Metal-Semiconductor Contacts, iv. Devices based on metal-semiconductor contacts
- **BIPOLAR TRANSISTORS** [9 Lectures]
  - i. Physics and operation of bipolar junction transistors
  - ii. Current conduction mechanism in bipolar junction transistor
  - iii. Ebers-Moll Model
  - iv. Effects of Collector Bias Variation (Early Effect)
  - v. Small-Signal Transistor Model
  - vi. Operation of bipolar junction transistor under high frequency vii. Devices based on bipolar junction transistor
- **FIELD-EFFECT TRANSISTORS (MOSFETs)** [9 Lectures]
  - i. The ideal MOS Structure
  - ii. Capacitance of the MOS System
  - iii. CV Behavior of a MOS System; Ideal condition, effect of oxide and interface charge
  - iv. Structure and operation of MOSFET devices
  - v. Improved Models for Short-Channel MOSFETs vi. Devices based on MOSFET

- **ELECTRONIC DEVICES AND NANOELECTRONICS** [3 Lectures]
  - i. Electronic Device Materials: Silicon, Germanium, and Gallium Arsenide.
  - ii. Introduction to advanced device technology: Purification and growth, wafer production, epitaxy and deposition, oxidation and metallisation; lithography and implantation
  - iii. Emerging Device Technologies

**TEXT BOOKS:**

1. S. M. Sze and M.K. Lee, **Semiconductor devices - Physics and Technology**, 3nd Edition, John Wiley & Sons, 2012.

**REFERENCES:**

1. S. M. Sze and Kwok K.Ng, **Physics of Semiconductor Devices**, 3rd Edition, John Wiley & Sons, 2002.
2. Ben G. Steetman and Sanjay Banerjee, **Solid State Electronic Devices**, 6th Edition, Prentice Hall, 2005
3. Robert F. Pierret, **Semiconductor Device Fundamentals**, Addison-Wesley Publishing, 1996
4. Donald A. Neamen, **Semiconductor Physics and Devices**, 3rd Eddition, McGrawHill, 2003
5. Jasprit Singh, **Semiconductor Devices - Basic Principles**, John Wiley and Sons, 2001.

## 7.33 EE 312 P: Microelectronics Circuits Design Practicum (MCDP)

**Course Code: EE 312 P**

**Course Name: Microelectronics Circuits Design Practicum (MCDP)**

L-T-P-C: 0-0-3-2
Prerequisites: IC 161 , EE 311 or Instructors consent
Students intended for: UG
Elective or Core: Core for 3rd yr. Electrical Engineering
Approval: 10th Senate

**Course Contents**

- **Diode characteristics and diode circuits** [12 Lectures]:
  - p-n junction, ideal diode, terminal characteristics of junction diodes, operation in the reverse breakdown region, Zener diodes, Diode rectifier circuits, Limiting and clamping circuits, Special diode types.

- After exposure of this practicum, students should be able to compare the experimental data to the theoretical curve of the diodes. The students will use appropriate laboratory equipment to plot the I-V characteristics of the diodes. The students will also construct rectifier and filtering circuits using diodes and capacitors.

- **BJT I-V characteristics and Amplifier** [12 Lectures]
  - Device structure and physical operation, I-V characteristics of BJT DC circuits, Application of the BJT in amplifier design, Small-signal operation and models, Basic BJT amplifier configurations and biasing the BJT amplifier circuits
  - As part of laboratory assignments, the students will obtain and analyse the I-V characteristic of the BJTs. Students will also design and implement single-stage BJT amplifiers and observe amplitude and frequency response.
- **MOSFET Characteristics and Amplifiers** [12 Lectures]
  - Device structure and physical operation, I-V characteristics of MOSFET, Small-signal operation and models, Basic MOSFET amplifiers, Biasing in MOSFET amplifiers
  - At the end of this practicum, the students will construct the circuit to explore the current-voltage characteristics of MOSFET. The students will also design MOSFET amplifier
- **Non-ideal operational amplifier and op-amp circuits** [6 Lectures]
  - Operational amplifiers and amplifier circuits, op-amp inverting and non-inverting configuration, Difference amplifiers, Integrator and differentiator circuits
  - In this practicum, the students will evaluate characteristics of the non-ideal operational amplifiers. Students will analyse two most popular configurations of op-amp circuits (inverting and non-inverting amplifiers), predict the results, and observe the gain and frequency response.

**Course Lectures:**

The laboratory practicum learning will be supplemented by total of 3 hours of lectures on the different topics of the course spread over the semester.

**Mini-project**

The students will also carry out a mini-project after discussion with the instructor. The aim of this project will be to understand, solve and implement solutions to real world problems.

**Text Book**

1. Adel S. Sedra and Kenneth C. Smith, **Microelectronics Circuits**, 6th Edition

## 7.34 EE 313: Measurement and Instrumentation

### Course Code: EE 313

### Course Name: Measurement and Instrumentation

L-T-P-C: 2-1-0-3
Prerequisites: IC 160: Basic Electrical Engineering and IC 161 Basic Electronics Engineering Intended for: UG
Distribution: Elective
Semester: 5th and 7th semester
Approval: 9th Senate

### Course Contents

- **Fundamentals of measuring instruments:** Terminology, Units and standards, functional elements of an instrument, input-output configuration, static characteristics and static calibration - least squares calibration curves -static sensitivity - linearity, dynamic characteristics - dynamic response analysis - operational and sinusoidal transfer function - zero-, first-, and second-order instruments, Errors and handling of errors in measurement. [10 lectures]

- **Motion and dimensional measurement**: Relative displacement and velocity: translational and rotational - resistive potentiometers - resistance strain gauge - differential transformers - eddy current noncontacting transducers - ultrasonic transducers - mechanical flyball angular velocity sensor - mechanical revolution counters and timers, relative acceleration, accelerometers - deflection type - null balance type, gyroscopic angular-displacement and velocity sensors, laser rangefinders, ultrasonic rangefinders, radars for automobiles. [12 lectures]

- **Force, torque, and shaft power measurement:** Elastic force transducers - bonded-strain-gauge transducers - differential-transformer transducers - piezoelectric transducers - variable-reluctance, torque measurement on rotating shafts, dynamometers, vibrating-wire force transducers. [3 lectures]

- **Sound and Vibration measurement**: Deadweight gauges and manometers, elastic transducers, vibrating cylinder transducers, high- pressure measurement, low pressure measurement - diaphragm gauges - McLeod gauge - Knudsen gauge - momentum transfer gauges - thermal conductivity gauges - ionisation gauges - dual gauge technique, sound measurement - microphones - pressure response - acoustic intensity - acoustic emission. [3 lectures]

- **Temperature and heat-flux measurement**: Thermal expansion methods - bimetallic thermometers - liquid-in-glass thermometers - pressure thermometers, thermoelectric sensors, electrical resistance sensors - conductive - bulk semiconductor, junction semiconductor sensors, digital thermometers, radiation methods - detectors - automatic null balance - optical - two color - fluoroptic - infrared imaging. [5 lectures]

- **Manipulation, transmission and recording of data**: Bridge circuits, amplifiers, filters, integration and differentiation, cable transmission, fiber- optic data, radio telemetry, Pneumatic transmission, instrument connectivity, potentiometers, digital voltmeters and mutimeters, electromechanical servotype XT and XY recorders, data acquisition systems. [4 lectures]

- **Electrical and Electronic Measurements**: Signal generation, Principle of LCR meter, Probe compensation, Spectrum analysis, Instrument Transformers, Measurement of Power and Wattmeters, Measurement of Energy and Industrial Metering, Digital Storage Oscilloscope, Issues of sampling, memory, ADC speed. [6 lectures]

**Textbooks:**


1. E. O. Doebelin, D. N. Manik, **Measurement systems Application and Design**, 5th Edition, McGraw Hill Book Company, 2007.

2. D. Patranabis, **Principles of Industrial Instrumentation**, 3rd Edition, Tata McGraw Hill Publishing Ltd., 2010.


**References:**


1. A.K. Sawhney, **A course in electrical and electronic measurements and instrumentation**, 19th Edition, Dhanpat Rai Publications, 2011.

2. A. S. Morris, **Measurement and Instrumentation Principles**, 3rd Edition, Butterworth-Heinemann, 2001.

3. J. P. Holman, **Experimental Methods for Engineers**, McGraw Hill Book Company, 1971.

4. W. C. Dunn, **Fundamentals of Industrial Instrumentation and Process Control**, McGraw Hill, 2005.


## 7.35 EE 314 : Digital Signal Processing

**Course Code : EE 314**

**Course Name : Digital Signal Processing**

L-T-P-C : 3-0-2-4

Intended for : B.Tech. 2nd, 3rd year students

Prerequisite : IC210: Probability, Statistics and Random Processes, EE 304: Communication Theory or the instructor's consent

Mutual Exclusion: EEXXX (Signals & Systems)

**Revision:**

Approval: 54th BoA

### Course Contents

- **Review of discrete-time signals and systems**: LTI systems and their properties, impulse response and convolution, Difference equations, Eigen-functions of LTI systems. (4 hours)

- **Fourier and Z-transforms**: Discrete-time Fourier transform and its properties; Z-transform and its properties; Discrete Fourier Transform and its properties; Fast Fourier Transform. (10 hours)
- **Sampling**: Time domain and frequency domain representation, Nyquist theorem, Signal reconstruction, Discrete-time processing of continuous-time signals, Continuous-time processing of discretetime signals, Changing the sampling rate, Multi-rate signal processing, Sub-Nyquist sampling and its applications. (8 hours)
- **Filtering**: Discrete-time frequency selective filtering, Phase distortion and delay, Characterization with difference equations, Stability and Causality, Frequency response of rational system functions, All pass and minimum phase systems, Basics of filter design, Z-transform characterization of IIR filters, Window functions for FIR filters, Filter structures for IIR and FIR filters. (10 hours)
- **Introduction to wavelets and their applications**: Haar expansions, Wavelets in continuous time, Discrete Wavelet Transform using Haar basis, Construction of wavelets using Fourier techniques, Multiresolution analysis and construction of the wavelet. (10 hours)

**Laboratory/practical/tutorial Modules:**

- The exercises/projects should cover various real-world applications of DSP. A few suggested topics: image processing and compression; Speech processing; Compressed sensing; Signal processing in communication systems

**Textbooks:**

1. Alan V. Oppenheim, Ronald W. Schafer, John R. Buck., **Discrete-Time Signal Processing**, 2nd edition, Pearson, 1999.
2. Martin Vetterli, Jelena Kovacevic and Vivek Goyal, **Fourier and Wavelet Signal Processing**, Cambridge University Press, 2014

**References:**

1. John G. Proakis, Dimitris G. Manolakis., **Digital Signal Processing – Principles, Algorithms, and Applications**, 4th Edition, Pearson 2007.
2. Stephen Mallat, **A Wavelet Tour of Signal Processing The Sparse Way**, Elsevier, 2009

## 7.36 EE 326 : Compmer Organization and Processor Architecture Design

**Course Code :EE 326**

**Course Name : Compmer Organization and Processor Architecture Design**

L-T-P-C : 3-0-2-4

Intended for : B. Tech in Electrical Engineering

Prerequisite : Digital System Design (EE 210) or equivalent
Mutual Exclusion :
Approval: 52nd BoA

**Course Contents**

- **Introduction to Computer Organization:** Notion of organization and architecture. Von Neumann and Harvard architectures; Evolution of computers; Role of VLSI Technology in miniaturization of computers. (1 Lecture)

- **Computer System Design:** Introduction , design of computer system, register transfer level (RTL) structure realizing behavior expressed in an algorithm, logic circuit level structure of RTL components, HDL description of RTL structure at architectural and logic levels. (2 Lectures)

- **Datapath Design:** Block diagram description fo a processor, overview of basic digital building blocks in the data-path, adder, subtractre, shifter, multiplier and divider, comparator circuits, optimization of adders and multipliers, integration of arithmetic logic unit, design of general purpose register files in RISC And CISC processes, integration of data-path using ALU and general purpose register file, integer versus floating point ALU, IEEE 754 single precision, double precision and extended double precision floating point formats, algorithms and RTL realization of floating point adders, subtractors, multipliers, dividers, design of floating point ALU. (8 Lectures)

- **Controller Design:** Motivation behind use of controller circuits, instruction interpretation and execution, design of hardwired controller based on finite state machine model, design of microprogrammed control circuits, horizontal and vertical microprogramming, integration of controller and data-path into a processor, design of RISC and CISC processors, examples of some well-known processors. (5 Lectures)

- **Instruction Set architecture and addressing modes:** Concept of instruction formats, types of instructions, different types of addressing modes, programming considerations in register transfers and assembly languages. Example case study of ARM processor including its instruction formats and addressing modes. Assembly language programming of ARM processor. (5 Lectures)

- **Memory Organization and design:** Introduction, processor-memory interaction, storage technology, memory array organization and technology, semiconductor memories, ROM, static and dynamic Ram, 1D vs 2D RAM, FPMDRAM, EDO-DRAM, SDRAM, RDRAM, DDRRAM, DDR2RAM, DDR4RAM, content addressable memory (CAM), memory hierarchy, cache organization, cache coherence protocols, cache mapping techniques – direct, associative, set-associative, and sector mapping techniques, cache optimization techniques, virtual memory, multiple module memory, gap filler memories – magnetic bubble memories, and charge coupled devices, secondary storage device, disc recording methods, disk drives and controllers, cyclic redundancy check logic. (8 Lectures)

- **Input Output organization:** Introduction, data transfer techniques, bus interface, programmed I/O, interrupt driven I/O, conflict resultion of interrupts, programmable interrupt controller, direct memory access (DMA), DMA controller, types of DMA. (5 Lectures)

- **Pipelining:** Linear piplelined architectures, synchronous versus asynchronous pipelining, non-linear pipelining, reservation and latency analysis, collision free scheduling, pipeline schedule optimization. (4 Lectures) Multiprocessor Architectures: Flynn's classification of computers, SISD, SIMD, MISD and MIMD architectures, shared memory multiprocessors, distributed memory multicomputers, distributed coherent caches. (4 Lectures)

**Labotaroty / practical / tutorial Modules:**

- Hardware description language: Introduction to some HDL (Verilog, VHDL, BSV). Digital Design using HDLs, Modeling and simulation of ALU, controller and processors using HDL Timing analysis of processors with inertial and transport delays.

- Assembly language programming: The assignments should cover the following concepts: Registers, different types of instructions (load, store, arithmetic, logic, branch); operand addressing modes: memory addressing modes: conditions (codes / flats and conditional branches) stack manipulation; procedure calls; procedure call conventions (load / store of; arguments on stack, activation records)

- Realization of Computer Circuits: Realization of arithmetic and logic circuits on bread board, realization of memory and I/O interface circuits on bread board, study of universal synchronous-asynchronous receiver transmitter on bread board.

**Textbooks:**

1. V. Carl Hamecher. Zvonko G. Vranesic, Safwat Zaky, **Computer Organization**, 5th Edition, Mc Graw Hill Education, 2017.

**References:**

1. John P. Hayes, **Computer Organization and Architecture**, 3rd Edition, Mc Graw Hill Education, 2017.

2. William Stallings, **Computer Organization and Architecture**, 11th Edition, Pearson, 2022.

3. Zainalabedin Navabi, **VHDL: Modular Design and Synthesis of Cores and Systems**, 3rd Edition, Mc Graw Hill Education, 2022.

## 7.37 EE 500 : Network Control System

**Course Code : EE 500**

**Course Name : Network Control System**

L-T-P-C : 3-0-0-3
Intended for : B.Tech. EE (3rd and 4th year), M.Tech., M.Tech. (R), PhD

Prerequisite : For B.Tech. – Control System or equivalent course
Mutual Exclusion:
Approval: 54th BoA

**Course Contents**

- **Introduction**: Introduction to Network Control Systems, The Rendezvous Problem, Algebraic Graph Theory, Graph Connectivity and Robustness (Cheeger's inequality, proximity graphs). (10 Hours)
- **Consensus**: The Consensus Protocol, Discrete-Time Consensus, Directed Consensus, Switching Consensus, Lyapunov Stability with Switching Networks, The Synchronization Problem and Kuramoto Model. (10 Hours)
- **Multi-Agent Robotics**: Formation, Graph rigidity and Persistence, Formation Control and Design Choices, Leader-Follower Networks, Network controllability and network feedback, Distributed optimal control. (10 Hours)
- **Mobile Sensor & Communication Networks**: Sensor networks, Gabriel and Voronoi graph, Coverage Control, Communication models, random graphs, random consensus. (10 Hours)

**Laboratory/practical/tutorial Modules:**

- None

**Textbooks:**

1. M. Mesbahi and M. Egerstedt, **Graph Theoretic Methods in Multiagent Networks**, Princeton University Press, 2010.
2. F. Bullo, J. Cortes, and S. Martinez, **Distributed Control of Robotic Networks**, Princeton University Press, 2009.

**References:**

1. T. Hatanaka, N. Chopra, M. Fujita, and M.W. Spong, **Passivity-Based-Control and Estimation in Networked Robotics**, Springer, 2015.
2. C. Godsil and G. Royle, **Algebraic Graph Theory**, Springer, 2001.
3. P. J. Antsaklis and P. Tabuada, (Editors), **Networked Embedded Sensing and Control**, Springer 2006.

## 7.38 EE 501: Power System Operation and Control

**Course Code: EE 501**

**Course Name: Power System Operation and Control**

L-T-P-C: 3
Prerequisite: Consent of the faculty member

Students intended for: UG and PG
Elective or Core: Elective
Approval: 2nd Senate

**Course Contents**

An overview of power system operations and control, basic objectives of security and economics in power system operation and control, security analysis, reactive power dispatch and optimal power flows, automatic generation control, reactive power control, state estimation, brief introduction to power system restructuring and power market operations.

**Text & Reference Books:**

Textbooks:

1. A. J. Wood and B. F. Wollenberg, **Power generation, Operation and Control**, 2nd Edition, John Wiley and Sons, 1996.
2. Prabha Kundur, **Power System Stability and Control**, Tata Mcgraw Hill Education Private Limited, 2006.
3. Loi Lei Lai, **Power System Restructuring and Deregulation: Trading, Performance and Information Technology**, John Wiley & Sons, 2001.

## 7.39 EE 502P: Analog System Design Laboratory

**Course Code: EE 502P**

**Course Name: Analog System Design Laboratory**

L-T-P-C: 0-0-3-2
Students intended for: EE 3rd year and CS 3rd Year
Elective or Core: Elective
Prerequisite: Knowledge of basic analog electronics, basic circuit analysis, Networks and Systems
Approval: 2nd Senate
The course is based on the Analog System Lab modules prepared by Texas Instruments. System Lab Kit ASLKv 2010 Starter Kit from Texas Instruments will be used for performing the experiments and also simulation tools will be used for analysis exhaustively.

**Experiments:**

- Negative Feedback Amplifiers and Instrumentation Amplifier
- Regenerative Feedback System, Astable and MonostableMultivibrator
- Integrators and Diferentiators
- AnalogFilters
- Self Tuned Filters

- Function Generator and Voltage Controlled Oscillator
- Phase Locked Loop
- Automatic Gain Control/Automatic Volume Control
- DC-DC Converter
- Low Dropout (LDO)/Linear Regulator

**Text & Reference Books:**


- Jerald G. Graeme, **Applications of Operational Amplifiers**, Third Generation Techniques
- James K. Roberge, **Operational Amplifiers: Theory and Practice**, Wiley.
- B Razavi, **Fundamentals of Microelectronics**
- A. Sedra and K. Smith, **Microelectronic Circuits**


## 7.40 EE 503: Advance Communication Theory

**Course Code : EE 503**

**Course Name : Advance Communication Theory**

L-T-P-C : 3-0-0-3
Prerequisites : IC-210: Probability, Statistics and Random Processes, EE-304:Communication Theory and the instructors consent
Intended for :UG/MS/PhD
Distribution : Elective for EE
Approval: 5th Senate

### 7.40.1 Course Contents

- **Module I**: Review of digital modulation schemes for baseband and bandlimited channels and their corresponding optimal detectors and error probabilities [6 Lectures]
- **Carrier and Symbol Synchronization**: importance in signal demodulation, carrier frequency and phase estimation decision directed and power of N methods, timing estimation - spectral-line, MMSE, and ML methods, joint carrier and symbol synchronization. [6 Lectures]
- **Equalization**: Optimal zero-forcing equalization, Linear, Decision-feedback, Adaptive Linear, Adaptive Decision-feedback, and Blind equalization. [6 Lectures]
- **Multichannel and Multicarrier Systems**: AWGN multichannels, Multicarrier communications: OFDM modulation and demodulation, spectral characteristics, bit and power allocation, channel coding. [6 Lectures]
- **Spread Spectrum Communications**: model, Direct sequence SS, PN sequences, Frequency- hopped SS, synchronization, jamming, CDMA. [5 Lectures]

- **Introduction to Information and Coding Theories**:
  - Information Theory: information measures, Shannon entropy, differential entropy, mutual information, capacity theorem for point-to-point channels with discrete and continuous alphabets. [4 Lectures]
  - Coding Theory: linear block codes definitions, properties, bounds on minimum distance (singleton, Hamming, GV, MRRW), soft versus hard decision decoding, some specific codes (Hamming, RS, Concatenated); Convolutional codes structure, decoding (the Viterbi and BCJR algorithms); Turbo codes, LDPC codes. [9 Lectures]

**Reference Books:**

1. T. Cover and J. Thomas, **Elements of Information Theory**, 2nd Edition, Wiley, 2006.

2. R. G. Gallager, **Principles of Digital Communication**, Cambridge Univ. Press, 2008.

3. A. Lapidoth, **A Foundation in Digital Communication**, Cambridge Univ. Press, 2009.

4. S. Lin and D. Costello, **Error Control Coding**, 2nd Edition, Prentice Hall, 2004.

5. J. G. Proakis and M. Salehi, **Digital Communications**, 5th Edition, McGraw-Hill, Prentice Hall, 2007.

6. B. Sklar, **Digital Communications: Fundamentals and Applications**, 2nd Edition, Prentice Hall, 2001.

## 7.41 EE 504: Switch Mode Power Conversion

**Course Code : EE 504**

**Course Name : Switch Mode Power Conversion**

L-T-P-C : 2.5-0.5-0-3
Prerequisites : EE 309 Power Electronics and Teachers Consent
Students intended for : UG/MS/PhD
Elective or Compulsory: Elective
Approval: 5th Senate

**Course Contents**

- **Introduction**: About Switch Mode Power Conversion; overview of the course; industrial relevance of this topic; SMPC requirements. [2 Lectures]

- **Basic DC to DC power converters**: Basic DC-DC converters - buck, boost, buck-boost&Cuk converters - and their principles of operation; continuous and discontinuous modes of operation; SEPIC converter. [6 Lectures]

- **Power semiconductor switches**: Review of power diodes, Schottky didoes, power MOSFETs &IGBTs. Recent developments in power devices for switch mode power supplies. Drive requirements, switching performance and snubberdesign . Selection of devices & basic heat sink design. [6 Lectures]

- **Transformer-Isolated Converters**: Single-switch and multi-switch transformer-isolated DC-DC converters. Flyback and forward converters; transformer isolated half-bridge, full-bridge converters. Push-pull converters. Voltage-fed and current-fed converters. [6 Lectures]

- **Magnetic Component Design**: Magnetic core materials and performance; basic inductor and transformer design; practical magnetic design; design aspects to be considered for designing transformers for specific applications flyback, push-pull, bridge, forward converters. [4 Lectures]

- **Switching Regulator Control**: Small-signal models for switching regulators. Performance analysis and design of closed-loop system under different control methods, and operating modes. Measurement of small signal transfer functions. [6 Lectures]

- **Soft-Switched and Resonant DC-DC Power Converters**: Motivation. Hard-switching vs soft-switching. Introduction to resonant power converters and their characteristics. Detailed study of a few soft-transition converters. [6 Lectures]

- **Single-Phase Power-Factor Correction**: Problems due to harmonics in the current drawn by equipment. Basic concept of active power-factor correction (PFC) techniques. Performance analysis and comparison of different PFC techniques. [6 Lectures]

**Reference Material:**


1. N Mohan, T M Undel and and W P Robbins, **Power Electronics: Converters, Applications and Design**, Wiley

2. A I Pressman, **Switching Power Supply Design**, McGraw-Hill

3. Selected Conference and Journal Articles

4. **Texas Instruments Power Management Application Notes** including articles from the well known Unit rode Seminar Series.

5. **Application Notes** from International Rectifiers and other Power Devices and ICs manufacturers.


## 7.42 EE 505 (3) Materials for Semiconductor Industry

Approval: 8th Senate; OTA

**Course Outline:**

Semiconductor fundamentals, band structure, indirect and direct band gap, optical properties, carrier statistics, semiconductor material purification and crystal growth, epitaxy, CVD and MBE, P-N Junction, Schottky and Mas device structures, specific material requirements, Doping by implantation and diffusion, dielectric and insulators, ohmic and barrier contacts, band edge behaviour, empirical rule, alloy design.

## 7.43 EE 506: Solar Photovoltaic Energy Systems

**Course Code : EE 506**

**Course Name : Solar Photovoltaic Energy Systems**

L-T-P-C : 2.5-0.5-0-3
Prerequisites : EE309 Power Electronics (or Instructors permission)
Students intended for : B.Tech./M.S./Ph.D
Elective or Compulsory : Elective
Approval: 5th Senate

**Course Contents**

- **Introduction**: Fossil fuel energy usage and global warming; role of renewable energy in sustainable development; renewable energy sources; global potential for solar electrical energy systems. [3 Lectures]
- **Solar radiation**: Extra terrestrial and terrestrial solar spectrum; clear sky direct-beam radiation; total clear sky insulation on a collecting surface; radiation on the collector in tracking systems; calculation of average monthly insolation from measured data. [9 Lectures]
- **PV cells and modules**: Photovoltaic cell and its simple model; i-v and p-v characteristics; PV modules and arrays; effect of shading, use of bypass and blocking diodes; influence of temperature; types of solar cells and their performance; schemes for maximum power point tracking; solar PV concentrators. [6 Lectures]
- **PV inverters**: Grid-connected single phase PV inverter schemes and control; power processing schemes based on single string, multi-string and ac module technologies; types of grid interface; power electronic converters used in single phase PV systems and their operation; transformer less inverters, centralized grid-connected three- phase inverters for large PV installations. [9 Lectures]
- **Schemes with battery energy storage**: Power processing schemes and control for stand-alone applications; batteries for energy storage types, charging, battery sizing and turn-around efficiency; other types of energy storage for PV systems; grid connected schemes with standby energy storage. [9 Lectures]
- **System level issues**: Design related issues; grounding, dc arcing and other safety related issues; islanding; harmonics; electro- magnetic interference; energy yield and economics of a PV installation. [6 Lectures]

**Text Book:**

1. Gilbert M. Masters, **Renewable and Efficient Electric Power Systems**, John Wiley & Sons, 2004

**Reference Books:**

1. Roger A. Messenger & Jerry Ventre, **Photovoltaic Systems Engineering**, 2nd Edition, CRC Press, 2004.

2. Solanki, **Solar Photovoltaics: Fundamentals, Technologies and Applications**, PHI Learning Pvt Ltd, 2009.

## 7.44 EE 507: Transmission Lines and Basic Microwave Engineering

**Course Code : EE 507**

**Course Name : Transmission Lines and Basic Microwave Engineering**

Course L-T-P-C : 3-1-0-4
Prerequisite : Consent of the faculty member
Intended for : UG/PG
Distribution : Discipline Elective for 3rd and 4th year BTech in EE, MTech in EE and MS & PhD in the area
Approval: 12th Senate

**Course Contents**

- **Introduction to transmission lines** : Basic Transmission line equations: Two line theory, capacitance and inductance in transmission lines and impedance of loaded and unloaded transmission line. Reflections and VSWR: Scattering matrix and impedance transformation. Smith chart: Stub matching. [10 Lectures]

- **Guided EM waves**: - Wave propagation in different types of transmission lines: Co-axial, microstrip, strip-lines, co-planar lines and co-planar wave guides lines. Loss and loss-less transmission lines. Metallic and dielectric wave guides: Propagation of modes. [11 Lectures]

- **Introduction to Left Handed medium**: - Wave Propagation in Left-Handed medium: metamaterial-transmission line approach. Introduction to Electromagnetic Band-gap (EBG) structures. [8 Lectures]

- **Basic microwave devices**: - H-Plane, E-Plane and Magic-T, Wave-Guide Couplers. Ferrites & ferrite devices. Diodes: Schottky, PIN, Varactor. Bipolar Junction Transistors (BJT). [10 Lectures]

- **Microwave Resonators**: - Series and parallel resonators, Transmission line resonators, Dielectric resonators and its applications. Microwave cavity: Klystron, Magnetron, TWT. Excitation techniques of resonators. [10 Lectures]

- **Microwave propagation**: - Effects of atmosphere and ground on microwave propagation, plasma Effects, microwave heating. Introduction to wire-less power transfer. Biological effects of microwave radiation and safety. [7 Lectures]

Note: All the Units will have tutorials and in the end of course there will be a presentation assignment in which student (or a group) will present latest advancement in any-one of the topics taught in class

**Text Books:**


1. R K Shevgaonkar, **Electromagnetic Waves**, McGraw Hill Education, India, 2006.

2. David M Pozar, **Microwave Engineering**, 4th Edition, John Wiley & Sons.


**References:**


1. C. Caloz and T. Itho, **Electromagnetic Metamaterial: Transmission Line Theory and Microwave Applications**, Wileys Publications.

2. Research Papers as instructed by course Instructors.


## 7.45 EE 508: Fundamentals of Electric Drives

**Course Code: EE 508**

**Course Name: Fundamentals of Electric Drives**

L-T-P-C: 3-0-0-3
Prerequisites: EE 309 (Power Electronics), EE 201 (Eletromechanics)
Intended for: UG/PG
Distribution: Elective for EE
Approval: 8th Senate

**Course Contents**

- **Introduction to drives**: [2 Lectures]
  - Importance of drives, Factors governing the choice of drives, Basics of drive dynamics, Types of load, Selection of motor power rating, Applications
- **DC motor drives**: [17 Lectures]
  - Types of dc motors, starting and braking, transient analysis of separately excited motor with armature and field control [4 Lectures]
  - Controlled rectifier fed drives, multi-quadrant operation of separately excited dc motor fed from fully-controlled converter [4 Lectures]
  - Control of electric drives, closed loop torque, speed and position control, current and speed sensing [5 Lectures]
  - Chopper controlled dc drives [2 Lectures]
  - Supply harmonics, power factor and current ripple [2 Lectures]

- **Induction motor drives**: [18 Lectures]
  - Induction motor operation with non-sinusoidal voltage supply, starting and braking of induction machines [4 Lectures]
  - Methods of speed control stator voltage control, variable frequency control, field weakening [4 Lectures]
  - Voltage Source Inverter (VSI) control of induction motors [3 Lectures]
  - Current Source Inverter (CSI) control of induction motors [3 Lectures]
  - Current regulated VSI control [2 Lectures]
  - Introduction to Vector Control [2 Lectures]
- **Synchronous motor drives**: [5 Lectures]
  - Types of synchronous motors Cylindrical-rotor and Salient-pole motors, Operation from fixed frequency supply starting, braking, load disturbance transients
  - Variable frequency control true-synchronous mode, Self-controlled mode, Self-controlled
  - Synchronous motor drive using Load Commutated Thyristor Inverter
  - Introduction to special machines Permanent Magnet synchronous motor, Brushless dc motor etc.

**Textbooks:**

1. 1. G. K. Dubey, **Fundamentals of Electric Drives**, Alpha Science International Ltd., 2001.
2. 2. Dubey G. K., **Power Semiconductor Controlled Drives**, Prentice Hall International Edition. 1989.

**Reference books:**

1. Mohan N., Undeland T.M. and Robbins W.P., **Power Electronics Converters, Applications and Design**, 3rd Edition, Wiley India. 2008
2. Bose B. K., **Power Electronics and Variable Frequency Drives Technology and Applications**, IEEE Press, Standard Publisher Distributors, 2001
3. Rashid M., **Power Electronics - Circuits, Devices and Applications**, 3rd Edition, Pearson Education, 2003.
4. Krause, P. C., Wasynczuk, O., Sudhoff, S. D., **Analysis of Electric Machinery and Drive Systems**, Wiley-Interscience, 2002.
5. S. K. Pillai, **A First Course on Electrical Drives**, New Age International Pvt. Ltd., 2004
6. R. Krishnan, **Electric Motor Drives: Modeling, Analysis, and Control**, Prentice Hall, 2001.
7. N. K. De and P. K. Sen, **Electric Drives**, Prentice-Hall of India Pvt. Ltd., 1999

## 7.46 EE 508P: Practicum on Electric Drives

### Course Code: EE 508P

### Course Name: Practicum on Electric Drives

L-T-P-C: 0-0-3-2

Prerequisites: EE 201 and EE 20lP- Electromechanics or Equivalent, EE 309 and EE 309P- Power Electronics or Equivalent

Intended for : Final year BTech Electrical Engineering (EE), M.Tech in Power Electronics and Drives (PED)

Distribution :Core for 1 year M.Tech. (PED), Elective for other PG and BTech Final year EE

Approval: 13th Senate

This is a laboratory course with 3-hour sessions per week. Following is the list of course modules and experiments.

- **Introduction to Drives** [6 hours]
  - Calculation of moment of inertia of drive+ load system
  - Verification of Fundamental Drive Equation
  - . Study of types of loads and thei r torque-speed characteristics
- **DC Drives** [12 hours]
  - Characteristics of d ifferent types of DC motors (series, shunt, separately excited)
  - Speed control (acceleration, braking) of DC motors (Rectifier fed, chopper fed)
  - Dynamic control of DC drives (closed loop controller design, simulation and validation)
  - Regenerative brakin g in closed loop DC drives
  - Closed loop controller desib111 and digital implementation of separately excited DC motor drive
  - Introduction to tield weakening mode operation and effect on dynamic performance
- **Induction Motor Drives** [15 hours]
  - No-load/blocked rotor test on induction motor
  - Plotting speed-torque characterist ics of an induction motor
  - Stator voltage control of induction motor (fed with VSl)
  - V/f control of induction motor (fed with VS J)
  - Slip speed control of ind uction motor (fed with VSI )
  - Rotor resistance control of sl ip-ring i nduction motor
  - Study of three-phase sel f-exited induction generator (SEIG)
- **Synchronous Motor Drives** [6 hours]

  - Driving the motor from a variable voltage and frequency supply
  - Study of V-curves

- **Speed control of Special machines** [3 hours]
  - BLDC, PMSMl elc.

**Textbook:**

Lab. experimental manuals will be provided.

**References:**


1. W. Leonhard, **Control of Electrical Drives**, Springer-Verlag, 200I .
2. Mohan N., Undcland T. M. and Robbins W. P., **Power Electronics- Converters, Applications and Design**, 3rd Edition, Wiley India, 2008.
3. Bose B. K., **Power Electronic;s and Variable Frequency Drives - Technology and Applications**, IEEE Press, Standard Publisher Distributors. 200 l .
4. Rashid M., **Power Electronics - Circuits, Devices and Applications**, 3rd Edition, Pearson Education.
5. Krause, P. C., Wasynczuk, O., Sudhoff, S.D., **Analysis of Electric Machinery and Drive Systems**, Wiley-lnterscicnce.


## 7.47 EE 509: Linear Dynamical Systems

**Course code: EE 509**

**Course Name: Linear Dynamical Systems**

L-T-P-C: 3-0-0-3
Prerequisites: EE 301 Control Systems
Intended for: UG/PG
Elective/Core: Elective
Approval: 8th Senate

**Course Contents**

- **Mathematical modelling and basics of linear spaces**: Mathematical descriptions: transfer function and state-space, state space representation of electrical and mechanical systems, some basics of linear vector space: vector space, basis, linear dependent, matrix representation. [4 Lectures]
- **Canonical realizations and similarity transformation**: Controller canonical realization, observer canonical realization, diagonal realization, analog computer simulation, Non-uniqueness of state-space representation, transformation to diagonal form, Jordan form, controller canonical form and observer canonical form. [8 Lectures]

- **Time response and stability**:Time response of linear systems, modal analysis (associated with eigenvalues and eigenvectors), stability analysis: external and internal stability. [6 Lectures]

- **Controllability and observability**: Controllability and observability matrices, rank test, controllable and uncontrollable modes, matrix decomposition corresponding to controllable and uncontrollable modes. [7 Lectures]

- **State feedback and state estimation**: State feedback, pole assignment, state estimation, observer design, combined controller-observer design. [10 Lectures]

**Textbooks:**

1. T. Kailath, **Linear Systems**, Prentice-Hall, 980.

**References Books:**

1. P.J. Antsaklis and A.N. Michel, **Linear Systems**, McGraw-Hill, 1997,

2. K. Ogata, **Modern Control Engineering**, Prentice-Hall, 2010.

**Course Code: EE 510**

**Course Name: Mathematical Methods for Signal Processing**

L-T-P-C: 4-0-0-4
Prerequisites: IC111 Linear Algebra, IC 210 Probability, Statistics and Random Processes
Students intended for: 3rd and 4th year UG/PG or teachers consent
Elective or Compulsory: Elective

**Course Contents**

- **Vector Spaces and Linear Algebra**: Metric spaces, vector spaces, norm, inner product, Hilbert and Banach spaces, linear transformations, projections. [10 Lectures]

- **Representation and approximation in vector spaces**: Approximation in Hilbert space, orthogonality, error minimization, least squares, polynomial approximation, linear regression, MMSE, optimal filtering, IRLS, generalized Fourier representation. [11 Lectures]

- **Linear operators**: Linear operators, operator norms, adjoint, matrix inverse, pseudo inverse, condition number, eigenvalues and eigenvectors. [9 Lectures]

- **Matrix factorizations**: LU, Cholesky and QR factorization. Singular value decomposition. [5 Lectures]

- **Selected topics in detection, estimation and optimization**: Neyman-Pearson theory, Bayes decision theory, ML detection, ML estimate, Cramer-Rao bound, MAP estimate, Kalman filter, iterative methods -conjugate gradient, k-means and EM algorithm, constrained non-linear programming Lagrange multipliers, duality, KKT conditions. [21 Lectures]

**Text Books:**

1. Todd K. Moon and Wynn C. Stirling, **Mathematical Methods and Algorithms for Signal Processing**, Prentice Hall, 2000.

**Reference Books:**

1. A.D. Lewis, **A Mathematical Introduction to Signals and Systems**, Vol. 1 and Vol. 2, 2013. (Available at Queen's University Website).

2. Edward A. Lee, Pravin Varaiya, **Structure and interpretation of Signals and Systems**, Addison Wesley, 2002.

3. Alexandre Megretski and John Wyatt, **Linear Algebra and Functional Analysis for Signals and Systems**, MIT 2009.

4. David G. Luenberger, **Optimization by Vector Space Methods**, John Wiley, 1969.

## 7.48 EE 511_9 : Computer Vision

**Course Code: EE 511_9**

**Course Name : Computer Vision**

L-T-P-C : 3-I -0-4
Intended for :
Prerequisite : IC210 Probability, Statistics and Random Processes
Mutual Exclusion : None
Approval: 9th Senate

**Course Contents:**

- **Mathematical foundations:** Basics concepts in linear algebra, Variational calculus, singular value decomposition, principal component analysis, Bayesian theory, MAP and ML estimation, inverse and ill-posed problems. (5 lectures)

- **Optics:** Camera models and Image formation models. (3 lectures)

- **Feature detection and matching**: Detecting point, edge and line features, Establishing feature Applications involving geometric features. (8lectures)

- **Shape from X:** correspondences, Shape from shading, defocus. Stereo, Epipolar geometry, Optical flow, Feature tracking. (13 lectures)

- **Recognition:** Object/face detection and recognition, instance recognition, category recognition, context and scene understanding. (13 lectures)

**Textbooks:**

1. David A. Forsyth and Jean Ponce, **Computer Vision: A Modem Approach**, 2nd Edition, Prentice Hall, 2011.

**References**


1. A. Zisserman and R. Hartley, **Multiple View Geometry in Computer Vision**, 2nd Edition, Cambridge University Press, 2004.

2. B.K.P. Hom, **Robot Vision**, MIT Press, 1986.

3. Richard Szeliski, **Computer Vision: Algorithms and Applications**, Springer, 2010.

4. Trucco and Verri, **Introductory techniques for 3-D computer vision**, Prentice Hall

5. Current literature.


## 7.49 EE 511_22: Computer Vision

**Course Code: EE 511_Revised**

**Course Name: Computer Vision**

L-T-P-C: 3-0-2-4
Prerequisites: Linear algebra, Probability and Statistics
Intended for: UG /MS / M. Tech. / PhD
Distribution:Elective: B. Tech III/IV year / MS / M. Tech./ PhD
Approval: 22nd Senate

**Course Contents:**

- **Essential mathematical tools**: Lea st squares, RANSAC, Eigen-analysis, PCA, SVD, clustering,gradient-based optimization methods. (4 Lectures)

- **Geometry, Camera models, Epipolar geometry, Stratified reconstruction, Applications**: large scale reconstruction, single-view metrology (8 Lectures)

- **Probabilistic graphical models**: MRF, CRF, Combinatorial optimization methods (5 Lectures)

- **Module IV**: Stereo disparity estimation, Optical flow (Lucas Kanade and Horn Schunk approaches, contemporary energy minimization methods) (5 Lectures)

- **Features detection and tracking**: Harris corner detector, KL tracking,SIFT, Overview of other contemporary descriptors. (5 Lectures)

- **Segmentation**: Low-level segmentation,energy minimization and clustering based methods, semantic segmentation (5 Lectures)

- **High level vision**: CNN overview, single image depth estimation, Flow-net,3D scene understanding and segmentation. (6 Lectures)

- **Synthesis**: GAN overview, 3D shape synthesis, integrating viewpoint and texture, semantic image synthesis (4 Lectures)

**Textbooks:**

1. D. Forsyth and J. Ponce, **Computer vision- A modern approach**, 2nd edition, Pearson, 2012.

**References:**

1. R. Hartley and A. Zisserman, **Multiple view geometry in computer vision**, 2nd edition, Cambridge university press, 2003
2. S. Prince, **Computer vision- Models, learning and inference**, Cambridge university press, 2012.
3. C. Bishop, **Pattern Recognition and Machine learning**, Springer, 2006.

## 7.50 EE 512: CMOS Analog IC Design

**Course Code: EE 512**

**Course name: CMOS Analog IC Design**

L-T-P-C: 3-0-2-4
Prerequisite: Network theory (EE203), Signals and System (IC260), Control Theory (EE301) and the Instructors consent.
Intended for: 3rd and 4th Year UG/PG
Elective or Core: Elective
Approval: 8th Senate

**Course Contents**

- **MOS device models and short channel effects**: [4 Lectures]
  - MOSFET level 1 and level 2 models, threshold voltage model, capacitance model, mobility model, MOSFET basics, small-signal model derivation for a single transistor amplifier
  - Process, voltage, temperature (PVT) dependency and analog layout design essential onsiderations
- **Single stage amplifiers**: [4 Lectures]
  - Basic concept, Common source stage: with resistive load, with diode connected load, with current- source load, with triode load, with source degeneration
  - Source follower (common-drain) and common gate with various loads
- **CMOS Differential amplifiers**: [4 Lectures]
  - Single ended differential operation, basic differential pair (qualitative and quantitative analysis), common mode response, differential pair with MOS loads and Gilbert cell multiplier
  - Concept of matching transistors for analog layout, analog layout techniques for differential amplifier

- **CMOS Current mirrors**: [4 Lectures]
  - Scheme and implementation: basic current mirrors, cascode current mirrors and active current mirrors with large and small signal analysis
  - Understanding of common-mode properties
  - Analog layout making techniques for current mirrors
- **CMOS amplifier Frequency response**: [4 Lectures]
  - Miller effect, common source (CS), common gate (CG), common drain (CD) stages and cascode stage
  - Analog layout techniques for MIM, MOM and fringe capacitor
- **Noise analysis of the CMOS amplifier circuits**: [4 Lectures]
  - Types of noise, significance of flicker and thermal.
  - Analysis and representation of noise in single stage amplifiers: CG, CS, CD (source follower) and cascode stage and noise in differential pairs.
- **Feedback**: [4 Lectures]
  - Feedback topologies (voltage-voltage, current-voltage, voltage-current, current-voltage) and the noise and the loading effect analysis.
- **Design of the CMOS operational amplifiers**: [9 Lectures]
  - One-stage opamps and two stage opamps,
  - Gain boosting techniques, folded cascode, telescopic amplifier and common mode feedback (CMFB) amplifier
  - Three stage opamp architectures, opamp specifications analysis, Design of high speed and high gain amplifiers
- **Stability and frequency compensation**: [4 Lectures]
  - Specification analysis, multi-pole system, three stage opamp, phase margin
  - Frequency compensation, pole-zero doublet analysis
- **Analog layout techniques**: [1 Lectures]
  - Design rule check (DRC), layout versus schematic (LVS) and antenna effects
  - Design of pad-ring and gds file generation

**Text book:**

1. Behzad Razavi, **Design of Analog CMOS Integrated Circuits**, McGraw Hill Education, 2000.

**Reference books:**

1. Phillip Allen and Douglas R. Holberg, **CMOS Analog Circuit Design**, 3rd Edition, 2011.

2. Yannis Tsividis, **Operation and Modeling of the MOS Transistor**, 2nd Edition, Oxford University Press, 2003.

3. A.S. Sedra and K.C. Smith, Adapted by A.N. Chandorkar, **Microelectronic Circuits-Theory & Applications**, 6th Edition, Oxford, 2013.

## 7.51 EE 513: Special Electrical Machines

**Course Name: EE 513**

**Course Code: Special Electrical Machines**

L-T-P-C: 3-0-0-3
Prerequisites: EE 201 Electromechanics
Students intended for: UG/PG
Elective or Compulsory: Elective
Approval: 8th Senate

**Course Contents**

**Permanent Magnet Brushless D.C. Motors**: Fundamental equations EMF and Torque equations Torque speed characteristics Rotor position sensing Sensorless motors Motion control. [9 Lectures]

**Permanent Magnet Synchronous Motors**: Construction - Principle of operation EMF and torque equations Starting Rotor configurations Dynamic model. [9 Lectures]

**Synchronous Reluctance Motors**: Constructional features axial and radial flux motors operating principle characteristics. [8 Lectures]

**Switched Reluctance Motors**: Constructional features principle of operation torque production characteristics power controllers. [8 Lectures]

**Stepping Motors**: Features fundamental equations PM stepping motors Reluctance stepping motors Hybrid stepping motors Torque and voltage equations characteristics. [8 Lectures]

**Text Books:**

1. Miller, T. J. E., **Brushless Permanent Magnet and Reluctance Motor Drives**, Oxford Science Publications, 1989.

2. Kenjo, T., and Sugawara, A., **Stepping Motors and their Microprocessor Controls**, Oxford Science Publications, 1984.

3. Venkataratnam K., **Special Electrical Machines**, CRC Press, 2009.

**Reference Books:**

1. Krishnan, R., **Permanent Magnet and BLDC Motor Drives**, CRC Press, 2009.

2. Chang-liang, X., **Permanent Magnet Brushless DC Motor Drives and Controls**, 2012.

## 7.52 EE 514: Robust Control Systems

**Course code: EE 514**

**Course Name: Robust Control Systems**

L-T-P-C: 3-0-0-3
Prerequisites: UG Control theory
Intended for: UG/MS/PhD
Elective/Core: Elective Semester: Odd/Even
Approval: 11th Senate

**Course Contents**

- **Mathematical Preliminaries**: Vector and matrix norms, Signal and system norms, Singular value decomposition, LMis. [7 Lectures]

- **System Analysis**: System representation, sensitivity and complementary sensitivity function, concept of poles and zeros, pole and zero directions, perfonnance limitations. [7 Lectures]

- **Feedback interconnection & Stability theory**: Well-posedness, Internal stability of feedback system, Nyquist plot, Small gain theorem. [5 Lectures]

- **Uncertainty and robustness**: Uncertainty representation (structured/parametric and unstnlctured), robust stability and robust performance, Kharitonov's theorem, linear fractional transformation (LFT), applications of robust control in physical systems. [12 Lectures]

- **Controller Synthesis**: Stabilizing controllers, $H_\infty$ control, $\mu$ Synthesis. [7 Lectures]

**Textbooks**

1. S. Skogestad and I. Postlethwaite, **Multivariable Feedback Control: Analysis and Design**, 2nd Edition, John Wiley & Sons, 2001.

2. S.P. Bhattacharyya, H. Chapellat, L.H. Keel, **Robust Control: The parametric approach**, Prentice Hall, 1995.

3. K. Zhou, J.C. Doyle, K. Glover, **Robust and Optimal Control**, Prentice Hall, 1996.

4. O H. Bosgra, H. Kwakemaak, G. Meinsma, **Design Methods for Control Systems**, Notes for a course of the Dutch Institute of Systems and Control, Winter term 2007- 2008.

5. S. Boyd, L. E. Ghaoui, **Linear Matrix Inequalities in System and Control Theory**, SIAM, 1994.

## 7.53 EE 515: Nonlinear Stability and Control

**Course Code: EE 515**

**Course Name: Nonlinear Stability and Control**

L-T-P-C: 4-0-0-4

Prerequisites: EE 301 Control Systems, EE 509 Linear Dynamical Systems or teachers consent

Intended for: U.G./P.G.

Distribution: Elective

Approval: 9th Senate

**Course Contents**

- **Linear and nonlinear system behaviours**: Quick recapitulation of linear differential equations, and their solutions. Qualitative properties of nonlinear systems. Existence and uniqueness of solutions to Ordinary differential equations. Linearizations. Hartman-Grobman theorem. Volterras functional expansions. [10 Lectures]

- **Lyapunovs stability theory**: Notions of stability. Lyapunovs stability theorem. Lasalles invariance principle. Circle criterion, Popov criterion. Lyapunov-Krasovskii functionals. [16 Lectures]

- **Limit cycles, Bifurcations, Chaos**: Poincar-Bendixson theorem. Center manifold theory. Simple examples of Bifurcations, and, Chaos. [7 Lectures]

- **Describing functions**:The describing function method, Computing amplitude and frequency of oscillations. [6 Lectures]

- **Nonlinear geometric control**: Lie brackets and controllability. Examples. [3 Lectures]

- **Passivity and Backstepping control**: From Absolute stability to Passivity. Passivity based design. Zero dynamics. Lg V control. Control Lyapunov functions. Recursive designs. Examples. [8 Lectures]

- **Lab exercises**: Experiments on Describing functions, Backstepping controllers etc. for Pendulum and cart system, DC to DC converter, Four tank water level control system etc. [10 Lectures]

**Note:** This is mainly a theoretical course. There is a small experimental component needing about 10 hours of lab work. This is included to give some practical demonstration of techniques taught, and also because some of our students (especially future M.Tech. students) would be heading to industry after their studies.

**Textbooks:**

1. H. Khalil, **Nonlinear Systems**, 3rd edition, Pearson, 2014
2. W. J. Terrell, **Stability and Stabilization**, Princeton University press, 2009
3. R. Sepulchre et al., **Constructive Nonlinear Control**, Springer, 1996
4. M. Krstic et al., **Nonlinear and Adaptive Control Design**, Wiley-Blackwell, 1995

**Additional References:**

1. S. Sastry, **Nonlinear Systems: Analysis, Stability, and Control, Springer**, 1999
2. W. Hahn, **Stability of Motion**, Springer, 1968
3. A. Mees, **Dynamics of feedback systems**, Wiley-Blackwell, 1981
4. A. Isidori, **Nonlinear Control Systems**, volumes 1, 2, Springer, 1995 and 1999
5. A. Blaquiere, **Nonlinear System Analysis**, Academic press, 1966
6. W. Haddad, and V. Chellaboina, **Nonlinear Dynamical Systems and Control**, Princeton University press, 2008
7. V. A. Yakubovich, G. A. Leonov, and, A. Kh. Gelig, **Stability Of Stationary Sets In Control Systems With Discontinuous Nonlinearities**, World-scientific, 2004

## 7.54 EE 516: Biomedical Systems

**Course Code: EE 516**

**Course Name: Biomedical Systems**

L-T-P-C: 2.5-0.5-1-4
Prerequisites: IC 110 Engineering Mathematics (IC110), IC 161 Applied Electronics
Intended for: UG/PG
Approval: 9th Senate

**Course Contents**

- **Introduction to Biomedical Systems**: Introduction to System Science - Notion of dynamic systems: modeling and simulation using MATLAB - Biomedical systems as dynamic systems - Compartmental modeling of biological systems - Eye movement model - Muscle model - Classical system identification. [4 Lectures]
- **Anatomy and Physiology**: Introduction-Cellular organization Tissues - Major organs and systems - Homeostasis. [6 Lectures]
- **Modelling of human body**: Cardiovascular model, Lung model, Nervous System model, Muscular system model. [5 Lectures]

- **Biomedical sensing**: Bioelectric phenomena - Origin of bio-potentials - Bio-potential measurements ECG, EEG, EMG, ERG, ENG Notion of system identification - Chemical biosensors electrochemical sensors and chemical fibro- sensors - Notion of ion selective field effect transistor (ISFET) and immunologically sensitive field effect transistor (IMFET) - Fundamentals of light propagation in biological tissue - Biophysical measurement techniques using light photoplethysmography - Acoustic biosensors phonocardiography - Photo-acoustic bio-signals estimation of blood glucose. [11 Lectures]

- **Bio-signal processing**: Characterization of bio-signals morphological, statistical and transform features - Frequency domain representation of bio-signals - Noise characteristics - Noise reduction by Ensemble Averaging and Linear Time Invariant A Posteriori - filtering techniques - Signal averaging - Wavelet transform - Compression of bio-signals - lossless and lossy compression. [6 Lectures]

- **Biomedical embedded systems**: Choice of embedded core - Notion of Internet of Things as extended to biomedicine - Embedded processing for disease diagnosis Wearable biomedical embedded systems - Point of care testing devices - Diagnostic processing for detection and classification of diseases - Computational intelligence techniques for disease diagnosis - Classification of cardiac, neuromuscular, neurological and hematological diseases - Memory management issues for diagnostic processing - Power reduction techniques in diagnostic systems. [8 Lectures]

- **Moral and ethical issues in developing Biomedical Systems**: Morality and ethics - Two moral norms: beneficence and nonmaleficence - Human experimentation - Regulation of medical device innovation - Ethical issues in feasibility studies - Ethical issues in treatment use. [2 Lectures]

**Course Project:**

A 6 weeks project where the student will develop a practical biomedical system going through the problem formulation, analysis, design and development phases.

**Text books:**

1. J. Enderle, S. Blanchard, J. Bronzino, **Introduction to Biomedical Engineering**, Elsevier Academic Press, 2009.

2. R. Begg, D.T.H. Lai, M. Palaniswami, **Computational Intelligence in Biomedical Engineering**, CRC Press, 2008.

**Reference books:**

1. L. Sornmo, P. Laguna, **Bioelectrical Signal Processing in Cardiac and Neurological Applications**, Elsevier Academic Press, 2005.

2. J.G. Webster, **Medical Instrumentation: Application and Design**, John Wileyand Sons, 2003.

### 7.55 EE 517: Wireless Communications and Networking

**Course Code: EE 517**

**Course Name: Wireless Communications and Networking**

L-T-P-C: 3-0-0-3

Prerequisites: EE-304 Communication Theory, EE-503 Advance Communication Theory or their equivalents, or the instructors consent

Intended for: UG/PG

Distribution: Elective

Approval: 9th Senate

**Course Contents**

- **Review of Information Theory, and Detection and Estimation Theory**: channel coding theorems, capacity of various channel models; detection and estimation in additive Gaussian noise. [3 Lectures]
- **Wireless Channel**: Path loss, Physical modeling, I/O models, Channel models. [4 Lectures]
- **Point to Point Communication**: Detection in Rayleigh fading channels, Diversity: time, frequency, antenna, receiver and transmitter; Impact of channel uncertainty. [5 Lectures]
- **Capacity of Wireless Channels**: AWGN channel capacity, LTI Gaussian channels, Capacity of fading channels. [4 Lectures]
- **Multiuser Channel Capacity**: Up/down-link AWGN channel, Up/down-link fading channel, frequency selective fading channels, multiuser diversity. [5 Lectures]
- **MIMO Channels**: Physical modeling, Slow and fast fading channels, Capacity, Multiplexing architectures: V-BLAST and D-BLAST, Diversity gain, Diversity-multiplexing tradeoff and universal code design for optimal DM tradeoff, Multiuser communication. [9 Lectures]
- **Cellular Systems**: Channel reuse, Multiple access, Interference management, Dynamic resource allocation: Cognitive Radio, Narrowband systems: GSM, Wideband systems: OFDM and CDMA, Cellular phone standards. [9 Lectures]
- **Other Topics**: Wireless LANs: Aloha, CSMA/CA, Protocols, Mesh networks: capacity, routing, and scheduling. [3 Lectures]

**Reference Books:**


1. D. Tse and P. Viswanath, **Fundamentals of Wireless Communication**, Cambridge Univ. Press, 2005.
2. A. Goldsmith, **Wireless Communications**, Cambridge Univ. Press, 2005.
3. A. Kumar, D. Manjunath, and J. Kuri, **Wireless Networking**, Morgan Kaufmann, 2008.

4. B. Clerckx and C. Oestges, **MIMO Wireless Networks**, Academic Press, 2/e, 2013.

5. Related research papers.

## 7.56 EE 518: Information Theory

**Course Code: EE 518**

**Course Name: Information Theory**

L-T-P-C: 3-0-0-3

Prerequisites: IC-210 Signal and Systems, EE-304 Communication Theory or equivalent and the instructors consent

Intended for: UG/PG

Distribution: Elective

Approval: 9th Senate

**Course Contents**

- **Module I**: Concept of information, Information measures: Hartley measure, Shannon Entropy. [3 Lectures]

- **Basic notions**: Entropy, joint and conditional entropy, relative entropy, mutual information, KL-distance, Jensen and Log-sum inequalities. [6 Lectures]

- **Source compression**: Asymptotic Equipartition Property (AEP) and its consequences for data-compression, types of codes, Kraft inequality, optimal codes and bounds of their lengths, Huffman codes and their optimality, Shannon code, Arithmetic coding. [6 Lectures]

- **Channel coding**: the notion of channel capacity, discrete memoryless channels, channel capacity computation for elementary DMC channels, symmetric channels, jointly typical sequences, data-processing and Fanos inequalities, channel coding theorem (achievability and converse), feedback capacity, source-channel separation theorem and joint source- channel coding: multimedia communications. [9 Lectures]

- **Differential entropy**: AEP for continuous variables, joint and conditional differential entropy, relative entropy and mutual information. [3 Lectures]

- **Gaussian channel**: Coding theorem for Gaussian channels, Bandlimited channels, parallel Gaussian channels, channels with colored Gaussian noise: water-filling argument. [9 Lectures]

- **Advanced topics**: Rate-distortion theory, Network coding, Introduction to Network Information Theory. [6 Lectures]

**Reference Books:**

1. I. Csiszr and J. Krner, **Information Theory: Coding Theorems for Discrete Memoryless Systems**, Cambridge Univ. Press, August 2011.

2. R. G. Gallager, **Information Theory and Reliable Communicatio**n, Wiley, 1968.

3. T. M. Cover and J. A. Thomas, **Elements of Information Theory**, 2nd Edition, Wiley, 2006.

4. D. J. C. MacKay, **Information Theory, Inference and Learning Algorithms**, Cambridge Univ. Press, 2003.

## 7.57 EE 519 P: CMOS Digital IC design Practicum

**Course Code: EE 519 P**

**Course name: CMOS Digital IC design Practicum**

L-T-P-C: 1-0-2-2
Intended for: MTech
Elective or Core: Core
Prerequisites: None
Approval: 10th Senate

**Course Contents**

All the experiments will be performed using a standard 180 nm CMOS technology, provided by SCL Chandigarh or a smaller technology node.

- **Physics and modeling of MOS transistor**: [2 lectures + 2 laboratory hours]
  - MOS Device understanding, NGSPICE and PSPICE modeling
  - Introduction to industry standard tools such as Cadence's Virtuoso schematic, Spectre/Eldo simulator,
- **Digital design and simulations**: [2 lectures + 4 laboratory hours]
  - MOSFET device characteristics using NGSPICE and Cadence's Virtuoso schematic and Spectre/Eldo simulators.
  - Design of CMOS inverter for a given load and generation of I/O characteristics, gain and bandwidth measurement.
- **Layout design techniques and methodologies**: [2 lectures + 2 laboratory hours]
  - Design rule, antenna effects, multi-finger transistor, passive device layout and inter connects
  - Layout of CMOS inverter design rule check(DRC) and layout v/s schematic (LVS). Post layout simulation (PLS) using Calibre of MentorGraphics of CMOS inverter using understanding of parasitics R, L and C.
- **Design, layout and PLS of combinational logic circuits**: [2 lectures + 6 laboratory hours]

- Design, layout and PLS of CMOS digital functions using Complementary CMOS, Pass transistor, Pseudo
- NMOS logic, Complementary Pass Transistor Logic.
  * Design, layout and PLS of multiplexer and demultiplexer.

- **Design, layout and PLS of sequential logic circuits**: [2 lectures + 6 laboratory hours]
  - Design, layout and PLS of sequential logic circuits.
  - Finite state machine implementation (FSM)
- **Memory design**: [2 lectures + 4 laboratory hours]
  - Design, layout and PLS of memory unit cell, and the complete memory. Learning of GDS generation generation.
  - The students will submit the project on memory using industry standard tools. The students will follow all the steps from schematic entry to GDS file generation.
- **FPGA**: [2 lectures + 4 laboratory hours]
  - Introduction to FPGA. Hand-on sessions on XILINX FPGA kits.

**Reference books:**

1. Neil H. E. Weste and D. Harris, **CMOS VLSI Design A Circuits and Systems Perspective**.
2. J. Rabaey, **Digital Integrated Circuits**.

## 7.58 EE 520: Microelectronics Devices and Modelling

**Course Code: EE 520**

**Course Name: Microelectronics Devices and Modelling**

L-T-P-C: 3-0-0-3
Prerequisites: Applied Electronics (IC 161 & IC 161 P) and Device Electronics for Integrated (EE311 and EE312 P)
Intended for: M.Tech EE (VLSI) / UG
Elective or Core: Core for M.Tech EE (VLSI) and Elective for UG
Approval: 10th Senate

**Course Contents**

- **SEMICONDUCTOR ELECTRONICS**:
  - Physics of Semiconductor Materials, Band Model of Solids Thermal-Equilibrium Statistics, Carriers in Semiconductors, Drift Velocity, Mobility and Scattering, Drift & Diffusion Current, Device: Hall-Effect. [6 Lectures]
- **METAL-SEMICONDUCTOR CONTACTS and P-N JUNCTIONS**:

- Metal-Semiconductor junctions, Current-Voltage Characteristics, Surface Effects. The pn junction, Step Junction, Linearly Graded Junction, Heterojunctions, Reverse-Biased p-n junctions and break down mechanism. Generation and Recombination. [8 Lectures]

- **FIELD-EFFECT TRANSISTORS (MOSFETs): PHYSICAL EFFECTS AND MODELS**:
  - MOS Capacitor, Oxide and Interface Charge: Origin and Experimental Determination Charge- Coupled Devices, non-volatile memory.
  - Basic MOSFET behaviour, MOSFET scaling and short channel model. Devices: Complementary MOSFETs (CMOS), electric fields and velocity-saturation, basic leakage currents, channel length modulation, body bias effect, threshold adjustment, sub-threshold conduction. [9 Lectures]

- **Device Modeling**:
  - Limitation of long channel analysis, short-channel effects: velocity saturation, device degradation, channel length modulation, body bias effect, threshold adjustment, mobility degradation, hot carrier effects, MOSFET scaling goals, gate coupling, velocity overshoot, high field effects in scaled MOSFETs, substrate current and effects in scaled MOSFETS.
  - Moore law, Technology nodes and ITRS, Physical & Technological Challenges to scaling, Nonconventional MOSFET (FDSOI, SOI, Multi-gate MOSFETs). [10 Lectures]

- **Numerical Simulation**:
  - Numerical simulation, basic concepts of simulations, grids, device simulation and challenges. Importance of semiconductor device simulators - Key elements of physical device simulation, historical development of the physical device modeling.
  - Introduction to the TCAD Simulation Tool, Examples of TCAD Simulations MOSFETs and SOI. [8 Lectures]

**Text Books:**


1. S. M. Sze and M.K. Lee, **Semiconductor devices- Physics and Technology**, 3rd Edition, John Wiley & Sons, 2012.
2. Muller and Kkammins, **Device Electronics for Integrated circuits**.
3. VagicaVasileska and Stephen M. Goodnick, **Computational Electronics: Semiclassical and Quantum Device Modeling and Simulation**.
4. Shundri Oda & David Ferry, **Silicon Nanoelectronics**, CRC Press.

**References:**


1. S. M. Sze and Kwok K. Ng, **Physics of Semiconductor Devices**, 3rd Eddition, John Wiley & Sons, 2002.

2. Ben G. Steetman and Sanjay Banerjee, **Solid State Electronic Devices**, 6th Edition, Prentice Hall, 2005

3. Robert F. Pierret, **Semiconductor Device Fundamentals**, Addison-Wesley Publishing, 1996

4. Donald A. Neamen, **Semiconductor Physics and Devices**, 3rd Eddition, McGrawHill, 2003

5. Jasprit Singh, **Semiconductor Devices - Basic Principles**, John Wiley and Sons Inc., 2001


## 7.59 EE 522: Matrix Theory for Engineers

**Course Code: EE 522**

**Course Name : Matrix Theory for Engineers**

L-T-P-C : 3-0-0-3

Prerequisites: IC 111 Linear Algebra, or a similar course or permission from the lnstructor.

Intended for: M.Tech./MS/PhD, The 3rd/4th year BTech.

Distribution: Core for M.Toch.in Communication and Signal Processing (CSP), Elective for other postgraduates and T1hird and Final Year BTech.

Approval: 13th Senate

**Course Contents**

- **Background and review**: Quick recapitulation of linear system of equations, and their solutionsMatrices, Detenninant, Rank, Linear Vector spaces, B is, Dimensions, Subspaces, Inner product and orthogonality. Range space and null space, Eigenvalues and eigenvectors. [4 Lectures]

- **Norms for vectors and matrices**: Vector norms and their properties, Matrix norms, Error analysis in linear systems. [4 Lectures]

- **Canonical forms, Symmetric and Hermitian matrices**: Jordon Canonical fonn, Definition, properties, and characterization of Hermitian matrices, Congruence and simultaneous diagonalization of Hermitian and symmetric matrices. [5 Lectures]

- **Perturbation theory and Eigenvalue problems**: The condition of Eigenvalues, Condition numbers and Lheir application, location and perturbation of Eigenvectors, Generalized Eigenvalue problems, Rayleigh Quotient. [5 Lectures]

- **Matrix factorization and Least square problems**: Singular value decomposition, generalized pseudoinvcrscs.QR factorization, PCA, Least square problems. [4 Lectures]

- **Sparse matrices, their annlysis and algorithms**: Graphs and matrices, Linear sol vers and their complexity, Sparse Gaussian elimination, Krylov-subspace iterations, Preconditioned methods: Incomplete factorization, Sparse approximate inverses, Sparse eigenvalue and singular value problems. [5 Lectures]

- **Different types and matrices, tbeir properties and analysis**: Irreducible, primitive. stochastic and doubly stochastic matrices; Properties of posit ive definite matrices; Sparse matrices and their analysis, Toeplitz and Circulant matrices. [5 Lectures]

- **Random matrices and their applications**: Introduction to randomness: concentration of measure, Lemma of Johnson and Lindcnstrauss. Random matrices: Matrix norms, Golden-Thompson ineq uality, Non commutative Bernstein inequal ity, Lieb's theorem, Applications: matrix multiplication and m trix completion. [5 Lectures]

- **Numerical analysis and iterative methods**: Overview of iterative methods, Arnoldi iteratil)OS, Generalized minimal residual method, Lanczos iterations, Conjugate gradients, Biorthogonalization method. [5 Lectures]

**Textbooks:**

1. Roger A. Horn and Charles R. Johnson, **Matrix Analysis**, Cambridge university press, 2012.

2. Gene H. Golub and Charles F. Van Loan, **Matrix computations**, 3rd Edition, John Hopkins University Press, 2012.

**Additional Referenctos:**

1. David Lcwis, **Matrix Theory**, 3rd edition, Allied Publishers, 2014

2. T. A. Davis, **Direct Method for Sparse Linear Systems**, SlAM, 2006

3. Joel Tropp, **An Introduction to Matrix Concentration lnequalities**, 2015

4. Terence Tao, **Topics in Random Matrix Themy**, AMS, 2012

5. Lloyd N. Trefethen and David Bau Ill, **Numerical linear algebra**, Siam, 1997.

6. Alan J. Laub, **Matrix analysisfor scientists and engineers**, Siam2005.

7. Harry Dym, **Linear algebra in action**, American Mathematical Society, 2013.

8. Gilbert Strang, **Linear Algebra and its application**, 3rd Edition, Harcourth Brace Jovanovich Pubs.

## 7.60 EE 523: Digital VLSI Architecture Design

**Course Code : EE 523**

**Course Name : Digital VLSI Architecture Design**

L-T-P-C : 3-0-2-4.

Pre-requisite : IC161 - Applied Electronics, EE312P-Microelectronics Circuit Design Practicum, EE208P-Digital System-Design Practicum or Equivalent

Intended for :Final year BTech Electrical Engineering (EE), MS, M. Tech. & PhD.

Distribution : Elective for Final year B. Tech (EE), MS, M. Tech. & PhD

Approval: 14th Senate

**Course Contents**

- **Introduction**: Review of VLSI design flow, goals of VLSI design: optimization of speed, power dissipation, cost and reliability. [2 Lectures]
- **System Design Flow & Fixed-point Arithmetic**: Overview, system design flow, representation of numbers, floating point format, Qn.m format for fixed point arithmetic, floating-point to fixed-point conversion, block floating-point formats, forms of digital filters. [2 Lectures]
- **Algorithm to Architecture Transformation**: Architectural antipodes, transform approach to VLSI architectures, graph based formalism for describing processing algorithms, isomorphic architecture. [3 Lectures]
- **Equivalence Transforms for Combinational Computations**: Common assumptions, pipelining, replication, time sharing, associatively transform and other algebraic transforms. [5 Lectures]
- **Clocking of Synchronous Circuits**: Single-phase and two-phase clocking, wave pipelining, collective clock-buffer design, distributed clock-buffer trees, hybrid-clock distribution networks, impact of clock distribution delay on input/output (I/O) timing. [6 Lectures]
- **Asynchronous Data Processing Architectures**: Data consistency problem of vectored acquisition-plain bit parallel synchronization, unit distance coding, suppression of cross patterns, handshaking, partial handshaking, data consistency problem of scalar acquisition-synchronization at single place, synchronization at multiple places, synchronization from a slow clock, meta-stable synchronizer behavior. [5 Lectures]
- **Digital Signal Processing Using Array Architectures**: Systolic and wavefront arrays, mapping dependence and signal flow graphs to systolic and wave-front arrays, asynchronous communication protocols for wave-front arrays. [5 Lectures]
- **Architectural Synthesis and Optimization**: Circuit specifications for architectural synthesis, fundamental architectural synthesis problems, temporal domain-scheduling, spatial domain-binding, sequencing graphs, hierarchical models, synchronization problem, area and performance estimation, data path and control unit synthesis, constrained and unconstrained scheduling, scheduling of pipelined circuits. [8 Lectures]

- **CORDIC Based Architectures**: Introduction, CORDIC algorithm for hardware implementation, hardware mapping, time-shared architecture, C-slow time shared architecture, modified CORDIC algorithm, recording of binary representation as 1, hardware optimization, optimal hardware design for CORDIC. [2 Lectures]

- **Digital Design of Communication Systems**: Top-level design options: bus-based design, point-to-point design, network-based design, hybrid connectivity, point-point KPN-based top-level design, KPN with shared bus and DMA controller, network-on-chip (NoC) top- level design, design of a router for NoC, run-time configuration, NoC for software defined radio. Typical digital communication system: source encoding, data compression, encryption, channel coding, framing, modulation, digital up-conversion and mixing, front end of the receiver. [4 Lectures]

**Text Books:**


1. Hubert Kaeslin, **Digital Integrated Circuit Design: From VLSI Architectures to CMOS Fabrication**, Cambridge University Press, 2009.

2. Giovanni De Micheli, **Synthesis and Optimization of Digital Circuits**, McGraw Hill, 2012.


**References:**


1. A.M. Fahim, **Clock generators for SoC processors: Circuits and Architectures**, Kluwer Academic Publishers, 2005.

2. Magdy A. Bayoumi, **VLSI Design Methodologies for Digital Signal Processing Architectures**, Springe, 2012.

3. Shoab Ahmed Khan, **Digital Design of Signal Processing Systems: A Practical Approach**, Wiley, 2011.

4. S.Y. Kung, **VLSI Array Processors**, Prentice Hall, 2012.


## 7.61 EE 524: Digital MOS LSI Circuits

**Course Code : EE 524**

**Course Name : Digital MOS LSI Circuits**

L-T-P-C : 3-0-0-3.

Pre-requisite : IC161 - Applied Electronics or Equivalent, EE311-Device Electronics for Integrated Circuits or Equivalent

Intended for :BTech Electrical Engineering (EE), M. Tech., MS & PhD.

Distribution : Elective for Third and Final year B. Tech (EE), MS, M. Tech. & PhD

Approval: 14th Senate

**Course Contents**

- **Introduction**: An overview of IC development and trends. A review of basic properties of MOS transistors and device physics relevant for digital logic design. CMOS process technology, layout and design rules. [5 Lectures]

- **CMOS Inverter**: Static CMOS inverter, static behavior switching threshold, noise margin, robustness. Dynamic behavior capacitance computation, propagation delay- first order analysis, power, energy and energy delay. [3 Lectures]
- **Combination logic gates in CMOS**: Static CMOS design complementary CMOS, Ratioed Logic, Pass transistor logic- dynamic CMOS Design dynamic logic principles, speed and power dissipation, issues in dynamic design, cascading dynamic gates, designing logic for reduced supply voltage, simulation and layout techniques for complex gates. [5 Lectures]
- **Sequential logic circuits in CMOS**: Timing metrics for sequential circuits, memory element classifications, static latches and Registers, dynamic latches and Registers, Alternative register styles pulse and sense amplifier based registers, pipelining, Non Bi stable sequential Circuits, Choosing clock strategy. [5 Lectures]
- **Design Criteria**: Introduction Custom, semi custom and structured array design approaches, cell based Design methodology, Array based implementations prediffused pre-wired arrays, characterizing logic and sequential cells. [5 Lectures]
- **Interconnect Gilbert Strang**: Coping with interconnect , capactiveparasitics cross talk, resistive parasitics Ohmic voltage drop- electromigration-RC delay, inductive parasitics voltage drop transmission line effects, advanced interconnect techniques reduced Swing Circuits Current mode transmission Techniques. [4 Lectures]
- **Timing issues**: Timing classification of digital systems, synchronous interconnect, Synchronous timing basics, source of skew and jitter, clock distribution techniques and latch based clocking, self timed circuit design- clock synthesis and synchronization using a phase Locked loop. [5 Lectures]
- **Design verification**: Datapaths in digital Processor architectures, the adder, multiplier, shifter, power and speed tradeoffs in datapath structures -memory architecture and buliding blocks, memory core, peripheral cicuit, reliability and yield, power dissipation. [5 Lectures]
- **Design for Testability**: issues in design for testability, ad hoc testing, scan based testing, boundary scan design, Built in self Test, test pattern generation, fault models. [5 Lectures]

**Text Books:**

1. Neil H.E. Weste and Harris D M, **CMOS VLSI Design: A circuit and Systems Perspective**, Fourth Edition, Addison Wesley, 2011.

**References:**

1. Jan M. Rabaye, **Digital Integrated Circuits: A Design Perspective**, 2nd Edition, Prentice-Hall, 2003.
2. Ken Martin, **Digital Integrated Circuit Design**, Oxford University Press, 2000.
3. Sung-Mo Kang,Yusuf Leblebici, **Digital Integrated Circuits: Analysis and Design**, McGraw-Hill, 2002.

4. A. Chandrakasan, W. Bowhill, F. Fox, **Design of High Performance Microprocessor Circuits**, IEEE Press, 2000.

5. John P. Uyemura, Thomson, **Chip Design for Submicron VLSI: CMOS Layout and Simulation**, 2005.

## 7.62 EE 526:Power Semiconductor Devices

**Course Code : EE 526**

**Course Name :Power Semiconductor Devices**

L-T-P-C : 3-0-0-3
Approval: 14th senate meeting
Prerequisite : IC160-Applied Electronics or equivalent, EE311-Device electronics for integrated circuit or equivalent
Intended for :BTech Third and Final year/M.Tech./MS/PhD
Distribution :Elective for third and final year Electrical Engineering, M.Tech. Power Electronics and Drives (PED), M.Tech VLSI, MS, PhD
Approval: 14th Senate

**Course Contents**

- **Introduction and Emergence of power semiconductor devices**: Overview of energy intensive civilization and its growth, impact on sustainable world, circuit requirements from power devices, power devices requirements from materials. [2 Lectures]

- **Materials Properties and Transport Physics**: Basics of semiconductor physics, polarization, quantum structures, bandgap narrowing, impact ionization, resistivity, recombination, scattering. [6 Lectures]

- **Semiconductor Junctions**: Review of p-n junction and metal-semiconductor junction, heterojunction, insulator- semiconductor junction, Zener and avalanche breakdown, design of breakdown voltage and edge terminations, parasitic circuit elements in rectifiers. [4 Lectures]

- **Power Diodes and rectifiers**: Power Schottky rectifiers, forward conduction and reverse blocking, device capacitance and thermal analysis, P-i-N rectifiers, switching performance. [4 Lectures]

- **5 BJT for Power Application**: Structure, operating principle, current gain, emitter current crowding, output and on-state and switching characteristics, Darlington configuration. [4 Lectures]

- **6 Power MOSFETs and HEMTs**: Ideal specific on-resistance, device structure and operation, characteristics, blocking voltage, VD-MOSFET, U-MOSFET, high frequency operation, switching characteristics, heterostructure, triangular potential well, 2DEG, charge control model, small-signal characteristics, power- frequency limit. [6 Lectures]

- **Thyristors**: Structure and operation, bloc king and on-state and switching characteristics, Gate Turn-Off thyristor and triac structure and operations. [4 Lectures]
- **Insulated Gate Bipolar Transistor**: Structures, operation and output characteristics, equivalent circuit, blocking and on-state characteristics, current saturation model, power loss optimization, superjunction. [4 Lectures]
- **Widebandgap semiconductors and Advanced Technologies**: Properties and advantages of SiC and GaN, shielded technology, lateral and vertical device, enhancement mode device, reliability aspects,fabrication, homo-epitaxy, hetero-epitaxy, molecular beam epitaxy, metal organic chemical vapor deposition, packaging and thermal management, power IC, integration of devices with CMOS, oxide electronics. [8 Lectures]

Students will perform one project/practical work based on modeling, simulation with Technology Computer Aided Design (Synopsys Sentaurus/ Silvaco ATLAS) or fabrication for further improvement of devices performances as instructed.

**Text books:**

1. B. J. Baliga, **Fundamentals of Power Semiconductor Devices**, Springer, 2008.
2. Yung C Liang and Ganesg S Samudra, **Power Microelectronics: Device and Process Technologies**, World Scientific.

**References:**

1. B. Streetman and S. Banerjee, **Solid State Electronic Devices**, 7th Edition, 2006.
2. S.M. Sze, **Physics of Semiconductor Devices**, 2nd Edition, Wiley, 2008
3. M. Meneghini, G. Meneghesso, E. Zanoni, **Power GaN Devices: Materials, Applications and Reliability**, Springer, 2017.
4. Tore M. Undeland, Riobbins, **Power electronics: converters, applications, and design**, Wiley, 2007.
5. R.S. Ramshaw, **Power Electronics Semiconductor Switches**, Champman & Hall, 2013.

## 7.63 EE 527 : Analysis and De::;ign of Power Electronic Converters

**Course Code : EE 527**

**Course Name : Analysis and De::;ign of Power Electronic Converters**

L-T-P-C:3-0-0-3

Prerequisites : EE 309 - Power Electronics or Equivalent or instuctor Consent
Intended for:BTcch Final year/M.Tech./MS/PhD

Distribution: Core course Lor M.Tech. Power Electronics and Drives (PED), Elective for final year Electrical Engineering, MS. PhD

Approval: 13th Senate

**Course Contents**

- **Introduction**: [2 Lectures]
  - Review of basic power electronics concepts, power control through switchingoverview of power devices, convef[ers and emerging applications
- **AC-DC Converters**: [11 Lectures]
  - Introduction types of AC-DC conve11ers such as line commutate.d type, Multipulse topologies, and PWM rectifiers
  - Power quality issues related to AC-DC converters, Mitigation through AC-DC power factor correction circuits in single phase and three phase application and through multi-level AC-DC conversion
  - Modelling, design and control of power factor correction circuits
  - Bi-directional PWM rectifiers: Dynamic switching function models, control and appl ications as fiont end converters
- **DC-AC converters**: [12 Lectures]
  - Introduction to DC-AC converters including multilevel, inverters for open ended load configur lions and their switching strategies
  - Voltge source and current source converters - topologies and PWM techniques
  - Sing1e phase and three phase inverters: Dynamic models, control methods and applications as grid connected converter
  - Applications in low frequency AC synthesis and three-phase PWM techniques
  - Calculation of switching and conduction losses in DC-AC converters
- **AC-AC Converters**: [10 Lectures]
  - lntroduction to AC-AC converters including matrix converters and multi-stage converters
  - Single phase and three phase matrix converters - topologies and PWM techniques
  - Modelling and control strategies of matrix converters
  - Multi-stage converters: Voltage link & current link topologies, dynamic models, Control methods and applications
- **High frequency link Converters**: [7 Lectures]
  - Introduction to high frequency link converters including resonant inverters and high frequency rectifiers
  - Basic concepts on inverters with resonant DC link, high-frequency rectifiers, and de-de resonant converters and their applications in enefgy storage system

**Textbooks:**

1. Mohan N., Undeland T.M. and Robbins W.P., **Power Electronics -Converters, Applications and Design**, 3rd Edition, Wily India. 2008

2. L. Umanand, **Power Electronics: Essentials & Applications**, Wiley Jndia, 2009.

**Reference books**

1. R.W. Erickson, D. Maksimovic, **Fundamentals of Power Electronics**, 2nd Edition, Kluwer Academic Publishers.

2. Bin Wu, **High-Power Converters and AC Drives**, IEEE Press, John Wiley & Sons, 2006.

3. Rashid M., **Power Electronics- Circuits, Devices and Applications**, 3rd Edition, Pearson Education.

4. A. LPressman, **Switch Mode Power Supply Desig**n, McGraw-Hill, 1999.

5. R.S. Ramshaw, **Powcr Electronics Semiconductor Switches**, Champman & Hall, 1993.

6. D. Grahamc Holmes, Thomas A. Lipo, **Pulse width modulation for power converters: principles and practic**e, John Wiley & Sons, 2003.

## 7.64 EE 527P: Practicum on Analysis and Design of Power Electronic Converters

**Course Code : EE 527P**

**Course Name: Practicum on Analysis and Design of Power Electronic Converters**

L-T-P-C: 0-0-3-2
Prerequisites: EE309 and EE309P- Power Electronics or Equivalent
Intended for: BTech final year and M.Tech in Power Electronics and Drives (PED)
Distribution:Core for M.Tech. in PED, Elective tor final year Electrical Engineering and other PG
Approval: 13th Senate

**Course Contents**

This is a laboratory course with 3-hour sessions per week. Following is the list of course modules and experiments.

- **Part I** Part-1 will involve experiments related to analysis, design, control and applications' of power clectronk converters
  - Basic and few advanced AC-DC, DC-AC, DC- DC and AC-AC converters: Analysis and design (11 hours)

    - Closed loop control of power electronics c.onverter (10 hours)

- Demonstration of few power elect1:onics converter applications such as renewable grid interactive converter, power tactor correction circuits etc. (6 boors)
- **Part-II** (15 hours) Part-II will involve a design project related to analysis, design and control of power electronic converters

**Textbook:**

1. Lab experimental manuals will be provided lor Part-1.

4. References:


1. Mohan N., Undeland T.M. and Robbins W.P., **Power Electronics – Converters, Applications and Design**, 3rd Edition, Wiley India, 2008
2. L. Umammd, **Power Electronics: Essentials & Applications**, Wiley India, 2009.
3. R.W. Erickson, D. Maksirnovic, **Fundamentals of Power Electronics**, 2nd Edition, Kluwer Academic Publishers.
4. Bin Wu, **High Power Converters and AC Drives**, I EEE Press, John Wiley & Sons, 2006.
5. Rashid M., **Power Electronics - Circuits, Devices and Applications**, 3rd Edition, Pearson Education.
6. A. T.Pressman, **Switch Mode Power Supply Design**, McGraw-Hill, 1999.
7. R.S. Ramshaw, **Power Electronics Semiconductor Switches**, Champman & Hall, 1993.
8. D. Grahame Holmes, Thomas A. Lipo, **Pulse width modulation for power converters: principles and practice**, John Wiley & Sons, 2003.


## 7.65 EE 528: Modelling and Analysis of Electrical Machines

**Course Code : EE 528**

**Course Name : Modelling and Analysis of Electrical Machines**

L-T-P-C : 2-0-2-3

Prerequisites :EE 201 and EE201P - Electromechanics Theory and Laboratory/ Instructor Consent

Intended for : BTech/M.Tech./MS/PhD

Distribution : Core course for M. Tech. in Power Electronics and Drives, Elective forBTech, MTech, MS, PhD

Approval: 13th Senate

**Course Contents**

- **Basic Principles of Electric Machine Analysis** [4 Lectures]
  - Review on basic magnetic circuits and electromagnets including analysis of magnetic circuits with airgap and permanent magnets.
  - Principle of Electromagnetic Energy Conversion
  - Basic Two pole DC Machine – primitive 2 axis machine -Voltage and Current relationship – Torque equation
- **DC Machine Modeling**: [5 Lectures]
  - Mathematical modeling of D.C. Machine (Separately Excited, shunt and series type)
  - Linearization of machine equations and state space modeling of the machine
- **Induction Machine Modeling**: [9 Lectures]
  - Distributed Winding in AC Machinery, winding function, air gap mmf, rotating mmf. Calculation of self and mutual inductances
  - Reference frame theory, stator and rotor voltage equations and torque equation in different reference frames, Linearized machine equations and Eigenvalue analysis, Derivation of model for steady-state analysis
  - Derivation of induction motor model in rotor fluxand stator flux oriented reference frame
- **Synchronous Machine Modeling**: [4 Lectures]
  - Voltage and torque equations of salient pole synchronous machine including damper winding in stator and rotor reference frames
  - Derivation of steady state model
- **Permanent Magnet Machine Modeling**: [6 Lectures]
  - Modeling of sine-wave and square-wave machines
  - Voltage and torque equations of surface-mounted permanent magnet machine in stator and rotor reference frames
  - Derivation of steady state model

**Modeling and Simulation Lab. Sessions:**

- Introduction to softwares
- Mathematical modeling of simple circuits & systems
- Mathematical modeling of D.C. machines
- Reference frame theory
- Induction machine modelling in different reference frames including saturation effects

- Induction machine modelling for steady-state analysis
- Synchronous machine modelling in different reference frames including saturation effects
- Synchronous machine modelling for steady-state analysis
- Permanent magnet synchronous machine modelling
- Brushless DC machine modelling

**Textbooks:**


1. Paul C. Krause, Oleg Wasynczuk, Scott D.Sudhoff, **Analysis of Electric Machinery and Drive Systems**, 2nd Edtion, John Wiley and Sons, 2006.
2. Chee MunOng, **Dynamic Simulation of Electric Machinery**, Prentice Hall, 1997. (https://in.mathworks.com/matlabcentral/fileexchange/9941-dynamic-simulations-of-electric-machinery-using-matlab-simulink)
3. R Krishnan, **Permanent Magnet Synchronous and Brushless DC Motor Drives**, CRC Press, 2009.


**References**


1. Prof. S P Das, **NPTEL Videos: Advanced Electric Drives** (https://nptel.ac.in/courses/108/
2. Prof. K. Vasudevan, **NPTEL Videos: Modelling and Analysis of Electric Machines** (https://nptel.ac.in/courses/108/106/108106023/)
3. Bimbhra P.S., **Generalized Circuit Theory of Electrical Machines**, 5th Edition, Khanna Publishers Limited, 2000.
4. B. K. Bose, **Modern Power Electronics and AC Drives**, PearsonEducation, 2015
5. R. Krishnan, **Electric Motor Drives Modelling, Analysis and Control**, Pearson Education, 2015.
6. P. Vas, **Vector Control of A.C. Machines**, Clarendon Press, Oxford 1990.


## 7.66 EE 528 : Modelling and Analysis of Electrical Machines

**Course Code: EE 528**

**Course Name: Modelling and Analysis of Electrical Machines**

L-T-P-C: 3-0-0-3

Prerequisites: EE 201 and EE201P Electromechanics Theory and Labor Instructor Consent

Intended for: M. Tech Final year/M.Tech./MS/PhD

Distribution: Core course for M. Tech. in Power Electronics and Drives, Elective for final year BTech Electrical Engineering, MS, PhD

Approval: 40th BoA; Updated version of 13th Senate

**Course Contents:**

- Basic Principles of Electric Machine Analysis (3 hours)
  - Review on basic magnetic circuits and e lectromagnets including analysis of magnetic circuits with airgap and pemument magnets
  - Principle of Electromagnetic Energy Conversion
  - Basic Two pole DC Machine - primitive 2 axis machine -Voltage and Current relationship - Torque equation
- DC Machine Modeling (9 hours)
  - Mathematical modeling of D.C. Machine (Separately Excited, shunt and series type)
  - Linearization of machine equations and state space modeling of the machine
- Induction Machine Modeling (14 hours)
  - Distributed Winding in AC Machinery, winding function, air gap mmf, rotating mmf. Calculation of self and mutual inductances
  - Reference frame theory, stator and rotor voltage equations and torque equation in diffeerent reference frames, Linearized machine equations and Eigenvalue analysis, Derivation of model for steady-state analysis
  - Derivation of induction motor model in rotor fluxand stator flux oriented reference frame
- Synchronous machine Modeling (8 hours)
  - Voltage and torque equations of salient pole synchronous machine including damper winding in stator and rotor reference frames
  - Derivation of steady state model
- Permanent Magnet Machine Modeling (8 hours)
  - Modeling of sine-wave and square-wave machines
  - Voltage and torque equations of surface-mounted permanent magnet machine in stator and rotor reference frames
  - Derivation of steady state model

**Textbooks**

1. Paul C. Krause, Oleg Wasynczuk, Scott D.Sudhoff, **Analysis of Electric Machinery and drive systems**, 2nd Edition, John Wiley and Sons, 2006.
2. C.V. Jones, **Unified Theory of Electrical Machines**, Buttenvorths Publishers, l967.
3. Bimbhra P.S., **Generalized Circuit Theory of Electrical Machines**, 5th Edition, Khanna Publishers Limited, 2000.

**Reference Books:**

1. J. Meisel, **Principles of Electromechanical Energy Conversion**, McGraw Hill, 1966.

2. John Salmon, **Applications of General Theories to Electrical Machines Contributions to their Design and Performance**, Troubador Publishing Ltd, 2008.

3. P. Vas, **Vector Control of A.C. Machines**, Clarendon Press, Oxford, 1990.

4. R Krishnan, **Electric Motor Drives - Modelling, Analysis and Control**, PHI Learning private Ltd.

5. K R Padiyar, **Power System Dynamics - Stability and Control**, B S publications.

## 7.67 EE 529 : Embedded Systems

**Course Code : EE 529**

**Course Name : Embedded Systems**

L-T-P-C : 3-0-2-4

Pre-requisite : IC161 - Applied Electronics, CS201 Computer Organization or any course on microprocessors or Equivalent

Intended for : BTech Computer Science Engineering (CSE) and Electrical Engineering (EE), MS, M. Tech. & PhD.

Distribution : Elective for Third and Final year B. Tech (CSE/EE), MS, M. Tech. in VLSI/Signal Processing and Communication/Power Electronics and Drives & PhD

Approval: 14th Senate

**Course Contents**

- **Introduction to embedded systems**: Understanding an embedded system, design metrics, design challenges, technologies for embedded systems. [2 Lectures]

- **Custom Single Purpose Processor for Embedded Systems**: Design of datapaths and controllers, finite state machines, custom single purpose processor design at RT level, optimizing custom single purpose processors. [3 Lectures]

- **Hardware Description Language**: Introduction to hardware description language, overview of structural, behavioral and dataflow modeling of digital systems using hardware description language, notion of finite state machines, delay modeling, memory modeling, synthesizable & non-synthesizable HDL codes for digital system design. [3 Lectures]

- **Introduction to FPGA**: Introduction to complex digital systems design, notion of programmable logic devices, overview of FPGA architecture, realization of data-path and controller, timing analysis of data-path and controller, synthesis, placement, routing, performance optimization. [3 Lectures]

- **FPGA based systems design**: Implementation of simple systems using FPGA exercising the timing closure paths. [2 Lectures]
- **Physical design automation of embedded systems (from the perspective of custom single purpose processors for embedded systems)**: Partitioning, floor-planning, placement, routing; clock design considerations, timing margins, clock skew, clock distribution networks. [3 Lectures]
- **Dynamically reconfigurable Embedded Systems**: Static versus dynamic reconfiguration of embedded systems, full versus partial reconfiguration, voltage scaling and power management issues in dynamic reconfiguration. [3 Lectures]
- **Introduction to Microcontrollers**: Introduction to microcontrollers, overview of architecture of a typical microcontroller such as AVR microcontroller, addressing, assembly language programming. [4 Lectures]
- **Memory interfacing**: Memory technologies SRAM, DRAM and ROM, different types of DRAM architectures 2D RAM, FPMDRAM, EDODRAM, SDRAM, RDRAM, DDRRAM, DDR2RAM, etc, different types of ROM- PROM, EPROM, EEPROM, memory interfacing circuits, single cycle versus multiple cycle interfacing, timing diagrams, etc. [3 Lectures]
- **Interfacing with I/O devices**: Port and bus based I/O, Memory mapped and I/O mapped I/O, register and tristate buffer based I/O interfacing, arbitration methods priority, daisy chain and network oriented arbitration methods, serial protocols SPI and I2C. [4 Lectures]
- **Timers and Counters**: Timer/counter programming, notion of watch dog timers and real time clocks. [1 Lectures]
- **Interrupt processing**: Introduction to interrupts, external versus internal interrupts, software versus hardware interrupts, synchronous versus asynchronous interrupts, single interrupt versus multiple interrupt systems, prioritization of interrupts, inversion of interrupt priorities, inheritance of interrupt priorities and associated protocols. [4 Lectures]
- **Real world interfacing of microcontrollers**: Interfacing with simple devices such as LCD, keyboard, motor control, sensors, LED 7 segment display, DTMF decoder, etc. [2 Lectures]
- **Hardware Software Codesign**: Notion of hardware software partitioning, graph based and pareto optimal approaches to hardware software partitioning, resource and timing constrained hardware software partitioning. [3 Lectures]
- **Internet of Things (IoT)**: Overview of Internet of Things, IoT architecture, Communication protocols, Notion of internet of everything. [1 Lecture]

**Laboratory Experiments:**

Laboratory exercises based on timers and counters, interrupts, serial peripheral interface, inter-integrated circuit, hardware description language based hardware modeling of embedded cores, hybrid embedded processors, FPGA implementation of embedded processor architectures.

**Text Books:**

1. F. Vahid and T. Givargis, **Embedded Systems: A Unified Hardware Software Introduction**, John Wiley and Sons, 2011.

**References:**


1. G. Nicholescu and P.J. Mosterman, **Model based design of Embedded Systems**, CRC Press, 2009.

2. DhananjayGadre, **Programming and Customizing the AVR microcontroller**, Tata McGraw Hill, 2014.

3. Wayne Wolf, **FPGA based Systems Design**, Pearson Education, 2003.

4. Volnei A. Pedroni, **Circuit Design with VHDL**, The MIT Press, 2004.

5. Steve Kilts, **Advanced FPGA Design: Architecture, Implementation and Optimization**, J. Wiley and Sons, 2007.

6. Seetharaman Ramachandran, **Digital VLSI Systems Design**, Springer Verlag, 2012.

7. Peter J. Ashenden, **The designers guide top VHDL**, Morgan Kaufmann, 2008.

8. Charles H. Roth Jr., **Digital Systems Design using VHDL**, Cengage Learning, 2014.


## 7.68 EE 530: Optimization theory

**Course Code: EE 530**

**Course Name : Optimization theory**

L-T-P-C : 3-0-0-3

**Intended for :** UG /MS/MTech (CSP)/PhD/M.Sc(Maths)

**Prerequisite :** Linear algebra (MA512 or IC 111) or Matrix Theory (EE522), instructor consent

**Distribution :** Core for Mtech (CSP), Elective for B.Tech. (EE. & CSE) III/IV year, MS, Ph.D, M.Sc(Maths).

Approval: 15th Senate; Revised in 24th Senate

**Course Contents:**

- **Math background:** Vector spaces, sequences, limit and continuity. Matrix norms, eigenvalues, eigenvectors, symmetric and positive definite matrices. Coercive functions. Weierstrass theorem. (5 hours)

- **Convex analysis:** convex sets, theorem of alternatives, convex cones, polyhedral sets, extreme points and directions. Convex functions, conjugate function, quasiconvex and pseudoconvex functions. (7 hours)

- **Linear programming:** fundamental theorem of LP, simplex method, transportation and network flow problems, Interior-Point methods. (7 hours)
- **Unconstrained optimization:** Necessary and sufficient conditions. Descent methods, convergence and rate of convergence. (6 hours)
- **Constrained optimization:** tangent plane, eigenvalues in tangent space, cone of feasible directions and improving directions. Problems with equality and inequality constraints - Lagrangian function and the Lagrange multipliers, KKT conditions (necessary and sufficient). (7 hours)
- **Duality:** Lagrangian dual problem, weak and strong duality theorems, properties of dual functions, getting the primal solution for convex, linear and quadratic programs. (5 hours)
- **Module VII**: Applications of convex programming, geometric programming, quadratic programming, second-order cone programming,and semi-definite relaxation to problems from communication and signal processing and other areas. (5 hours)

**Textbook:**

1. M.S. Bazaraa, H.D. Sherali and C.M. Shetty, **Nonlinear Programming**, 3rd Edition, Wiley, 2006.

**Reference books:**

1. S. Boyd and L. Vandenberghe, **Convex optimization**, Cambridge University Press, 2008.
2. D. P. Bertsekas, **Nonlinear programming**, Athena Scientific, 1999.
3. D. G. Luenberger and Y. Ye, **Linear and nonlinear programming**, 3rd Edition, Springer, 2008.

## 7.69 EE 530: Applied Optimization

**Course Code: EE 530**

**Course Name : Applied Optimization**

L-T-P-C : 3-0-0-3

Prerequisites : Linear algebra (MA512 or IC 111) or Matrix Theory (EE522). Intended for : UG /MS/MTech (CSP)/PhD/M.Sc. (Applied Mathematics)

Distribution : Core for MTech (CSP), Elective for B.Tech. III/IV year, MS, Ph.D, M.Sc (Applied Mathematics).

Semester : Even

Approval: 24th Senate; Old Course approved in 15th Senate

**Course Contents**

- **Convex analysis**: convex sets, convex cones, polyhedral sets, extreme points and directions. Convex functions, properties and tests for convexity, operations that preserve convexity, conjugate function. [6 Lectures]
- **Convex optimization problems**: standard form, equality and inequality constraints, slack variables, eliminating equality and inequality constraints. Local and global optima. Optimality criterion for unconstrained, equality constrained and inequality constrained problems. [7 Lectures]
- **Module III**: Linear optimization problems with examples, linear and generalized linear-fractional programming. Quadratic problems with examples. Second order cone programming robust linear programming, linear programming with random constraints. Geometric programming with examples. Generalized inequality constraints conics form problems, semidefinite programming, examples. [14 Lectures]
- **Handling non-convexity**: Lagrangian duality theory Lagrangian dual function, strong and weak duality, duality gap. Certificate of suboptimality and stopping criteria, complementary slackness. KKT optimality conditions. Solving the primal via dual. [9 Lectures]
- **Applications of convex programming in communication and signal processing**: The choice of applications is left to the faculty member handling the course. Examples that could be used are: Optimal decentralized estimation (single and multisensor case). Pulse shaping filter design. Quasi-ML detection via SDP relaxation (or any other problems in CSP). [6 Lectures]

**Textbook:**

1. S. Boyd and L. Vandenberghe, **Convex optimization**, Cambridge University Press, 2008.

**Reference books:**

1. M.S. Bazaraa, H.D. Sherali and C.M. Shetty, **Nonlinear Programming**, 3rd Edition, Wiley, 2006.
2. D. P. Bertsekas, **Nonlinear programming**, Athena Scientific, 1999.
3. D. G. Luenberger and Y. Ye, **Linear and nonlinear programming**, 3rd Edition, Springer, 2008.
4. Relevant literature.

## 7.70 EE 531: Estimation and Detection Theory

**Course Code: EE 531**

**Course Name: Estimation and Detection Theory**

L-T-P-C: 3-0-0-3

Prerequisites: EE304/ EE503/ EE305/ MA524 or equivalent, or instructor consent
Intended for: B.Tech./M.S./M.Tech./Ph.D.
Distribution: Core for M.Tech.(CSP), El ective for B.Tech. 3rd and 4th year, M.S., M.Tech(non CSP), Ph.D.
Approval: 15th Senate

**Course Contents**

- **Mathematical backgtound**: [3 Lectures]
  - Random variables and processes: vector spaces of random vari ables, CLT. stochastic processes, stationa rit y, spectral representati on of stochastic processes, Wi ener- Khinchin theorem , Gaussian process, w hite noise, stochastic processes throu gh LTI systems.
  - Modeling of signals a nd n oise: models, and selection of model and model order.
- **Ideal estimation for deterministic parameters**: [6 Lectures]
  - Principle of estimation and its a ppli cat io ns, properties of estimators.
  - Minimum Variance U nb iased Estimation: existence and search of MVU estimators, sufficient statistics an d its role in finding MVU estimator, extension to vector parameters. Neyman-Fi sher factori zation and R ae-Blackwell theorems.
  - Cramer-Rae Lower Bound: signals in white Ga ussian noise. parameter transfonnation, vector parameters, general Gaussian case, an d WSS Gaussian random processes, efficiency.
- **Practical estimation for deterministic parameters**: [5 Lectures]
  - Linear Model s and Unbiased Estimators, sca lar and vector Best Linear Unbiased Estimators (BLUE); Maximum Likelihood estimation, expectation-maximization (EM) algorithm; Least Squares estimation: lin ear, order-recurs i ve, sequential , constrained , a nd non-l i near.
- **Estimation for random parameters**: [6 Lectures]
  - Bayesian Estimation: Bayesian linear model, nuisance parameters. Bayesian estimation for deterministic parameters, risk functions, MMSE and MAP estimators, scalar, vector, and sequential Linear MMSE estimators, Wiener filtering.
  - Advanced topics: Levinson-Durbin and Innovation algorithms, graphical models, hidden
  - Markov models.
- **Estimation beyond stationarity**: [4 Lectures]
  - Kalman filtering: State-space modeling, scalar, vector, and extended Kalman filters.

- **Statistical Detection Theory**: [5 Lectures]
  - Binary and multiple hypothesis testing, Neyman-Pearson theorem, receiver operating characteristics, minimum Bayes ri sk detectors, sequential detection, Composite hypothesis testing: Bayesian and generalized likelih ood ratio test (GLRT), local l y most powerful (LMP) detectors, asymptotically equivalent tests.
- **Detection of deterministic signals**: [4 Lectures]
  - Signals with known parameters: matched filter, lin ear model , multiple si gn al detection. Signals with unknown parameters: signal modelin g and detector performance, sinusoidal detection, linear models, energy detectors.
- **Detection of random signals**: [5 Lectures]
  - Signals with known parameters: Estimator-correlator, lin ear model , general Gaussian detection.
  - Signals with unknown parameters: incompletely known signal cova n ance, weak si gna l detection.
- **Detection with non-Gaussian and colored noise**: [4 Lectures]
  - Signals with known and unknown pa rameters, Karhunen-Loeve expansion a nd wh iten i ng fiIters.
  - Advanced topics: Complex and vector extensions of detectors: known deterministic si gnal in
  - CWGN , spatially/temporally uncorrelated noi se, random signal in CWGN.

**Textbooks:**


1. S. M. Kay, **Fundamentals of Statistical Signal Processing**, Vol I: Estimation Theory, Prentice Hall , 1993.
2. S. M. Kay, **Fundamentals of Statistical Signal Processing**, Vol 2: Detection Theory, Prentice Hall, 1998.


**Reference books:**


1. L. L. Scharf, **Statistical Signal Processing: Detection, Estimation, and Time Series Analysis**, Addison-Wesley, 1991.
2. H. Y. Poor, **An Introduction to Signal Detection and Estimation**, Springer-Verlag, 1994.
3. C. W. Helstrom, **Elements of Signal Detection and Estimation**, Prentice Hall, 1995.
4. G. Casella and R. L. Berger, **Statistical Inference**, Duxbury Press, 2002.
5. H. L. van Trees, K. L. Bell, and Z. Tian, **Detection, Estimation, and Modulation Theaty, Part I: Detection, Estimation, and Filtering Theory**, Wiley, 2013.

## 7.71 EE 532P: Supervised Research Exposure

**Course Code : EE 532P**

**Course Name : Supervised Research Exposure**

L-T-P-C : 0-0-4-2
Prerequisites : Non e
Intended for : MTech (CSP)
Distribution : Core for Mtech (CSP)
Approval: 15th Senate

**Course Contents**

By the end of first semester th e students would have completed the following core courses: probability and random processes, advanced signal processing, advanced commun cati on t heory and m atrix theory. Also one either of the following electives - speech signal processing/radiating systems/pattern recognition, is covered. So students can do a ny project in signal processing/communication area which requires any of the above subjects as a prerequisite.

**Quantitative contact hours:**

This is a project. The student is supposed to work around 40 hours a week for the project out of whi ch th ere a re 4 contact hours mentioned durin g which the student has to interact with the faculty.

**Textbook:**

1. NA

## 7.72 EE 534: Probability and Random Processes

**Course Code : EE 534**

**Course Name : Probability and Random Processes**

L-T-P-C : 3-0-0-3 (L-T-P-C)
Prerequisites : Linear algebra (MA512 or IC 111) and IC 252 or equivalent of both (MA512 and IC252)
Intended for : UG /MS/MTech (CSP)/PhD/M.Sc(Maths)
Distribution : Core for Mtech (CSP), Elective for B.Tech. III/IV year, MS, Ph.D, M.Sc(Maths). Semester : Odd
Approval: 22nd Senate

**Course Contents**

- **Module I**: Sigma field. Review of - axiomatic probability, conditional probability and independence. [2 Lectures]
- **Module II**: Recap of random variables and functions of random variables. [3 Lectures]

- **Module III**: Probability generating function, moment generating function and characteristic functions properties and applications. [3 Lectures]
- **Module VI**: Markov chains, classification of states and chains, stationary distribution and limit theorem, Poisson process. [5 Lectures]
- **Module V**: Convergence of random variables basic results, inequalities (Markov and Chebyshev), law of large numbers (weak and strong), central limit theorem. [5 Lectures]
- **Module VI**: Concentration inequalities Chernoffs bound, Hoeffdings inequality, Bennetts inequality, Bernstiens inequality and Efron-Stein inequality. [8 Lectures]
- **Module VII**: Random vectors and covariance matrix. Random processes stationarity, WSS. Autocorrelation, cross correlation, power spectral density. Filtering of WSS processes. Basic notion of ergodicity. Wiener processes, Markov processes. [10 Lectures]
- **Module VIII**: Queueing models - Little's law, M/M/1, M/M/m, M/M/m/m, M/G/1 queuing systems, priority queuing. [6 Lectures]

**Textbook:**


1. Grimmett and Stirzaker, **Probability and Random Processes**, Oxford University Press, 2001.


**Reference books:**


1. Erhan Cinlar, **Introduction to Stochastic Processes**, Dover Books on Mathematics, 2013
2. R. G. Gallager, **Stochastic Processes: Theory for applications**, Cambridge University Press, 2014.
3. S. M. Ross, **Stochastic processes**, 2nd Edition, John Wiley, 1996.
4. J. R. Norris, **Markov chains**, Cambridge University Press, 1999.
5. Papoulis and Pillai, **Probability, Random variables and Stochastic processes**, 4th Edition, McGraw- Hill, 2002.


## 7.73 EE 535P: Communication and Signal Processing Systems Design

**Course Code: EE 535P**

**Course Name: Communication and Signal Processing Systems Design**

L-T-P-C: 0-0-4-2
Prerequisites: None
Intended for: M.Tech. Communications and Signal Processing (CSP)
Distribution: Core for M.Tech. (CSP)

Semester: Winter Session of Year I
Approval: 24th Senate

- **Course modules**: It is advisable that the projects should be related to the courses M.Tech.(CSP) students may credit or the specializations that this program offers. Therefore, students can opt for any project in Signal Processing, Communications or Machine Learning. Additionally, they are allowed to select a project from other areas, e.g., VLSI, Power electronics, Electrical drives or Control systems, as long as the project has 30% or more overlap with any of the three specialization of M.Tech. (CSP) curriculum.
- **Deliverables**: A student must declare the deliverables of her/his project in the initial project proposal after consulting with the respective mentor(s). While the initial project proposal and the final report carry some marks, a significant portion of the marks, 70% or more, is allotted to the deliverables to emphasize their importance.
- **Contact hours**: On average, a student should work 40 hours per week on her/his project. The students are supposed to meet their respective mentors at least once in a week to report their progress.

**Textbooks:**

1. Related literature.

## 7.74 EE 536: IoT Systems

**Course Code: EE 536**

**Course Name: IoT Systems**

L-T-P-C: 2-0-2-3
Prerequisites: Communication theory (EE304); Computer networks (CS406); Microcontroller programming and Digital systems design (IC161)
Intended for: B.Tech. III/IV year/ MS/M.Tech./PhD
Distribution: Core for M.Tech. (CSP)
Approval: 24th Senate

**Course Contents**

- **An introduction to IoT systems**: [1 Lectures]
  - Introduction and motivation of IoT systems
- **Hardware components of IoT systems**: (2 Lectures + 2 lab hours)
  - A quick overview of different components---micro-controllers, SoCs, communication modules, power supply and sensing modules---of off-the-shelf prototyping boards, e.g., Arduino UNO, MSP430 LaunchPad; NodeMCU, STM32, Raspberry Pi.
- **Software component of IoT systems**: (6 Lectures + 6 lab hours)

- Introduction to IDEs for off-the-shelf boards, e.g., Arduino IDE, Waspmote IDE, Code composed studio; Contiki-OS and RIOT OS; 6LowPAN network stack; Sensor interfacing; GPIO programming

- **Communication paradigm of IoT systems**: (12 Lectures + 12 lab hours)
  - Different wireless standards, e.g., IEEE802.15.4, ZigBee, BLE, IEEE802.11; link layer technologies, Medium Access Control; Routing; Application layer protocols; Network topologies.
- **Performance evaluation of IoT systems**: (4 Lectures + 4 lab hours)
  - Developing mathematical models for energy consumption, Optimal node placement, resource allocation over wireless sensor networks to meet QoS requirements.
- **Case studies/mini projects**: (3 Lectures + 4 lab hours)
  - Home automation; Building energy management; Indoor positioning; Air quality monitoring; Precision agriculture; Smart parking

**Textbooks:**

1. David Hanes et al., **IoT Fundamentals: Networking Technologies, Protocols and Use Cases for the Internet of Things**, Pearson, 2017

**Reference Books:**

1. Parry Lea, **Internet of Things for Architects: Architecting IoT Solutions by Implementing Sensors, Communication Infrastructure**, Edge Computing, Analytics, and Security, Packt Publishing Limited, 2018
2. Shuang-Hua Yang, **Wireless Sensor Networks: Principles, Design and Applications**, Springer.
3. Kazem Sohraby, Daniel Minoli, Taieb F. Znati, **Wireless Sensor Networks: Technology, Protocols, and Applications**, Wiley Interscience, 2009
4. White papers, RFCs, survey articles on Wireless communication standards and technologies.
5. Antonio Linan Colina, Alvaro Vives, Antoine Bagula, Marco Zennaro and Ermanno Pietrosemoli, **IoT in five Days**, https://github.com/marcozennaro/IPv6-WSN-book/releases/

## 7.75 EE 537 Power Quality Problems and Mitigation Techniques in Microgrids

**Course Code : EE 537**

**Course Name : Power Quality Problems and Mitigation Techniques in Microgrids**

Credit : 3

Distribution : 3-0-0-3
Intended for : UG/PG
Prerequisite : Power System (EE303) & Power Electronics (EE 309)
Mutual Exclusion : NA
Approval: 44th BoA

**Course Contents**

- **Power Quality Issues**: Harmonics, frequency deviations, voltage fluctuations, voltage dips, swells, and interruptions. Power tetrahedron, power factor, and other figures of merit under balanced, unbalanced and nonsinusoidal conditions, power quality standards. [8 Lectures]

- **Power Quality Enhancement**: Generation of reference currents/voltages- natural frame of reference (abc), stationary frame of reference ($\alpha\beta 0$) and synchronously reference frame (dq0) and symmetrical components frame reference (+-0). Advanced control architectures for hybrid ACDC Microgrid-decentralized and hierarchical control- droop, primary, secondary and tertiary controls. Cooperative control for power quality enhancement in microgrids-active power Injection, reactive power-sharing, harmonic current sharing and voltage regulation via smart loads. [10 Lectures]

- **Autonomous Control of Distributed Energy Resources in Microgrids**: power sharing schemes for voltage unbalance and harmonics compensation in an Islanded microgrid- Power droop control, virtual impedance loop, local unbalance and harmonics compensation schemes. Effect of faults, overloading and loss of generation on power quality. [8 Lectures]

- **Power Quality Problems associated with Electric Vehicle Charging Infrastructure**: Various configurations of chargers-contact and contact-less chargers, wired AC, DC charging-on-board slow, fast charging, off-board fast, rapid charging. Wireless chargers- inductive, capacitive and hybrid charging topologies. [10 Lectures]

- **Recent Trends and Case Studies**: power quality enhancement in AC-DC hybrid microgrids under grid interactive mode, autonomous control of distributed energy resources, power quality problems and their mitigation techniques for various EV charger topologies. [6 Lectures]

**Text books:**


1. Arindam Ghosh and Gerard Ledwich, **Power quality enhancement using custom power devices**, Springer Science & Business Media, 2012.

2. Hirofumi Akagi, Edson Hirokazu Watanabe and Mauricio Aredes, **Instantaneous power theory and applications to power conditioning**, John Wiley & Sons, 2017.

**References:**

1. Narain G Hingorani and Laszlo Gyugyi, **Understanding FACTS: concepts and technology of flexible AC transmission systems**, Wiley-IEEE press, 2000.

2. Selected papers, standards and reports

## 7.76 EE 540: Wide Band Gap Devices in Power Electronics Applications

**Course Code: EE 540**

**Course Name: Wide Band Gap Devices in Power Electronics Applications**

L-T-P-C: 3-0-0-3
Prerequisite: Power Electronics (EE 309/EE527/ EE504) or Power Semiconductor Devices (EE526) or equivalent
Intended for: UG/MS/MTech/PhD
Distribution: Elective: B. Tech III and IV year /M.S./ M.Tech / PhD
Approval: 28th Senate, 35th BoA

**Course Contents**

- **Wide band gap devices**: [4 Lectures]
  - Introduction of wide band-gap
  - Vertical and lateral structures of wide band-gap devices
  - Different types of the wide band gap devices
  - Advantages of wide band-gap semiconductors
  - Challenges in designing converters with wide band-gap devices
- **Switching characteristics**: [4 Lectures]
  - Turn-on and Turn-off characteristics of the device
  - Hard switching loss analysis
  - Double pulse test set-up
- **Drivers for wide band-gap devices**: [8 Lectures]
  - Gate driver
  - Impact of gate resistance
  - Gate drivers for wide bandgap power devices
  - Transient immunity integrated gate drivers
  - Overcurrent protection, UVLO protection
- **Thermal management of power converters**: [6 Lectures]
  - Thermal modelling
  - Thermal management and reliability

  - Improving the performance with heatsink

- **High frequency design complexity**: [4 Lectures]
  - Effects of parasitic inductance
  - Effects of parasitic capacitance
  - EMI filter design for high frequency power converters

- **PCB designing**: [4 Lectures]
  - High frequency PCB design
  - Conventional power loop design
  - High frequency power loop optimization
  - Single and multi-layer PCBs
  - Separation of power from signal PCB

- **Power density advantages**: [4 Lectures]
  - Power density of wide bandgap devices
  - High power density power electronics converters

- **Applications of wide bandgap devices**: [8 Lectures]
  - Consumer electronics applications
  - Wireless power transfer applications
  - Electric vehicle applications
  - Renewable energy sources applications
  - Students will carry out one project based on modeling, simulation of any of the wide bandgap device in power electronics applications. This work can be extended with the practical work.

**Text books:**


1. A. Lidow, J. Strydom, M. D. Rooij, D. Reusch, **GaN Transistors for Efficient Power Convertion**, Wiley, 2014.

2. G. Meneghesso, M. Meneghini, E. Zanoni, **Gallium Nitride-enabled High Frequency and High Efficiency Power Conversion**, Springer International Publishing, 2018.


**References:**


1. Ned Mohan, Tore M. Undeland, William P. Robbins, **Power Electronics**, John Wiley & Sons, 2003.

2. F. Wang, Z. Zhang and E. A. Jones, **Characterization of Wide Bandgap Power Semiconductor Devices**, IET, 2018.

3. L. Umanand and S. R. Bhat, **Design of Magnetic Components for Switched Mode Power Converters**, John Wiley & Sons, 1992.

4. B.J.Baliga, **Gallium Nitride and Silicon Carbide Power Devices**, World Scientific Publishing Company, 2017.

5. E. L. Corradini, D. Maksimovic, P. Mattavelli, R. Zane, **Digital Control of High-Frequency Switched-Mode Power Converters**, Wiley, 2015.

## 7.77 EE 541: Tensors: Techniques, Algorithms, Applications for Signal Processing, and Machine Learning.

**Course Code : EE 541**

**Course Name : Tensors: Techniques, Algorithms, Applications for Signal Processing, and Machine Learning.**

Credit Distribution : 3-0-2-4
Intended for : B.Tech. (3rd/4th year)/ MTech/ MS/ PhD of the SCEE.
Prerequisite : Linear algebra, basic probability, and statistics.
Mutual Exclusion : None (at present)
Approval: 50th BoA

**Course Contents:**

- **Linear algebra recap:** Vector spaces, subspaces, linear in/dependence, bases, dimensions, principle of orthogonality and projections, linear models least-squares problems, Rank-decomposition for matrix, SVD and low-rank matrix approximation. (5 hours)

- **Working with Tensors:** Useful products and their properties (Inner, Outer, Hadamard, Kronecker, and Khatri-Rao, and mode-n). Tensor, its different views, and reshaping. Operators on tensors, tensor contraction, their algebraic properties, tensor rank, low rank tensor approximation, Tensor calculus and it's fundamental operations. (10 hours)

- **Tensor factorization and its computation:** Rank decomposition for tensor, CP decomposition (CANDECOMP/ PARAFAC), properties of CP decomposition, Hardness of CP decomposition, algorithms for computing decompositions (ALS, Jennrich's algorithm, etc.); Other notions of tensor decomposition: Tucker decomposition, HOSVD (higher order SVD), Tensor train decomposition (TT-SVD). (9 hours)

- **Techniques for compressing tensors:** Dimensionality reduction (random projection) for vectors, Tensorized random projection, Compressing Tensors using Count Sketch, Higher Order Count Sketch. (8 hours)

- **Applications:** Blind Multiuser CDMA, Blind Source Separation, Harmonics, Gaussian Mixture parameter estimation, learning latent variables, Topic modelling, Learning Hidden Markov Models, Community detection, Collaborative filtering-based recommender systems, including recent ML/ SP based approaches. (10 hours)

**Laboratory/ practical/ tutorial Modules:** The two-hours of lab session will enhance the understanding of the concepts taught in the class. The lab will cover the concepts including, principle of orthogonality, least Squares, SVD, low-rank matrix decomposition, Inner, Outer, Hadamard, Kronecker, and Khatri-Rao products, mode-n Tensor, PARAFAC, HOSVD, TT-SVD, ALS, low-rank tensor decomposition, etc.

**Text books:**

1. J. Landsberg, **Tensors: Geometry and Applications**, vol. 128. Providence, RI, USA: Amer. Math. Soc., 2011.
2. Haiping Lu, Konstantinos N. Plataniotis, Anastasios Venetsanopoulos, **Multilinear Subspace Learning - Dimensionality Reduction of Multidimensional Data**, 1st Edition, CRC press, 2015.

**References:**

1. Ankur Moitra, **Algorithmic aspects of machine learning**, Cambridge University Press, 2018.
2. T. G. Kolda, B. W. Bader, **Tensor Decomposition and Applications**, SIAM Review, 2009.
3. N. D. Sidiropoulos, L. De Lathauwer, X. Fu, K. Huang, E. E. Papalexakis, and C. Faloutsos, **Tensor decomposition for signal processing and machine learning**, IEEE Trans. Signal Process., vol. 65, no. 13, pp. 3551–3582, Jul. 2017.

## 7.78 EE 542: Modelling, Simulation and Control of Hybrid Electric Vehicle

Course number : EE 542
Course Name : Modelling, Simulation and Control of Hybrid Electric Vehicle
Credit Distribution : 3-0-0-3
Intended for : 3rd and 4th year UG, PG, PhD
Prerequisite : Linear Algebra
Mutual Exclusion :
Approval: 50th BoA

**Course Contents:**

- **Modelling in performance parameter:** Modelling Vehicle Acceleration-Acceleration performance parameters, modeling the acceleration of an electric scooter, modeling the acceleration of a small car. (5 hours)
- **Modelling of Battery Electric Vehicles:** Electric Vehicle Modelling Tractive Effort, Rolling resistance force, Aerodynamic drag, Hill climbing force, Acceleration force, Total tractive effort, Modelling Electric Vehicle Range-Driving cycles, Range modeling of battery electric vehicles, Constant velocity range modelling, Range modelling of fuel cell vehicles, Range modelling of hybrid electric vehicles. (8 hours)

- **Drive Train Characteristics:** Modelling and Characteristics of EV/HEV Power trains Components-ICE Performance Characteristics, Electric Motor Performance Characteristics- Battery Performance, Characteristics-Transmission and Drive train Characteristics- Regenerative Braking Characteristics-Driving Cycles Modelling and Analysis of Electric and Hybrid Electric Vehicles Propulsion and Braking- Longitudinal Dynamics Equation of Motion-Vehicle Propulsion Modelling and Analysis-Vehicle Braking Modelling and Analysis. (8 hours)

- **Energy Management:** Handling Analysis of Electric and Hybrid Electric Vehicles-Simplified Handling Models Energy/Power Allocation and Management-Power/Energy Management Controllers-Rule-Based Control Strategies- Optimization-Based Control Strategies. (8 hours)

- **Vehicle Dynamic Control:** Control of Electric and Hybrid Electric Vehicle Dynamics-Fundamentals of Vehicle Dynamic Control (VDC) Systems, VDC Implementation on Electric and Hybrid Vehicles Case Studies, Rechargeable Battery vehicles, Hybrid Vehicles, Fuel Cell Powered Bus. (8 hours)

- **Estimation Techniques:** Identification of important state variables and parameters of HEV, Kalman filter-based methods, Least Square based methods. (5 hours)

**Text books: (Relevant and Latest, only 2)**


1. Wei Liu, **Introduction to Hybrid Vehicle System Modeling and Control**, Wiley, 2015.

2. Y. Xu, J. Yan, H. Qian, and T. L. Lam, **Hybrid Electric Vehicle Design and Control**, vol. 1, McGraw Hill, 2021.


**References:**


1. James Larminie, John Lowry, **Electric Vehicle Technology Explained**, John Wiley & Sons Ltd, 2003.

2. Amir Khajepour, Saber Fallahand Avesta Goodarzi, **Electric and Hybrid Vehicles-Technologies, Modelling and Control: A Mechatronic Approach**, John Wiley & Sons Ltd, 2014.

3. Antoni Szumanowski, **Hybrid Electric Power Train Engineering and Technology: Modelling, Control, and Simulation**, IGI Global, 2013.

4. Mehrdad Ehsani, Yimin Gao, Ali Emadi, **Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals, Theory, and Design**, 2nd Edition, CRC Press,2010.


## 7.79 EE 543: Vision and Learning Based Control

Course number : EE 543
Course Name : Vision and Learning Based Control
Credit Distribution : 3-0-0-3
Intended for : 3rd/4th year B.Tech. EE, CS, and M.Tech/Ph.D.

Prerequisite : None
Mutual Exclusion : None
Approval: 50th BoA

**Course Contents:**

- **Introduction :** Overview, motivation, and real-world practical applications. [1L]
- **Visual Sensor Model and Calibration:** Camera model, Coordinate Frames and Transforms, Intrinsic camera calibration, and extrinsic camera calibration. [10L]
- **Visual Servoing:** Image Jacobian, Robot Jacobian, Image Based Visual Servoing, Position Based Visual Servoing, Eye-in-hand and Eye-to-hand Configurations, Comparison among different class of visual servoing. [14L]
- **Robot Learning:** Basic concepts of reinforcement learning, reinforcement learning algorithms. Robot learning by demonstration. [14L]
- **Hybrid Method Design:** Comparative analysis for various methods. Explore, understand and identify different ways to design a hybrid scheme to control the given system of interest. Case study and course projects. [3L]

**Text books:**


1. Corke, Peter I., and Oussama Khatib, **Robotics, vision and control: fundamental algorithms in MATLAB**, Vol. 73. Berlin: Springer, 2011.
2. Vakanski, Aleksandar, and Farrokh Janabi-Sharifi, **Robot learning by visual observation**, John Wiley & Sons, 2017.


**References:**


1. Ijspeert, Auke Jan, et al., **Dynamical movement primitives: learning attractor models for motor behaviors**, Neural computation 25.2 (2013): 328-373.
2. Chaumette, FranÃ§ois, and Seth Hutchinson, **Visual servo control I:Basic approaches**, IEEE Robotics & Automation Magazine 13.4 (2006): 82-90.
3. Chaumette, FranÃ§ois, and Seth Hutchinson, **Visual servo control IIL Advanced approaches [Tutorial]**, IEEE Robotics & Automation Magazine 14.1 (2007): 109-118.


## 7.80 EE 551: Applied Photonics for Scientists and Engineers

**Course Code : EE 551**

**Course Name : Applied Photonics for Scientists and Engineers**

L-T-P-C: 2-1-0-3
Prerequisite : IC110, IC111, lC221
Intended for: UG, PG, M. Tech, M. Sc. Physics, 1-PhD, PhD
Approval: 38th BoA

**Course Contents**

- **Fundamentals of the Electromagnetic theory of light**: complex represen tation of electromagnetic field disturbances, Maxwell's eq uations, Fresnel equations, limitations of th e electromagnetic description. [2 Lectures]
- **Optical systems**: Fermat's principle, basic optical elements, matrix methods for optics, thick lens and their systems, determination of cardinal points, basic optical systems. [3 Lectures]
- **Polarisation**: fundamenta ls, special devices - crystals, compensators, spatia l li gh t modulators, mathematical representations ofpolariscd light. [3 Lectures]
- **Gaussian Beam Optics:** beam propagation equation, beam properties and their characterization, matrix approach for Gaussian beam optics. [2 Lectures]
- **Interferometry**: principles and applications - fundamental concepts - conditions for interference, coherence theory elements, You ng's double slit experiment, multiple-beam interference. Systems - Michelson, Twyman Green, Fizeau and other select configurations. Selected applications- e.g. metrology, sensors. [4 Lectures]
- **Fourier Transforms in Optics**: Foundational concepts and theorems, Fourier methods in diffract ion theory, Abbe Porter's experiment, applications - e.g. optical waveshapers. [3 Lectures]
- **Fibre optic systems**: principles of guided wave propagation, basics of single mode and multimode, passive components, active components, fibre-optics based system design considerations, select applications - e.g. Dispersive Fourier Transformer, fibre optic sensors, imaging configurations. [4 Lectures]
- **Nonlinear optics**: Light-matter interaction a nd the nonlinear wave equation, second order nonlinearity- second hannonic generation, three-wave mixing, third order nonlinearity- third harmonic generation, four-wave mixing, Kerr nonlinearity and its applications. [4 Lectures]
- **Detection of Optical Radiation**: Time-domain methods: High speed detectors, Photomultipliers, Time of flight detectors, Cameras, characterization of ultrashort pulses. Spectral-domain methods -Essential components, resol ving power of dispersive devices, the optical spectrum anal yzer. Basics of quantum light -- singlephnton generation and detection , applications - e.g. qubi1s. Full-field measurement techniques. [4 Lectures]

Tutorial sessions - 10.

Resource required for tutorial sessions - Access to computer labs for numerical/computational solving of problems.

**Text books:**

1. Hecht, E., **Optics**, 4th Edition, Pearson.
2. Ghatak, A. K., & Thyagarajan, K., **Optical Electronics**, Cambridge University Press, 2018.

**References:**

1. Saleh, B. E. A, & Teich, M. C., **Fundamentals of Photonics**, 2nd Edition, Wiley Interscience 2007.

## 7.81 EE 552 : Power and Energy Systems

**Course Code : EE 552**

**Course Name : Power and Energy Systems**

L-T-P-C : 3-1-0-4
Intended for : UG
Prerequisite : EE 201 Electromechanics or Instructors consent
Mutual Exclusion:
Approval: 54th BoA

**Course Contents**

- **Introduction to power systems and its structure**: Generation, transmission and distribution, substation arrangements. (2 Hours)
- **Representation of power system components**: Generator, Transformers, Transmission lines, line parameters, transmission line design, interference of power lines with communication circuits, line insulators, power cables, per unit system. (10 Hours)
- **Network Analysis** – Concepts of PV, PQ and Slack Bus, Load flow using NR Method, DC load flow, Economic load dispatch, unit commitment (12 Hours)
- **Fault Analysis**: Symmetrical components, symmetrical and unsymmetrical fault calculations, transient analysis (7 Hours)
- **Network Protection**: relaying strategies, circuit breakers, numerical relays (5 Hours)
- **Power System Dynamics**: stability, swing equation, equal area criterion, voltage and frequency control (10 Hours)
- **Energy systems**: Solar photovoltaic, solar thermal, wind energy, energy storage (8 Hours)
- **Smart grid components**: SCADA, Smart sensors, communication (2 Hours)

**Laboratory/practical/tutorial Modules:**

- NA

**Textbooks:**

1. J. J. Grainger and W. D. Stevenson, **Power System Analysis**, Tata McGraw Hill.
2. D. P. Kothari and I. J. Nagrath, **Modern Power System Analysis**, Tata McGraw Hill.
3. A. J. Wood and B. F. Wollenberg, **Power Generation, Operation and Control**, 2nd Edition, Wiley-Blackwell.
4. S. Jha, S. Sen, R. Kumar and D. P. Kothari, **Smart Grid- Fundamental and Applications**, New Age International.

**References:**

1. NA

## 7.82 EE 553 : Foundations of Intelligent Communication Systems-I

**Course Code : EE 553**

**Course Name : Foundations of Intelligent Communication Systems-I**

L-T-P-C : 3-0-2-4
Intended for : MTech/MTech (R)/ PhD students of the SCEE
Prerequisite : IC 111 Linear Algebra, IC 260 or equivalent
Mutual Exclusion: EE522, CS512, MA512, MA525, MA551, or equivalent
Approval: 54th BoA

**Course Contents**

- **Signal Space Representation**: Lowpass representation of bandpass signals, vector spaces, signal space concepts, subspaces, linear dependence/ independence, basis and dimension, sampling and reconstruction, inner product, orthogonal expansion of signals, orthogonal matrices, four fundamental subspaces. (9 Hours)
- **Linear Time-Invariant Systems**: Response, properties, eigenfunctions of a continuoustime and discrete-time linear time-invariant systems. Systems described by the differential equations and the difference equations. State-space analysis. Applications: Principle of Orthogonality, least squares problem, state space representation of continuous-time and discrete-time LTI systems. (9Hours)
- **Inner product spaces**: Determinants, Eigenvalues and Eigenvectors, Positive definite and semidefinite matrices, Inner product and Lp - norms; Singular Value Decomposition/ QR/ Schur & Principal Component Analysis, Pseudo-inverse of a full row/column-rank matrix, generalized inverse for a matrix which is non-singular and not a full full row/ column-rank. Applications: Best k-Rank approximation and matrix compression, fitting and linear regression problem; solving underdetermined/ overdetermined systems of linear equations. (12 Hours)

- **Optimization Methods**: Optimization framework description, linear and quadratic optimization problems, Lagrange dual function, geometric interpretation, and its applications; solving underdetermined/ overdetermined systems of linear equations with additional constraints like sparsity and regularization, etc. (12 Hours)

**Laboratory/practical/tutorial Modules:**

- The two-hours of lab session per week will enhance the understanding of the concepts taught in the class. The lab will cover the concepts including principle of orthogonality, least Squares, SVD, low-rank matrix decompositions and its applications in the modern systems.

**Textbooks:**

1. Deisenroth, M. P., Faisal, A. A., Ong, C. S., **Mathematics for Machine Learning**, Cambridge University Press, 2020.

2. Strang, G., **Linear Algebra and Learning from Data**, Wellesley-Cambridge Press, 2019.

3. J. G. Proakis and M. Salehi, **Fundamentals of Communication Systems**, Prentice Hall, December 2004.

**References:**

1. Friedberg, S.H., A Insel, A.J.,A Spence, L.E., **Linear Algebra**, Pearson Education, 2014.

2. Boyd, S., & Vandenberghe, L., **Convex optimization**, Cambridge university press, 2004.

3. Alan V. Oppenheim, Ronald W. Schafer., **Discrete-time signal processing**, Pearson Education, 2010.

## 7.83 EE 554 : Low Power VLSI Design

**Course Code : EE 554**

**Course Name : Low Power VLSI Design**

L-T-P-C : 3-0-0-3

Intended for : B. Tech in Engineering (EE), Microelectronics and VLSI, M. Tech in Microelectronics and VLSI Design, MS, M. Tech. & PhD

Prerequisite : Digital System Design (EE210)

Mutual Exclusion:

Approval: 54th BoA

**Course Contents**

- **Introduction to low power design**: Components of power dissipation of VLSI circuits. (2 Hours)
- **Circuit techniques for Low Power Design**: Standby leakage control using transistor stacks, multi-threshold and dynamic threshold techniques, supply voltage scaling technique. (4 Hours)
- **Low power low voltage arithmetic circuits**: Low power adder architectures – ripple carry adder, carry look-ahead adder, carry select adder, carry save adder, carry skip adder, current mode adder using multi-valued logic, residue adders, low power multiplier architectures- serial multiplier, parallel multiplier, serial-parallel multiplier, Braun multiplier, Baugh Wooley multiplier, Booth multiplier, Wallace tree multiplier. (10 Hours)
- **Low power low voltage memories**: Read only and random access memories. Power reduction of read only and random access memories at architectural, logic, and transistor levels. (8 Hours)
- **Transforms for low power VLSI circuits**: Behavioral level transform, algorithm and architecture level transform, negative differences, sorted recursive differences, shared multiplier based voltage scaling operation, architecture driven voltage scaling, power reduction using operation reduction and operation substitution. (9 Hours)
- **Multiple and Dynamic supply voltage design**: Multiple supply voltage design, dynamic supply voltage design, rate of change of supply voltages, power supply network, variation of the clock speed. (6 Hours)
- **Low power multi-core architectures**: Notion of multi-cores, hardware and software techniques for power reduction in multi-core architectures. (3 Hours)

**Laboratory/practical/tutorial Modules:**

- None

**Textbooks:**

1. K.S. Yeo, K. Roy, **Low Voltage Low Power VLSI Systems**, McGraw Hill, 2013.
2. A. Pal, **Low power VLSI design**, McGraw Hill, 2014.

**References:**

1. J. M. Rabaey and M. Pedram, Eds., **Low Power Design Methodologies**, Kluwer Academic Publishers, 1996.
2. B. Parhami, **Computer Arithmetic: Algorithms and Hardware Designs**, 2nd Edition, Oxford University Press, 2010.
3. I. Koren, **Computer Arithmetic Algorithms**, CRC Press, 2001.

## 7.84 EE 555 : Intelligent Control System

**Course Code : EE 555**

**Course Name : Intelligent Control System**

L-T-P-C : 3-0-0-3
Intended for : B.Tech. EE (3rd and 4th year), M.Tech., M.Tech. (R), PhD
Prerequisite : For B.Tech. – Control System or equivalent course; For all – Linear Algebra
Mutual Exclusion: None
Approval: 54th BoA

**Course Contents**

- **Nonlinear Control - Primer**: Norms, Sign-definiteness, State-space model, Lyapunov stability theory, Discrete-time systems, Nonlinear control strategies. (4 Hours)
- **Neural Network**: Feed-forward networks, Multi-layered neural networks, Radial-Basis function networks, Feedback networks, System identification using neural network (6 Hours)
- **Fuzzy Logic**: Classical sets, Fuzzy sets, Approximate reasoning, Fuzzy logic control, System identification using Fuzzy models (6 Hours)
- **Indirect Adaptive Control using Neural Networks**: Continuous-time affine systems, Discrete-time affine systems, Discrete-time non-affine systems (6 Hours)
- **Direct Adaptive Control using Neural Networks**: Direct Adaptive control, Single-input single-output affine systems, Multi-input multi-output systems, Backstepping control (6 Hours)
- **Reinforcement Learning (Approximate Dynamic Programming)**: Linear quadratic regulator, HJB formulation, HJB for affine systems, Heuristic and Dual heuristic dynamic programming, Single network adaptive critic, Continuous-time adaptive critic (8 Hours)
- **Intelligent Control of Benchmark Systems**: Pendulum on cart, Mobile robot, Robot manipulator, HVAC system (6 Hours)

**Laboratory/practical/tutorial Modules:**

- None

**Textbooks:**

1. Ali Zilouchian and Mo Jamshidi, **Intelligent Control Systems using Soft Computing Methodologies**, CRC Press.
2. Dusko Katic and Miomir Vukobratovic, **Intelligent Control of Robotic Systems**, Springer.

3. Laxmidhar Behera and Indrani Kar, **Intelligent Systems and Control: Principles and Applications**, Oxford University Press.

**References:**

1. Thrisantha Nanayakkara, Ferat Sahin, and Mo Jamshidi, **Intelligent Control Systems with an Introduction to System of Systems Engineering**, CRC Press.

## 7.85 EE 556 : Nuclear Reactor Control

**Course Code : EE 556**

**Course Name : Nuclear Reactor Control**

L-T-P-C : 1-0-0-1
Intended for : UG (3rd year and final year) and PG students
Prerequisite : Differential Equations, Laplace Transform, Elementary Matrix Algebra
Mutual Exclusion: None
Approval: 54th BoA

**Course Contents**

- Introduction: India's nuclear energy scenario, Nuclear Power Plants (NPP) Schematic, Components of a NPP, Nuclear Reactor types and applications. (1 Hour)
- Selected Topics from Reactor Physics: Interactions of neutron with nuclei (matter), Nuclear Reaction Cross—sections, Mechanism of nuclear fission, Nuclear fission reactions, Energy released in fission; Prompt and delayed neutrons, Multiplication factor, Four factor formula, Non-leakage probability; The one – speed neutron diffusion equation, General solution of one – speed neutron diffusion equation; Reactor criticality condition for parallelopiped and cylindrical geometries, Effect of reflector. (3 Hours)
- Nuclear Reactor Kinetics: Derivation of point kinetics model from one speed neutron diffusion equation; Solution of point kinetics model for step change in reactivity, reactor period, In-hour equation, Interpretation of reactor shut-down and trip. (2 Hours)
- Reactor as a Control Element: Linearization of point kinetics model and representation into standard state-space form, transfer function, Reactor stability, Controllability and Observability. (2 Hours)
- Reactor Dynamics Studies: Modeling of Internal feedback effects due to changes in fuel, coolant and Moderator temperatures; Modeling of Internal feedback effect due to fission product xenon; xenon spatial instability; Modeling of Internal feedback effect due to fission product samarium; Issues in modeling and control of large reactors. (3 Hours)
- Reactor Instrumentation: Methods of neutron flux measurement; n, log n, dn/dt and d(logn)/dt signals for reactor control, Thermal power measurement; Power correction; Flux mapping. (1 Hour)

- Miscellaneous Topics: Examples of typical reactor power control systems; Reactivity estimation – Inverse point kinetics method, Kalman Filter method. (2 Hours)

**Laboratory/practical/tutorial Modules:**

- Not envisaged

**Textbooks:**

1. James J. Duderstadt and Louis J. Hamilton, **Nuclear Reactor Analysis**, Wiley, 1976
2. L. E. Weaver, **Reactor Dynamics and Control: State Space Techniques**, American Elsevier Publishing Company, 1968

**References:**


1. A. P. Tiwari, et. al., **Modelling and Spatial Control of 540 MWe Pressurized Heavy Water Reactor**, Trans. INAE, Vol. 6, pp. 731–753, Sept. 2021.
2. P.V. Surjagade, et. al., **Robust Optimal Integral Sliding Mode Controller for Total Power Control of Large PHWRs**, IEEE Trans. Nucl. Sci., Vol. 65, Issue 7, pp. 1331-1344, 2018.
3. C. S. Subudhi, et. al., **A mathematical model for total power control loop of large PHWRs**, IEEE Trans. Nucl. Sci., vol. 63, no. 3, pp. 1901–1911, June 2016.
4. Patel SB, Mukhopadhyay S, Tiwari A, **Estimation of reactivity and delayed neutron precursors' concentrations using a multiscale extended kalman filter**, Ann Nucl Energy 111:666–675, 2018.
5. Bhatt TU, Patel SB, Tiwari AP, Reactivity and delayed neutron precursors' concentration estimation based on recursive nonlin- ear dynamic data reconciliation technique, IEEE Trans Nucl Sci 66(2):541–548, 2019.
6. Mishra AK, Shimjith SR, Bhatt TU, Tiwari AP, **Kalman filter- based dynamic compensator for vanadium self powered neutron detectors**, IEEE Trans Nucl Sci 61(3):1360–1368, 2014.
7. M. G. Na, I. J. Hwang, and Y. J. Lee, **Design of a fuzzy model predic- tive power controller for pressurized water reactors**, IEEE Transactions on Nuclear Science, vol. 53, no. 3, pp. 1504–1514, June 2006.
8. R. N. Banavar and U. V. Deshpande, **Robust controller design for a nuclear power plant using h-infinity optimization**, IEEE Transactions on Nuclear Science, vol. 45, no. 2, pp. 129–140, Apr 1998.
9. H. Eliasi, M. Menhaj, and H. Davilu, **Robust nonlinear model predictive control for a PWR nuclear power plant**, Progress in Nuclear Energy, vol. 54, no. 1, pp. 177 – 185, 2012.

## 7.86 EE 557 : Adaptive Control

**Course Code : EE 557**

**Course Name : Adaptive Control**

L-T-P-C : 3-0-0-3

Intended for : Engineering graduates (pursuing M. Tech, PhD)

Prerequisite : Basic (Level 1) course in Automatic Control, e.g., EE301 – Control Systems Engineering. Familiarity to some extent with Standard statespace description of dynamical systems and Digital Control is desirable.

Mutual Exclusion:

Approval: 54th BoA

### Course Contents

- **Introduction**: Feedback control system design steps, effect of process variations, adaptive schemes and applications. Models of dynamic systems (recapitulation only): State space and Input-output models, plant parametric models. (3 Hours)
- **Stability**: Norms, Quadratic forms, Positive definiteness of matrices; BIBO stability, Stability in the sense of Lyapunov, Stability of linear systems. (4 Hours)
- **Parameter Estimation**: Least squares and Regression models, Recursive estimation. (6 Hours)
- **Deterministic and Stochastic Self-tuning Regulators**: Pole placement design, Continuous-time self-tuners, Direct self-tuning regulators; Minimum-variance and moving average controllers, stochastics self-tuning regulators, Linear quadratic self-tuning regulator, Adaptative predictive control. (6 Hours)
- **Model Reference Adaptive Control**: Simple direct model reference adaptive control (MRAC) schemes, MRAC for SISO plants, Direct MRAC with unnormalized and normalized adaptive laws, Indirect MRAC with unnormalized and normalized adaptive laws, Adaptive laws with projection. (8 Hours)
- **Auto Tuning and Gain Scheduling**: Auto tuning of PID controllers, Design of gain scheduling controllers. (4 Hours)
- **Robust Adaptive Laws**: Plant uncertainties and robust control, Instability phenomena in Adaptive systems, Robust adaptive laws. (5 Hours)
- **Robust Adaptive Control Schemes**: Robust identifiers and adaptive observers, Robust MRAC, Robust adaptive pole placement control schemes. (4 Hours)
- **Perspectives on Adaptive Control**: Expert control systems, Learning systems, Future trends, Conclusion. (2 Hours)

### Laboratory/practical/tutorial Modules:

- Not envisaged

**Textbooks:**

1. K. J. Astrom and B. Wittenmark, **Adaptive Control**, 2nd Eidtion, Addison Wesley, 1995 (2e), Dover Publications, 2008 (2e rev.)
2. Petros A. Ioannou and Jing Sun, **Robust Adaptive Control**, Dover Publications, 2012
3. S. Sastry and M. Bodson, **Adaptive Control: Stability, Convergence and Robustness**, Dover Publications, 2011
4. R. Isermann and M. Munchhof, **Identification of Dynamic Systems: An introduction with applications**, Springer 2011

**References:**

1. NA

## 7.87 EE 560: Reconfigurable Computing

**Course Code: EE 560**

**Course Name: Reconfigurable Computing**

L-T-P-C: 3-0-2-4
Prerequisites: EE 210/201P- Digital System Design & Practicum, CS 201/201P Computer Organization & Practicum.
Intended for: PG/UG
Distribution: Elective forM. Tech (VLSI), UG and other PG courses
Approval: 39th BoA

**Course Contents**

This course has three hour lecture session accompanied by two hours of laboratory session per week. List of course modules are provided below.

- **Introduction to reconfigurable computing**: [3 Lectures]
  - Reconfigurable computing, history and survey, fixed Vs reconfigurable computing, applications of reconfigurable computing
- **FPGA Design**: [6 Lectures]
  - Introduction to FPGA, LUT devices and mapping, partitioning, placement and routing algorithms. A case study on ALU design
- **Reconfigurable computing architectures**: [5 Lectures]
  - Performance evaluation, Coarse grained and fme grained reconfigurable computing, a case study on coarse grained reconfigurable computing, Multi-FPGA architectures, Dynamic reconfiguration, total versus partial reconfiguration
- **Reconfigurable computing**: [2 Lectures]

    - Power Reduction techniques for FPGA

- **Reconfigurable computing applications** [6 Lectures]
    - Distributed Arithmetic, CORDIC algorithm on FPGA

- **Reconfigurable computing-Security to FPGA** [4 Lectures]
    - Physical Unclonable Functions-Introduction and implementation on FPGA, on-chip authentication ofFPGA-based devices

- **Hardware-Software Co-design** [4 Lectures]
    - Introduction, Partitioning, Scheduling, Synthesis, Retiming, Pipelining. Unfolding, analysis and Estimation

- **Finite State Machine with Datapath** [3 Lectures]
    - Introduction, finite state machines, finite state machine with datapath (FSMD), a case study on FSMD

- **Hardware -Software Interfaces** [3 Lectures]

- Hardware software Communication, one way and two way handshake, blocking and non-blocking data transfer, On-chip Bus, Bus transfer and topologies

- **Case study** [6 Lectures]
    - Decoders, Crypto processor, CORDIC processor.

**Experiments:**

The practicurn of this course implements the FPGA based implementation of the algorithms and architectures discussed during the course. Experiments such as UART interfacing with FPGA, CORDIC algorithm, interfacing camera with FPGA, image compression and cryptographic algorithm on FPGA.

**Textbooks:**

1. Scott Hauck Andre DeHon, **Reconfigurable Computing: The theory and practice of FPGA based Computation**, Morgan Kaufmann, 2008.

2. F. Vahid and T. Givargis, **Embedded Systems: A Unified Hardware Software Introduction**, John Wiley and Sons, 2011.

**References:**

1. Patrick Schaumont, **A Practical Introduction to Hardware/Software Co design**, Springer, 2010.

2. Bobda, Christophe, **Introduction to Reconfigurable Computing: Architectures, algorithms and applications**, Springer, 2007.

3. I. Koren, **Computer Arithmetic Algorithms**, A.K. Peters Ltd., 2002.

4. Behrooz Parhami, **Computer Arithmetic - Algorithms and Hardware Designs**, 2nd Edition, Oxford university press, 2010.

5. Peter J. Ashenden, **The designer's guide top VHDL**, Morgan Kaufmann, 2008.

6. IEEE research papers on relevant topics.

## 7.88 EE 570 : Advanced Communication Theory

**Course Code : EE 570**

**Course Name : Advanced Communication Theory**

L-T-P-C : 3-0-2-4
Intended for : BTech/MTech/MTech (R)/ PhD students of the SCEE.
Prerequisite : IC210: Probability, Statistics and Random Processes, EE 304: Communication Theory or the instructor's consent
Mutual Exclusion: None so far
Approval: 54th BoA

**Course Contents**

- **Digital modulation schemes**: Bandpass and lowpass signal representation, Digital modulation schemes (PAM, PM, QAM, Multidimensional Signals, CPFSK, CPM) and their corresponding optimal receivers and error probabilities for AWGN Channel. (12 Hours)

- **Carrier and Symbol Synchronization**: Importance in signal demodulation, carrier frequency and phase estimation – decision directed and power of N methods, timing estimation - spectral-line, MMSE, and ML methods, joint carrier and symbol synchronization. (8 Hours)

- **Equalization**: Optimal zero-forcing equalization, Linear, Decision-feedback, Adaptive Linear, Adaptive Decision-feedback, and Blind equalization. (12 Hours)

- **Multichannel and Multicarrier Systems**: Wireless & AWGN multi-channels, Multicarrier communications: OFDM – modulation and demodulation, spectral characteristics, bit and power allocation, channel. (8 Hours)

- **Case Studies**: A brief overview of modern communication/broadcast technologies. (3 Hours)

**Laboratory/practical/tutorial Modules:**

- Not envisaged

**Textbooks:**

1. J. G. Proakis and M. Salehi, **Digital Communications**, 5th Edition, McGraw-Hill, Prentice Hall, 2007.

2. R. G. Gallager, **Principles of Digital Communication**, Cambridge Univ. Press, 2008.

**References:**

1. B. Sklar, **Digital Communications: Fundamentals and Applications**, 2nd Edition, Prentice Hall, 2001.

2. John R. Barry, David G. Messerschmitt, and Edward A. Lee, **Digital Communication**, 3rd Edition, Kluwer Academic Publishers, 2003.

3. A. Lapidoth, **A Foundation in Digital Communication**, Cambridge Univ. Press, 2009.

4. Simon Haykin, **Digital Communications**, Wiley Publishing, 2006.

## 7.89 EE 574 : Biomedical Signal and Image Analysis

**Course Code : EE 574**

**Course Name : Biomedical Signal and Image Analysis**

L-T-P-C : 3-0-0-3
Intended for : Open Elective for All 3rd/4th year (odd-sem) BTech/MTech/MS/MSc/MA/Ph.D.
Prerequisite : None
Mutual Exclusion: EEXXX (Signals & Systems)
Approval: 54th BoA

**Course Contents**

- **Introduction to fundamental concepts**: Signal processing overview; Fundamental signals (1-D and 2-D); Classification of systems; Characteristics of linear and non-linear systems, Concepts of convolution and Autocorrelation. Frequency analysis: Fourier Transform, DTFT, FFT, Welch's method; Data Acquisition: Sampling in time, aliasing, interpolation, and quantization. Introduction to random variables and probability density functions (PDFs). Stationary and Nonstationary Processes. (4 Hours)

- **Electrophysiology and Electrographic modalities**: Electric properties of a cell: Ion transport, transmembrane potential, membrane resistance and capacitance, action potential, Hodgkin-Huxley model. Electric data acquisition and biomedical electrodes. ECG: Function and structure of heart, cardiac muscle and excitation process, origin of ECG, ECG electrode placement, noise sources, Modeling and representation of ECG, ECG and cardiovascular diseases. EEG: Neuron, scalp potentials, EEG recording systems, EEG rhythms, Evoked potentials, EEG attifacts, Disease of CNS and EEG. EMG: Muscle, motor unit, muscle contraction, muscle force, noise in EMG, Neuromuscular disease and EMG. (6 Hours)

- **Biosignal processing**: Feature extraction methods: Frequency domain (PSD, dominant frequency, spectral entropy), Nonlinear features (Lyapunov exponents, fractal dimensions, complexity and mobility measures), entropy-based measures, cross-correlation and coherence, phase-based features (phase synchronization, phase coherence, phase-amplitude coupling), time-frequency methods (short-time Fourier Transform, Wigner-Ville distribution, Morlet Wavelets), connectivity analysis (graph theoretic measures, synchronization measures, Granger causality). Noise Removal:

Removal of linear and nonlinear trends, Filtering techniques active and passive filters; Design of digital filters. Generalized Eigen Decomposition (GED) for denoising, Empirical mode decomposition (EMD), and blind source. (10 Hours)

- **Introduction to Medical Images**: Imaging Modalities: introduction of major modalities for medical imaging: ultrasound, X-ray, CT, MRI, PET, and SPECT. Image formation and tissue energy interaction as a basis for different imaging modalities, quantitative medicine, multi-scale and multi-resolution relations in medical diagnostics, Cardiovascular and Neuro Imaging and Analysis. Automated Image Quality Assessment in Medical Images. (8 Hours)
- **Statistical and Structural Analysis**: Statistical and structural classification, morphological and topological component analysis. Rigid and non-rigid transformations. Co-registration of images, and motion correction. Extension of filtering and Fourier methods to 2-D signals and systems. Noise reduction methods, optimal and adaptive filters, homomorphic filtering, edge detection, time-frequency, and fractal analysis. Bayesian graphical modeling and inference for image restoration. (8 Hours)
- **Pattern Analysis**: Pattern classification and diagnostic decision-Measures of diagnostic accuracy. Abnonnality detection and pattern recognition in cardiac, brain, and abdominal images, image categorization, and computer-aided diagnosis. Image descriptors, Image similarity, rendering surfaces and volumes, 3D neurostructure analysis, hypothesis testing, and prediction modeling. Deep learning for medical images. (6 Hours)

**Laboratory/practical/tutorial Modules:**

- There shall be practical demonstration of certain fundamental algorithms of data processing and its analysis that shall be explained in computational modeling fashion. This shall be conducted in the form of minor projects and analyzing real problems in clinical practice to aid theoretical concepts.

**Textbooks:**

1. John L. Semmlow, **Biosignal and Biomedical Image Processing: MATLAB Based Applications**, CRC press.

**References:**

1. Rangayyan R M, **Biomedical Image Analysis**, 5th Edition, CRC Press, 2005
2. Atam Dhawan, **Medical Image Analysis**, 2nd edition, by WILEY.
3. Reddy, D.C., **Biomedical signal processing: principles and techniques**, McGraw-Hill, 2005.
4. Gonzalez, R., and R. E. Woods., **Digital Image Processing**, 2nd Edition, Prentice-Hall, 2002.
5. E.N. Bruce, **Biomedical Signal Processing and Signal Modelling**, John Wiley and Sons, 2001.

## 7.90 EE 575 : Applied Statistics for Data and Signals

**Course Code : EE 575**

**Course Name : Applied Statistics for Data and Signals**

L-T-P-C : 3-0-2-4
Intended for : B.Tech./M.S./M.Tech./Ph.D.
Prerequisite : EE304/ EE503/ EE305/ MA524 or equivalent
Mutual Exclusion: EEXXX (Signals & Systems)
Approval: 54th BoA

**Course Contents**

- **Mathematical background**: Probability measure space, sample space, cr-algebra, measure theory, random variables, CDF, PDF, joint, marginal and conditional PDFs, transformation of random variable, statistical averages, vector space, inner products, nom1s, metric, stochastic processes, stationarity, Gaussian process, white noise, stochastic processes through LTI systems. (4 Hours)
- **Statistical Detection Theory**: Binary testing, Decision criteria: Neyman-Pearson Criterion, Bayes Criterion, Min-Max Criterion, receiver operating characteristics (ROC), M-ary decision, erasure decision Bayes risk detectors, sequential detection, Composite hypothesis testing: Bayesian and generalized likelihood ratio test (GLRT), locally most powerful (LMP) detectors, asymptotically equivalent tests. (15 Hours)
- **Estimation for deterministic parameters**: Principle of estimation and its application, properties of estimators. - Minimum Variance Unbiased Estimation: existence and search of MVU estimators, extension to vector parameters. Cramer-Rao Lower Bound: signals in white Gaussian noise, parameter transformation, vector parameters, general Gaussian case. - Linear Models and Unbiased Estimators, scalar and vector Best Linear Unbiased Estimators (BLUE); Maximum Likelihood estimation, Least Squares estimation: linear, order-recursive, sequential , constrained , and nonlinear. (11 Hours)
- **Estimation for random parameters**: Bayesian Estimation: Bayesian linear model, nuisance parameters. Bayesian estimation for deterministic parameters, risk functions, MMSE and MAP estimators, scalar, vector, anti sequential Linear MMSE estimators, Wiener filtering. (6 Hours)
- **Regression analysis**: Simple linear regression, multiple linear regression, estimation and interpretation of regression coefficients, goodness of fit, confidence intervals and hypothesis testing for regression coefficients, generalized linear models. (6 Hours)

**Laboratory/practical/tutorial Modules:**

- Data preprocessing, Density Estimation methods, feature vector selection, numerical integration methods, ROC

**Textbooks:**

1. S. M. Kay, **Fundamentals of Statistical Signal Processing, Vol I: Estimation Theory**, Prentice Hall, 1993.
2. H. L. van Trees, K. L. Bell, and Z. Tian, **Detection, Estimation, and Modulation Theory, Part 1: Detection, Estimation, and Filtering Theory**, Wiley, 2013.

**References:**

1. L. L. Scharf, **Statistical Signal Processing: Detection, Estimation, and Time Series Analysis**, Addison-Wesley, 1991.
2. . H. Y. Poor, **An Introduction to Signal Detection and Estimation**, Springer-Verlag, 1994.
3. C. W. Helstrom, **Elements of Signal Detection and Estimation**, Prentice Hall, 1995.
4. G. Casella and R. L. Berger, **Statistical Inference**, Duxbury Press, 2002.
5. S. M. Kay, **Fundamentals of Statistical Signal Processing, Vol 2: Detection Theory**, Prentice Hall, 1998.

## 7.91 EE 580: Network Systems: Modelling and Analysis

**Course Code : EE 580**

**Course name : Network Systems: Modelling and Analysis**

L-T-P-C : 3-0-0-3

Prerequisites : MA 512 Linear Algebra or EE 522 Matrix theory for engineers and EE509 Linear Dynamical Systems or instructor's consent

Intended for : 3rd/ 4th year B.Tech. (all branches), MSc., M.Tech, Ph.D.

Elective/Core : Discipline elective for B.Tech. (EE, CSE), free elective for others

Approval: 28th Senate, 35th BoA

**Course Contents**

- **Introduction**: Examples of networks systems, engineered (sensor & robotic networks) and natural (social & compartmental networks). Need for tools to understand and analyse these systems. [2 Lectures]
- **Review of Matrix theory & Graph theory**: Jordan normal form, stochastic matrices and spectral radius, Perron-Frobenius theory. Graphs and digraphs, weighted digraphs. [4 Lectures]
- **Algebraic graph theory**: Adjacency matrix, graph theoretical characterization of primitive & irreducible matrices. Elements of spectral graph theory. [4 Lectures]

- **Averaging systems**: Discrete-time and continuous-time averaging systems. Consensus in averaging systems. Convergence properties. Laplacian flow. Design of weighted digraphs. Scalability, optimization. Time-varying and randomized averaging algorithms. Examples: sensor networks, opinion dynamics over social networks. [10 Lectures]

- **Compartmental systems**: Positive systems and Metzler matrices. Compartmental matrices. Dynamic properties. Spectral properties. Algebraic and graphical properties. Examples: epidemiology, drug kinetics. [8 Lectures]

- **Stability theory for networks**: Dynamical systems and stability notions, Lyapunov stability criteria, Krasovskii-LaSalle invariance principle. Linear, nonlinear and linearized systems. Negative gradient systems. [7 Lectures]

- **Introduction to simulation**: Motivation - role of simulation in understanding and engineering network systems. Discussion on available tools MATLAB/Simulink, NetSim, NS2. Design of simulation experiments for sensor networks, computations on models for compartmental systems. [3 Lectures]

- **Advanced topics**: Multi-agent systems, Wireless sensor and actuators networks, robot swarms. Problems and trends. [3 Lectures]

**Text Books:**

1. Francesco Bullo, **Lectures on Network Systems**, CreateSpmace, 2018.

2. lbert-Laszlo Barabasi, **Network Science**, Cambridge University Press, 2016.

**Additional References:**

1. Mark Newman, Albert-Laszlo Barabasi and Duncan J. Watts, **The structure and dynamics of networks**, Princeton university press, 2006.

2. Mark Newman, **Networks An Introduction**, Oxford University Press, 2018.

3. Guanrong Chen, Xiaofan Wang, and Xiang Li, **Fundamentals of complex networks: models, structures and dynamics**, John Wiley & sons, 2014.

4. Selected publications to be chosen by the instructor.

## 7.92 EE 581 : Applied Statistics for Data and Signals

**Course Code : EE 581**

**Course Name : Applied Statistics for Data and Signals**

L-T-P-C : 3-0-2-4

Intended for : MTech/MTech (R)/ PhD students of the SCEE

Prerequisite : IC 210/ IC252 Probability, statistics, and random variables or equivalent.

Mutual Exclusion: EE534, CS511, MA 511, MA521, MA524, MA568, MA 601, or equivalent.

Approval: 54th BoA

**Course Contents**

- **Analysis**: The Real Number System, Euclidean Spaces, Metric Spaces, Closed and open sets. (6 Hours)
- **Module II**: Numerical sequences and series, convergence of sequences of numbers, Limits, Continuity of functions, Derivatives of functions, Integration (Riemann integration, Lebesgue integration, Riemann-Stieltjes, Lebesgue-Stieltjes). (8 Hours)
- **Probability Theory**: The axioms of probability theory, Independence and conditional probability, Random variables and their distribution, Expectation, Conditional distribution, Convergence of sequences of random variables, Laws of large numbers and Central limit theorem. General concepts of stochastic processes. (11 Hours)
- **Data driven/ Statistical detection and Estimation**: Hypothesis testing, Optimal detectors, minimum variance unbiased estimation, mean squared estimation; filtering, and prediction, and Kalman filtering, parametric/ nonparametric distribution estimation, data driven detection and estimation. (11 Hours)
- **Basics of Queueing theory**: Introduction to Markov chains, Kendall's notation for queueing systems, M/M/1, M/M/m, M/M/infinity, M/M/m/m, M/G/1, G/G/1 queueing systems and applications. (6 Hours)

**Laboratory/practical/tutorial Modules:**

- The two-hours of lab session per week will enhance the understanding of the concepts taught in the class. The lab will cover the concepts including sets, sequence convergence, random variables, central limit theorem, detection, and estimation techniques for statistical and data driven scenarios.

**Textbooks:**


1. Hajek, B., **Random Processes for Engineers**, Cambridge University Press, 2015.
2. S. M. Kay, **Fundamentals of Statistical Signal Processing, Vol - 1 & 2**, Pearson, 20210.


**References:**


1. Deisenroth, M. P., Faisal, A. A, Ong, C. S., **Mathematics for Machine Learning**, Cambridge University Press, 2020.
2. J. G. Proakis and M. Salehi, **Fundamentals of Communication Systems**, Prentice Hall, 2004.
3. Harry L. Van Trees, Kristine L. Bell, Zhi Tian, **Detection, Estimation, and Modulation Theory: Detection, Estimation, and Linear Modulation Theory**, Wiley, 2013.
4. Dimitri P. Bertsekas, and Robert G. Gallager, **Data Networks**, 2nd Edition, Pearson Publication

## 7.93 EE 582: Nonlinear Analysis and Control of Power Electronic Converters

**Course Code: EE 582**

**Course Name: Nonlinear Analysis and Control of Power Electronic Converters**

L-T-P-C: 3-0-0-3
Pre-requisite: EE301, EE309
Intended for: UG and PG
Distribution: Elective
Approval: 36th BoA, 32nd Senate

**Course Contents**

- **Introduction**

  Introduction to nonlinear models, nonlinear phenomena, common nonlinearities, qualitative behavior of linear systems, phase portraits, limit cycle oscillation, Jacobi linearization, direct method and indirect method of Lyapunov [6 Lectures]

- **Sources of Nonlinearities in Power Electronic Converters**

  Nonlinearity due to switch and reactive components, nonlinearity introduced by the closed loop control, nonlinear phenomena observed in power electronic converters. [3 Lectures]

- **Control techniques for power electronic converters**

  Voltage mode control, current mode control, PWM of type 1 and type 2, hysteresis control, sliding mode control, digital control, time optimal control. [7 Lectures]

- **Dynamic Modeling Techniques**

  Average modelling of PWM converters, limitations of average model, Discrete-time 1-D and 2- D models. [4 Lectures]

- **Stability Analysis**

  Basics of bifurcation theory and chaos, bifurcation of smooth and piecewise-smooth maps, nonstandard bifurcation in discontinuous maps, techniques of experimental investigations. [7 Lectures]

- **Describing Function Analysis of Power Electronic Converters**

  Basics of describing function, describing function of different nonlinearities, stability analysis of limit cycle using Nyquist criteria. [7 Lectures]

- **Simulation Study** Matlab based project work on i) Analysis of instability introduced by the different nonlinear components, ii) Nonlinear controller design to improve transient performance and stability boundary. [7 Lectures]

**Text Books**

1. S. Banerjee and G. C. Verghese, (Editors), **Nonlinear Phenomena in Power Electronics: Attractors, Bifurcations, Chaos, and Nonlinear Control**, IEEE Press, 2001.

**Reference Books**

1. H. K. Khalil, **Nonlinear Control**, Pearson Education, 2015
2. C. K. Tse, **Complex Behavior of Switching Power Converters**, CRC, 2003.
3. N. Mohan, T. M. Undeland, and W. P. Robbins, **Power Electronics Converters, Applications, and Design**, 3rd edition, Wiley India, 2008.
4. R. W. Erickson and D. Maksimovic, **Fundamentals of Power Electronics**, 2nd edition, Dordrecht, Kluwer, 2001.
5. L. Corradini, R. Zane, D. Maksimovic, P. Mattavelli, **Digital Control of High-Frequency Switched-Mode Power Converters**, John Wiley & Sons, 2015

## 7.94 EE 583: Smart Grids

**Course Code: EE 583**

**Course Name: Smart Grids**

L-T-P-C: 3-0-0-3
Prerequisites: EE-303 (Power systems)
Intended for: UG/PG
Distribution: Elective for B. Tech (EE), M.S., M. Tech. & Ph.D.
Approval: 37th BoA

**Course Contents**

- **Introduction**: Smart Grid: Concept, architecture, standards and protocols, Smart Grid in Indian Grid context. [3 Lectures]
- **Power System Operations**: Load flow for smart grids, voltage stability assessment, and state estimation. [6 Lectures]
- **Communication Infrastructure**: [4 Lectures]
  - Communication standards, requirements for data links, data quality, cyber security: state of the art, risks and mitigation
- **Wide Area Measurement Systems (WAMS)**: - Phasor measurement units (PMU), WAMS architecture, applications of WAMS for power system operation improvement: advantages and disadvantages. [3 Lectures]
- **Integration of Renewable Energy Sources and Energy storage**: Renewable energy sources, penetration and variability issues, environmental implications, demand response, electric vehicles, energy storage techniques: battery, pumped hydro, modelling of storage devices. [8 Lectures]

- **Smart Devices**: FACTS, STATCOM, HVDC, fault current limiters. [5 Lectures]
- **Protection and Security**: Intelligent protection, contingency analysis and classification, security, outage management, remedial action schemes, special protections schemes. [5 Lectures]
- **Meters and Sensors**: Hardware, demand side integration, communication standards and protocols, smart meters, automatic meter reading (AMR), advanced metering infrastructure (AMI). [4 Lectures]
- **Microgrids**: System operation, consumer energy management. [3 Lectures]
- **Hardware in Loop (HIL) testing**: HIL requirements, advantages and disadvantages. [1 Lecture]

**Text books:**

1. S. F. Bush, **Smart Grid: Communication-enabled intelligence for the electric power grid**, John Wiley and Sons, Ltd., 2014.
2. I. S. Jha, S. Sen, R. Kumar, D. P. Kothari, **Smart Grid Fundamentals & Applications**, New Age International Publishers, 2019.

References:

1. J. Momoh, **Smart Grid: Fundamentals of design and analysis**, John Wiley and Sons, Ltd., 2012.
2. B. M. Buchholz, Z. Styczynski, **Smart Grids - Fundamentals and Technologies in Electricity Networks**, Springer, 2014.
3. C. W. Jennings, **The Smart Grid: Enabling Energy Efficiency and Demand Response**, Fairmont Press Inc., 2009.
4. N. Hatziargyriou, **Microgrids: Architectures and Control**, John Wiley and Sons, Ltd., 2014.

## 7.95 EE 584: Power System Protection

**Course Code: EE 584**

**Course Name: Power System Protection**

L-T-P-C: 3-0-0-3
Prerequisites: EE-303 (Power systems)
Intended for: UG/PG
Distribution: Elective for B. Tech (EE), M.S., M. Tech. & Ph.D.
Approval: 37th BoA

**Course Contents**

- **Introduction**: Fundamentals of protection- Security, selectivity and reliability, measurement principles unit and non-unit protection, legacy relays, solid state and numerical relays, standards in power system protection. [3 Lectures]
- **Instrument Transformers**: Working principle of current transformers (CT), voltage transformers (VT), dynamic response of CTs and capacitor coupled voltage transformer (CCVT) during faults and its effect on relaying. [4 Lectures]
- **Fault Analysis using Symmetrical components** : Sequence components, sequence modelling of power system components such as transformers, generators, transmission lines, fault analysis. [4 Lectures]
- **Numerical Relaying**: Sampling of analog values, analog to digital conversion, least square method for estimation of phasors, Fourier analysis, discrete Fourier transform: properties, phasor calculation, fast Fourier transform. [4 Lectures]
- **Directional Overcurrent Protection**: Directional and overcurrent relay principles, directional relay coordination problem associated with multiple loop system. [4 Lectures]
- **Transmission line Protection**: Distance and non-distance-based protection concepts. Zones of protection and back up protection, distance relay settings, pilot protection with distance relays. [6 Lectures]
- **Power Swing**: [2 hours] Power swing detection, stable and unstable swing, blocking and unblocking of distance relays during power swing, analysis of power swing in multi machine system, operation of relays during out of step condition. [2 Lectures]
- **Transformer protection**: Inrush phenomenon, Inrush detection methods; Differential and over-excitation protection. [3 Lectures]
- **Bus Protection**: Bus configurations; High and low impedance protection concepts. External Fault detection methods and remedial measures to account for CT saturation detection. [3 Lectures]
- **Rotating Machinery Protection**: Motor and generator protection, generator construction and grounding methods, Detection of faults and abnormal operating conditions. [4 Lectures]
- **Distribution system protection**: Feeder protection philosophies, Coordination examples, Power system restoration concepts - Reclosing, Automatic sectionalizing. [2 Lectures]
- **Introduction to relay setups and Standards**: Distance, overcurrent, over/under frequency relay set up demonstration. Discussion on standards for protection scheme in Indian power grid. [3 Lectures]

**Text books:**

1. S. Horowitz and A. G. Phadke, **Power System Relaying**, 4th Edition, Wiley, 2014.

2. A. G. Phadke and J. S. Thorpe, **Computer Relaying for Power Systems**, Wiley, 2009

3. Juan Gers, **Protection of Electricity Distribution Networks**, 3rd Edition, lET press, 2011.

**References:**


1. P.M. Anderson, **Power System Protection**, Wiley-IEEE press, 1999.

2. J. L. Blackburn, T. J. Domin, **Protection Relaying: Principles and Applications**, 3rd Edition, Taylor and Francis, 2006

3. J.D. Glover, M. S. Saema, T. J. Overbye., **Power System Analysis and Design**, 5th Edition, Cengage Learning, 2010.

4. Bhavesh Bhalja, R. P. Maheshwari and N. Chothani, **Protection and Switchgear**, 2nd Edition, Oxford University Press, 2019.


## 7.96 EE 601_9th senate Solid State Devices

**Course Code: EE 601_9th senate**

**Course Name: Solid State Devices**

L-T-P-C: 3-0-0-3
Prerequisites:
Students Intended for:
Core or Elective:
Approval: Not Available

**Course Contents:**

- **Circuit Modeling** Basic Concepts, Functional Modeling at Logic and Register levels, Structural Models.

- **Logic Simulation** Simulation based Design Verification, Delay Models, Gate-level Event Driven Simulation.

- **Fault Modeling** Logical Fault Models, Fault Detection, Equivalence and Dominance, Single and Multiple Stuck-Fault Model.

- **Fault Simulation** General Fault Simulation Techniques, Fault Simulation for Combinational Circuits, Fault Sampling.

- **Testing** Algorithms tor Testing Single Stuck Fault and Bridge Faults, Automatic Test Generation Concepts, Functional Testing, Random Test Generators. Encoding techniques.

- **Design tor Testability** Scan Based Design. Boundary Scan Techniques, Compression Techniques, LFSFs, Built-in Self Test (BIST), BIST Architectures and Advanced BIST Concepts.
- **Formal Verification** Model Checking. Equivalence Checking and Theorem Proving, Design of tools for Formal Verification.

## 7.97 EE 601: Advanced Electric Drives

**Course Code: EE 601**

**Course Name: Advanced Electric Drives**

L-T-P-C: 2.5-0.5-0-3
Prerequisite: EE 201 Electromechanics and Power Electronics
Students intended for: B.Tech. and MS/Ph.D.
Elective or Core: Elective
Approval: 2nd Senate

**Course Contents**

- **Introduction**: Definition of electric drive, type of drives; Speed torque characteristic of driven unit/loads, motors, joint speed-torque characteristic; Classification and components of load torque; Review of power converters used in drives, multi-quadrant operation of electric drive, example of hoist operation in four quadrant.
- **Module II**: Closed loop control of solid state DC drives, Scalar and vector control of induction motor, Direct torque and flux control of induction motor, Self controlled synchronous motor drive, Vector control of synchronous motor, Switched reluctance motor drive, Brushless DC motor drive, Permanent magnet drives, Industrial drives.
- **Module III**: Harmonic reduction techniques, PWM inverters, Space Vector Modulation

**Text & Reference Books:**


1. Mohan N., Underland T.M. and Robbins W.P., **Power Electronics Converters, Applications and Design**, 3rd Edition, Wiley India. 2008
2. Bose B.K., **Power Electronics and Variable Frequency Drives Technology and Applications**, IEEE Press, Standard Publisher Distributors. 2001
3. B.K.Bose, **Power Electronics & A.C. Drives**, Prentice Hall, 1986.
4. Rashid M., **Power Electronics- Circuits, Devices and Applications**, 3rd Edition, Pearson Education.
5. Dubey G. K., **Power Semiconductor Controlled Drives**, Prentice Hall, 1989
6. Murphy J. M. D. and Turnbull F. G., **Power Electronics Control of AC Motors**, Peragmon Press.
7. G.K.Dubey, **Fundamentals of Electric Drives**.

## 7.98 EE 602: Control System Applications

**Course Code: EE 602**

**Course Name: Control System Applications**

L-T-P-C: 2.5-0.5-0-3
Prerequisite: Consent of the faculty member
Students intended for: MS/PhD
Elective or Core: Elective
Approval: 2nd Senate

**Course Contents**

- **Basic concepts**: Introduction, basic terminology, objective of subject, some basic examples, Notion of feedback; open- and closed-loop systems.
- **Mathematical Models**: Representation of physical systems and analogous systems, Lapalce transforms, block diagrams, transfer functions for different type of systems, block diagrams reduction techniques; Signal flow graphs and Masons gain formula.
- **Control hardware and their models**: Potentiometers, synchros, LVDT, DC and AC servo motors, tachogenerators, electro-hydraulic valves, and pneumatic actuators.
- **Time-domain analysis**: Time domain performance criterion, transient response of first order, second order and higher order systems; Steady state errors: Static and dynamic error constants, system types, steady state errors for unity and non unity feedback systems, performance analysis for P, PI and PID controllers.
- **Frequency-domain analysis**: Bode and polar plots, frequency-domain specifications, correlation between transient response and frequency response.
- **Stability analysis**: Concept of stability by Routh stability criterion, Nyquist stability criterion, gain and phase margins, relative stability, constant M and N circles, Nichols chart and its application.
- **Root-locus technique**: Nature of root-locus, rules of construction, root-locus analysis of control systems.
- **Compensation**: Types of compensation, Proportional, PI and PID controllers; Lead-lag compensators.
- **State-space concepts**: Eigen values and eigen vectors; Solution of state equations; Controllability; Observability; pole placement result, Minimal representations.

**Text & Reference Books:**


1. Nagrath I. J. and Gopal M., **Control System Engineering**.
2. Kuo B. C., **Automatic Control Systems**.
3. Ogata K., **Modern Control Engineering**.

4. Gopal M., **Control Systems: Principle and Design**.

## 7.99 EE 603: Renewable Energy and Smart Grid

**Course Code: EE 603**

**Course Name: Renewable Energy and Smart Grid**

L-T-P-C: 3-0-0-3
Prerequisite: EE 203 Electromechanics, EE 303 Power Systems
Students intended for: UG/MS/PhD
Elective or Core: Elective
Approval: 2nd Senate

**Course Contents**

Basic concepts, definitions and classifications of energy resources; grid code and characteristics; electrical output characteristics of various renewable energy sources; compatibility issues and options.

Introduction to major RES, grid integration issues, challenges and methodologies, power electronics converters for grid integration, hybrid systems and virtual power plants, storage, Cost of interconnection and responsibilities, forecasting, scheduling of RES, regulatory issues and energy markets. Introduction to smart grid concept.

**Text & Reference Books:**

1. Ali Kehani, Mohammad N. Marwali, Min Dai, **Integration of Green and Renewable Energy in Electric Power Systems**, Wiley Interscience, 2009.

2. Gil Masters, **Renewable and Efficient Electric Power Systems**, Wiley-IEEE Press, 2004.

3. Felix A. Farret, M. Godoy Simoes, **Integration of Alternative Sources of Energy**, IEEE Press and Wiley Interscience Publication, 2006.

4. John Twidell and Tony Weir, **Renewable Energy Resources**, Talyor and Francis, 2006.

5. T. Ackermann, **Wind Power in Power Systems**, John Wiley

6. Other Sources: IEEE Transactions on Smart Grid

## 7.100 EE 604P: Practicum on Advanced Electric Drives

**Course Code : EE 604P**

**Course Name : Practicum on Advanced Electric Drives**

L-T-P-C : 0-0-3-2
Prerequisites : EE508 - Fundamentals of Electric Drives, EE508P - Practicum on Electric Drives or Equivalent
Intended for : M.Tech in Power Electronics and Drives (PED)

Distribution : Core for M.Tech in Power Electronics and Drives (PED)
Approval: 13th Senate

**Course Contents**

This is a laboratory course with 3-hour sessions per week. Following is the tentative structure of the course.

- **Part 1: Predesigned experiments on the following topics**
  - **1. Induction Motor Drives** (9 hours)
    - Field oriented control of induction motor, Direct torque/flux control of induction motor, Effect of parameter variation on the above control performance, Power
    - Failure Ride-through of induction motor drive, Sensorless control of induction motor drive methods of speed estimation
  - **2. Synchronous Motor Drives** (9 hours)
    - Vector control of synchronous motor drive, Controller design
  - **3. Other Motor Drives** (6 hours)
    - Vector control of PMSM, Closed loop control of BLDC drive, Closed loop control of SRM drive
- **Part 2: Design Project**: Sizing and controller design for a closed loop drive for a given application - This will be in form of a course project (9 hours)

**References:**


1. W. Leonhard, **Control of Electrical Drives**, Springer-Verlag, 2001.
2. Mohan N., Undeland T. M. and Robbins W. P., **Power Electronics - Converters, Applications and Design**, 3rd Edition, Wiley India, 2008.
3. Bose B. K., **Power Electronics and Variable Frequency Drives - Technology and Applications**, IEEE Press, Standard Publisher Distributors, 2001.
4. Rashid M., **Power Electronics - Circuits, Devices and Applications**, 3rd Edition, Pearson Education.
5. Krause, P. C., Wasynczuk, O., Sudhoff, S. D., **Analysis of Electric Machinery and Drive Systems**, Wiley-Interscience.


## 7.101 EE 605: Information Theory

**Course Code : EE 605**

**Course Name : Information Theory**

L-T-P-C : EE309: 3-0-0-3
Pre-requisites : IC 210, EE 304 or equivalent or Consent of Teacher
Distribution : Elective
Students intended for: B.Tech 4th year and Research Students
Approval: 5th Senate

**Course Contents:**

- Concept of information, Information measures: Hartley measure, Shannon Entropy. [3 hours]
- **Basic notions**: Entropy, joint and conditional entropy, relative entropy, mutual information, KL-distance, Jensen and Log-sum inequalities. [6 hours]
- **Source compression**: Asymptotic Equipartition Property (AEP) and its consequences for data- compression, types of codes, Kraft inequality, optimal codes and bounds of their lengths, Huffman codes and theiroptimality, Shannoncode, Arithmetic coding. [6 hours]
- **Channel coding**: the notion of channel capacity, discrete memory less channels, channel capacity computation for elementary DMC channels, symmetric channels, jointly typical sequences, data-processing and Fanoas inequalities, channel coding theorem (achievability and converse), feedback capacity, source-channel separation theorem and joint source- channel coding: multimedia communications. [9 hours]
- **Differential entropy**: AEP for continuous variables, joint and conditional differential entropy, relative entropy and mutual information. [3 hours]
- **Gaussian channel**: Coding theorem for Gaussian channels, Band limited channels, parallel Gaussian channels, channels with colored Gaussian noise: water-filling argument. [9 hours]
- **Advanced topics**: Rate-distortion theory, Network coding, Introduction to Network Information Theory. [6 hours]

**Reference Books:**


1. I.Csiszar and J.Korner, **Information Theory:Coding Theorems for Discrete Memory less Systems**, Cambridge Univ. Press, August 2011.
2. R. G. Gallager, **Information Theory and Reliable Communication**, Wiley,1968.
3. T. M. Cover and J. A. Thomas, **Elements of Information Theory**, 2nd Edition, Wiley, 2006.
4. D.J.C.MacKay, **Information Theory, Inference and Learning Algorithms**, Cambridge Univ. Press, 2003.


## 7.102 EE 606: Introduction to High Voltage Engineering and Dielectric Breakdown

**Course Code : EE 606**

**Course Name : Introduction to High Voltage Engineering and Dielectric Breakdown**

L-T-P-C : 3-0-0-3

Prerequisites : EE 303 Power Systems or teachers consent

Students intended for : B.Tech./M.S./Ph.D.
Elective or Compulsory : Elective
Approval: 5th Senate

**Course Contents**

- Electric Field Strength. [4 Lectures]
- Gaseous Dielectrics. [9 Lectures]
- Properties of Liquid and Solid Dielectrics. [6 Lectures]
- Breakdown in Liquid and Solid Dielectrics. [4 Lectures]
- Generation of High Test Voltages. [6 Lectures]
- Measurement of High Test Voltages. [4 Lectures]
- Non-destructive High Voltage Testing and Quality Control. [4 Lectures]
- Insulation Coordination and Over Voltages in Power Systems. [2 Lectures]
- Introduction National and International standards such as IEC-60060-1, 60-2, etc. [1 Lecture]
- Recent trends and developments. [2 Lectures]

**Textbooks:**

1. R. Arora, W. Mosch, **High Voltage and Electrical Insulation Engineering**, IEEE Press, 2011.
2. M. S. Naidu, Kamaraju, **High Voltage Engineering**, TMH, 2009.

**References:**

1. Kuffel, E., **High voltage engineering**, Newnes, 2009.
2. Alston L. L., **High Voltage Technology**, Oxford University Press, 2011.

**List of Experiments:**

1. To Study the corona phenomena alongside thin copper wire by use of power frequency HV test source.
2. To study electrical breakdown of a sample of in-service HV insulating oil for electrical breakdown against contamination & moisture.
3. To carry out measurements of earthling resistance by three probe method.
4. To carry out measurement of earth resistance by four probe method.
5. To carry out air insulation breakdown studies by using uniform sphere gap spacing.

6. To carry out air insulation breakdown studies by using non-uniuniform sphere gap spacing.
7. To carry out electrical breakdown studies on solid insulations using test setup.

## 7.103 EE 607 Optical Communication Systems

**Course Code: EE 607**

**Course Name: Optical Communication Systems**

L-T-P-C: 3-0-0-3
Prerequisites: EE-304: Communication Theory and the instructor's consent
Students Intended for:UG/MS/PhD
Core or Elective: Elective
Approval: 5th Senate

**Course Contents:**

- **INTRODUCTION TO OPTICAL COMMUNICATION AND FIBER CHARACTERISTICS** Evolution of Light wave systems, System components, Optical fibers, Step Index & Graded index Mode theory, Fiber modes, Dispersion in fibers, Limitations due to dispersion, Dispersion shifted and dispersion flattened fibers, Fiber Losses and Non-linear effects [8 Lectures]
- **OPTICAL TRANSMITTERS** Basic concepts, LED's structures, Spectral Distribution, Semiconductor lasers, Structures, Threshold Conditions, Transmitter design. [4 Lectures]
- **OPTICAL DETECTORS AND AMPLIFIERS** Basic Concepts, PIN and APD diodes structures, Photo detector Noise, Signal impairments, Receiver design. Amplifiers: Basic concepts, Semiconductor optical amplifiers, Raman, Brillouin amplifiers, Erbium doped fiber amplifiers, pumping requirements, cascaded in-line amplifiers. [8 Lectures]
- **COHERENT LIGHTWAVE SYSTEMS** Basic coherent systems, Coherent detection principles, Homodyne and heterodyne detection, Modulation formats, BER in synchronous receivers, Equalization, carrier phase and frequency synchronization, timing synchronization. [4 Lectures]
- **MULTICHANNEL SYSTEMS WDM** Lightwave Systems, WDM Components, WDM System Performance Issues, Time- Division Multiplexing, Subcarrier Multiplexing, Orthogonal Frequency Division Multiplexing (OFDM) and Code-Division Multiplexing. [6 Lectures]
- **OPTICAL TRANSMISSION LINK LIMITS** Power budget and banwidth limited point-to-point lightwave system, OSNR evaluation in high speed optical transmission systems, Dispersion Management, Nonlinearity management. [6 Lectures]
- **OPTICAL NETWORKS** LANs, MANs, Long-Haul Networks, Design Guidelines. [6 Lectures]

**Reference Books:**

1. John M. Senior, **Optical Fiber Communications: Principles and Practice**, 2nd Edition, Prentice Hall of India

2. G. P. Agrawal, **Fiber Optic Communication Systems**, 3rd Edition, John Wiley & Sons, 2002.

3. G. Keiser, **Optical Fiber Communication Systems**, McGraw Hill, 2000.

4. M. Cvijetic and Ivan Djordjevic, **Advanced Optical Communication Systems and Networks**, Artech House, 2013

5. Ramaswami, Sivarajan, and Sasaki's, **Optical networks: A practical persepctive**, 3rd Edition , Morgan- Kauffman, 2009.

## 7.104 EE 608 Digital Image Processing

Course Name: Digital Image Processing
Course No.: EE 608
Credit: 3-0-2-4
Students Intended for: UG/MS/PhD
Prerequisite: Basics of signal processing and Probability theory
Elective or Compulsory: Elective
Approval: 5th Senate

**Course contents:**

- **Introduction to digital image processing**: What is image processing, Different types of images, Visual perception, Image sensing and Acquisition, Quantization, Sampling, color image processing, Revision of Mathematical concepts for image processing. [3 Lectures]

- **Intensity transformation, Filtering in spatial and Frequency domain**: Image negatives, Log transformations, Histogram processing, Spatial filter: smoothing and Sharpening, Discrete Fourier transform, properties of 2-D DFT, Image smoothing and Sharpening in Fourier domain. [8 Lectures]

- **Image transforms**: Two-dimensional orthogonal and Unitary transforms, Optimum transform, Properties of Unitary transforms, 2D DFT, Cosine transforms, Hadamard transforms, KL transforms, Comparison of image transforms. [5 Lectures]

- **Edge detection**: Gradient and Laplacian based edge detection, Diffusion based edge detection: Isotropic and anisotropic diffusion. [3 Lectures]

- **Wavelet transform for Image Processing**: Multi resolution expansion, Wavelet functions, Wavelet Series expansion, Continuous and Discrete Wavelet transforms, Wavelet transforms for two-dimensional signals (images), Applications of wavelet transforms for edge extraction, noise suppression. [5 Lectures]

- **Image segmentation**: Thresholding, region-based Morphological Watersheds, Bayesian based image segmentation. [5 Lectures]

- **Image restoration and reconstruction**: Models of image degradation, noise models, Spatial and Frequency domain based approaches for image restoration, Inverse filtering, Wiener Filtering, Bayesian denoising. [5 Lectures]

- **Image Compression**: Spatial and Temporal redundancy, Basic image compression models, compression standards, basic compression methods: Huffman coding, Run-length coding, Block transform coding, Predictive coding. [4 Lectures]

- **Color Image Processing**: Color Fundamentals, Color Models, Color transformation, smoothing, sharpening and edge detection in color images. [4 Lectures]

**Textbooks:**


1. R. C. Gonzalez and R. E. Woods, Digital Image Processing, 3rd Edition, Pearson Education, 2009

2. Anil K Jain, **Fundamental of Digital Image Processing**, Prentice Hall, 1989


**References:**


1. A. C. Bovik, **The essential guide to image processing**, 2nd Edition, Academic Press, 2009

2. A. M. Teckalp, **Digital Video Processing**, Prentice Hall, 1995.


## 7.105 EE 609: Network Information Theory

**Course Code : EE 609**

**Course Name : Network Information Theory**

L-T-P-C : 3-0-0-3
Prerequisites : IC210, EE-304, Advanced Communication Theory
Intended for : 4th year B.Tech. (CS+EE) and research students
Distribution : Elective for CS and EE
Approval: 4th Senate

**Course Contents**

- **Module I**: Network information flow problem, Max-flow Min-cut Theorem, Point-to-Point Information Theory versus Network Information Theory. Brief overview of Point-to-Point Information Theory. [7 Lectures]

- **Multiple access channels**: Definition, Bounds on and single letter characterization of the capacity region, Time sharing, Gaussian MAC, extensions to more than two senders. [5 Lectures]

- **Broadcast channels (Degraded and General)**: Definitions, Bounds on the capacity region, Superposition coding inner bound, Gaussian broadcast channel, Martons inner bound (also with common message), Outer bounds, Inner bounds for more than two receivers. [5 Lectures]

- **Channels with state**: Definition, Compound channel, Arbitrarily varying channel, Channels with random state, ISI channels, Dirty paper writing. [5 Lectures]

- **Distributed source coding**: Slepian-Wolf Theorem, Duality between Slepian-Wolf Theorem and MAC, Achievability schemes, Various generalizations (DSC with side-information, with helper, etc.). [5 Lectures]

- **Relay channels**: Definition, Cutset upper bounds, Gaussian relay channel, Performance of various achievability schemes (Decode-and-forward, Compress-and-forward, Compute- and- forward, Quantize-map-and-forward, Amplify-and-Forward, etc.). [5 Lectures]

- **Interference channels**: Definition, Coding schemes, Gaussian IC, Han-Kobayashi inner bound, Deterministic approximation of the Gaussian IC. [5 Lectures]

- **General multiterminal networks**: Gaussian networks, Capacity scaling-laws, Gupta-Kumar Network. [5 Lectures]

**References:**


1. R. G. Gallager, **Information Theory and Reliable Communication**, Wiley, 1968.

2. A. El Gamal and Y.-H. Kim, **Network Information Theory**, Cambridge Univ. Press, 2012.

3. I. Csiszr and J. Krner, **Information Theory: Coding Theorems for Discrete Memoryless Systems**, Cambridge Univ. Press, 2011.

4. Related research papers.


## 7.106 EE 611: VLSI Technology

**Course Code : EE 611**

**Course Name : VLSI Technology**

L-T-P-C : 3-0-0-3

Intended for 4th year B. Tech. (EE) and MS, Ph.D.

Prerequisites : EE 160 Applied Electronics, EE 208P Digital System Design Practicum, Semiconductor devices or Instructors consent

Core or Elective : Elective

Approval: 5th Senate

**Course Contents**

- **Vacuum Technology**:
- Principles of vacuum pumps in range of 10-2torr to 10-11torr, principle of different vacuum pumps, roots pump, rotary, diffusion, turbo molecular pump, cryogenic-pump, ion pump, Ti-sub limitation pump, importance of measurement of vacuum, Concept of different gauges, bayet- albert gauge, pirani, penning, pressure control. [5 Lectures]
- **Conditions for the Formation of Thin Films**:
- Environment for thin film deposition, deposition parameters and their effects on film growth, formation of thin films (sticking coefficient, formation of thermodynamically stable cluster theory of nucleation), capillarity theory, microstructure in thin films, adhesion, properties of thin films, Mechanical, electrical, and optical properties of thin films, few applications of thin films in various fields, Quartz crystal thickness for measurement of film thickness. [5 Lectures]
- **Physical Vapor Deposition Electrical Discharges for Thin Film Deposition**:
- Thermal evaporation, resistive evaporation, Electron beam evaporation, Laser ablation, Flash and Cathodic arc deposition, Sputtering, Glow discharge sputtering, Magnetron sputtering, Ion beam sputtering, Ion plating, oxidizing and Nitriding, Atomic layer deposition (ALD), Importance of ALD technique, Atomic layer growth, Physics and technology. [8 Lectures]
- **Chemical Vapor Deposition Techniques**:
- Advantages and disadvantages of Chemical Vapor deposition (CVD) techniques over PVD techniques, reaction types, boundaries and flow, Different kinds of CVD techniques: Metallorganic CVD (MOCVD), Thermally activated CVD, Spray pyrolysis, etc. [8 Lectures]
- **Lithography and Pattern Transfer**:
- Overview of Lithography, Optics of Lithography: Metrics, Optics of Micro-Lithography, Aligners, Photomasks, Photoresists, Components of Photoresist, Metrics, Photoresist processing, Multi-layer resist, positive, negative and image reversal, Advanced Lithography: E-beam Lithography, Soft Lithography, Etch verses Lift Off.Basic Concepts of Etching,Wet Etching, Specific Wet Etches : Silicon, Silicon Dioxide, Aluminum, Dry (Plasma) Etch etc. [8 Lectures]
- **MEMS and CMOS Manufacturing Technologies**:
- Anisotropic Etching, Description of the Process and Testing, Bulk Micromachining :DRIE-Based, Wet Processes, Surface Micromachining, Wafer Bonding, Introduction of Front end (Fusion Bonding), Back end (Anodic Bonding), Plastic Processes,Molding,Embossing,LIGA , interconnects, CMOS process etc. [8 Lectures]
- **Mini-project**: The students will also carry out a mini-project involving the exposure of lab work. The aim of this project will be to understand, solve and implement solutions to real world problems.

**Reference Books:**


1. S. Franssila, **Introduction to Microfabrication**, 2nd Edition, Wiley, 2010.

2. James D. Plummer, Michael D. Deal and Peter B. Griffin, **Silicon VLSI Technology: Fundamentals**, Practice and Modeling, Prentice Hall, 2000.

3. Richard C. Jaeger, **Introduction to Microelectronic Fabrication**, 2nd Edition, Prentice Hall, 2002.

4. Gary S. May, Simon M. Sze, **Fundamentals of Semiconductor Fabrication**, Wiley, 2004.

5. G.L.Weissler and R.W. Carlson, **Methods of Experimental Physics** (Vol 14), Vacuum Physics and Technology.

6. T.A. Delchar, **Vacuum Physics and Techniques**, Chapman and Hall

7. J.P. Hirth and G.M.Pound, **Evaporation: Nucleation and Growth Kinetics, MEMS Manufacturing Technologies**, Pergamon Press


## 7.107 EE 611P: VLSI Fabrication Practicum

**Course Code: EE 611P**

**Course Name: VLSI Fabrication Practicum**

L-T-P-C: 0-0-3-2 (L-T-P-C)
Prerequisite: Device modeling and microelectronics (EE 519)
Students intended for: M.Tech. in EE (VLSI)
Elective or Core: Core
Approval: 11th Senate

**Course Contents**

- **Basic clean room training and introduction to instruments** [3 hours]
  - Clean room: dos and donts
  - Identification of wafers and its type
  - Wafer dicing techniques
  - Standard wafer cleaning procedures (RCA)
  - Instruments: oxidation furnace, pulsed layer deposition, plasma enhance chemical vapor deposition and RF sputtering, spin coater, thermal evaporator, mask aligner, electron beam lithography (EBL), reactive ion itching (RIE), mask less lithography, atomic force microscopy, parametric analyzer, probe station.
  - Wet bench demonstration
- **Experiment 1**:
  - Draw a comprehensive wafer clean process flow/cleaning of wafer and validate the hydrophobic and hydrophilic nature through contact angle measurements.

- **Metal-Semiconductor contact fabrications and characterizations** [3 hours]
  - Design and fabricate metal semiconductor junction
  - Characterize it to determine its nature (Ohmic / Schottky)
  - If Schottky, deduce the Schottky barrier height and built-in potential from both I-V and C-V characteristics. Discuss the results.
- **Experiment 2**:
  - Ag/p-type Si based Schottky barriers fabrication and characterization
  - Al/n-type Si based Schottky barriers fabrication and characterization.
- **MOS capacitor fabrications and characterizations** [3+3+3 hours]
  - Design and fabricate a MOS based diode using a standard deposition and lithography techniques.
  - Observe the current voltage (I-V) characteristics.
  - Determine the On resistance, ideality factor, reverse saturation current, breakdown voltage and explain the result with respect to material quality.
  - Observe capacitance voltage (C-V) characteristics at different frequency.
- **Experiment 3**:
  - Basic process flow for NMOS device fabrication having constant transistor channel width W=10 micron and L=5 to 12 micron
  - Photolithography process flow.
  - Fabrication and characterization of Si/SiO2/Al based MOS device
- **Transistor fabrications and characterizations** [3+3+3 hours]
  - Design and fabricate a MOSFET/MESFET device using standard thin film and lithography techniques.
  - Characterize material compositions; observe topography, measure thickness of films.
  - Measure drains current, transfer and gate leakage current characteristics.
  - Comment on linearity and gain of the transistor
  - Determine threshold voltage, breakdown voltage and sub-threshold slope.
  - Discuss the application areas of the fabricated FET depending on the obtained results.
- **Experiment 4**:
  - Diffusion process flow with subsequent steps for dry diffusion, implantation and wet diffusion.
  - Fabrication and characterization of SiO2 and High-k based n/p-MOSFET and characterization.
- **Sensor device fabrications and characterizations** [3+3+3 hours]

  - Design and fabricate a sensor device for gas or pressure.
  - Characterize physical properties.
  - Characterize sensitivity (response magnitude), stability, reproducibility, baseline recovery, selectivity.
  - Determine response time, recovery time.

- **Experiment 5**:
  - Fabrication and characterization of thin film based acoustic/ gas/chemical/ biological sensors: e.g Palladium/ Si based hydrogen gas sensors.
  - Fabrication and characterization of ID/comb/accelerometer structure based gas/chemical/biological sensors.

- **Photo detector fabrications and characterizations** [3+3+3 hours]
  - Design and fabricate a photo-detector using metal-semiconductor-metal configuration.
  - Characterize photo-responsivity, time domain response, repeatability and stability.
  - Determine quantum efficiency, sensitivity, linearity, time constant, and leakage current.

- **Experiments 6**:
  - Synthesis and characterization of CuCl or CuBr deposition on Si for blue light emission or electroluminescence or ultraviolet applications.

[Note: Different types of quantum structures (heterojunction, nanowire, quantum dots) based on different types of materials such as oxides, compound semiconductor, polycrystalline or two dimensional may be further used to realize the above applications]

**Text books:**

1. S. M. Sze, **VLSI Technology**, 2nd Edition.
2. Sorab K. Ghandhi, **VLSI Fabrication Principles: Silicon and Gallium Arsenide**, 2nd Edition.
3. Dieter K. Schroder, **Semiconductor Material and Device Characterization**, 3rd Edition.

**Reference books:**

1. James D. Plummer, M. D. Deal and P. B. Griffin, **Silicon VLSI Technology: Fundamentals, Practice and Modeling**
2. E. H. Nicollian, J. R. Brews, **MOS (metal oxide semiconductor) physics and technology**.

## 7.108 EE 612 (3) OFDM For Optical Communications

Approval: 5th Senate; OTA Course

**Course Outline:**

- **Introduction** : Mathematical Formulation -' of , an : _ OFDM Signal, Discrete FOurier Transform ImplementatiOn of OFDM, Cyclic Prefix for OFDM, Spectral Efficiency for Optical OFDM, Cross—Channel OFDMi Multiplexing without Guard Band, Complex and Real , Representations of an- OFDM Signal, Peak-to-Average Power Ratio Of OFDM Signals, Frequency Offset and Phase Noise Sensitivity, Frequency Offset Effect, Phase Noise Effect,
- **Module II**: Coding for Optical OFDM Systems Linear Block Codes, Cyclic Codes, Bose-Chaudhuri—Hocquenghem Codes, Reed— Solomon
- **Module III:** Codes, Concatenated Codes, and Product Codes, Codes on Graphs, Turbo Codes, Turbo v Product Codes, LDPC Codes, Generalized LDPC. Codes, Symbol Error rate for QAM (16, 64, 256,.., M-QAM)
- **Various Types of Optical OFDM**: Coherent Optical OFDM, Principle of CO-OFDM, Optical Transmitter Design . for CO-OFDM, Up-IDown-Conversion Design Options for CO-OFDM Systems, Optical I/Q Modulator for Linear RF-to-Optical up Conversion, Receiver
- **Module V**: Sensitivity for ,CO-OFDM, Direct Detection -Optical' OFDM
- **OFDM. Applications in Access Optical Network**: OFDM in Radio-over—Fiber Systems,OFDM in Passive Optical Networks,
- Wideband Signals and Optical OFD

## 7.109 EE 613: Wireless Communication

**Course Code: EE 613**

**Course Name: Wireless Communication**

L-T-P-C: 3-0-0-3
Prerequisites:
Students intended for:
Elective or Compulsory:Elective
Approval: 5th Senate

**Course Contents**

- **Cellular Communications**: Introduction to Cellular Communications, Frequency reuse, Channel assignment strategies, Hand-off strategies, Interference and system capacity, Trunking and Grade of services, Improving Coverage and capacity in cellular systems (cell splitting, sectoring, microcell Zone, Tele-traffic Theory

- **Large scale path loss, small scale fading and Diversity**: Wireless Channel Modeling, Path loss, Hata, Okumura Models, Shadowing, Diffraction Knife Edge models, Fast Fading, Rayleigh/Ricean Fading Channels, BER Performance, Radio Power budgeting, Diversity, BER Performance with diversity, Types of Diversity, RMS Delay Spread, Doppler Fading, Jakes Model, Autocorrelation, Jakes Spectrum, Impact of Doppler Fading
- **Modems for Wireless Communications**: Analog modulation, Digital Modulation, Pulse Trains and Pulse shaping, ASK, BPSK, M-ary Modulation, Constant Envelope Modulation Techniques, M-ary phase modulation, M-ary QAM, O-QPSK, Pi/4 QPSK, MSK, GMSK, Shannon theorem, Channel capacity in Rayleigh fading
- **CDMA**: Introduction to CDMA, PN Sequences, DS CDMA, FH CDMA, Multipath diversity, RAKE Receiver, CDMA Receiver Synchronization
- **WirelessStandards**: AMPS, IS 54, GSM, CDMA 2000

## 7.110 EE 614: Optical Communication Systems

**Course Code : EE 614**

**Course Name : Optical Communication Systems**

L-T-P-C : 3-0-0-3
Prerequisites : EE-304: Communication Theory and the instructors consent
Intended for : UG/MS/PhD
Core or Elective : Elective
Approval: 5th Senate

**Course Contents**

- **INTRODUCTION TO OPTICAL COMMUNICATION AND FIBER CHARACTERISTICS**:
- Evolution of Light wave systems, System components, Optical fibers, Step Index &Graded index Mode theory, Fiber modes, Dispersion in fibers, Limitations due to dispersion, Dispersion shifted and dispersion flattened fibers, Fiber Losses and Non-linear effects. [8 Lectures]
- **OPTICAL TRANSMITTERS**:
- Basic concepts, LED's structures, Spectral Distribution, Semiconductor lasers, Structures, Threshold Conditions, and Transmitter design. [4 Lectures]
- **OPTICAL DETECTORS AND AMPLIFIERS**:
- Basic Concepts, PIN and APD diodes structures, Photo detector Noise, Signal impairments, Receiver design. Amplifiers: Basic concepts, Semiconductor optical amplifiers, Raman, Brillion amplifiers, Erbium doped fiber amplifiers, pumping requirements, cascaded in-line amplifiers. [8 Lectures]

- **COHERENT LIGHTWAVE SYSTEMS**:
- Basic coherent systems, Coherent detection principles, Homodyne and heterodyne detection, Modulation formats, BER in synchronous receivers, Equalization, carrier phase and frequency synchronization, timing synchronization. [4 Lectures]
- **MULTICHANNEL SYSTEMS**:
- WDM Light wave Systems, WDM Components, WDM System Performance Issues, Time- Division Multiplexing, Subcarrier Multiplexing, Orthogonal Frequency Division Multiplexing (OFDM) and Code-Division Multiplexing. [6 Lectures]
- **OPTICAL TRANSMISSION LINK LIMITS**:
- Power budget and bandwidth limited point-to-point light wave system, OSNR evaluation in high speed optical transmission systems, Dispersion Management, Nonlinearity management. [6 Lectures]
- **OPTICAL NETWORKS**:
- LANs, MANs, Long-Haul Networks, Design Guidelines. [6 Lectures]

**Reference Books:**


1. John M. Senior, **Optical Fiber Communications: Principles and Practice**, 2nd Edition, Prentice Hall of India.
2. G. P. Agrawal, **Fiber Optic Communication Systems**, 3rd Edition, John Wiley & Sons, 2002.
3. G. Keiser, **Optical Fiber Communication Systems**, McGraw Hill, 2000.
4. M. Cvijetic and Ivan Djordjevic, **Advanced Optical Communication Systems and Networks**, Artech House, 2013.
5. Ramaswami, Sivarajan, and Sasaki, **Optical networks: A practical perspective**, 3rd Edition, Morgan- Kauffman, 2009.


## 7.111 EE 615: Nano Electronics and Nano Microfabrication

**Course Code : EE 615**

**Course Name : Nano Electronics and Nano Microfabrication**

L-T-P-C : 3-0-0-3

Prerequisites : IC 161-Applied Electronics, EE XX2 Microelectronics Circuits Design Practicum (MCDP), EE XX1 Electronics Devices, PH 501 Solid State Physics

Intended for : UG/MS/PhD

Elective or Core : Elective Semester : Odd/Even

Approval: 6th Senate

**Course Contents**

- **Unit I**: Tunnel junction and applications of tunneling, Tunneling Through a Potential Barrier, Metal Insulator, Metal-Semiconductor, and Metal-Insulator-Metal Junctions, Coulomb Blockade, Tunnel Junctions, Tunnel Junction Excited by a Current Source. Spintronics and Foundations of nano-photonics. [6 Lectures]

- **Unit II**: Field Emission, GateOxide Tunneling and Hot Electron Effects in nano MOSFETs, Theory of Scanning Tunneling Microscope, Double Barrier Tunneling and the Resonant Tunneling Diode. [6 Lectures]

- **Unit III**: Introduction to lithography- Contact, proximity printing and Projection Printing, Resolution Enhancement techniques, overlay-accuracies, Mask-Error enhancement factor (MEEF), Positive and negative photoresists, Electron Lithography, Projection Printing, Direct writing, Electron resists. Lithography based on Surface Instabilities: Wetting, De-wetting, Adhesion, Limitations, Resolution and Achievable / line widths etc. Lift off process, Bulk Micro machining. [8 Lectures]

- **Unit IV**: Introduction to MEMS and NEMS, working principles, as micro sensors (acoustic wave sensor, biomedical and biosensor, chemical sensor, optical sensor, capacitive sensor, pressure sensor and thermal sensor), micro actuation (thermal actuation, piezoelectric actuation and electrostatic actuationmicro gripers, motors, valves, pumps, accelerometers, fluidics and capillary electrophoresis, active and passive micro fluidic devices, Pizoresistivity,Pizoelectricity and thermoelectricity, MEMS/NEMS design, processing, Oxidation, Sputter deposition, Evaporation, Chemical vapor deposition etc. [10 Lectures]

- **Unit V**: Introduction Scaling of physical systems Geometric scaling & Electrical system scaling. The Single-Electron Transistor: The Single- Electron Transistor Single-Electron Transistor Logic, Other SET and FET Structures, Carbon Nanotube Transistors (FETs and SETs), Semiconductor Nanowire FETs and SETs,Coulomb Blockade in a Nanocapacitor, Molecular SETs and Molecular Electronics. [10 Lectures]

**Text Books:**

1. Stephen D. Sentaria, **Microsystem Design**, Kluwer Academic Press
2. Marc Madou, **Fundamentals of microfabrication & Nanofabrication**.
3. T. Fukada & W.Mens, **Micro Mechanical system Principle & Technology**, Elsevier, 1998.
4. Julian W.Gardnes, Vijay K. Varda, **Micro sensors MEMS & Smart Devices**, 2001.

**Suggested Reference Books:**

1. WR Fahrner, **Nano Terchnology and Nano Electronics Materials, devices and measurement Techniques**, Springer.

2. T.Pradeep, **Nano: The Essentials Understanding Nano Scinece and Nanotechnology**, Tata McGraw Hill.

3. M. Ziese and M.J. Thornton, **Spin Electronics**

4. Karl Goser, Peter Glosekotter, Jan Dienstuhl, **Nanoelectronics and Nanosystems: From Transistor to Molecular and Quantum Devices**.

5. Shunri Odo and David Feny, **Silicon Nanoelectronics**, CRC Press.

6. C.N.R. Rao and A. Govindaraj, **Nanotubes and nanowires**, RSC Publishing.

7. M. Dutta and M.A. Stroscio, **Quantum-Based Electronic Devices and Systems**, World Scientific.

8. James R Sheats and Bruce w. Smith, **Microlithography Science and Technology**, Marcel Dekker, 1998.

9. J.P. Hirth and G.M.Pound, **Evaporation: Nucleation and Growth Kinetics**, Pergamon Press, 1963.

## 7.112 EE 616: Microwave engineering

**Course Code : EE 616**

**Course Name : Microwave engineering**

L-T-P-C : 2-0-0-2
Prerequisite : Basic Course in Electromagnetics / Engineering Electromagnetics
Students Intended for : Senior B.Tech, Mtech, PhD students of Electrical Engineering
Elective or Compulsory : Elective
Approval: 6th Senate

**Course Contents**

- **Transmission Line Theory and network analysis**: Electromagnetic analysis and transmission line theory of coaxial lines and waveguides, metamaterial lines, Impedance matching in microwave circuits, Microwave network analysis, N-port microwave network , Scattering matrix, Properties of the scattering matrix , S-parameters at arbitrary planes, S parameter measurements. [5 Lectures]

- **Power Dividers and Directional Couplers**: Basic Properties of power dividers and couplers, T junction, Wilkinson type, quadrature hybrid power dividers, coupled line directional coupler,180 deg. Hybrid coupler. [4 Lectures]

- **Microwave Filters**: Basic Filter design techniques like image parameter and insertion loss, Filter transformations and implementations, low pass filters, coupled line filters, coupled resonator based filters, metamaterial filters. [4 Lectures]

- **Ferrite devices**: Circulators, isolators, phase shifters. [04 hrs]

- **Active Microwave components**: RF Diode, Microwave Transistors, Microwave ICs. [4 Lectures]

- **Microwave sources and Amplifiers**: Tube type sources like magnetrons, klystrons, Single stage Transistor amplifier, Stability circles, Broad band amplifier design, Solid state Power amplifiers. [4 Lectures]

- **Oscillators and Mixers**: Microwave oscillators using Transistors, dielectric resonators, diode and transistor based mixers. [3 Lectures]

**Textbooks:**

1. David. M. Pozar, **Microwave Engineering**, Wiley.

**Reference book:**

1. R.E. Collins, **Foundations for Microwave Engineering**, IEEE Press.

## 7.113 EE 618: Industrial Process Control

**Course Code: EE 618**

**Course Name: Industrial Process Control**

L-T-P-C: 2.5-0.5-0-3
Prerequisites: EE 514 Linear Dynamical Systems or teachers consent
Intended for: U.G. and P.G. Distribution: Elective Semester: Even
Approval: 9th Senate

**Course Contents**

- **Introductory concepts of Process control**: The Chemical Process, An Industrial Perspective of a Typical Process Control Problem, Variables of a Process, The Concept of a Process Control System, Introduction to Control System Implementation, Instrumentation, Material and Energy Balances, Form of Dynamic Models, Linear Models and Deviation Variables.[3 Lectures]

- **Process dynamics, modelling and identification**:Models for dynamical systems, Similarity transformations and minimal representations, Analysing linear dynamical systems, Development of Theoretical Process Models, Parameter Estimation, Validation of Theoretical Models, Principles of Empirical Modelling, Step-Impulse-Frequency response Identification, Closed-loop stability, Control performance in different frequency ranges, Unstable systems, Limitations due to uncertainty in the plant model and input constraints. [6 Lectures]

- **Single-loop and multivariable process control**: Control loop structures for the regulatory control layer, Feedforward control, Ratio Control, Cascade control, Auctioneering control, split range control, parallel control, Controller tuning using Fundamental process models, approximate process models, frequency response models, tuning without a Model, Design of More Complex Control Structures, Controller Design for Processes with Difficult Dynamics, Controller Design for Nonlinear Systems, Nature of Multivariable Systems, Open-Loop and closed loop Dynamic Analysis, Relative Gain Array, Loop Pairing and shaping, Decoupling, Steady- State

Decoupling by Singular Value analysis, Model-Based Controllers for Multivariable Processes, Tuning of decentralised controllers. [12 Lectures]

- **Control structure selection and plant-wide control**: Top-down analysis, bottom-up design, regulatory control, determining degrees of freedom, selection of controlled variables based on local analysis, selection of manipulated variables, mass balance control and throughput manipulation, economic considerations in plantwide control. [5 Lectures]
- **?? Model-based predictive control**:
- Formulation of a QP problem for MPC, step response models, updating the process model, Kalman filters, disturbance handling and off-set free control, feasibility and constraint handling, closed-loop stability with MPC controllers, target calculation, robustness of MPC controllers. [6 Lectures]
- **Special topics in process control**: Discrete time implementation - aliasing - sampling interval, pure integrators in parallel, anti-windup control, Hanuss self conditioned form, observer-based controllers, bumpless transfer, nonlinear systems - methods of dynamical analysis and linearization, basics of process monitoring and diagnosis, linear regression techniques applied in process control - principal component analysis - partial least squares - Fourier-Motzkin elimination. [6 Lectures]
- **Lab Exercises**: [4 lectures] Experiments on process control applications on water tank system, robotic arm, etc.

**Textbooks:**


1. B. A. Ogunnaike, W. H. Ray, **Process Dynamics, Modelling and Control**, Oxford University Press, 1994.
2. D. E. Seborg, T. E. Edgar, D. A. Mellichamp, **Process Dynamics and Control**, John Wiley and Sons, 2004.


**References:**


1. B. W. Bequette, **Process Control: Modeling, Design, and Simulation**, Prentice Hall International Series, 2002.
2. F. G. Shinskey, **Process Systems: Application, Design and Adjustments**, McGraw Hill, 1967.


## 7.114 EE 619: Mixed Signal VLSI Design

**Course Code: EE 619**

**Course Name: Mixed Signal VLSI Design**

L-T-P-C: 3-0-2-4
Prerequisite: EE 512 CMOS Analog IC design
Students intended for: UG/PG
Elective or Core: Elective
Approval: 9th Senate

**Course Contents**

- **Sample and hold and trans-linear circuits** [2 Lectures]
  - Performance of sample-and-hold circuits testing sample and holds, MOS sample-and-hold basics, examples of CMOS S/H Circuits, bipolar and BiCMOS Sample-and-Holds, Trans-linear gain Cell, trans-linear multiplier
- **Switched Capacitor circuits** [4 Lectures]
  - Basic building blocks opamps, capacitors, switches, non-overlapping clocks, Basic operation and analysis of switched capacitor circuits, resistor equivalence of a switched capacitor, parasitic- sensitive integrator, parasitic-insensitive integrators, signal-flow-graph analysis, noise in switched-capacitor circuits
  - First-Order Filters switch sharing, fully differential filters, biquad filters, low-Q biquad filter, high-Q biquad filter, Charge injection, switched-capacitor gain circuits, parallel resistor-capacitor circuit, resettable gain circuit, capacitive-reset gain circuit, correlated double-sampling techniques, other switched-capacitor circuits viz. amplitude modulator, full-wave rectifier, peak detectors, voltage-controlled oscillator, sinusoidal oscillator
  - **Comparators** [3 Lectures]
    - Comparator specifications input offset and noise, hysteresis
    - Opamp as a comparator input-offset voltage errors, charge-injection errors, making charge- injection signal independent, minimizing errors due to charge-injection, speed of multi-stage comparators
    - Latched comparators, latch-mode time constant, latch offset, examples of CMOS and BiCMOS comparators, input-transistor charge trapping
- **Data converters specifications** [2 Lectures]
  - Ideal D/A converter, ideal A/D converter, quantization noise, deterministic approach, stochastic approach, signed codes, performance limitations, resolution, offset and gain error, accuracy and linearity
- **Nyquist rate digital-to-analog converters (DAC)** [4 Lectures]
  - Decoder-based converters resistor string converters, folded resistor-string converters, multiple resistor-string converters, signed outputs,
  - Binary-scaled converters binary-weighted resistor converters, reduced-resistance-ratio ladders, R-2R-based converters, charge-redistribution switched-capacitor converters, current-mode converters, glitches
  - Thermometer-code converters thermometer-code current-mode D/A converters, single-supply positive-output converters, dynamically matched current sources
  - Hybrid converters resistor-capacitor hybrid converters, segmented converters
- **Nyquist rate analog-to-digital converters (ADC)** [12 Lectures]
  - Introduction to integrating converters, flash converters, issues in designing flash ADC,

  - Successive-approximation converters DAC-based successive approximation, charge-redistribution A/D, resistor-capacitor hybrid, speed estimate for charge redistribution converters, error correction in successive-approximation converters, multi-bit successive-approximation
  - Algorithmic (or cyclic) A/D Converter ratio-independent algorithmic converter,
  - Pipelined A/D converters one-bit-per-stage pipelined converter, 1.5 bit per stage pipelined converter, pipelined converter circuits, generalized k-bit-per-stage pipelined converters
  - Two-step A/D converters, two-step converter with digital error correction,
  - Interpolating A/D converters, folding A/D converters, time-interleaved A/D converters

- **Oversampling ADCs** [8 Lectures]
  - Oversampling without noise shaping, quantization noise modeling, white noise assumption, oversampling advantage, the advantage of 1-bit D/A converters
  - Oversampling with noise shaping, noise-shaped delta-sigma modulator, first-order noise shaping, switched-capacitor realization of a first-order A/D converter, second-order noise shaping, noise transfer-function curves, quantization noise power of 1-bit modulators, error-feedback structure
  - System architectures system architecture of delta-sigma A/D converters, system architecture of delta-sigma D/A converters,
  - Digital decimation filters multi-stage, single stage, higher-order modulators interpolative architecture, multi-stage noise shaping (MASH) architecture, bandpass oversampling converters, Practical considerations stability, linearity of two-level converters, idle tones, dithering, opamp gain,
  - Multi-bit oversampling converters dynamic element matching, dynamically matched current source D/A converters, digital calibration A/D converter, A/D With both multi-bit and single-bit feedback

- **Phase locked loop** [6 Lectures]
  - Basic phase-locked loop architecture, voltage controlled oscillator, divider, phase detector, loop filer, the PLL in lock,
  - Linearized small-signal analysis second-order PLL model, limitations of the second-order small-signal model, PLL design example
  - Jitter and phase noise period jitter, P-cycle jitter, adjacent period jitter, other spectral representations of jitter, probability density function of jitter
  - Electronic oscillators ring oscillators, LC oscillators, phase noise of oscillators, jitter and phase noise in PLLS, input phase noise and divider phase noise, VCO phase noise, loop filter noise

**Text book:**


1. David A. Johns, Kenneth W. Martin, Tony Chan Carusone, **Analog Integrated Circuit Design**, 2nd Edition, Wiley, 2012.

**Reference books:**

1. Phillip Allen and Douglas R. Holberg., **CMOS Analog Circuit Design**, 2nd Edition, Oxford university press, 2002.

2. Willy M. C. Sansen, **Analog Design Essentials**, Springer, 2006

3. Behzad Razavi, **Design of Analog CMOS Integrated Circuits**, McGraw Hill, 2001

## 7.115 EE 620_10 : Advanced Digital Signal Processing

**Course Code: EE 620_10**

**Course Name : Advanced Digital Signal Processing**

L-T-P-C : 3-0-0-3

Prerequisites : Digital Signal Processing, Probability and Random Process, Mathematical Methods in Signal Processing

Intended for :

Distribution : Core subject for M.Tech. in Electrical Engineering with VLSI specialization)

Approval: 10th Senate; Reviesed in 24th Senate

**Course Contents:**

**Module I**: Review of signals and systems: Linear time-invariant filtering, Fourier analysis, sampling, discrete time-invariant filters, DFT. (4 lectures)

**Module II**: Sub Nyquist sampling, multirate systems. (6 lectures)

**Module III**: Time-frequency atoms, windowed Fourier transform, wavelet transform. (9 lectures)

**Module IV**: Frames and Riesz basis. (9 lectures)

**Module V**: Linear and non-linear approximations in basis. (9 lectures)

**Module VI**: Compressive Sensing Textbook. (5 lectures)

**Textbooks:**

1. Stephen Mallat, A Wavelet Tour of Signal Processing The Sparse Way, Elsevier, 2009.

**References:**

1. Vetterli M., Kovacevic J., Goyal V.K., **Foundations of Signal Processing**, Cambridge University Press, 2014.

2. Vetterli M., Kovacevic J., Goyal V.K., **Fourier and Wavelet Signal Processing**, Cambridge University Press, 2013.

3. P.P. Vaidyanathan, **Multirate Systems And Filter Banks**, Prentice Hall, 1993.

4. Current literature.

## 7.116 EE 620_24 : Advanced Digital Signal Processing

**Course Code : EE 620_24**

**Course Name: Advanced Digital Signal Processing**

L-T-P-C : 3-0-0-3

Prerequisites: Digital Signal Processing (EE305), Linear algebra (MA512 or IC 111)/Matrix Theory (EE522).

Intended for: UG /MS/MTech (CSP)/PhD/M.Sc (Applied Mathematics)

Distribution: Specialization course for MTech (CSP), Elective for B.Tech. III/IV year, MS, Ph.D.

Approval: 24th Senate; Previous version: 10th Senate

**Course Contents:**

- **Review:** Signal spaces: L1(R), L2 (R), l1 (Z), l2 (Z), finite dimensional vector spaces. Filter design: FIR, IIR and all pass filter design. BJorth gtl!lal b.asis. Bounded linear operators (on Hilbert spaces). Convergence and regulaitty of functions. (9 hours)

- **Mutlirate systems**: decimation, interpolation, fractional sampling rate, digital filter bank, multi rate filters, Noble identities. Polyphase representation, efficient stmctures for interpolation, decimation filters. (7 hours)

- **Module III**: Haar and sine expansion of discrete-time signals. Two channel filter banks - time, modulation and polyphase domain analysis and relation between the three representations. Perfect reconstruction and approximate reconstmction - alias-free reconstmction, QMF. Orthogonal FIR filter banks. Linear phase FIR filter banks. IIR filter banks. Tree-structured and multichannel filter banks, modulated filter banks - STFT and cosine modulated tilter banks. (10 hours)

- **Module IV:** Series (Fomies and sine) expansion of signals and their time frequency resolution. Haar expansion. Multiresolution analysis and constmction of the wavelet. Construction of wavelets using Fourier techniques. Wavelets from iterated filter banks and regularity. Wavelet series. (10 hours)

- **Applications**: Choice of applications is left to the in tntctor. Example: signal compression and subband coding. (6 hours)

**Textbook:**


1. Martin Vetterli and Jelena Kovacevic, **Wavelets and Subband Coding**, Prentice Hall PTR, 2007.


**Reference books:**


1. Vetterli M., Kovacevic J., Goyal V.K., **Fourier and Wavelet Signal Processing**, Cambridge University Press, 2013.

2. P.P. Vaidyanathan, **Multirate Systems And Filter Banks**, Prentice Hall, 1993.

3. Stephen Mallat, **A Wavelet Tour of Signal Processing The Sparse Way**, Elsevier 2009.

## 7.117 EE 621: Radiating systems

**Course Code : EE 621**

**Course Name: Radiating systems**

Course L-T-P-C : 3-1-0-4

Prerequisite : PH 521 - Electromagnetic Theory, EE 507 - Transmission lines and microwave engineering.

Intended for : UG/PG Electrical Engineering: MS, M.Tech, PhD, B.Tech 3rd year, 4th Year

Distribution : Discipline Elective for BTech (3es and 4th year), MTech in EE, MS and PhD in the area

Approval: 12th Senate

**Course Contents**

- **Basic antenna theory:** Basic dipoles theory: Flared transmission lines, Field equations, Dipoles, Monopoles, Antenna transmission and radiation parameters, Antennas polarisation, Antenna miniaturization and ChuHarrington limit [10 Lectures]
- **Standard antennas**: Loops, Folded dipoles, Helical antennas, Yagi-Uda, Spiral antennas, antenna-impedance matching and tuning techniques. Aperture theory and equivalence principle, Slot antennas, Horn antennas, leaky wave antennas, Vivaldi antennas [10 Lectures]
- **Printed and planar antennas**: Microstrip antennas and feeding techniques, broad-band techniques for printed and planar antennas, fractal geometries, printed monopoles and dipole structures, antennas for cellular communication, diversity/MIMO techniques. [10 Lectures]
- **Reflector and Dielectric resonator antennas**: Reflector theory, Parabolic reflector and feeding techniques. Dielectric resonators: Radiation mechanism from DRA, Feeding techniques for DRA [7 Lectures]
- **Array theory**: Array synthesis of linear elements, Linear and Planar arrays, Active and passive beam scanning, Excitation techniques in Array, synthesis of antenna arrays using Schelkunoff polynomial method, Fourier-transform method, and Woodward-Lawson method. [11 Lectures]
- **Frequency Selective Surfaces and EBG Structures for antennas**: Effects of EBG and FSS structure on Planar and non-planar antennas. Metamaterial Inspired antennas. Antenna design and parameter analysis using EM simulators [8 Lectures]

Note: All the Units will have tutorials. Every unit will include recent research paper analysis. In the end of this course a presentation assignment will be conducted in which student present recent development in the area of antennas. The presentation can be in the form of literature survey or simulation results or matlab code program.

**Text Books:**

1. J.D Kraus, **Antennas**, 2nd edition, TMH Publications
2. C. A. Balanis, **Antenna theory, analysis and design**, 3rd Edition, Wiley-publications

**References:**

1. Ramesh Garg, P. Bhartia, I Bhel, A. Ittipiboon, **Microstrip antenna design hand book**, Artech House publications.
2. Girish Kumar, K. P. Ray, **Broadband Microstrip antennas**, Artech House publications
3. Ben. A. Munk, **Frequency Selective surface theory and design**, Wiley publications.
4. Fan Yang & Y. Rahmat, Samii, **Electromagnetic Band-gap structures in Antenna Engineering**, Cambridge University Press, 2009

## 7.118 EE 622: Microwave Integrated Circuits

**Course Code : EE 622**

**Course Name : Microwave Integrated Circuits**

L-T-P-C : 3-0-0-3

Prerequisite: EE507 - Transmission Lines and Basic Microwave Engineering or equi va lent, PH52 I - Electromagnetic Theory or equivalent,

Intended for : BTech Third and Final year/M.Tech./MS/PhD

Distribution: Elective for third and final year Electrical Engineering, MTech VLSI, And Communication and Signal Processing (CSP), M.S., Ph.D.

Approval: 14th Senate

**Course Contents**

- **Introduction to Printed Transmission lines and Transitions**: Concept of 2 Port Network and S Parameters, Matchi ng transmission line sections a nd theory of mu ltiple reflections, Transitions in different transmission lines, Micro-Strip and Strip lines, Left handed transmission lines. Smith chart: Double stu b Matching. [8 Lectures]
- **Power Dividers and Directional Couplers**: Basic Properties of power di v iders and couplers, T junctions, Wilkinson type, quad rature hybrid power dividers, coupled li ne di rectional coupler, 90 deg. and 180 deg, - H ybrid branch line couplers. Circulators-Active and Passive. Broad-Band techniques. [6 Lectures]
- **Filters and Isolator**: Basic Filter design techniques li ke image parameter and insertion loss, Filter transformations and implementations, low pass fi lters, coupled line filters, coupled resonator based filters, metamaterial filters. Ferrite isolator circuits and design. [6 Lectures]

- **Microwave Amplifiers**: Single Stage Transistor amplifier, Power gain equations, Stability circles, Broad-band amplifier design, Solid state Power amplifiers. [8 Lectures]
- **Microwave diodes and transistors**: BJT,GaAs FETs,and their applications, IMPATT, TRAPATT, Gunn diodes. [4 Lectures]
- **Oscillators and Phase**: Shifters - Microwave oscillators using Transistors, dielectric resonators, Active and passive Phase-Shifters. [6 Lectures]
- **Technologies in MIC**: Mono lithic and Hybride substrates, Metamaterial substrates, Millimeter wave techniques, Simulations based study of printed microwave device. [4 Lectures]

Note: All the Units will have tutorials and in the end of course there wi ll be a presentation assignment in which student (or a group) will present latest advancement in any-one of the topics taught in class

Text Books:


1. David M Pozar, **Microwave Engineering**, Fourth Edition, John Wiley & Sons Publications.
2. G. Gonzalez, **Microwave transistor amplifier: design and analysis Handbook**, 2nd Edition, Prentice hall Publications.


**Reference:**


1. Leo Young and H. Sobol, Ed., **Advances in Microwaves**, vol.2, Academic press.Inc.
2. S. Y. liao, **Microwave circuit and analysis and amplifiers design**, Prentice Hall.
3. C. Caloz and T. Itho, **Electromagnetic Metamaterial: Transmission Line Theory and Microwave Applications**, Wileys Publications.
4. Research Papers as instructed by course Instructors.


## 7.119 EE 623P : Practicum on Digital Control of Electric Drives

**Course Code : EE 623P**

**Course Name: Practicum on Digital Control of Electric Drives**

L-T-P-C : 1-0-3-3

Prerequisites: Fundamentals of Electric Drives (EE508) and Practicum on Electric Drives (EE 508P)

Intended for: UG/PG

Distribution: Core for M.Tech. (PED), Elective for UG and other PG

Approval: 15th Senate; Update: 36th BoA

**Course Contents:**

1-hour of classroom session accompanied by 3-hour laboratory sessions per week.

- **Introduction to Microcontrollers and Digital Signal Processors** (2+6 hours)
  - **Content**: Review of microcontrollers and digital signal processors - numerical capabilities and peripheral units, Fixed and Floating point architectures, Real-time programming in assembly and C languages, Review of numerical methods for solving of ODEs
  - **Laboratory**: Numerical simulation of simple motor models (e.g. DC motors), use of look-up tables, study of numerical method errors and accuracy, familiarity with floating and fixed point DSPs and rapid prototying
- **Digital simulation and implementation of machines and drives concepts** (3+9 hours)
  - **Content**: Reference frame transformation, PLL implementation, PWM implementation - including space vector PWM, machine models, harmonic and reactive power compensation,
  - **Laboratory**: A few hardware lab sessions will be designed to practice the concepts taught above.
- **Digital control of drives - simulation and implementation** (7+21 hours)
  - **Content**: Discrete time control of current, torque, flux, speed and position, cascade controllers, sensing and sampling of motor quantities, interfacing issues with digital processor, estimation of flux, torque and speed, digital implementation of FOC and DTC of induction motor, digital implementation of drive protection
  - **Laboratory**: Implementation of closed loop AC drive control using the concepts learned in this module. This session could be in the form of a course project, which can continue over multiple sessions.
- **DSP based monitoring and diagnosis** (2+6 hours)
  - **Content**: Introduction to fault diagnosis, early detection of fault, introduction to online condition monitoring, real-time FFT spectrum computation, introduction to parameter estimation algorithms
  - **Laboratory**: A couple of demo/experiment hardware sessions focused on fault detection and diagnosis

**Textbook:**

1. Krause, P. C., Wasynczuk, O., Sudhoff, S. D., **Analysis of Electric Machinery and Drive Systems**, Wiley-Interscience, 2003.

2. Vas, P., **Parameter estimation, condition monitoring, diagnosis of electrical machines**, Oxford Science Publications, 1993.

**References:**

1. W. Leonhard, **Control of Electrical Drives**, Springer-Verlag, 2001.

2. Vas, P., **Sensorless vector and direct torque control**, Oxford University Press, 1998.

## 7.120 EE 623P: Practicum on Digital Control of Power Electronics and Drives

**Course Code: EE 623P**

**Course Name: Practicum on Digital Control of Power Electronics and Drives**

**L-T-P-C**: 1-0-4-3
**Pre-requisite**: EE504, EE508, EE527
**Intended for**: UG and PG
**Distribution**: Core for M. Tech (PED), Elective for UG and other PG courses
Approval: 36th BoA; Old Version: 15th Senate

**Course content**

- **Introduction to digital control, microprocessor/FPGA**

  **Lecture**: Why digital control, challenges in digital platform, fixed-point and floating point representations, sampling, mathematical modelling of sampling, quantization and its impact on stability, s-domain to z-domain mapping (tustin, forward difference, backward difference), stability analysis in z-domain, discretization of analog controllers. [5 Lectures]

  **Laboratory**: Implementation of various building blocks (ADC sampling, PWM block, controller block) required for closed-loop control of power electronic converters (using C/Verilog coding). [20 Hours]

- **Closed-loop control of DC-DC converters**

  **Lectures**: Controller design techniques, discretization of analog controllers, different types of delays introduced by the digital controllers. [5 Lectures]

  **Laboratory**: Implementation of digital voltage mode control, load transient performance, soft start-up, anti-windup arrangement. [20 Hours]

- **Module III**

  **Lecture**: Digital Proportional-Resonant and Proportional Integral controller design for a single-phase and a three-phase voltage source inverter [2 Lectures]

  **Laboratory**: Implementation of a single-phase voltage source inverter with different loads (standalone case), digital controller design and implementation of different modulation techniques in a three-phase voltage source converter [8 Hours]

- **Module IV**

  **Lecture**: Design of a digital controller in a buck fed DC motor [1 Lectures]

  **Laboratory**: Digital implementation of closed-loop control [4 Hours]

- **Module V**

  **Lecture**: Digital V/F controller design in an induction machine[1 Lectures]

  **Laboratory**: Implementation of digital V/F control [4 Hours]

**Text Books**

1. B. C. Kuo, **Digital Control Systems**, Oxford University Press, 2012.
2. N. Mohan, T. M. Undeland, and W. P. Robbins, **Power Electronics Converters, Applications, and Design**, 3rd edition, Wiley India, 2008.

**References**

1. S. N. Vukosavic, **Digital Control of Electrical Drives**, springer, 2017.
2. R. W. Erickson and D. Maksimovic, **Fundamentals of Power Electronics**, 2nd edition, Dordrecht, The Netherlands: Kluwer, 2001.

**Course Name: Post-Graduate Project**
**L-T-P-C**: 0-0-36-18
**Pre-requisite**: EE626P
**Intended for**: Fourth semester M. Tech Communications and Signal Processing
**Distribution**: Core
**Course Objectives**:
This course is meant to provide comprehensive project work for M. Tech in Communications and Signal Processing 4th semester students. Project will be based on specific research problems taken up by students under supervision of one or more faculty mentors and topics should be strongly related to Communications or Signal Processing or both. The course allows the students to carry a part of their thesis in industry or other academic institutes inside or outside India , provided they have a guide from IIT Mandi. The course will assist the student to undertake R & D, report writing, presentation and defense.
**Contents**: This is the continuation of the project done in third semester.

## 7.121 EE 630: HVDC Transmission and Flexible AC Transmission Systems

**Course Code: EE 630**

**Course Name: HVDC Transmission and Flexible AC Transmission Systems**

L-T-P-C: 3-0-0-3
Prerequisites: EE-303 (Power systems) and EE-309 (Power electronics)
Intended for: PG
Distribution: Elective for M.S., M. Tech. & Ph.D.
Approval: 37th BoA

**Course Contents**

- **Introduction to HVDC**: Introduction of DC power transmission technology, comparison of AC and DC transmission, limitation of HVDC transmission, reliability of HVDC systems, application of DC transmission, description of DC transmission system, planning for HVDC transmission, modem trends in DC transmission, advantages of HVDC. [5 Lectures]

- **Analysis of HVDC converters**: Simple rectifier circuits, required features of rectification circuits for HVDC transmission, choice of converter configuration, converter bridge characteristics. [4 Lectures]

- **Control of HVDC converter and systems**: Necessity of control of a DC link, rectifier control, compounding of rectifiers, power reversal of DC link, voltage dependent current order limit (VDCOL) characteristics of the converter, inverter extinction angle control, pulse phase control, starting and stopping of DC link, constant power control, control scheme of HVDC converters. [5 Lectures]

- **Harmonics and filters**: Generation of harmonics by converters, characteristics of harmonics on DC side, characteristics of current harmonics, characteristic variation of harmonic currents with variation of firing angle and overlap angle, effect of control mode on harmonics, non characteristic harmonic. [5 Lectures]

- **FACTS devices**: Introduction to FACTS; Compensation of transmission systems, Series and Shunt FACTS controllers - variable impedance type and switched converter type, Unified Power Flow Controller and other types ofFACTS devices. [5 Lectures]

- **Load flow and stability analysis**: Component Models for the Analysis of AC DC Systems, Power flow analysis of AC-DC systems, Transient stability analysis, Dynamic stability analysis. Application of FACTS controllers in improvement of power system operation and stability. [5 Lectures]

- **Reactive power control**: Reactive power requirements in steady state, sources of reactive power, static VAR systems, reactive power control during transients. [3 Lectures]

- **Fault and protection schemes in HVDC systems**: Nature and types of faults, faults on AC side of the converter stations, converter faults, fault on DC side of the systems, protection against over currents and over voltages, protection of filter units. [5 Lectures]

- **Multiterminal HVDC systems**: Types of multiterminal (MTDC) systems, parallel operation aspect of MTDC. Control of power in MTDC. Power upgrading and conversion of AC lines into DC lines, Parallel AC/DC systems, FACTS and HVDC system application in wind power generation- VSC based applications for wind power systems. [5 Lectures]

**Text books:**

1. K. R. Padiyar, **HVDC Power Transmission Systems**, Wiley, 1990

2. J. Arrillaga, **High Voltage Direct Current Transmission**, The Institution of Electrical Engineers, 1998.

3. N. G. Hingorani, **Understanding FACTS**, IEEE Press, 2001.

**References:**

1. K. R. Padiyar, **FACTS Controllers in Power Transmission and Distribution**, New age international, 2007.

2. 2. EW Kimbark, **Direct Current Transmission**, Wiley-Interscience, 1971.

3. S N Singh, **Electric Power Generation, Transmission and Distribution**, 2nd Edition, PHI, 2008.

4. T J E Miller, **Reactive Power Control in Electric Systems**, Wiley, 1982.

## 7.122 EE 641: Advance Wireless Technologies

**Course Code: EE 641**

**Course Name: Advance Wireless Technologies**

**L-T-P-C**: 3-0-0-3
**Pre-requisite**: EE304, EE503
**Intended for**: UG and PG
**Distribution**: Discipline elective for 3rd/ 4th year B.Tech. (CSE and EE)/ MS/ M.Tech./ PhD and free elective for other branches.
Approval: 36th BoA

**Course Modules**

- **Introduction**

  Challenges of next generation wireless networks. Basics of wireless communications, multipath propagation and fading nature of wireless channel, BER. Performance of multi-antenna wireless systems, precoding and power allocation for multi-user MIMO systems. [7 Hours]

- **Cognitive Radio Systems**

  Concepts, challenges of Software Defined Radio (SDR), spectrum-sensing techniques, optimal power allocation, Interference suppression, and robust detection. [5 Lectures]

- **Massive MIMO Systems**

  Introduction and challenges. Signal processing with perfect & imperfect channel state information, rate scaling, performance of multi-cell massive MIMO systems and spatial modulation. [7 Lectures]

- **mmWave/THz Wireless Systems**

  Introduction, properties and modeling of wireless channels, analog, digital and hybrid processing, sparse processing, channel estimation, optimal precoders and combiners. [6 Lectures]

- **Cooperative Wireless Communication**

  Introduction to cooperative communication and cooperation protocols (AF, DF, and SDF). Performance analysis of DF for MIMO and multi-relay wireless systems. [6 Lectures]

- **Non-Orthogonal Multiple-Access (NOMA)**

  Introduction, system model and decoding for NOMA systems. Outage probability, opt. performance, average rate, key aspects of uplink and downlink NOMA systems. [6 Lectures]

- **Full-Duplex Wireless Technology** Introduction, self-interference and resulting performance. Optimal signal processing, power allocation and performance of FD Systems. [5 Lectures]

- **Optional topics**

  Molecular Communication, Backscatter Communication, Energy Harvesting, Low Power Wide-area Networks (LPWA), Long Range Wireless Transfer (LoRa), D2D, Distributed MIMO, Physical layer caching and Physical layer security.

**Text Books**


1. Luo, Fa-Long and Zhang, Charlie (Jianzhong), Luo, Fa-Long, **ignal processing for 5G: algorithms and implementations**, Wiley-IEEE Press, 2017.

2. Wei Xiang, Kan Zheng, Xuemin, **5G Mobile Communications**, Springer, 2017


**Reference Books**


1. Wong V., Schober, R., Ng, D., and Wang, L. (Editors), **Key Technologies for 5G Wireless Systems**, Cambridge, 2017.

2. Dahlman, E., Parkvall, S., & Skold, J., **5G NR: The next generation wireless access technology**, Elsevier 2018.

3. A. Chockalingam, B. S. Rajan, **Large MIMO Systems**, Cambridge, 2014.

4. Liu, K., Sadek, A., Su, W., and Kwasinski, A, **Cooperative Communications and Networking**, Cambridge University Press, 2008.

5. Tho Le-Ngoc, Ahmed Masmoudi, **Full-Duplex Wireless Communications Systems**, Springer, 2017.

6. Biglieri, Ezio, Andrea J. Goldsmith, Larry J. Greenstein, Narayan B. Mandayam and Herve Vincent, **Principles of Cognitive**, Cambridge, 2012.

7. N. Farsad, H. B. Yilmaz, A. Eckford, C. Chae and W. Guo, *A Comprehensive Survey of Recent Advancements in Molecular Communication*, in **IEEE Communications Surveys & Tutorials**, vol. 18, no. 3, pp. 1887-1919, 2016.

## 7.123 EE 642 : Research Study

**Course Code: EE 642**

**Course Name : Research Study**

L-T-P-C : 0-0-6-3
Intended for : M.Tech (VLSI)
Prerequisite : None
Mutual Exclusion : None .
Approval: 44th BoA

**Preamble:**

Research study course is brought into the realms of M.Tech (VLSI) programme to enable a student pursue a research topic of interest under the supervision of a faculty member hereinafter referred to as advisor for the research study. Research Study is designed to provide credit for field research, survey of literature leading to problem identification and extended knowledge in a focused field of study. The topic can be from academic or industrial research fields in the domain of VLSI.

**Objectives:**

(based action verbs at appropriate levels of Bloom's Taxonomy):

1. Understand in details a particular area of research through contemporary publications in that area.
2. Analyze the flow of research in a particular direction.
3. Identify the gap in that area.
4. Formulate a problem to identify that gap.
5. Propose an initial solution for the problem formulated.

**Methodology guidelines:**

1. A student enrolled in M.Tech (VLSI) programme has to register for 3 credits of research studies during winter break after 1st semester. The credits earned through the research study will be added to the credits earned during the 2nd semester.
2. A student may be given the option to choose the broad area of Research Study (academic or industrial research), viz. Device Physics, Fabrication Technology, Circuit Design or Systems, based on which advisor(s) may be allotted to the student.
3. The topic chosen by student has to be approved by the faculty advisor.
4. The role of the advisor(s) is to assist the student during the research study.
5. It is expected that the student will meet the advisor at least once in a week.
6. The report of the research study has to be submitted in the form of a Term Paper at the end of the winter break.

7. The course will culminate with a seminar being presented at the end of winter break.
8. The seminar will be evaluated by a committee of four members involving faculty advisor (or nominee), advisor for the research study, two experts in that area from the faculty members of IIT Mandi.
9. The seminar is supposed to test presentation skills, clarity of problem, quality of slides being prepared and question-answer session at the end of seminar.
10. The seminar can be an open seminar, although the decision of the four member committee will be final.
11. The student is expected to put in an effort of 30 hours per week for two and half months from start of winter break to its end.
12. In events of a dispute between the student and advisor, the matter has to be settled in consultation with faculty advisor which in exceptional cases may go to course coordinator, Chairperson (SCEE) or Dean (Academics).
13. The advisor reserves the right to reject a student with sufficient reasons if a student fails to deliver up to the expectations of the advisor. In such a case, a student will have to find out his advisor on his own. However, the student will not be given any extra time to work out the new research study.
14. Any intellectual property (IP) generated out of an independent study is subjected to the IP regulations of IIT Mandi regarding sharing and ownership of IP rights.

## 7.124 EE 677 (3) Analog Circuit Design

Approval: 2nd Senate; OTA

**Course Outline:**

- Review of integratedcircuit deviCecharacteristics& models
- Review of elementary 1 transistoramplifiers 0 Twotransistoramplifiers
- Current Mirrors, active loads
- OutputStages
- Operational Amplifiers
- Frequency Response of IntegratedCircuits
- Feedbacktechniques for IntegratedCircuits
- Frequency Response & Stability of FeedbackAmplifiers
- Differential Operational Amplifiers
- Voltage and CurrentReferences (optional)
- Review of the practical application of an OPAMP in e.g. filter
- Other-Topics: Noise, non-linearity, mismatch, MOS vs Bipolar

## 7.125 EE 678 (3) Digital Circuit Design

Approval: 2nd Senate; OTA

### Course Outline:

Review: Basic MOS structure and its static behaviour; Quality metrics of a digital design: Cost, functionality, robustness, power,and delay. CMOS Inverter: Static CMOS inverter, switching threshold and noise margin ‘ concepts and their evaluation, dynamic behaviour, power consumption and effect of scaling on CMOS performance metrics. CMOS combinational Logic: Static CMOS design, ratioed logic, pass transistor logic, dynamic logic, speed and power dissipation in dynamic logic, cascading dynamic gates, CMOS transmission gate logic. CMOS Sequential Logic: Static latches and registers, bistability principle, MUX based latches, static SR flip-flops, master-slave edge-triggered register, dynamic latches and registers, concept of pipelining, pulse registers, nonbistable sequential circuit. Timing Issues: Synchronous timing basics, classification, s'kew and jitter, and their sources, clock distribution techniques, self-timed circuit design, synchronisers and arbiters, clock synthesis and synchronization using PLL. Design of Arithmetic Building Blocks: Adder, multiplier, shifter, and other operators; Power and speed trade-off 1n datapath structures. 5 0 3 0 0 15 00 35 50 00 0 3 ‘17.Memory and. Array Structure. Core, ROM, RAM, peripheral circuitry, memory reliability and yield, SRAM and DRAM design, evaluation of RNM and WNM from butterfly curves, flash memory.

## 7.126 EE 691: Advanced Topics in Dielectric Breakdown

**Course Code: EE 691**

**Course Title: Advanced Topics in Dielectric Breakdown**

L-T-P-C: 1-0-0-1

Prerequisites: EE 606 Introduction to High Voltage Engineering and Dielectric Breakdown or teachers consent

Students intended for: UG/PG

### Course Contents

- Electric Field Strength. [2 Lectures]
- Properties and Breakdown in Gaseous Dielectrics. [6 Lectures]
- Properties and Breakdown of Liquid and Solid Dielectrics. [4 Lectures]
- Recent trends and developments. [2 Lectures]

### Textbooks:

1. R. Arora, W. Mosch, **High Voltage and Electrical Insulation Engineering**, IEEE Press, 2011.
2. Arora and Mosch, **High Voltage Insulation Engineering**, New Age International, 1995.

**References:**

1. Kuffel, E., **High voltage engineering**, Newnes 2009.

2. Alston L. L., **High Voltage Technology**, Oxford University Press, 2011.

## 7.127 EC 101A Computer Systems & Programming

Course Code: EC-101A
Course Name: Computer Systems & Programming
L-T-P-C: 3-0-2-4
Pre-requisite: NIL Sem. Both
Approval: 5th Senate, OTA

**Course Contents:**

1. **Basic Computer Fundamentals**: Introduction to computer systems; number system integer, m signed integer, fixed and floating point representations; IEEE standards integer and floating point arithmetic; CPU organization ALU, registers, memory, the idea of program execution at micro level: concept of flow chart and algorithm, algorithms to programs Concept of strain, normal and shear strain, two dimensional state of principal strains, Poisson's ratio, volumetric strain, strain circle.

2. **Basic Programming elements in C++**: Input/Output: Constants, variables expressions and operations: Naming conventions and styles: Conditions and selection statements; Looping and control structures; File I/O header files, string processing; Pre-processor directives such as include, #define, #ifdef, #ifndef, Compiling and linking;

3. **Programming through functional decomposition**: Functions (void and value returning) parameters, scope and lifetime of variables, passing by value, passing by reference passing by constant reference : Design of functions and their interfaces (concept of functional decomposition), recursive functions, function overloading and default arguments; Library functions;

4. **Aggregate data-types**: Arrays and pointers: Structures : Dynamic data and pointers, dynamics arrays ; Introduction to data structures, use of pointers in linked structures;

5. **Object Oriented Programming Concepts**: Data hiding, abstract data types, classes, access control : Class implementation – default constructor, constructors, copy constructor, destructor, operator overloading, friend functions ; Object oriented design, inheritance and composition : Dynamic binding and virtual functions ; Polymorphism ; Dynamic data in classes.

**References:**

1. Dietel H. M. and Dietel P. J., **C ++ How to Program**, Prentice Hall Publications.

2. Nell D., Chip W. and Mark H., **Programming and Problem Solving with C++**, CBS Publishers and Distribution.

3. Cohoon J. P. & Davidson J. W., **C++ Program Design**, Tata McGraw Hill.

## 7.128 EC 101B Fundamentals of Object Oriented Programming

Course Code: EC-101B
Course Name: Fundamentals of Object Oriented Programming
L-T-P-C: 3-0-2-4
Pre-requisite: NIL Sem. Both
Approval: 5th Senate; OTA

**Course Contents:**

1. **Basic Computer Fundamentals**: Introduction to computer systems, computer as a programmed machine: CPU organization, ALU, registers, memory: machine language, assembly language, idea of program execution at micro level, high – level languages: concept of flow chart and algorithm algorithms to programs, efficiency of algorithms, big-O notation; object oriented programming concept difference in approach from procedural programming;

2. **Introduction to Linux and Java programming environment, Java compiler and virtual machine**: structure of a Java program, stand-alone programs and applets: concepts of portability;

3. **Basic Programming elements in Java**: data types, variables and array's operators, assignment and selection statements iterative structures, nested loops;

4. **Classes in Java**: general form of a class, creating objects, access control in classes. Constructors, methods, finalization, parameters, method overloading, recursive methods, returning objects, static members final, qualifier, nested and inner classes, string handling in Java, I/O mechanism, command line arguments.

5. **Inheritance**: basics super classes and subclasses, multilevel hierarchy, method overriding: run time polymorphism, abstract classes, final in inheritance, and the object class;

6. **Packages and Interfaces**: defining package, access protection, importing classes and packages, defining and implementing interfaces, nested interfaces, use of interfaces, variables in interfaces, the keyword extends;

7. **Exception handling** : fundamentals , types of exceptions catching exceptions, multiple catching nested try statements, uncaught exceptions, throw and throws, finally mechanism, built-in exceptions, creating exception subclasses, using exceptions;

8. **Applets** : applet fundamentals, native methods, static import, the applet class, applet display method, requesting repaining, a banner applet, passing parameters to applets, uses of applets.

**References:**


1. Dietel and Associates, **Java How to Program**, 7th Edition, Prentice- Hall.

2. David F., **Java in a Nutshell**, 5th Edition, O'Reilly Media, Inc.,

3. David Gries, **The Science of Programming**

4. Dijkstra E. W., **A Short Introduction to the Art of Programming**

5. Dromey, **How to solve it by Computer**

6. Bruce E., **Thinking in Java**, Prentice Hall

7. Goslimg J., Joy B., Steele G. and Bracha G., **The Java Language Specification**, 2nd Edition.


## 7.129 EC 102 Fundamentals of Electronics

Course Code: EC-102
Course Name: Fundamentals of Electronics
L-T-P-C: 3-1-2-4
Pre-requisite: NIL Sem. Both
Approval: 5th Senate; OTA

**Course Contents:**

- **Review of conductors, semiconductors, and insulators; Drift and diffusion currents**; p-n junction; junction under forward and reverse bias; circuit models; diode applications: rectifier, clipper, clamper; Zener diode regulator; simple power supply with capacitor filter and zener regulator.

- **Bipolar Junction Transistor**: structure and operation, various configurations, input and output characteristics, BJT as amplifier, DC analysis of various biasing circuits, biasing stability.

- **Field Effect Transistors**: JFET, depletion-mode and enhancement-mode MOSFETs, FET biasing, FET as an amplifier.

- **Small- signal analysis of BJTs and FETs**: h-parameter model of BJT, small-signal analysis of BJT amplifier circuits, frequency response of RC-coupled BJT and FET amplifiers.

- **Amplifiers**: cascade connection, current mirror, differential amplifier, operational amplifier, op-amp applications, power amplifiers, feedback in amplifiers.

- **Oscillators**: Barkhausen criterion, damped oscillations in LC circuits, audio and rf oscillators.

- **Digital Electronics**: Combinational Circuits – adder, de-coder, encoder, multiplexer, demultiplexer; Sequential Circuits – flip- flops, counters, and shift registers; ADC and DAC.

**References:**


1. Boylestad R. L. and Nashelsky L., **Electronic Devices and Circuit Theory**, 9th Edition, Pearson Education.

2. Millman J. and Halkias C. C., **Electronic Devices and Circuit**, McGraw-Hill.

3. Millman J. and Halkias C. C., **Integrated Electronics**, Tata McGraw- Hill.

4. Nagrath I. J., **Electronics – Analog and Digital**, Prentice Hall of India.

5. Santiram K., **Basic Electronics**, Prentice Hall of India.

# 8 Energy Engineering Courses

## 8.1 EM 504: Materials for Energy Applications

**Course Code: EM 504**

**Course Name: Materials for Energy Applications**

L-T-P-C: 3-1-0-4
Prerequisites: None
Students intended for: 3rd and 4th Year UG/PG
Elective or Core:
Approval: 8th Senate

**Course contents**

- **Module I**

  Creep resistance materials: principles of creep deformation, mathematical modeling and design application of creep resistance materials in power plants. Catalysis; Wear resistance materials: types of wear, mechanism of erosion and cavitation wear, tribo-corrosion, application of wear resistance materials in power plants, Fatigue types, types and protection. Life prediction of turbine materials. [15 Lectures]

- **Module II**

  Phase diagram, Conductors, transformer materials, Semiconductor physics and devices, Fundamentals and energy applications for Magnetic and Dielectric materials. [20 Lectures]

- **Module III**

  Energy efficient structure/building materials. [7 Lectures]

**Text Books:**

1. Hans Berns , Werner Theisen, Gillian Scheibelein, **Ferrous Materials**, Springer, 2008.
2. A. J. Moulson and J. M. Herbert, **Electroceramics: Materials, Properties and Applications**, 2nd Edition, Wiley, 2003.
3. M.Hall, **Materials for Energy Efficiency and Thermal Comfort in Buildings**, Elsevier Press, 2010.

**Reference Books:**

1. Oliver Gutfleisch , Matthew A. Willard , Ekkes Bruck , Christina H. Chen , S. G. Sankar , and J. Ping Liu, **Magnetic Materials and Devices for the 21st Century: Stronger, Lighter, and More Energy Efficient**, *Adv. Mater.*, 23, 821-842 (2011)

2. L.H.Lewis and F.J. Villacorta, **Perspectives on Permanent Magnetic Materials for Energy Conversion and Power Generation**, *Metallurgical and Mater. Trans. A*, 44A, S1-S20 (2013)

3. S.L. Swartz, **Topics in Electronic Ceramics**, *IEEE Trans. Elect. Insulation*, 25 [5] 935 (1990)

## 8.2 EM 505: Alternative Energy Sources for Transportation

**Course Code: EM 505**
**Course Name: Alternative Energy Sources for Transportation**

L-T-P-C: 3-0-0-3
Prerequisites: ME 355 IC Engines or teachers consent
Students intended for: UG/PG
Elective or Core: Elective for ME
Approval: 8th Senate

**Course contents**

- **Module I**

  Introduction: Description about primary energy use sector and energy requirement for transportation sector, Requirement of transport fuels in India and share of various sources, Transportation need and economic and environmental impact of various transportation modes. Relationship between energy Efficiency with CO2 emission reduction Fuel properties and fuel specifications. [5 Lectures]

- **Module II**

  Overview of engine technology and effect of fuel properties on advanced engine technologies: Efficiency and emission challenges and prevailing emission norms, brief pollutant formation mechanisms, Measures adopted for conforming these norms such as advances in engine fuel injection technology, exhaust gas recirculation, intake pressure boosting, engine control system and interrelation between various control parameters, after treatment technologies, advanced combustion concepts like HCCI, GDI etc. Alternative fuel acceptability factors: Well to wheel emission analysis, Modification requirements and migration route from conventional technology, Liquid and gaseous fuels, Fuels and engine material compatibility, Lubricating oil degradation, dual fuel, Multi fuel engines. [15 Lectures]

- **Module III**

  Alcohol fuels (ethanol, methanol, butanol), availability and production technology, utilisation in SI and CI engines, material compatibility and lubricating oil effects; Biodiesel: Production method of esters (biodiesel) and hydrotreated vegetable oil (renewable diesel), application in diesel engines, blending with other fuels for performance improvement, material compatibility, lubricating oil degradation etc; Other liquid fuels: DME (di-methyl ether), Fischer-Tropsch liquids, GTL, BTL, CTL, DMF, Fuel properties, availability, production technology, fuel injection, engine performance, emissions, combustion and material compatibility considerations. [8 Lectures]

- **Module IV**

  Gaseous Hydrocarbon Fuels: LPG, LNG, CNG, HCNG, Availability and production technology, Utilisation in CI and SI engines, Fuel supply system, Performance and emissions studies, Biogas, Safety features required while handling gaseous fuels. [8 Lectures]

- **Module V**

  Alternative Vehicles: Fuel cell technology, Electric vehicles and battery requirement, Hybrid vehicle technology. [6 Lectures]

**Text Books:**

1. Richard L. Bechtold, **Alternate Fuels – Transportation Fuels for Today and Tomorrow**, Society of Automotive Engineers (SAE), 2002.

2. AS Ramadhas (Eds.), **Alternative Fuels for Transportation**, CRC Press Taylor & Francis Group, 2011.

3. M.K. Gajendra Babu, K.A. Subramanian, **Alternative Transportation Fuels: Utilisation in Combustion Engines**, CRC Press, 2013.

## 8.3 EM 604: Energy: Environment Policy and Law

**Course Code: EM 604**
**Course Name: Energy: Environment Policy and Law**

L-T-P-C: 3-1-0-4
Prerequisites: None
Students intended for: B. Tech., M. Tech. (Energy Materials), M.S., and Ph. D.
Elective or Core: Energy core for M. Tech. (Energy Materials) and elective for B. Tech., M.S., and Ph. D. students
Approval: 8th Senate, OTA

**Course contents**

- **Engineering Economics**

  Estimation, Supply, Demand, Cost, Elasticity, Pareto Efficiency, Welfare Economics, Social Discounting, Hyperbolic Discounting, Pricing, Borrowing, Depreciation, Taxes, Market Failure, Risk Modeling, Attitudes and Utility, Multi-Attribute Decisions and Stochastic Dominance, Monte Carlo Simulation, and Cost Effectiveness Analysis/Value of Life. [14 Lectures]

- **Energy Economics**

  Unit cost calculation of power generation from different energy sources, Rules for investment in Energy sector, Payback period, NPV, IRR, ERR, and Benefit-cost analysis, Net Social Benefit (with Free riding concepts) and Rebound effects, Energy-GDP elasticity, Financing of energy systems, Energy – economy interaction, renewable and non-renewable sources of energy with their advantages and disadvantages on environment and climate change. [14 Lectures]

- **Energy Policy and Environmental Law**

  Energy policy, Tariffs and subsidies, Taxes, National energy plan and five-year plans, Energy Models, Trend analysis, Costs of exploration and alternate energy, International energy supply, Energy Pricing, Environment interaction, Clean development mechanism, Overview of renewable energy policy in India, India's Plan for a domestic energy cap & trade scheme, and renewable energy credits. Federalism, Energy Regulation, Environmental law with a focus on Water (prevention & control of pollution) act 1974, Environmental protection act 1986, and effluent standards and ambient air quality standards. Legal Regimes Governing Primary Sources of Energy – Non – Renewable and Renewable, and Regulatory Framework concerning Electricity, Gas, Coal, and Renewable Energy. [14 Lectures]

**Reference Books:**

1. Tiwari, G. N., & Mishra, R. K., **Advanced Renewable Energy Sources**, Royal Society of Chemistry, 2011.
2. Tung Au, Thomas P. Au., **Engineering Economics for Capital Investment Analysis**, Prentice Hall, Fac Sub edition, 1991.
3. Robert T. Clemen, Terence Reilly, **Making Hard Decisions with Decision Tools Suite**, Cengage Learning, 2004.
4. Laurance R. Geri, David E. McNabb, **Energy Policy in the U.S.: Politics, Challenges, and Prospects for Change**, CRC Press, 2011.
5. Henry M. Levin, Patrick J. McEwan, **Cost-Effectiveness Analysis: Methods and Applications** SAGE Publications, Inc. 2nd Edition. 2000.
6. Rubin, Edward, **Introduction to Engineering and the Environment**, McGraw-Hill Science, 2000.
7. **For Indian Energy and Environment policy program and Act**, please refer to the MNRE website: `http://www.mnre.gov.in/`
8. Mohammad Naseem, **Energy Law in India**, Wolters Kluwer, 2011.
9. Karen Makuch, **Environmental and Energy law**, Wiley, 2012.
10. SKL Chaterjee, **Commentary on Electricity Laws in India**, 1st Edition, Delhi Law House, New Delhi, 2006.

## 8.4 EM 651: Photovoltaic materials and fabrication

**Course Code: EM 651**
**Course Name: Photovoltaic materials and fabrication**

L-T-P-C: 3-0-0-3
Prerequisites: Device electronics for integrated circuits (EE 31 I)/ Introductory course on semiconductor devices/Instructor's consent
Students intended for: 3rd year and 4th year UG, PG
Elective or Core: Elective for ME
Approval: 11th Senate

**Course contents**

- **Semiconductor Electronics** [5 Lectures]
  - Physics of Semiconductor Materials
  - Band Model of Solids
  - Concept of equilibrium and non-equilibrium in semiconductor device
  - Current conduction mechanisms in semiconductors
  - Fundamentals of p-n junction
  - Operation of p-n junction under forward and reverse bias
- **Basics of Photovoltaics** [7 Lectures]
  - History of solar cells
  - Principle of detailed balance
  - Principles of carrier separation and generation-recombination
  - Operation of solar cells
  - Design of solar cells
- **Advanced concepts in solar cells**[7 lectures]
  - Theory of multi-junctions solar cells with an emphasis on tunnel junctions between them
  - Physics of heterojunctions and other junctions such as Schottky diodes and ohmic contacts
  - Induced junctions, MIS solar cell and carrier selective contact approaches
- **Solar resources and PV performance** [4 Lectures]
  - Solar radiation
  - Calculation of direct and diffuse radiation
  - Solar modules and arrays
  - Performance evaluation of PV modules
- **Reliability of photovoltaic modules** [6 Lectures]
  - Familiarization with IEC certification testing
  - Microclimate of PV module
  - Influence of microclimate on reliability ofPV module
- **Components of photovoltaic systems** [4 Lectures]
  - Different PV System Topology
  - Introduction to different power electronic components
  - Grid integration of photovoltaics

- **PV Technology**[7 Lectures]
  - Silicon solar cell fabrication
  - III-V technology
  - Thin film technology
  - Other emerging technologies

**Text Books:**


1. Jenny Nelson, **Physics of solar cells**, Imperial College Press, 2003
2. Roger Messenger, Jerry Ventre, **Photovoltaic systems engineering**, CRC press


## 8.5 EN 501: Energy Sources and Power Plants

**Course Code: EN 501**
**Course Name: Energy Sources and Power Plants**

L-T-P-C: 3-0-0-3
Prerequisites: Instructor's consent
Students intended for: UG/PG
Elective or Core: Compulsory foundation course for M.Tech. (Energy Engineering) and elective for other students
Approval: 9th Senate

**Course contents**

- **Introduction**

  Fossil fuel resources: Coal, petroleum, shale gas and oil, natural gas, extra heavy oil, Stationary combustion systems, Transportation energy technologies, Systems perspective on transportation engineering. [6 Lectures]

- **Thermal power plant**

  Steam boilers, steam turbines, gasification of hydrocarbon feedstock (e. g. coal, biomass, petroleum, waste) into 'syngas' combustion, fluidized bed combustion, integrated gasification combined cycle for high efficiency and low emissions electricity production, hybrid system of coal combustion and gasification, Improving power conversion, developing durable materials for handling hot brine, steam, cooling water and binary fluids; designing new methods for rejecting waste heat and improving the efficient handling of waste products associated with some operations, Advanced Rankine cycles, advanced gas turbine cycles, Kalina cycle, organic Rankine cycles and cogeneration may be incorporated. [14 Lectures]

- **Hydroelectric power**

  Technology of dam, hydro-turbines for power generation, environmental and societal effects, impact of reservoir on downstream rivers and lakes, impact on river morphology and suspended solids, river and flood plain ecology, fish ecology. [8 Lectures]

- **Nuclear Energy**

  Energy from fission of U-235, Nuclear chain reaction, uranium fuel cycles types of reactors- boiling water reactors, pressurized water reactors, benefits of nuclear energy, accidents and safety systems, radiation and radioactive wastes- storage of radioactive wastes and used fuels. [10 Lectures]

- **Geothermal energy**

  Type and temperature of geothermal sources, three kinds of power plants-direct steam, flash and binary plants, efficiency improvement and design challenges. [4 Lectures]

**Text Books:**


1. K. R. Rao, **Energy and Power Generation Handbook: Established and Emerging Technologies**, American Society of Mechanical Engineers, U.S., 2011.

2. Steven W Blume, **Electric Power Systems Basics**, IEEE Press 2007

3. Francis Vanek, Louis Albright, Largus Angenent, **Energy Systems Engineering: Evaluation and Implementation**, 2nd Edition, McGraw-Hill, 2012.


## 8.6 EN 502: Emerging Energy Sources

**Course Code: EN 502**
**Course Name: Emerging Energy Sources**

L-T-P-C: 3-0-0-3
Prerequisites: Instructor's consent
Students intended for: UG/PG
Elective or Core: Compulsory foundation course for M.Tech. (Energy Engineering) and elective for other students
Approval: 9th Senate

**Course contents**

- **Introduction**

  Different types of emerging energy sources, potential and installed capacities of these new generation energy sources, Conversion technologies for different primary energy sources, sustainability benefits, and challenges related with reliability, policy dependence, socio-economic advantages and disadvantages. [6 Lectures]

- **Biomass Energy**

  Organic matters available on renewable basis like forests, agricultural, mill and industrial wastes etc., direct fired plants, co fired power plants, gasification, fixed bed gasifiers, small version of gasification or directly fired plants for modular bio power. [8 Lectures]

- **Wind power**

Wind energy availability and basic working principle of wind turbines, wind turbine-rotor blades, tower, nacelle house- electrical generator, power control and other mechanical equipment, resource assessment overview, modern wind turbines, installations and wind farms, advantages and limitations of wind farms . [8 Lectures]

- **Module IV**

  Solar power–potential of solar energy reaching earth surface, collecting sunlight, solar photovoltaic and solar thermal techniques, solar cell efficiencies and theoretical limits, solar power plants, future challenges. [8 Lectures]

- **Ocean Energy**

  Availability in Indian context, Ocean Thermal Energy Conversion, wave energy conversion, Tidal power basic conversion principle, and challenges related with material corrosion, intermittent primary energy supply, sustainability assessment and improvement. [4 Lectures]

- **Module VI**

  Hybrid renewable syste [4 Lectures]

- **Fuel cell**

  Proton exchange membrane, PEM chemical reactions, alkaline fuel cells, molten carbonate fuel cell their working reactions and advantages, solid oxide fuel cells-their working reactions and advantages [6 Lectures]

**Text Books:**


1. K. R. Rao, **Energy and Power Generation Handbook: Established and Emerging Technologies**, American Society of Mechanical Engineers, U.S., 2011.

2. Aldo V.da Rosa, **Fundamental of Renewable Energy Processes**, Elsevier Press, 2009.

3. Jahangir Hossain, Mahmud Apel, **Large Scale Renewable Power Generation: Advances in Technologies for Generation**, Transmission and Storage (Green Energy and Technology), Springer, 2014.

4. Y. Goswami, **Principles of Solar Engineering**, CRC Press, 2013.

5. R. Ehrlich, **Renewable Energy: A First Course**, CRC Press, 2013.

6. D. Spera, **Wind Turbine Technology**, ASME, 2009.

7. S. Srinivasan, **Fuel Cells: From Fundamentals to Applications**, Springer, 2006.

8. D. A. J. Rand and R. M. Dell, **Hydrogen Energy: Challenges and Prospects**, RSC Publishing, 2008.

## 8.7 EN 503: Energy Storage Technologies

**Course Code: EN 503**
**Course Name: Energy Storage Technologies**

L-T-P-C: 3-0-0-3
Prerequisites: None
Students intended for: UG/PG
Elective or Core: Elective
Mutual Exclusion: None
Approval: 44th BoA

**Course contents**

- **Energy storage systems overviw**

  Scope of energy storage, needs and opportunities in energy storage, Technology overview and key disciplines, comparison of time scale of storages and applications, Energy storage in the power and transportation sectors. Importance of energy storage systems in electric vehicles, Current electric vehicle market. [5 Lectures]

- **Thermal storage system**

  heat pumps, hot water storage tank, solar thermal collector, application of phase change materials for heat storage-organic and inorganic materials, efficiencies, and economic evaluation of thermal energy storage systems. [6 Lectures]

- **Chemical storage system**

  Hydrogen, methane etc., concept of chemical storage of solar energy, application of chemical energy storage system, advantages and limitations of chemical energy storage, challenges, and future prospects of chemical storage systems. [5 Lectures]

- **Electromagnetic storage systems**

  double layer capacitors with electrostatically charge storage, superconducting magnetic energy storage (SMES), concepts, advantages and limitations of electromagnetic energy storage systems, and future prospects of electrochemical storage systems. [5 Lectures]

- **Electrochemical storage system** [11 Lectures]

  a **Batteries**: Working principle of battery, primary and secondary (flow) batteries, battery performance evaluation methods, major battery chemistries and their voltages- Li-ion battery & Metal hydride battery vs lead-acid battery.

  b **Supercapacitors**: Working principle of supercapacitor, types of supercapacitors, cycling and performance characteristics, difference between battery and supercapacitors, Introduction to Hybrid electrochemical supercapacitors.

  c **Fuel cell**: Operational principle of a fuel cell, types of fuel cells, hybrid fuel cell-battery systems, hybrid fuel cell-supercapacitor systems.

- **Module VI**

Battery design for transportation, Mechanical Design and Packaging of Battery Packs for Electric Vehicles, Advanced Battery-Assisted Quick Charger for Electric Vehicles, Charging Optimization Methods for Lithium-Ion Batteries, Thermal runaway for battery systems, Thermal management of battery systems, State of Charge and State of Health Estimation Over the Battery Lifespan, Recycling of Batteries from Electric Vehicles. [10 Lectures]

**Text Books:**

1. Frank S. Barnes and Jonah G. Levine, **Large Energy Storage Systems Handbook** (Mechanical and Aerospace Engineering Series), CRC press, 2011.
2. Robert A. Huggins, **Energy storage**, Springer Science & Business Media, 2010.
3. Ralph Zito, **Energy storage: A new approach**, Wiley, 2010.

**Reference Books:**

1. Pistoia, Gianfranco, and Boryann Liaw, **Behaviour of Lithium-Ion Batteries in Electric Vehicles: Battery Health, Performance, Safety, and Cost**, Springer International Publishing AG, 2018.
2. Robert A. Huggins, **Energy storage**, Springer Science & Business Media, 2010.

## 8.8 EN 503_Old: Energy Storage Technologies

**Course Code: EN 503**
**Course Name: Energy Storage Technologies**

L-T-P-C: 3-0-0-3
Prerequisites: None
Students intended for: UG/PG
Elective or Core: Foundation/core course for M.Tech. (Energy Engineering) students, Elective for MS, PhD, Final year UG students
Approval: 9th Senate; Updated in 44th BoA

**Course contents**

- **Energy storage systems overview**

  Scope of energy storage, needs and opportunities in energy storage, Technology overview and key disciplines, comparison of time scale of storages and applications. [3 Lectures]

- **Mechanical and thermal storage system**

  Introduction to major forms of mechanical storages such as flywheels, pumped hydro storage, compressed air, hydraulic accumulator, heat pumps, heat engine flywheel, hot water storage tank, vacuum solar thermal collector, steam accumulator, application of phase change materials for heat storage, characteristics of mechanical systems, efficiencies and economic evaluation of mechanical energy storage systems. [8 Lectures]

- **Electrochemical storage system**

  Introduction to the fundamental aspects of electrochemistry, Battery working principle, primary and secondary (flow) batteries, battery performance evaluation methods, major battery chemistries and their voltages; supercapacitors working principle, types of supercapcitors, cycling and performance characteristics, difference between battery and supercapacitors, Introduction to Hybrid electrochemical supercapacitors; Stand alone and grid tied energy storage systems. [11 Lectures]

- **Chemical storage system**

  Hydrogen, synthetic natural gas, biofuels and biomass, liquid nitrogen, concept of chemical storage of solar energy, application of chemical energy storage system, advantages and limitations of chemical energy storage, challenges and future prospects of chemical storage systems. [10 Lectures]

- **Electromagnetic storage systems**

  double layer capacitors with electrostatically charge storage, superconducting magnetic energy storage (SMES), concepts, advantages and limitations of electromagnetic energy storage systems, and future prospects of electrochemical storage systems. [10 Lectures]

**Text Books:**

1. Frank S. Barnes and Jonah G. Levine, **Large Energy Storage Systems Handbook** (Mechanical and Aerospace Engineering Series), CRC press, 2011.

2. Robert A. Huggins, **Energy storage**, Springer Science & Business Media, 2010.

3. Ralph Zito, **Energy storage: A new approach**, Wiley, 2010.

## 8.9 EN 504: Energy: Environment Policy and Law

**Course Code: EN 504**
**Course Name: Energy: Environment Policy and Law**

L-T-P-C: 3-0-0-3
Prerequisites: None
Students intended for: UG/PG
Elective or Core: Energy core for M. Tech. (Energy Materials) and elective for B. Tech., M.S., and Ph. D. students
Approval: 10th Senate

**Course contents**

- **Engineering Economics**

  Estimation, Supply, Demand, Cost, Elasticity, Pareto Efficiency, Welfare Economics, Social Discounting, Hyperbolic Discounting, Pricing, Borrowing, Depreciation, Taxes, Market Failure, Risk Modeling, Attitudes and Utility, Multi-Attribute Decisions and Stochastic Dominance, Monte Carlo Simulation, and Cost Effectiveness Analysis/Value of Life. [14 Lectures]

- **Energy Economics**

  Unit cost calculation of power generation from different energy sources, Rules for investment in Energy sector, Payback period, NPV, IRR, ERR, and Benefit-cost analysis, Net Social Benefit (with Free riding concepts) and Rebound effects, Energy-GDP elasticity, Financing of energy systems, Energy – economy interaction, renewable and non-renewable sources of energy with their advantages and disadvantages on environment and climate change. [14 Lectures]

- **Energy Policy and Environmental Law**

  Energy policy, Tariffs and subsidies, Taxes, National energy plan and five-year plans, Energy Models, Trend analysis, Costs of exploration and alternate energy, International energy supply, Energy Pricing, Environment interaction, Clean development mechanism, Overview of renewable energy policy in India, India's Plan for a domestic energy cap & trade scheme, and renewable energy credits. Federalism, Energy Regulation, Environmental law with a focus on Water (prevention & control of pollution) act 1974, Environmental protection act 1986, and effluent standards and ambient air quality standards. Legal Regimes Governing Primary Sources of Energy – Non – Renewable and Renewable, and Regulatory Framework concerning Electricity, Gas, Coal, and Renewable Energy. [14 Lectures]

**Text Books:**

1. Tiwari, G. N., & Mishra, R. K., **Advanced Renewable Energy Sources**, Royal Society of Chemistry, 2011.

2. Tung Au, Thomas P. Au., **Engineering Economics for Capital Investment Analysis**, Fac Sub edition, Prentice Hall, 1991.

3. Robert T. Clemen, Terence Reilly, **Making Hard Decisions with Decision Tools Suite**, Cengage Learning. 2004.

4. Laurance R. Geri, David E. McNabb, **Policy in the U.S.: Politics, Challenges, and Prospects for Change**, CRC Press, 2011.

5. Henry M. Levin, Patrick J. McEwan, **Cost-Effectiveness Analysis: Methods and Applications**, 2nd Edition, SAGE Publications Inc., 2000.

6. Rubin, Edward, **Introduction to Engineering and the Environment**, McGraw-Hill Science/Engineering/Math, 2000.

7. **For Indian Energy and Environment policy program and Act**, please refer to the MNRE website: `http://www.mnre.gov.in/`

8. Mohammad Naseem, **Energy Law in India**, Wolters Kluwer, 2011.

9. Karen Makuch, **Environmental and Energy law**, Wiley, 2012.

10. SKL Chaterjee, **Commentary on Electricity Laws in India**, 1st Edition, Delhi Law House, 2006.

## 8.10 EN 505P: Energy Systems Laboratory

**Course Code: EN 505P**
**Course Name: Energy Systems Laboratory**

L-T-P-C: 0-0-4-2
Prerequisites: None
Students intended for:
Elective or Core: Core for M.Tech. Energy Engineering
Approval: 10th Senate

**List of Experiments**

- Study of properties of fuel oils & biomass, calorific value of Biomass samples
- Testing of Gasifier: Effect of feedstock on heat output and pollutants
- Energy conservation study of IC Engine
- Fabrication of photovoltaic solar cell
- Performance assessment of PV modules: I-V Characteristics and Efficiency of a Solar PV cell
- Measurement of Solar Radiation and study of efficiency of a Flat Plate Solar Collector
- Piezo-electric energy harvesting: comparison of conversion efficiency of different materials and effect of vibration frequency on conversion efficiency
- Electrical machines characteristics
- Pollutant level measurement
- Boiler, Pump & motor efficiency testing
- Characterization of Refrigeration system
- Study of fuel cells and measurement of their efficiency
- Implementation of a solar powered pump
- Design and implementation of a solar powered home with 24/7 availability of electricity
- Visit of Hydro-electric power plant
- Visit of Thermal power plant

## 8.11 EN 506 : Design of Energy Systems

**Course Code: EN 506**

**Course Name : Design of Energy Systems**

L-T-P-C : 3-0-0-3
Intended for : UG/PG
Prerequisite : Instructor Consent
Mutual Exclusion : None
Approval: 9th Senate

**Course Contents:**

- **Module I:** Introduction to energy systems, Introduction to critical components for design in energy system, thermal stresses, material selections (4 Lectures)
- **Module II:** Design of pressure vessels, Stresses in pressure vessels, Autofrettage, Thermal stresses, Design of pressure vessel components such as shell, heads, nozzles, flanges as per ASME & IS codes, Buckling (6 Lectures)
- **Module III:** Design of high pressure power plant piping systems, flow characteristics, material selection, thermal analysis of pipe and joints, thermal insulations (4 Lectures)
- **Module IV:** Design of material handling in power plants, coal conveyor belts, ash handling system, slurry disposal system, handling of radioactive materials (8 Lectures)
- **Module V:** Design of heat transfer equipments, Boilers: classification, selection, Heat exchangers: classification, selection, flow friction and pressure drop analysis, basic them1al design, eNTU, p-NTU, MTD methods. Shell and tube heat exchanger, construction and thermal features, thermal design procedure, Kern method, Bell Delaware method (8 Lectures)
- **Module VI:** Thermal design of regenerators, classifications, design parameters. Design of compact heat exchangers, plate and fin, fm-tube and plate and frame heat exchangers, fouling and corrosion in heat exchangers (6 Lectures)
- **Module VII:** Wind turbine blade design, overview of design criteria and certification guidelines_, aerodynamic design, structural design, design and choice of sub-systems and components (6 Lectures)

**Reference Books:**

1. J. F. Harvey, **Theory and Design of Pressure Vessels**, CBS Publishers and Distributors, 1987.
2. S. Walas, **Chemical Process Equipment, Selection and Design**, Buterworths Sr. in Chemical Engineering.
3. L. Brownell, E. Young, **Process Equipment Design**, John Wiley and Sons.

4. D. Kern, **Process Heat Transfer**, Tata McGraw-Hill, 2000.

5. Fraas, **Heat Exchanger Design**, 2nd Edition, John Wiley & Sons, 1989.

6. J. Manwell, J. McGowan, A. Rogers, **Wind Energy Explained, Theory, Design and Application**, Wiley, 2012.

7. R. Kulwiec, **Materials Handling Handbook**, ASME, John Wiley and Sons.

8. W. Stoecker, **Design of thermal systems**, 3rd Edition, Tata McGraw-Hill Education.

## 8.12 EN 507 : Transport Phenomena for Energy Systems

**Course Code: EN 507**

**Course Name : Transport Phenomena for Energy Systems**

L-T-P-C : 3-0-0-3
Intended for : UG/PG
Prerequisite : Instructor Consent
Mutual Exclusion : None
Approval: 9th Senate

**Course Contents:**

**Module I**: Introduction to transport phenomena, Vectors and tensors, types/uses of control volume, notion of conservation principles and constitutive relations (4 Lectures)

**Module II**: Mechanisms of momentum transport, shell-momentum balance, equations of change for isothermal systems, applications of shell-momentum balance and equations of change to solve lD problems in laminar flow, time dependent flow of Newtonian fluids, stream function and velocity potential, time smoothed equations for turbulent flows, boundary layer flow past different bodies (16 Lectures)

**Module III**: Thermal conductivity and energy transport, Fourier's law of heat conduction, shell-energy balance and boundary conditions, equations of change for non-isothermal systems, temperature distributions and unsteady heat conduction in solids, steady and unsteady free convection, temperature distributions in turbulent flow and turbulent heat flux, forced convection in tubes, submerged bodies and packed beds (14 Lectures)

**Module IV**: Mechanisms of mass transport, Fick's law of diffusion, shell-mass balance, equations of change for multi-component systems, laminar flow concentration profiles, steady and unsteady convective mass transport, diffusion in gases and liquids, .multi-component mass diffusion, reaction rates, mechanisms, time scales (8 Lectures)

**References:**

1. R. Byron Bird, Warren E. Stewart, Edwin N. Lightfoot, **Transport phenomena**, 2nd edition, Wiley, 2001.

2. J.C. Slattery, **Advanced transport phenomena**, Cambridge University Press, New York, 1999.

3. Welty J.R, Wicks J.E, Wilson R.E, Rorrer G, **Fundamentals of momentum, heat and mass transport**, 4th Edition, Wiley, 2001.

## 8.13 EN 508: Solid Mechanics for Energy Systems

**Course Code: EN 508**
**Course Name: Solid Mechanics for Energy Systems**

L-T-P-C: 3-0-0-3
Prerequisites: Mechanics of Solid
Students intended for: UG/PG
Elective or Core: Compulsory for Energy Engineering (Mechanical) and Elective for others
Approval: 9th Senate

**Course contents**

- **Introduction**

  Motivation for course; Review of elementary solid mechanics. [1 Lecture]

- **Kinematics**

  deformation, displacements, strain tensors, strain-displacement relations, compatibility equation. [3 Lectures]

- **Kinetics**

  Traction vector, stress tensors, principle stresses, equations of motion, equilibrium. [3 Lectures]

- **Constitutive Equations**

  anisotropic/orthotropic/transversely isotropic/ isotropic materials, generalized Hooke's law, linearized elasticity. [3 Lectures]

- **Basic Principles**

  stress and displacement formulations for energy system, superposition, St. Venant's principle, boundary conditions. [3 Lectures]

- **Variational Methods**

  strain energy, uniqueness, complementary energy, potential energy, virtual work principle, minimum total potential/complementary energy principle, approximate solutions. [4 Lectures]

- **Two-Dimensional (2-D) Theory**

  plane stress and plane strain, anti-plane shear, Airy's stress function, inverse method, complex variable method, displacement solution. [3 Lectures]

- **2-D Problems**

  Energy component (beam) bending, plate with a hole, curved beams, pressurized cylinders, wedges, rotating disks [3 Lectures]

- **Torsion**

  St. Venant torsion theory, Prandtl stress function, membrane analogy. [3 Lectures]

- **The finite element method for numerical analyses of energy system**

  Finite elements, Element, interpolation functions, Element strains, stresses and strain energy density, Element Stiffness Matrix, Global Stiffness Matrix, Boundary conditions. Demonstration of FEM based software (ANSYS) for analyzing stress, deformation and failure in components, assemblies and structures. [8 Lectures]

- **Boundary value problems for energy system made of elastic-plastic materials**

  Tension-torsion of thin walled tubes, Plastic limit load, Approximate methods in metal forming. [4 Lectures]

- **Failure modes in Energy components**

  Fracture, Fatigue, Buckling, Large deflections, Plastic collapse. [4 Lectures]

**Text and Reference Books:**


1. S. P. Timoshenko and J. N. Goodier, **Theory of Elasticity**, 3rd Edition, McGraw-Hill, New York, 1970
2. W. S. Slaughter, **The Linearized Theory of Elasticity**, Birkhauser, 2002 .
3. R. W. Little, **Elasticity**, Prentice-Hall, 1973.
4. P. Boresi and K. P. Chong, **Elasticity in Engineering Mechanics**, 2nd Edition, Wiley, 2000.
5. Hertzberg R.W., Vinci R.P., Hertzberg J., **Deformation and Fracture Mechanics of Engineering Materials**, Wiley, 2012.


## 8.14 EN 509_TD:Thermodynamics for Energy Systems

**Course Code: EN 509**
**Course Name: Thermodynamics for Energy Systems**

L-T-P-C: 3-0-0-3
Prerequisites: Instructor Consent
Students intended for: UG/M. Tech/MS/PhD
Elective or Core: Core for M. Tech Energy Engineering (Mechanical), elective for UG/MS/PhD
Approval: 9th Senate; Changed to ME 634 (11th Senate)

**Course contents**

- **Laws of Thermodynamics**

  The first law for open and closed system; steady and transient processes, work and heat transfer; second law of thermodynamics for open and closed systems; Local temperature equilibrium (LTE) Model, entropy maximum an energy minimum principles [ Lectures]

- **Module II**

  Entropy; Concept of reversibility and irreversibility; change in entropy in various thermodynamic processes, entropy balance for closed and open systems, mechanism of entropy generation, entropy generation minimization. [ Lectures]

- **Single and multiphase systems**

  Maxwell relatios; Clasius-Clapeyron equation; Gibbs-Duham relation, phase diagrams; phase transition; types of equilibrium and stability; multi-component and multi-phase systems, equations of state. [ Lectures]

- **Combustion and Thermochemistry**

  Stoichiometry of reactions, enthalpy of formation and reaction, adiabatic flame temperature, second law availability analysis of chemical reactions. [ Lectures]

- **Advanced Thermodynamic Cycles**

  Advanced vapour power cycles; advanced gas power cycles, combined cycle power cycles, cogeneration. [ Lectures]

- **Module VI**

  Exergy Analysis of energy systems and case studies. [ Lectures]

**Text and Reference Books:**


1. A. Bejan, **Advanced Engineering Thermodynamics**, Wiley, 2006.

2. M. J. Moran and H. N. Shapiro, **Fundamentals of Engineering Thermodynamics**, John Wiley and Sons

3. C. Borgnakke, G. Van Wylen and R. E. Sonntag, **Fundamentals of Thermodynamics**, Wiley India


## 8.15 EN 509: Functional Materials for Energy Engineering

**Course Code: EN 509**
**Course Name: Functional Materials for Energy Engineering**

L-T-P-C: : 3-0-0-3
Prerequisites: None
Students intended for: UG/PG
Elective or Core: Compulsory for M. Tech. in Energy Engineering with specialization in Materials, and Elective for others
Mutual Exclusion: ME 609
Approval: 33rd Senate; 44th BoA

**Course contents**

- **Introduction**

  Definition of functional materials, Different kind of functional materials; Inorganic and organic functional materials, Metal organic framework based materials, Hybrid organic-inorganic Perovskites, Use of functionalities of materials in fabricating devices, Causes for observed functionality in a material; Functionality arising due to (i) electronic, (ii) spin, and (iii) ionic degrees of freedom; Exploitation of combined effects in designing new functional materials. [4 Lectures]

- **Functionality driven by electronic degrees of freedom**

  Atoms and crystalline solids; electronic states of atoms and crystalline solids; Formation of bands in crystalline solids; Band dispersions; Density of states; Metals, semiconductors and insulators; Direct and indirect band gap semiconductors; Formation of impurity bands in the p-type and n-type semiconductors; Electrons effective mass in a semiconductor; Transport and optical properties of a semiconductor; Opto-electronic materials. [12 Lectures]

- **Functionality driven by spin degrees of freedom**

  Formation of magnetic moment in an atom; Spin and orbital part of magnetic moment in a solid; Magnetization of a solid; Diamagnetic, paramagnetic, ferromagnetic, and antiferromagnetic materials; Different kind of antiferromagnetic structures; Exchange interaction; Determination of magnetic transition temperature using mean-field theory; Formation of domain wall in ferromagnetic material; Soft and hard ferromagnets; CMR/GMR materials. [10 Lectures]

- **Functionality driven by ionic degrees of freedom**

  Covalent, ionic and metallic solids; Formation of dipole moment; Polarization of a material; Paraelectric, ferroelectric, antiferroelectric, piezoelectric, and pyroelectric materials; formation of domain wall in ferroelectric material; Multiferroic materials. [6 Lectures]

- **Functionality driven Energy Devices**

  Energy efficient devices, Light emitting diodes, Power Electronic Devices, Quantum computers and devices, Opto-electronic devices, Thermoelectric Devices, Electro caloric and Magneto caloric devices, Photovoltaic Devices. [10 Lectures]

**Text Books:**

1. N.W.Ashcroft and N.D. Mermin, **Solid State Physics**, Harcourt College Publishers, 1976.

2. Marius Grundmann, **The Physics of Semiconductors: An Introduction Including Devices and Nanophysics**, Springer, 2010.

**Reference Books:**

1. R.M.Martin, **Electronic Structure: Basic Theory and Practical Methods**, Cambridge University Press, 2004.

2. K.F. Wang, J. – M. Liu, and Z.F.Ren, **Multiferroicity: the coupling between magnetic and polarization orders**, *Advances in Physics*, 58, 321, 2009.

## 8.16 EN 510 : Electrochemical Systems for Energy Engineering

**Course Code: EN 510**

**Course Name : Electrochemical Systems for Energy Engineering**

L-T-P-C : 3-0-2-4

Intended for : UG/PG (Compulsory for MTech. in Materials and Energy Engineering, and Elective for others)

Prerequisite : None

Mutual Exclusion : None .

Approval: 44th BoA

**Course Contents:**

- **Electrochemical Engineering Fundamentals:** Electrical Current/Voltage, Faraday's Laws; Electric Efficiency, and Mass Balance; Electrode Potentials and Electrode–Electrolyte Interfaces; Potential Difference; Electrochemical Cells- Galvanic, Electrolytic and concentration. [5 Hours]
- **Thermodynamics and Kinetics of an Electrochemical Cell:** Electrochemical Cell Phases; The Nernst Equation; Mass Transfer Modes; Electrode Kinetics (Charger Transfer (Butler–Volmer Equation) and Mass Transfer (Diffusion Laws)); Limitations of Butler–Volmer Equation; Limiting Current Density; Galvanostatic Polarization; Polarization Methods- Linear Polarization, Tafel Extrapolation. [9 Hours]
- **Batteries:** Introduction; Basic Li battery; Lead acid battery; Nickel-Metal Hydride (Ni-MH) Rechargeable Batteries; Metal–Air batteries; Self-discharge of batteries; Jump starting a car; Battery safety and toxicity. [6 Hours]
- **Fuel Cells:** Introduction; Variety of fuel cells- proton exchange membrane fuel cell, Solid oxide fuel cell, Direct methanol fuel cell, Alkaline fuel cells; Hybrid fuel cell- battery system; Hydrogen Storage [6 Hours]
- **Supercapacitor:** Introduction; Electric double-layer capacitors (EDLCs); Pseudocapacitor; Asymmetric hybrid capacitors; Concerns with cell assembly; Energy density and power density. [5 Hours]
- **Electroanalytical methods:** Cyclic voltammetry and linear sweep voltammetry; The need for a reference electrode; Impedance Spectroscopy; Chronoamperometry; The open circuit potential; Galvanometric charge-discharge; Ring disc electrode [8 Hours]
- **Electrochemical manufacturing:** Electroplating; Electroless plating; Electrochemical machining and polishing. [3 Hours]

**Laboratory/practical/tutorial Modules: [28 Hours]**

- Experiment 1: Sample preparation
- Experiment 2: Cyclic voltammetry and linear sweep voltammetry
- Experiment 3: Impedance Spectroscopy
- Experiment 4: Chronoamperometry
- Experiment 5: Galvanometric charge-discharge
- Experiment 6: Ring disc electrode

**Text books:**


1. Zhang, J., Zhang, L., Liu, H., Sun, A., & Liu, R. S. (Eds.), **Electrochemical Technologies for Energy Storage and Conversion**, 2 Volume Set (Vol. 1). John Wiley & Sons, 2011.
2. Braun, A., **Electrochemical Energy Systems**, de Gruyter, 2018


**References:**


Dicks, A. L., & Rand, D. A. (2018). Fuel cell systems explained. John Wiley & Sons.


## 8.17 EN 511: Structure- Property Characterization

**Course Code: EN 511**
**Course Name: Structure- Property Characterization**

L-T-P-C: 3-0-0-3
Prerequisites: Instructor Consent
Students intended for: UG/PG
Elective or Core:
Approval: 9th Senate; Updated in 44th BoA

**Course contents**

- **Module I**

  Introduction to materials, their structural and functional applications, classification of materials, structure of Materials: crystals structure, phase diagrams; binary systems, micro structure of singles phase and two phase materials, Determination of str. using X-ray diffraction and microscopy. [15 Lectures]

- **Module II**

  Properties of materials: mechanical properties of (1) single phase materials, role of grain boundaries, (ii) two phase materials-precipitation and dispersion hardening systems, morphology of second phase and its influence on mechanical properties (iii) composites. [15 Lectures]

- **Module III**

  Conductors and semiconductor devices, magnetic properties, dielectric properties and their relation with structure. [12 Lectures]

**Text and Reference Books:**

1. A.J.Dekker, **Electrical Engineering Materials**
2. Hummel, **Electronic Properties of Materials**, Springer
3. Anthony R. West, **Solid State Chemistry and Its Applications**,John Wiley & Sons.

## 8.18 EN 511_44 BoA : Computational Methods in Material Science

**Course Code: EN 511_44 BoA**

**Course Name : Computational Methods in Material Science**

L-T-P-C : 1-0-6-4
Intended for : UG/PG (Compulsory for MTech. in Materials and Energy Engineering, and Elective for others)
Prerequisite : Instructor's consent
Mutual Exclusion : None .
Approval: 44th BoA; Old: 9th Senate

**Course Contents:**

**Theory:**

- Density functional theory, Pseudo potentials, Plane wave and Projector augmented wave methods, Exchange-correlation functionals, Self-consistent solutions, Density of states, Band structures, Optical properties, Electrical & thermal conductivities, Seebeck coefficient, Polarization, Piezoelectric tensor, Specific heat, Entropy, Free energy, Elastic tensors, Moduli of elasticity, phonon dispersion, and Machine learning. [14 Hours]

**Laboratory/practical/tutorial Modules: [84 Hours]**

- Part-1: Introduction to the various features of ABINIT code. Calculations of properties related to
  - Photovoltaic materials: Density of states, Band structures, & Optical properties;
  - Thermoelectric materials: Electrical conductivity, thermal conductivity, Seebeck coefficient, Specific heat, Entropy, Free energy; and
  - Piezoelectric materials: Polarization, Piezoelectric tensor, Elastic tensors & Moduli of elasticity. [48 Hours]

- Part-2: Introduction to the various features of AFLOW and JARVIS codes. Search of new materials with better
  - Electronic,
  - Optical,
  - Thermoelectric, and
  - Piezoelectric properties. [20 Hours]
- **Project:** Proposing and demonstrating various scenarios for improving the properties of the existing state-of-the-art Photovoltaic, Thermoelectric, and Piezoelectric materials. [16 Hours]

**Text books:**

1. Richard M. Martin, **Electronic Structure: Basic Theory and Practical Method**, Volume 2, Cambridge University Press, 2020.
2. Tim Mueller, Aaron Gilad Kusne and Rampi Ramprasad, **Machine Learning in Materials Science: Recent Progress and Emerging Applications**, A Chapter in Reviews in Computational Chemistry, Volume 29, Editors: Abby L. Parrill and Kenny B. Lipkowitz, John Wiley & Sons, Inc., 2016

**References:**

1. Burke, Kieron, **The abc of dft**, Department of Chemistry, University of California 40 (2007).

## 8.19 EN 512_old : Creep-Fatigue Interaction

**Course Code: EN 512_9th Senate**

**Course Name : Creep-Fatigue Interaction**

L-T-P-C : 3-0-0-3
Intended for : UG/PG
Prerequisite : Mechanical Behaviour of Materials
Mutual Exclusion : None
Approval: 9th Senate; Updated in 44th BoA

**Course Contents:**

- **Module I**: High temperature deformation and creep behavior, uniaxial and multi axial creep model, High temp fracture, nucleation and growth of creep, cavities, creep crack nucleation and growth, creep damage theory, and prediction of creep life. (20 Lectures)
- **Module II**: Creep-fatigue failure diagnosis, Creep-fatigue based design criteria, modeling of creep fatigue interaction and case studies (24 Lectures)

**References:**

1. J-S. Zhang, **High Temperature Deformation and Fracture of Materials**, ISBN: 978-0-85709- 079-9.

## 8.20 EN 512 : Structure-Property Correlations for Energy Applications

**Course Code: EN 512**

**Course Name : Structure-Property Correlations for Energy Applications**

L-T-P-C : 1-0-4-3

Intended for : UG/PG (Compulsory for MTech. in Materials and Energy Engineering, and Elective for others)

Prerequisite : IC241 (Materials Science for Engineers)/ Instructor Consent

Mutual Exclusion : None .

Approval: 44th BoA

**Course Contents:**

- **Module - 1:** Introduction to energy materials; photovoltaics, electrochemical systems, thermoelectrics, solar thermal systems. Importance of materials characterization (2 hours).
- **Module - 2:** Structure of Materials – Crystal structure, micro-structure, and macrostructure; Determination of crystal structure by diffraction, X ray diffraction and electron and neutron diffraction; Vibrational spectroscopy (IR and Raman spectroscopy) for structural characterization of materials. (4 Hours)
- **Module - 3:** Microstructure determination by light, and electron microscopy (SEM and TEM); binary alloys and distribution of phases in microstructure. (2 Hours)
- **Module - 4:** Thermal analysis by TGA-DSC; Determination of enthalpy, melting, decomposition and phase transition temperatures. (2 Hours)
- **Module - 5:** Mechanical property determination by indentation and tensile test, Stress-Strain diagram (2 Hours)
- **Module - 6:** Basics of electronic band structure, Electrical and optical properties of energy materials, determination of bandgap, Absorption (UV-Vis), emission (Photoluminescence) (2 Hours)

**Laboratory/practical/tutorial Modules: [42 Hours]**

- **Structural Characterization (Module-1):**
  - Preparation and processing of specimen and structural characterization using XRD, Determination of crystal structure by X-ray diffraction in a diffractometer
  - Preparation and processing of specimen and structural characterization using FT-IR, and Raman spectroscopy

- **Microstructural Characterization (Module-2):**
  - Preparation and processing of specimen and observation of microstructure in single phase alloy under optical microscope, scanning electron microscope
  - Preparation and processing of specimen and observation of microstructure and electron diffraction using transmission electron microscope
- **Thermal Characterization: (Module-3):**
  - Preparation and processing of specimen and thermal characterization using TGA-DSC
  - Thermal conductivity measurement
- **Mechanical Characterization (Module-4):**
  - Preparation and processing of specimen and characterization of mechanical property using tensile test UTM
  - reparation and processing of specimen and elastic modulus as well as hardness measurements by indentation method.
- **Electrical and Optical Characterization (Module 5):**
  - Preparation and processing of specimen and characterization of Current voltage measurement, electrical conductivity, opto-electrical property.
  - Preparation and processing of specimen for Absorption (UV-Vis), emission (Photoluminescence/fluorescence) spectroscopy and determination of band gap.

**Text books:**

1. Robert E Reed-Hill and Reza Abbaschian, **Physical Metallurgy Principles**, Thomson, 2003 reprint.

2. R. E. Hummel, **Electronic Properties of Materials**, Springer, 4th ed. 2011

**References:**

1. Mauro Sardela, **Practical Materials Characterization**, Springer New York, 2014

2. A.R. West, **Solid-State Chemistry and Its Applications**, Wiley, 2014

## 8.21 EN 513: Life Extension Engineering

**Course Code: EN 513**
**Course Name: Life Extension Engineering**

L-T-P-C: 3-0-0-3
Prerequisites:
Students intended for: UG/PG
Elective or Core:
Approval: 9th Senate

**Course contents**

- **Module I**

  Inspection, monitoring and materials degradation, Structural integrity assessment (input parameters and assessment method) and life prediction, Risk assessment, life extension and economics. [10 Lectures]

- **Module II**

  Life prediction for boiler components: Materials and damage mechanism, boiler tube failure mechanism, Header-damage mechanism, Damage mechanism in steam pipes, Damage and life assessment of boiler component, Extrapolation of statistics of part failures, Methods based on temperature estimation, Integrated methodology for life assessments.

  Life assessment for steam-turbine components: Materials and damage mechanism, Service failure experience, Remaining life assessment: methods for rotors, Remaining life assessment of valves and steam chests, Remaining-life analysis of blades, Remaining-life assessment of bolts. [12 Lectures]

- **Module III**

  Life assessment techniques for combustion-turbines: Life assessment techniques, Crack initiation assessment, Crack-propagation analysis for vanes, Crack tolerance of blades, Integrated methodology for life assessment. [8 Lectures]

- **Module IV**

  Service life, reliability and maintenance of structures: Structural reliability and service life Time dependent reliability and service life. Probabilistic methods for service life estimation of engineering structures. [6 Lectures]

- **Module V**

  Pipeline rehabilitation systems for service life extension: Extending service life,Trenchless renewal methods (TRMs), Selection of renewal method , Current design concepts for pipeline renewals, Emerging design concepts for pipeline renewal systems, Long-term testing. [6 Lectures]

**Text and Reference Books:**

1. Viswanathan, Ramaswamy, **Damage mechanisms and life assessment of high temperature components**, ASM international, 1989.

2. **Proceedings of the Third International Conference on Engineering Structural Integrity Assessment** organised by The Dynamic Testing Agency in conjunction with AEA Technology, held at Churchill College, Cambridge, U.K., September 24-26, 1996 Editors: J.H.Edwards, P.E.J. Flewitt, B.C. Gasper, K.A. McLarty, P. Stanley and B. Tomkins, 1996.

3. Karbhari, Vistasp M., and Luke S. Lee, **Service life estimation and extension of civil engineering structures**, 1st edition, Woodhead Publishing Limited, Elsevier, 2010.

## 8.22 EN 604: Energy: Environment Policy and Law

**Course Code: EN 604**
**Course Name: Energy: Environment Policy and Law**

L-T-P-C: 3-0-0-3
Prerequisites: None
Students intended for: UG/PG
Elective or Core: Energy core for M. Tech. (Energy Materials) and elective for B. Tech., M.S., and Ph. D. students
Approval: 9th Senate

**Course contents**

- **Engineering Economics**

  Estimation, Supply, Demand, Cost, Elasticity, Pareto Efficiency, Welfare Economics, Social Discounting, Hyperbolic Discounting, Pricing, Borrowing, Depreciation, Taxes, Market Failure, Risk Modeling, Attitudes and Utility, Multi-Attribute Decisions and Stochastic Dominance, Monte Carlo Simulation, and Cost Effectiveness Analysis/Value of Life. [14 Lectures]

- **Energy Economics**

  Unit cost calculation of power generation from different energy sources, Rules for investment in Energy sector, Payback period, NPV, IRR, ERR, and Benefit-cost analysis, Net Social Benefit (with Free riding concepts) and Rebound effects, Energy-GDP elasticity, Financing of energy systems, Energy – economy interaction, renewable and non-renewable sources of energy with their advantages and disadvantages on environment and climate change. [14 Lectures]

- **Energy Policy and Environmental Law**

  Energy policy, Tariffs and subsidies, Taxes, National energy plan and five-year plans, Energy Models, Trend analysis, Costs of exploration and alternate energy, International energy supply, Energy Pricing, Environment interaction, Clean development mechanism, Overview of renewable energy policy in India, India's Plan for a domestic energy cap & trade scheme, and renewable energy credits. Federalism, Energy Regulation, Environmental law with a focus on Water (prevention & control of pollution) act 1974, Environmental protection act 1986, and effluent standards and ambient air quality standards. Legal Regimes Governing Primary Sources of Energy – Non – Renewable and Renewable, and Regulatory Framework concerning Electricity, Gas, Coal, and Renewable Energy. [14 Lectures]

**Text Books:**


1. Tiwari, G. N., & Mishra, R. K., **Advanced Renewable Energy Sources**, Royal Society of Chemistry, 2011.

2. Tung Au, Thomas P. Au., **Engineering Economics for Capital Investment Analysis**, Fac Sub edition, Prentice Hall, 1991.

3. Robert T. Clemen, Terence Reilly, **Making Hard Decisions with Decision Tools Suite**, Cengage Learning. 2004.

4. Laurance R. Geri, David E. McNabb, **Policy in the U.S.: Politics, Challenges, and Prospects for Change**, CRC Press, 2011.

5. Henry M. Levin, Patrick J. McEwan, **Cost-Effectiveness Analysis: Methods and Applications**, 2nd Edition, SAGE Publications Inc., 2000.

6. Rubin, Edward, **Introduction to Engineering and the Environment**, McGraw-Hill Science/Engineering/Math, 2000.

7. **For Indian Energy and Environment policy program and Act**, please refer to the MNRE website: `http://www.mnre.gov.in/`

8. Mohammad Naseem, **Energy Law in India**, Wolters Kluwer, 2011.

9. Karen Makuch, **Environmental and Energy law**, Wiley, 2012.

10. SKL Chaterjee, **Commentary on Electricity Laws in India**, 1st Edition, Delhi Law House, 2006.

## 8.23 EN 605: Modeling and Simulation of Energy Systems

**Course Code: EN 605**
**Course Name: : Modeling and Simulation of Energy Systems**

L-T-P-C: : 2-0-2-3
Prerequisites: None
Students intended for: UG/PG
Elective or Core: Compulsory for M. Tech in Energy Engineering and elective for others
Approval: 9th Senate

**Course contents**

- **Physical Modelling**

  Dimensional analysis and dimensionless groups, Similarity criteria, development of physical models based on similarity and dimensionless group. Application of physical modelling to energy systems. [6 Lectures]

- **Mathematical modelling**

  Continuous time dynamic modelling through differential equation, lumped parameter and distributed parameter models, Input-output models, transfer function, state space models and their transfer functions, models for control, transient and steady state response, stability; Simulation of models by MATLAB, applications of dynamic modelling and simulation to energy management in ships and PV systems. [8 Lectures]

- **Fuzzy logic Modelling**

  Fuzzy sets, membership function, operations with fuzzy sets, Fuzzy knowledge, Fuzzy inference systems, fuzzy approach to identify power transformer criticality, data clustering to evolve fuzzy models, design of fuzzy logic controller for optimal control of boiler-turbine system. [5 Lectures]

- **Artificial neural network (ANN) modelling**

  Neuron, Neural network and its architecture, training, validation and test of the back propagation network (BPN), modelling of solar distillation system, ANFIS models. [6 Lectures]

- **Non-traditional techniques of optimization**

  simulated annealing and genetic algorithm. [3 Lectures]

**Text Books:**

1. Josef Kunes, Similarity and Modeliling in Science and Engineering, Cambridge International Science Publishing, 2012.

2. Katsuhiko Ogata, Modern Control Engineering, Prentice Hall India,

3. Timothy J. Ross, Fuzzy logic with eEngineering Applications, John Wiley & Sons, 2010.

4. Simon Haykin, Neural Networks, Pearson Education Inc.,1999.

5. K. Deb, Optimization for Engineering Design, Prentice Hall India Pvt. Ltd.,1991.

## 8.24 EN 611: : Durability Behavior of Energy Materials

**Course Code: EN 611**
**Course Name: : Durability Behavior of Energy Materials**

L-T-P-C: : 3-0-0-3
Prerequisites: None
Students intended for: UG/M.Tech./ MS/ PhD
Elective or Core: Compulsory for M.Tech. in Energy Engineering with specialization in Materials, and Elective for others
Approval: 10th Senate

**Course contents**

- **Static loading and Deformation behavior**

  Distinctive load – elongation behavior of different types of materials under uniaxial loading, definition of stress and strain, stress-strain diagram, elastic behavior, yielding and plastic behavior of ductile materials; necking instability, Important design criteria based on stress and strain at ambient temperature; strain rate and its influence of stress-strain diagram at elevated temperature. [4 Lectures]

- **Durability under static loading**

  Defects in materials; linear defects or dislocations – types, burgers vector, slip, slip planes and slip directions, cross slip and climb, movement of dislocations leading to plastic deformation, stacking fault and partial dislocations, strain hardening, grain boundaries, strengthening mechanisms; recovery, recrystallization and grain growth during heating of deformed materials. [6 Lectures]

- **Durability under Creep Deformation**

  Deformation under static loading at elevated temperature - creep curve, mechanisms of creep, temperature dependence of creep, deformation mechanism maps, cavitations, stress rupture versus creep, extrapolation schemes; Development of materials for ultra supercritical boilers for application in furnace panels, super-heaters, thick section components and steam lines. [8 Lectures]

- **Durability under Cyclic Loading**

  Deformation under cyclic loading, high cycle fatigue – S-N curve, effect of mean stress, Miner rule, cyclic stress-strain curve, low cycle fatigue, strain life equation, effect of stress concentration and size of component, Design for fatigue, effect of temperature on fatigue; development of turbine materials. [8 Lectures]

- **Durability under corrosion**

  Overview of corrosion, corrosion in water and steam, High temperature corrosion; corrosion under boiler flue gases, hot corrosion in gas turbine components, materials protection by coating. [6 Lectures]

- **Durability under Erosion and Cavitation**

  Overview of wear, erosion and cavitation wear, thermally sprayed coatings and weldings for repair of hydro-turbines and pumps. [6 Lectures]

**Text Books:**

1. George E. Dieter, **Mechanical Metallurgy**, McGraw Hill Book Company 1986

2. J. Lecomte-beckers, M. Carton, F. Schubert and P.J. Ennis (Editors), **Materials for Advanced Power Engineering**, Vol.53, Part-1, 2006.

3. Zaki Ahmed, **Principles of Corrosion Engineering and Corrosion Control**, Elsevier Science & Technology Books, 2006.

4. Peter J. Blau, **Friction and Wear transitions in Materials**, Noyes Publications, 1989

## 8.25 EN 612: Structure - Property correlation in materials for Energy Applications

**Course Code: EN 612**
**Course Name: Structure - Property correlation in materials for Energy Applications**

L-T-P-C: : 2-0-2-3

Prerequisites: IC241 (Materials Science for Engineers)/ Instructor Contest

Students intended for: UG/M. Tech./ MS/ PhD

Elective or Core: Compulsory for M. Tech. in Energy Engineering with specialization in Materials, and Elective for others

Approval: 10th Senate

**Course contents**

- **Module I**

  Structure of Materials – Crystal structure, micro structure and macrostructure; Determination of crystal structure by X-ray diffraction and microstructure by optical, scanning and electron microscopy, selected area diffraction; Phase diagram of binary alloys and distribution of phases in microstructure of cast and wrought alloys [10 Lectures]

- **Module II**

  Ni-based super-alloys – Austenitic Ni-Cr binary alloys, Ni-based superalloys based on $\gamma$ phase containing, nickel, cobalt, iron, chromium and molybdenum, Coherent and incoherent precipitates, y (Ni3Al based L12 structure) precipitates, nickel – iron superalloys (IN718 and IN706) hardened by $\gamma$" (Ni3Nb based D022 structure), basal plane coherency, Grain growth and pinning of grain boundaries, Carbides and borides in superalloys; refractory elements and hard intermetallic TCP phases, Influence of microstructure on strength, ductility and creep life. Iron and cobalt based superalloys. [10 Lectures]

- **Module III**

  Conductors and semiconductor devices, solar photovoltaic materials, organic photovoltaic materials. [8 Lectures]

**Experiments:**

1. Determination of crystal structure by X-ray diffraction in a diffractometer
2. Preparation of specimen and observation of microstructure in single phase alloy under optical microscope
3. Microstructure of cast and wrought alloys under optical microscope
4. Microstructure of iron based alloys in hydroturbines under optical and electron microscope
5. Microstructure of Ni-based superalloys in steam and gas turbines under optical and electron microscope along with SAD of precipitates.
6. Microstructure of alloys after service – erosion and cavitation in hydroturbines; creep cavitation in high temperature turbines
7. Microstructure of silicon wafers under optical and electron microscope

**Reference Books:**

1. Robert E Reed-Hill and Reza Abbaschian, **Physical Metallurgy Principles**, Thomson, 2003 reprint.
2. Chester T Sims, William C Hagel, **Superalloys II**, Wiley-Interscience, 1987
3. R. E. Hummel, **Electronic Properties of Materials**, 4th Edition, Springer, 2011.

## 8.26 EN 613: Creep-Fatigue Interaction

**Course Code: EN 613**
**Course Name: Creep-Fatigue Interaction**

L-T-P-C: 3-0-0-3
Prerequisites: EN 611 (Durability Behavior of Energy Materials)/ Instructor Consent
Students intended for: UG/MS/PhD/M.Tech.
Elective or Core:
Approval: 10th Senate

**Course contents**

- **Module I**

  High temperature deformation and creep behavior, uniaxial and multi axial creep model, High temp fracture, nucleation and growth of creep, cavities, creep crack nucleation and growth, creep damage theory, and prediction of creep life. [20 Lectures]

- **Module II**

  Creep-fatigue failure diagnosis, Creep-fatigue based design criteria, modeling of creep fatigue interaction and case studies. [22 Lectures]

**Reference Books:**

1. J-S. Zhang, **High Temperature Deformation and Fracture of Materials**, Woodhead Publishing Ltd., 2010.

## 8.27 EN 695P: Post Graduate Project-I

**Course Code : ME 695P**

**Course Name : Post Graduate Project-I**

L-T-P-C: 0-0-4-2
Intended for : MTech. in Materials and Energy Engineering
Prerequisite : None
Mutual Exclusion : None
Approval: 44th BoA; 34th Senate

**Course Modules with quantitative lecture hours:**

The students are expected to conduct their literature survey in the winter term based on the research topic the students and their advisors decide upon. Their level of satisfactory progress will be judged at the beginning of the 2nd semester based on the problem identification and their requisite literature survey. Their involvement on the project will be a key factor of their judgement and will contain various aspects like- discussion with the advisor, completion of literature survey, report writing and presentation.

**Textbooks:**

As suggested by advisor.

**References:**

As suggested by supervisor or the material student finds necessary while working on project

## Other courses and equivalent courses

The following courses are offered with one time approval.

1. EM 500 Design Practicum_11th Senate
2. EM 601 This course is equivalent to EM 504_14th Senate
3. EM 602 Experiments in Materials Science_11th Senate
4. EM 604 Energy: Environment Policy and Law_11th and 18th Senate
5. EM 651 Solar Photovoltaic Materials and Fabrication_14th Senate
6. EM 658 Deformation Behavior of Energy Materials: Equivalent Course is: EN 611 Durability Behavior of Energy Materials_18th Senate
7. EN 509_Old Thermodynamics for Energy Systems; Equivalent course is ME 634 Thermodynamics for Energy Systems
8.

# 9 Electric Transport Courses

## 9.1 ET 501 : Power Electronic Applications in Electric Transportation

**Course Code: ET 501**

**Course Name : Power Electronic Applications in Electric Transportation**

L-T-P-C : 3-0-0-3
Intended for : PG
Prerequisite : Power Electronics/Consent of the instructor
Mutual Exclusion : None
Approval: 44th BoA

**Course Contents:**

- **Introduction to hybrid and electric vehicles** (3 hours)
  - Electrification concepts
  - HEV architectures and classifications
  - Technological trends
  - Electric drivetrains
- **Introduction to Power Electronics** (7 hours)
  - Basic power electronics concepts
  - Overview of power semiconductor devices
  - Various converters for EVs
- **Power electronics Converters** (12 hours)
  - DC-DC converters
  - AC-DC converters
  - DC-AC converters
- **Battery Connected Systems** (6 hours)
  - Battery pack
  - Battery management system
  - Thermal management system
  - Body control unit
- **Charging Infrastructure for EVs** (6 hours)
  - On-board charging
  - Fast charging
  - Battery-swapping station
  - DC-microgrid based charging station
- **Modelling and Simulation** (8 hours)
  - System design considerations
  - Rating and sizing of electric drivetrain components
  - Complete system modelling
  - Simulation of the complete system

**Laboratory/practical/tutorial Modules:**

A laboratory course is proposed separately to support this course.

**Text books:**


1. A. Emadi, M. Ehsani and J. M. Miller, **Vehicular Electric Power Systems: Land Sea Air and Space Vehicles**, New York:Marcel Dekker, 2003.

2. J. Larminie and J. Lowry, **Electric Vehicle Technology Explained**, New York:Wiley, 2003.


**References:**


1. Ned Mohan, Tore M. Undeland, William P. Robbins, **Power Electronics, Applications and Design**, John Wiley & Sons, 2003.

2. M.H. Rashid, **Power Electronics: Circuits, Devices and Application**, Fourth edition, Pearson Education, 2017

3. Sheldon S. Williamson, **Energy Management Strategies for Electric and Plug-in Hybrid Electric Vehicles**, 1st Edition, Springer, 2003.

4. B. K. Bose, **Modern Power Electronics and AC Drives**, Pearson Education India, 2015


## 9.2 ET 502 : Embedded Systems and IoT for E-Transportation

**Course Code: ET 502**

**Course Name : Embedded Systems and IoT for E-Transportation**

L-T-P-C : 3-0-2-4
Intended for : PG
Prerequisite : Digital System Design (EE 210) or equivalent
Distribution : Core for M.Tech in Electric Transportation students, elective for other advanced B.Tech /M.Tech students
Mutual Exclusion : None
Approval: 44th BoA

**Course Contents:**

- **Introduction to embedded systems:** Understanding an embedded system, design metrics, design challenges, technologies for embedded systems. (2 hours)

- **Custom Single Purpose Processor for Embedded Systems**: Design of datapaths and controllers, finite state machines, custom single purpose processor design at RT level, optimizing custom single purpose processors, introduction to hardware description languages, modeling of custom single purpose processors using hardware description languages. (3 hours)

- **Introduction to FPGA**: Introduction to complex digital systems design, notion of programmable logic devices, overview of FPGA architecture, realization of data-path and controller, timing analysis of data-path and controller, synthesis, placement, routing, performance optimization. (2 hours)

- **Introduction to Microcontrollers**: Introduction to microcontrollers, overview of architecture of a typical microcontroller such as AVR microcontroller, addressing, assembly language programming, Memory and I/O interfacing, device drivers for I/O devices. (4 hours)

- **Sensors and Actuators**: Basic principles of sensors and actuators, classification of sensors and actuators, interface methodology and circuits, integration aspects (3 hours) 6. Embedded Systems for Electric Transportation: Battery management system (BMS), cell monitoring, battery safety and protection, state of charge estimation, state of health estimation, cell balancing, thermal management, charging control, BMS architectures. (8 hours)

- **Introduction to IoT**: Overview of Internet of Things, IoT architecture, Communication protocols (4 hours)

- **Protocols for Wired communication**: Device configuration and protocols, e.g., CAN, LIN, FlexRay, MOST, Ethernet, OBDII, (5 hours)

- **Protocols for Wireless communication**: Wifi, ZigBee, Bluetooth Low Energy (BLE) (5 hours)

- **IoT for Electric Transportation**: Centralized charging scheme, decentralized charging scheme, performance comparison and evaluation. (6 hours)

**Experiments for lab: 28 hours**

- Hardware modeling using hardware description language
- Modeling a custom single purpose processor for electric vehicle applications
- Hardware realization using FPGA
- Interrupt handling through microcontroller
- Stepper Motor control using microcontroller
- Battery management using microcontroller
- FPGA based battery management architectures
- Designing a multiprotocol system
- Wired communication using CAN bus, LIN, FlexRay, MOST, Ethernet, OBDII 10. TCP-UDP client server systems
- IoT application layer protocols - MQTT-CoAP
- Applications of IoT on centralized charging scheme
- Applications of IoT in decentralized charging scheme

**Textbooks:**

1. Rui Xiaong, Weixiang Shen, Advanced Battery Management Technologies for Electric Vehicles, Wiley publishers, 2019.

2. James K. Peckol, Embedded Systems: A Contemporary Design Tool, Wiley publishers, 2009.

**Reference books:**

1. Peter Xiao, **Designing Embedded Systems and the Internet of Things (IoT) with the ARM mbed**, Wiley publishers, 2018.

2. Edward Ashford Lee and Sanjit Arunkumar Seshia, **Introduction to Embedded Systems – A Cyber–Physical Systems Approach**, MIT Press, 2017.

3. Charles H. Roth Jr., Lizy Kurian John, **Digital Systems Design Using VHDL**, Cengage Learning, Third Edition, 2016.

## 9.3 ET 503 : Electrical Machine and Drives in Electric Transportation

**Course Code: ET 503**

**Course Name : Electrical Machine and Drives in Electric Transportation**

L-T-P-C : 3-0-0-3
Intended for : UG/PG
Prerequisite : : Electromechanics (EE 201), Control System (EE301) and Power Electronics (EE 309)
Mutual Exclusion : None
Approval: 44th BoA

**Course Contents:**

- **Introduction to Electric Transportation**: Example of EVs; State of the art in Electric Vehicle Technology, Overview of EV technologies, Fuel Cell Electric Vehicles, Hybrid Electric Vehicles (HEVs), Vehicle Dynamics and Drive cycle, Introduction to Railway Systems. (5 Hours)

- **Fundamentals of Electric Drive control**: Control Block diagram, Reference frame Theory, dq-reference frame, PI- controllers Design, Hysteresis controller Control Methods: Field oriented control, Direct torque control, Sensor less control, Model Reference Adaptive Control (MRAC) Approach, Sliding mode control DC machine Drive: Closed loop Speed Control of DC Motor Through armature voltage control and field control, Regenerative Braking Control of motors in the EV: Multi Wheel Drive (MWD) or All Wheel Drive (AWD) systems, Torque vectoring etc. (12 hours)

- **Induction Motor Drives**: Induction Machines: Squirrel Cage Induction Machine and Slip Ring Induction Machines $\alpha\beta$ and dq- modeling of Induction Machines, Inverters for Induction Motors, PWM Switching Inverters, Soft-Switching Inverters

Induction Motor Control: Voltage by Frequency Control, Field-Oriented Control, Direct Torque Control, Design Criteria of Induction Motor Drives for EVs, Design Example of Induction Motor Drives for EVs, Application Examples of Induction Motor Drives in EVs and Railways. (10 hours)

- **Permanent Magnet Brushless Motor Drives**: PM Materials, PM Brushless Machines: Structure of PM Brushless Machines, Principle of PM Brushless Machines, Modeling of PM Brushless Machines, Inverters for PM Brushless Motors, Inverter Requirements, Switching Schemes for Brushless AC Operation, Switching Schemes for Brushless DC Operation PM Brushless Motor Control: PM Synchronous Motor Control, PM Brushless DC Motor Control Design Criteria of PM Brushless Motor Drives for EVs: Design Examples of PM Brushless Motor Drives for EVs, Planetary-Geared PM Synchronous Motor Drive, Outer-Rotor PM Brushless DC Motor Drive, Application Examples of PM Brushless Motor Drives in EVs and Railways. (11 hours)

- **Introduction to Special Machines**: Switched Reluctance machine (SRM), Synchronous Reluctance Machine (SyRM) etc. (4 hours)

**Laboratory/practical/tutorial Modules:**

Nil

**Textbooks:**

1. K. T. CHAU, **Electric Vehicle Machines and Drives: Design, Analysis and Application**, Wiley-IEEE Press, 2015.

2. Morris Brenna, Federica Foiadelli, Dario Zaninelli, **Electrical Railway Transportation Systems**, Wiley-IEEE Press, 2018.

**References:**

1. Ned Mohan, Siddharth Raju, **Analysis and Control of Electric Drives: Simulations and Laboratory Implementation**, Aug. 2020

2. John G. Hayes, G. Abas Goodarzi, **Powertrain: Energy Systems, Power Electronics and Drives for Hybrid, Electric and Fuel Cell Vehicles**

3. W. Leonhard, **Control of Electric Drives**, 2001.

4. P. Vas, **Sensorless Vector and Direct Torque Control**, Oxford Science Publications

5. Boldea, S. A. Nasar, **Electric Drives**, 2nd Edition, CRC Press, 2006.

6. Bose B.K., **Power Electronics and Variable Frequency Drives – Technology and Applications**, IEEE Press, Standard Publisher Distributors. 2001

7. Rashid M., **Power Electronics- Circuits, Devices and Applications**, 3rd Edition, Pearson Education.

8. Krause, P. C., Wasynczuk, O., Sudhoff, S. D., **Analysis of Electric Machinery and Drive Systems**, Wiley-Interscience.

9. S. K. Pillai, **A First Course on Electrical Drives**, New Age International Pvt. Ltd.

10. R. Krishnan, **Electric Motor Drives: Modeling, Analysis, and Control**, Prentice Hall, 2001.

## 9.4 ET 504P: Systems Design for Electric Vehicles

Course number : ET 504 P
Course Name : Systems Design for Electric Vehicles
Credit : 0-0-3-2 (L-T-P-C)
Prerequisite : None
Intended for : M.Tech in Electric Transportation
Distribution : Core for M.Tech in Electric Transportation students,
Semester: Winter Session of Year I
Mutual Exclusion : NA
Approval: 50th BoA

**Course Contents:**

**Course modules:** It is advisable that the projects should be related to the courses M.Tech.(ET) students may credit or the specializations that this program offers. Therefore, students can opt for any project in various subcomponents of EVs. Additionally, they are allowed to select a project from other areas, as long as the project has 30% or more overlap with any of the three specialization of M.Tech. (ET) curriculum.

**Deliverables:** A student must declare the deliverables of her/his project in the initial project proposal after consulting with the respective mentor(s). While the initial project proposal and the final report carry some marks, a significant portion of the marks, 70% or more, is allotted to the deliverables to emphasize their importance.

**Contact hours:** On average, a student should work 40 hours per week on her/his project. The students are supposed to meet their respective mentors at least once in a week to report their progress.

**Evaluation**: There will be two evaluations—one in the beginning of the winter vacation and the other one in the beginning of the forthcoming even semester. In the first evaluation, the students will be graded based on the initial project proposals they have submitted. During the second evaluation, they will be evaluated based on their progress with respect to the promised deliverables, their project reports and the understanding they have gained from their respective projects.

**Textbooks:**

1. Related literature.

# 10 General Engineering Courses

## 10.1 GE 501 : Creative Engineering Design

**Course Code : GE 501**

**Course Name : Creative Engineering Design**

L-T-P-C : 2-0-2-3
Intended for : Open to All
Prerequisite :
Mutual Exclusion:
Approval: 54th BoA

**Course Contents**

- **Understanding Design**: Introduction to Design Principles and Histmy: Evolution of design, key milestones, and influential figures, Comparison of design across cultures and eras, Terminologies and Definitions Product Lifecycle and Systematic Design Process: Stages of the product lifecycle, Introduction to systematic design processes and methodologies. (6 Hours)
- **Thinking Methods**: Introduction to Design Thinking: Core principles and stages of Design Thinking Empathize: User journey mapping, persona development, empathy exercises, affinity diagram, mind map, DefLne, Ideate, Prototype, Test. (8 Hours)
- **Engineering Design**: Characteristics of Successful Products: Analysis of market-leading products and their design attributes, Good Design vs Bad Design. (2 Hours)
- **Problem Design**: Opportunity Identification and Customer Needs: Identifying target groups and stakeholders, Techniques for identifying market gaps and acquiring customer feedback. Task Clarification and User Research: Conducting effective user research and habitat studies, Translating customer feedback into user needs Problem Identification and Analysis: Establish Cause-Effect Relationships in user needs, Benchmark existing products - product and patent study, Creating a requirements list and assigning importance to it and SNPS. (8 Hours)
- **Conceptual Design**: Introduction to Conceptual Design: Function structures and the Sapphire Framework Imagination, Motivation, and Inspiration: Techniques for fostering creativity, such as mood boards and bio-inspiration. Ideation Techniques: Brainstmming, Synectics, Random words and other ideation methods Concept Generation and Visualization Tools: Concept generation by combining ideas. Concept Evaluation and Selection: Analytical, simulation, and physical evaluation techniques. (8 Hours)
- **Systematic Embodiment Design**: System Thinking and System Design, Embodiment Design, Detailed Design, Prototyping, Design for Manufacture, Assembly, and Environment (DFMAE) Prototyping Technologies: Introduction to 3D printing, clay, and foam modeling Teclmiques for rapid prototyping and testing Sketching and Sculpting: Traditional and digital sketching techniques using VR, Basics of sculpting for concept modeling. (10 Hours)

**Textbooks:**

1. Chakrabarti, A., **Engineering Design Synthesis**, Springer, 2013.
2. Kaushik Kumar, Muralidhar Kurni, **Design Thinking a Forefront Insight**, CRC Press, 2023.

**References:**


1. Pahl, G., Beitz, W., **Engineering Design: A Systematic Approach, Vol. 3**, Springer, 2007.
2. Dieter, George E.; Schmidt, Linda C., **Engineering Design**, 5th Edition, McGraw-Hill Education, 2012.
3. Pressman, Andrew, **Design Thinking: A Guide to Creative Problem Solving for Everyone**, Routledge/Productivity Press, 2019.
4. Lewrick, Michael, **Design Thinking and Innovation Metrics**, Wiley Publications, 2023 .
5. Brown, Tim, **Change by Design**, Harper Collins Publisher, 2020.
6. Eriksson, Yvonne, **Different Perspectives in Design Thinking**, CRC Press, 2022.
7. Muller-Rotterberg, Christian, **Design Thinking for Dummies**, John Wiley & Sons, 2020.
8. Cross, N., **Engineering Design Methods,** Vol. 4, John Wiley and Sons Ltd., 2008.
9. Reid, K., Estell, J., **Engineering Design and the Product Lifecycle**, Momentum Press Engineering, 2018.


## 10.2 GE 502 : Consciousness and Professional Ethics

**Course Code : GE 502**

**Course Name : Consciousness and Professional Ethics**

L-T-P-C : 2-1-0-3
Intended for : UG/PG/PhD
Prerequisite :
Mutual Exclusion:
Approval: 54th BoA

**Course Contents**

- **Introduction and Background**: Evolution of the engineering profess ion; Basis for universal human values and ethical human conduct; Engineering profession in the light of comprehensive human goal; Responsibility in engineering; Social and value dimensions of technology; Continuous happiness and prosperity as basic human goal?; connection of basic human goal with profess ional conduct; process of exploring human goal; Summary of few cases of professional ethics code developed by professional societies. (4 Hours)

- **Exploring Harmony in the Human Being and Consciousness**: Understanding human being as a co-exi stence of the sentient consciousness and the material 'Body' , Understanding the needs of consciousness and body - happiness and physical facility, Appraisal of Physical needs, meaning of Prosperity in detail. ( 4 Hours)

- **Harmony in the Family (Human-Human Interaction)**: Understanding values in humanhuman relationship; meaning of Justice and program for its fulfilment to ensure mutual happiness; Trust and Respect as the foundational values of relationship, Understanding the meaning of Trust; Difference between intention and competence, Understanding the meaning of Respect, Difference between respect and differentiation; the other salient values in relationship, Notion of Justice as fu lfi lling relationship. (4 Hours)

- **Harmony in the Society (Human-Human Interaction)**: Understanding the harmony in the society (society being an extension of fam ily): Reso lution, Prosperity, fearlessness (trust) and co-existence as comprehensive Human Goals, Visualizing a universal harmonious order in societyUndivided Society. (4 Hours)

- **Understanding Harmony in the Nature and Existence:** Whole existence as Coexistence: Understanding the harmony in the Nature, Interconnectedness and mutual fu lfilment among the various units of nature, recyclability and self-regulation in nature. Understanding Existence as Co-existence of mutually interacting units in all pervasive space, Holistic perception of harmony at all levels of existence. ( 4 Hours)

- **Implications of the Holistic Understanding of Harmony on Professional Ethics**: Natural acceptance of human values, Definitiveness of Ethical Human Conduct, Basis for Humanistic Education, Humanistic Constitution and Humanistic Universal Order, Competence in professional ethics: (i) Ability to utilize the professional competence for augmenting universal human order (ii) Ability to identify the scope and characteristics of people friendly and ecofriendly production systems, (iii) Ability to identify and develop appropriate technologies and management patterns for above production systems. Case studies of typical holistic technologies, management models and production systems. (5 Hours)

- **Strategy for transition from the present state to Universal Human Order**:

    1. At the level of individual: as socially and ecologically responsible engineers, technologists and managers
    2. At the level of society: as mutually enriching institutions and organizations (3 Hours)

**Laboratory/practical/tutorial Modules:**

Lecture hours are to be used for interactive discussion, placing the proposals about the topics at hand and motivating students to reflect, explore and verify them for developing a holistic view so that basis for professional ethics can be established. Tutorial hours are to be used for practice sessions. While analyzing and discussing the topic, the instructor's role is in pointing to essential elements to help in sorting them out from the surface elements. In other words, help the students explore the important or critical elements. In the discussions, particularly during practice sessions (tutorials), the instructor encourages the student to connect with one's own self and do self-observation, self-reflection and self-exploration. Scenarios may be used to initiate discussion. Observations and their analyses are shared and discussed among all students, in a group sitting. Indicative plan of fourteen tutorials is as follows: Differentiating the notions of Preconditioning, Sensation and Natural Acceptance; Notions of Happiness; Case study of cunent economic activities and associated expectations of humans through the short video story of stuff'; Self-awareness through the list and analysis of individuals desires; Self-awareness and individuals role in ensuring the healthy condition of the body; Self-assessment of our status of prosperity; Appreciation of impact of individual behaviors on others through short movie Right Here Right Now ; Observing the feeling of gratitude; Discussion through short movie Economics of Happiness for understanding the role in localization and globalization; Discussion through short movie Swaraj in Hiware Bazar for appreciating the possibility of transformation through relationship; Discussion through short movie An inconvenient truth for understanding the role of humans for mitigation of global warming; Discussion on the role of students for improving the status of justice in the institute and asking them to make a framework; Discussion on role of students for improving the economic sustainability of the institute; Discussion on role of students in reducing the carbon emissions impact of the institute; Differentiating the internal and external sources of happiness.

**Textbooks:**


1. R.R. Gaur, R. Asthana and G.P. Bagaria, **A Foundation Course in Human Values and Professional Ethics**, 3rd Revised Edition, UHV Publications, 2023.

2. W. R. Bowe, **Engineering Ethics: Outline of an Aspirational Approach**, Springer, 2009.

3. P. A.Vesilind, **Engineering Peace and Justice: The Responsibility of Engineers to Society**, Springer, 2010.


**References:**


1. C.E. Harris,M. S. Pritchard and M. J. Rabins, **Engineering Ethics: Concepts and Cases**, 4th Edition, Cengage Learning, 2009.

2. G. D. Baura, **Engineering Ethics: An Industrial Perspective**, Academic Press (Elsevier), 2006.

3. J. Lucena, **Engineering Education for Social Justice: Critical Explorations and Opportunities**, Springer, 2013.

## 10.3 GE 521 : Essentials of Entrepreneurship

**Course Code : GE 521**

**Course Name : Essentials of Entrepreneurship**

L-T-P-C : 3-0-0-3
Intended for : UG and PG students
Prerequisite :
Mutual Exclusion:
Approval: 54th BoA

**Course Contents**

- **Entrepreneurship Concepts**: Understanding nuances of being an entrepreneur: Difference between a startup venture and small business: Identifying entrepreneurial styles. (4 Hours)
- **Idea/Problem and Customer**: Identifying problems worth solving, identifying business opportunities, methods for problem interviews: Design thinking process" Generation of potential solutions: Identifying customer segment and early adopters, the difference between a consumer and a customer, craft your value proposition, outcome-driven innovation, testing out solutions for the problem: Unique value proposition. (12 Hours)
- **Business Model Validation**: Basic lean approach and canvas, types of business models, documenting business plan with a lean canvas, documenting hypotheses: Introduction to risks: Develop solution demos: The problem-solution test, solution interviews, sizing the opportunity, building a minimum viable product: The product-market fit test: Revenue streams: How companies with different business models earn money: Understanding income, costs, gross and net margins: Identifying primary and secondary revenue stream: Costing and pricing: How to finance your business idea: Financing your venture at different stages, what investors expect from you: Various sources of funding and pros & cons of each. (12 Hours)
- **Building a resourceful team**: Shared leadership model, the role of a good team in a venture's success, what to look for in a team, define clear roles and responsibilities; How to pitch to candidates to attract to join your team, explore collaboration tools and techniques – brainstorming, mind mapping; Kanban board. (4 Hours)
- **Marketing, Sales and Support**: Understanding the difference between product and brand and the link between them; Product/service positioning; Channels and strategies, budgeting and planning; Sales planning, target setting; Unique sales proposition (USP); follow-up and closing sale: Planning and racking, the importance of project management to launch and track progress; Understanding time management, workflow, the delegation of tasks; Business regulations of starting and operating a business; Documentation, how to find help to get started; Various government scheme. (10 Hours)

**Textbooks:**

1. NA

**References:**

1. NA

## 10.4 GE 522 : Entrepreneurship and Technology Commercialization

**Course Code : GE 522**

**Course Name : Entrepreneurship and Technology Commercialization**

L-T-P-C : 3-0-2-4
Intended for : UG and PG students
Prerequisite :
Mutual Exclusion:
Approval: 54th BoA

**Course Contents**

- Module I:
  - Introduction, 4Ps ofEntrepreneurship, S3: Entrepreneurship and Innovation in Today's Technological Environment, Technology 6 Disruption. (6 Hours)
  - Societal Problems - oppmtunity recognition ((hands-on exercise), Value Proposition-Business Models - & Business 6 Canvas, Failure- Friend or Foe, learning is a habit T 2. (6 Hours)
- Module II:
  - Building Your Team (hands-on exercise), First steps towards commercialization, Building Your Minimum Viable Product 6 (self-reflection exercise) (Mahesh leaves, Sanjay arrives). (6 Hours)
  - Organizing The Business Entity (Finance and Management) Critical Career Junctures for Founders and Early Employees 6 Recruiting and Managing The Young Venture's Workforce. (6 Hours)
  - Raising Ventme Capital, Negotiating with Angels for Early Financing, Equity as Compensation 6 3 (6 Hours)
- Module III:
  - Exit Strategy: Selling The Hi-Tech Venture, Introduction to Patents and Intellectual Property, Conditions for Patentability ( New and Useful ), Comparison of Patent Law of India and 6 other Countries. (6 Hours)
  - Obtaining A Patent - The Process and The Challenges, Patent process - a demonstration, Other Forms of Intellectual Property. (6 Hours)

**Laboratory/practical/tutorial Modules:**

Team presentation on their ideas, Working with IIT Mandi Incubation Center, Team projects - Guidance for independent work by student team, Student teams work independently - with touchpoints with faculty via office hours, Final presentation (longer session -all teams -besides lead instructors others from liT mandi to be invited)

**Textbooks:**

1. Janet K.ilholm Smith, Richard L. Smith, and RichardT. Bliss, **Entrepreneurial Finance: Strategy, Valuation, and Deal Structure**.
2. Brad Feld and Jason Mendelson, **Venture Deals: Be Smarter Than Yom Lawyer and Venture Capitalist**.
3. Philip Adelman and Alan M. Marks, **Financial Management for Entrepreneurs**.
4. Mahendra Ramsinghani, **The Business of Venture Capital: Insights from Leading Practitioners on the Art of Raising a Fund, Deal Structuring, Value Creation, and Exit Strategies**.

**References:**

1. NA

## 10.5 GE 523 : Startup Framework: Finance, Valuation, and Structure

**Course Code : GE 523**

**Course Name : Startup Framework: Finance, Valuation, and Structure**

L-T-P-C : 3-0-0-3
Intended for : UG and PG students
Prerequisite :
Mutual Exclusion:
Approval: 54th BoA

**Course Contents**

- **Structuring and Business**: Introduction to company Structures, Overview of various company structures, Explanation of legal and financial implications of each type (2 Hours)
- **Shareholding and Equity Distribution**: Understru1ding basics of equity, shares, and stock options, Allocating equity between co-founders, employees, and investors, Fair equity distribution and common pitfalls, Vesting Schedules and Cliff Periods, Legal protections for different stakeholders, Implications of shareholding structw-e on company control and decision-making (8 Hours)

- **Company Valuation & Financial Forecasting**: Introduction to Valuation Concepts, Factors Influencing Valuation, Approaches to Valuation: Income, Market, and Asset-based, Projecting Income Statements, Balance Sheets, and Cash Flows. Cash flow estimation, assumptions of cash flow estimations, and financial models specific to different industry types (12 Hours)

- **Startup Financing Strategies**: Self-financing and Bootstrapping, External Funding: Grant funding, Government Schemes, Angel Investors, Venture Capital, Crowdftmding, IPO, Private Equity, Pros and cons ofteach type of funding, Understanding Term Sheets and Negotiation, Discussion on various funding options and their suitability (10 Hours)

- **Exit Strategies**: Understanding and Designing Shareholder Agreements and Contracts, Key Clauses in Shareholder Agreements and their Implications, Best Practices and Common Pitfalls, Role and Significance of Promoter Shares in a Company, Exit Strategies and Liquidation Preferences, Overview of Vmious Exit strategies (lPOs, Mergers, and Acquisitions), Impact of exit strategies on company valuation and shareholder value (10 Hours)

**Laboratory/practical/tutorial Modules:**

Team presentation on their ideas, Working with IIT Mandi Incubation Center, Team projects - Guidance for independent work by student team, Student teams work independently - with touchpoints with faculty via office hours, Final presentation (longer session -all teams -besides lead instructors others from liT mandi to be invited)

**Textbooks:**


1. Janet Kilholm Smith, Richard L. Smith, and Richard T. Bliss, **Entrepreneurial Finance: Strategy, Valuation, and Deal Structre**.

2. Brad Feld and Jason Mendelson, V**enture Deals: Be Smarter Than Your Lawyer and Venture Capitalist**.

3. Philip Adelman and Alan M. Marks, **Financial Management for Entrepreneurs**.

4. Mahendra Ramsinghani, **The Business of Venture Capital: Insights from Leading Practitioners on the Art of Raising a Fund, Deal Sbucturing, Value Creation, and Exit Strategie**s.


**References:**

1. NA

# 11 HCI Courses

## 11.1 HC 600 : Research Methodology

**Course Code : HC 600**

**Course Name : Research Methodology**

L-P-T-C: 1-0-0-1
Intended for:
Prerequisites:Nil
Mutual Exclusion: Other Research Methodology Courses
Approval : 57th BoA

**Course Contents**

1. Introduction to research methodologies
2. Literature review
3. Experiment design
4. Statistical analysis
5. Surveys and interviews
6. Case studies
7. Ethnography
8. Usability testing
9. Analyzing qualitative data
10. Automated data collection methods
11. Measuring the human: Real time testing and need for ethical clearance
12. Ubiquitous HCI research
13. Research with human subjects with and without disabilities
14. Interdisciplinarity in research

**Text books:**

Not Available

**References:**

Not Available

# 12 Humanities and Social Sciences Courses

## 12.1 HS 101: Technical communication

**Course Code:HS 101**

**Course Name: Technical communication**

L-T-P-C: 1-0-2-2
Category: Core
Prerequisites: Nil
Approval: 5th Senate

**Course Contents**

- **Communication Basics** Scope, process, barriers, Non-verbal Communication, tools for Effective Communication
- **Writing Skills A. Technical Reports**: Definition; Types; Planning and Prepration; Structure; Writing of Technical Reports Technical Style
- **Writing Skills**: **B. Writing Resume**/ Job Application Letter /CVs
- **Oral Skills**: Pre-placement Group Discussion; Interview Techniques: Effective Strategies for Oral Presentations. Listening Variations of English Language in the Global Scenario.

**References:**


1. Guffey,MaryE., **Essentials of BusinessCommunication**, 5th Edition, South-Western College Publishing
2. Bovee, Courland L. and John T., **Business Communication Today**, 8th Edition, Pearson Education.
3. Stevenson, Susan and Whitmore S., **Strategies for Engineering Communication**, John Willey and Sons.
4. Sharma R. C. and Mohan K., **Business Correspondence and Report Writing**, 3rd Edition, Tata McGraw Hill.
5. Raman, Minakshi and Sharma S., **Technical Communication: Principles and Practice**, OUP


## 12.2 HS 102: Art and Architecture

**Course Code: HS 102**

**Course Name: Art and Architecture**

L-T-P-C: 0-0-2-1
Prerequisite: Consent of the faculty member
Students intended for: BTech

Elective or Core: Elective
Semester: Even/Odd
Approval: 2nd Senate

**Course Contents:**

- Module I Craft and Art: The Artists Craft
- Module II Short Survey: Pictures as Optical Surrogates; The Dimension of Visual Space (Brunellschis importance for art); Color Theory
- Module III Short Survey of Indian Art and Architecture, Western Art and Architecture
- Module IV City Spaces
- Module V Field trips to temples around Mandi, to Chandigarh, to Kamand Campus of the IIT Mandi

**Recommended Reading:**

1. Kit White, **101 Things to Learn in Art School**, The MIT Press, 2011.
2. Ernst Billgren, **What is Art and a 100 other questions**, Bokforlaget Langenskiold, 2011.
3. E.H. Gombrich, **The Story of Art**, Phaidon, 1995.
4. Stephen Farthing, **Art: The Whole Story**, Thames & Hudson, 2010.
5. The Yorck Project, **Software of the Digitale Bibliothek**, (Resources of the Central Library, IIT Mandi).
6. In addition: Relevant Publications of the **Publications Division, Ministry of Information & Broadcasting**, Govt. of India.

## 12.3 HS 103: Dance and Drama

**Course Code: HS 103**

**Course Name: Dance and Drama**

L-T-P-C: 1-0-0-1
Prerequisite: Consent of the faculty member
Students intended for: BTech
Elective or Core: Elective
Semester: Even/Odd
Approval: 2nd Senate

**Course Contents**

- **Module I** From Classical Drama to the Epic Theatre
- **Module II** Street Play and Playback Theater for Theater Production

**Prescribed Texts:**

1. Introductory Lectures / Stage Production
2. In addition: **Relevant Publications of Publications Division**, Ministry of Information & Broadcasting, Govt. of India.

## 12.4 HS 104: Music

**Course Code: HS 104**

**Course Name: Music**

L-T-P-C: 1-0-0-1
Prerequisite: Consent of the faculty member
Students intended for: BTech
Elective or Core: Elective
Semester: Even/Odd
Approval: 2nd Senate

**Course Contents**

Students are expected to become familiar at the end of the course with at least one composer and some samplings of his/her oeuvre.

**Prescribed Material:**

1. Music Collection (CDs/DVDs) in the Central Library of the IIT Mandi
2. **Relevant Publications from the Publications Division**, Ministry of Information & Broadcasting, Govt. of India.

## 12.5 HS 105: Basic Communication Skills

**Course Code: HS 105**

**Course Name: Basic Communication Skills**

L-T-P-C: 3-0-0-3
Prerequisite: Consent of the faculty member
Students intended for: BTech
Elective or Core: Elective
Semester: Even/Odd
Approval: 2nd Senate

**Course Contents**

- **Module I** Communication Processes and Models; Forms of Communication; Communication Levels, Routes and Boosters, Communication Factors; Types of Communication; Language Registers (Formal/Informal/Literary/Media/Gender); Nonverbal communication.

- **Module II** Meaning: Interpreter-Symbol-Referent Relationship, Positive and Dialectic Terms, Abstraction and Ambiguity; Functions of Language: The Report Function, The Persuasive Function, The Attitude-Revealing Function, The Self-Revelation Function, The Relationship Function.
- **Module III** Ways of Establishing Credible Communication: Source-Message Relationship, Source-Channel Relationship, Source-Receiver Relationship, Message-Channel Relationship, Message-Receiver Relationship, Channel-Receiver Relationship.
- **Module IV** Abstracting and Outlining; Listening Skills; The Aware Communicator.
- **Module V** Writing about: Single Items/Single Completed Events/Abstract Concepts/Collection of Items/ Group of Events Including Processes/Questions

**Prescribed Reading**

1. Select reading materials to be had of the instructor

**Recommended Reading**


1. John Berger, **Ways of Seeing**, Harmondsworth (Penguin), 1972.
2. William Strunk Jr. & E.B.White, **The Elements of Style**, Macmillan, 1979.
3. Graeme Burton, **More Than Meets The Eye: An Introduction to Media Studies**, Edwin Arnold, 1997.
4. Owen Hargie, **The Handbook of Communication Skills**, Routledge, 1997.
5. Richard Dimbleby & Graeme Burton, **More than Words: An Introduction to Communication**, Routledge, 1998.
6. Andrew Beck, Peter Bennett & Peter Wall, **Communication Studies: The Essential Introduction**, Routledge, 2001.
7. Richard Ellis, **Communication Skills: Stepladders to Success for the Professional**, Intellect Books, 2002.


## 12.6 HS 106: English I

**Course Number: HS 106**

**Course Name: English I**

L-T-P-C: 3-0-0-3
Prerequisites: Consent of Teacher
Students intended for: UG
Elective or Compulsory: Elective Semester: Odd
Approval: 9th Senate

**Course Contents**

- Introduction to the course, interactive session with students [1 Lecture]
- Articles and Nouns (countable and uncountable, singular and plural) [4 Lectures]
- Present and Past Tense (simple and continuous) [2 Lectures]
- Present Perfect and Past Tense [3 Lectures]
- Future Tense [1 Lecture]
- Modals [3 Lectures]
- Pronouns and Determiners [4 Lectures]
- Adjectives and Adverbs [6 Lectures]
- Conjunctions and Prepositions [5 Lectures]
- Voice (Passive and Active) [4 Lectures]
- Reported Speech [1 Lecture]
- Grammar in use: [8 Lectures]
  - Spelling and punctuation
  - Common errors in English
  - Paragraph writing, report writing

**Textbooks (with supplementary exercises):**


1. Murphy, Raymond., **English Grammar in Use**, Cambridge University Press, 2012.
2. Naylor, Helen (with Raymond Murphy), **Essential Grammar in Use Supplementary Exercises**, Cambridge University Press, 2007.
3. Raman, Meenakshi and Sangeeta Sharma, **Technical Communication: Principles And Practice**, 3rd Edition, Oxford University Press, 2015.


## 12.7 HS 107: Exploring Creative Art Forms

**Course Code:HS 107**

**Course Name: Exploring Creative Art Forms**

L-T-P-C: 1-0-0-1
Intended for :UG
Approval: 12th Senate

**Course Contents**

- **Module I** Performing Arts [5 hours] In this module, students will be introduced to various forms of performing arts including drama, music and dance.
- **Module II** Visual Arts [4 hours] In this module, students will be introduced to visual arts such as sketching, painting, photography, crafts and installations.
- **Module III** Literary arts [3 hours] In this module, students will be introduced to literary art forms such as poetry and f iction/non fiction writing.
- **Module IV** Project work [2 Hours] In this module, students will explore and engage themselves in one specific art form in greater depth.

## 12.8 HS 108: Basic English for Engineers

**Course Code : HS 108**

**Course Name : Basic English for Engineers**

L-T-P-C : 3-0-0-3
Intended for : B.Tech.
Prerequisite : None
Mutual Exclusion : None
Approval: 52nd BoA

**Course Contents**

- **Unit 1: Interactive speaking skills** (8 Lectures)
  - Effective formal introductions
  - Formal short speeches
  - Extempore speaking and oratory
  - Formal presentations (non-technical)
- **Unit 2: Written correspondence** (7 Lectures)
  - Letters–enquiries, requests, invitation, complaints, orders
  - Emails–formal and informal
  - Memos and minutes of the meeting
- **Unit 3: Comprehension skills** (12 Lectures)
  - Active listening and reading
  - Note-making
  - Summarizing
  - Paraphrasing
- **Unit 4 : Writing Skills** (15 Lectures)

- Descriptive writing (products and processes; with attention to time, place, objects, people)
- Instruction writing (technical)
- Describing graphs/pie-charts/tables
- Paragraph writing
- Essay writing-expository and narrative

**Suggested texts:**

1. Lachance, Julie, **Basic English**, McGraw Hill, 2019.
2. Raman, Meenakshi and Sangeeta Sharma, **Technical Communication: Principles and Practice**, Oxford University Press, 2004.

## 12.9 HS 109: Advanced English for Engineers

**Course Code : HS 109**

**Course Name : Advanced English for Engineers**

L-T-P-C: 3-0-0-3
Intended for : B.Tech.
Prerequisite : None
Mutual Exclusion : None
Approval: 52nd BoA

**Course Contents**

- **Unit 1: Speaking skills** (14 Lectures)
  - Technical presentations
  - Group discussions (planned and unplanned)
  - Interview Skills
  - Principles of rhetoric and argumentation
  - Debating
- **Unit 2: Written skills (professional)** (6 Lectures)
  - CV/Resume
  - Cover Letter
  - Bio note and Statement of Purpose
- **Unit 3: Writing online (professional)** (6 Lectures)
  - Posting on social media
  - Writing an academic blog/magazine article
  - Writing a technical blog–product reviews, analysis, etc.

- **Unit 4: Writing skills (academic)** (16 Lectures)
  - Essay writing–critical and argumentative
  - Abstracts–video and written
  - Effective posters (technical)
  - Project and research proposals
  - Technical report writing
  - Ethics of academic writing

**Suggested texts:**

1. Anderson, Paul., **Technical Writing: A Reader Centered Approach**, Harcourt, 1991.

2. Markel, Mike and Stuart A. Selber., **Technical Communication**, Bedford St. Martin's, 2017.

## 12.10 HS 110 : Japanese Language for Beginners

**Course Code : HS 110**

**Course Name : Japanese Language for Beginners**

L-P-T-C: 3-0-0-3
Intended for: UG
Prerequisites: None
Mutual Exclusion: None
Approval : 57th BoA

**Course Contents**

Classes are conducted according to the textbook 'Marugoto'.

Marugoto focuses on communication using Japanese and consists of scene syllabus. It systematically introduces the sentence patterns, grammar, vocabulary and kanji step by step showing every situation where these things are actually used.

Each lesson provides opportunities to read sentences, understand grammar, practice pronunciation, solve listening comprehension questions and sometimes write sentences in Japanese.

About 50 kanji characters are introduced, and a worksheet is provided separately in class to give students the opportunity to practice writing them.

The course also includes a number of questions that offer an opportunity to understand Japanese culture and can be discussed with learners in class.

The textbook Minna no Nihongo and its supplementary materials are also used as part of the main textbook as appropriate.

- The first session is Introduction (1 hour).

- Lessons 1 to 6 are scheduled for three hours each, with the lecture of two types of characters. (18 hours)

- Lessons 7 to 16 are scheduled for two hours each. (20 hours)
- Exams (or assignments) are given in the middle and at the end of the semester. (3 hours) (Total of 42 hours planned.)

1. Lesson 1 – Hello: Exchange greetings
2. Lesson 2 – Would you say that again?: Use basic classroom expressions
3. Lesson 3 – Nice to meet you: Give a simple self introduction
4. Lesson 4 – There are three people in my family: Talk briefly about your family
5. Lesson 5 – What kind of food do you like?: Talk about your favorite foods
6. Lesson 6 – Where are you going to have lunch today?: Say what your favorite dish is
7. Lesson 7 – There are three rooms in my home: Say what kind of home you live in
8. Lesson 8 – It's a nice room: Ask/Say where to put things in the room
9. Lesson 9 – What time do you get up?: Say the time you do something
10. Lesson 10 – When is convenient for you?: Talk about your schedule for this week
11. Lesson 11 – What's your hobby?: Talk about your hobbies
12. Lesson 12 – Shall we go together?: Recognize information on posters and calendars for events
13. Lesson 13 – How are you going to get there?: Recognize station and taxi signs
14. Lesson 14 – It's a famous temple: Say how to get to a destination
15. Lesson 15 – Cute!: Talk about what you want to buy
16. Lesson 16 – I'll take this: Make a brief comment on things in a shop

**Text books:**

1. The Japan Foundation, **MARUGOTO: Japanese language and culture Starter A1 Coursebook**, SANSYUSYA, Japan, 2013
2. 3A corporation, **Minna no Nihongo Elementary**, 3A corporation, Japan, 2012

**References:**

1. Arc academy, **Hajimete No Nihongo Nouryoku Shiken N5 Tango 1000** (English/ Vietnamese Edition), ASK Publishing, Japan, 2017
2. Kyoko Igarashi, **The Best Complete Workbook for the Japanese-Language Proficiency Test N5 – Language Knowledge** (Vocabulary/Grammar), Reading & Listening, The Japan Times Publishing, Japan, 2022
3. The Japan Foundation, **IRODORI-Japanese for Life in Japan-**, The Japan Foundation, Japan, 2020

## 12.11 HS 111 : Japanese Language for Daily Life

**Course Code : HS 111**

**Course Name : Japanese Language for Daily Life**

L-P-T-C: 3-0-0-3
Intended for: UG
Prerequisites: None
Mutual Exclusion: None
Approval : 57th BoA

**Course Contents**

Hiragana-Katakana (20 min at the beginning of each lesson)

- Introduction: (1 Hours) Unit 01: Self-introduction (5 Hours)
- Unit 02: Daily conversation (3 Hours)
- Unit 03: Interview Etiquette (1 Hours)
- Unit 04: SocializingI- Making small talk (3 Hours)
- Unit 05: Present and past tenses (6 Hours)
- Unit 06: Talking about plans and activities (6 Hours)
- Unit 07: SocializingII - Invitations (5 Hours)
- Unit 08: Taste words & politely refuse foods you don't like/don't eat (3 Hours)
- Unit 09: Talking about impressions (3 Hours)
- Unit 10: Making request, get permission (6 Hours) Total of 42 hours planned.

**Text books:**

1. Yukiko Ogata, **Nihongo Fun & Easy: Survival Japanese Conversation for Beginners**, ASK Publishing, Japan, 2009
2. Kiyomi Ogawa, Orrin Cummins, **YASANICHI MANGA JAPAN GUIDE**, IBC Publishing, Japan, 2022
3. Yoji Yamakuse, Michael A. Coony, **Heart & Soul of the Japanese**, IBC Publishing, Japan, 2023
4. Atusko Tokui, **Tabunka kyousei no Komyunike-shon: Nihongo kyouiku no genba kara**, ALC Publishing, Japan, 2020
5. Erin Meyer, **THE CULTURE MAP**, Public Affairs, 2016.
6. MARUGOTO Plus (Online) https://marugotoweb.jp/ja/index.php
7. TSUNAHIRO (Online) https://tsunagarujp.mext.go.jp/
8. 3A corporation, **Minna no Nihongo Elementary**, 3A corporation, Japan, 2012

**References:**


1. Kyoko Igarashi, **The Best Complete Workbook for the Japanese-Language Proficiency Test N5 – Language Knowledge (Vocabulary/Grammar)**, Reading & Listening. The Japan Times Publishing, 2022.

2. ATSUKO TOKUI, **Multicultural Communication**, ALC PRESS, 2020.


## 12.12 HS 151: Introduction to English Literature

**Course Code: HS 151**

**Course Name: Introduction to English Literature**

L-T-P-C: 3-0-0-3
Prerequisites: Consent of the faculty member
Students intended for: B.Tech
Elective or Compulsory: Elective Semester: Even/Odd
Approval: 2nd Senate

**Course Contents**

- **Module I** Browning (My Last Duchess), Tennyson (The Defence of Lucknow), Arthur Conan Doyle (The Adventure of Speckled Band), Saki (The Open Window), OHencry (The Ransom of Red Chief), Kipling (Gunga Din), George Orwell (Shooting an Elephant) [10 Lectures]

- **Module II** Elizabeth Barrett Browning (How Do I Love Thee? Let Me Count the Ways), Kate Chopin (A Respectable Woman), Sylvia Plath (Conversation Among the Ruins), Alice Walker (Except Nothing), Charlotte Perkins(The Yellow Wallpaper), Angela Carter (The Courtship of Mr. Lyon) [10 Lectures]

- **Module III** Leo Tolstoy (Three Questions), Maupassant (The Englishman of Etretat), Stephen Crane (Bride Comes to Yellow Sky), Mark Twain (The Stolen White Elephant), Jack London (The Law of Life), Edgar Allen Poe (Cask of Amontillado), Washington Irving (Legend of the Sleepy Hollow)[10 Lectures]

- **Module IV** Ruskin Bond (The Hidden Pool), IsmatChugtai (The Quilt), Sadat HasonManto (TabaTek Singh), KekiN.Daruwalla (Love Across the Salt Desert), Nissim Ezekiel (The Patriot), A.K Ramanujan (The River), Agha Shahid Ali (Postcard From Kashmir/The Wolf,s Postscript to Little Red Riding Hood), Kamla Das (An Introduction), JayantMahapatra (Dawn At Puri) [10 Lectures]

**Self Study:**

**Novel:**

1. Rushdie, Salman. Shame. Vintage: New York, 1983.

2. Narayan, R.K. Man-Eater of Malgudi. Indian Thought Publications, 2007.

**Play:**

1. Miller, Arthur., The Crucible, Penguin, 1995.
2. Wilde, Oscar., The Importance of Being Earnest, Penguin Books, 2010.
3. King, Bruce., Modern Indian Poetry in English, OUP, 2005.
4. Ali, Agha Shahid., The Veiled Suite: The Collected Poems.Penguin, 2010.
5. Manto, Sadat Hasan, Toba TekSingh, Penguin.
6. Chugtai, Ismat, Hameed, Syeda and Naqvi, Tahira. A Chugtai Collection, Women Unlimited, 2003.
7. Daruwalla, Keki, Love Across the Salt Desert: Selected Short Stories, Penguin, 2011.
8. Bond, Ruskin., The Hidden Pool, Penguin, 2004.
9. Irving, Washington., The Legend of the Sleepy Hollow, Tor Classics, 1991.
10. Tolstoy, Leo., The Greatest Short Storiesvof Leo Tolstoy, Jaico Publishing House, 2009.
11. Poe, Edgar Allen., Complete Stories And Poems of Edgar Allen Poe, Knopf Doubleday Publishing Group, 1984.
12. Carter, Angela., The Bloody Chamber: And Other Stories, Penguin Books, 1990.
13. Gilman, Charlotte Perkins., The Yellow Wallpaper, Dover Publications, 1997.
14. Chopin, Kate, Johnson, Cynthia Brentley, and HaradAlyssa., The Awakening and Selected Stories of Kate Chopin, Pocket Book Classics, 2004.
15. The remaining stories and poems will be given as class handouts.

**Essays:**

1. Class handouts

## 12.13 HS 152: Introduction to Rhetoric

### Course Code: HS 152

### Course Name: Introduction to Rhetoric

L-T-P-C: 3-0-0-3
Prerequisite: Consent of the faculty member
Students intended for: B.Tech
Elective or Core: Elective
Approval: 2nd Senate

**Course Contents**

**Module I** Definition; Brief History of Rhetoric; Literacy in Historical Perspective [3 Lectures]

**Module II** Basic Logic Sorting, Grading and Classifying; Categorical and Hypothetical Syllogisms, Enthymemes, Fallacies [5 Lectures]

**Module III** Discovery of Arguments Common and Special Topics; The Process of Persuasion: the Rhetorical Appeals; Advertisements [10 Lectures]

**Module IV** Forms of Argument: Arguments pertaining to Issues of Fact/ of Definition/ of Value [10 Lectures]

**Module V** Ethics of Argument and Persuasion.

**Module VI** Arrangement of Materials; Rhetorical Genre as Organising Principle [6 Lectures]

**Module VII** The Problem of Style [10 Lectures]

**Text & Reference Books:**

**Prescribed Text:**

1. Edward P. J. Corbett, Classical Rhetoric for the Modern Student, OUP, 1965. (With Robert J. Connors, 4/1998).
2. Additional Passages excerpted for practice from:
3. H.D. Sharma (Ed.), 100 Best Pre-Independence Speeches, 1870-1947, Harper Collins, 1998.
4. THE HANSARD, Edited verbatim report of the proceedings of both the House of Commons and the House of Lords, http://www.parliament.uk/business/publications/hansard/

**Recommended Reading:**

1. G. Stuart Adam & Roy Peter Clark, Journalism: The Democratic Craft, OUP, 2005.
2. Mathew Allen, Smart Thinking: Skills for Critical Understanding & Writing, OUP, 2004.
3. Cleanth Brooks & Robert Penn Warren, Modern Rhetoric, Harcourt, 1958.
4. James C. McCroskey, An Introduction to Rhetorical Communication, Allyn & Bacon, 2001.
5. Stephen Lynn: Rhetoric and Composition, CUP, 2001.
6. R.M. Ritter, The Oxford Style Manual, OUP, 2003.
7. William Strunk Jr. & E.B. White, The Elements of Style, Allyn& Bacon, 2000.

## 12.14 HS 201: Indian Economic Development

**Course Code: HS 201**

**Course Title: Indian Economic Development**

L-T-P-C: 3-0-0-3
Course Offered to: B. Tech.
Course Distribution: Elective
Approval: 4th Senate

**Course Contents**

- **Module I** Indian economy in the Pre-British Period; Economic Consequences of the British Rule; State of the Economy at the Beginning of the Fifties - Policy of Planned Development Growth and Structural Change till the Eighties Evolution of Controls and Obstacles to Fast Growth New Economic Policy Performance of the Economy since 1991 Major Aspects of Transformation. [10 Lectures]

- **Module II** Trends in Agricultural and Rural Development Review of Agricultural Growth Land Reforms Agricultural Research and Green Revolution Review Price and Other Policies relating to Agriculture - Policy Initiatives needed in relation to Agriculture and Rural Sector Non-Farm Activities, Diversification and Exports Impact of Liberalization and WTO - Investment in agriculture and Other strategies. [9 Lectures]

- **Module III** Growth of Industrial and Infrastructure Sectors: The Growth and Maturing of Indian Industry since Liberalization Productivity Growth and Rise in Competitiveness Exports Rise of Service Industry India and I.T. Policy regarding Public Enterprises Disinvestment and Partial Privatization Impact of WTO and Trade Liberalization Public Private Partnership. [9 Lectures]

- **Module IV** Social Development: Human Development Indicators: Review of Change since early Fifties Wide Regional Variations Measurement of Poverty Extent of Reduction in Poverty Demographic Transition Regional Differences Employment and Unemployment Trends - Employment Guarantee Schemes Long-term Policy to reduce Poverty and Unemployment. [8 Lectures]

- **Module V** Macroeconomic Policy and External Environment: Growth Trends; Monetary and Fiscal Policy Management - Savings and Capital Formation- Inflation Stagflation and policies - External Sector Trade Policy, FDI, Exchange Rate Management - Investment Climate Competition Policy Human Development Strategies for Sustainable Development. [8 Lectures]

**Course Readings:**


1. Kapila, Uma, Indian Economy since Independence, Academic Foundation, 2001.

2. A.N. Agarwal, Indian Economy: Problems of Development and Planning Vikas Publishing Company, Delhi, 2012.

3. Jalan, Bimal, the Indian Economy: Problems and Prospects, Penguin Books, 1992.

4. A. Virmani, Accelerating Growth and Poverty Reduction: A Policy Framework for Indian Development. Academic Foundation, New Delhi, 2004.

5. Datt, R. and K.P.M. Sundharam, Indian Economy, S. Chand & Company Ltd., New Delhi, 2001.

**Further Readings:**

1. Dutt, R.C., the Economic History of India under Early British Rule, Low Price Publications. Delhi, 1950.

2. Rangarajan, C., Select Essays on Indian Economy, Vol.1&2., Academic Foundation, New Delhi, 2004.

3. Krueger Anne (ed.) Economic Policy Reforms and the Indian Economy, Oxford University Press, 2003.

4. Mohan, Rakesh, Facets of the Indian Economy, Oxford University Press. 2003.

5. Chakravarty, Sukhamoy, Development Planning: The Indian Experience, Oxford University Press. 1987.

6. Joshi, Vijay and I.M.D. Little., Indias Economic Reforms 1991-2001, Oxford University Press. 1998.

7. Planning Commission, National Human Development Report, Oxford University Press, 2002 and 2012.

8. Planning Commission, Eleventh and Twelfth Five Year Plans, Government of India.

9. NCAER, India Infrastructure Report.

10. RBI Annual Report; Economic Survey; Ex-Im Policy; Important Committee Reports. Latest National Human Development Report (http://www.undp.org.in/).

11. Indian Economy- (Special Issues of Pratiyogita Darpan).

12. Reports on Employment and unemployment by NSSO / Planning Commission

## 12.15 HS 202: Principles of Economics

**Course Name: HS 202**

**Course Name: Principles of Economics**

L-T-P-C: 3-0-0-3
Prerequisite: Consent of the faculty member
Students intended for: B.Tech
Elective or Core: Elective
Approval: 2nd Senate

**Course Contents**

- **Introduction and Overview** Economics, the dismal science; Scope of Economics; Diverse types of Economies; Economic Problems and attempted Solutions: Scarcity and Choice; Demand and Supply; Consumers, Producers and the Efficiency of Markets; Elasticity and Its Applications; Consumer Surplus.
- **Behind the Supply Curve** The Producers Outlook; Operational Costs and Revenues; Profit Maximization.
- **Behavior of firms in diverse market environments** Monopoly and antitrust policy; Government policies towards competition; Oligopoly; Monopolistic Competition.
- **Inputs Markets** Markets for the Factors of Production; Discrimination and exploitation of inputs in the imperfect market.
- **Three Key Macro Variables** Gross Domestic Product (Different Concepts of national income, approaches to calculate national income); GDP and the parallel economy; Unemployment; Inflation.
- **Macroeconomic Equilibrium** Business Cycles; The Tradeoff between Inflation and
- **Unemployment** The Phillips Curve; Investment: determinants; Multiplier and its working.
- **Monetary system and Policies** Money in the Modern Economy; Banking and credit creation; Credit Control: Open Market Operations and other measures; Money Multiplier; Money Demand and Interest Rates; Money and Inflation in the Long Run: The Quantity Theory of Money
- **Fiscal Policy** Overview: Facts and Figures; The Role of Social Security; Government Spending and Tax Multipliers.
- **Application** The Costs of Taxation: Income Inequality and Poverty; Externalities: Public Goods and Common Resources; Exploring the Macroeconomics of an Open Economy and Basics of Trade; Balance of Payments-The current and capital account; Welfare Analysis of Trade and Tariffs; Interdependence and the Gains from Trade.
- **Related International Issues** Why are Poor Countries are Poor;Can India Overtake China?

**Course readings:**


1. N. Gregory Mankiw, **Principles of Economics**, 6th Edition, South Western Cengage Learning, 2011.
2. Glenn Hubbard and Anthony OBrien, **Economics**, 3th Edition, Prentice Hall, 2009.

3. Karl E. Case and Ray C. Fair, **Principles of Economics**, 8th Edition, Prentice Hall, 2007.

4. J.E. Stiglitz, and C.E. Walsh, **Principles of Economics**, 3rd Edition, W.W. Norton & Company, 2002.

5. Rest of the assigned reading will be drawn regularly from current newspaper and magazine articles.

## 12.16 HS 203: Understanding Society

**Course Code: HS 203**

**Course Name: Understanding Society**

L-T-P-C : 3-0-0-3
Prerequisite: Consent of the faculty member
Students intended for: B.Tech
Elective or Core: Elective
Approval: 2nd Senate

**Course Contents**

**Basic Sociological Concepts** Society, Community, Social Structure, Function, Status & Role, Power & Authority, Social Groups Primary and Secondary, Socialization and Culture

**Classical Sociological Thought and Perspectives** Aguste Comte (Positivist)-Emile Durkheim (Functionalist), Karl Marx (Conflict), Max Weber (Structural Functionalist)

**Historical Concepts and Perspectives** Evolution of Indian Society, Historical dimensions of Caste, Class, Religion and Gender, Changes and Continuities in Indian Society

**Psychological Concepts and Perspectives** Introduction: Nature and scope of social psychology. Groups: Structure, functions and effects; social facilitation, social loafing and social conformity, Communication: Verbal and nonverbal processes; language and social interaction; barriers to communication, Social perception: Impression formation, role of non-verbal cues; attribution process; theories of Kelly and Weiner, Attitudes: Formation, measurement and change. Prejudice and discrimination: Sources and dynamics; techniques of overcoming prejudice, Pro-social behavior: Cooperation and helping behavior; personal, situational and socio-cultural determinants of helping.

**Recommended Reading List**

1. Alex Inkeles., What is Sociology?: an Introduction to the Discipline and Profession, Prentice-Hall Publishing, 1964.

2. Anthony Giddens., Sociology, 5th Edition, Polity Press, 2006.

3. Michael Haralambos, Sociology: Themes and Perspectives, 7th Edition, Collins Publishing, 2008.

4. Penguin Dictionary of Sociology, 5th Edition, Penguin publishing, 2006.

5. Shankar Rao, Sociology: Principles of Sociology, S. Chand & Company Ltd, 2011.

6. T.B. Bottomore., Sociology: A Guide to Problems and Literature, Routledge Publication, 1962

7. Alcock, J. E., Carment, D. N., Sadava, S. N., Collins, J. E. & Green J. M., A textbook of social psychology, Prentice Hall, 1998.

8. Aronson, E., Wilson, T. D., &Akert, R. M., Social Psychology, 7th Edition, Prentice Hall, 2010.

9. Baron, R. A., & Byrne, D., Social psychology, 8th Edition, Prentice Hall of India, 1998.

10. Taylor, S. E., Peplau, A. L., & Sears, D. O., Social Psychology, 12th Edition, Prentice Hall, 2006.

11. Dumont, L., Homo Hierarchicus, University of Chicago Press, 1980.

12. Ghurye, G.S. 1932. Caste and Race in India. London: K. Paul, Trench, Trubner& Co.

## 12.17 HS 204: Introduction to Political Science

**Course Code: HS 204**

**Course Name: Introduction to Political Science**

L-T-P-C: 3-0-0-3
Prerequisite: Consent of the faculty member
Students intended for: B.Tech
Elective or Core: Elective
Approval: 2nd Senate

**Course Contents**

- **Module I** Rational Optimism; the scope of decision-making and social action; types of social power; types of associations; forms of government; constitutions and the legal framework; order and change; distributive justice.

- **Module II** Current Issues: Tolerance and Pluralism; Race, Gender & Politics of Identity, Challenges to the Liberal-Democratic Paradigm.

**Prescribed Reading**

1. Paul F. de Lepinasse, **Basic Political Concepts**, Global Text Project, Jacobs Foundation, Zurich, 2008.

2. Roskin/Cord/Madeiros/Jones, **Political Science: An Introduction**, Pearson, 2011.

3. Kenneth Minogue, **A Very Short Introduction to Politics**, OUP, 1994.

**Recommended Reading:**

1. Gabriel Almond and Sidney Verba, The Civic Culture Revisited, Sage, 1989.
2. Aristotle, Politics. Ed. Stephen Everson, CUP, 1989.
3. Ernest Barker, Principles of Social & Political Theory, Oxford Paperbacks, 1961.
4. Bernard Crick, In Defence of Politics, Penguin,1993.
5. Christopher Hood, The Art of the State: Culture, Rhetoric, and Public Management, OUP, 1998.
6. Dorothy M. Pickles, Introduction to Politics, Methuen, London, 1964.
7. George H. Sabine, A History of Political Theory, Holt, Reinhart, 1937.
8. Roger Scruton, A Dictionary of Political Thought, Macmillan, 1982.
9. Anthony D. Smith, Nationalism: Theory, Ideology & History, 2001.

**Managerial competence**

Manage your choice from the three courses here:

- **Principles of Organizational Management** From the drawing board to the shop floor, from the production lines to the market, every industrial concern is guided by the concern to streamline processes, to speed up production, and to reach the market on time, in order to maximize profits. What are the problems and unique solutions that have made business gurus into legendary figures today?
- **Principles of Financial Accounting** Nothing matters like facts and figures, whether you are reporting to shareholders or to financial managers. How are standard accounting reports prepared? And for whom? How does Financial Accounting help in decision-making processes in a business concern?
- **Organizational Behavior** How do individuals and groups work within an organization? How does the organizational structure condition group dynamics? Can psychological and sociological insights help to control and to predict the behavior of the workforce?

## 12.18 HS 205: Financial Accounting

**Course Code: HS 205**

**Course Name: Financial Accounting**

L-T-P-C: 3-0-0-3
Prerequisite: Consent of the faculty member
Students intended for: B.Tech
Elective or Core: Elective
Approval: 2nd Senate

**Course Contents**

- **Module I** Financial Accounting- concept, importance and scope, accounting principles, journal, ledger, trial balance, depreciation (straight line and diminishing balance methods), preparation of final accounts with adjustments. Analysis and interpretation of financial statements meaning, importance and techniques, ratio analysis; fund flow analysis; cash flow analysis (AS-3). Cost accounting-meaning, importance, methods, techniques; classification of costs and cost sheet; inventory valuation; an elementary knowledge of activity based costing. Cost concepts, Direct & Indirect cost, Types of cost, full costing, overhead allocations, and preparation of cost sheet; Concept, distinctive features of Activity-Based Costing, Cost Drivers, Cost of Activities, and Cost object such as product, service, and customer; Product mix decisions, cost and financial profit reconciliation

- **Module II** Management accounting- concept, need, importance and scope; Budgetary control- meaning, need, objectives, essentials of budgeting, different types of budgets; standard costing and variance analysis (materials, labour); marginal costing and its application in managerial decision making. Cost, Volume, Profit analysis, P/V ratio, analysis and implications, Concept and uses of contribution; Differential costing and incremental costing; concept, uses and applications; Method of calculation of these cost and its role in management decision making like sales, replacement, buying etc. Meaning, definition & objectives of fund flow statement, Meaning of funds & flow, Technique of preparation of fund flow statement-Sources of funds & application of fund, provision for income tax, proposed dividend, digging out hidden information, payment of dividend, purchase or sale of investments, uses of funds flow statement, limitations of funds flow statement, difference between: Schedule & Statement, Net profit & funds from operations, fund flow statement & income statement, fund flow statement & balance sheet.

- **Module III** Meaning & objective of cash flow statement, Procedure of preparing cash flow statement-direct & indirect method, cash flows from operating activities, cash flow from investing activities, cash flows from financing activities, special aspects- provision for income tax, proposed dividend, provision for depreciation, depreciation on fixed assets, loss or profit on sale of fixed assets difference between fund flow statement & cash flow statement. Concept of standard costs, establishing various cost standards, calculation of Material Variance, Labour Variance, and Overhead Variance, and its applications and implications. Concept and various approached to responsibility accounting, concept of investment center, cost center, profit center and responsibility center and its managerial implications, Transfer Pricing Multinational transfer pricing, market based transfer pricing, cost-based transfer pricing, Cost of Quality and Time.

**Suggested Readings:**


1. Khan, M.Y. and Jain, P.K., **Management Accounting**, TMH.

2. Singhal, A.K. and Ghosh Roy, H.J., **Accounting for Managers**, JBC Publishers and Distributors.

3. Pandey, I.M., **Management Accounting**, Vikas Publishing House.

4. Horngren, Sundem and Stratton, **Introduction to Management Accounting**, Pearson Education.

5. Anthony R. N. and Reece J. S., **Management Accounting Principles**, Homewood, Illinois, Richard D. Irwin, 1995.

6. Hansen & Mowen, **Cost Management**, Thomson Learning

7. Mittal, S. N., **Management Accounting and Financial Management**, Shree Mahavir Book Depot.

8. Jain, S. P. and Narang, K. L., **Advanced Cost Accounting**, Kalyani Publishers.

9. Bhattacharyya S K and Dearden J, **Accounting for Management**, Vikas.

10. Williamson Duncan, **Cost & Management Accounting**, Wheeler Publishing.

11. Narayanswami, **Financial Accounting: A Managerial Perspective**, 2nd Edition, PHI.

12. Mukherjee, **Financial Accounting for Management**, TMH.

13. Ramchandran & Kakani, **Financial Accounting for Management**, 2nd Edition, TMH.

14. Ghosh T P, **Accounting and Finance for Managers**, Taxman.

15. Maheshwari S.N. & Maheshwari S K, **An Introduction to Accountancy**, 9th Edition, Vikas.

16. Gupta Ambrish, **Financial Accounting for Management**, 2nd Edition, Pearson Education.

17. Chowdhary Anil, **Fundamentals of Accounting and Financial Analysis**, Pearson Education.

## 12.19 HS 206: Public Speaking and Debating Skills

**Course Code: HS 206**

**Course Name: Public Speaking and Debating Skills**

L-T-P-C: 3-0-0-3
Prerequisite: Consent of the faculty member
Students intended for: B.Tech
Elective or Core: Elective
Approval: 2nd Senate

**Course Contents**

- **Organizing the Material**: Stating the Problem; Collecting the Facts; Getting and Evaluating Other Inputs; Ways of Proving; Planning the Message; Writing and Reviewing; Revising and Editing.

- **Basic Concepts of Argument** Familiar Notions of Argument; Assumptions: The Substrata of Argument; The Anatomy of Dispute; Issues; Validity, Truth and Ethics; Public Disputes and Audience Response; Applications.

- **Argument in Contemporary Society** Advertising as Persuasive Process; Argument in Politics; Argument in Law; Media: Argument in News Reporting, Persuading the Informed Public; Argument in Science and Technology; Argument in Law and Literature; Argument on Stage and in Film; Argument in Cartoons; Argument in Song and in Lyric; Argument in Interpersonal Relations/ Intercultural Relations.

- **Module IV** Acquisition of Domain Vocabularies in Contemporary Functional English, Standard Idioms and Phrases, Discourse Markers, Proverbs and Sayings.

**Prescribed Reading Material:**

Select Reading Material can be had of the Instructor.
In addition excerpts from:

1. Edward P. J. Corbett, Classical Rhetoric for the Modern Student, OUP, 1965. (With Robert J. Connors, 4/1998)

2. THE HANSARD, Edited verbatim report of the proceedings of both the House of Commons and the House of Lords. (www.parliament.uk/business/publications/hansard/)

**Recommended Reading:**

1. G. Stuart Adam & Roy Peter Clark, **Journalism: The Democratic Craft**, OUP, 2005.

2. Mathew Allen, **Smart Thinking: Skills for Critical Understanding & Writing**, OUP, 2004.

3. Cleanth Brooks & Robert Penn Warren, **Modern Rhetoric**, Harcourt, 1958.

4. Cleanth Brooks Robert Perm Warren, **Fundamentals of Good Writing: A Handbook of Modern Rhetoric**, Harcourt 1949. (Fitts Press Repr.2008.)

5. Edward P.J. Corbett & Robert J.Connors, **Style and Statement**, OUP, 1999.

6. Eric Henderson, **The Active Reader: Strategies for Academic Reading & Writing**, OUP, 2012.

7. J. Michael Sproule, **Argument: Language and its Influence**, McGraw-Hill, 1980.

## 12.20 HS 208: English II

**Course Code: HS 208**

**Course Title: English II**

L-T-P-C: 3-0-0-3
Prerequisites: HS 106 English I (or at the discretion of course instructor)
Students intended for: UG
Elective or Compulsory: Elective Sem
Approval: 9th Senate

**Course Contents**

- Introduction to the course, interactive session with students (competency objective)[2 Lectures]
- Grammar:
  - Direct and Indirect speech [4 Lectures]
  - Gerunds and Infinitives [4 Lectures]
  - Conjunctions [5 Lectures]
  - General gap filling (both, neither, either, this, that, such, like, etc.) [3 Lectures]
- Writing continued: [14 Lectures]
  - Paragraph writing
  - Report writing
  - Forms of official communication
  - Presentations
- Speech: [10 Lectures]
  - Interactive discussions on the topics (not necessarily limited to these): Personal life, social life, religions, sports, the world around us, workplaces, etc.

**Textbooks (with supplementary exercises):**

1. Murphy, Raymond., **English Grammar in Use**, Cambridge University Press, 2012.
2. Naylor, Helen (with Raymond Murphy)., **Essential Grammar in Use Supplementary Exercises**, Cambridge University Press, 2007.
3. Raman, Meenakshi and Sangeeta Sharma, **Technical Communication: Principles And Practice**, 3rd Edition, Oxford University Press, 2015.

## 12.21 HS 209: New Media Arts

**Course Code: HS 209**

**Course Name: New Media Arts**

L-T-P-C: 1-0-3-3
Prerequisites: 1C 150P
Intended for: B.Tech.
Distribution: Elective
Approval: 9th Senate

**Course Courses**

- **Module - I** Introduction to Art, Fundamentals of Art, Introduction to Traditional Media, Introduction to New Media Arts, Visual Communication. [14 Lectures]
- **Module - II** Drawing and Composition, Creating Illustration. [12 Lab Hours]
- **Module - III** Introduction to photography, Introduction to Animation. [15 Lab Hours]
- **Module - IV** The Face and the Public: Race, Secrecy, and Digital Art Practice, Introduction to Audio Editing, Introduction to Video Editing, Multimedia portfolio, Show casing. [15 Lab Hours]

**Textbooks:**

1. 1. Richard L. Lewis & James Luciana, **Digital Media: An Introduction**, Prentice Hall, 2004.
2. 2. Christiane Paul, New Media, **New Media in the White Cube and Beyond - Curatorial Models for Digital Art**, University of California Press, 2009.
3. 3. Mark Tribe, **New Media Art** (Taschen Basic Art Series), Taschen GmbH, 2006.
4. 4. Lisa Nakamura, **Digitizing Race: Visual Cultures of the Internet**, Univ Of Minnesota, 2007.

**References:**

1. Andrew Graham-Dixon, **The Definitive Visual Guide**, DK Publication, 2008.
2. Gayatri Sinha, (2009), **Art and Visual Culture in India (1857-2007)**, Marg.
3. Nancy Adajania, **New-Context Media: A Passage from Indifference to Adulation**.
4. Michael Rush, **New Media in Art**, Thames and Hudson, 2005.
5. UGC Model Curriculum, **Report of The Curriculum Development Committee,** In Visual Arts, 2001.

6. Vision Statement: School of Culture and Creative Expressions, Ambedkar University, Delhi.
7. Gayatri Sinha & Paul Sternberger, **India: Pubic Places, Private Spaces Contemporary Photography and Video Art**, Marg Publication, 2007.
8. P.N.Mago, **Contemporary Art in India: A Perspective**, National Book Trust Publication, 2001.

## 12.22 HS 235: Introductory Econometrics

**Course Code: HS 235**

**Course Name: Introductory Econometrics**

L-T-P-C: 3-0-0-3
Prerequisites: None
Intended for: UG
Distribution: HS Course
Approval: 9th Senate

**Course Contents**

- **Introduction** What is econometrics? [1 Lecture]
- **A Review of some useful statistical tools** Random variables; populations and sample, techniques of sampling and distribution; statistical estimation- estimators and their properties; testing of hypothesis [10 Lectures]
- **Introduction to regression analysis** Assumptions of Classical Linear Regression Models; Ordinary Linear Least Square regression; Gauss Markov theorem; Multiple Regression Analysis- introduction to matrix formulation; interpreting regression coefficients, concepts of residual, fitted value and goodness of fit; Beware of the issues of model misspecifications! Understanding errors in measurement of variables, model selection and non-linear functional forms; Use of Dummy variables [10 Lectures]
- **Violation of assumptions in our model** Multicollinearity, Autocorrelation, Heteroskedasticity: Who are they? How to identify them? What are the causes, effects, and remedies? [12 Lectures]
- **Instrumental variables** Instrumental Variables- their use in solving the problem of omitted variables in regression analysis. [4 Lectures]
- **How econometrics is applied to a real world problem?** Reading and understanding application of econometrics in 1-2 relevant research papers; some basic problem solving- hands-on exercises (preferably in groups). [5 Lectures]

**Reading Suggestions:**

1. Casell, G and Berger, R.L., **Statistical Inference**, 2nd Edition, Duxbury Advanced Series, 2002. (Chapter 2 in particular for statistical distribution)
2. Johnston, J and Dinardo, J., **Econometric Methods**, 4th Edition, McGraw Hill: International Editions, 1997.
3. Wooldridge, Jeffrey M., **Introductory Econometrics**, Thompson, 2003.
4. 1-2 relevant research papers.

## 12.23 HS 241: Introduction to Drama: Theory and Practice

**Course Code: HS 241**

**Course Name: Introduction to Drama: Theory and Practice**

L-T-P-C: 2-1-0-3
Prerequisites:
Students intended for:
Elective or Compulsory Elective 5th Senate
Approval: 5th Senate

**Course Contents**

- **Introduction** The idea of Play and performance in life and on stage. History of drama, types of drama
- **Elements of Drama** important terms and concepts
- **Theories of drama** Aristotle and Bharata
- **Tragedy, elements, important** A play by Sophocles
- **Comedy, elements, types** A play by Shakespeare
- **Sanskrit Drama, elements, types** Bhasas play
- **Folk Theatres of India, types, different forms** A play by H S Shiva Prakash
- **Module VIII** Brief overview of Modern European and American Drama
- **Module IX** Overview of Indian Drama after Independence

**Tutorials**

The weekly tutorial will be an interactive session, where the topics taught at the lecture will be discussed in depth, with video aid if possible. Few tutorial sessions will be used for theatre practice, where the students will be given interactive exercises which will help clear the concept of space, body, movements and so forth. In the middle of the semester, the class will be divided into two groups and two different productions will be staged.

The students are expected to read the assigned readings and participate actively in the theatre practice sessions and class discussions.

## 12.24 HS 252: Introduction to Psychology

**Course Code : HS 252**

**Course Name: Introduction to Psychology**

L-T-P-C : 3-0-0-3
Students intended for : B.Tech
Core or Elective : Elective
Prerequisites : Teacher' s Consent
Approval: 15th Senate

**Course Contents**

- **Nature of Psychology** [2 Lectures]
  - Adding to what we know: The process of psychological research.
- **A brief history of pychology** [2 Lectures]
  - Psychology's family lbum
- **Biopsychology** [2 Lectures]
  - Concepts of biopsychology, reductionism,
  - Neuron, synapses, neurotransmitters, nervous system, Hemisphere function
- **Learning** [4 Lectures]
  - Classical Conditioning: Learning Predictable Signals
  - Operant Conditioning: Learning what does what.
  - Observational Learning: Learning from the behaviour and outcomes of others.
- **Cognitive Processes** [4 Lectures]
  - Nature, emergence and stages, methods of study
- **Attention and Conciousness** [6 Lectures]
  - Types: Selective, Divided and sustained
  - Theories: Early and late selection, Capacity and Mental efforts model
  - Consciousness
- **Memory** [5 Lectures]
  - What is memory?
  - Sensory Memory, Short term memory, and working Memory
  - Long Term Memory: Where past lives live!
- **Perception** [6 Lectures]
  - Auention- What is attention? Methods of studying attention.

- Perceptual Constancies and Perceptual Organi zation.
- Psychophysics, Theory of Signal Detection, Pattern/Object Perception and recognition)

- **llldividual Differences** [7 Lectures]
  - Theories of Intelligence; The most(?/!) controversial concept in Psychology.
  - The measurement of intelligence.
  - Nature vs. Nmture Debate.
  - The Psychodynamic Perspective: Excavating the iceberg, the Trait perspective, Learning Theory Perspective; Social-Cognitive Theory, the Humanistic Existential Perspective; the Socio-Cultural Personality
  - Assessing Personality.
  - Genetic and Environmental Component in Various Psychological Processes.

- **Affective Processes: Emotions**
  - Emotions: Adding Colour to life.
  - Theories of Emotions. [4 Hours]

**Text Books:**

1. Baron, Robert A (2002). Psychology (5th Edition). Allyn and Bacon

Recommended Reading:

1. Zimbardo and Gerrig, **Psychology and Life**, Prentice Hall
2. Coon, D., & Mitterer, J.O., **Introduction to psychology: Gateways to mi11d and behaviour**, Wadsworth (Cengage Learning).
3. Atkinson and Hilgard's **Introduction to Psychology**, Cengage Learning.

## 12.25 HS 253: Introduction to Sociology

**Course Code :HS 253 and HS 344**

**Course Name: Introduction to Sociology**

L-T-P-C :3-0-0-3
Students intended for :B.Tech
Elective or Compulsory :Elective
Prerequisites :Teachers Consent
Approval: 5th Senate

**Course Contents**

- **Module I** What is Sociology? Study of Social Life Understanding Society Uses of Sociology
- **Module II** Basic Concepts in Sociology Society, Community, Social Structure, Function, Status & Role, Power & Authority, Social Groups Primary and Secondary, Socialization and Culture
- **Module III** Social Institutions Marriage, Family, Kinship, Political System, Economic System, Religion
- **Module IV** Sociological Perspectives Evolutionist, Functionalist, Conflict Classical Sociological Thought - Aguste Comte, Emile Durkheim, Karl Marx, Max Weber

**References**


1. Alex Inkeles,**What is Sociology?: an Introduction to the Discipline and Profession**, Prentice-Hall Publishing, 1964.
2. Anthony Giddens, **Sociology**, 5th Edition, Polity Press , 2006.
3. Michael Haralambos, **Sociology: Themes and Perspectives**, 7th Edition, Collins Publishing, 2008.
4. Penguin Dictionary of Sociolo, 5th Edition, Penguin publishing, 2006.
5. Shankar Rao, **Sociology: Principles of Sociology**, S. Chand & Company Ltd, 2011.
6. T.B. Bottomore, **Sociology: A Guide to Problems and Literature**, Routledge Publication, 1962.


## 12.26 HS 254: Introduction to European Philosophy

**Course Code: HS 254**

**Course Name: Introduction to European Philosophy**

L-T-P-C: 3-0-0-3
Prerequisite: Consent of the faculty member
Students intended for: B.Tech.
Elective or Core: Elective
Approval: 2nd Senate

**Course Contents**

**The Problem of Knowledge** How do we come by knowledge? From Menos Paradox to Polanyis Tacit Knowing [10 Lectures]

**The Problem of Justice** From Platonic Communism to Marxist Dialectics; from the Polis to the Open Society; from isonomia to distributive justice [10 Lectures]

**The Problem of Religion** From the City of God to the City of Man; the Church and the State; The Saint and the Statesman; Transcendence and Immanence [10 Lectures]

**The Problem of Technology** From the Novum Organon to the Question Concerning Technology; Technology and the Character of the Good Life [10 Lectures]

**The Problem of Philosophy Today** The Battle of the Ancients against the Moderns [5 Lectures]

**Text & Reference Books:**

**Prescribed Texts:**


1. Eric Lund, MogensPihl and Johannes Slk, A History of European Ideas, Hurst, London, 1971.

2. Select excerpts from the writings of leading European philosophers since Plato (can be had of the teacher)


**Recommended Readings:**


1. Alistair J. Sinclair, **What Is Philosophy? An Introduction**, Dunedin Academic Press, 2008.

2. Anthony Kenny, **The Oxford Illustrated History of Western Philosophy**, Oxford, 1994.

3. Bertrand Russell, **A History of Western Philosophy**, Routledge,2004.

4. Jacob Needleman, **The Heart of Philosophy**, Jeremy P. Tarcher, 2003.

5. JosteinGaarder, **Sophies Dream**, 1995 (soft copy placed in the library).

6. James L.Christian, **Philosophy, An introduction to the Art of Wonderin**, Wordsworth, 2009.

7. Richard David Precht, **Who am I**, Spiegel &Grau, 2011.

8. Richard Schacht, **Hegel and After: Studies in Continental Philosophy Between Kant and Sartre**, University of Pittsburgh Press, 1975.

9. **Classical Modern Philosophers: Descartes to Kant**, Routledge & Kegan Paul, 1984.

10. Ted Honderich, **The Oxford Companion to Philosophy**, Oxford University Press, 1995.


## 12.27 HS 255: India Since Independence

**Course Code: HS 255**

**Course Name: India Since Independence**

L-T-P-C: 3-0-0-3
Prerequisite: Consent of the faculty member
Students intended for: B.Tech.
Elective or Core: Elective
Approval: 2nd Senate

**Course Contents**

- **After independence** [6 Lectures]
    1. Independence and partition,
    2. The unification of princely states,
    3. The Constitution and the making of the Republic
- **Political history** [6 Lectures]
    - Nehruvian era,
    - The Indira and Rajiv years,
    - The era of globalization
- **The economy** [6 Lectures]
    - Five year plans,
    - Industrialization,
    - Green revolution,
    - Nationalization,
    - Liberalization
- **Movements and uprisings** [6 Lectures]
    - Agrarian unrest,
    - Dalit movement,
    - womens movement,
    - Labour movements,
    - Naxal uprising
- **Identity** [6 Lectures]
    - Hindu nationalism,
    - Regionalism,
    - The assertion of Islamic groups,
    - Caste and community,
    - Diaspora
- **Science and arts** [6 Lectures]
    - Science and technology,
    - Literature,
    - Cinema and other entertainments,
    - Sports

**Prescribed Texts:**

1. Ramachandra Guna, **India after Gandhi**, Picador India, 2007
2. Bipan Chandra et al, **India since Independence**, Penguin, 2008.

**Recommended Readings:**

1. Shashi Tharoor, **India Midnight to Millennium**, Arcade, 1997.
2. Patrick French, **India A Portrait**, Penguin, 2007.

## 12.28 HS 261: The Indian Constitution

**Course Code: HS 261**

**Course Name: The Indian Constitution**

L-T-P-C: 3-0-0-3
Prerequisites : None
Offered to: B. Tech (Higher Semesters)
Approval: 4th Senate

**Course Contents**

- **Module 1** The History of the Making of Indian Constitution
- **Module 2** Preamble and the Basic Structures
- **Module 3** Fundamental Rights and Duties
- **Module 4** Directive Principles of State Policy
- **Module 5** Legislature, Executive and Judiciary
- **Module 6** Emergency Powers
- **Module 7** Special Provisions for Jammu and Kashmir, Nagaland and Other Regions
- **Module 8** Amendments

**Prescribed Texts:**

1. D D Basu, Introduction to the Constitution of India, 20th Edn.,Lexisnexis Butterworths, 2012.

**Recommended Readings:**

1. Rajeev Bhargava (ed), **Ethics and Politics of the Indian Constitution**, Oxford University Press, New Delhi, 2008.

2. Granville Austin, **The Indian Constitution: Cornerstone of a Nation**, Oxford University Press, 1966.

3. Zoya Hassan, E. Sridharan and R. Sudarshan (eds), **Indias Living Constitution: Ideas, Practices, Controversies**, Permanent Black, 2002.

4. Subhash C. Kashyap, **Our Constitution**, National Book Trust, 2011.

## 12.29 HS 263: Popular Culture in Modern India: A Historical Perspective

**Course Code: HS 263**

**Course Name: Popular Culture in Modern India: A Historical Perspective**

L-T-P-C: 3-0-0-3
Prerequisites: Consent of the Instructor
Intended for: UG
Distribution: Semester:
Approval: 9th Senate

**Course Contents**

- History of Cricket [8 Lectures]
  - Unit 1: Race and Sport in Colonial India: Parsi cricket in India
  - Unit 2: Caste and Cricket in Colonial India: A Case Study of Palwankar Baloo
  - Unit 3: Class and Cricket: A Case Study of Maharaja Ranjitsinhji
- 2. Popular Musical Traditions and Technology [4 Lectures]
  - Unit 1: Oral Musical Traditions: A Survey (Bhands, Qawalls )
  - Unit 2: The Guru and the Gramophone Technology and Changes in
  - Consumption of Music
- 3. Popular Visual Culture [10 Lectures]
  - Unit 1: What is Visual Culture?
  - Unit 2: Posters of National Leaders in the Colonial Period
  - Unit 3: Maps of India in Calendar Art
  - Unit 4: Cartoons and their impact: R.K. Laxmans Common Man
- 4. Popular Films History [7 Lectures]
  - Unit 1: Colonial Anxieties Regarding Film in India

- Unit 2: Nation-?building Cinema of the 1950s
- Unit 3: The Idea of the Secular in Indian Films
- Unit 4: Changing Portrayals of the Villain in India

- 5. Advertisements after Economic Liberalization [3 Lectures]
- 6. Food History [10 Lectures]
  - Unit 1: Food in Ancient and Medieval India
  - Unit 2: Migration Patterns and Changes in Food Consumption
  - Unit 3: What is Authentic Indian Cuisine?

**Prescribed Texts:**

1. A.R. Venkatachalapathy, **In Those Days There was No Coffee: Writings in Cultural History**, Yoda Press, 2006.
2. Rohit Wanchoo and Mukesh Williams, **Representing India: Literature, Politics, and Identities**, Oxford University Press India, 2008.
3. Dilip M. Menon (ed.), **Cultural History of Modern India**, Social Science Press, 2011.

**Suggested Readings:**

1. Vasudha Dalmia and Rashmi Sadana (eds.), **The Cambridge Companion to Modern Indian Culture**,Cambridge University Press, 2012.
2. Ashis Nandy, **The Tao of Cricket: On Games of Destiny and the Destiny of Games**, Oxford University Press, 2001.
3. Ramachandra Guha, **A Corner of a Foreign Field: The Indian History of a British Sport**, Picador, 2002.
4. Peter Manuel, **Cassette Culture: Popular Music and Technology in North India**, University of Chicago Press, 1993.
5. Christopher Pinney, **Photos of the Gods': The Printed Image and Political Struggle in India**, Reaktion Books, 2004.
6. Sumathi Ramaswami, **The Goddess and the Nation: Mapping Mother India**, Duke University Press, 2010.
7. Ravi S. Vasudevan (ed.), **Making Meaning in Indian Cinema**, Oxford University Press, 2001.
8. William Mazzarella, **Shoveling Smoke: Advertizing and Globalization in Contemporary India**, Duke University Press, 2003.
9. Rache Dwyer, Picture Abhi Baaki Hai: Bollywood as a Guide to Modern India, Hachette, New Delhi, 2014.

10. K.T. Achaya, **A Historical Dictionary of Indian Food**, Oxford University Press, 2003.

11. Lizzie Collingham, **Curry: A Tale of Cooks and Conquerors**, Vintage, 2006.

12. John Thieme and Ira Raja (eds.), **The Table is Laid: An Anthology of South Asian Food Writing**, Oxford University Press, 2007.

13. Utsa Ray, **Culinary Culture in Colonial India: A Cosmopolitan Platter and the Middle-Class**, Cambridge University Press, 2015.

14. Arjun Appadorai, **How to Make a National Cuisine: Cookbooks in Contemporary India**, Comparative Studies in Society and History, vol.30, no.1, 1988.

15. Douglas Haynes et al (eds.), **Toward a History of Consumption in South Asia**, Oxford University Press, 2010.

16. R.K. Laxman, **Brushing up the Years: A Cartoonists History of India, 1947-2004**, Penguin Viking, 2005.

17. R.K. Laxman, **The Best of Laxman: The Common Man Casts his Vote**, Penguin, 2005.

18. Abu Abraham, **Why does Kerala produce so many cartoonists? India International Centre Quarterly**, Vol. 22, No 2/3, Summer-Monsoon 1995, pp. 60-?64.

19. R.K. Laxman, **Freedom to Cartoon, Freedom to Speak**, Daedalus: Another India, Vol. 118, No 4, Fall 1989, pp. 68-?91.

## 12.30 HS 301: Policy Analysis and Advocacy Skills

**Course Code: HS 301**

**Course Name: Policy Analysis and Advocacy Skills**

L-T-P-C: 3-0-0-3
Prerequisite: Consent of the faculty member
Students intended for: B.Tech
Elective or Core: Elective
Approval: 2nd Senate, 11th Senate

**Course contents**

- Logical Thinking, the Enthymeme; standard fallacies
- Common topoi
- Features of the Forensic Debate: The Proposition, Affirmative and Negative Sides, Presumption and Burden of Proof, Prima Facie Case, Justification for a Program of Action, Disparity and Stock Issue Analysis, Techniques of Gathering Evidence from various sources including newspapers, journals, periodicals, government documents, of using citizens empowerment provisos to elicit information etc.

- Standard Speaker Formats, Parliamentary Debates and Resolutions, Techniques of Cross- Examination, Academic Debate, Debate Flow Sheet and Debate Critique.

**Prescribed Reading:**

1. Select Excerpts from **The Hansard**, Edited verbatim report of the proceedings of the House of Commons and the House of Lords.

2. Select Newspaper Articles besides select essays from journals like Resurgence, Down to Earth, back numbers of the now defunct MANAS etc.

3. J. Michael Sproule, **Argument: Language and its Influence**, McGraw-Hill, 1980: Chapters ten & eleven only.

**Recommended Reading:**

1. Eugene Bardach, **A Practical Guide for Policy Analysis: The Eight Fold Guide to More Effective Problem Solving**, CQ Press Washington 2005.

2. George M. Guess & Paul G. Farnham, **Cases in Public Policy Analysis**, Georgetown University Press, 2000.

3. Gerald Miller, **Handbook of Public Policy Analysis**, Taylor & Francis, 2007.

**Social Competence**

Here again, you have a choice of three courses.

- **Principles of Economics**: How do nations generate wealth? How does the state regulate its distribution to ensure reasonable standards of living for all? What is the impact of mans economic pursuit on environment and ecology? Is there a link between the prosperity of the developed nations and the massive poverty elsewhere? The course examines the economic principles that govern daily life; it traces the rise of consumerism from the barter economy of early societies to the casino capitalism of today. Field trips and surveys in the Himachal region shall complement your understanding.

- **Understanding Society**: The course invites students to examine the unfolding forms and modes of human collective living from ancient to modern times. Students will also study the institutional framework as well as living conditions of humans across distinctive historical periods. Besides, they will investigate the impact of modern life in its various forms on the mind, on marriage, on family and its breakdown and of its significance for the future. They will attempt to comprehend diverse levels of stress in modern life and the solutions attempted, also economic factors and their psycho-social impact. Field trips to various tribal communities in Himachal Pradesh complement students understanding.

- **Political Science**: Why does Aristotle describe Politics as the Master Science? Just think how difficult it is for us to maintain peace and harmony in our homes! How much more difficult would it then be to keep a country of 1.2 billion to live in peace with one another? How are we to understand Aristotles paradoxical assertion that the evil in man makes society necessary but it is the good in man that makes society function. Field trips to local communities in the neighborhood make for understanding firsthand key issues in politics, law and governance.

## 12.31 HS 302: Introduction to Drama in English

Course number : HS 302
Course Name : Introduction to Drama in English
Credit Distribution : 3-0-0-3
Intended for : Undergraduate
Prerequisite : None
Mutual Exclusion : None
Approval: 50th BoA

**Course Contents:**

- Module 1: **Introduction to drama** (3 hours)
  - Historical overview of the dramatic form
  - The basic elements of a play (plot, character, setting, atmosphere, mood, etc.)
- Module 2: **Tragedies** (6 hours)
  - Historical overview of tragedies
  - Components of tragedies (catharsis, hamartia, dramatic irony, etc.)
  - Structure of tragedies
  - Revenge tragedy
  - Domestic tragedy
- Suggested text: William Shakespeare, Macbeth (1623); Hamlet (c.1509)
- Module 3: **Comedies** (6 hours)
  - Historical overview of comedies
  - Old comedy and New comedy
  - Tragicomedy
  - Satire
  - Comedy of errors
  - Sentimental comedy
  - Domestic comedy
- Suggested texts: Oscar Wilde, The Importance of Being Earnest (1895); Neil Simon, The Odd Couple (1965); Northrop Frye, The Argument of Comedy (1949)
- Module 4: **Modern Theatre** (11 hours)
  - An overview of modern drama
  - Expressionism

  - Naturalism
  - Living newspapers
  - Epic theatre
  - Theatre of the absurd

- Suggested texts: Eugene O' Neill, The Emperor Jones (1920); Hallie Flanagan Davis, E=mc2 (1947); Edward Albee, The Zoo Story (1958); Martin Esslin, The Theatre of the Absurd (1960)

- Module 5: **Drama on the Global Stage** (8 hours)

  - Colonialism and its legacy in theatre
  - Politics of language
  - Global neo-imperialism

- Suggested texts: Wole Soyinka, Death and the King's Horseman (1975); Brian Fiel, Translations (1980); Manjula Padmanabhan, Harvest (1997); Mahesh Dattani, Dance like a Man (1989); Helen Gilbert and Joanne Tompkins, Post-Colonial Drama: Theory, Practice, Politics (1996)

- Module 5: **Performing Plays** (8 hours)

  - This module will be devoted to performances based on plays from or relevant to the syllabus. These performances will be conducted in class and all students are expected to contribute to the performance. The tentative audience for the performance will most likely be the registered participants for the course. Students will be divided into groups after which they will perform portions of a selected play from the syllabus or any play of their choice. Students will be informed about this requirement in the beginning of the course itself so that they can adequately prepare and decide upon possible texts. They are not expected to spend excessive time beyond class hours in preparation for the play—memorizing scripts is only optional, as is the preparation of costumes, props, stage, etc. In lieu of a full-performance, students may also perform a table reading/ read aloud portions of the play in a simulated theatre setting for the class.

**Textbooks:**


1. Klaus, Carl H., Miriam Gilbert, and Bradford S. Field, Jr., eds. Stages of Drama: Classical to Contemporary Theater, U.S. 2003.

2. Pickering, Kenneth, Key Concepts in Drama, Palgrave Macmillan, U.S. 2005.


**References:**


1. Albee, Edward. The Zoo Story, 1958. Aristotle, Poetics, Penguin Classics, (Revised Edition), U.K. 1996.

2. Soynika, Wole, "Death and the King's Horseman," in Contemporary African Plays by Martin Banham and Jane Plastow, Methuen Publishing, U.K., 1999.

3. Dattani, Mahesh, Dance like a Man, Penguin Petit, (2006)

4. Esslin, Martin. “The Theatre of the Absurd,” The Tulane Drama Review, 4.4:3-15, 1960.

5. Frye, Northrop “The Argument of Comedy.” Shakespeare: An Anthology of Criticism and Theory. Ed. Russ McDonald. Malden, MA: Blackwell Publishing, 2004. 94-95, 97.

6. Gilbert, Helen and Joanne Tompkins. Post-Colonial Drama: Theory, Practice, Politics London: Routledge, 1996.

7. G.J. Watson, Drama: An Introduction, Macmillan Press, U.K. 1983.

8. Flanagan Davis, Hallie, E=mc2 in Routledge Drama Anthology and Sourcebook from Modernism to Contemporary Performance by Maggie B. Gale and John F. Deeney (Editors), U.S. and U.K. 2010.

9. O'Neill, Eugene. The Emperor Jones, Dover Publications, U.S. 2012.

10. Padmanabhan, Manjula. Harvest, Kali for Women, India 1997.

11. Shakespeare, William, Macbeth, Penguin Classics, U.K., 2015. Shakespeare, William, Hamlet, Penguin, Dover Thrift Edition, U.S. 2000.

12. Simon, Neil. The Collected Plays of Neil Simon, Plume, U.S. 1986.

13. Wilde, Oscar. The Importance of Being Earnest and other Plays, Penguin Group, Signet Classics, 1985.

## 12.32 HS 303: Partition of India: History and Legacy

Course number : HS 303
Course Name : Partition of India: History and Legacy
Credit Distribution : 3-0-0-3
Intended for : B.Tech. (7th and 8th Semesters)
Prerequisite : None
Mutual Exclusion : None
Approval: 50th Senate

**Course Contents:**

- Unit 1: Why is Partition history important? (1 hour) [R3 suggestion incorporated and this new unit has been added.]
  - Interrogating popular understandings of Partition
  - Partition as event and process
- Unit 2: Trauma and Memory: Methodologies Old and New (4 hours)
  - What is the relationship between history and memory?
  - Interrogating the archive

  - Potentials and limitations of oral history [R3 suggestion has been incorporated and ‘pitfalls’ has been replaced with ‘limitations’.]
- Unit 3: The High Politics of Partition (10 hours)
  - Majorities and minorities in a colonial context: Issues of representation and power
  - Elections of 1937 and 1946
  - Negotiations: The Congress, the Muslim League, and the British
- Unit 4: The Partition in Punjab and Bengal: Varying Trends and Trajectories (6 hours)
  - Patterns of violence
  - Refugee relief and rehabilitation
- Unit 5: Impact on Cities (5 hours)
  - Evacuee property: custodians and claims
  - Delhi
  - Calcutta
- Unit 6: Neglected Histories of Partition (6 hours)
  - Gender – the recovery of ‘abducted’ women
  - Caste – challenging the idea of the monolithic refugee
  - Region – the experience of Sindh
- Unit 7: The ‘Long Partition’: The Impact of Partition on Indian Polity (4 hours)
  - Minority rights in the Indian Constitution
  - Citizenship: short-term and long-term trends
  - Partition’s shadow on the India-Pakistan relationship [R3 suggestion has been incorporated.]
- Unit 7: Representing the Partition in Literature and Film (6 hours)
  - Literature – short stories by Rajinder Singh Bedi, Saadat Hasan Manto, Intizar Husain and Ismat Chughtai. Source book: Bhalla, Alok (ed.). Stories about the Partition of India, Vols I-III. Publishers, 2011.
  - Film Ghatak, Ritwik. Meghe Dhaka Tara [The Cloud-Capped Star], 1960. Sumar, Sabiha. Khamosh Paani [Silent Waters], 2004.

**Text books:**

1. Khan Yasmin, The Great Partition: The Making of India and Pakistan. Yale University Press, 2008. • Roy, Haimanti. The Partition of India. Oxford University Press, 2018.

**References:**


1. Butalia Urvashi. The Other Side of Silence: Voices from the Partition of India. Penguin, 1998.

2. Chatterji Joya. Bengal Divided: Hindu Communalism and Partition, 1932- 1947. Cambridge University Press, 1995.

3. Chatterji, Joya. Spoils of Partition: Bengal and India, 1947–1967. Cambridge University Press, 2007. [R1 suggestion incorporated.]

4. Das, Veena. 'National Honour and Practical Kinship: Of Unwanted Women and Children'. In Critical Events: An Anthropological Perspective on Contemporary India. Oxford University Press, 1995.

5. Gauba, Kanika. "Forgetting Partition: Constitutional Amnesia and Nationalism." Economic and Political Weekly, vol. 51, no. 39, 2016, pp. 41–47. [R1 suggestion incorporated.]

6. Hasan Mushirul (ed.). India's Partition: Process, Strategy and Mobilization. Oxford University Press, 2001.

7. Jalal, Ayesha. The Sole Spokesman: Jinnah, the Muslim League and the Demand for Pakistan. Cambridge University Press, 1994.

8. Kaul Suvir (ed.), The Partitions of Memory: The Afterlife of the Division of India. Permanent Black, 2001.

9. Kaur, Ravinder. Since 1947: Partition Narratives among Punjabi Migrants of Delhi. Oxford University Press, 2007.

10. Malhotra, Aanchal. Remnants of a Separation: 21 Objects from a Continent Divided. Hurst & Co. 2019.

11. Menon Ritu and Kamala Bhasin. Borders and Boundaries: Women in India's Partition. Kali for Women, 2000.

12. Nair, Neeti. Changing Homelands: Hindu Politics and the Partition of India. Harvard University Press, 2011.

13. Pandey, Gyanendra. Remembering Partition: Violence, Nationalism and History in India. Cambridge University Press, 2001.

14. Talbot, Ian and Gurharpal Singh. The Partition of India. Cambridge University Press, 2009.

15. Tan Tai Yong and Gyanesh Kudaisya. The Aftermath of Partition. Routledge, 2000.

16. Zamindar, Vazira Fazila. The Long Partition and the Making of Modern South Asia. Columbia University Press, 2007.

17. Primary source repository: 1947 Partition Archive (https://in.1947partitionarchive.org/)

## 12.33 HS 304: Organizational Management

**Course Code: HS 304**

**Course Name: Organizational Management**

L-T-P-C: 3-0-0-3
Prerequisite: Consent of the faculty member
Students intended for: B.Tech
Elective or Core: Elective
Approval: 2nd Senate

**Course Contents**

- **Scope of organizations** Nature and function of organizations; Individual organization environment interface; Longitudinal thinking. Organization Management: Theory, practice and major schools of thought, application potentials and possibility.

- **Organizational architecture** Systems perspective on organizations and contingency approach. The socio-technical systems approach. Theory of organizational structures; Nature and consequences of structure; Organization process; IT & organizations.

- **Integrating the elements** Organizational culture; Coping strategies- individual & organizational; Impact of environmental and cultural variables on organizational structure and style; Organization design; Mechanization, automation and computerization; Organizational interdependence and organizational evaluation.

## 12.34 HS 306 : Introduction to German Literature

**Course Code : HS 306**

**Course Name : Introduction to German Literature**

L-T-P-C: 3-0-0-3
Intended for : Outside Discipline/ Free Elective for MA, UG (3rd and 4th year)
Prerequisite : None
Mutual Exclusion : None
Approval: 52nd BoA

**Course Contents**

- **Fairy Tales/ Folktales**: In this module select fairy tales/ folktales (by Grimm Brothers) will be discussed in order to introduce students to reading literary texts in German language. The selected texts will further be analyzed from a literary and linguistic perspective, enabling students to engage critically with these universal texts. Literary tools, methods of interpretation and basic German grammar will also be an intrinsic part of this module. (12 Lectures)

- **Fables**: Similar to the first module, this module shall discuss fables and provide students with a different genre to explore. One can also discuss characteristics of every genre in question and allow students to get an insight into studying different types of literary texts. (8 Lectures)

- **Short Stories, Anecdotes, and Parables**: This module shall be dedicated to yet another type of prose, short stories, anecdotes and parables in order to enable students to engage with as many types of texts as possible. Select anecdotes, parables and prominent short stories, particularly from the Truemmer-literature (Post War Germany 1945-1947) will also be a part of this module. Some well-known authors of this time include Wolfgang Borchert and Heinrich Boell. (12 Lectures)

- **Poetry**: This module shall deal primarily with different forms of poetry, including ballads, poems. Select popular German authors and their poetry shall be the object of analysis in this module. Students will be provided with basic literary and linguistic tools to analyze the deep layers of poetry and encouraged to produce individual interpretations. (10 Lectures)

**Textbooks:**

1. Daniel Chandler, **An Introduction to Genre Theory**, 1997

2. Thomas Beebee, **German Literature as World Literature**, Bloomsbury 2014

**References:**

1. Aesops Fables: The Wolf and the Lamb (Der Wolf und der Lamm)

2. Aesops Fables: The Fox and the Crow (Vom Fuchs und Raben)

3. Charles Perrault: Bluebeard (Blaubart)

4. Christa Reinig: Scorpion (Skorpion)

5. Grimm Brothers: Cinderella (Aschenputtel)

6. Grimm Brothers: Hansel und Gretel (Haensel und Gretel)

7. Grimm Brothers: Little Red Riding Hood (Rotkaeppchen)

8. Grimm Brothers: The Fisherman and his Wife (Vom Fischer und seiner Frau)

9. Heinrich Boell: Anecdote concerning the Lowering of Productivity (Anekdote zur Senkung der Arbeitsmoral)

10. Johann Wolfgang von Goethe: Elf King (Erlkoenig)

11. Joseph von Eichendorff: Moon Night (Mondnacht), Longing (Sehnsucht)

12. Rainer Maria-Rilke: The Panther (Der Panther)

13. Wolfgang Borchert: The Kitchen Clock (Die Kuechenuhr)

14. Wolfdietrich Schnurre: On The Run (Auf der Flucht)

### 12.35 HS 307: Macroeconomics I

**Course Code : HS 307**

**Course Name : Macroeconomics I**

L-T-P-C : 3-0-0-3
Intended for : B. Tech./ Undergraduate students
Prerequisite :
Mutual Exclusion:
Approval: 54th BoA

**Course Contents**

- **Introduction**: Nature and scope of Macroeconomics. (2 Hours)
- **National Income Accounting**: National income: concepts and measurement —— Circular flow of national income in two, three, and four-sector economy —— National income and economic welfare. (5 Hours)
- **Money and Inflation**: What is money? —— The quantity theory of money —— Inflation and interest rates —— The nominal interest rate and the demand for money —— Hyperinflation. (5 Hours)
- **Money supply and money demand**: Money supply: 100-percent and fractional-reserve banking —— A model of the money supply —— Monetary policy approaches and its frameworks —— Money demand: different theories of money demand. (5 Hours)
- **Consumption and investment theories**: Consumption function —— Keynes's psychological law of consumption and its implications —— Consumption function puzzle: Kuznet's findings —— Investment and its type —— Investment determination: Classical and Keynesian approach. (5 Hours)
- **Economy in the short run**: Introduction to economic fluctuations —— Aggregate demand: the goods market and the IS curve, the money market and the LM curve —— The short-run equilibrium (10 Hours).
- **Introduction to the open economy**: The international flows of capital and goods —— Saving and investment in a small open economy —— Exchange rates: nominal and real exchange rates —— Economic polies and exchange rate. (5 Hours)
- **Introduction to macroeconomics datasets**: This session aims at exploring macroeconomic databases and to empirically testify some of the economic theories in India context. (5 Hours)

**Textbooks:**

1. Mankiw N. Gregory, **Macroeconomics**, Worth Publishers, 2023.
2. Froyen, R. T., **Macroeconomics: theories and policies**, Pearson Publication, 2023.

**References:**


1. Mishkin, F., **Economics of money, banking and financial market**, Pearson Publication, 2023.


## 12.36 HS 308: Introduction to Modern European Literature

**Course Code : HS 308**

**Course Name : Introduction to Modern European Literature**

L-T-P-C : 2-0-0-2
Intended for : Undergraduate students
Prerequisite :
Mutual Exclusion:
Approval: 54th BoA

**Course Contents**

- **Introduction**: (6 Hours)
  - Europe in the late 19th and early 20th centuries.
  - Overview of preceding literary movements.
  - Introduction to Literary theory and criticism
- **From Realism to Modernism**: (6 Hours)
  - Knut Hamsun, Hunger
  - August Strindberg The Dance of Death
  - James Joyce, Dubliners
- **High Modernism**: (6 Hours)
  - Gertrude Stein, Tender Buttons
  - Franz Kafka, The Metamorphosis
  - Virginia Woolf, "The Mark on the Wall"
- **(Post)Modernism**: (6 Hours)
  - Albert Camus, The Stranger.
  - Jorge Luis Borges, The Aleph
  - Eugene Ionesco, The Bald Soprano
- **Conclusions**: (4 Hours):
  - Modernism VS Postmodernism: what's at stake?
  - The death of the Author
  - The Postmodern Condition. 2

**Textbooks:**

1. NA

**References:**

1. **Norton Anthology of Literary Criticism and Theory**
2. **Modernism**, Blackwell Anthology

## 12.37 HS 331: Role of Aesthetics in Design

**Course Code: HS 331**

**Course Name: Role of Aesthetics in Design**

L-T-P-C:: 1-0-4-3
Prerequisites: Consent of the Instructor
Intended for:UG
Elective or Core: Elective for B. Tech 3rd and 4th year
Approval: 12th Senate

**Course Contents**

- **Theory** [14 Lectures]
  - Aesthetics and Product Design, Correlation in Design and Colour, Rich potential of the human senses: vision, hearing, touch, taste, and smell, Appearance and emotions playing role in consumer choice and consumer evaluation, Attraction, impression and communication characteristics.
  - Attraction: colour, gloss, shininess, haze, and translucency and geometric attributes of appearance: shape and texture, Defining Im pression/Personality of a product, Communication - Culture,
  - Gender, Market Trend and Age group.
  - Case Studies: Identifying the dif ferent ways to effect the appearance of a product e.g. Coca Cola product's appearance, creation of scale and agility, Nano and Apple's products, etc. Determination of aesthetic values. Use the semantic power of sign, symbols and shape trilogy.
- The Practicals (Lab):
  - Idea, Concept and Inspiration by designing: spoon, mobile, laptop etc.
  - Image making, representation and storyboards.
  - Problem solving through free hand drawings.
  - Reading design and rendering visual language.
  - Survey [40 Hours]
- Final Project Submissaon 16 Hours

**Text Books:**

1. Clive Grinyer, Smart Design - The Products of lateral thinking.
2. Patrick W Jordan , Designing Pleasurable Products.

**Reference Books:**

1. Gail Gret Hannah, Elements of Design - the structure of visual relationships.
2. Edith Anderson Feisner, How to use Colour in Art and Design.
3. Design Secrets: Products 50 real-life projects uncovered, Industrial Designers Society of America1564964760

**Drawing/Sketching:**

1. Koos Eisen, Roselien Steur, Sketching the Basics.
2. Betty Edwards, The New Drawing on the Right Side of the Brain.
3. Dick Powell, Presentation Techniques -a guide to drawing and presenting design ideas.
4. Gregor Krisztian, Nesrin Schlernpp-Alker, Visualizing Ideas: From Scribbles to Storyboards.

**Creative Thinking:**

1. Alan Fletcher, The Art of Looking Sideways.
2. Paul Smith, You can find inspiration in everything (and if you can't look again).

## 12.38 HS 341: Communication and Discourse Strategies

**Course Code : H5341**

**Course Name : Communication and Discourse Strategies**

L-T-P-C : 3-0-0-3
Prerequisites:
Students intended for:
Approval: 2nd Senate

**Course Description**

This is an elementary coursedesignedto acquaint students with essential aspects of communication processes common to all languages. It seeks to equip them to respond adequately and appropriately in any particular communication situation. The course,structuredaround four learning modules spread over a semester, is based wholly on practice, and,laterally, to analysisof communication situations.

**Course Contents:**

Communication Models; the Medium and the Message; Basic Conceptsof Argument; Discourse Strategies; Communication Strategies in Contemporary Society; Building Special Vocabularies

**Recommended Reading:**

1. John Berger, **Ways of Seeing**, Penguin, 1972.
2. WilliamStrunkJr.& E.B.White, **The Elements of Style**, Macmillan, 1979.
3. Michael Sproule Argunment, **Language and Its Influence**, McGraw-HIll, 1980.
4. Graeme Burton, **More Than Meets The Eye, An Introduction to Media Studies**, Edwin Arnold, 1997.
5. Owen Hargie, **The Handbook of Communication Skills**, Routledge, 1997.
6. Richard Dimbleby & Graeme Burton, **More than Words: An Introductionto Communication**, Routledge, 1998.
7. Andrew Beck, Peter Bennett & Peter Wall, **Communication Studies: The Essential Introduction**, Routledge, 2001.
8. Richard Ellis, **Communication Skills: Steppladers to Success for the Professional**, Intellect Books, 2002.

## 12.39 HS 342: German I

**Course Code: HS 342**

**Course Name: German I**

L-T-P-C: 3-0-0-3
Prerequisite: Consent of the faculty member
Students intended for: B.Tech
Elective or Core: Elective
Approval: 2nd Senate

**Course Contents**

Basic grammatical features: position of verbs in affirmative sentences and questions, conjugation, the use of articles, imperative, the accusative case and the personal pronouns in the dative case. Listening and speaking practice: understanding simple information at railway stations, in telephone calls and being able to hold simple conversations where the partner in conversation assists in the communication process. Writing and reading: short messages and notes, filling up simple forms. Vocabulary: personal information, food and drinks, shopping, numbers, orientation.

**Prescribed Textbook**

1. Rosa-Maria Dallapazza / Eduard von Jan / Til Schnherr: Tangram aktuell 1, Lektion 1-4; Deutsch als Fremdsprache. New Delhi (Goyal Saab, rpt.) 2007.

**Select References**

1. Christine Eckhard-Black / Dr. Ruth Whittle, **Cassell's Contemporary German: A Handbook of Grammar, Current Usage, and Word Power**, MacMilan, 1993.

2. Heinz Oehler, **Grundwortschatz Deutsch**, Klett Verlag, 1994.

3. Krishna Murari Sharma, **German-Hindi Dictionary**, Rachna publication, 1978.

4. Idiomatische Redewendungen von A Z. , Langenscheidt Verlag, 1993.

5. **Langenscheidts German-English, English-German Dictionary**, Goyal Saab, 2009.

## 12.40 HS 343: Introduction Into Political Philosophy

**Course Code: HS 343**

**Course Name: Introduction Into Political Philosophy**

L-T-P-C: 3-0-0-3
Prerequisite: Consent of the faculty member
Students intended for: B.Tech
Elective or Core: Elective
Approval: 2nd Senate

**Course Description:**

All political communities come into being not only for the sake of living, but for the sake of a way of living. Characteristic, then, of any political association is the attendant discourse on achieving the best and avoiding the worst for the community and its members. Political philosophy addresses itself to the concepts underlying political beliefs and practices, such that the clarification of concepts can yield a framework for the critical evaluation of these beliefs and practices.

**Text & Reference Books:**

**Required Reading:**

Select excerpts from
Plato: The Republic
Aristotle: Politics
Machiavelli: The Prince

**Recommended Reading**

1. D.D. Raphael, Problems of Political Philosophy, Macmillan, 2007.

2. Dorothy Pickles, Introduction to Politics, ,Methuen, 2008.

3. Leo Strauss, What is Political Philosophy?, Greenwood, 1973.

**Select References**


1. Ernst Cassirer, **The Myth of the State**, Yale U.P., 1946
2. Machiavelli, **The Prince**, trs. P.Bondanella&M.Musa, O.U.P., 1984.
3. Karl Marx, **On Historical Materialism, from: Marx and Engels**, Collected Works, New York International, 1976.
4. Michael Oakshott, **Rationalism in Politics**, LSE Inaugural Lecture, London 1962.
5. Henry David Thoreau, **On Civil Disobedience** (any edition).
6. Mohandas Karamchand Gandhi, **Satyagtraha**, ed. Anand Hingorani, BharatiyaVidya Bhavan.
7. Eric Voegelin, **The New Science of Politics**, Chicago 1952


## 12.41 HS 344: Introduction to Sociology

**Course Code: HS 344**

**Course Name: Introduction to Sociology**

L-T-P-C :3-0-0-3
Students intended for :B.Tech
Elective or Compulsory :Elective
Prerequisites :Teachers Consent
Approval: 10th Senate

**Course Contents**

- Module I [8 Lectures]
  - What is Sociology?
  - Study of Social Life
  - Understanding Society
  - Uses of Sociology
- Module II [8 Lectures]
  - Basic Concepts in Sociology Society, Community, Social Structure, Function, Status & Role, Power & Authority, Social Groups Primary and Secondary, Socialization and Culture
- Module III [16 Lectures]
  - Social Institutions Marriage, Family, Kinship, Political System, Economic System, Religion
- Module IV [10 Lectures]
  - Sociological Perspectives Evolutionist, Functionalist, Conflict Classical Sociological Thought - Aguste Comte, Emile Durkheim, Karl Marx, Max Weber

**References**


1. Alex Inkeles, **What is Sociology?: an Introduction to the Discipline and Profession**, Prentice-Hall Publishing, 1964.

2. Anthony Giddens, **Sociology**, 5th Edition, Polity Press, 2006.

3. Michael Haralambos, **Sociology: Themes and Perspectives**, 7th edition, Collins Publishing (), 2008.

4. **Penguin Dictionary of Sociology**, 5th Edition, Penguin publishing, 2006.

5. Shankar Rao, **Sociology: Principles of Sociology**, S. Chand & Company Ltd, 2011.

6. T.B. Bottomore, **Sociology: A Guide to Problems and Literature**, Routledge Publication, 1962.


## 12.42 HS 350: Traditional Media Arts

**Course Code: HS 350**

**Course Name: Traditional Media Arts**

L-T-P-C:: 1-0-4-3
Prerequisites: Instructor's Consent
Intended for: B.Tech. 3rd and 4th year
Approval: 10th Senate

**Course Contents:**

- **Module - I** Fundamentals of art, basic understanding of folk art, popular art, classical art and general understanding of contemporary art with reference to global art forms. [4 Lectures]

- **Module - II** (8 Lab Hours) Still Life: Study of man-made and objects from nature(flowers, vegetables, fruits etc.) , sketching. Medium - tempera, water, acrylic / oil colours.

- **Module - III** (8 Lab Hours) Creative Painting: sketching, drawing and creative composition. Medium- tempera, water and acrylic / oil colours.

- **Module - IV** Landscape painting: outdoor practice rapid sketching and painting. [8 Lectures]

- **Module - V** (6 Lab Hours) Print Making: (lino cut/ wood cut printing techniques)

- **Module - VI** (8 Lab Hours) Mural and Installation: Experimentation with different material and medium.

- **Final Project group exhibition/installation** This course is based on indoor and outdoor practices, readings, discussions and field trips. It will provide demonstrations, hands-on experience of traditional art media and tools. (Wood, clay and paint.)

**Textbooks:**

1. Prosenjit Saha(Author), Arundhati Saha (Author), **Drawing Still Life**, Unicorn Books, 2009.
2. E. Tomory, **A History of Fine Arts in India and the West**, Orient BlackSwan, 1989.
3. Hugh Honour (Author), John Fleming (Author), **A World History of Art**, 7th Revised Edition, Laurence King Publishing, 2009.

**References:**

1. J. Comyns Carr, **The ideals of painting**, Macmillan.
2. E. B. Greenshields, **Landscape painting and modern Dutch artists**, Baker and Taylor.
3. J. Comyns, **The ideals of painting**, Macmillan.

## 12.43 HS 351: Popular Fiction

**Course Code: HS 351**

**Course Name: Popular Fiction**

L-T-P-C: 3-0-0-3
Prerequisite: Consent of the faculty member
Students intended for: B.Tech
Elective or Compulsory: Elective
Approval: 2nd Senate

**Course Contents**

- Flemming, Ian., **From Russia With Love**, Penguin Books India, 2004
- Christie, Agatha., **The Murder of Roger Ackroyd**, Harper Collins India, 2002.
- Herge, **Tintin in Tibet**, Egmont Publications, 2002.
- Moore, Alan, Marx, Barry, and Gibbons, Dave., **Watchmen**, D C Comics, 2008.

**For Self Study:**

1. Rowling, J. K., **Harry Potter**, Bloomsbury, 2010.
2. Tolkien, J. R. R., **Lord of the Rings**, Harper Collins, 2005.
3. Kane, Bob., **Batman**.
4. Satrapi, Marjane., **Persepolis**, Vintage, 2008.
5. Essays, Class handouts.

## 12.44 HS 352: German II

### Course Code: HS 352

### Course Name: German II

L-T-P-C: 3-0-0-3
Prerequisite: Consent of the faculty member
Students intended for: B.Tech
Elective or Core: Elective
Approval: 2nd Senate

### Course Contents

Basic Grammatical Features: Modal Verbs, Prepositions (Revision as well as Prepositions with Dative), Perfect Tense, Separable Verbs, The Subjunctive Mood, Advanced Conversation skills (pertaining chiefly to simple dialogues in everyday situations), Writing skills geared to communicative tasks such as writing e-mails, short messages and notes, Listening and Reading Comprehension. Basic information on German speaking countries.

### Prescribed Textbook

1. Rosa-Maria Dallapazza / Eduard von Jan / Til Schnherr, Tangram aktuell 1, Lektion 5-8; Deutsch als Fremdsprache, Goyal Saab, 2007.

### Select References

1. Christine Eckhard-Black / Dr. Ruth Whittle, Cassell's Contemporary German: A Handbook of Grammar, Current Usage, and Word Power, MacMilan, 1993.
2. Heinz Oehler, Grundwortschatz Deutsch, ,Klett Verlag, 1994.
3. Krishna Murari Sharma, German-Hindi Dictionary, Rachna publication, 1978.
4. Idiomatische Redewendungen von A Z., Langenscheidt Verlag, 1993.
5. Langenscheidts German-English, English-German Dictionary, Goyal Saab, 2009.

## 12.45 HS 353: Science, Technology and Society

### Course Code: HS 353

### Course Name: Science, Technology and Society

L-T-P-C: 3-0-0-3
Students intended for: B.Tech
Prerequisite: Consent of the faculty member
Approval: 2nd Senate

**Course Contents**

- **Module I** Importance of science and technology; The nature and philosophy of science; Structure of scientific revolution; Science and Scientific community; The rights and wrongs of science Case studies [10 Lectures]
- **Module II** The nature and philosophy of technology; Technology and the character of everyday life; Humans versus computers; The technological life world; Technology as a shadow constitution [10 Lectures]
- **Module III** Controversies regarding science and technology; Science, technology and the less-developed countries; technology and transformation of work; Science, technology and economic theory; Science, democracy and stem cells [10 Lectures]
- **Module IV** The Science wars: Debating scientific knowledge and technology; History of Indian science and technology; Science and Technology policy making in India: An overview [8 Lectures]

**Recommended Reading**


1. Albert Borgmann, **Technology and the Character of Contemporary Life**, University of Chicago Press, 1987.
2. Bruno Latour, **Laboratory Life: The Construction of Scientific Facts**, Princeton University Press, 1986.
3. Chalmers A.F., **What is this thing called Science**, University of Queensland Press, 1999.
4. Don Ihde., **Existential Technics**, State University of New York Press.
5. **American Philosophy of Technology: The Empirical Turn**, Indiana University Press;
6. Jacques Ellul., **The Technological Society**, Vintage Books, 1967.
7. Keith Parsons, **The Science Wars: Debating Scientific Knowledge and Technology**, Prometheus Books, 2003.
8. Martin Bridgstock(Ed), **Science, Technology and Society: An Introduction**, Cambridge University Press, 1998.
9. Rudi Volti, **Society and Technological Change**, 6th Edition, Worth Publishers, 2008.
10. Wenda K. Bauchspies, **Science, Technology and Society: A Sociological Approach**, Blackwell Publishers, 2005.

## 12.46 HS 354: Social Psychology

**Course Code: HS 354**

**Course Name: Social Psychology**

L-T-P-C: 3-0-0-3
Students intended for: B. Tech
Prerequisite: Consent of the faculty member
Elective/core: Elective
Approval: 2nd Senate

**Course Contents**

- **Theories and explanations of social behavior** Social psychology-Past, present & future; Evolution of social psychology in India; An introduction to the major theoretical approaches in social psychology- field theory, role theory, learning theory, cognitive theory, symbolic interaction approach.

- **Understanding and Evaluating the Social World** Social cognition, Attitudes and Attitudes change.

- **Aspects of Social Interaction and Influence** Interpersonal attraction, Prosocial behavior, Aggression, Changing others behavior.

- **Group Dynamics and Intergroup Relations** Nature of groups, Consequences of belonging-performance, decisionmaking, cooperation and conflict, Nature of intergroup relation-prejudice, Intergroup conflict, Intervention techniques

- **Social Identity and Intergroup Relations** Identity and Social categorization theories, Violence and Terrorism, Applications of theories for resolution of problems

**Prescribed Text:**


1. Baron.R.A., Byrne,D. & Bhardwaj.G, **Social Psychology**, 12th Edition, Pearson, 2010.

2. Taylor,S.E., Peplau,L.A. & Sears,D.O., **Social Psychology**, 12th Edition, Pearson, 2006.

3. Brehm, S. & Kassin, S.M., **Social Psychology**, Houston & Muffin Co., 1990.

4. Hogg, M.A. & Vaughan, G.M., **Social Psychology**, Pearson Education, 2005.

5. Myers, D.G., **Social Psychology**, Tata McGraw Hill, 2006.

6. Stephen, C.W. & Stephen, W.G., **The two social psychologies**, The Dorsey Press, 1985.

## 12.47 HS 355: India Through its Epics

**Course Code: HS 355**

**Course Name: India Through its Epics**

L-T-P-C : 3-0-0-3
Students intended for: B. Tech.
Elective or Compulsory : Elective
Prerequisite: Consent of the faculty member
Approval: 2nd Senate

**Course Contents**

- **Module I** A brief overview of Indian history, The Ramayana and its age [6 Lectures] (6 hours)
- **Module II** Kingship and statecraft, Territorial consciousness, the economy [7 Lectures]
- **Module III** The individual, Family, Community [7 Lectures]
- **Module IV** The ideal man and the ideal woman, Devas and asuras, Good and evil [6 Lectures]
- **Module V** Love and hatred, Ethics and morality, Learning and teaching [6 Lectures]
- **Module VI** The city, the country and the forest, Humans and animals, Technology [6 Lectures]

**Prescribed Texts:**

1. Ramesh Menon, **The Ramayana**, Harper Collins, 2010.

**Additional Readings:**

**Ramayana:**

1. C Rajagopalachari, **The Ramayana**, Bharatiya Vidya Bhawan, Mumbai, 2009
2. Robert Goldman et. Al. (eds. and tr.), **The Ramayana of Valmiki An Epic of Ancient India**, Vols. 1-7, Motilal Banarsi dass, 2007.
3. William Buck, **Mahabharata**, Motilal Banarsi dass, Delhi, 2006

**The Bhagavata**

1. A Board of Scholars (eds), **Bhagavata Purana**, Vols. 7-11, Motilal Banarsi dass, 1997-2011.
2. Kamala Subramanian, **Srimad Bhagavatam**, BharatiyaVidyaBhavan, 2010.

**Recommended Readings:**


1. A.L. Basham, **The Wonder that was India, with an introduction** by Thomas R Trautmann, Picador, 2004.

2. RomilaThapar, **Early India**, Penguin, 2002.

3. R. S. Sharma, **Indias Ancient Past**, Oxford University Press, 2005


## 12.48 HS 357: Creative Writing

**Course Code: HS 357**

**Course Name: Creative Writing**

L-T-P-C: 3-0-0-3
Prerequisites: None Intended for: UG
Distribution: Elective for all
Approval: 9th Senate

**Course Contents**

**Module I** Defining Creative Writing - An overview -Introduction. Voice Words, Images, Story [4 Lectures]

**Module II** Modes of Writing- Story of self, Memory, Travel Personal [7 Lectures]

**Module III** Defining literary terms- Introducing important literary terms. [7 Lectures]

**Module IV** Reading & Writing short story - Narrative voice/s; illustrates with examples. [6 Lectures]

**Module V** Short story- Defining Short Story Characteristics, Gogols The Overcoat-Plot- Examples from English/French fiction(Useless Beauty) [8 Lectures]

**Module VI** Character - Discussion in relation to character development with examples The Overcoat& The Primeval [7 Lectures]

**Module VII** Descriptions-Examples from J.Krishnamurtis writings and Edgar Allan Poes stories are discussed & writing practice. [7 Lectures]

**Module VIII** Workshop [2 Lectures]

**References**


1. Philip K.Jaron & Allan B.Lefcouitz, **Creative writers Hand Book**, 4th Edition, Prentice Hall, 2004.

2. Colin Bulman, **Creative Writing: A guide & glossary to fiction writing**, Polity Press, 2007.

3. **How to write Short Stories**, Thomson Series.

4. **How to Interpret Poetry**, Thomson Series.

## 12.49 HS 358: Science Writing

**Course Code: HS 358**

**Course Name: Science Writing**

L-T-P-C: 3-0-0-3
Prerequisites: None
Intended for: UG
Distribution: Elective for all
Approval: 9th Senate

**Course Contents**

- **Introductions** Class overview- Writing for a general audience- Zinsser, William. Sci- ence, Technology and Nature. Chapter 15 in On Writing Well: The Classic Guide to Writing Nonfiction. 30th Anniversary ed. Harper Perennial, 2006, pp. 14764. ISBN: 9780060891541. [4 Lectures]
- **The pleasures and challenges of science writing** The science essay- Introduce Essay1 Lightman, Alan. The Accidental Universe. Harper's, December 2011. [4 Lectures]
- **Description** Accuracy + making it fresh- A writer's voice From Devils to Mathematics. Example student work. [2 Lectures]
- **WORKSHOP** Essay 1 (full class and small groups) [EH] Chapter 1, and skim chapter 2 ALSO, Select book for Book Review. [3 Lectures]
- **Return essays** What do we mean by revision?-Discuss News and Profile article assign- ments- Short News Articles on Science-Read several articles from different disciplines on ScienceNews.org [5 Lectures]
- **The profile** Writing about science by writing about scientists Brainstorm Profile/Archive assignment ideas, incl. background reading-Issues re: News stories? -Burgos, Ana. A Professor of Puzzles. Angels, 2012. [5 Lectures]
- **Complex issues** Getting readers to think like scientists-The research process: Why we cite. [4 Lectures]
- **aking a stand** Writing to persuade-The research process: Note-taking-Discuss Research proposals [4 Lectures]
- **The research process** Citing, quoting, paraphrasing-Writing and Structure (Hancock and handouts)-Organizing a longer article. [4 Lectures]
- **Revision issues** Discussion of favourite science writing -The Book Review: an impor- tant genre. [4 Lectures]
- **WORKSHOP Book Reviews** 1 full class, & small groups - Share best writing-Sum- ming up & reflecting-Evaluations-All work due . [3 Lectures]

**References**

1. Elizabeth, Royte., **Fracking Our Food Supply**, The Nation, November 2012.

2. Hancock, Elise., **Ideas into Words: Mastering the Craft of Science Writing**, The Johns Hopkins University Press, 2003. ISBN: 9780801873300.

3. Kanigel, Robert., **The Science Essay**, Chapter 22 in A Field Guide for Science Writers: The Official Guide of the National Association of Science Writers. 2nd ed. Edited by Deborah, Mary Knudson, and Robin Marantz Henig. Oxford University Press, 2005, pp. 14550. ISBN: 9780195174991.

4. Pollan, Michael., **Our Decrepit Food Factories**, The New York Times Magazine, December 16, 2007.

5. Quammen, David., **Deadly Contact**, National Geographic, October 2007.

6. Steingraber, Sandra., **The Whole Fracking Enchilada**, Orion, September/October 2010. Zinsser, William. On Writing Well: The Classic Guide to Writing Nonfiction. 30th An- niversary ed. Harper Perennial, 2006, pp. 14764. ISBN: 9780060891541. http://www.ScienceNews.org

## 12.50 HS 362: German III

**Course Code: HS 362**

**Course Name: German III**

L-T-P-C: 3-0-0-3
Prerequisite: Consent of the faculty member
Students intended for: B.Tech
Elective or Core: Elective Semester: Even/Odd
Approval: 2nd Senate

**Course Contents**

- **Basic grammatical features** Preterite form of auxiliary and modal verbs, perfect tense, subjunctive form of important verbs, subordinate clauses, comparative and superlative.

- **Listening and speaking practice** Talking about past events, describing people, writing about single items/objects.

- **Reading and writing practice** Reading about a survey, reading and writing postcards and e-mails.

- **Vocabulary** where people live, vacations, health, colours, clothes, the human body.

**Prescribed Textbook**

1. Rosa-Maria Dallapazza / Eduard von Jan / Til Schnherr: Tangram aktuell 2, Lektion 1-4; Deutsch als Fremdsprache. New Delhi (Goyal Saab, rpt.) 2007.

**Select References**

1. Christine Eckhard-Black / Dr. Ruth Whittle: **Cassell's Contemporary German, A Handbook of Grammar, Current Usage, and Word Power**, MacMilan, 1993.

2. Heinz Oehler, **Grundwortschatz Deutsch**, Klett Verlag, 1994.

3. Krishna Murari Sharma, **German-Hindi Dictionary**, Rachna publication, 1978.

4. Idiomatische Redewendungen von A Z., Langenscheidt Verlag, 1993.

5. **Langenscheidts German-English, English-German Dictionary**, Goyal Saab, 2009.

**Communicative Competence**

Presents students three different choices:

- **Basic Communication Skills** Every word we utter tells others what we really are. The course makes you aware of the need to present yourself to others exactly the way you would like them to perceive you.

- **Public Speaking and Debating Skills** How can you win over the hearts and minds of others in speech? How do you structure an argument to persuade others to accept it? The course introduces you to the basic principles of the art of effective speaking.

- **Policy Analysis and Advocacy Skills** Our public life, be it economics or the environment, is influenced by policies made by various advisory and regulatory bodies to the government. In the business world, corporate concerns too have their own policies. How does one examine the deep implications of these policies? How does one go about framing policies, say science and technology policies, for sustainable development?

## 12.51 HS 363: Post-war Germany: A Literary Perspective

**Course Code: HS 363**

**Course Name: Post-war Germany: A Literary Perspective**

L-T-P-C: 3-0-0-3
Students intended for: B.Tech.
Elective or Core: Elective
Approval: 3rd Senate

**Course Contents**

**Select Reading Material on:**

Vergangenheitsbewltigung or Coming to terms with the Nazi past; Cold War; the two Germanys; the German Economic Miracle; the Workers Uprising of 1953; the Berlin Wall; the Student Revolt of 1968, the RAF; Citizens Initiatives; Glasnost und Perestroika the route map to German re-unification; European Union and German Identity.

**Prescribed Texts**

**Excerpts from:**

1. Heinz Ludwig Arnold: Deutschland! Deutschland? Texte aus 500 Jahren von Martin Luther bis Gnter Grass. Frankfurt a.M.: Fischer, 2002. Pages 345-447.

**Select Short Stories:**

1. Wolfgang Borchert: An diesem Dienstag Wolfdietrich Schnurre: Auf der Flucht Heiner Mller: Das Eiserne Kreuz Heinrich Bll: Der Wegwerfer

2. Max von der Grn: Wir sind eine demokratische Familie

**Select Passages from:**

1. Bernhard Schlink: Der Vorleser;

2. Ulrich Plenzdorf: Die neuen Leiden des jungen Werther.

**Select References**

1. Martin Kitchen: The Cambridge Illustrated History of Germany. Cambridge: CUP, 2000. Moderne Erzhler Series. Paderborn: Ferdinand Schningh. 1957ff.

2. Erlebnis Geschichte. Produced by the Foundation Haus der Geschichte der Bundesrepublik

3. Deutschland. Bonn 2003.

4. Spiegel Special. The Germans. Sixty Years after the War. Intl Edition 4/2005.

## 12.52 HS 364: Modern China: A Historical Survey

**Course Code: HS 364**

**Course Name: Modern China: A Historical Survey**

L-T-P-C: 3-0-0-3
Prerequisites:
Intended for: UG Distribution:
Approval: 9th Senate

**Course Contents**

- **China in the 19th Century: Wars** [8 Lectures]
  - Unit 1: The Confucian Value System
  - Unit 2: Chinese Feudalism
  - Unit 3: Opium Wars
  - Unit 4: The Informal Colonization of China
- **China in the 19th Century: Popular Movements** [8 Lectures]

  - Unit 1: Popular Uprisings: The Taiping and Boxer Movements
  - Unit 2: Internal Reforms in China: The Self Strengthening Movement and the 100 Days Reform Movement

- **China in the 20th Century: Nationalism** [8 Lectures]
  - Unit 1: The Revolution of 1911; Role of Sun Yat-sen and Yuan Shi-kai
  - Unit 2: Warlordism in China: 1916-1928
  - Unit 3: The May Fourth Movement of 1919
  - Unit 4: Nationalism: 1921-1937

- **China in the 20th Century: Communism** [8 Lectures]
  - Unit 1: The Rise and Growth of the Communist Movement
  - Unit 2: China During the Second World War (1939-45)
  - Unit 3: The Communist Revolution (1949)

- **The Mao Era** [10 Lectures]
  - Unit 1: The Great Leap Forward (1958-61)
  - Unit 2: The Cultural Revolution (1966-76)
  - Unit 3: Maos Legacy

### Prescribed Texts

1. John K. Fairbank and Merle E. Goldman, **China: A New History**, Belknap Press (Harvard University Press), 2006.
2. Rana Mitter, **Modern China: A Brief Insight**, Sterling, 2009.

### Additional Readings

1. Immanuel C. Y. Hsu, **The Rise of Modern China**, 6th Edition, Oxford University Press, 1999.
2. Jung Chang and Jon Halliday, **Mao: The Unknown Story**, Jonathan Cape, 2005
3. Jonathan Spence, **The Search for Modern China**, 3rd Edition, W.W. Norton & Co., 2012.
4. Jonathan Fenby, **The Penguin History of Modern China: The Fall and Rise of a Great Power, 1850 to the Present**, 2nd Edition, Penguin, 2013.

**Additional Activities**

1. Film Screening
   (a) The Last Emperor (Bernardo Bertolucci, 1987).
2. Reading Group (optional)
   (a) Non fiction: Pallavi Aiyer, Smoke and Mirrors, An Experience of China, Harper Collins, New Delhi, 2008.
   (b) Fiction: Dai Sijie, Balzac and the Little Chinese Seamstress, Vintage, London, 2002.

## 12.53 HS 372: German IV

**Course Code: HS 372**

**Course Name: German IV**

L-T-P-C : 3-0-0-3
Students intended for: B.Tech
Elective or Core: Elective
Prerequisite: Consent of the faculty member
Approval: 3rd Senate

**Course Contents**

- **Grammatical features** Genitive prepositions; subordinating conjunctions; relative clauses; passive voice; present subjunctive; indirect speech; phrasal verbs and common idioms.
- **Listening and speaking skills** listening to radio news: responding to questions thereon; preparing news summary, interviewing people to elicit complex information.
- **Writing skills** Express concrete as well as abstract ideas, write short biographies, prepare resumes, write brief essays on topics of general import. Reading skills:
- Read simple stories and recount, read newspaper reports and prepare outlines.

**Prescribed Text**

1. Dieter & Ingrid Sevin: Wie Gehts? Boston, Thomson & Heinle, 2007.

**Select References**

1. Christine Eckhard-Black / Dr. Ruth Whittle: Cassell's Contemporary German, A Handbook of Grammar, Current Usage, and Word Power, MacMillan, 1993.
2. Heinz Oehler, Grundwortschatz Deutsch, Klett Verlag, 1994.
3. Idiomatische Redewendungen von A Z., Langenscheidt Verlag, 1993.

4. Langenscheidts German-English, English-German Dictionary, Goyal Saab, 2009.
5. Podcasts of the Deutsche Welle.
6. Excerpts from standard German newspapers, national and regional.

## 12.54 HS 373: Readings from German History

**Course Code: HS 373**

**Course Name: Readings from German History**

L-T-P-C : 3-0-0-3
Students intended for: B.Tech.
Elective or Core: Elective
Approval: 3rd Senate

**Course Contents**

**Select Reading Material on:**

The Birth of the German Nation (1806 1848); Prussia and Austria 1848 1871; the Nation State; Empire and Colonial Ambitions (1890 1910); from World War I to the Weimar Republic (1914 1933); Nazi Germany (1933 1942); Finis Germaniae to the Basic Law (1942 1949); Divided Legacy (1949 1990); United Germany

**Prescribed Texts:**

**Excerpts from:**


1. Heinz Ludwig Arnold: Deutschland! Deutschland? Texte aus 500 Jahren von Martin Luther bis Gnter Grass. Frankfurt a.M.: Fischer, 2002.
2. Hagen Schulze: Kleine deutsche Geschichte. Mit Bildern aus dem Deutschen Historischen Museum. Munich: Beck, 1996.


**Select References**


1. Karin Hermann: Reading German History. A German Reading Course for Beginners. Munich: Max Hueber, 1992.
2. Eberhard Jckel: Das deutsche Jahrhundert. Eine historische Bilanz. Stuttgart: Deutsche Verlags-Anstalt, 1996.
3. Martin Kitchen: The Cambridge Illustrated History of Germany. Cambridge: CUP, 2000.
4. Klaus Schulz: Aus deutscher Vergangenheit. Ein geschichtlicher berblick. Munich: Max Hueber, 1971.
5. Peter Watson:The German Genius. Europe's Third Renaissance, the Second Scientific Revolution and the Twentieth Century. New York: Harper Collins, 2010.

## 12.55 HS 381: Indian Society: Structure and Change

**Course Code: HS 381**

**Course Title: Indian Society: Structure and Change**

L-T-P-C : 3-0-0-3
Course Offered to : B.Tech. 3rd year
Elective or Compulsory : Elective
Approval: 4th Senate

**Course Contents**

- **Classification of Societies based on Mode of Survival**
  - Hunting and Gathering Societies
  - Herding or Pastoral Societies
  - Horticultural Societies
  - Agricultural or Agrarian Societies
  - Industrial Societies
- **Indian Society and Structure**
  - Traditional Hindu Society
  - Indian Caste System
  - Changes under Pre-Industrial Period
  - Change under post-colonial Period
  - Indian Jajmani System
- **Social Change and Problems of India**
  - The idea of Nation and Nationalism
  - Indian National movement
  - Over-population
  - Unemployment
  - Poverty
  - Juvenile Delinquency
  - Dysfunctions of Urbanization
  - Domestic Violence
  - Corruption and Black Money
- **Social Change and Mobility**
  - Sanskritization
  - Westernization
  - Modernization

  - Indian Tradition and Resilience

- **Social Movements**
  - The concept of Social Movement
  - Formation of Social Movements
  - Theories of Social Movements

**Recommended Readings:**


1. Bipan, Chandra., **India's Struggle for Independence**, Penguin Books, 1989
2. Deasi, A.R., **Rural Sociology in India**, South Asia Books, 1978.
3. Dumont, L., **Homo Hierarchicus**, University of Chicago Press, 1980
4. Ghurye, G.S., **Caste and Race in India**, K. Paul, Trench, Trubner& Co., 1932
5. Gupta Dipankar, **Social Stratification**, Oxford University Press, 1992.
6. Rama Ahuja., **Social Problems in India**, Rawat Publications, 1992
7. Shankar Rao., **Sociology: Principles of Sociology**, S. Chand & Company Ltd.
8. Srinivas, M.N., **The Dominant Caste and Other Essays**, Oxford University Press, 1987.
9. Srinivas, M.N., **Social Change in Modern India**, Orient Longman, 1995.


## 12.56 HS 382: Social Movements in India

**Course Code: HS 382**

**Course Name: Social Movements in India**

L-T-P-C : 3-0-0-3

Approval: 11th Senate; OTA

Course Outline : At the outset, this course introduces various notions and meanings of social change, which is inevitable and also dynamic in many ways, and how it had long been entangled with issues of caste, class, religion, ethnicity, and language in modern Indian context. The argument this course essentially tries to drive home is that social change in Indian context is no single narrative; it has always been plural in character and diverse in its scope and composition. Through concepts, theoretical frameworks, perspectives, styles of protest and critical events of dissent, it predominantly aims to offer students a comprehensive understanding on plural and diverse interpretations of the Idea of India, both historically and today, with a special reference to social movements in modern India. Along the way, this course also deals with inevitability and significance of dissent in the making of modern and contemporary India.

## 12.57 HS 391: Introduction to World History

**Course Number: HS 391**

**Course Name: Introduction to World History**

L-T-P-C: 3-0-0-3
Prerequisites: None
Intended for: : 3rd/4th year B. Tech
Distribution: Elective
Approval: 4th Senate

**Course Contents**

- **Approaches to world history** [3 Lectures]
- **Empire-building and the development of global webs** (15th to late 18th Century)
  - The world in the 15th Century
  - The movement of goods in the 17th Century
  - Slave trade and piracy in the 18th Century Atlantic [15 Lectures]
- **Industrialization, interdependence, and divergence** (late 18th to early 20th Century)
  - Industrial revolution
  - Colonialism in India and Imperialism in China
  - An ecological perspective: 19th Century El Nio famines [12 Lectures]
- **Crises, the emergence of three worlds, and contemporary globalization** (Early 20th Century to the present)
  - Bolshevik revolution
  - The World Wars and the Cold War c. Globalization since the 1970s [9 Lectures]
- **Connecting World History to issues today** (lessons learnt) [3 Lectures]

**Textbooks:**

1. Marks, Robert B., The Origins of the Modern World: A Global and Ecological Narrative from the Fifteenth to the Twenty-first Century, 2nd Edition, Rowman& Littlefield, 2007.

**References:**

1. Brook, Timothy, Vermeers Hat, **The Seventeenth Century and the Dawn of the Global World**, Bloomsbury Press. 2008
2. Davis, Mike, Late Victorian Holocausts, **El Nio Famines and the Making of the Third World**, Verso, 2001

3. Lindsay, Lisa A., **Captives as Commodities: The Transatlantic Slave Trade**, Pearson Prentice Hall, 2008
4. Steger, Manfred B., **Globalization: A Very Short Introduction**, 2nd Edition, Oxford University Press, 2009

## 12.58 HS 392: Modern China

**Course Number: HS 392**

**Course Name: Modern China**

L-T-P-C: 3-0-0-3
Prerequisites: None
Intended for: 3rd/ 4th year B.Tech,
Distribution: Elective (Free Elective)
Equivalent Course: HS 364

**Course Contents**

- China in the 19th Century: Wars [8 Lectures]
  - Unit 1: The Confucian Value System
  - Unit 2: Chinese Feudalism
  - Unit 3: Opium Wars
  - Unit 4: The Informal Colonization of China
- China in the 19th Century: Popular Movements [8 Lectures]
  - Unit 1: Popular Uprisings: The Taiping and Boxer Movements
  - Unit 2: Internal Reforms in China: The Self Strengthening Movement and the 100 Days Reform Movement
- China in the 20th Century: Nationalism [8 Lectures]
  - Unit 1: The Revolution of 1911; Role of Sun Yat-sen and Yuan Shi-kai
  - Unit 2: Warlordism in China: 1916-1928
  - Unit 3: The May Fourth Movement of 1919
  - Unit 4: Nationalism: 1921-1937
- China in the 20th Century: Communism [8 Lectures]
  - Unit 1: The Rise and Growth of the Communist Movement
  - Unit 2: China During the Second World War (1939-45)
  - Unit 3: The Communist Revolution (1949)
- The Mao Era [10 Lectures]
  - Unit 1: The Great Leap Forward (1958-61)
  - Unit 2: The Cultural Revolution (1966-76)
  - Unit 3: Maos Legacy

**Prescribed Texts:**

1. John K. Fairbank and Merle E. Goldman, **China: A New History**, Belknap Press (Harvard University Press), 2006.

2. Rana Mitter, **Modern China: A Brief Insight**, Sterling, 2009.

**Additional Readings:**

1. Immanuel C. Y. Hsu, **The Rise of Modern China**, 6th Edition, Oxford University Press, 1999.

2. Jung Chang and Jon Halliday, **Mao: The Unknown Story**, Jonathan Cape, 2005

3. Jonathan Spence, **The Search for Modern China**, 3rd Edition, W.W. Norton & Co., 2012.

4. Jonathan Fenby, **The Penguin History of Modern China: The Fall and Rise of a Great Power, 1850 to the Present**, 2nd Edition, Penguin, 2013.

**Additional Activities**

1. 1. Film Screening
   (a) The Last Emperor (Bernardo Bertolucci, 1987).

2. Reading Group (optional)
   (a) Non fiction: Pallavi Aiyer, Smoke and Mirrors, An Experience of China, Harper Collins, New Delhi, 2008.
   (b) Fiction: Dai Sijie, Balzac and the Little Chinese Seamstress, Vintage, London, 2002.

## 12.59 HS 393: Technology and world History: 1400 to the present

**Course Number: HS 393**

**Course Name: Technology and world History: 1400 to the present**

L-T-P-C: 3-0-0-3
Students intended for: B. Tech students all years
Elective or Compulsory: Elective
Approval: 12th Senate

**Course Contents**

- **Age of Discovery**
  - Ships, maps and knowledge of ocean currents
  - Weapons and European Almed Trading
  - Clocks at Sea: Longitudes and Navigation

- **Conquest of the Americas**
  - Environment and diseases
  - Horses and weapons
- **Technology for Trade**
  - Rise ofDutch and British trading enterprises
  - Limits of the pre-industrial age
- **Industrialization and imperialism**
  - Steamboat Imperialism
- **Technology and Domination**
  - Medicines, weapons and the scramble for Africa
  - Aviation and new teclmologies of war
- **Limits of Technological Domination**
  - Guenilla warfare
  - Intemet and resistance

**Textbook:**

1. Daniel R. Headrick, **Power over Peoples: Technology, Environments and Western Imperialism, 1400 to the present**, Princeton Univ Press, 2010

**References:**

1. Daniel R. Headrick, **Technology: A World History**, OUP, 2009
2. Thomas Misa, **Leonardo to the Internet: Technology and Culture from the Renaissance to the Present**, Johns Hopkins Univ Press, 2011

## 12.60 HS 401: Tribal India, Indigenous Latin America

**Course Number: HS 401**

**Course Name: Tribal India, Indigenous Latin America**

L-T-P-C : 3-0-0-3
Prerequisites : None
Students intended for : 3rd/4th year B. Tech
Distribution : Elective
Approval: 4th Senate

**Course Contents**

- **INTRODUCTION**
  - Defining tribal and indigenous [4 Lectures]
- **HISTORICAL**
  - Issues in Pre Colonial Period
  - Issues in Colonial Period
  - Post-colonial nation-making and tribal/indigenous [18 Lectures]
- **CONTEMPORARY**
  - Globalization
  - Resource wars and Bio-piracy
  - Tourism and eco-tourism
  - Representations (media and museums) [16 Lectures]
- **TRIBES IN THE HIMACHAL AREA**
  - Issues and challenges
  - Comparisons with tribes in other parts of India (eg. the 'Central Indian tribes') [4 Lectures]

**Textbooks:**

There is no prescribed text-book for this course. Targeted readings including relevant book chapters, journal articles etc. will be provided for each days lesson.

**References:**


1. Andrien, , Kenneth., **Andean Worlds: Indigenous History, Culture, and Consciousness under Spanish Rule**, 1532-1825, 2001

2. Behera, Deepak Kumar (Ed.), **Contemporary Society: Tribal Studies**, 2005

3. Betteille, A., **The Concept of Tribe with Special Reference to India**, European Journal of Sociology, 1986.

4. Burkholder, Mark A, **Colonial Latin America**,2010

5. Chaudhuri, B.B. (Ed.),**Tribes, Forest And Social Formation In Indian History**, 2004

6. Dhagamwar, Vasudha (Ed.), **Role And Image Of Law In India: Tribal Experience**, 2006

7. Ghurye, S C., **The Scheduled Tribe**, 1963

8. Hardiman, D., **The Coming of the Devi: Adivasi Assertion in Western India**, 1987

9. Larson, Brooke., **Trials of Nation Making: Liberalism, Race, And Ethnicity In The Andes**, 18101910, 2004

10. Meade, Teresa A., **History Of Modern Latin America: 1800 To The Present**, 2010

11. Verma, V, **Ban-Gujars: Nomadic Tribe In Himachal Pradesh**, 1999

12. Verma, V, **Kanauras Of Kinnaur: Scheduled Tribe In Himachal Pradesh**, 2002

13. Xaxa, Virginius, **State, Society And Tribes: Issues In Post-Colonial India**, 2008

14. Xaxa, Virginius, **Tribes as Indigenous People of India**, Economic and Political Weekly, 1999

## 12.61 HS 402: Literature and Culture

**Course Code: HS 402**

**Course Name: Literature and Culture**

L-T-P-C: 3-0-0-3
Prerequisite: Consent of the faculty member
Students intended for: B.Tech.
Elective or Core: Elective
Approval: 5th Senate

**Course Contents:**

- **I. Readings**:
  - The Castle of Otranto Horace Walpole, 1764
  - Frankenstein Mary Shelly, 1818
  - Strange Case of Dr. Jekyll and Mr. Hyde R. L. Stevenson, 1886
  - The Picture of Dorian Gray Oscar Wilde, 1890 Dracula Bram Stoker, 1897
- **II. Movies:**
  - Alien, 1979
  - Edward Scissorhands, 1990
  - Sleepy Hollow, 1999
  - Pan's Labyrinth, 2006
  - Sweeny Todd: The Demon Barber of Fleet Street, 2007

**Textbooks:**

1. The Castle of Otranto Horace Walpole, 1764
2. Frankenstein Mary Shelly, 1818
3. Strange Case of Dr. Jekyll and Mr. Hyde R. L. Stevenson, 1886
4. The Picture of Dorian Gray Oscar Wilde, 1890
5. Dracula Bram Stoker, 1897

## 12.62 HS 403: Organizational Behavior

**Course Code: HS 403**

**Course Name: Organizational Behavior**

L-T-P-C: 3-0-0-3
Prerequisite: Consent of the faculty member
Students intended for: B.Tech
Elective or Core: Elective
Approval: 2nd Senate

**Course Contents**

- **Introduction** Historical development; concept of organization; elements of organizational structure; scope of organizational behaviour.
- **Motivation and job satisfaction** Major theories; content and process; (Adams, Maslow, Vroom, Herzberg). Intrinsic and extrinsic motivation; incentive systems: Job satisfaction; concept and determinants.
- **Leadership** Functions and approaches; trait, behavioural and contingency models; characteristics of successful leaders; role of power in leadership.
- **Communication** Communication process: types of communication; communication channels and networks; barriers to communication.
- **Group behavior and conflict** Defining and classifying groups; stages of group development; concept, causes and consequences of conflicts; methods of conflict-resolution.

**Recommended Books**

1. Aamodt, M. G., **Industrial/organizational psychology**, Cengage, 2001.
2. Luthans, F., **Organizational behavior**, 12th Edition, McGraw Hill, 2005.
3. Muchincky, **Psychology applied to work**, Cengage, 2009.
4. Robbins , S., Judge, T.A., & Sanghi, S., **Organizational behavior**, 13th Edition, Pearson Education, 2009.
5. Riggio, R.E., **Introduction to Industrial/Organizational Psychology**, 4th Edition, Prentice-Hall , 2003.

## 12.63 HS 404: Technology in Pre-modern India

### Course Code: HS 404

### Course Name: Technology in Pre-modern India

L-T-P-C: 3-0-0-3
Prerequisite:
Students intended for: B.Tech.
Elective or Core: Elective
Approval: 5th Senate

### Course Description:

This course introduces students to technology in pre-modern India. It begins by examining the notions of science, which prevailed in India before the advent of the modern period. It then offers an overview of different aspects of science like the mathematics, astronomy, metallurgy, engineering, architecture, agriculture and irrigation. As part of the course-work, students will be made to develop models for sustainable agriculture, irrigation, housing and public utility structures like bridges.

### Course Contents:

- **Introduction to science in pre-modern India**: i) the nature of science ii) the distinction between science and knowledge, iii) structures of cognition
- **Mathematics and astronomy**: i) Indian systems of mathematics, ii) Advances in astronomical sciences
- **Metallurgy**: i) the advent of copper and bronze, ii) discovery of iron and its implications on Indian history, iii) forms of metallurgy
- **Engineering and architecture**: i) earliest forms of engineering, ii) town planning, ii) housing patterns, iii) religious architecture
- **Agriculture and irrigation**: i) the emergence of agriculture, ii) agrarian expansion and changes in agrarian technology, iii) irrigation

### Prescribed Texts:

1. D M Bose, S N Sen and B V Subbarayappa, A Concise History of Science in India, Indian National Science Academy, New Delhi, 1998.

### Recommended Readings:

1. Debiprasad Chattopadhyaya, History of Science and Technology in Ancient India, Firma K.L. Mukhopadhyaya, Calcutta, 1977.
2. Vibha Tripathi, History of Iron Technology in India, Rupa and Infinity Foundation, New Delhi, 2008.
3. Helaine Selin and RoddamNarasimha, Encyclopedia of Classical Indian Sciences, Universities Press, Hyderabad, 2007.

4. Ashok Jhunjhunwala, Indian Mathematics, Wiley Eastern, New Delhi, 1993.

## 12.64 HS 450 : Financial Management

**Course Code: HS 450**

**Course Name: Financial Management**

L-T-P-C: 3-0-0-3
Prerequisites: Preferably Financial Accounting
Intended for: UG/PG
Distribution: Elective
Approval: 9th Senate

**Course Contents**

- **Introduction to finance function** Corporate form of business, Reading financial statements, Financial decision making, Profit maximization versus wealth maximization debate, Time value of money, Interest rates, Term structure and yield curve [8 Lectures]
- **Investment decisions** Rules for investment decision making, Free Cash Flow calculation, Investment in shares and bonds [10 Lectures]
- **Risk and return** Introduction to capital market and risk pricing, Capital asset pricing model, Estimation of cost of capital: Cost of equity and debt [6 Lectures]
- **Financing decisions** Capital structure in perfect and imperfect markets, implication of debt and taxes on capital structure, Financial Distress, Managerial Incentives [8 Lectures]
- **Dividend decisions** Payout process and policies, Dividend versus share repurchase, Payout versus retention, Signaling with payout, Taxes and dividend [6 Lectures]
- **Other strategic financial decisions** Short term financial planning, working capital management, Initial public offers, Strategic alternatives in Mergers and acquisitions, Corporate governance [4 Lectures]

**Text Book:**

1. Berk, DeMarzo and Thampy, **Financial Management,** Indian Subcontinent Edition, Pearson Education (India), 2010

**Reference Books**

1. Prasanna Chandra, **Financial Management: Theory and Practice**, 8th Edition, McGraw Hill Education (India), 2012
2. Kester, Ruback and Tufano, **Case Problems in Finance**, 12th eEdition, McGraw Hill, 2008

3. Robert F. Bruner, **Case Studies in Finance: Managing for Corporate Value Creation**, McGraw Hill International Edition, 2006.

## 12.65 HS 451: Modern Literature

**Course Code: HS 451**

**Course Name: Modern Literature**

L-T-P-C: 3-0-0-3
Prerequisites: None
Intended for : B.Tech
Approval: 4th Senate

**Course Contents**

- Poems
- Drama
- Novel
- Short Story.

**Textbooks:**

1. J. Alfred Prufrock, T. S. Eliot, **The Love Song of 1920**.
2. W. B. Yeats, **Sailing to Byzantium**, 1928.
3. G. B. Shaw, **Major Barbara**, 1905.
4. T. S. Eliot, **Murder in the Cathedral**, 1935.
5. Joseph Conrad, **Heart of Darkness**, 1899.
6. Mrs. Dalloway, **Virginia Woolf**, 1935.
7. D. H. Lawrence, **The Prussian Officer**, 1914.

## 12.66 HS 461 Consumer Behavior

**Course Code: HS 461**

**Course Name: Consumer Behavior**

L-T-P-C: 3-0-0-3
Prerequisites:
Students Intended for: B.Tech
Core or Elective: Elective
Approval: 30th Senate; OTA

**Course Contents:**

- Part One: Introduction
  - Consumer Behaviour: Meeting Changes and Challenges
  - Consumer Research Process
  - Marketing Segmentation and Strategic Training
- Part Two: The Consumer as an Individual
  - Consumer Motivation
  - Personality and Consumer Behaviour
  - Consumer Perception
  - Consumer Learning
  - Consumer Attitude Formation and Change
  - Communication and Consumer Behaviour
- Part Three: Consumer in their Social and Cultural Settings
  - The Family and Social Class
  - Influence of Culture on Consumer Behaviour
  - Cross Cultural Consumer Behaviour: An International Perspective
- Part Four: The Consumer's Decision Making Process and Ethical Dimensions
  - Consumer and the Diffusion of Innovations
  - Consumer Decision Making and Beyond
  - Marketing Ethics and Social Responsibility

**Suggested Books:**

1. Schiffman, Leon G., Kanuk, L.L., & Kumar, S.Ramesh, **Consumer Behavior**, 10th Edition, Pearson Education, 2010.
2. Blackwell, R.D., Miniard, P.W., & Engel, J.F., **Consumer Behaviour**, Cengage Learning, 2006.
3. Kumar, S. Ramesh, **Case Studies in Consumer Behaviour**, Pearson Education, 2013.

## 12.67 HS 471: Contemporary India

**Course Code: HS 471**

**Course Name: Contemporary India**

L-T-P-C: 3-0-0-3
Prerequisites: no
Intended for: 3rd and 4th Year B.Tech/PhD
Distribution: Elective for HSS
Approval: 10th Senate; Dropped in 23rd Senate

**Course Contents**

- **Critical Events**
  - The Year 1991: A decisive move towards economic liberalization
  - Coalition politics and assertive presence of Regional Political Parties
  - The Mandal Commission Report: Aftermath
  - Debates on Indian secularism in the 1980s
  - Hindutva movement, ethnic violence and minority politics f. Expansion and Deepening role of Visual Media [6 Lectures]
- **State, Governance and Political Structure**
  - Economic Liberalization and Economic Growth (India and state level), Institutional Changes for Policy Delivery, and Emerging Nature of State in the New Economy
  - Nature of Party System, Federalism, new forms of political mobilization
  - Political Decentralization and deepening democracy
  - Newer forms of decentralization and variety of local formal institutions [8 Lectures]
- **Religion and Culture**
  - secularism and secularization
  - (re)casting and (re)construction of social history
  - religious effervescence and identity: minority and majority debate d. religious and ethnic violence
  - religious market [8 Lectures]
- **Transnationalism and New Spaces for Socio-Economic Articulation**
  - transnationalism and cosmopolitanism
  - spaces for consumption and spaces of consumption
  - virtual spaces and digital technology
  - spaces at margins
  - new spaces inclusion and marginalization [10 Lectures]
- **Socio-Political Groups and Ideologies: Old and New**
  - Trade Unions, New Forms of Trade Unionism and Business Interest Groups
  - Old and New Social Movements
  - NRIs, Indian Middle Class and New Middle Class
  - Youth in Contemporary India: Demographic Dividends, Aspirations and Aspects of mobilities [10 Lectures]

**References:**


1. Das, Veena., 1995, Critical Events: an anthropological perspective on contemporary India, OUP.

2. Inda, Jonathan Xavier and Renato Rosaldo., 2002, The anthropology of globalization: a reader, Blackwell.

3. Sen, Amartya., 1983, Development: which way now? The Economic Journal. Vol. 93. pp 745-62.

4. Rajagopal, Arvind., 2002, Politics after television: Hindu nationalism and reshaping of the public in India, Cambridge University Press.

5. Reddy, Ram Manohar., How is India Doing, Guhan Memorial Lecture.

6. Dreze, Jean and Amartya Sen,. 1995, India: economic development and social oppurtunity, Oxford University Press.

7. Harriss-White, Barbara., 2003, India working: essays on society and economy, Cambridge University Press.

8. Corbridge, Stuart and John Harriss., 2000, Reinventing India: liberalization, Hindu nationalism and popular democracy, Polity Press.

9. Bhargava, Rajiv (ed.), 1998, Secularism and its critique, OUP.

10. Bhargava, Rajiv., 2013, Reimagining Secularism: respect, domination and principled distance, Economic and Political Weekly. Pp 79-92.

11. Venu, M.K., The India of 2013 is not the India of 1991, The Hindu, August 29, 2013.

12. Ahluwalia, Montek Singh., Economic Reforms in India since 1991: Has Gradualism Worked?

13. Nagaraj, R., 1997, What has happened since 1991? assessment of India's economic reforms. Economic and Political Weekly. 2869-79.

14. Jaffrelot, Christophe., 2000, The rise of the other backward classes in the Hindi belt, The Journal of Asian Studies, Vol. 59(1):86-108.

15. Ram, Nandu (ed.)., 2008, Dalits in contemporary India: discrimination and discontent, Siddhant Publications. pp 37-64.

16. Robinson, Rowena, 2012, Minority Studies, Oxford University Press. Pp 1-48.

17. Donner, Henerik., 2011, Being middle-class in India: a way of life,Routledge.

18. Fernandes, Leela., The Politics of Forgetting: class politics, state power and the restructuring of urban space., Urban Studies, Vol. 41, 12, pp 2415-30.

19. Kohli, Atul., 2012, Poverty amid Plenty in the New India: Politics, Economics and Inequality, Cambridge University Press.

20. Kohli, Atul., 2009, Democracy and Development in India: From Socialism to Pro-Business, Oxford University Press.

21. Shatkin, Gavin and Sanjeev Vidhyarthi, 2013, Contesting the Indian city: global visions and politics of the local, Pp 1-38. Oxford: Wiley Blackwell.

22. Guha-Banerjee, Swapna., 2010, Accummulation by dispossession: transformative cities in the new global order, Sage.

23. Mathur, Nita,. 2013, Consumer culture, modernity and identity, Sage.

24. Kakar, Sudhir., 1996, Colours of violence: cultural identities, religion and violence, OUP.

## 12.68 HS 472: Sociology of Development

**Course Code: HS 472**

**Course Name: Sociology of Development**

L-T-P-C: 3-0-0-3
Pre-requisite: None
Intended For: UG
Distribution: Elective
Approval: 10th Senate

**Course Contents**

- **Module I** [10 Lectures]
  - Notions of Social Change in the context of Classical Sociology: Idea of Evolution and Progress
  - Historical Location of the Idea of Development.
  - Liquidation of Colonialism.
  - Rise of Nationalism in the Third World societies and the desire for Development.

**Essential Readings:**

1. Alavi, H. and T. Shanin. 1982. Introduction to the Sociology of Developing Societies, Macmillan, pp. 1-29

2. Escobar, Arturo .1995. Encountering Development: The Making and Unmaking of the Third World. Princeton University Press.

3. Esteva, Gustavo.1997. Development (pp.8-34), in Sachs, Wolfgang (ed.) The Development Dictionary Hyderabad: Orient Longman.

4. K C Alexander. 1994. The process of Development of Societies. New Delhi: Sage Publication

5. Lauer, R.H. 1978. Perspectives on Social Change, pp. 50-70.

6. Nisbet, R.A. 1969. Social Change and History, OUP, pp. 104-136; 159-188

7. Smith, A.D. 1973. The Concept of Social Change, pp. 1-95

- **Module II** [8 Lectures]
  - Development and Modernization Theories: Inkeles, Moore, Rostow, Lerner, McLelland

**Essential Readings:**

1. Alex Inkeles, A Model of the Modern Man: Theoretical and Methodological Issues in Black, C.E. 1976. (ed.), Comparative Modernisation, The Free Press, pp. 320-348.

2. Moore, W. 1978. Social Change, pp.94-118.

3. Lerner, D.1964. The Passing of Traditional Society.

- **Module III** [8 Lectures]
  - Critiques of Modernization Theories.
  - Dependency Theories and its critiques.

**Essential Readings**

1. Gusfield, J.R. Tradition and Modernity: Misplaced Polarities in the Study of Social Change.

2. Blomstrons, M. and B. Hettne.1984. Development Theory in Transition, Zed, pp. 27-65; 79-97.

- **Module - IV** [8 Lectures]
  - Limits to growth thesis.

**Essential Readings**

1. Meadows, Donella H. et al. 1974. The Limits of Growth, Pan Books

2. Schumacher, E.F. 1977. Small is Beautiful, New Delhi: Radha Krishna

3. Illich, Ivan. 1977. Toward a History of Needs, Bantam.

- **Module V** [8 Lectures]
  - Post-Development.
  - Globalization and Development
  - Underdevelopment of Development
  - World System Theory

**Essential Readings**


1. Escobar, Arturo (1995) Encountering Development: The Making and Unmaking of the Third World. Princeton University Press.

2. Sachs, Wolfgang (ed.) (1997) The Development Dictionary Hyderabad: Orient Longman.

3. Schuurman, Frans J. (2001) Globalization and Development Studies, New Delhi: Vistaar Publications

4. Pieterse, Jan Nederveen (2001) Development Theory: Deconstructions/ Reconstructions, New Delhi: Vistaar Publications.

5. Wallerstein, Immanuel. 1974. The modern World System I: Capitalist Agriculture and the Origins of the European World-Economy in the Sixteenth Century. New York: Academic Press.

6. Amin, Samir. (1976). Unequal Development: An Essay on the Social Formations of Peripheral Capitalism. New York: Monthly Review Press.

7. Sing C Chew & Robert A Denemark (1996). The Underdevelopment of Development: Essays in Honor of Andre Gunder Frank. Sage Publications.


## 12.69 HS 481: International Economics

**Course Code: HS 481**

**Course Name: International Economics**

L-T-P-C : 3-0-0-3
Course Offered to : B. Tech.
Elective or Compulsory : Elective
Approval: 5th Senate

**Course Contents**

- **Module I** International Business Management and Trade Theories: Meaning and features of international business management; modes and Risk analysis of international business: political, economic, social and cultural; Globalization forces Meaning, dimensions and stages in globalization; Globalization boon or bane; Introduction to the theories of international trade by Adam Smith, Ricardo, Mill, Haberler and Heckscher - Ohlin. [10 lectures]

- **Module II** Trade Barriers and Laws: Tariffs and quotas - impact in partial and general equilibrium analysis; Free trade and policy of tariffs in relation to economic growth with special reference to India; Concept of optimum tariff; non-tariff barriers; effective rate of protection; General Agreements on Trade & Tariffs (GATT); World Trade Organization (WTO) - different rounds; IPR, TRIPS, TRIMS, GATS and Ministerial Conferences; SAARC; Rise of new economies like Brazil, Russia, India and China (BRIC). [10 lectures]

- **Module III** Balance of Payment and International Finance : Balance of trade and balance of payment; International Monetary Fund; Asian Development Bank; World Bank Group; Introduction to export and import finance; Methods of payment in international trade. [6 lectures]
- **Module IV** International Marketing and Currency Crisis: Objectives and challenges in international marketing; Major players in international marketing; Market selection and entry strategies; Euro phases - benefit and cost; Euro and implication for India; Trade invoicing in Euro Vs Dollar; Partial and full convertibility of rupee; Problems of Indias international debt. [7 lectures]
- **Module V** Globalization and its Impact on India: Globalization and internal reform process; Trade policies in India during the last six decades; Rationale and impact of trade reforms since 1991 on balance of payments, employment and growth; Current Exim Policy; Indias competitive advantage in industries like. I.T., Textiles, Gems & Jewelry etc. - potential and threats; Indian multinationals; SEZ Introduction Types of economic zones; Mechanism and opposition of setting of SEZ; Foreign direct investment in India. [9 lectures]

**Course Readings:**

1. John D. Daniels, Prashant Salwan, Daniel P. Sullivan, Lee H. Radebaugh, **International Business : Environments And Operations**, 12th Edition, Pearson, 2010
2. Dominick Salvatore, **International Economics: Trade and Finance**, Wiley India, 2012.
3. Robert J. Carbaugh, **International Economics**, South Western Cengage learning, 2011.

**Further Readings:**

1. Sundaram and Black, **International Business Environment**, PHI Publication, 2010.
2. Wild, John J. and Kenneth L., **International Business: The Challenges of Globalization**, Prentice Hall, 2008.
3. P.G. Apte, **International Financial Management**, Tata McGraw-Hill Education, 2011.

## 12.70 HS 501 : Global Health and Demography

**Course Code : HS 501**

**Course Name : Global Health and Demography**

L-T-P-C: 3-0-2-4

Intended for : Discipline Elective for MA Development Studies and Outside Discipline/Free Elective for Other Postgraduates and undergraduates (3rd and 4th year)

Prerequisite : Elementary knowledge of probability and statistics; consent of the instructor

Mutual Exclusion : None

Approval: 52nd BoA

**Course Contents**

- **Unit 1: Introduction to Global Health and Demography** (5 lecture Lectures + 4 lab Lectures)
  - Why should we study global health and demography?
  - Evolution of these subjects and their scope
  - Current population and health trends across the globe, South Asia, and India
  - Globalization, Population and health transformations
  - Sources of data for measuring population process and health
- **Laboratory Assignments**
  - Introduction to handling large scale health datasets such as the Demographic and Health Surveys; Gateway to Global Ageing data (with focus on LASI); National Sample Survey Organisation - Health consumption rounds; IHME-Global Burden of Disease data; Census of India; Sample Registration System Data
- **Demographic Measurement** (5 lecture Lectures + 12 lab Lectures)
  - Age-Sex structure- measurement and trends
  - Population aging and dependency ratios
  - Basic measures of fertility, mortality, nuptiality and migration
  - Estimating life expectancy using life tables
  - Stable population model
- **Laboratory Assignments**
  - Creating population pyramids
  - Direct indirect adjustment of Crude death rates for different age sex structures Adjusting health data for age-sex structure
  - Construction of abridged life table
  - Estimating under-five mortality rates using DHS data
- **Morbidity and Public Health** (10 lecture Lectures + 8 lab Lectures)
  - Measures of population health- prevalence and incidence
  - Measuring burden of disease-DALYs, DFLE, HLE
  - Basic concepts of epidemiology, study designs, risk of a disease,
  - Exploring the issues of association, causation, interaction, inference, confounding and generalisability

- Survival analysis

- **Laboratory Assignments**
  - Calculation of disability rates
  - Calculation of disease free life expectancy
  - Calculation of prevalence rates for childhood diseases and undernutrition using DHS
  - Calculation of prevalence rates of major diseases using LASI, and the NSSO data

- **Demographic determinants of health** (7 lecture Lectures)
  - Health issues during infancy and childhood- nutrition, infectious diseases and breastfeeding etc
  - Adolescent health- sexual and reproductive health, anemia, BMI etc
  - Maternal health
  - Later adulthood and onset of non communicable diseases
  - Health of older adults- NCDs, disability, Pain and Cognition etc
  - Lifestyle and health behavior
  - Mental health across age groups
  - Note: We will discuss gender differential in health issues at each age

- **Social Determinants of Health** (7 lecture Lectures + 4 lab Lectures)
  - Poverty, inequality and health
  - Mortality selection and poverty
  - Education and health- lifestyle choices, morbidity and health care utilization
  - Social capital and health- variations by income, education and ethnicity
  - Migration, urbanization and health;
  - Multiple deprivations and health
  - Social vulnerability and intergenerational impact of health

- **Laboratory Assignments**
  - Estimating the socio-economic gradient of any health issue (of choice) and quantifying their association

- **Space, Place and Health** (3 Lectures)
  - Space, culture and health-why is it essential to study health at disaggregated geographies
  - Impact of natural and indoor environment on health
  - Thinking about health at multiple level of geographies

- **Health Policy and Innovations** ( 5 Lectures)

- Health systems across developed and developing nations- special focus on India and its states
- National and state policies on child health, sexual and reproductive health, major diseases and family welfare
- Universal health coverage- components and measurement
- Health system strengthening and health care financing reforms
- Policy and social innovations for modifying health behaviors, health care utilization and health care financing- with special focus on India

**Textbooks:**

1. Bhende, A., **Principles of Population Studies**, 7th Edition, Himalaya Publishing House, 1996.
2. Skolnik, R., **Global health 101**, Burlington, 2011.

**Note:** Classroom notes will be provided that will include list of research articles for reference

**Reference books for laboratory sessions**

1. Preston, S. H., Heuveline, P., & Guillot, M., **Demography: Measuring and modeling population processes**, Oxford: Blackwell Publishers Ltd., 2001.
2. Moultrie TA, RE Dorrington, AG Hill, K Hill, IM Timaeus and B Zaba (eds), **Tools for Demographic Estimation**, Paris: International Union for the Scientific Study of Population, 2013.
3. demographicestimation.iussp.org
4. Croft, Trevor N., Aileen M. J. Marshall, Courtney K. Allen, et al., **Guide to DHS Statistics**, Rockville, 2018.

**References:**

1. Rothman, K. J., Greenland, S., & Lash, T. L., **Modern epidemiology** (Vol. 3), Wolters Kluwer Health/Lippincott Williams & Wilkins, 2008.
2. Jacob S. Siegel and David a. Swanson, **The Methods and Materials of Demography**, 2nd Edition, Elsevier Science, USA, 2004.
3. Lee E T, **Statistical Methods for Survival Data Analysis**, 2nd Edition, John Wiley & Sons.
4. Ladusingh, L, **Survey Sampling Methods**, PHI Learning, 2018.
5. Hsiao, W.C., **What is a health system? Why should we care?,** Harvard School of Public Health Working Paper, 2003.
6. Mosley, W. H. and L. C. Chen, Analytical framework for the study of child survival in developing countries, **Population and Development Review 10 (Supplementary Copy)**, 1984.

7. Murray, C. J. L., **Quantifying the Burden of Disease: The Technical Basis for Disability Adjusted Life Years**, Bulletin of the WHO, Vol. 72(3), pp.429-445, 1994.

8. Berkman, L. F., Kawachi, I., & Glymour, M. M. (Eds.), **Social epidemiology**, Oxford University Press, 2014.

9. Deaton, A., **The great escape**, Princeton University Press, 2013.

10. Morland, P., **The human tide: how population shaped the modern world**, Hachette UK, 2019.

## 12.71 HS 502: Philosophy of Technology

**Course Code: HS 502**

**Course Name: Philosophy of Technology**

L-T-P-C : 3-0-0-3
Students intended for: B.Tech /MS/PhD
Elective or Core: Elective
Prerequisite: Consent of the faculty member
Approval: 3rd Senate

### Course Contents

techne and episteme, technology and human self-conception; philosophies of science and technology, analytic and praxis traditions (pragmatism, phenomenology and the transformation of hermeneutics, critical theory), technoscience; cognitive issues and the human-technology interfaces; focal practices and device paradigms; transcendentalizing technologies and dystopian technologies; instrumentalism, epistemologic engines, simulation and modeling, gender issues; alternative technologies, appropriate technologies, sustainable environmental practices; technology and social practice; technology transfer and cross-cultural issues

### Prescribed Text:

1. Scharff, Robert C. and Val Dusek (eds.), Philosophy of Technology: The Technological Condition, Blackwell Publishers, 2003.

References:

1. Achterhuis, Hans (ed.), **American Philosophy of Technology: The Empirical Turn, Translated by Robert Crease**, Indiana University Press, 2001.
2. Borgmann, Albert, **Technology and the Character of Contemporary Life: A Philosophical Inquiry**, University of Chicago Press,1984.
3. Feenberg, Andrew, **Critical Theory of Technology**, Oxford University Press, 1991. Reprinted as Transforming Technology, Oxford University Press, 2002
4. Feenberg, Andrew, **Questioning Technology**, Routledge, 1999.
5. Galison, Peter, **Einsteins Clocks, Poincares Maps**, W.W.Norton, 2003.
6. Hacking, Ian, **The Social Construction of What?**, Harvard University Press, 1983

7. Heidegger, Martin, **The Question Concerning Technology in Basic Writings**, Harper /Collins, 311-341, [1954] 1993.
8. Hickman, Larry, **John Deweys Pragmatic Technology**, Indiana University Press, 1990.
9. Higgs, Eric, Andrew Light, and David Strong (eds.), **Technology and The Good Life**, University of Chicago Press, 2000.
10. Ihde, Don, **Technics and Praxis: A Philosophy of Technology**, Reidel Publishers, 1979.
11. Ihde, Don, **Technology and the Lifeworld: From Garden to Earth**, Indiana University Press, 1990.
12. Ihde, Don, **Instrumental Realism: The Interface Between Philosophy of Science and Philosophy of Technology**, Indiana University Press, 1991.
13. Ihde, Don, and Evan Selinger (eds.), **ChasingTechnoscience: Matrix for Materiality**, Indiana University Press, 2003.
14. Kuhn, Thomas., **The Structure of Scientific Revolutions**, University of Chicago Press, 1962.
15. Latour, Bruno and Steve Woolgar, **Laboratory of Life: The Social Construction of Scientific Facts**, Sage, 1979.
16. Latour, Bruno, **Science in Action**, Harvard University Press, 1987.
17. Pitt, Joseph, **Thinking about Technology: Foundations of the Philosophy of Technology**, Seven Bridges Press, 2000.
18. Zimmermann, Michael, **Heideggers Confrontation with Modernity: Technology, Politics, Art**, Indiana University Press, 1990.

## 12.72 HS 503 : German Literature from World War II to Reunification

**Course Code : HS 503**

**Course Name : German Literature from World War II to Reunification**

L-T-P-C: 3-0-0-3
Intended for : Outside Discipline/ Free Elective for MA, UG (3rd and 4th year)
Prerequisite : None
Mutual Exclusion : None
Approval: 52nd BoA

**Course Contents**

- **Unit 1: Truemmer-literature – The Zero Hour** (8 Lectures)
  - Immediate consequences of World War II and Holocaust
  - Stunde Null
  - Trauma and memories of the War and Holocaust
  - Wolfgang Borchert, Paul Celan, Guenter Eich et al.
- **Unit 2: Literature from a divided Germany** (9 Lectures)
  - Division of Germany

- Vergangenheitsbewaeltigung – coming to terms with the past
- Inner Emigration
- Gruppe
- Heinrich Boell, Guenter Grass, Paul Celan et al.

- **Unit 3: Exile Literature** (9 Lectures)
  - Literary texts from authors of East Germany or GDR
  - Division of Germany and socio-political consequences thereof
  - Life in exile and under communist surveillance in GDR
  - Question of Heimatlosigkeit (homelessness)
  - Bertolt Brecht, Christa Wolf, Wolf Biermann et al

- **Unit 4: Jewish authors and survivors of the Holocaust** (8 Lectures)
  - Select Jewish authors who have lived and survived the Holocaust
  - Victim's perspective of the Third Reich
  - Rose Auslaender, Nelly Sachs, Paul Celan et al

- **Unit 5: Re-unification of Germany (Wendeliteratur)** (8 lecture Lectures)
  - Fall of the Berlin Wall (die Wende)
  - Immediate after-effects of the re-unification of Germany
  - Identity crisis of the citizens

**Textbooks:**


1. Peter Demetz, **Post War German Literature. A Critical Introduction**, Pegasus, 1970
2. Ingo R. Stoehr, **German Literature of the Twentieth Century**, Camden House, 2001


**References:**

**Suggested Reading:**

1. Wolfgang Borchert: The Kitchen Clock (Die Kuechenuhr, 1947)
2. Paul Celan: Death Fugue (Todesfuge, 1948)
3. Heinrich Boell: The Train Was on Time (Der Zug war puenktlich, 1949)
4. Guenter Eich: Inventory (Inventur, 1947)
5. Wolfdietrich Schnurr: On The Run (Auf der Flucht, 1950)
6. Bertolt Brecht: On The Term Emigrants/ Ueber die Bezeichnung Emigranten, 1937/ To Those Who Follow in Our Wake (An die Nachgeborenen, 1939)

7. Christa Wolf: Der geteilte Himmel, 1963 (Divided Heaven: Film 1964)
8. Anna Seghers: The Seventh Cross (Das siebte Kreuz, 1942)
9. Nelly Sachs: In the Houses of Death (In den Wohnungen des Todes, 1947)
10. Thomas Brussig: Heroes Like Us (Helden wie wir, 1995)
11. Christa Wolf: What Remains (Was bleibt, 1990)
12. Sven Regener: Berlin Blues (Text or Film: 2003) (Herr Lehmann, 2001)
13. Rose Auslaender: The Luck (Das Glueck, 1939)
14. Johannes Bobrowski: Shadowland/ The Latvian Autumn (1994)
15. Marcel Reich-Ranicki: Videos from Literarische Quartett (Youtube)
16. Hans Egon Holthusen: A Literature in Transition. Main Currents of Post War German Writing, The Atlantic
17. Aaron Denis Horton: Catastrophe and Identity in Post War German Literature, 2005

**Films:**

1. Schindler's List (1994)
2. The Boy in Striped Pyjamas (2008)
3. The Pianist (2002)
4. The Lives of Others (2006)
5. The Tin Drum (1979)
6. The Reader (2008)
7. Downfall (2004)
8. Enemy at the Gates (2001)

## 12.73 HS 504 : Personal Finance and Portfolio Management

**Course Code : HS 504**

**Course Name : Personal Finance and Portfolio Management**

L-T-P-C: 3-0-0-3
Intended for : UG final year, and PG students
Prerequisite : None
Mutual Exclusion : None
Approval: 52nd BoA

**Course Contents**

- **Introduction to Personal Finance:** Introduction to personal finance and its importance, Overview of the financial planning process, time value of money, Overview of Indian Financial instruments, budgeting, Unique challenges and opportunities in the Indian context, Role of culture and social norms in personal finance management in India (6 Lectures)

- **Banking:** The role of banks in the economy, The different types of banks (e.g., commercial, investment, central), Introduction to banking products and services (e.g. deposit accounts, loans, credit cards, mortgages), The importance of banking services to individuals. (4 Lectures)

- **Saving and Investing:** Creating and managing a personal budget, the Importance of saving and investing for personal finance, Financial Planning Tools, Types of savings and investment instruments (e.g., mutual funds, stocks, bonds, real estate, commodity, fixed income, Real Estate, Unit Linked Investment), Risk and return, diversification, and asset allocation. (10 Lectures)

- **Debt Management:** Understand debts (e.g. credit cards, loans, mortgages), Types of debts and loans, Overview of credit scores and reports, and Strategies for managing debts and improving credit scores. (4 Lectures)

- **Retirement Planning:** Overview of retirement planning and its importance, Types of retirement accounts (NPS, Private pension, Provident funds), Retirement income sources (e.g., Pensions, rental incomes) (6 Lectures)

- **Tax Planning:** Overview of tax planning and its importance, Tax planning strategies for individuals (e.g. tax deductions, credits, and exemptions), Overview of tax laws and regulations (6 Lectures)

- **Financial Tools and Resources:** Overview of financial tools and resources for personal finance management, Examples of financial tools, such as budgeting apps, investment platforms, and retirement calculators, Evaluation of financial resources and tools (6 Lectures)

**Text books:**


1. Ramit Sethi, **I will teach you to be rich**, Workman Publishing, 2019.
2. Basant Maheshwari, **The thoughtful investor**, The Equity Desk, 2021.


**References:**


1. George S. Clason, **The Richest Man in Babylon**.
2. Benjamin Graham, **The Intelligent Investor**.
3. Morgan Housel, **The Psychology of Money**.
4. Robert T. Kiyosaki, **Rich Dad Poor Dad**.
5. JL Collins, **The Simple Path to Wealth**.

6. Thomas J. Stanley and William D. Danko, **The Millionaire Next Door**.
7. Vicki Robin and Joe Dominguez, **Your Money or Your Life**.
8. John C. Bogle, **The Little Book of Common Sense Investing**.
9. Burton Malkiel, **A Random Walk Down Wall Street**.
10. Tony Robbins, **Money Master the Game**.

## 12.74 HS 505: Circularity in Modern European Literature

**Course Code : HS 505**

**Course Name : Circularity in Modern European Literature**

L-T-P-C : 3-0-0-3
Intended for : Undergraduate students
Prerequisite :
Mutual Exclusion:
Approval: 54th BoA

**Course Contents**

- Introduction: Modern European Literature (8 hours)
  - Europe in the late 19th and early 20th centuries.
  - Key concepts in literary theory.
  - The genealogy of linearity
- Ouroboros: On the concept of Circularity (8 hours)
  - Introduction to the concept of circularity in Western Philosophy.
  - Overview of the philosophy of Friedrich Nietzsche
- Circular Drama (10 hours)
  - August Strindberg's The Dance of Death
  - Eugene Ionesco's The Bald Soprano
  - Samuel Beckett's Waiting for Godot
  - Daniil Kharm's Elizabeth Bam
- Circular Prose (10 hours)
  - Daniil Kharms' The Knife
  - Jorge Luis Borges' The Circular Ruins
  - Cortazar The Continuity of the Parks
  - Maurice Blanchot The Madness of the Day.

**Textbooks:**

1. NA

**References:**

1. Juan Luis Toribio Vazquez, **Circular Narratives in Modern European Literature**.
2. Arthur Danto, **Nietzsche and Philosophy**.

## 12.75 HS 506: Population Studies: Theory and Basic Analysis

**Course Code : HS 506**

**Course Name : Population Studies: Theory and Basic Analysis**

L-T-P-C : 3-0-0-3
Intended for : M.A. (Development Studies) (Discipline Elective) and B.Tech. 3rd and 4th year
Prerequisite :
Mutual Exclusion:
Approval: 54th BoA

**Course Contents**

- Unit 1: Population science/demography (4 Hours)
  - Evolution of demography as a scientific discipline
  - Multidisciplinary nature of demography
  - Sources of demographic data
  - Basic demographic concepts
  - Components of population change and balancing equation
  - Theory of Demographic Transition
- Unit 2: Population Size, Growth and Characteristics (6 Hours)
  - Overview of the size and growth of world population by regions
  - Overview of the size and growth of India's population
  - Demographic profile of Indian states
  - Age and sex structure of the population and population pyramids
  - Determinants of age and sex structure of the population and their implications
  - Sex ratios: total sex ratio, sex ratio at birth, child sex ratio, sex ratio
  - Changing patterns of sex ratio in India, North-south divide, 'Missing women'
- Fertility and Nuptiality (10 Hours)
  - Concepts and measurements of fertility: period and cohort measures

- Age patterns of fertility
- Bongaart's proximate determinants of fertility
- Socio-economic determinants of proximate variables
- Rele's Method and Reverse Survival Method in fertility analysis
- Fertility levels and differentials in developed and developing countries and India
- Nuptiality: Concept and analysis of marital status, proportion single, Singulate Mean Age at Marriage (SMAM) and trends in child marriages (marriage ¡18 years) in India 2

- Morbidity and Mortality (12 Hours)
  - Basic concepts and analysis of morbidity
  - Concepts and measurements of mortality
  - Standardization of mortality rates
  - Life tables: Concepts, types, uses, and methods of construction
  - Differentials and Determinants of Mortality
  - Causes of death and epidemiological transition

- Migration and urbanization (10 Hours)
  - Concepts and measurement of migration
  - Differentials in migration
  - Causes and consequences of internal migration
  - Trends and patterns of internal and internal migration
  - Migration theories and models: Ravenstein's, Lee's, Wolpert's and Todaro's model
  - Spatial distribution and urbanization
  - Growth and distribution of rural-urban population in developed and developing countries and India

**Textbooks:**


1. Asha Bhende and Tara Kanitkar, **Principles of Population Studies**, Himalaya Publishing House

2. Henry, S. Shryock, **The Methods and Materials of Demography**, Vol. 1 and 2, U.S. Department of Commerce, Bureau of Census.


**References:**

1. NA

## 12.76 HS 508: Socio-technical Systems Engineering

**Course Code: HS 508**

**Course Name: Socio-technical Systems Engineering**

L-T-P-C : 2-1-0-3
Prerequisites : none
Intended for : B. Tech./M.S./Ph.D.
Distribution : Elective
Approval: 6th Senate

**Course Contents**

28 Lectures to cover the main topics (approx 2 Lectures per week) 4 Tutorials/workshops TOTAL: 3 hrs per week, plus assessment time as required

- **Introduction to systems science and engineering**
  - Principles of systems science
  - Overview of systems engineering
  - Lifecycle, and other system views
- **Socio technical systems**
  - Background
  - Evolution and key issues
  - Overview of the state of the art
- **Knowledge Systems, the Web**
  - The role of knowledge in STS (Knowledge representation, modelling)
  - Distributed /Intelligent systems design
  - Collective Intelligence and Social networks
- **Task Analysis**
  - Traditional Task Decomposition
  - Knowledge/cognitive modelling of tasks
  - Cognitive walkthroughs
- **User centered design**
  - Purpose and approaches
  - Tools and techniques
- **Human computer interaction**
  - History of HCI
  - User Models

- Interface Design

- **Interaction design**
  - Fundamentals of interaction design
  - Types of interactions
  - Handling dynamic complexity

- **STS Requirements**
  - Stakeholder analysis and management
  - Understanding social behaviors

**Textbooks:**


1. William Pasmore and John Sherwood. (editors), Principles of Sociotechnical Design, Sociotechnical Systems: A Sourcebook,

2. Somerville et al Whitworth, Brian with Ahmad, Adnan, Socio Technical Systems Engineering Handbook: SocioTechnical (available online), 2013.

3. Soegaard, Mads with Dam, Rikke Friis (eds.)System Design. In: The Encyclopedia of Human, Computer Interaction, 2nd Ed.. Aarhus, Denmark: The Interaction Design Foundation. Available online at

4. http://www.interactiondesign.org/encyclopedia/sociotechnical_system_design.html


**References:**


1. Stevens Institute of Technology

2. The Knowledge Level Reinterpreted: Modeling Socio Technical Systems William J. Clancey


## 12.77 HS 510: Essentials of Entrepreneurship

**Course Code: HS 510**

**Course Name: Essentials of Entrepreneurship**

L-T-P-C:: 3-0-0-3
Prerequisites: Nil
Intended for: PhD/Masters/B.Tech 3rd and 4th year
Distribution: Open Elective
Approval: 17th Senate

**Course Contents**

- **Entrepreneurship Concepts** Understanding nuances of being an entrepreneur; Difference between a startup venture and small business; Identifying entrepreneurial styles. [4 Lectures]
- **Idea/Problem and Customer** Identifying problems worth solving, identifying business opportunities, methods for problem interviews; Design thinking process; Generation of potential solutions; Identifying customer segment and early adopters, difference between a consumer and a customer, craft your value proposition, outcome driven innovation, testing out solutions for the problems; Unique value proposition. [12 Lectures]
- **Business Model Validation** Basic lean approach and canvas, types of business models, documenting business plan with a lean canvas, documenting hypotheses; Introduction to risks; Develop solution demos; The problem-solution test, solution interviews, sizing the opportunity, building a minimum viable product; The product-market fit test; Revenue streams; How companies with different business models earn money; Understanding income, costs, gross and net margins; Identifying primary and secondary revenue streams; Costing and pricing; How to finance your business idea; Financing your venture at different stages, what investors expect from you; Various sources of funding and pros & cons of each [12 Lectures]
- **Building a Resourceful Team** Shared leadership model, role of a good team in a venture's success, what to look for in a team, define clear roles and responsibilities; How to pitch to candidates to attract to join your team, explore collaboration tools and techniques - brainstonning, mind mapping; Kanban board [4 Lectures]
- **Marketing, Sales and Support** Understanding the difference between product and brand and link between them; Product/service positioning; Channels and strategies, budgeting and planning; Sales planning, target setting; Unique sales propositions (USP); Follow-up and closing sale; Planning and tracking, importance of project management to launch and track progress; Understanding time management, workflow, delegation of tasks; Business regulations of starting and operating a business; Documentation, how to find help to get started; Various govem ent scheme [10 Lectures]

**Textbooks:**

1. Blank, S. G., & Dorf, B., **The startup owner's manual: The step-by-step guide for building a great company** Pescadero, Calif: K & S Ranch, 2012.

**Reference:**

1. Maurya, A., **Scaling Lean: Mastering the Key Metrics for Startup Growth**, Portfolio/Penguin, 2016.
2. Sethi, A., **From Science to Startup**, Springer, 2016.

## 12.78 HS 522: Research Methodology in Social Science

**Course Code: HS 522**

**Course Name: Research Methodology in Social Science**

L-T-P-C : 3-0-0-3
Prerequisites :
Students intended for : Ph.D.
Elective or Compulsory : Elective
Approval: 6th Senate, 50th BoA; Credits changed to 4 in 50th BoA

**Course Contents**

- **Philosophical Foundations of Social Science**
  - Positivism, Behavioral Sciences and later developments in Social Science Thought (Sociological Thinkers and Psychologists)
  - Idea of Social Sciences (Peter Winch/Charles Taylor)
  - Idea of Human Sciences (Wilhelm Dilthey)
  - Idea of Social Construction of Reality (Ian Hacking)
  - Postcolonial Theory (Gayatri Spivak, Dipesh Chakrabarty, and Homi Bhabha) [16 Lectures]
- Module: 2
- **Approaches to Social Science Research**
  - Content analysis
  - Survey and field research
  - Quantitative and qualitative analysis
  - Case studies
  - Ethical considerations in research [12 Lectures]
- Module: 3
- **Designing Research**
  - Formulating appropriate research questions
  - Hypothesis construction
  - The literature review
    * Use of the literature
    * Steps in conducting a literature review iii. Citations, formatting and style
  - The use of theory
  - Approaches to Data Analysis
    * Induction
    * Deduction

* Verification
* Falsification
* Empiricism and Social Research
* Analytical dilemmas

**Reference books:**


1. Peter Winch, **The Idea of a Social Science and Its Relation to Philosophy** (Routledge Classics), Routledge, 2007.

2. Wilhelm Dilthey, Rudolf A. Makkreel, and Frithjof Rodi, **Selected Works Volume I: Introduction to the Human Sciences**, Princeton University Press, 1991.

3. Ian Hacking, **The Social Construction of What?**, Harvard University Press, 2000.

4. Dipesh Chakrabarty, **Provincializing Europe: Postcolonial Thought and Historical Difference**, Princeton University Press, 2007.

5. Wayne C. Booth et al., **The Craft of Research**, 3rd Edition, University Of Chicago Press, 2008.

6. J. W. Creswell, **Research Design: Qualitative, Quantitative and Mixed Methods Approaches**, 4th Edition, SAGE Publications, 2013.

7. Jacques Barzun, Henry F. Graff, **The Modern Researcher**, 6th Edition, Cengage Learning, 2003.

8. William Strunk, E. B. White, and Roger Angell, **Elements of Style**, Longman, 1999.

9. David Henderson, **Interpretation and Explanation in the Human Sciences**, SUNY Press, 1993.

10. Edward Corbett and Robert Connors, **Classical Rhetoric for the Modern Student**, 4th Edition, Oxford University Press, 1998.

11. Diana Hacker, **Rules for Writers**, 7th Edition, Bedford/St. Martin's, 2011.


## 12.79 HS 523: Decision-Making for Social Change

**Course Number: HS 523**

**Course Name: Decision-Making for Social Change**

L-T-P-C : 3-0-0-3

Prerequisites :None

Intended for : M.A. Development Studies/M.S./Ph.D./B. Tech. students

Distribution: Discipline Elective for M.A. Development Studies/ HSS Free Elective for B. Tech. students/Free Elective for other students

Approval: 19th Senate

**Course Contents**

- **Mental Models, System Thinking, and Probability Judgments** Introduction to system thinking, introduction to mental models, confirmation bias, identifying and improving mental.models, linear models of judgement, fast-and-frugal heuristics, representativeness heuristic, availability heuristic, support theory, judgment of condition probability, anchoring-and-adjustments in judgements. [6 Lectures]

- **Decision-making under Risk and Cognitive Biases** Expected-utility theory, prospect theory, framing and framing effect, decisions under uncertainty, endowment effect, status-quo bias, omission bias, sunk-cost effect, single-action bias, finite pool of worry, fundamental computational bias, single action bias, intuitive versus reflective judgements. [6 Lectures]

- **Judgments involving Time and Group Decision Making** Theory of time preference, reasons for time preferences, inter-temporal choices, hyperbolic discow1ting, information sharing in groups, group polarization, group think, techniques for improving group decision-making: brainstorming, decision rules, systematic decision procedures, leadership. [6 Lectures]

- **Dynamic and Naturalistic Decision Making** Use of microworld games, feedback, feedback delays, instance-based learning, individual differences in DDM, nature of naturalistic decision making, image theory, recognition-primed decision-making. [6 Lectures]

- **Perception of Risk** (6 hours) Revealed preference approach to risk, risk dimensions, factors underlying risk dimensions, affective influence on risk, social amplification of risk, influence of personality on risk, influence of gender on risk, influence of race on risk, expert versus lay perception of risk, risk communication. [6 Lectures]

- **Optimism, Confidence, and Nudges** Overconfidence, calibration curves, cross-cultural differences, case study on investment behavior, introduction to nudges, nudging over time, influence, nudging in the real world. [6 Lectures]

- **Social Dilemmas and Environmental Decision Making** Introduction to social dilemmas, prisoner's dilemma, tragedy of commons, public goods, factors affecting social dilemmas, environmental biases - reliance on correlation heuristics and violation of mass balance, factors affecting correlation heuristic and violation of mass balance (backgrounds, type of feedback). [6 Lectures]

**Textbooks:**


1. Hardman, D., & Hardman, D. K. (2009). Judgment and decision making: Psychological perspectives (Vol. 11). John Wiley & Sons.

2. Kim, N . (2017). Judgment and Decision-making: In the Lab and the World. Macmillan International Higher Education.

**Reference:**


1. Bazerman, M.H. and Moore, D.A, **Judgment in Managerial Decision Making**, 7th Edition, Wiley, 2008.

2. Fiscbhoff, B., **Judgment and Decision Making**, Routledge, 2012.

3. Hastie, R., & Dawes, R. M., **Rational choice in an uncertain world: The psychology of judgment and decision making**, Sage, 2010.

4. Pious, S., **The psychology ofjudgrnent and decision making**, McGraw-Hill Book Company, 1993.

5. Shome, D., Marx, S., Appelt, K., Arora, P., Balstad, R., Broad, K., et al., **The psychology of climate change communication: a guide for scientists, journalists, educators, political aides, and the interested public**, Center for Research on Environmental Decisions, 2009.


## 12.80 HS 524: India in the 1950s: Biography of a Foundational Decade

**Course Code: HS 524**

**Course Name: India in the 1950s: Biography of a Foundational Decade**

L-T-P-C : 3-0-0-3
Prerequisites : None
Intended for : Ph.D./Masters/B.Tech. (3rd and 41h Sem)
Distribution : Free Elective
Approval: 18th Senate

**Course Contents**

- **Introduction to a Foundational Decade**
  - Why (and who should) study the 1950s? [2 Lectures]
- **Refugees an d Citizens in fnd epend ent India**
  - The Impact of Partition on I ndian Polity
  - Resettlement: A Case Study of Delhi
  - Rehabilitation: A Case Study of Ca lcutta [8 Lectures]
- **Forging India:States and the Nation**
  - Integration of Princel y States
  - Linguistic Reorganization of States
  - Making of the Indian Constitution [8 Lectures]
- **Experimenting with Democracy**
  - I st General Elections

- Developmental Strategies: Debates [6 Lectures]

- **Legislating Gender Relations**
  - The Hindu Code BilJ Controversy [2 Lectures]

- **India's International Rela tions in the 1950s**
  - The Cold War context (Relations with the USA and the USSR) The Non-Aligned movement
  - Relations with Pakistan (Kashmir, Indus Waters)
  - Relations with China [8 Lectures]

- **The State and Media in the 1950s**
  - Debates over 'free speech ' in Independent India
  - 1st Amendment to the Constitution: Public Reaction
  - Press Act of 1952
  - Nation-Building Cinema of the 1 950s [8 Lectures]

**Textbooks:**

1. Gyanesh Kudaisya, A Republic in the Making: India in the 1950s (Oxford Un i versity Press, 2017).

**References :**

1. Ravinder Kaur, **Since 1947: Partition and Punjabi Migrants of Delhi**, Oxford University Press, 2007.

2. Joya Chatterji, **The Spoils of Partition: Bengal and India, 1947-67**, Cambridge University Press, 2007.

3. Tai Yong Tan and Gya nesh Kudaisya, **The Aftermath of Partition in South Asia**, Routl edge, 2000.

4. Ornit Shani, **How Tndia Became Democratic: Citizenship and the Making of the Universal Franchise**, Cambridge University Press, 2017.

5. Ananya Vajpeyi, **Righteous Republic: The Political Foundations ofModern India**, Harvard University Press, 2012.

6. Asha Sarangi, **Language and Politics in India**, Oxford University Press, 2009.

7. Sudha Pai and Avinash Kumar, **Revisiting 1956: BR Ambedkar and States Reorganization**, Orient Blackswan 2014.

8. Paul Brass, Language, **Religion and Politics in North India**, Cambridge University Press, 1974.

9. Pulapre Bal akrishnan, **Economic Growth in India: History and Prospect**, Oxford Universi ty Press, 20 l 0.

10. B.R. Tomlinson, **The Economy of Modern India**, 1860-1970, Cambridge University Press, 1993.

11. Ch.itra Sinha, **Debating Patriarchy: The Hindu Code Bill Controversy in India, 1941-1956**, Oxford University Press, 2012.

12. Paul M. McGarr, **India, Pakistan and the Early Cold War, 1947-1956**, Cambridge University Press, 2013.

13. Srinath Raghavan, **War and Peace in Modern India**, Permanent Black, 2010.

## 12.81 HS 525: History of Development Thought

**Course Number : HS 525**

**Course Name: History of Development Thought**

L-T-P-C : 3-0-0-3
Prerequisites : None
Intended for : Postgraduate students, 3rd and 4th Year B.Tech students
Distribution : Core course for M.A. in Development Studies, Elective for others
Approval: 16th Senate

**Course Contents**

- **Early global relations and Colonialism** [9 Lectures]
  - Global economic relations between 16th and 18thCentury: Economic linkages connecting the known world, growth of joint stock trading companies, mercantilism, rise of transatlantic slave trade.
  - Industrialization and urbanization in Western Europe
  - Colonialism in India, Africa and Imperialism in China; Colonization as a basis of globalization: Latin American export oriented economy [9 Lectures]
- **Development Theories: Varying role of market and state** [15 Lectures]
  - Classical approach (Liberalism, Classical Economic Approach)
  - Keynesian approach: Post World War I
  - Modernization
  - Marxist theory of development
  - Socialism
- **Structuralism and Dependency Theories** [8 Lectures]
  - Structuralism: Impediments of the economic growth of developing countries
  - Dependency theory and Neo-Marxism
  - Neo-liberalism: MNCs, Structural Adjustment
- **Discourses on Development** [10 Lectures]

- Post-development: Does development represent colonialism and Euro-centrism?
- Capabilities approach
- Grassroots approaches to development
- Gender and development
- Culture and development
- Limits to growth and sustainable development [10 Lectures]

**Textbooks:**

1. Marks, Robert B., The Origins of the Modern World: A Global and Ecological Narrative from the Fifteenth to the Twenty-first Century. 2nd Edition, Rowman & Littlefield, 2007.
2. Willis, K., Theories and Practices of Development, Routhledge, 2005.

Reference:

1. Brook, T., **Vermeers Hat: The Seventeenth Century and the Dawn of the Global World**, Bloomsbury Press, 2008.
2. Davis, M., **Late Victorian Holocausts: El i o Famines and the a ing of the Third World**,Verso, 2001.
3. Lindsay, Lisa A., **Captives as Commodities: The Transatlantic Slave Trade**, Pearson Prentice Hall, 2008.

## 12.82 HS 526: Human Geography: A Western Himalayan Perspective

**Course Code: HS 526**

**Course Name: Human Geography: A Western Himalayan Perspective**

L-T-P-C : 3-0-0-3
Prerequisites : None
Intended for : Post graduate students, 3rd and 4th Year B.Tech. students
Distribution : Core course for M.A. in Development Studies, Elective for others
Approval: 16th Senate

**Course Contents**

- **Why does Human Geography Matter?** [4 Lectures]
  - Defining Human Geography: Themes and relevance
  - Introduction to a spatial perspective: regional and global
  - What are the basic geographic questions?
  - Environmental Determinism: debates
- **Economic Geography** [8 Lectures]

  - Geography of the world economy: Measurement and problems
  - Trends in agriculture (India/Himachal Pradesh/Western Himalaya)
  - Food production and food security (Himachal Pradesh/ Western Himalaya)
  - Worlds of consumption: Global and local geographies of consumption

- **Population Geography** [8 Lectures]
  - Geography of health
  - Population dynamics
  - Migration: push and pull factors
  - Indias demographic profile and National Population Policy

- **Geography across Global and Regional History: Urbanization** [5 Lectures]
  - Urbanization: A global survey of trends and patterns
  - Case Study: Imperial and Post-Colonial Shimla

- **Humans and Nature** [6 Lectures]
  - Natural Disasters and Human Intervention (19th-20th century India)
  - Human-Animal Conflict and Cooperation in India (Ancient to Contemporary India)

- **Cultural Geography: Space and Society** [5 Lectures]
  - Language: Linguistic Nationalism in India
  - Religion and the cultural landscape in Himachal Pradesh/ Western Himalaya

- **Case Study** [6 Lectures]
  - Change and Continuity in Himachal Pradesh/ Western Himalaya (19th-20th centuries) from the perspective of Human Geography

**Textbooks:**

1. Fouberg, Erin H. et al. **Human Geography: People, Place, and Culture**, 11th Edition, Wiley, 2015.

2. Cloke, Paul et al. Introducing Human Geographies, 3rd Edition, Routledge, 2014.

**References:**

1. Alam, Aniket., **Becoming India: Western Himalaya under British Rule**, Cambridge University Press. 2008.

2. Coe, Neil et al., **Economic Geography: A Contemporary Introduction**, Wiley, 2013.

3. Diamond, Jared., **Guns, Germs and Steel: The Fate of Human Societies**, WW Norton, 2017.

4. Elmore, Mark., **Becoming Religious in a Secular Age**, University of California Press, 2016.

5. Guha, Ramachandra, **Environmentalism: A Global History**, Penguin Random House India, 2016.

6. Roy, Tirthankar., **Natural Disasters and Indian History**, Oxford University Press, 2012.

7. Singh, Chetan., **Natural Premises: Ecology and Peasant Life in the Western Himalaya**, 1800-1950, Oxford University Press, 1998.

## 12.83 HS 527: Indian Social Structure and Development

**Course Code: HS 527**

**Course Name: Indian Social Structure and Development**

L-T-P-C : 3-0-0-3
Prerequisites : None
Intended for : Post graduate students, 3rd and 4th Year B.Tech.
Distribution : Core course for M.A. in Development Studies, Elective for others
Approval: 16th Senate

**Course Contents**

- Module I: **Understanding Indian Society** [6 Lectures]
  - Perspectives to understand Indian society: Orientalist; Nationalist; Subaltern; Postcolonial
  - Indian society: Socio-spatial dimension
    * Rural, Urban and Rural-urban Continuum.
- Module II: **Constituents of Indian Society**
  - **Caste in India** [6 Lectures]
    * Understanding caste among Hindu and other religious communities
    * Debates on Caste: Brahminical and Non-Brahminical
    * Dynamics of Caste in Cities
    * Politics and Caste: Vote bank politics; Political Parties; Politicization of caste
    * Changing dynamics of caste system: Caste as structure and Caste as substance
  - **Tribes of India** [4 Lectures]
    * Popular and social scientific understandings of tribe and tribal community
    * Tribes in colonial times: Criminal Tribes, De-notified and Nomadic tribe
    * Developmental programs and transformations in tribal society
    * Tribal movements: colonial and post-independence era

- **Class** [4 Lectures]
    * Issues of identification of class in India
    * Structure of Agrarian Class
    * Indian Middle Classes: Origins, Structure, Politics
    * Poor as class
- * **Gender** [4 Lectures]
    * Sex, Gender and Third Gender
    * Gender socialization and gender inequality
    * Patriarchy, production and women workforce in Indian economy
    * Women Empowerment: idea, debate and politics

- Module III: **Village in India** [6 Lectures]
  - Villages in India: popular imaginations and social scientific understandings
  - Village Studies and Community Development Program
  - Rural Development in Post-Independent India: Plans, Programs and Policies
  - Indian Villages: Change and Continuity
- Module IV: **City and Urban Space in India** [6 Lectures]
  - Understanding urbanization and urbanism
  - The Urban Turn
  - Urban stratification and Urban Public Space
  - Slums in India: issues and problems
  - Urban Development since Independence: Plans, Programs, Policies
- Module V: **Religion and Development** [6 Lectures]
  - Religion and Imaginations of Modern Society
  - Religious Minorities: Issues of Representation and Development
  - Secularism, communalism and fundamentalism

**Textbooks:**

1. Deshpande, Satish., **Contemporary India: A Sociological View**, Penguin Books, 2003.
2. Gupta, Dipankar (ed)., **Social Stratification in India**, Oxford University Press, 1992.

**References:**


1. Cohn, B.S. 1987. 'Notes on the history of the study of Indian society and culture' [Chapter-7] in An anthropologist among the historians and other essays. New Delhi: OUP; pp: 136-171.

2. Danagare, D.N. 2007. Practising Sociology through History: The Indian Experience I and Part II. Economic and Political Weekly. Vol. 42, No. 33, pp. 3414-3421; and Vol. 42, No. 34, 3499-3508.

3. Embree, A.T. and M. Juergensmeyer. 1989. Imagining India: Essays in Indian history. New Del- hi: OUP [Introduction; and Chapters-3, 11 & 12].

4. Gandhi, Leela. 1998. Postcolonial Theory: A Critical Introduction. Pp. 1-22 and 167-176. New Delhi: Oxford University Press.

5. Inden, Ronald. 2006. Text and Practice: Essays on South Asian History. [Chapter 1. Orientalist constructions of India. (pp 13-60)]. New Delhi: Oxford University Press.

6. Mongia, Padmini. (ed.). 1997. Contemporary Postcolonial Theory: A Reader. New Delhi: Oxford University Press. Pp. 1-9.

7. Oommen, T.K. 2005. 'Understanding Indian society: The relevance of the perspective from below' in S.M. Dahiwale (ed) Understanding Indian society: The non-Brahmanic perspective. Jaipur. Rawat; pp: 33-50.

8. Dahiwale, S.M. 20005. Understanding Indian society: The non-Brahmanic perspective. Jaipur. Rawat. (Chapter-1).

9. Ambedkar, B.R. Ambedkar, B.R. 2002 [1936]. 'Castes in India' in Valerian Rodrigues (ed) The essential writings of B.R. Ambedkar. New Delhi: OUP; pp: 241-262.

10. Desai, Sonalde and AmareshDubey. 2011. Caste in 21st Century India: Competing Narratives. Economic and Political Weekly. 46(11): 40-49.

11. Ghurye, G.S. 1992. 'Features of the caste system' in Dipankar Gupta (ed) Social Stratification in India. New Delhi. OUP; pp: 35-48.

12. Fuller, C.J. 1992. Kerala Christians and the caste system. In Dipankar Gupta (ed.) Social Stratifi- cation in India. Delhi: Oxford Uni Press, pp: 195-212.

13. Bokil, M. 2002. De-notified and Nomadic Tribes: A Perspective. Economic and Political Weekly. Vol. 37(2): 148-154.

14. Guha, Ramachandra. 1996. Savaging the civilised: Verrier Elwin and the tribal question in late colonial India. Economic and Political Weekly. Vol. 31, No. 35/37; pp:2375-2380, 2382-2383, 2385-2389.

15. Xaxa, Virginius. 1999. Transformation of tribes in India. Terms of Discourse. Economic and Po- litical Weekly. Vol. 34(24): 1519-1524.

## 12.84 HS 528: Information Technology and Development

**Course Code: HS 528**

**Course Name: Information Technology and Development**

L-T-P-C : 3-0-0-3
Prerequisites : None
Intended for : Post-graduate students; 3rd and 4th Year B. Tech. students
Distribution : Core course for M.A. in Development Studies, Elective for others
Approval: 16th Senate; Revised in 50th BoA

**Course Contents**

- **Introduction to technology and development** Definitions of technology, Systemic views of Technology-Society relationships, Development paradigms, Social and commercial mechanisms for linking technology to developmental needs; (Certain example cases could include: a case study on same language subtitling (SLS) for improving reading ability in India; a case study on hole- in-the-wall project in India, Bhutan, Cambodia, and Africa and how it encourages children to learn via entertainment; self-organized learning and mediated environments in India and Oscar-winning movie Slumdog Millionaire; failure of little intelligent community based ICT in Central America.) [8 Lectures]

- **Overview of ICT for development** Development agenda and positioning of ICT for development; information and knowledge society; technological interests and social change; real-world applications of ICT in development; the role of technology in reducing poverty (e.g., computer aided learning and Mille.org); the role of ICT in overcoming healthcare challenges (e.g., telemedicine, information gathering, and low-cost point of care testing medical devices- translating health care from bench to bedside); the role of technology in causing agricultural innovation (e.g., telecentres and digital Green like the green-wifi.organd and the e-sagu project); role of ICT in surveillance and good governance, communications, infrastructure, and user-interface design. [12 Lectures]

- **Participatory methods in technology and development** Discussion on participatory methods (e.g., documentary Water of Ayol (Sandra Nichols)); different principles and modes of participation; contributors to ICT projects failures; role and issues in community-based participatory research (e.g., case of the African Digital Renaissance). [5 Lectures]

- **Networking, access, mobile technologies, and development** Access to hardware, software, information and services; LTE and Internet backbone; role of TCP/IP and other protocols; (Certain example cases could include the case of the last 10km in Rwanda; case of microwave in rural Alaska; role of cellular voice and data; case of M-PESA in India and Kenya.) [5 Lectures]

- **Cyber-security and development** Intrusion-detection systems; deception; block chain technology; Cloud access security brokers (CASB); Endpoint detection and response (EDR); Non-signature approaches for endpoint prevention; Remote browser. [3 Lectures]

- **User interface design, cloud computing, HCI and development** Role of cloud computing in promoting development; configuring Wikispaces and a website; role of HCI in development since its emergence in 1980s; symbiotic relationship between humans and computers (example, the case of spoken web: using voice as an accessibility tool for disadvantaged people in developing countries); grand challenges in HCI for development. [4 Lectures]

- **New devices, sensor networks in development** Role of sensor and IoT revolution and how its aids development (examples of IoT for farming and natural disasters); notion of wearable computing devices and its impact on sustainable development; wireless sensor networks and their role in development; influence of IoT on different policy areas. [5 Lectures]

**Textbooks:**

1. Heeks, R. (2017). Information and Communication Technology for Development (ICT4D). Routledge, London, UK.

2. Seth, K. (2016). Computers, Internet And New Technology Laws-A Comprehensive Reference Work With Special Focus On Developments In India. Lexis Nexis

**References:**

1. Barrat, J., Our final invention: Artificial intelligence and the end of the human era. Macmillan, 2013.

2. Cooper, C., Technology and development in the Third industrial revolution. Routledge, 2017.

3. Cornwall, A., &Jewkes, R., What is participatory research?.Social science & medicine, 41(12), 1667-1676, 1995.

4. Dodson, L. L., Sterling, S., & Bennett, J. K., Considering failure: eight years of ITID research. In Proceedings of the fifth international conference on information and communication technologies and development (pp. 56-64). ACM, 2012.

5. Garrity, J., Harnessing the Internet of Things for Global Development. SSRN Electronic Journal. doi:10.2139/ssrn.2588129, 2015.

6. Ho, M. R., Smyth, T. N., Kam, M., & Dearden, A., Human-computer interaction for development: The past, present, and future. Information Technologies & International Development, 5(4), pp-1, 2009.

7. Kendall, J., &Voorhies, R., The mobile-finance revolution: How cell phones can spur development. Foreign Affairs, 93(2), 9-13, 2014.

8. Kumar, A., & Agarwal, S. K., Spoken web: using voice as an accessibility tool for disadvantaged people in developing regions. ACM SIGACCESS Accessibility and Computing, (104), 3-11, 2012.

9. Mandal, G. C., Social Impact of Banking, Technology and Development In Village India.Rajat Publications, 2012.

10. Mas, I., & Radcliffe, D. (2010). Mobile payments go viral: M-PESA in Kenya. The Capco Institute Journal of Financial Transformation, 169-182, 2010.

11. Rathakri & Thomas, M., Participatory Technology Development: A Technique for Indigenous Technical Knowledge Refinement. Scientific Publisher, 2012.

12. Pannu, P., &Tomar, Y. A., Communication Technology for Development. I K International Publishing House Pvt. Ltd, 2012.

13. Raina, R. S., Science, Technology and Development in India: Encountering Values. Orient Longman, 2015.

14. Sankar, S., The rise of human-computer cooperation. In TED Talk Lesson, TED Conferences, junho de, 2012.

15. Smith, M. L., Spence, R., & Rashid, A. T., Mobile phones and expanding human capabilities. Information Technologies & International Development, 7(3), pp-77, 2011.

16. Toyama, K., On turbocharged, heat-seeking, robotic fishing poles. Communications of the ACM, 54(12), 29-31, 2011.

17. Unwin, T., ICT4D: Information and Communication Technologies for Development. Cambridge University Press, Cambridge, 2008.

## 12.85 HS 529: Natural Resource and Development

**Course Code: HS 529**

**Course Name: Natural Resource and Development**

L-T-P-C : 3-0-0-3
Prerequisites : None
Intended for : Post graduate students in SHSS
Distribution : Core course for M.A. in Development Studies
Approval: 16th Senate

**Course Contents**

- **Natural resources and their role in sustainable energy** [14 Lectures]
  - Introduction: Natural Resources renewable v/s non-renewable. What is renewable energy? Why do we need renewable energy? Different renewable energy sources. (3 hours)
  - Solar energy: potential of solar energy reaching earth surface, collecting sunlight, solar photovoltaic and solar thermal techniques, solar power plants, solar water desalination, solar dryers, future challenges (3 hours)
  - Wind energy: Wind energy availability and basic working principle of wind turbines, resource assessment overview, modern wind turbines, installations and wind farms, advantages and limitations of wind farms (3 hours)

- Biomass energy: Organic matters available on renewable basis like forests, agricultural, mill and industrial wastes etc., direct fired plants, co fired power plants, gasification (3 lectures)
- Limitations of renewable sources. (2 hours)

- **Sustainable Development and Pollution Prevention** [14 Lectures]
  - Natural Cycles: Water cycle, oxygen cycle, phosphorous cycle, Appreciation of disturbance in these cycles as cause of pollution. (2 lectures)
  - Water Pollution Control and Technologies: Indian potable water and treated waste water standards , Health impact of potable drinking water, sources of water pollutants for urban and rural habitats, Waste water treatment technologies (4 lectures)
  - Air Pollution Control Technologies: Gaseous and particulate emissions, Health impact, sources of gaseous pollutants for urban and rural habitats, Air pollution control technologies
  - Solid Waste Management: Case Studies on Best Practices of Domestic Solid Waste Management/ Case Studies on Electronic Waste Management Practices (4 lectures)

- **Introduction to Biodiversity and Conservation** [14 Lectures]
  - The key concepts of biodiversity, its definition, meaning and functional significance (2 lectures)
  - Conservation of natural resources - Water, Soil, Flora, Fauna, endangered species etc.; In-situ and Ex-situ conservation (2 lectures)
  - International and National conventions (2 lectures)
  - Biodiversity and Conservation for Development - Poverty alleviation (2 lectures)
  - Critical approaches to Biodiversity conservation - policy and practice (1 lecture)
  - Biodiversity Technologies for Conservation (2 lectures)
  - Selected Case studies (3 lectures)

**Textbooks:**


1. Ruth Weiner Robin Matthews, **Environmental Engineering**, 4th Edition, Elsevier, 2003.

2. Aldo V.da Rosa, **Fundamental of Renewable Energy Processes**, Elsevier Press, 2009.

3. Michael J Jeffriesby, **Biodiversity and Conservation** (Routledge Introductions to Environment series), 2nd Edition, 2006.

4. **References:**


1. Gautam, A., De, S., Dhar, A., Gupta, J.G., Pandey, A. (Eds.), **Sustainable Energy and Transportation**, Springer Singapore, 2018, ISBN 978-981-10-7508-7

2. http://worldhappiness.report/ed/2017/

3. http://www.epa.ohio.gov/ocapp/p2/sustainable.aspx#124473580-practices

4. Jahangir Hossain, Mahmud Apel, **Large Scale Renewable Power Generation: Advances in Technologies for Generation, Transmission and Storage** (Green Energy and Technology), Springer, 2014.


## 12.86 HS 530: Planning, Welfare and Development

**Course Number: HS 530**

**Course Name: Planning, Welfare and Development**

L-T-P-C : 3-0-0-3
Prerequisites : None
Intended for : Postgraduate students, 3rd and 4th Year B.Tech students (with instructors permission)
Distribution : Core course for M.A. in Development Studies, Elective for others
Approval: 16th Senate

**Course Contents**

- **Theories and Concepts** [7 Lectures]
  - Concepts and Discourse: Planning; Welfare; Development
  - History of development planning in Independent India
    * Nehruvian Era
    * Neoliberal India
- Module 2: **Planning: Strategies, Policy Formulation and Implementing Bodies** [10 Lectures]
  - Institutions: State; Market; Civil Society
  - Policy making, state and stake holders
    * Legislative practices and law making
    * New public management
  - Multi-level Planning
    * Local Bodies: PRIs and ULBs
    * Planning Commission and NITI Aayog
    * Global Regimes
- **Policy, Governance and Development** [9 Lectures]
  - Idea and Discourse of Development

    * Infrastructural development
    * Social development
    * Inclusive Development
    * Multi-level Governance
    * Local governance
    * Global governance

- Module 4: **Politics of Development: Dispute and Resolution** [9 Lectures]
  - Property
    * Property Laws
    * Customary laws
    * Public property v/s private property
    * Common property and its privatization
  - Dispute
    * Contested development
    * Judicial resolution
    * The role of local bodies in dispute resolution
- Module 5: **International agencies and development** [3 Lectures]
  - Donor Agencies: World Bank; IMF; ADB
  - Agencies that influence policies: GATT and WTO
- Module 6: **Measuring development** [4 Lectures]
  - Idea and discourse of index
  - Popular indices
  - Aspects of measurement
    * Data generation and data mining
    * Variables and classifications
    * The politics behind measurement

**Textbooks:**

None; Textbooks for this course is not suggested. Select Journal articles and book chapters will be used for the topics. Since the focus of the course is to look at various intersections of politics, economy and social structures, the readings that provide such insights will be highly useful.

**References:**

1. Darooka, Priti., Roads to Rights: Women, Social Security and Protection in India, Sage, 2016.
2. Maheswari, S.R, Local Government in India, OrientLongman, 2004.

3. Bhattacharya, Mohit., New Horizons of Public Administration, Jawahar Books, 2011.

4. Kohli, Atul., Democracy and development in India: from socialism to pro-business, Oxford University Press. pp 140-252, 2013.

5. World Bank, Perspectives on poverty in India, World Bank, 2011

6. Dreze, Jean and Amartya Sen, India: development and participation, OUP, 2014.

7. Kohli, Atul., Poverty amid plenty in the new India, Cambridge Uni Press, 2012.

8. Guha, Ramachandra and Jonathan Parry (eds.)., Institutions and inequalities: essays in honour of Andre Beteille, Oxford University Press, 2012.

9. Sen, Amartya., Development as freedom, OUP, 2014

10. Dreze, Jean and Amartya Sen, An uncertain glory: India and its contradictions, Penguin, 2013.

11. Ghertner, D. Asher., Rule by aesthetics: world-class city making in Delhi, OUP, 2015.

12. Mishra, Ramesh and John Berry, Ecology, Culture and Human Development, Sage, 2018.

13. Shanmugam, K.R. and K.S. Kavi Kumar, Environment and Development, Sage, 2016.

14. Chalam, K.S., Social Economy of Development in India, Sage, 2017.

## 12.87 HS 531: Gender and Development

**Course Code: HS 531**

**Course Name: Gender and Development**

L-T-P-C :3-0-0-3
Prerequisites :None
Intended for :Ph.D./Masters/B.Tech. (3rd and 4th Yrs)
Distribution : Discipline Elective for M.A.Development Studies, HSS Free Elective for B.Tech. and Free Elective for others
Approval: 19th Senate

**Course Contents**

- **Introduction to Development:Situating Gender** [2 Lectures]
  - Gender, development, locating women in development, empowerment
- **Theoretical Approaches** [15 Lectures]
  - Sex and gender
  - Feminist theories, feminism in India

- lntersectionality
- Women In Development (WID): advancement ofwomen by means of development
- Women and Development (WAD): women's inclusion in development
- Gender and Development (GAD) : gender and development, relations between and role of patriarchy and capitalism
- Empowerment

- **Gender, Labour, Education** [6 Lectures]
  - Causes and consequences of gender gaps
  - Broadening the definitions of work, inclusion of domestic sphere and sexual division of labour
  - Globalisation and effects on women
  - Role ofNGOs and self help groups
  - Access to education

- **Gender, H ealth, Reproductive Rights** [6 Lectures]
  - Differences in health needs, access to health facilities
  - Gendered nature of epidemic
  - Decision making about fertility
  - Abortion laws, discussions and legislation

- **Gender, Environment, Sustainable Development** [5 Lectures]
  - Ecosystems, environment and women: interdependencies
  - Ecofeminism

- **Women and Security** [5 Lectures]
  - Violence against women: causes and consequences

- **Gender and State** [3 Lectures]
  - Decision making in public policy: women, state actors and global agencies

**Textbooks:**

1. Visvanathan, Nalini, Lynn Duggan, Nan Wiegersma and Laurie Nisonoff (eds.)., The Women, Gender and Development Reader, Second Edition, Zed Books, 2011.

**References:**


1. Beneria, L. and S. Feldman (eds.), Unequal Burden, Economic Crisis, Persistent Poverty, and Women's Work, Westview Press, 1992.

2. Bouta, Tsjeard, Georg Frerks and Ian Bannon, Gender, Conflict, and Development, World Bank, 2005.

3. Braidotti, R., E. Charkiewicz, S. Hausler and S. Wieringa, Women, Environment and Sustainable Development: Towards a Theoretical Synthesis, Zed Books, 1994.

4. Cornwall, A. and A. Welboum, A (eds)., Realizing Rights: Transforming Approaches to Sexual and Reproductive Wellbeing. London: Zed Books, 2002.

5. Cornwall, A., E. Harrison, and A. Whitehead (eds.). Feminisms in Development: Contradictions, Contestations and Challenges, Zed Books, 2007.

6. Elson, D. (ed.)., Male Bias in the Development Process, 2nd Edition, Manchester University Press, 1995.

7. Harcourt, W. (ed.), Women Reclaiming Sustainable Livelihoods: Lost Spaces, Spaces Gained, Palgrave Macmillan, 2012.

8. Henshall-Momsen, J., Gender and Development, Routledge, 2004.

9. Jain, Devaki., Women, Development, and the UN: A Sixty-year Quest for Equality and Justice, Indiana Press, 2005.

10. Jeffery, R. and A.M. Basu (eds)., Girls' Schooling, Women's Autonomy and Fertility Change in South Asia, Sage, 1996.


## 12.88 HS 532: Sustainable Development and Environmental Protection

**Course Code: HS 532**

**Course Name: Sustainable Development and Environmental Protection**

L-T-P-C : 3-0-0-3
Prerequisites : None
Intended for : Post graduate students, 3rd and 4th Year B.Tech students (with instructors permission)
Distribution : Core course for M.A. in Development Studies, Elective for others
Approval: 16th Senate

**Course Contents**

- **Precursors of sustainable development** [8 Lectures]
  - Limits to Growth (1972); Stockholm Conference on Environment and Development (1972); Earth Summit/ Rio Conference (1989); World Conservation Strategy (1990)

- World Commission on Environment and Development (1997): Our Common Future
- Debates and intellectual underpinnings: Basic Needs Approach, Entitlement Analyses, Human Development; Capabilities Approach

- **Measuring Sustainable Development** [12 Lectures]
  - Measuring well-being; Policy based indicators and Capital based indicators: Financial capital, Produced Capital, Human Capital, Natural Capital and Social Capital; Human Development Index, World Development Index, Inclusive Wealth Index.
  - From Millennium Development Goals to Sustainable Development Goals
  - System of National Accounts (SNA) and System of Environmental and Economic Accounts (SEEA)
  - The role of discounting

- **Exploring the agenda for sustainable development** [12 Lectures]
  - Inclusive growth, poverty eradication and sustainable livelihoods
  - Access to education and health
  - Environment: Energy, Forest and Water resources
  - Sustainable city and urban common
  - Climate Change

- **Environmental Protection in Indian Himalayan Region** [10 Lectures]
  - National Mission on Sustainable Himalayan Ecosystem
  - Vulnerability, exposure and risk assessment of Indian Himalayan Regions

**Textbooks:**

1. Sachs, D. Jeffrey, The Age of Sustainable Development, Columbia University Press, 2015.

**References:**

1. Rogers, P. P., Jalal, K. F., Boyd, J. A., An Introduction to Sustainable Development, Earthscan, 2012.
2. Office of the Resident Coordinator of India, United Nations, 2016, Sustainable Development Goals: A Handbook.
3. Original reports pertaining to the Stockholm Declaration on the Human Environment,World Conservation Strategy, The Brundtland Report and Agenda 21
4. https://sustainabledevelopment.un.org/memberstates/india
5. Selected journal articles

### 12.89 HS 533: Urban Development

**Course Code: HS 533**

**Course Name: Urban Development**

L-T-P-C : 3-0-0-3

Prerequisites : None

Intended for : Post graduate students, 3rd and 4th Year B.Tech students (with instructors permission

Distribution : Elective course for M.A. in Development Studies, Elective for others

Approval: 16th Senate

**Course Contents**

- **Making Sense of Urban** [8 Lectures]
  - Understanding Urbanisation and Urbanism
  - Official Definition and Categorisation of Cities in India
  - Trends, Debates, and Trajectories of Urbanisation in India
  - Urban Migration and Patterns of Migration
- **The City as an Object of Study** [12 Lectures]
  - The Chicago School (Louis Wirth, Robert Park, Ernest Burgess)
  - New Urban Sociology (Manuel Castells, David Harvey and debates with early urban sociology)
  - Cities in the World System: Global Cities (Saskia Sassen) and Spaces of Flows (Manuel Castells)
  - The Stranger and the City (George Simmel, Ash Amin)
  - Thinking about the city (Davis, Henri Lefebvre, Michel de Certeau, Jane Jacobs)
  - Ideas on City: World-class City; Mega City; Global City; Ordinary City, Small Cities
- **Urban Planning** [10 Lectures]
  - Origins and Paradigms of Urban Planning in India
  - Colonial Capital Cities such as Delhi and Calcutta Colonial Port Cities: Bombay and Madras
  - Planned Cities such as Chandigarh and Bhubaneswar
  - Company Industrial Towns such as Jamshedpur and Bhilai
  - Emerging Megacities such as Bengaluru and Hyderabad
  - Politics of Land and Infrastructure;
  - Growth of Real Estate Failure and Paradox of Planning in India
- **Informal City** [6 Lectures]

- Informal Sector: Concept, Prevalence, Livelihoods and Settlements
- Public Spaces and Contestations
- Logics of Segregation, Resident Welfare Associations, Gated Communities
- Urban Poverty
- Slums

• **Governing the Indian City** [6 Lectures]

  - Political Economy of Basic Services Provision and Infrastructure
  - Urban Decentralisation/Municipal Arrangement
  - Urban Policy Paradigms
  - Urban Commons
  - Small Town Governance and Subaltern Urbanisation
  - Smart City

**Textbooks: None**

1. UGC-INFLIBNET e-Pathshala course Sociology of Urban Transformations is recommended. Select Journal Articles and book chapters.

**References:**

1. Abu-Lughod, J. L. & R. Hay, eds. (1979). Third World Urbanization. New York; London, Methuen.

2. Davis, M. (2006). Planet of slums. London; New York, Verso.

3. Bunnell, Tim, and Anant Maringanti. 2010. Practising Urban and Regional Research beyond Metrocentricity. International Journal of Urban and Regional Research 34 (2): 41520.

4. Castells, Manuel. The rise of the network society: The information age: Economy, society, and culture. Vol. 1. New York: Wiley-Blackwell, 1996.

5. Amin, Ash, and Stephen Graham. The ordinary city. Transactions of the Institute of British Geographers 22, no. 4 (1997): 411-429.

6. Maringanti, Anant. Ordinary entanglements in the world city.Environment and Planning A 45, no. 10 (2013): 2314-2317.

7. Raymond Williams, Culture and Society: 1780-1950 (Garden City, New York: Anchor Books, 1960)

8. Roy, Ananya. 2009. The 21st-Century Metropolis: New Geographies of Theory. Regional Studies 43 (6): 81930.

9. Frank, Andre Gunder. The development of underdevelopment. Boston, MA: New England Free Press, 1966.

10. Friedmann, John. The world city hypothesis. Development and change 17, no. 1 (1986): 69-83.

11. Harvey, David. The condition of postmodernity: An enquiry into the conditions of cultural change. New York: Wiley, 1992.

12. Sassen, Saskia. The Global City: New York, London, Tokyo. Princeton, NJ: Princeton University Press, 1991.

13. Gooptu, N. (2001). The Politics of the Urban Poor in Early Twentieth-Century India. Cambridge, Cambridge University Press.

14. Ramsamy, E. (2006). The World Bank and urban development: from projects to policy. London, Routledge.

15. Beall, J. and Fox, S. (2009) Cities and Development. Abingdon, Routledge.

## 12.90 HS 534: Economics of Climate Change

**Course Code: HS 534**

**Course Name: Economics of Climate Change**

L-T-P-C : 3-0-0-3
Prerequisites : HS202 or equivalent course
Intended for : Postgraduate Students, Undergraduate (3rd and 4th year)
Elective or Compulsory : Discipline Elective for M.A. in Development Studies, elective for the rest
Approval: 16th Senate

**Course Contents**

- **Economic foundation** [10 Lectures]
  - Externality and market failure;
  - Public goods, private goods and common property resources;
  - Social and private costs and benefits;
  - Climate change as a case of transboundary negative externality?; 1.5 degree climate goal.
  - Brief introduction of game theory and its application in climate change.
- **Mitigation policies theory and practice** [12 Lectures]
  - Command and control, fiscal policy instruments, market based policy instruments; carbon tax or carbon credit?
  - Design of national policies National Action Plan on Climate Change (NAPCC) in India,
  - European Union Emission Trading Scheme (EU-ETS), Unites States Cap-and-Trade programme;

- Role of international cooperation: from Kyoto Protocol (Joint Implementation, Clean Development Mechanism, and Emission Trading) to Paris Agreement (Nationally Determined Contribution (NDC)).

- **Climate change adaptation** [12 Lectures]
  - Defining vulnerability to climate change; role of adaptation;
  - Cost and benefit of adaptation;
  - Barriers and limits to adaptation.
  - Case studies on adaption in practice in developed and developing counties;
- **Climate change adaptation and mitigation in Himalayan region** [8 Lectures]
  - Review of National Mission for Sustaining the Himalayan Ecosystem under NAPCC.
  - Selected case studies on the impact of climate change, mitigation opportunities and adaptation strategies in the Himalayan region.

**Textbooks:**

1. Stern, N., **The Economics of Climate Change: The Stern Review**, Cambridge University Press, 2006.

**References:**

1. Relevant section of Assessment Reports from Intergovernmental Panel on Climate Change
2. Relevant documents of United Nations Framework Convention on Climate Change
3. Contemporary articles published in relevant journals

## 12.91 HS 535: Financial Inclusion in India

**Course Code: HS 535**

**Course Name: Financial Inclusion in India**

L-T-P-C:: 3-0-0-3
Prerequisites : None
Intended for : Ph.D./Masters/B.Tech. (3rd and 4th year)
Distribution : Discipline Elective for M.A. Development Studies, HSS Free Elective for B. Tech. and Free Elective for others
Approval: 23rd Senate

**Course Contents**

- **Introduction Financial Inclusion** Introduction of Indian financial system, evolution, growth and developments in the Indian financial system over the years. Meaning and scope of financial inclusion, breadth and depth of financial inclusion in India, Economic and social causes of financial exclusion, Financial inclusion Indices, Status of financial inclusion in India, Barriers to financial inclusion in India. [6 Lectures]

- **Demand Side Issues** Nature and characteristics of clientele, economic status of rural folks, need for tailor made products and services: savings, investments, micro credit, micro insurance, remittances, pension, etc. Client vulnerability and credit risks, women empowerment, livelihood creation. [9 Lectures]

- **Supply Side Issues** Informal and formal sources of finance, Transaction cost, Institutional interventions: Microfinance institutions, Joint liability groups, Self Help Groups, Branchless banking models, Collateral issues, Business correspondent model of banking, Issues relating to interoperability, Convergence of digital identity and financial services, Impact on poverty reduction and employment generation. [9 Lectures]

- **Emerging Trends and Innovations** Recent Trends and Innovations: Mobile banking, Digital Identity Aadhaar, Innovations in Fintech, International case studies: Kenya and M-Pesa, Philippines and smart money, Bangladesh and bKash, and/or similar case studies. [10 Lectures]

- **Challenges for Future** Inclusive growth: Scaling financial inclusion Role of banks, Jan-dhan yojna trends & progress, non-banking finance companies, and technology, Rural Banking Infrastructure, Institutional changes required for financial inclusion, Client Trust, Financial Literacy, Financial Awareness, Privacy and Security concerns. [8 Lectures]

**Textbooks:**

1. Mani, N. (2015). Financial Inclusion in India: policies and Programmes. New Century Publications.

**References:**

1. Barua, A., Kathuria, R., & Malik, N. (2016). The Status of Financial Inclusion, Regulation, and Education in India. ADBI Working Paper Series, (568), 124. https://doi.org/10.1017/S0020818300006032

2. CRISIL. (2018). CRISIL Inclusix: Financial inclusion surges, driven by Jan-Dhan Yojana (Vol. 4). Retrieved from https://www.crisil.com/content/dam/crisil/our-analysis/reports/Research/documents/2018/march/crisil-inclusix-financial-inclusion-surges-driven-by-Jan-Dhan-yojana.pdf

3. Deepak Mohanty. (2015). Report of the Committee on Medium-term Path on Financial Inclusion.

4. Garcia Arebehety, P., Chen, G., Cook, W., & McKay, C. (2016). Digital Finance Interoperability & Financial Inclusion. Cgap, (December), 16. Retrieved from http://www.cgap.org/publications/digital-finance-interoperability-financial-inclusion

5. Gardeva, A., & Rhyne, E. (2011). Opportunities and Obstacles to Financial Inclusion.

6. Retrieved from https://centerforfinancialinclusionblog.files.wordpress.com/2011/07/opportunities and-obstacles-to-financial-nclusion_110708_final.pdf

7. Gupta, S. K. (2011). Financial Inclusion - IT as enabler. Reserve Bank of India Occasional Papers, 32(2).

8. Holloway, K., Naizi, Z., & Rouse, R. (2017). Women s Economic Empowerment Through Financial Inclusion A Review of Existing Evidence and Remaining Knowledge Gaps. (March).

9. Karmakar, K. G., Banerjee, G. D., Mohapatra, N. P. (2011). Towards Financial Inclusion in India. Sage Publications

10. Ngweno, A., Oldja, L., Hassan, M. and, & Kapoor, P. (2018). Demand-side review of Financial Inclusion for Women in entrepreneurship and smallholder agriculture. International Development Research Centre. Retrieved from www.idrc.ca

11. Pradhan, N. C. (2013). Persistence of Informal Credit in Rural India: Evidence from All-India Debt and Investment Survey and Beyond. RBI Working Paper, 123.

12. Realini, C., & Mehta, K. (2015). Financial Inclusion at the Bottom of the Pyramid. Friesen Press.

13. Sriram, M.S. (2017). Talking Financial Inclusion in Liberalised India: Conversations with Governors of The Reserve Bank of India. Routledge.

14. Singh, A. S., Venkataramani, B., & Ambarkhane, D. (2014). Role of Mobile Banking in Financial Inclusion. SSRN Electronic Journal, (February). https://doi.org/10.2139/ssrn.248577

15. Singh, C., & Naik, G. (2017). Financial Inclusion in India: A Case Study of Gubbi. SSRN Electronic Journal, (May), 169. https://doi.org/10.2139/ssrn.2973741

16. Sethy, S.K. (2017). Financial Inclusion An Overview: A Road Map For Inclusive Growth. Bharti Publications.

17. Ujjawal, A., Champatiray, A. K., Sadhu, S., & Mendiratta, T. (2012). Business Correspondent Model: An Analysis of the Financial Viability of Customer Service Providers and Client Satisfaction.

18. World Bank. 2014. Global Financial Development Report 2014 : Financial Inclusion. Washington, DC. World Bank. https://openknowledge.worldbank.org/handle/10986/16238 License: CC BY 3.0 IGO

## 12.92 HS 536: Social Movements in India

**Course Code: HS 536**

**Course Name: Social Movements in India**

L-T-P-C: 3-0-0-3
Prerequisites: Nil
Intended for: UG/PG
Distribution: HS Course
Approval: 9th Senate

**Course Contents**

- **Concepts and Context** [6 Lectures]
  - Protest and Social Change
  - Mobilization and Institutionalization
  - Issues in the Analysis of Social Movements
- **Social Movements in Independent India** [24 Lectures]
  - Peasant movements
  - Tribal Movements
  - Feminist Movement
  - Dalit Movement
  - Backward Caste movements
  - Maoist/Naxalite movement
  - Separate Statehood movements
  - Human rights and Environmental Movements
  - Students movements
- **Theoretical Issues and Perspectives** [6 Lectures]
  - Nine Theses on Social Movements
  - Social Movements and State Response
  - Sources of Deprivation and Styles of Protest

**Reading Material & References:**

1. Dhanagare, D & John, J, **Cyclical Movement towards the Eternal Nine Theses on Social Movements: A Critique**, Economic and Political Weekly, Volume 23(21), Pp. 1089-1092, 1988.

2. Dhanagare, D., **Peasant Movements in India**, Oxford University Press, 1998.

3. Frank, Andre Gunder & Marta Fuentes, **Nine Theses on Social Movements**, Economic and Political Weekly, 32(35), Pp. 1503-1510, 1987.

4. Gurr, T. R., **Why Men Rebel**, Princeton University Press, 1970.

5. Jones, W. Kenneth., **Socio-religious Reform Movements in British India**, Cambridge University Press, 2008.

6. Oommen, T K., **Sociological Issues in the Analysis of Social Movements in Independent India**, Sociological Bulletin, 26(1), 1977.

7. Oommen, T K., **Protest and Change: Studies in Social Movements**, Sage Publications, 1990.

8. Oommen, T K., (Ed.,), **Social Movements: Issues of Identity**, Oxford University Press, 2010.

9. Rao, MSA. (Ed.,), **Social Movements in India**, Volume I, Manohar Publishers, 1979.

10. Shah, Ghanshyam., **Social Movements in India: A Review of Literature**, Sage Publications, 2004.

11. Shah, Ghanshyam (Ed.,), **Social Movements and the State**, Sage Publications, 2001. (Readings in Indian Government and Politics)

## 12.93 HS 537: Post-Reform India: Polity, Society and Economy

**Course Code: HS 537**

**Course Name: Post-Reform India: Polity, Society and Economy**

L-T-P-C: 3-0-0-3
Prerequisites: None
Intended for: Ph.D./Masters/ B. Tech. (3rd and 4th Year)
Distribution: Discipline Elective for M.A. Development Studies, HSS Free Elective for B.Tech. and Free Elective for others
Approval: 23rd Senate

**Course Contents**

- **Before and After the 1990** [10 Lectures]
  - Market: Structural Adjustment Program and economic liberalisation
  - Mandir-Masjid: Hindutva movement and idea of secular? State
  - Mandal: Other Backward Classes and politics of/over reservation
  - Media: Expansion and deepening of media
  - Mobilisation: Politics and assertions
- **State, Governance and Management of Development** [10 Lectures]
  - Paradox of Development: India vs. Bharat
  - Policies and politics of governance
  - Bureaucracy and Governmentality

- International Conventions and new legal mechanisms

- **Nature of Conflicts** [8 Lectures]
  - Sectarian conflicts and Ethnic Violence
  - Reconfiguration of histories
  - Old and New contestant: NRIs and Indian Middle Class
  - Conflict over Development: unions, projects, acquisition and beneficiaries

- **Legal Frameworks and Development Goals** [8 Lectures]
  - Environment and ecology: international conventions and national policies
  - Right to Education: from NEP to RTE
  - Employment: as guarantee; contractual jobs and entrepreneurship
  - Women's Health, Security and Development

- **Arenas of empowerment and enfeeblement** (6 hours)
  - Instruments, Institutions and National Commissions
  - Vocabularies and Dimensions of: inequalities, discriminations, deprivations
  - Assessing ideas of Democracy, Citizenship and Mobilities in post-reform period

**Textbooks:**


1. 1. John, Mary M, Praveen Kumar Jha and Surinder Singh Jodhka (eds.). 2006. Contested Transformations: Changing Economies and Identities in Contemporary India. New Delhi: Tulika Books.

2. 2. Ruparelia, Sanjay et. al. 2011. Understanding Indias New Political Economy: A Great Transformation?. London: Routledge.

3. 3. Corbridge, Stuart, John Harris and Craig Jeffrey (2012). India Today: Economy, Politics and Society. Cambridge: Polity Press.


**References:**


1. Thapar, Romila (ed.). 2000. India: Another Millennium. Delhi: Penguin

2. Deshpande, Satish. 2004. Contemporary India: A Sociological View. Delhi: Penguin

3. Gupta, Akhil and K. Sivaramakrishnan (eds.). 2012. The State in India after Liberalization. New York: Routledge

4. Reddy, Ram Manohar. How is India Doing. Guhan Memorial Lecture

5. Dreze, Jean and Amartya Sen. 1995. India: economic development and social opportunity. New Delhi: Oxford University Press

6. Corbridge, Stuart and John Harriss. 2000. Reinventing India: liberalization, Hindu nationalism and popular democracy. Cambridge: Polity Press

7. Bhargava, Rajiv. 2013. Reimagining Secularism: respect, domination and principled distance. Economic and Political Weekly. Pp 79-92

8. Ram, Nandu (ed.). 2008. Dalits in contemporary India: discrimination and discontent. New Delhi: Siddhant Publications. pp 37-64

9. Kohli, Atul. 2009. Democracy and Development in India: From Socialism to Pro-Business. New Delhi: Oxford University Press

10. Jaffrelot, Christophe. 2000. 'The rise of the other backward classes in the Hindi belt'. The Journal of Asian Studies, Vol. 59(1):86-108

11. Saeed, Saima (2013) Screening the Public Sphere: Media and Democracy in India, New Delhi: Routledge.

12. Ganguly-Scrase, R and T.J. Scrase (2009) Globalization and the Middle Classes in India: The Social and Cultural Impacts of Neo-liberal Reforms, London: Routledge

13. Aslany, M. (2019) The Indian Middle Class, its Size, and Urban-Rural Variations, Contemporary South Asia, Vol. 27 (2), pp.196-213.

14. Sharma, Aradhana (2006) Crossbreeding Institutions, Breeding Struggle: Women's Empowerment, Neoliberal Governmentality, and State (Re)Formation in India, Cultural Anthropology, Vol.21 (1), pp.60-95.

15. Sharma, Aradhana (2008) Logics of Empowerment: Development, Gender and Governance in Neoliberal India, Minneapolis: University of Minnesota Press.

16. Levien, M. (2018) Dispossession without Development: Land Grabs in Neoliberal India, New Delhi: Oxford University Press.

17. Nielsen, Kenneth and Alf G. Nilsen (2016) Social Movements and the State in India: Deepening Democracy? London: Palgrave.

18. Gupta, Akhil (2012) Red Tape: Bureaucracy, Structural Violence and Poverty in India, Hyderabad: orient Blackswan.

19. Sahu, Geetanjoy (2014) Environmental Jurisprudence and the Supreme Court: Litigation, Interpretation, Implementation, Hyderabad: Orient Blackswan.

20. Muenster, Daniel and Christian Struempell (2013) The Anthropology of Neoliberal India: An Introduction, Contributions to Indian Sociology (Special Issue), Vol.48 (1), December, pp.1-16

21. Dreze, Jean and Amartya Sen. 2013. An Uncertain Glory: India and its Contradictions. New Jersey: Princeton University Press.

22. Kohli, Atul. 2012. Poverty amid Plenty in the New India: Politics, Economics and Inequality. Cambridge: Cambridge University Press.

## 12.94 HS 538: Development Economics

**Course Code: HS 538**

**Course Name: Development Economics**

L-T-P-C: 3-0-0-3
Prerequisites: None
Students intended for: Ph.D/Masters/B.Tech. (3rd and 4th year)
Elective or Compulsory: Discipline Elective for M.A. Development Studies, HSS Free Elective for B. Tech. and Free Elective for others
Approval: 23rd Senate

**Course Contents**

- Module I: **Introduction** Distinction between growth and development; Paradigms of development; Development indicators to sustainable development indicators and comparison of countries with respect to sustainable development indicators; a brief journey from growth economics to sustainable development. [3 Lectures]
- Module II: **Theories of Economic Growth and Development** Historical legacies, economic growth and development: A brief overview of Adam Smiths Theory, Richardian Theory, Malthusian Theory, Mills Theory, Classical, Marxian and Schumpeterian theories of economic development, Stages of Growth: Rostow and Marx; The Big-push Theory; Critical Minimum Effort; Low Level Equilibrium Trap; Lewis and Ranis Fei models of economic development, Harrod-Domar model; Kaldor model of growth; Model of Capital Accumulation; Nurkses theory of disguised unemployment as a saving potential; Neoclassical growth models: Solow-Swan Model (problem of dynamic inefficiency), steady state equilibrium, transitional dynamics; Ramsey-Cass-Koopsman (infinite horizon optimal growth framework); Samuelson-Diamond model (overlapping generations framework); Technological progress and total factor productivity growth; Introduction to sustainable development models, approaches and operational principles of sustainable development. [18 Lectures]
- Module III: **Issues of Development** Poverty and Inequality; Demography; Migration; Human Capital and Economic Development; Sectoral development; Trade and development; Foreign investment, Aid, and Conflict. [15 Lectures]
- Module IV: **Concepts and Tools in use for Developmental Project Evaluation** Project evaluation and cost benefit analysis; concepts of investment and cost benefit analysis for environmental projects; Input-Output Table; Investment criteria in economic development, concept of Capital-Output Ratio; Shadow prices; Introduction to model estimation. [6 Lectures]

**Textbooks:**


1. Todaro, Michael P. and Stephen C. Smith, **Economic Development**, Pearson Education, 2015.

2. Thirlwall, A.P., **Growth and Development**, Palgrave McMillan, 2011.

**References:**


1. Meier, Gerald M. and James E. Rauch, **Leading issues in Economic Development**, Oxford University Press, 2005.

2. Ray, D., **Development Economics**, Oxford University Press, 1998.

3. Lipsey, R. G. and K. A. Chrystal, **Economics**, Oxford University Press, 2007.

4. Basu, K. **Analytical Development Economics: The Less Developed Economy Revisited**, Oxford University Press, 2003.

5. Sachs, J., **The Age of Sustainable Development**, Chapter 14: Sustainable Development Goals. Columbia University Press, 2015.

6. Hanley, N., Shogren, F and White, B., **Environmental Economics: In Theory and Practice**, Chapter 14: The Economics of Sustainable Development, Macmillan, 2008.


## 12.95 HS 539: Post-War Germany: Politics, Society, and Culture

**Course Code: HS 539**

**Course Name: Post-War Germany: Politics, Society, and Culture**

L-T-P-C : 3-0-0-3
Prerequisites : None
Intended for : Ph.D./Masters/B.Tech. (3rd and 4th year)
Distribution : HSS Free Elective
Approval: 23rd Senate

**Course Contents**

- **Module I** [2 Lectures]
  - This module provides the students with a background on the events leading up to the Second World War, briefly outlining topics like the First World War, Weimar Republic, and National Socialism among others.
- Module II: **Allied Occupation of Germany** [4 Lectures]
  - Zero hour/Stunde Null
  - Denazification
  - Four occupation zones
- Module III: **Germany-US relations** [2 Lectures]
  - Bizone/Trizone
  - Berlin Blockade
  - European Recovery Program/Marshall Plan

- Module IV: **GDR and FRG** [12 Lectures]
  - Formation of GDR and FRG
  - Comparison of political and economic systems. Basic Law
  - Democratisation of education
  - NATO and Warsaw Pact
  - Adenauer era
  - Brandts Ostpolitik
- Module V: **Anti Government Protests** [2 Lectures]
  - East German uprising
  - Students movement
  - Green movement (anti-nuclear movement, environmentalism)
- Module VI: **Migrants in Germany** [4 Lectures]
  - Gastarbeiter/Guest Worker
  - Debate over Multiculturalism
  - Current migrant crisis
  - Emergence of far-right parties like AfD
- Module VII: **The reunification of Germany** [2 Lectures]
  - Fall of the Berlin Wall
  - Reunification
  - Problems in the process of internal integration
- Module VIII: **Post-War German Cinema/Literature** [6 Lectures]
  - The students will engage with selected works of German literature/cinema, which will offer them a historical as well as a cultural perspective of the German society as it existed during the postwar period. It will include dealing with themes like Heimat (homeland), Vergangenheitsbewltigung (coming to terms with the past), and Wende (turn).
- Module IX: **European Union as it exists today** [8 Lectures]
  - European Integration (ECSC, EEC)
  - Expansion of the EU (1993 today)
  - Germanys role within the EU
  - Euroscepticism
  - Brexit

**Textbooks:**

1. Judt, Tony, **Postwar: A History of Europe since 1945**, Penguin Press, 2005.

2. Staab, Andreas, **The European Union Explained: Institutions, Actors, Global Impact, Bloomington**, Indiana University Press, 2008.

**Reference:**


1. Braunthal, G, Right-Wing Extremism in Contemporary Germany, Palgrave Macmillan UK, 2009

2. Childs, David, The Fall of the GDR: Germany's Road To Unity, Longman, 2001

3. Dennis, Mike, The Rise and Fall of the German Democratic Republic 1945-1990, London: Routledge, 2000

4. Dinan, Desmond: Europe Recast: A History of European Union, Boulder, Lynne Rienner Publishers, 2014

5. Fulbrook, Mary, A History of Germany 1918-2014: The Divided Nation, Wiley-Blackwell 2014

6. Gilbert, Mark: European Integration: A concise History, Rowman & Littlefield, 2012

7. Gktrk, Deniz, David Gramling and Anton Kaes (eds.), Germany in Transit: Nation and Migration, 1955-2005, California: University of California Press, 2007

8. Hofmann, Arne, The Emergence of Dtente in Europe: Brandt, Kennedy and the Formation of Ostpolitik, London, New York: Routledge: 2007.

9. Jones, Erik, Anand Menon and Stephen Weatherill (eds.): The Oxford Handbook of the European Union, Oxford, Oxford University Press, 2012

10. Kitchen, Martin: A History of Modern Germany 1800-2000, Malden, Blackwell, 2006

11. Maier, C.S. and G. Bischof (eds.) The Marshall Plan and Germany: West German Development within the Framework of the European Recovery Programme, Oxford: Berg, 1991.

12. McCormick, John: Understanding the European Union, New York, Palgrave, 2008

13. Mller, Jan-Werner (ed.): German ideologies since 1945; studies in the political thought and culture of the Bonn republic, New York 2003

14. Pulzer, Peter: German Politics 1945-1995, New York, Oxford University Press, 1996

15. Smith, Helmut Walser (ed.): The Oxford Handbook of Modern German History, Oxford, 2011

16. Vorlnder, Hans, Maik Herold, Steven Schller, PEGIDA and New Right-Wing Populism in Germany, Palgrave Macmillan, 2018.

17. Warleigh-Lack, Alex: European Union: The Basics, London, Routledge, 2008

18. Wilhelm, Cornelia (ed), Migration, Memory and Diversity: From 1945 to the Present, New York: Berghahn Books, 2016.

## 12.96 HS 541: Technical Communication

**Course Code: HS 541**

**Course Name: Technical Communication**

L-T-P-C: 1-0-0-1
Prerequisites: None
Students intended for: M.S/M.Tech/Ph.D/M.Sc
Elective or Compulsory: Elective/Core
Approval: 12th Senate

### Course Contents

- Review of appropriate and correct use of articles, adjectives and adverbs, active and passive voices, affirmative sentences, sentences with positive and negative connotations and presentation styles. Examples and class exercise [3 Lectures]
- Poster preparation and presentation in conferences [2 Lectures]
- Research article for conference and journal and slides for their presentations [4 Lectures]
- Thesis and/or book [3 Lectures]
- Job interviews [2 Lectures]

### References

1. Perelman, Leslie C., and Edward Barrett., **The Mayfield Handbook of Scientific and Technical Writing**, McGraw-Hill, 2003.

### General Resources

1. Carson, Rachel., **The Obligation to Endur**e, chapter 2 in Silent Spring. 104th anniversary ed. New York, NY: Mariner Books, 2002.

2. Day, Robert A., and Barbara Gastel., **How to Write and Publish a Scientific Paper**, 6th Edition, Greenwood Press, 2006.

3. **Scientific English: A Guide for Scientists and Other Professionals**, 2nd Edition, Oryx Press, 1995.

4. Hacker, Diana., **A Pocket Style Manual**, 4th spiral Edition, Bedford/St. Martin's, 1999.

5. Jackson, Ian C., **Honor in Science: Sigma Xi**, The Scientific Research Society, 1992.

6. Klotz, Irving M., **Diamond Dealers and Feather Merchants: Tales from the Sciences**, Birkhauser, 1986.

## 12.97 HS 542 : Ethnicity, State, and Nationalism in India

**Course Code: HS 542**

**Course Name : Ethnicity, State, and Nationalism in India**

L-T-P-C : 3-0-0-3
Intended for : UG/PG
Prerequisite : None
Mutual Exclusion : None
Approval: 45th BoA

**Course Contents:**

- **Module 1: Basic Concepts** (4 hours)
  - State
  - Nation
  - Nationalism
  - Ethnicity
- **Module 2: Theories of ethnicity** (12 hours)
  - Ethnicity, State and Nation
  - Civic and Ethnic nationalism
  - Approaches to understand ethnicity-
  - Structure-functional
  - Weberian
  - Marxist and Neo-Marxist,
  - Primordialist/Instrumentalist,
  - Postmodernist and Social Constructionist
- **Module 3: Theoretical Approaches to Nation and Nationalisms** (10 hours)
  - Growth of nation-state in Europe
  - Nation, Modernity and Capitalism
  - Nationalist awakening in Colonial India
  - Ideas of Nationalism in post-colonial India
  - Post-Nationalism
- **Module 4: Ethnicity and sub-nationalism** (8 hours)
  - Ethnic Minorities and the state in India
  - Ethnicity and ethnic violence

  - Ethnic violence, Minorities and Women
  - Ethnic conflict in North-east India: ethno-territoriality, conflicts, and movements for self-determination

- **Module 5: Managing Diversity in India** (8 hours)
  - Integration and Assimilation
  - Issues of pluralism, multiculturalism,
  - Ethnic identity, Identity claims and Ethnic resurgence
  - State's effort in managing difference and its consequences

**Laboratory/practical/tutorial Modules:**

None

**Textbooks:**


1. Baruah, Sanjib., **Beyond Counterinsurgency: Breaking the Impasse in Northeast India**, Oxford University Press, 2009.

2. Brubaker, Roger, **Ethnicity without Groups**, Harvard University Press, 2010.


**References:**


1. Chatterjee, Partha., **Nationalist Thought and the Colonial World: A Derivative Discourse**, Zed Books., 1986.

2. Chatterjee, Partha., **Nation and its fragments: Colonial and Postcolonial Histories**, Princeton University Press, 1993.

3. Gellner, Ernest., **Nations and Nationalism**, Cornell University Press, 1983.

4. Hutchinson, John and Anthony D. Smith (eds)., **Ethnicity**, Oxford University Press, 1996.

5. Hutchinson, John and Anthony D. Smith (eds)., **Nationalism**, Oxford University Press, 1994.

6. Jayal, Niraja Gopal., **Representing India: Ethnic Diversity and the Governance of Public Institutions**, Palgrave Macmillan, 2006.

7. Mann, Michael., **The dark side of Democracy: Explaining Ethnic Cleansing**, Cambridge University Press, 1995.

8. Phadnis, Urmila and Rajat Ganguly., **Ethnicity and nation-building in South Asia**, Sage, 1991.

9. Shneiderman, Sara., **Rituals of Ethnicity: Thangmi Identities between Nepal and India**, University of Pennsylvania Press, 2015.

10. Anderson, Benedict., **Imagined Communities: Reflections on the Origin and Spread of Nationalism**, Verso, 1991.

*Note: Any other text/Article suggested by the subject teacher from the list of reference listed below.

**The course will try to complement theoretical readings with some documentaries and films on the subject.

## 12.98 HS 543: Epidemics in World History: From the Black Death to COVID-19

**Course Code: HS 543**

**Course Name: Epidemics in World History: From the Black Death to COVID-19**

L-T-P-C: : 3-0-0-3
Intended for : B.Tech/M.A./Ph.D.
Prerequisite : Nil
Mutual Exclusion : Nil
Approval: 44th BoA

**Course Contents**

- **Introduction: Medicine, Disease and World History** [3 Lectures]
  - Basic features of world history vs. area studies
  - Benefits of placing medicine and disease within a world history framework
  - Evolution of medicine and understanding of disease across time and space
  - Emergence of modern scientific medicine
- **Medieval Pandemics: Leprosy and The Black Death** [6 Lectures]
  - Prevalence and treatment of leprosy in the middle ages
  - The persecuted leper in medieval Europe: myth or reality?
  - Global trading links in the 14th Century and the spread of the Black Death
  - Medieval responses to the plague
- **Epidemics and Conquest: Smallpox and Syphilis in the Americas** [4 Lectures]
  - The Columbian Exchange
  - Role of smallpox in the Conquest of the Americas
  - Syphilis: the Columbian Theory
  - Spread of syphilis and impact on society
- **Epidemics and Literature: Shakespeare in Quarantine, Tuberculosis in the Romantic Era** [6 Lectures]
  - Plague in 17th Century England and its effect on theaters
  - Representation of plague in Shakespeares plays (Romeo and Juliet, Othello, King Lear)

  - Industrialization and tuberculosis
  - Consumption and Romantic Literature
- **Diseases and Colonialism: Cholera and Plague in India, Yellow Fever in Africa and Haiti, Malaria in Africa** [6 Lectures]
  - Role of yellow fever in the Haitian revolution
  - The disease barrier of Africa
  - Malaria, quinine prophylaxis and the scramble for Africa
  - The science of bacteriology in the 19th Century
  - British colonial policies and the spread of cholera in India
- **Epidemics and War: the 1918 Influenza pandemic** [3 Lectures]
  - Medical understanding of influenza in the early 20th Century
  - Conditions of WWI that enabled spread of the disease
  - Global mortality of the epidemic
- **Epidemics and Sexuality: AIDS in the 1970s** [3 Lectures]
  - Cultural and social factors in the emergence of AIDS in Africa and the United States.
  - AIDS, stigmatization, and hysteria
- **Epidemics and Globalization: SARS, EBOLA, ZIKA, COVID-19** [9 Lectures]
  - Social and ecological factors behind emergence of zoonotic viruses.
  - Mobility, migration and spread of viruses.
  - The role of WHO
  - Superstition and cultural resistance to treatments
  - Politics, the State, and national security
  - Pandemics and behavioral change
- **Hope and recovery** [2 Lectures]
  - smallpox vaccine
  - eradication drive for polio
  - what we can learn from past medical successes and challenges.

**Text books:**

1. There is no textbook for this course. Readings will be assigned from the reference texts listed below.

**References:**


1. Arnold, David. Colonizing the Body: State Medicine and Epidemic Disease in Nineteenth century India, Berkeley and London, University of California Press, 1993

2. Barry, John M. The Great Influenza: The Epic Story of The Deadliest Pandemic in History. Penguin, 2005.

3. Crawford, Dorothy H. Deadly Companions: How Microbes Shaped Our History. OUP Oxford, 2007.

4. Crosby, Alfred W. Ecological Imperialism, the Biological Expansion of Europe, 900-1900 Cambridge: Cambridge University Press, 1986.

5. Crosby, Alfred W. The Columbian Exchange: Biological and Cultural Consequences of 1492. Vol. 2. Greenwood Publishing Group, 2003.

6. Honigsbaum, M. The Pandemic Century: A History of Global Contagion from The Spanish Flu to Covid-19. Penguin Books, 2020.

7. Barroll, Leads, Politics, Plague and Shakespeare's Theater: the Stuart years, lthaca & London, Cornell University Press, 1991

8. Pati, Biswamoy and Mark Harrison (eds), The Social History of Health and Medicine in Colonial India, Routledge Studies in Asian History, London: Routledge, 2009.

9. Price-Smith, Andrew T. Contagion and Chaos: Disease, Ecology, and National Security In The Era of Globalization. MIT press, 2008.

10. Ranger, Terence, and Paul Slack, eds. Epidemics and ideas: essays on the historical perception of pestilence. Cambridge University Press, 1995.)

11. Rawcliffe, Carole, Leprosy in Medieval England, Woodbridge: Boydell Press, 2006

12. Snowden, Frank M. Epidemics and Society: From the Black Death to the Present. Yale University Press, 2019.

13. Tumbe, Chinmay, Age of Pandemics (1817-1920): How they shaped India and the world. HarperCollins, 2020.

14. Watts, Sheldon J. Epidemics and History: Disease, Power, and Imperialism. Yale University Press, 1999.


**Additional resources:**

- Newspaper reports from NYTimes, The Guardian etc.

## 12.99 HS 544 : Disaster Risk Management

**Course Code: HS 544**

**Course Name : Disaster Risk Management**

L-T-P-C : 3-0-0-3
Intended for : UG/PG Elective
Prerequisite : None
Mutual Exclusion : None
Approval: 44th BoA

**Course Contents:**

- **Understanding Disaster** (12 lecture hours)
  - Basic Terms and concepts: Structural failures, Pollution, Accidents, Hazard, Disaster, Catastrophes, Risk, Vulnerability, Resilience
  - Types of disaster:
    * Natural disasters: landslide, avalanche, volcanic activities, drought, flood, cyclone, tsunami, earthquake
    * Anthropogenic disasters: industrial pollution, biological and nuclear disaster, forest fire, oil spills, gas leak, radiations, household waste
    * Exposure to disaster and abilities to avert risks; and, Resilience Global Conventions and National Frameworks
    * Inventories: Maps, Zonation, Scale, Frequency, Return period risk framework Environmental risks and Climate Change: Global Conventions; National Frameworks
- **Unit II: Risk Assessment** (8 lecture hours)
  - Hazard analysis: Hazard, vulnerability, susceptibility determination Consequence analysis: categories, elements of risk, vulnerability
  - Risk: Analysis, estimation, assessment
- **Unit III: Risk Reduction Approach** (5 lecture hours)
  - Structural measures Non-structural measures Total risk Acceptable risk Cost-Benefit Analysis
- **Unit IV: Response and Disaster Management** (10 lecture hours)
  - Social Response: household, community, administrative
  - Technical Responses and Management of Disaster
  - International Conventions and Institutional and Legal Responses:
    * Disaster Management Act 2005/ Plan 2016/2019
    * National Policy on Disaster Management
    * National Guidelines and Plans on Disaster Management, UNDP, UNDRR, UNSDR guidelines

- **Unit V: Sendai Risk Framework** (7 lecture hours)
  - Precursors, Framework content, Actions and Schemes,
  - Risk Governance,
  - Recovery, Rehabilitate and Reconstruction (R-R-R)
- Recent case studies from community level to national level disaster, mini projects (out of class assignments and activities)

**Textbook:**

1. Ulrich Ranke, **Natural Disaster Risk Management: Geosciences and Social Responsibility**, Springer International Publishing, 2016.
2. R Subramanian, **Disaster Management**, Vikas Publishing house pvt., ltd., 2018

**References:**

1. Pandey, Mrinalini, **Disaster Management**, Wiley India, 2014.
2. Ulrich Beck, **Risk Society: Towards a New Modernity**, Trans. by Mark Ritter, Sage Publications, 1992.
3. **Sendai Framework for Disaster Risk Reduction** 2015-2030, UNDRR
4. R**ecently published reports - UNDRR**
5. **National Disaster Management Guidelines**- 2019, NIDM, NDMA, India
6. **National Disaster Management Policy**, 2009, GoI (As the changes in disaster management act are drastic, the above references need to be followed as recently published material)

## 12.100 HS 545 : Applied Forensic Psychology

**Course Code: HS 545**

**Course Name : Applied Forensic Psychology**

L-T-P-C : 3-0-2-4

Intended for : B.Tech/Masters/PhD

Prerequisite : Basic Knowledge of Psychology and cognitive processes (Advised to enroll for Introduction to Psychology (HS252) course before joining this course), or Consent of the Instructor.

Mutual Exclusion : None

Approval: 45th BoA

**Course Contents:**

- Module 1: Overview of Forensic and Criminal Psychology (8 hours)
  - Forensic Psychology: Major areas, Scope, State of art
  - Role of Forensic psychologist: Educational and certification requirements
  - Theories of crime:
  - Lombroso approach to understand crime, its causes and remedies
  - Moral reasoning Theory
  - Social information-processing Theory
  - Developmental and psychological theories of offendin
  - Developmental propensity theory
  - Propensity Theory
  - Social learning Theory
  - Lifestyle Theory
  - Integrated Cognitive Antisocial Potential theory
  - Recent Psychological research and police investigations: Does the research meet the needs? Victims of crime
- Module 2: Eyewitness testimony (6 hours)
  - Eyewitness testimony as a central issue in criminal and forensic psychology
  - Accuracy of the witness evidence: Role of System and Estimator variables
  - Eyewitness evidence in courts
  - Children as witnesses
  - Factors that lead to criminal behaviour, criminal profiling
  - Scope for psychological assessments of suspects for facilitating understanding of the crime committed
- Module 3: Witness memory: encoding, storage and retrieval factors (6 hours)
  - Mistaken identity
  - Perceiving event
  - Retaining information in memory and retrieving the same Inattentional blindness
- Module 4: Visual Identification (6 hours)
  - Perceiving events
  - Recognizing people and facial recognition
  - Individual differences in eyewitness testimony
- Module 5: Profile Analysis: (6 hours)
  - The origin of offender's profile

- The process of police investigation
- Type of profiling: Inductive and deductive
- Profiling and personality
- What research speaks about profiling: whether it works?

- Module 6: Lies, Lie detecting and act of deception: Technological and non-technological involvement (6 hours)
  - Brain development and the parts of the brain underpinning social and antisocial behaviours
  - Ekman's theory of lie detection
  - Improving lie detection hit rates: Cognitive overload
  - The strategic use of evidence technique
    * The polygraph process and its validity, Alternatives to the polygraph
    * Layered Voice Analysis (LVA)
    * Suspect Detection System (SDS)
    * Brain Electrical Oscillations Signature (BEOS)
    * Gait analysis o Handwriting analysis
    * Use of Eye tracker and electroencephalograph in investigations
    * Non-technological forensic assessments/investigations: MMPI, PCL-R, TAT, Expert testimony

- Module 7: Interviewing/interrogating witnesses and suspects (8 hours)
  - Methods of interviewing witnesses and suspects:
  - Cognitive interview
  - Interviewing assailable witnesses such as children, elderly people and people with intellectual disability
  - Working with the courts: Judicial processes
  - Presentation of evidences in courts
  - Judges as decision makers
  - Advice for expert witnesses
  - Case studies of criminals with concluding judgments and convictions

**Laboratory/practical/tutorial Modules: (10 hours)**

Laboratory and practical sessions will be distributed into different modules (module, 2, 3, 4, 5 and 6). Students will be introduced to some of the forensic assessment tools, such as Rorschach Ink Blot, Personality Big-5, Psychopathic Checklist-Revised (PSL-R), Minnesota Multiple Personality Inventory-3, Electroencephalography, Thematic Apperception Test, Galvenic skin conductance etc. Additionally, expert testimony will also be included in the syllabus.

- Part 1: Personality test introduction and administration (paper-pencil based)

- Part 2: Electroencephalography and Galvanic skin conductance/lie detection tools introduction and administration
- Part 3: Field work, visiting police stations, courts interacting with police personnel and people in judiciary system to know the nature of criminal investigation and proceedings

**Textbooks:**


1. Graham. M. Davies and Anthony R. Beech, **Forensic psychology: Crime, justice, law, interventions**, 3rd Edition, John Wiley & Sons, 2018.
2. Curt R. Bartol and Anne M. Bartol, **Introduction to Forensic Psychology**, 5th Edition, Sage Publication, Thousand Oaks, California, 2018.


References:


1. Mickes, L. (2015). Receiver operating characteristic analysis and confidence-accuracy characteristic analysis in investigations of system variables and estimator variables that affect eyewitness memory. Journal of Applied Research in Memory and Cognition, 4, 93-102.
2. Sridhar Ramamurty, David E. Morrison III, Joseph W. Koletar and Kelly R. Pope, **A.B.C.'s of Behavioral Forensics: Applying Psychology to financial fraud and detection**, John Wiley & Sons, Hoboken, New Jersey, 2013.
3. Philip H. Melanson, **The Murkin Conspiracy: An Investigation into the Assassination of Dr. Martin Luther King Jr**., Praeger Publication, 1989.
4. Dennis Howitt, **Introduction to forensic and criminal psychology**, 6th Edition, Pearson Education, 2006.
5. Lombroso, C., **Crime, its causes and remedies** (Vol. 3). The University Press, 1911.
6. Elizabeth F. Loftus, **Eyewitness Testimony**, Harvard University Press, 1979.


## 12.101 HS 546 : Readings in World Literature

Course number : HS 546
Course Name : Readings in World Literature
Credit Distribution : 3-0-0-3
Intended for : Undergraduate and Postgraduate
Prerequisite : None
Mutual Exclusion : None
Approval: 50th BoA

**Course Contents:**

- Topic 1: Concepts of "World Literature" – an overview (6 hours)
  - Weltliteratur
  - Comparative / world literature
  - Vishwa-sahitya
  - Centres and peripheries
  - Distant reading
  - Untranslatability
- Topic 2: Reading across time (9 hours)
  - The classics
  - The literary canon
  - Prize-winning authors
  - Forms and mutations
  - Colonial / postcolonial writing
- Topic 3: Reading across space (9 hours)
  - The nationalist and the provincial
  - The cosmopolitan writer
  - Planetarity and universalism
  - The literary marketplace
  - Travel, migration, and diaspora
  - Alternative communities
- Topic 4: Reading in translation (9 hours)
  - Role of the translator
  - The bilingual / multilingual writer
  - Hierarchies of languages
  - Translation and gender
  - Untranslatability
- Topic 5: Reading across cultures (9 hours)
  - World literature as a mode of reading
  - Resistance and diffusion
  - The multicultural text
  - Globalization
  - New media and the World Wide Web

**Text books:**

1. Damrosch, D. et al., The Princeton Sourcebook in Comparative Literature, Princeton University Press, USA, 2009/2021.
2. Martin Puchner, The Norton Anthology of World Literature (Shorter 4th Edition), Vol. 1 & 2, W. W. Norton & Company, USA, 2021.

**References:**

**Suggested Reading:**

1. For Topic 1
   (a) Johann Wolfgang Goethe, 'Conversations on Weltliteratur'
   (b) Rabindranath Tagore, 'Vishwa-Sahitya'
   (c) Frederic Jameson, 'Third-World Literature in the Era of Multinational Capitalism'
   (d) Franco Moretti, 'Conjectures on World Literature and More Conjectures'
   (e) David Damrosch, 'Conclusion' from What is World Literature?
   (f) Writing About World Literature by Karen Gocsik (first two chapters)
2. For Topic 2
   (a) Homer, The Iliad, Book 1 (The Wrath of Achilles)
   (b) Vyasa, The Mahabharata, Book 5 (The Temptation of Karna)
   (c) Tales from The Thousand and One Nights
   (d) Doris Lessing, 'The Old Chief Mshlanga'
   (e) T. S. Eliot, 'What is a Classic?' and 'Tradition and the Individual Talent'
   (f) Ankhi Mukherjee, 'Introduction' in What is a Classic?
3. For Topic 3
   (a) W. B. Yeats, 'The Lake Isle of Innisfree'
   (b) Louis Aragon, 'The Rose and the Reseda'
   (c) Sadat Hasan Manto, 'Toba Tek Singh' • Julio Cortázar, 'House Taken Over'
   (d) Sheldon Pollock, 'Cosmopolitanisms'
   (e) Judith Butler, 'Universality in Culture'
   (f) Pheng Cheah, 'What is a World? On World Literature as World-making Activity'
4. For Topic 4
   (a) Rabindranath Tagore, 'The Hungry Stones'
   (b) Nikolai Gogol, 'Diary of a Madman'
   (c) Lu Xun, 'Diary of a Madman'

(d) Samuel Beckett, Not I
(e) Gayatri Spivak, ‘The Politics of Translation’
(f) Emily Apter, ‘A New Comparative Literature’

5. For Topic 5
   (a) J. M. Coetzee, ‘The Dog’
   (b) Yoko Tawada, ‘The Bridegroom was a Dog’
   (c) Kow Shih Li, ‘Peach Blossom Luck’
   (d) Marjane Satrapi, selections from Persepolis
   (e) Jorge Luis Borges, ‘The Argentine Writer and Tradition’
   (f) Salman Rushdie, ‘Imaginary Homelands’

**Further references:**


1. Apter, E. 2013. Against World Literature: On the Politics of Untranslatability. London: Verso.
2. Bassnett, S. (Ed) 2019. Translation and World Literature. New York: Routledge.
3. Casanova, P. 2004. The World Republic of Letters. Trans. M. B. DeBevoise. Cambridge: Harvard University Press.
4. Damrosch, D. 2003. What is World Literature? Princeton: Princeton University Press.
5. Dev, A. and Das, S. K. 1988. Comparative Literature: Theory and Practice. Shimla: IIAS.
6. Mufti, A. 2016. Forget English! Orientalisms and World Literatures. Cambridge: Harvard University Press.
7. Mukherjee, A. 2014. What is a Classic? Postcolonial Rewriting and Inevention of the Canon. Stanford: Stanford University Press.
8. Ramakrishnan, E. V. et al (Eds). 2013. Interdisciplinary Alter-Natives in Comparative Literature. New Delhi: Sage.
9. Zepetnek, S., & Mukherjee, T. (Eds.). 2014. Companion to Comparative Literature, World Literatures, and Comparative Cultural Studies. Cambridge: Cambridge University Press.


## 12.102 HS 547: Philosophy of Texts and Narratives

Course number : HS 547
Course Name : Philosophy of Texts and Narratives
Credit Distribution : 3-0-0-3
Intended for : Ph.D., Masters, Advanced B.Tech. students
Prerequisite : None
Mutual Exclusion : None
Approval: 50th BoA

**Course Contents:**

- Unit 1: Philosophical Underpinnings and Key Concepts (12 hours)
  - What is a Text?
  - Text and Signs
  - Text and Genre
  - Intertextuality
  - Intermediality
  - Translation
- Unit 2: Narrative Forms, Structures and Time (10 hours)
  - Text and Narrative
  - Narrative forms
  - Order in Narrative
  - Time and Narrative
  - Historical Narration
- Unit 3: Literary Narratives and the Question of Realism (10 hours)
  - Fiction
  - The Limits of Fictionality
  - Epic and Novel
  - Realism and Irrealism
  - Is Literature a Universal?
- Unit 4: Beyond Text? (10 hours)
  - Literary System
  - World Literature
  - Planetary Textuality
  - Science Fiction
  - Beyond Text?

**Text books:**

1. Duff, D (Ed.). 2014. Modern Genre Theory. London: Routledge.
2. McQuillan, M (Ed.). 2000. The Narrative Reader. London: Routledge.

**References:**


1. Bakhtin, M. 1986. Speech Genres and Other Late Essays. Edited by Caryl Emerson and Michael Holquist. Translated by Vern W. McGee. Austin, Texas: University of Texas Press.

2. Barber, K. 2007. Anthropology of Texts, Persons and Publics: Oral and Written Culture in Africa and Beyond. Cambridge: Cambridge University Press.

3. Barthes, R. 1967. Elements of Semiology. New York: Hill and Wang.

4. Barthes, R. 1974. S/Z. Translated by Richard Miller. New York: Hill and Wang.

5. Benjamin, W. 2019. Illuminations: Essays and Reflections. Edited by Hannah Arendt. Translated by Harry Zohn. Boston: Mariner Books.

6. Bohannan, L. 1966. 'Shakespeare in the Bush'. Available at: https://www.naturalhistorymag.com 09_pick.html

7. Danto, AC. 1985. Narration and Knowledge. New York: Columbia University Press.

8. Even-Zohar, I. 1990. 'The Literary System' Poetics Today, Vol. 11 (1): 27-44.

9. Genette, G. 1980. Narrative Discourse: An Essay in Method. Translated by Jane E. Lewin. Ithaca, New York. Cornell University Press.

10. Ghosh, A. 2016. The Great Derangement: Climate Change and the Unthinkable. Gurgaon: Penguin Random House India.

11. Goodman, N. 1977. Ways of Worldmaking. Indianapolis: Hacket Publishing.

12. Jameson, F. 2013. Antinomies of Realism. London: Verso.

13. Kristeva, J. 1980. Desire in Language: A Semiotic Approach to Literature and Art. Edited by Leon S. Roudiez. Translated by Thomas Gore, Alice Jardine, and Leon S. Roudiez.

14. Lamarque, P. 1990. 'Narrative and Invention: The Limits of Fictionality', in Christopher Nash (ed.) Narrative in Culture: The Uses of Storytelling in the Sciences, Philosophy, and Literature. London: Routledge, 133-156.

15. Le Guin, UK. 1980. The Left Hand of Darkness. New York: Harper and Row.

16. Lévi-Strauss, C. 1973. 'Structure and Form: Reflections on a Work by Vladimir Propp', in Structural Anthropology 2. Translated by Monique Layton. Harmondsworth: Penguin Books, 115-145.

17. Lévi-Strauss, C. 1986. The Raw and the Cooked. Translated by John and Doreen Weightman. New York: Harper and Row.

18. Moretti, F. 2005. Graphs Maps Trees: Abstract Models for a Literary Theory. London: Verso.

19. Mbembe, A. 2001. On the Postcolony. Berkeley: University of California Press.

20. Propp, V. 2009. Morphology of the Folktale. Translated by Laurence Scott. Edited by Louis A. Wagner. Texas: University of Texas Press.

21. Ricoeur, P. 1984. Time and Narrative, Vol. 1. Chicago: The University of Chicago Press.

22. Wolf, W. 2018. Selected Studies on Intermediality by Werner Wolf (1992-2014). Edited by Walter Bernhart. Leiden: Brill Rodopi.

23. Ong, W. J. 2002. Orality and Literacy. London. Routledge.

## 12.103 HS 548: Science and Society

Course number : HS 548
Course Name : Science and Society
Credit Distribution : 3-0-0-3
Intended for : Ph.D., Masters, Advanced B.Tech. students
Prerequisite : None
Mutual Exclusion : None
Approval: 50th BoA

**Course Contents:**

- Unit 1: Science, Values and the Social: (12 hours)
  - What is Science?
  - The 'Epistemic', the 'Cognitive', and the 'Social' in Science
  - Is Science Value-Free?
  - The Normative Structure of Science
  - Normal Science and the Structure of Scientific Revolutions
  - Scientific Objectivity
- Unit 2: Construction of Facts (10 hours)
  - Construction of Scientific Facts
  - 'Social' in 'Science' and 'Science' in 'Social' or the Mutual Constitution of Science and Society
  - Scientific Objects
  - Truth and Representation in the Sciences
  - Circulating Reference: 'Context' and 'Content' of Science
- Unit 3 Practices of Science (10 hours)
  - Scientific Practices
  - Epistemic Cultures
  - Science as a Vocation, Technical Life, and the Scientist as an Individual
  - Social Epistemology of Experiments

  - (En)gendered Science

- Unit 4 Science, Democracy and Governance (10 hours)
  - Expertise and Science
  - Politics of Science: Science as Ideology
  - Infrastructural Imaginaries
  - Debating Science Policies
  - Science and Citizens

**Text books:**

1. Machamer, P and Wolters, G (Eds.). 2004. Science, Values, and Objectivity. Pittsburgh: University of Pittsburgh.
2. Sismondo, Sergio. 2004. An Introduction to Science and Technology Studies. Malden, USA. Blackwell Publishing Ltd.

**References:**


1. Biagioli, M (Ed.). 1999. The Science Studies Reader. New York, NY: Routledge.
2. Daston, L (Ed.). 2000. Biographies of Scientific Objects. Chicago: University of Chicago Press.
3. Daston L, Galison P. 1992. 'The Image of Objectivity'. Representations 40 (special issue): 81-128.
4. Douglas, H. 2009. Science, Policy, and the Value-free Ideal. Pittsburgh: University of Pittsburgh.
5. Fleck, L. 1979. Genesis and Development of a Scientific Fact. Chicago: The University of Chicago Press.
6. Galison, P. 1987. How Experiments End. Chicago: The University of Chicago Press.
7. Golinski, Jan. 1998. Making Natural Knowledge: Constructivism and the History of Science. Cambridge, UK: Cambridge University Press.
8. Hess, D. 1997. Science Studies: An Advanced Introduction. New York: New York University Press.
9. Jasanoff, S (Ed.). 2004. States of Knowledge: The Co-Production of Science and Social Order. London: Routledge.
10. Kuhn, T.S. 2012. The Structure of Scientific Revolution. Chicago: University of Chicago Press.
11. Knorr Cetina, K. 1999. Epistemic Cultures: How the Sciences Make Knowledge. Cambridge, Massachusetts: Harvard university Press.

12. Latour, B. and Woolgar, S. 1986. Laboratory Life: The Construction of Scientific Facts. Princeton, New Jersey. Princeton University Press.

13. Latour, B. 1999. Pandora's Hope: Essays on the Reality of Science Studies. Cambridge: Harvard University Press.

14. Leach, M, I. Scoones, and B. Wynne (Eds.). 2005. Science and Citizens: Globalization and the Challenge of Engagement. London: Zed Books.

15. Lewontin, R. 1992. Biology as Ideology: The Doctrine of DNA. New York: Harper Perennial.

16. Merton, R, N. Storer. 1973. The Sociology of Science: Theoretical and Empirical Investigations. Chicago: The University of Chicago Press.

17. Mitchell, T. 2002. Rule of Experts: Egypt, Techno-politics, Modernity. Berkeley: University of California Press.

18. Porter, T.M. 2020. Trust in Numbers: The Pursuit of Objectivity in Science and Public Life. Princeton, New Jersey: Princeton University Press.

19. Sarukkai, S. 2005. 'Revisiting the 'Unreasonable Effectiveness' of Mathematics'. Current Science, Vol. 88(3): 415-423.

20. Sarukkai, S. 2012. What is Science? New Delhi: National Book Trust, India.

21. Shapin, S and Schaffer, S. 1985. Leviathan and the Air-Pump: Hobbes, Boyle, and the Experimental Life. Princeton: Princeton University Press.

22. Sukumar, AM. 2019. Midnight's Machines: A Political History of Technology in India. New York: Penguin Random House.

23. Weber, M. 1946. 'Science as a Vocation'. In Gerth HH and C Wright Mills (Eds.). From Max Weber: Essays in Sociology. New York: Oxford University Press, 129-156.

## 12.104 HS 549 : Indian Literatures in English Translation

Course number : HS 549
Course Name : Indian Literatures in English Translation
Credit Distribution : 3-0-0-3
Intended for : B.Tech./M.Tech/M.A./Ph. D students
Prerequisite : None
Mutual Exclusion : None
Approval: 50th BoA

**Course Contents:**

- Module 1: Introduction to Indian Literature 8 hours
  - Defining Indian Literature
  - Indian Language Literatures

- The Postcolonial Nation State
  - De-coloniality
  - Translation from English into Indian languages and vice versa
- Module 2: Drama 6 hours
  - Dramaturgy
  - Ancient Drama
  - Modern Drama
- Suggested Texts:
  - Kalidasa's Malavika and Agnimitra, Visakhadatta's Rakshasa's Ring.
  - Wild Harvest by Manoranjan Das, Sahitya Akademy 1994,
  - Bharatendu Harishchandra's Andhernagari Chowpatraja. (The City of Darkness).
- Module 3: Novels 12 hours
  - Novels published on the cusp of Independence
  - Issues of nationalism and the impact of Gandhian ideals
  - Colonial modernity/rationality Suggested Texts: Unnava Lakshmi Narayana's Malapalli, Kuvempu's Bride in the Rainy Mountains, and Phaneeshwarnath Renu's Maila Anchal.
- Module 4: Short Story 8 hours
  - Narrative
  - Oral and Written Literature
  - Translation from source language to target language
- Suggested Texts:
  - Folktales from Andaman and Nicobar, Rahul Sankrityayan Volga to Ganga.
  - Premchand's short stories from The Complete Oxford Premchand,
  - Vaikom Mohammed Basheer's Poovan Banana and Other Stories,
  - Damodar Majo's These Are My Children,
  - Tarashankar Bandopadhyaya's "Boatman Tarini" and Collected short stories from the North East.
- Module 5: Poetry 8 hours
  - Gender.
  - Buddhist Literature.
  - Proscription in the 19 C.
- Suggested Texts:
  - Selections from Therigatha, Ilango Atikal's Silappadikkaram (1939)
  - Muddupalani's Radhika Santvanamu (Appeasing Radhika),
  - Amrita Pritam's – "An Ode to Waris Shah."

**Text Books**

1. Bassnett, Susan. Comparative Literature. Oxford: Wiley-Blackwell, 1993.

2. Das, Sisir Kumar. History of Indian Literature 1800-1910 & 1911-1956. Vol. I&II. New Delhi: Sahitya Akademi, 1991.

3. George, K.M. Comparative Indian Literature. Vol. I, II&III. New Delhi: Sahitya Akademi,1994.

**References**


1. Basheer, Vaikom Mohammed. Poovan Banana and Other Stories. New Delhi: Orient BlackSwan,1994.

2. Bhattacharya. Bhabani. (Ed) Contemporary Indian Short Stories. New Delhi: Sahitya Akademi,1958.

3. Bharata. Manmohan Ghosh. (Transl) Natya Shastra.Vol. I&II Calcutta: Asiatic Society of India, 1951.

4. Biguenet, John and Rainer Schulte (eds). Translation Theories: From Dryden to Derrida. Chicago: University of Chicago Press, 2020.

5. Bodhi, Bikku. (Ed). Great Disciples of the Buddha. Boston: Wisdom Publications, 2003.

6. Das, Manoranjan. Prabhat Nalini Das (Transl). Wild Harvest. New Delhi: Sahitya Akademy,1994.

7. Forster, E. M. Aspects of the Novel. New York: Harcourt Brace and World, 1954.

8. Harishchandra, Bharatendu. The City of Darkness. (Amarchitrakatha Series) Andher Nagari Chowpatraja. (Hindi). Kalidasa. Daniel Balogh and Eszter Somogyi. (Transl) Malavika and Agnimitra. New York: NYU Press, 2009.

9. Kothari, Rita. Translating India. New Delhi: Routledge, 2003.

10. Kuvempu.K.M. Srinivasa Murty and G.K.Srikanta Murthy (Transl). Bride in the Rainy Mountains. Kuppali: Kuvempu Trust, 2020.

11. Lakshiminarayana, Unnava. V.V.B.Rama Rao. (Transl). Malapalli. New Delhi: Sahitya Akademi, 2008.

12. Ilango Atikal. V.R. Ramachandra Dikshitar (Transl). Silappadikkaram. Oxford: OUP,1939.

13. Lukacs, George. The Theory of the Novel. Massachusetts: MIT Press, 1974.

14. Mauzo, Damodar. These Are My Children. New Delhi: Katha Publishers, 2019.

15. Muddupalani. Narayana Rao and Shulman (Tansl) Radhika Santvanamu (Appeasing Radhika). Hyderabad: Telugu University Publications,2008.

16. Mukherjee, Meenakshi. Realism and Reality. New Delhi: OUP,1999.

17. Mukherjee, Sujit. Towards a Literary History of India. Simla: IIAS, 1975.

18. Munday, Jeremy. (ed.) The Routledge Companion to Translation Studies. London & New York: Routledge, 2009.

19. Narayana Rao and Shulman. Classical Telugu Poetry. New Delhi: OUP, 2004.

20. Paz, Octavio. "Literature and Letters". Translated by Irene del Corrall. Premchand. The Oxford India Premchand. New Delhi: OUP, 2004.

21. Pritam, Amrita. Selected Poems of Amrita Pritam. Calcutta: Dialog Calcutta, 2019.

22. Raveendran, P. P. "Genealogies of Indian Literature" Economic and Political Weekly, Vol. 41, No. 25 (Jun. 24-29, 2006), pp. 2558-2563.

23. Renu. Indira Junghare. (Transl). The Soiled Border. Chanakya Publications: New Delhi, 1991.

24. Roychowdhury, Rabin. (ed.) Folktales from Andaman and Nicobar. New Delhi: Sahitya Akademi, 2017.

25. Sai Deepak, J. India, that is Bharat: Coloniality, Civilization, Constitution. New Delhi: Bloomsbury India, 2021. Sankrityayan, Rahul. Victor Kiernan (Transl). Volga to Ganga. Mussoorie: Rahul Publication, 1953.

26. Tarashankar. "Boatman Tarini." From Contemporary Indian Short Stories. New Delhi: Sahitya Akademy,1958.

27. Tharu & Lalita. Women Writing in India Vol. I. New Delhi: OUP,1991.

28. Tharu & Lalita. Women Writing in India Vol. II. New Delhi: OUP,1993.

29. Visakhadatta. Michael Coulson (Transl) Rakshasa's Ring. New York: New York University Press, 2017.

30. Unknown. Mahendra, Angaraka.(Transl). Therigatha. Roslindale: Dhamma Publishers, 2017.

31. Collected short stories from the North East. Calcutta: Zubaan,

## 12.105 HS 550: Statistical Methods

### Course Code: HS 550

### Course Name: Statistical Methods

L-T-P-C:: 3-0-2-4

Prerequisites : A prior course in probability, statistics and random processes; or, consent of the instructor

Intended For: Ph.D. and Masters

Distribution: Discipline Elective for M.A. Development Studies, Free elective for others

Approval: 19th Senate

**Course Contents**

- **Representation of Data and Descriptive Statistics** [4 Lectures + 2 lab hours] Raw data and frequency data- tabular and diagrammatic representation; concept of moments; measures of central tendency, dispersion, skewness, and Kurtosis; quartile and percentile- their use in the measurement of inequality, Gini Coefficient and Lorenz curve; Bivariate frequency distribution, correlation coefficients Pearson and Spearman coefficients.

- Lab: Exercise on various ways of representing quantitative data; Measuring Central tendency, dispersion, skewness, and kurtosis of a given dataset; deriving quartile and percentile; Deriving Gini coefficient and Lorenz curve to understand inequality present in a dataset; ca lculation of correlation coefficients of various forms.

- **Probability and Random Variables** [4 Lectures] Basic concepts in set theory as applied in probability; concept of probability- classical, frequency based, axiomatic approach, Bayesian probability; conditional probability, Bayes theorem, statistical independence of events; random variables - discrete and continuous, probability distribution functions, cumulative distribution functions, Expectation and Variance of a random variable, joint distribution of two random variables and their correlation, l aw of large number.

- **Random Sampling and Parametric Statistical Inference** [8 Lectures + 6 lab hours] Concepts of population and sample, parameter and statistic, random sampling and sampling distribution, Central Limit Theorem; Expectation and Standard Error of sample mean and sample proportion; concepts of theoretical distribution: Normal distributions and four fundamental distributions derived from Normal distribution - Standard Normal, Chi-square, t and F distribution; estimation and testing of hypothesis - point estimation and interval estimation of parameters, Maximum Likelihood Estimator, hypothesis testing, and calculation of effect size.

- Lab: Drawing random samples from the population simple random sampling (with and without replacement); Fitting distribution curves to a given dataset; Statistical estimation . - parametric point estimation and interval estimation; Maximum Likelihood Estimator, Hypothesis testing and calculation of effect size.

- **Non-parametric Statistical Inference** [8 Lectures + 6 lab hours] Need for non-parametric tests, estimation oflocation and dispersion, tolerance interval; one sample and two sample non-parametric tests for. location and dispersion (involving independent and related samples); non parametric measures and tests of association.

- Lab: Carrying out non-parametric tests, estimation of location and dispersion, tolerance interval and tests of association.

- **Designs of Experiment** [8 Lectures + 6 lab hours] Experimental design strategies; Blocking a nd Randomization; Factorial design of experiments.

- Lab: Designing a suitable experiment to test a given hypothesis, testing the hypotheses by changing the variables within the experiment. Carrying out experiments based on Blocking and Randomization; Factorial design of experiments.

- Module 6: **Regression Analysis and Analysis of Variance** [10 Lectures + 5 lab hours] Gauss Markov theorem and Ordinary Linear Least Squa re regression; interpreting regression coefficients, concepts of residual, fitted value and goodness of fit, test of significance; diagnostic tests; bina.ty expla natory va riables; multiple regression ana lysis; two-way independent ANOVA and two-way Mixed ANOVA.

- **Lab**: Estimate multiple linear regressions to carry out the diagnostic tests_; finding out the key determinants; interpretation of estimates, testing the significance and carrying out an Analysis of Variance (ANOVA).

**Textbooks:**


1. Field, A. P., Miles, J., and Field, Z., **Discovering statistics using R**, Sage, 2012.

2. Woold ridge, J. M., **Introductory Econometrics: A Modern Approach**, Cengage Learning, 2013.


4. References:


1. STATA Manual: https://www.stata.com/manuals13/u.pdf

2. Heiman, G. W. (2011). Basic Statistics for the Behavioral Sciences. Sixth Edition. Wadsworth.

3. Field, A. P. (2013). Discovering statistics using IBM SPSS Statistics. London: Sage.

4. Agresti, A., and Finlay, B. Statistical Methods for the Social Sciences. (1997). Dellen, San Francisco.

5. Arnold, J. C., and Milton, J. S. (2003). Introduction to Probability and Statistics. McGraw-Hill.

6. Gibbons, J. D. and Chakraborti, S. (2003). Nonparametric Statistical Inference, Fifth Edition. Marcel Dekker, Inc.

7. Johnston, J. and DiNardo, J. (2006). Econometric Methods, 4 1 Edition. McGraw-Hill

8. Montgomery, D. C. nd Runger, G.C. (2011) Applied Statistics and Probability for Engineers. 5th ed. New Delhi: Vf iley-India.

9. Montgomery, D. C. (2012). Design and Analysis of Experiments, gth Edition. John Wiley & Sons, Inc.

10. Ross, S.M. (2014). Introduction to probability and statistics for engineers and scientists. Academic Press.

11. Robatgi, V. K. and Saleh, A. K. E. (2015). An Introduction to Probability and Statistics.

## 12.106 HS 550P: Statistical Methods Practical

**Course Code: HS 550P**

**Course Name: Statistical Methods Practical**

L-T-P-C: 0-0-2-l
Prerequisites: This course should be taken along with HS550: Statistical Methods
Intended for : Postgraduate and B.Tech.
Distribution : HSS Course - Elective
Approval: 15th Senate

### Course Contents

**Representation of Data and Descriptive Statistics** (2 hrs) Representation of data; Central tendency, dispersion, skewness, and kurtosis; Quartile and percentile; Gini coeffici ent and Lorenz curve; Con-elation.

**Random Sampling and Parametric Statistical Inference** (6 hrs) Drawing random samples from the population -si mple ra ndom sampl ing (with a nd without repl acemen t); Sampling distribution ; Statistical estimation - parametric point estimati on and interval estimation; Maximum Likelihood Est imator, Hypothesis testing and calculation of effect si ze.

**Non-parametric Statistical Inference** (6 hrs) Ca rryin g out non-parametric tests, estimation of location and dispersion, tol erance interval ; non parametric measures and tests of association.

**Designs of Experiment** (6 hrs) Experimental design strategi es; Blocking a nd Randomization; Factorial design of experiments.

**Regression Analysis and ANOVA** (8 hrs) Multiple regression analysis, interpretation of estimates, testing of significance; Analysis of
Variance (ANOVA) - one way ANOVA and two way ANOV A.

### Textbooks:


1. Heiman, G. W., **Basic Statistics for the Behavioral Sciences**, 6th Edition, Wadsworth, 2011.


### References:


1. Field, A. (2013). Discovering Sta ti stics Using TBM SPSS Stati st i cs. Sage Publishing.

2. Field, A., Miles, J. and Field, Z., Discovering Stat istics Using R, Sage Publishing, 2012.

3. STATA Manual: https://www.stata.com/man uals13/u.pdf

## 12.107 HS 551: Financial Management

**Course Code: HS 551**

**Course Name: Financial Management**

L-T-P-C : 3-0-0-3
Prerequisites : HS205 Financial Accounting or with instructors approval
Intended for : PhD/Masters/BTech 3rd and 4th years
Distribution : Discipline Elective for MA in Development Studies and free elective for others
Approval: 17th Senate

**Course Contents**

- **Introduction to Finance Function** Corporate form of business, Reading financial statements, Financial decision making, Profit maximization versus wealth maximization debate, Time value of money, Interest rates, Term structure and yield curve [6 Lectures]
- **Investment Decisions** Valuations of projects and firms, Rules for investment decision making, Free Cash Flow calculation, Valuation of shares and bonds [8 Lectures]
- **Risk and Return** Introduction to capital market and risk pricing, Capital asset pricing model, Estimation of cost of capital: Cost of equity and debt [6 Lectures]
- **Financing Decisions** Capital structure in perfect and imperfect markets, implication of debt and taxes on capital structure, Financial Distress, Managerial Incentives [6 Lectures]
- **Dividend Decisions** Payout process and policies, Dividend versus share repurchase, Payout versus retention, Signaling with payout, Taxes and dividend [6 Lectures]
- **Short Term Financial Decisions** Short term financial planning: Tools for working capital management, cash management and inventory management [4 Lectures]
- **Strategic Financial Decisions** Initial public offers, Strategic alternatives in Mergers and acquisitions, Debt Securitization, Corporate restructuring, Corporate governance [6 Lectures]

**Textbooks:**

1. Berk, DeMarzo and Thampy, **Financial Management**, Indian Subcontinent Edition, Pearson Education (India), 2010

**References:**

1. Prasanna Chandra, **Financial Management: Theory and Practice**, 8th Edition, McGraw Hill Education (India), 2012

2. Kester, Ruback and Tufano, **Case Problems in Finance**, 12th Edition, McGraw Hill, 2008

3. Robert F. Bruner, **Case Studies in Finance: Managing for Corporate Value Creation**, McGraw Hill International Edition, 2006

## 12.108 HS 551P: Development Studies Practicum I

## 12.109 HS 552P: Development Studies Practicum II

**Course Number : HS 551P and HS 552P**

**Course Name: Development Studies Practicum I and Development Studies Practicum II**

L-T-P-C:: 0-0-8-4
Prereq uisites : None
Intended for : MA in Development Studies
Distribution : Discipline Core for M.A. in Development Studies
Approval: 19th Senate

**Course Contents**

Faculty members will float the topics related to development challenges. A student/group of students interested in working on any particular topic may consult the faculty and the faculty can float the topic accordingly.

The group of students will work on the topic. The work can be theoretical, archival or empirical. Evaluation will be based on

1. A mid-term presentation on the progress of work

2. Open-house presentation at the end of the semester

3. Submission of a final report.

**Textbook:**

Will be suggested by the faculty mentor as per requirement of each group.

**References:**

Will be suggested by the faculty mentor as per requirement of each group.

## 12.110 HS 553P: Field Study

**Course Code: HS 553P**

**Course Name: Field Study**

L-T-P-C:: 0-0-8-4
Prerequisites:None
Intended for : MAin Development Studies
Distribution: Discipline Core for MA in Development Studies

Semester: Summer session (between Semester II and Semester III)
Approval: 19th Senate

**Course Contents**

- **Module I** In the first week, before leaving for field-work, students will be asked to choose a place from a list of places. These places will be pre-identified after discussion with faculty advisors. Students may propose places from their side; however, in this situation, they need to justify the place of visit in discussion with their faculty advisor (place profiling, as discussed below,may help this justification). Furthermore, in the first week, before leaving f or field-work, the students will be asked to do a soci'?/econornic/culturallgeographical profiling of the place of visit. They need to discuss their profile with their faculty advisor before they are permitted to leave for the place of visit.

- **Module II** Students will stay at the field site during week 2-5/6. Around a 3-week period, students will be asked to send a write-up to their faculty advisor detailing their experience (based upon a diary entry) about their place of visit as well as certain unique problems in the place (they need to provide details about the problem as much as possible).

- **Module III** Upon return from the field visit, during the final week, students will be asked to submit a field report and diary. Also, students will be asked to make a presentation on their experience and findings (they may also suggest possible solutions to the problems).

A 4 credit lab course is equivalent to 8 lab hr/week during Feb-Jun or Aug-Dec semester (14 weeks under each semester).This adds up to 112 hours. Since students have to take up this Field Study Course during the Summer Term over a period of 4-6 weeks, weekly hours will be adjusted accordingly keeping the total to be 112 hrs.

**Textbooks:**

Scheyvens, R., Development Fieldwork: A Practical Guide, Sage Publishing, 2014.

**References:**

Any relevant journal paper.

## 12.111 HS 554P: Post Graduate Project

**Course Code: HS 554P**

**Course Name: Post Graduate Project**

L-T-P-C : 0-0-46-23
Prerequisites : None
Intended for : MA in Development Studies
Distribution : Discipline Core for M.A. in Development Studies in the 4th Sem
Approval: 24th Senate

**Course Contents**

- **Mode 1**: Each student is assigned to a faculty supervisor and carries out a short research project under the his/her supervision at IIT Mandi. Faculty will float the topics related to development challenges. A student interested in working on any particular topic may consult the faculty and the faculty may float the topic accordingly.
- **Mode 2**: Each student has to be come up with a proposal for guided internship with a suitable organization/institute. The internship will be performed at that organization/institute itself. The proposal has to include the name of the organization/institute, nature of work to be carried out, area of work and the duration of work. The duration of the internship has to be no less than 12 weeks and the student has to report back to IIT Mandi at least 2 weeks before the end of the semester. There has to be one faculty member from IIT Mandi who will supervise the internship jointly with the supervisor at the organization/institute where the internship is carried out.

**Textbook**

Will be suggested by the faculty mentor as per requirement of the student.

## 12.112 HS 555: Infrastructural Development in Highland South Asia

**Course Code : HS 555**

**Course Name : Infrastructural Development in Highland South Asia**

L-T-P-C : 3-0-0-3
Intended for : M.A. (Development Studies) (Discipline Elective) and B.Tech. 3rd and 4th year
Prerequisite :
Mutual Exclusion:
Approval: 54th BoA

**Course Contents**

- Introduction to Anthropology of infrastructure (6 Hours)
  - The infrastructural turn
  - The mobility paradigm in anthropology
  - Promises and perils of infrastructural creation in highland South Asia
  - Road Ethnographies
- Connecting the remote: The poetics and politics (8 Hours)
  - From mule tracks to imperial highways
  - Remoteness and connectivity channels
  - Roads as the harbinger of progress, development and connectivity

  - Roads as state conceived spaces
  - Land acquisition and other issues.
- The Dromocratic revolution (6 Hours)
  - Speed and flows
  - Connection and communication channels
  - Corporeal and kinetic connection
- Mobility and Mobile connections (8 Hours)
  - Embodied travel experiences
  - Temporal and material conditions of infrastructure
  - Roadside contacts: stationary and the non-stationary
  - People as infrastructures: Gender experiences of mobility
- Tunneling and damming the hills (8 Hours)
  - The destructive production of infrastructure: railway tunnels and aerial connection
  - Dams and the moral ecology of infrastructure
  - Debri and debacle along infrastructure channels
  - Extraction of Raw-materials
- Infrastructure and Sustainability (6 Hours)
  - Issues of sustainability in infrastructure development
  - Loss of forested lands, natural habitats and other environmental concerns
  - Environmental Impact Assessment and other issues
  - Negotiating the loss.

**Laboratory/practical/tutorial Modules:**

Field visits, invited lectures, film screening and other activities including evaluation of the Environmental and Social Impact assessment reports submitted before the commencement of the project.

**Textbooks:**

1. Anand, Nikhil, Akhil Gupta, and Hannah Appel, **The Promise of Infrastructure**, Duke University Press 2018.
2. Harvey, Penny, Casper Bruun Jensen, and Atsuro Morita, **Infrastructures and Social Complexity: A Companion**, Taylor & Francis, 2016.
3. Dalakoglou, D., Harvey, P. (Eds.)., **Roads and Anthropology: Ethnography, Infrastructures, (Im)mobility**, Routledge, 2014.

**References:**


1. Appel, Hannah, Anand, Nikhil and Gupta, Akhil Introduction: The Infrastructure Toolbox — Society for Cultural Anthropology (culanth.org), 2015.

2. Adey, P., Bissell, D., Hannam, K., Merriman, P., & Sheller, M. (Eds.), The Routledge Handbook of Mobilities, Routledge, 2013.

3. Bhatt, Jay P, Sudha Tiwari & Maharaj K. Pandit, Environmental impact assessment of river valley projects in upper Teesta basin of Eastern Himalaya with special reference to fish conservation: a review. Impact Assessment and Project Appraisal, 35:4, 340-350, DOI: 10.1080/14615517.2017.1354642, 2017.

4. Cresswell, Tim and Peter Merriman., Geographies of Mobilities: Practices, Spaces, Subjects, Taylor & Francis, 2016.

5. Dalakoglou, D., The road: An ethnography of the Albanian-Greek cross-border motorway, American Ethnologist, no. 37 (1):132-149, 2010.

6. Delmon, Jeffrey, Public Private Partnership projects in Infrastructure: An essential guide for policy makers, Cambridge University Press, 2011.

7. Demenge, Jonathan P., The Road to Lingshed: Manufactured Isolation and Experienced Mobility in Ladakh. Himalaya, the Journal of the Association for Nepal and Himalayan Studies, 32 (1): 51–60, 2013.

8. Ferguson, J., The Anti-Politics Machine: 'Development,' Depoliticization, and Bureaucratic Power in Lesotho. 2003 ed. Minneapolis: University of Minnesota Press, 1994.

9. Gohain, Swargajyoti, Imagined Geographies in the Indo-Tibetan Borderlands: Culture, Politics, Place. Netherlands: Amsterdam University Press, 2020.

10. Gordillo, Gaston, Rubble: The afterlife of destruction. Durham: Duke University Press, 2014.

11. Gupta, Akhil, The future in ruins: Thoughts on the temporality of infrastructure. In N. Anand et al (eds.), The Promise of Infrastructure, Duke University Press, 2018.

12. Harvey, Penny., Knox, Hannah, The Enchantments of Infrastructure. Mobilities, 7:4, 521-536, DOI: 10.1080/17450101.2012.718935, 2012.

13. Harvey, Penny., Knox, Hannah, Roads: An Anthropology of Infrastructure and Expertise, Cornell University Press, 2015.

14. Masquelier, A., Road Mythographies: Space, Mobility, and the Historical Imagination in Postcolonial Niger, American Ethnologist, 29 (4):829-856, 2002.

15. Murton, Galen and Luke Heslop, Highways and Hierarchies: Ethnographies of Mobility from the Himalaya to the Indian Ocean, Amsterdam University Press, 2021.

16. Murton, Galen and Austin Lord, Trans-Himalayan power corridors: Infrastructural politics and China's Belt and Road Initiative in Nepal, Political Geography, 77 (102100): 1- 13, 2020.

17. Negi, D. P., & Abdul Azeez EP., 'No Means No': People's Protest Against Hydroelectric Development in Kinnaur, Himachal Pradesh, India, Contemporary Voice of Dalit, https://doi.org/10.1177/2455328X2110694, 2022.

18. Rest, Matthaus and Alessandro, Rippa, Road animism. HAU: Journal of Ethnographic Theory, 9: 373 - 389, 2019.

19. Saxer, Martin, Places in Knots: Remoteness and Connectivity in the Himalayas and Beyond, Cornell University Press, 2022.

20. Simpson, Edward, Highways to the End of the World: Roads, Roadmen and Power in South Asia, Hurst Publishers, 2022.

21. Simone, Abdou, Maliq, People as Infrastructure: Intersecting Fragments in Johannesburg, Public Culture, 16 (3): 407–429, 2004.

22. Star, Susan. Leigh, The Ethnography of Infrastructure. American Behavioral Scientists, 43 (3): 377-391, 1999.

23. Wiejaczka, Łukasz; Danuta Pirog; Lakpa Tamang; and Paweł Prokop, Local Residents' Perceptions of a Dam and Reservoir Project in the Teesta Basin, Darjeeling Himalayas, India. Mountain Research and Development, 38 (3): 203–210 http://dx.doi.org/10.1659/MRD-JOURNAL-D-16-00124.1, 2018

24. Ziipao, R. Raile, Infrastructure of Injustice: State and Politics in Manipur and Northeast India, Routledge, 2020.

## 12.113 HS 556: Classical Social Theories

**Course Code: HS 556**

**Course Name: Classical Social Theories**

L-T-P-C: 3-0-0-3
Prerequisites: Consent of the Course Instructor
Intended for: UG/PG
Distribution: Elective
Approval: 9th Senate

**Course Contents**

- **INTRODUCTION**
  - What is social theory
  - Historical and Intellectual Contexts
  - Various traditions of social anthropology and sociology

**Essential readings:**

- Appelrouth, Scott and Laura Desfor Edles. 2008. Classical and contemporary sociological theory: Text and readings. California: Pine Forge Press. [It may be used as a textbook for theories in Sociology for undergraduate students].
- Calhoun, Craig et.al. 2007. Classical Social Theory. Blackwell Publishing. [Chapter 2, What is Enlightenment. Pp 39-43].
- Erickson, Paul A. and Liam D. Murphy. 2013. A history of Anthropological theory. Ontario: University of Toronto Press. (Chapter-1).
- Ian Craib. 1997. Introduction: Whats wrong with theory and why we still need it? In Classical Social Theory. New York: Oxford University Press; pp: 3-14.
- Randal Collins and Michael Makowsky. 2010. Introduction: Society and Illusion. In Randal Collins (ed) The Discovery of Society. pp. 1-15.
- **Emile Durkheim** (1858-1917)
  - A Biographical Sketch; intellectual influences and core ideas
  - Functionalism
  - Social Fact, Social solidarity, collective conscience
  - Theories of Religion: sacred and profane, Collective representation
  - Anomie, Suicide

**Essential Readings:**

- Calhoun, Craig et.al. 2007. Classical Social Theory. Blackwell Publishing. Pp 133-202.
- Edles, Laura Desfor and Scott Appelrouth. 2010. Sociological Theory in the Classical Era: Text and Readings. California: Pine Forge Press.
- Lewis A. Coser, 1996. Masters of Sociological Thought. Jaipur: Rawat Publications.
- **Karl Marx** (1818-1883)
  - A Biographical Sketch; intellectual influences and core ideas
  - Capital, Mode of Production, Relations of Production
  - Class Consciousness and Class struggle
  - Alienation/Estrangement, Commodity fetishism
  - Surplus value Theory, Asiatic Mode of Production

**Essential readings:**

- Cohen, G.A. 2000. Karl Marx's Theory of History. Oxford University Press; pp: 63-87, 364-388.
- Calhoun, Craig et.al. 2007. Classical Social Theory. Blackwell Publishing; pp: 82-120.
- Edles, Laura Desfor and Scott Appelrouth. 2010. Sociological Theory in the Classical Era: Text and Readings. California: Pine Forge Press.
- Lewis A. Coser, 1996. Masters of Sociological Thought. Jaipur: Rawat Publications.
- **Max Weber** (1864- 1920)
  - A Biographical Sketch; intellectual influences and core ideas
  - Social action and Sociology, Verstehen
  - Ideal types, Types of Legitimate Domination, Bureaucracy
  - Class, Status, and party; Protestantic Ethic & the Spirit of Capitalism
  - 'Iron cage' of rationality

**Essential readings:**

- Calhoun, Craig et.al. 2007. Classical Social Theory. Blackwell Publishing. Pp 228-246.
- Edles, Laura Desfor and Scott Appelrouth. 2010. Sociological Theory in the Classical Era: Text and Readings. California: Pine Forge Press.
- Kalberg, Stephan. 2005. Max Weber: readings and commentary on modernity. London: Blackwell Pub. (This book has some good selections from Weber's writings)
- Ritzer, George. 2008. Sociological Theory. Chapter 4, pp 119-121; pp 125-127; pp 136-142.
- Lewis A. Coser, 1996. Masters of Sociological Thought. Jaipur: Rawat Publications.
- **Georg Simmel** (1858-1918)
- A Biographical Sketch; intellectual influences and core ideas
- Duality, sociation, the surplus value of wealth

**Essential readings:**

- Edles, Laura Desfor and Scott Appelrouth. 2010. Sociological Theory in the Classical Era: Text and Readings. California: Pine Forge Press.
- Lewis A. Coser, 1996. Masters of Sociological Thought. Jaipur: Rawat Publications.

## 12.114 HS 563: Theory and Methods of Policy Analysis

**Course Code: HS 563**

**Course Name: Theory and Methods of Policy Analysis**

L-T-P-C 3-0-0-3

Prerequisites : IC 210: Probability, Statistics and Random Processes; or, after instructors approval.

Intended for : 3rd, 4th year B. Tech.; M.S., Ph.D.

Distribution : Elective for all B. Tech. students

Approval: 4th Senate

**Course Contents**

- **Introduction to Policy Analysis** Policy research and analysis; policy analysis versus natural science; goals versus analysis; philosophical frameworks for analysis; motivations for taking policy analysis. [6 Lectures]
- **Discounting and CBA** Discounting; real/nominal discount rates; social discount rate; borrowing, leasing, depreciation, and taxes; cost-benefit analysis. [8 Lectures]
- **Decision Analysis and Uncertainty** Elements of policy (decision) problems; decisions, outcomes, and values; time value of money; nature and sources of uncertainty; structuring decisions: decision trees; risk profile and using decision trees to make choices; sensitivity analysis; multi-attribute decisions. [8 Lectures]
- **Modeling Uncertainty** Probability basics; subjective probability and biases; probability models (binomial, poisson, exponential, normal, and beta distributions); using data to construct distributions; Monte Carlo estimation. [8 Lectures]
- **Modeling Preferences** Evaluating risk attitudes; cost-effectiveness; risk analysis; and, value of life analysis. [6 Lectures]
- **Conflicting Objective, Utility Axioms, Paradoxes, and Policy Implications** Axioms for expected utility; paradoxes; conflicting objectives analyses; implications for policy analysis [6 Lectures]

**Textbooks:**

1. Clemen, **Making Hard Decisions**, Clemen and Reilly, Duxbury/Thomson.
2. Morgan, Henrion, and Small, **Uncertainty: A Guide to Dealing with Uncertainty in Quantitative Risk and Policy Analysis**, Cambridge University Press.

**References:**

1. Sepulveda et al., **Schaum's Outlines of Engineering Economics**, McGraw-Hill, Note this is a study guide type book on the subject of engineering economics.
2. Campbell, **Benefit-Cost Analysis**, Campbell and Brown, Cambridge University Press.

3. Boardman, Greenberg, and Vining, **Cost Benefit Analysis: Concepts and Practice**, 3rd Edition, Prentice Hall.

## 12.115 HS 575: Mayan America

**Course Code: HS 575**

**Course Name: Mayan America**

L-T-P-C : 3-0-0-3

Students intended for : B. Tech. 3rd and 4th year students; and, M.A. and Ph.D. students in HSS

Elective or Compulsory : Elective

Approval: 4th Senate

**Course Contents**

- **ANCIENT MAYAN CIVILIZATION** [10 Lectures]
  - The Classic Period
  - Decline and Collapse
  - Space, time and cosmos
- **MAYA UNDER COLONIAL RULE** [10 Lectures]
  - Conquest
  - Colonialism
  - Resistance in Yucatan, Chiapas and Guatemala
- **MAYA IN THE POSTCOLONIAL PERIOD** [12 Lectures]
  - Legacy of colonialism
  - The Caste War of Yucatan
  - Capitalism and commodities
  - Revolution in Mexico and repression in Guatemala
- **TRANSNATIONAL MAYA** [10 Lectures]
  - Pan Maya Activism
  - Neoliberalism and the Zapatista uprising
  - Migration and DiasporaMayans in contemporary United States

**Textbooks:**

1. There is no prescribed text-book for this course. Targeted readings including relevant book chapters, journal articles etc. will be provided for each days lesson.

**Reference Books:**


1. Bricker, Victoria., The Indian Christ, the Indian King: the Historical Substrate of Maya Myth and Ritual, 1981

2. Clendinnen, Inga., Ambivalent Conquests: Maya and Spaniard in Yucatan, 1517-1570, 1987

3. Coe, Michael, The Maya, 2005.

4. Farriss, Nancy., Maya Society Under Colonial Rule: The Collective Enterprise Of Survival, 1984.

5. Fischer, Edward F. and Peter Benson, Broccoli and Desire: Global Connections and Maya Struggles in Postwar Guatemala, 2006.

6. Loucky, James and Marilyn M. Moors eds., The Maya Diaspora: Guatemalan Roots, New American Lives, 2000

7. Mench, RigobertaI, Rigoberta Mench: An Indian Woman in Guatemala, 1984

8. Patch, Robert Maya Revolt and Revolution in the Eighteenth Century, 2002

9. Rugeley, Terry Yucatns Maya Peasantry and the Origins of the Caste War, 1996

10. Schele, Linda and David Friedel, A Forest of Kings: Untold Stories of the Ancient Maya, 1990

11. Stephens, John Lloyd Incidents of Travel in Central America, Chiapas and Yucatan, 1993.

12. Warren, Kay Indigenous Movements and Their Critics: Pan-Maya Activism in Guatemala, 1998


## 12.116 HS 582: Energy Economics

**Course Code: HS 582**

**Course Name: Energy Economics**

L-T-P-C: 3-0-0-3
Students intended for: B. Tech./M.S./Ph.D.
Elective or Compulsory: Elective
Approval: 10th Senate

**Course Contents**

- **Orientation** [3 Lectures]
  - The rejuvenation of energy economics- with OPEC and the oil price shocks in 1970s and with climate change debates in 1990s
  - Recapitulation of some basic concepts: behavior of consumer, producer, prosumer (production by consumer), elasticity, growth rate, resource rent, rate of discount, net and present value, internal rate of return, energy intensity

- **An introduction to energy resource** [3 Lectures]
  - Classification of energy resource- depletable and non-depletable, primary and secondary, commercial and non-commercial
  - Units, conversion factors and aggregations of energy flow
  - Energy accounting framework-introduction to Energy Balance Statistics with example from India;
- **Basics of energy demand** [15 Lectures]
  - Evolution of energy demand analysis;
  - Economic foundations of energy demand consumer demand for energy, producer demand (input demand) for energy;
  - Introduction to analytical frameworks- accounting approach (decomposition analysis), econometric approach and techno-economic approach;
  - Energy demand management;
  - Rebound effect
- **Basics of energy supply** [15 Lectures]
  - Depletable primary energy resource- economics of exploration, optimal extraction rule, investment decision, resource production- coal, oil, natural gas; relation between discovery and production, depletion dimension;
  - Economics of secondary energy supply (electricity);
  - Economics of renewable energy supply- growth curve and rate of exploitation; drivers of renewable energy, cost features, support mechanism (feed-in-tariff, competitive bidding process, renewable obligations)
  - New economic principle when conventional consumer-producer divide is blurred
- **Energy access** [3 Lectures]
  - Energy use ladder;
  - Indicators of energy poverty; Affordability
  - Energy poverty and/or environmental protection A critical analysis
- **Energy Security** [3 Lectures]
  - Indicators of energy security- dependence, concentration and diversity of supply; optimal level of energy dependence; Geopolitics
  - Policies to enhance energy security import restriction and diversification, diversification of fuel mix, energy efficiency improvement;
  - Trade-off between energy security and climate change mitigation

**Course reading:**

1. Stevens, P., **An Introduction to Energy Economics**, In Stevens, P. (ed.) The Economics of Energy, Vol. 1, Edward Elgar, 2000.
2. Bhattacharyya, Subhes. C., **Energy Economics: Concepts, Issues, Markets and Governance**, Springer, 2011. (Selected chapters)
3. Hartwick, J. M, and Olewiler, N. D., **The Economics of Natural Resource Use**, Harper and Row Publishers, 1986.
4. GEA, 2012: Global Energy Assessment - Toward a Sustainable Future, Cambridge University Press.

## 12.117 HS 600: Research Methodology

**Course Code : HS 600**

**Course Name : Research Methodology**

L-T-P-C : 1-0-0-1
Intended for : Ph.D./ MA by Research students at SHSS
Prerequisite :
Mutual Exclusion:
Approval: 54th BoA

**Course Contents**

- Thinking like a researcher (2 Hours)
  - What constitutes research?
  - Types of research
  - What is the role of a researcher?
  - Concepts and constructs
  - How to write a research proposal
- Selecting and defining a research problem (2 Hours)
  - Propositions and hypothesis formulation
  - Framing research objectives
  - Framing research questions
- Literature Review (2 Hours)
  - Scoping and identification of a preliminary set of literature
  - Annotated bibliography vis-a -vis literature review
  - Methods of literature review
  - Summarizing literature review
- Managing Bibliography (2 Hours)

  - Types of citations
  - Formats of bibliography
  - Use of bibliography software
- Research Communication (2 Hours)
  - Oral communications
  - Written communications
  - Making effective presentations
  - Use of multimedia
- Interpersonal Skills: Building academic relationships (1 Hour)
  - Interaction with co-researchers and supervisors
  - Effective workplace communication 2
- Research Ethics (1 Hours)
  - Work-ethic (Time, quality, integrity of research input)
  - Acquiring permission to use printed material/images from artists
  - Vigilance against unintentional plagiarism
- Field Work (1 Hour)
  - Different types of field work
  - Need for field work
  - Field work protocols
- Managing Resources ( 1 Hour)
  - Key funding agencies in HSS
  - How to manage and keep account of financial resources
  - Library resources at IIT Mandi
  - Other recourse at IIT Mandi

**Textbooks:**

1. NA

**References:**

1. NA

## 12.118 HS 601: Literary Methods: Theory and Interpretation

**Course Code: HS 601**

**Course Name: Literary Methods: Theory and Interpretation**

L-T-P-C : 3-0-0-3
Prerequisites : Consent of the Course Instructor
Students intended for : Ph.D.
Elective/Compulsory : Elective
Approval: 6th Senate

**Course Contents**

- **Introduction and Traditional Literary Criticism** What is Literary Theory? Theory and Philosophy, Empiricism, Positivism and other Early Approaches. [3 Lectures]
- **New Criticism and Formalism** Including Russian Formalism. Viktor Shklovsky, Jakobson, I. A. Richards, Cleanth Brooks and Wayne C. Booth. [4 Lectures]
- **Psychoanalytic Criticism** Sigmund Freud, Carl Jung, Lacan. [3 Lectures]
- **Marxist Criticism** Karl Marx, Terry Eagleton, Fredric Jameson, Raymond Williams, Louis Althusser, Walter Benjamin, Antonio Gramsci, Georg Lukacs, Friedrich Engels, Theordor Adorno. [6 Lectures]
- **Structuralism and Semiotics** Ferdinand de Saussure, Claude Lvi-Strauss, Noam Chomsky, Roland Barthes, Umberto Eco. [6 Lectures]
- **Postmodern Criticism** Immanuel Kant, Friedrich Nietzsche, Jean Paul Sartre, Jacques Derrida, Jean-Franois Lyotard, Martin Heidegger, Gilles Deleuze and Felix Guattari [6 Lectures]
- **New Historicism and Culture Materialism** Michel Foucault, Hayden White, Stephen Greenblatt, Pierre Bourdieu. [5 Lectures]
- **Postcolonial Criticism** Edward Said, Gayatri Spivak, Homi Bhabha, Ngugi wa Thiong'o, Albert Memmi, Frantz Fanon, Amie Cesaire, [5 Lectures]
- **Gender Studies and Queer Theory** Simone de Beauvoir, Elaine Showalter, Helene Cixous, Julia Kristeva, Judith Butler, Eve Sedgwick, Robert Bly. [4 Lectures]

## 12.119 HS 602: Indian Writing in English

**Course Code: HS 602**

**Course Name: Indian Writing in English**

L-T-P-C : 3-0-0-3
Prerequisites : Consent of the Course Instructor
Students intended for : Ph.D.
Elective or Compulsory: Elective
Approval: 6th Senate

**Course Contents**

- **Module I: Fiction** [15 Lectures]
  - Raja Rao. Kanthapura. 1938
  - Kamla Markandaya. Nectar in a Sieve. 1954
  - Manohar Malgaonkar. A Bend in the Ganges.1964
  - Salman Rushdie. Midnights Children. 1980
  - Arundhati Roy. The God of Small Things. 1997
- **Module II: Drama** [15 Lecture hours]
  - Asif Currimbhoy. Goa. 1964
  - Girish Karnad. Hayavadana.1971
  - Vijay Tendulkar. Kamala. 1982
  - Gurcharan Das. Larins Sahib.2003
  - Mahesh Dattani. Brief Candle. 2010
- **Module III: Poetry** [12 Lectures]
  - Early poetry A selection of poem from the poetry of Derozio, Toru Dutt, Tagore, Sarojini Naidu and Sri Aurubindo.
  - Later Poetry A selection of poetry from the poems of from Nissim Ezekiel, Kamla Das, Eunice De Souza, Arun Kolatkar, Jayant Mahapatra, A.K. Ramanujan, Agha Shahid Ali, Sujata Bhatt

**Backgroung reading:**


1. Aijaz Ahmad, **In Theory: Classes, Nations, Literatures**.
2. A.K. Mehrotra, **An Illustrated History of Indian English Writing**.
3. Aparna Bhargava Dharwadker, **Theatres of Independence, Drama, Theory and Urban Performance in India since 1947**.
4. Gauri Vishwanathan, **Masks of Conquest**.
5. Meenakshi Mukherjee, **The Twice Born Fiction; Themes and Techniques of the Indian Novel in English**.
6. M.K. Naik and S. Mokashi-Punekar, P**erspectives on Indian Drama in English**.
7. Rajeswari Sunder Rajan, ed., **The Lie of the Land: English Literary Studies in India**.
8. Harish Trivedi, **Colonial Transactions: English Literature and India**.
9. Ranajit Guha, A Subaltern Studies Reader, 1986-1995.
10. Salman Rushdie, **Imaginary Homelands**.

11. Susie Tharu and K Lalitha, **Women Writing in India**, Vol I and II
12. Svati Joshi, **Rethinking English: Essays in Literature, Language, History**.
13. Vasudha Dalmia, **Poetics, Plays and Performances: The Politics of Modern Indian Theatre**.

## 12.120 HS 606: Political Philosophy

**Course Code: HS 606**

**Course Name: Political Philosophy**

L-T-P-C: 4-0-0-4

Pre-Requisites: For research scholars; familiarity with history of Western thought and Teachers Consent

Intended for: PG

Elective/Core: Elective

Approval: 8th Senate

### Course Contents

The course seeks to examine the following aspects: the human sense of justice; the quest for and the pursuit of the Good Life; the theoretical study of political life constituting political theory; political philosophy proceeding from the Classics to pose the problems of the unexamined life and to investigate political life as it ought to be; the search for the right order of public life, the constraints it encounters and the resources it seeks in its bid to tame power and compound the ruler and the ruled into the true frame of a commonweal.

Samplings from some of the following representative texts seek to familiarize the scholar with the long tradition of politico-philosophic writing:

1. Plato: **Republic**, Book II 2. Aristotle: **Nicomachean Ethics**, Book III; **Politics**, Book II 3. Xenophon: **Cyropaedia** 4. St Augustine: **City of God**, Part II, Books xi to xiv; 5. Machiavelli: **Discorsi**, Book I, Chs. 1-20 6. Shakespeare: **The Tempest** 7. Montesquieu: **The Spirit of the Laws**, Book 17 8. Thomas Hobbes: **Leviathan**, Part I; 9. Rousseau: **mile**, or **On Education**; 10. Immanuel Kant: **Idea for a Universal History from a Cosmopolitan Point of View**; 11. Edmund Burke: **Reflections on the Revolution in France**; 12. Karl Marx: **Preface to the Critique of Political Economy**; 13. John Stuart Mill: **Utilitarianism**; 14. Thoreau: **On Civil Disobedience**; 15. Gandhi: **Satyagraha**; 16. Carl Mitcham:**Technology and the Character of the Good Life**.

### Prescribed Reading:

1. Cassirer, Ernst, The Myth of the State. New Haven/New York (Yale U.P.) 1946.
2. Germino, Dante, Machiavelli to Marx. Modern Western Political Thought. Chicago 1979.
3. White, Michael J., Political Philosophy. An Historical Introduction. Oxford 2003.

**Select Bibliography:**


1. Cohen, Martin, Political Philosophy. From Plato to Mao. London 2001.
2. Cushman, Robert E., Therapeia. Platos Conception of Philosophy. North Carolina 1958.
3. Goodin, Robert E./Pettit, Philip (Ed.), Contemporary Political Philosophy. An Anthology. Oxford 1997.
4. Kailitz, Steffen, Schlsselwerke der Politikwissenschaft. Wiesbaden 2007.
5. Kymlicka, Will, Justice in Political Philosophy, 2 Volumes. Aldershot 1992.
6. Matravers, Derek/Pike, John, (Ed.), Debates in Contemporary Political Philosophy. An Anthology. London 2003.
7. Meier, Heinrich, Warum Politische Philosophie? Stuttgart 2000.
8. Oakeshott, Michael, Rationalism in Politics. LSE Inaugural Lecture. London 1962. (any edition).
9. Rawls, John, Lectures on the History of Political Philosophy. Harvard 2008.
10. Strauss, Leo, What is Political Philosophy? New York 1973.
11. Strauss, Leo/Cropsey, Joseph, History of Political Philosophy. Chicago 1987.
12. Voegelin, Eric, the New Science of Politics. Chicago 1952.


## 12.121 HS 607: Weimar Classicism

**Course Code: HS 607**

**Course Name: Weimar Classicism**

L-T-P-C: 3-0-0-3
Pre-Requisites: Proven Competence in German and Teachers Consent
Intended for: PhD
Elective/Core: Elective
Approval: 8th Senate

**Course Contents**

- A. **Excerpts from select texts as illustration of chosen themes:**
  - Aesthetic Autonomy and Self-Containment - Goethe: Wilhelm Meisters Lehrjahre;
  - Aesthetic Education as Political Propedeutic - Schiller: Ober die asthetische Erziehung des Menschen;
  - Antiquity and History - Schiller: Was heifJt und zu welchem Ende studiert man Universalgeschichte?
  - Classical Drama- Schiller: Die Braut von Messina; Goethe: Iphigenie aufTauris

- Classical Poetry - Later Poems of Goethe ( from HA, Vol. II); Holderlin: Poems (Reclam Anthology, Ed. W.Braungart)
- Classical Restraint - Goethe: Ober Laokoon; Goethe: Hermann und Dorothea (Bk. VIII); Classical Science- Goethe: Metamorphose der Pflanzen;
- Classicism as Typology - Goethe: Literarischer Sansculattismus; Goethe: Klassiker und Romantiker in Italien, sich heftig bekampfend; Herder: Fragmente iiber die neuere deutsche Literatur;
- Erotica- Goethe: Romische Elegien
- Faustian Classicism- Goethe: Faust II (Helena Act and Classical Walpurgis Night)
- The French Revolution- Goethe: Campagne in Frankreich

- B. **In addition, following aspects shall be examined in brief:**
  - Correspondence between Goethe and Schiller; their response to the French Revolution; Journalistic Contributions: Die Horen and Jenaer Allgemeine Litteraturzeitung
  - Peripheral Figures of Weimar Classicism: Wieland, Bottiger, Bertuch, Herder, Karl Phillip
  - Moritz, Jean Paul, Heinrich von Kleist, Brothers Humboldt and Schlegel; HOlderlin; Women of Weimar Classicism: Caroline von Wolzogen, Sophie Mereau

**Prescribed Reading:**

1. Borchmeyer, Dieter, Weimarer Klassik. Eine Einftihrung. Hemsbach 1998.
2. Bruford, Walter, Kultur und Gesellschaft im klassischen Weimar 1775-1806. Gottingen 1966.
3. Doering, Sabine/Schulz, Gerhard, Klassik. Geschichte und Begriff. Mlinchen 2003.
4. Richter, Simon (Ed.), The Literature of Weimar Classicism. The History of German Literature, Volume 7. Rochester 2005.

**Select Bibliography:**

1. Bockholdt, R. (Hg.), Uber das Klassische. f rankfurt am Main 1987.
2. Conrady, K. 0. (Hg.), Deutsche Literatur zur Zeit der Klassik. Stuttgart 1977.
3. Eliot, T. S., Was ist ein Klassiker?- Dante- Goethe der Weise. Frankfurt am Main 1963.
4. Grimm, R./Hermand, J. (Hg.), Die Klassik-Legende. Frankfurt am Main 1971.
5. Herzog, R./Koselleck, R. (Hg.), Epochenschwelle und Epochenbewusstsein. Mlinchen 1987.

6. Manger, Klaus, Klassizismus und AufkHirung. Das Beispiel des spaten Wieland. Frankfurt am Main 1991.

7. MUller-Seidel, W., Aufklarung und Weimarer Klassik. Wiederaufnahme einer Diskussion [mit Beitragen von J. McCarthy, D. Borchmeyer, Chr. Jamme, A. Stephens]. In: Jb. d. Dt. Schillergesellschaft XXXVI (1992) S. 409-454.

8. Reed, T. J., Die klassische Mitte. Goethe und Weimar. 1775-1832. Stuttgart 1982.

9. Simm, H. - J. (Hg.), Literarische Klassik. Frankfurt am Main 1988.

10. Vosskamp, W. (Hg.), Klassik im Vergleich. Normativitat und Historizitat europaischer Klassiken. Stuttgart, Weimar 1993.

## 12.122 HS 608: Modern Western Social Thought

**Course Code: HS 608**

**Course Name: Modern Western Social Thought**

L-T-P-C: 3-0-0-3
Prerequisites: M.A. and Ph.D. students in HSS
Intended for: Ph.D.
Distribution: Core/Compulsory Course for SHSS Ph.D.
Approval: 10th Senate

**Course Contents**

- Unit I: **Emergence of Modern Society** [10 Lectures]
- The Intellectual Break with Tradition The philosophic underpinnings The Scientific Revolution - The socio-political conditions: industrialization, urbanization; the birth of ideology the idea of progress (6 contact hours)
- Unit II: **Some Approaches to the Study of Modern Society** [10 Lectures]
  - Individual & Community; Church & State; State as Actor in World History (Hegel)
  - Critique of Political Economy (Marx)
  - The Protestant work ethic (Weber), Division of Labour (Durkheim)
  - Urban society (Simmel, Lewis Mumford, Lewis Wirth)
  - Civilization and its Discontents (Freud)
- Unit III: **Political Thought** [12 Lectures]
  - Principato civile (Machiavelli); Three Forms of the Modern European State (Minogue)
  - Primary Social Goods and the Problem of Distributive Justice (Rawls, Dworkin, Nozick); Communitarianism and the Philosophy of the Common Good (Sandel, Taylor)

  - Open Society (Popper, Bergson); Democracy and Citizenship (Habermas: Civic Republicanism); Representation in Politics (Voegelin)
  - The Quarrel between the Ancients and the Moderns (Strauss/Cropsey)

- Unit IV: **Modern Economic System** [10 Lectures]
  - Capitalism and the approaches to understand Modern Economic System
    * Philosophical Foundations of Capitalism (Adam Smith)
    * Critique of Capitalism and the origin of Modern Socialism (Marx and Engels)
    * Capitalism and its Discontents
  - World System Theory (Immanuel Wallerstein)
  - Neoliberal Capitalism and Globalisation (Stiglitz/Bhagavati/Friedmann)

**Suggested General Reading:**


1. Barzun, Jacques: From Dawn to Decadence, 500 Years of Western Cultural Life, New York (Harper Collins) 2000.
2. Bell, Daniel: The End of Ideology. On the Exhaustion of Political Ideas in the Fifties, With The Resumption of History in the New Century. Harvard University Press, 2000.
3. Davies, Norman: Europe: A History, New York, OUP, 1996
4. Germino, Dante: Machiavelli to Marx, Modern Western Political Thought, University of Chicago Press, 1979
5. Hayek, Friedrich: New Studies in Philosophy, Politics, Economics and the History of Ideas, London, Routledge and Kegan Paul, 1978.
6. Hughes, Stuart: Consciousness and Society, The Re-orientation of European Social Thought 1890-1930, London, Paladin, 1973.
7. Morris, Ian: The Measure of Civilization, How Social Development Decides the Fate of Nations, Princeton University Press, 2014.
8. Plamenatz, John: Man and Society: A Critical Examination of Some Important Social and Political Theories from Machiavelli to Marx, London, Longmans, 1963.
9. Sedlacek, Tomas: Economics of Good and Evil, The Quest for Economic Meaning from Gilgamesh to Wall Street, New York, OUP 2011
10. Smith, Preserved: The Origins of Modern Culture, vols. 1 & 2. (Revised Ed.) Crane Brinton. (Collier) New York 1962.
11. Solomon, Robert C. History and Human Nature. A Philosophical Review of European Philosophy and Culture, 1750-1850. (Harvester) Brighton 1980.
12. Strauss, Leo: Liberalism Ancient and Modern, Chicago, UCP, 1989.

## 12.123 HS 610: Reading Cultural Studies

### Course Code: HS 610

### Course Name: Reading Cultural Studies

L-T-P-C : 3-0-0-3
Prerequisites : Consent of the Course Instructor
Students intended for: Ph.D.
Elective or Compulsory: Elective
Approval: 6th Senate

### Course Contents

- **Defining Culture Studies** What is culture, popular culture and culture studies? Definitions in terms of intellectual and political traditions, academic disciplines, theoretical concerns. (Raymond Williams, Richard Hoggart) [4 Lectures]
- **Production, Regulation, Ideology** Field of Cultural production, ideology, State, hegemony (Gramsci, Raymond Williams, Fiske, Bourdieu, Althusser) [11 Lectures]
- **Cultural Industry** High Art, Low Art, Mass Culture (Theodore Adorno, Walter Benjamin, Stuart Hall, Tony Bennet,) [11 Lectures]
- **Representation and Identity, Cultural Imperialism and Globalization, Gender** Frederic Jameson, Edward Said, Roland Barthes, Julia Kristeva, Judith Butler, Foucault) [11 Lectures]
- **Consumption** public vs private (Greenblatt, McLuhan) [5 Lectures]

### Reading List:


1. Adorno, Theodor & Horkheimer, Max. The Culture Industry: Enlightenment as Mass Deception. [Orig. German 1944, trans. Dialectic of Enlightenment 1972].
2. Althusser, Louis. Ideology and Ideological State Apparatuses. [Orig. French; trans. 1971].
3. Anderson, Benedict. Imagined Communities: Reflections on the Origin and Spread of Nationalism. London: Verso, 1991.
4. Appaduri, Arjun. Disjuncture and Difference in the Global Cultural Economy. [Orig. Public Culture, 1990].
5. Bakhtin, Mikhail. Carnival and Carnivalesque. [Orig. Russian 1963].
6. Barthes, Roland. Myth Today. Mythologies. Trans. Jonathan Cape. Paris: Farrar, Straus and Giroux, 1972, 109-160.
7. Baudrillard, Jean. The Precession of Simulacra. Simulations. New York: Semiotext(e), 1983, 1-80.
8. Benjamin, Walter. The Work of Art in the Age of Mechanical Reproduction. [Orig. 1936].

9. Bordo, Susan. Material Girl: The Effacements of Postmodern Culture. Unbearable Weight: Feminism, Western Culture, and the Body. Berkeley: University of California Press, 1993.

10. Bourdieu, Pierre. Pierre Bourdieu, Distinction, and The Aristocracy of Culture, Distinctions. [Orig. French 1979].

11. Butler, Judith. Imitation and Gender Insubordination. In Fuss, Diana, ed., Inside Out: Lesbian Theories, Gay Theories. Taylor & Francis. 1992.

12. Cawelti, John. The Study of Literary Formulas. Adventure, Mystery, and Romance: Formula Stories as Art and Popular Culture. Chicago: University of Chicago Press, 1976.

13. De Certeau, Michel. Introduction. The Practice of Everyday Life. Trans. by Steven Rendall. Berkeley: University of California, 1984.

14. Fiske, John. The Popular Economy. Television Culture. New York: Routledge, 1987. 253-67.

15. Foucault, Michel. The History of Sexuality, Vol. I. New York: Vintage, 1990.

16. Geertz, Clifford. Thick Description: Towards an Interpretative Theory of Culture. The Interpretation of Cultures. New York: Basic Books, 1973.

17. Gramsci, Antonio. Hegemony, Intellectuals and the State [orig. Italian 1926-1937].

18. Habermas, Jurgen. The Structural Transformation of the Public Sphere: An Inquiry into a Category of Bourgeois Society. Trans. Thomas Burger. Boston: The MIT Press, 1991.

19. Hall, Stuart. Encoding, Decoding. [orig. 1980].

20. Hobsbawm, Eric. Introduction: Inventing Traditions. In Invention of Tradition. Eds. Eric Hobsbawm and Terence Ranger. New York: Cambridge UP, 2003.

21. Jameson, Fredric. Postmodernism, or the Cultural Logic of Late Capitalism. [Orig. New Left Review, 1984]

22. Jenkins, Henry. Textual Poachers: Television Fans & Participatory Culture. New York: Routledge, 1992.

23. Lacan, Jacques. The Mirror Stage. [Orig. French 1949; trans. 1977]

24. Levi-Strauss, Claude. The Structural Study of Myth. Structural Anthropology. Vol. 1. Trans. Clair Jacobson and Brooke Grundfest Shoepf. New York: Basic, 1963.

25. Marx, Karl. Base and Superstructure. [Orig. 1859].

26. Marx, Karl, and Engels, Frederick. The Ruling Class and the Ruling Ideas. [Orig. 1845].

27. Radway, Janice. Reading the Romance. Reading the Romance: Women, Patriarchy, and Popular Literature. Revised Edition. Chapel Hill, NC: University of North Carolina Press, 1991.

28. Rubin, Gayle. Thinking Sex: Notes for a Radical Theory of the Politics of Sexuality. Pleasure and Danger. Ed. Carole Vance. London: Pandora, 1992.

29. Said, Edward. Introduction. Orientalism. New York: Pantheon Books, 1978.

30. Sedgwick, Eve Kosofsky. Introduction: Axiomatic. Epistemology of the Closet. Berkeley: University of California Press, 1990.

31. 30. Gayatri Spivak. Can the Subaltern Speak? Marxism and the Interpretation of Culture. Eds. Cary Nelson and Larry Grossberg. Chicago: University of Illinois Press, 1988.

32. Tomlinson, John. Cultural Imperialism: A Critical Introduction. Baltimore, MD: The Johns Hopkins University Press, 1991.

33. Williams, Raymond. The Analysis of Culture. [Orig. 1961].

## 12.124 HS 611: Research Writing

**Course Code: HS 611**

**Course Name: Research Writing**

L-T-P-C: 3-0-0-3
Prerequisites:M.A. and Ph.D. students in HSS
Students intended for: Ph.D.
Elective or Compulsory: Elective
Approval: 10th Senate

**Course Contents**

- **Module I** [4 Lectures]
  - Prewriting - questions and strategies. o Identification of the problem.
- **Module II** [6 Lectures]
  - Literature review.
  - Reading primary and secondary sources effectively. o Note-taking strategies..
- **Module III** [3 Lectures]
  - Types of writing: analytical, expository and argumentative.
- **Module IV** [6 Lectures]
  - Thesis statement/s and hypotheses. o Methodology.
- **Module V** [6 Lectures]

  - Creating an outline and fom1ing an argument. o Writing the introduction and conclusion.
  - Abstract writing.

- **Module VI** [6 Lectures]
  - Managing sources: referencing and citations. o Plagiarism and research ethics.

- **Module VII** [4 Lectures]
  - Results, analysis and discussion.

- **Module VIII** [4 Lectures]
  - Editing and revision strategies.

- **Module IX** [3 Lectures]
  - Presenting research.

**Reading list:**


1. Becker, Howard S. **Tricks of the Trade: How to Think About Your Research While Doing It**. Chicago: University of Chicago Press, 1998.

2. Booth, Wayne C., Gregory G. Colomb and Joseph M. Williams. T**he Craft of Research**. Chicago: Chicago University Press, 2008.

3. Machi, Lawrence A. and Brenda T. McEvoy. **The Literature Review: Six Steps to Success**. Thousand Oaks: Corwin, 2009.

4. Pinker, Stephen. **The Sense of Style: The Thinking Person's Guide to Writing in the 21th Century**. New York: Penguin, 2014.

5. Strunk Jr., William and E.B. White. **The Elements of Style**. Fourth Edition. Longman, 2000.

6. Swales, J. M. and C. B. Feak. **Academic Writing for Graduate Students**. Third edition. Ann Arbor: University of Michigan Press, 2012.

7. Zinsser, William. **On Writing Well: The Classic Guide to Writing Nonfiction**. New York: Harper Collins, 2016 (30th Anniversary edn.).


## 12.125 HS 616: Managerial Thinking and Decision Making

**Course Code: HS 616**

**Course Name: Managerial Thinking and Decision Making**

L-T-P-C: 3-0-0-3

Prerequisites: IC 210 Probability, Statistics and Random Processes; or, with instructors permission

Intended for: B. Tech./M.S./Ph.D. students

Distribution: SHSS elective for B. Tech. students; A core or elective course for M.S./Ph.D. students.

Approval: 8th Senate

**Course Contents**

- **Introduction to decision making: descriptive, normative, prescriptive styles** Introduction to decision making; Decision-making approaches: Descriptive (psychological), Normative (rational), and Prescriptive (pragmatic); Bounded rationality and satisficing. [6 Lectures]

- **Introduction to decision analysis and problem framing** Study of decision analysis and technical tools for analyzing decisions; framing decisions, applications of decisions framing to marketing and management. [6 Lectures]

- **Decision analyses for certain and uncertain (probabilistic) decision situations** Methods of decision-making under certainty; Methods of decision-making under risk and uncertainty; Sequential decisions and decision trees; Multi-Criteria decision analysis and methods of resolving tradeoffs and conflicting objectives. [8 Lectures]

- **Prediction, forecasting, and judgments** Analytical methods for predictions; Anticipating and Forecasting using non-statistical methods; Role of Intuition versus Analysis in Judgments; Use of statistical (linear regression) models to capture human intuition; Judgment of Association and Causation; Counterfactual thinking. [8 Lectures]

- **Biases and heuristics in decision making** Introduction to different heuristics and biases, endowment effect, loss aversion, status-quo bias, inter-temporal biases, availability, representativeness, anchoring-and-adjustment, illusion of control, overconfidence, and confirmation bias. [8 Lectures]

- **Decision making in groups** From individual decision making to group decision processes; group polarization; groupthink; cognitive repairs; nudges; brainstorming; decision rules. [6 Lectures]

**Textbooks:**

1. J. Edward Russo & Paul Schoemaker, Winning Decisions: Getting it Right the First Time, Doubleday, 2002.

2. John S. Hammond, Ralph L. Keeney, & Howard Raiffa, Smart Choices: A Practical Guide to Making Better Decisions,Harvard Business School Press, 1999.

**Reference Books:**

1. Allen, David (2009). Making it all Work: Winning at the Game of Work and the Business of Life. New York: Penguin (ISBN-10: 0143116622).

2. Ayres, I. (2007). Super Crunchers: Why Thinking-by-Numbers is the New Way to Be Smart. New York: Bantam Books (ISBN 0553384732).

3. Bazerman, M.H., & Moore, D. (2005, 7th ed). Judgment in Managerial Decision Making. New York: Wiley (ISBN-13: 978-0-470-04945-7).

4. Gigerenzer, G. (2000). Adaptive Thinking: Rationality in the Real World. New York: Oxford Uni- versity Press.

5. Gigerenzer, G., Todd, P., & ABC Research Group. (1999). Simple heuristics that make us smart. New York: Oxford University Press.

6. Gladwell, M. (2005). Blink: The Power Of Thinking Without Thinking. New York: Back Bay Books (ISBN-10: 0316010669).

7. Hardman, D. (2009). Judgment and Decision Making: Psychological Perspectives. New York: Wiley (ISBN: 978-1-4051-2398-3)

8. Heath, C. & Heath, D. (2007). Made To Stick: Why Some Ideas Survive And Others Die. New York: Random House (ISBN: 10-1400064287).

9. Kahneman, D. (2011). Thinking, fast and slow. New York: Farrar, Straus and Giroux.

10. Kahneman D., Slovic P., and Tversky, A. (Eds.) (1982) Judgment Under Uncertainty: Heuristics and Biases. New York: Cambridge University Press

11. Slovic, P. (2000). The Perception of Risk. Earthscan Publications.

12. Surowiecki, J. (2004). The Wisdom of Crowds. New York: Doubleday (ISBN 0-34-911605-9)

**Articles:**

Some journal articles on JSTOR and cases, articles, and teaching notes from Harvard Business School Press (http://harvardbusinessonline.hbsp.harvard.edu).

## 12.126 HS 620: Popular Narratives

**Course Code: HS 620**

**Course Name: Popular Narratives**

L-T-P-C : 3-0-0-3
Approval: 6th Senate Meeting
Prerequisites : Consent of the Course Instructor
Students intended for : Ph.D.
Elective or Compulsory : Elective
Approval: 6th Senate

**Course Contents**

- **Introduction** [4 Lectures] (4 lecture hours)
  - What is Popular? High art and low art. Paperbacks. Dime Novels. Formula and literature. Bestsellers lists and influences. Comics strips to graphic narratives.
- **Bestsellers** [24 Lectures]
  - Gothic (Mary Shelly, Bram Stoker)
  - Detective Fiction (Arthur Conan Doyle, Agatha Christie)
  - Spy Fction (Le Carre, Ian Flemming)
  - Romance (Margaret Mitchell, Daphne Du Maurier)
  - Graphic Narratives (Art Spiegelman, Marjane Satrapi)
- **Young Adult Fiction** [8 Lectures]
  - Quest Novels (J. R. R. Tolkien, J. K. Rowling, Louis Sachar)
- **Fandom** [6 Lectures]
  - (E. L. James, Hugh Howey)

**Reading List:**


1. Behler, Anne. Getting Started with Graphic Novels: A Guide for the Beginner. Reference & User Services Quarterly: 46: 2 (Winter 2006).
2. Brown, Jeffrey. Comic Book Fandom. Black Superheroes, Milestone Comics, and Their Fans. Jackson, MI: University of Mississippi Press, 2001.
3. Chandler, Raymond. The Simple Art of Murder. Originally published in Atlantic Monthly, December, 1945.
4. de Certeau, Michel. Reading as Poaching. In The Practice of Everyday Life. Translated by Steven Rendall. Berkeley, CA: University of California Press, 2002.
5. Denning, Michael. Fiction Factories: The Production of Dime Novels. In Mechanic Accents: Dime Novels and Working-Class Culture in America. Revised edition. London, UK: Verso, 1998.
6. Eisner, Will. Comics and Sequential Art. Florida: Poorhouse Press, 1985. Print.
7. Fish, Stanley. Literature in the Reader: Affective Stylistics. New Literary History 2, no. 1, A Symposium on Literary History (Autumn 1970).
8. Iser, Wolfgang. Interaction Between Text and Reader. In Prospecting: From Reader Response to Literary Anthropology. Baltimore, MD: Johns Hopkins University Press, 1993.

9. Jenkins, Henry. Scribbling in the Margins: Fan Readers / Fan Writers. Textual Poachers: Television Fans and Participatory Culture. New York, NY: Routledge, 1992.

10. Miller, Laura. The Best-Seller List as Marketing Tool and Historical Fiction. Book History 3 (2000): 286-304.

11. Penley, Constance. Feminism, Psychoanalysis, and the Study of Popular Culture. Cultural Studies. Edited by Lawrence Grossberg, Cary Nelson, and Paula A. Treichler. New York, NY: Routledge, 1991.

12. Radway, Janice. Introduction , The Readers and their Romances. In Reading the Romance: Women, Patriarchy, and Popular Literature. 2nd ed. Durham, NC: University of North Carolina Press, 1991.

13. Saxena, Vandan. And the story goes on....: Harry Potter and Online Fan Fiction. Technoculture 2 (2012).

14. Twitchell, James B. Paperbacked Culture. Carnival Culture: The Trashing of Taste in America. New York, NY: Columbia University Press, 1992.

15. Wilson, Edmund. Who Cares Who Killed Roger Ackroyd? Originally published in New Yorker, January 20, 1945.

16. Zboray, Robert. Gender and Boundlessness in Reading Patterns. In A Fictive People: Antebellum Economic Development and the American Reading Public. New York, NY: Oxford University Press, 1992.

## 12.127 HS 621: Advance Qualitative Research Methods

**Course Code: HS 621**

**Course Name: Advance Qualitative Research Methods**

L-T-P-C: 4-0-0-4
Pre-requisites: Consent of the Course Instructor
Approval: 9th Senate

**Course Contents**

- Unit -I: **Foundations of Qualitative Research** Nature-characteristics-ontology-epistemology-methodology-objectivism-naturalism-positivism-steps-primacy of data-contextualization-triangulation- History of Qualitative Research, Qualitative Research Process: conceptualizing problem, conceptual mapping, Theoretical Sampling, Theoretical Saturation; Negative Cases in data; Comparing & Contrasting with quantitative research. [6 Lectures]

- Unit -II: **Major Paradigms and Approaches in Qualitative Research** Empirico-Analytical: Positivism-Natural Sciences; Interpretive: Phenomenology- Symbolic Interactionism-Hermeneutics; Critical paradigm: Psychoanalytic- Marxist-Feminist-Phenomenology-Ethnography-Ethno methodology-Grounded theory-case study-Participatory action research-Historical research-Descriptive research. [9 Lectures]

- Unit -III: **Qualitative Data Collection Methods** Interview: Structured interview, semi-structured interview, unstructured interview, individual interview, in depth interview -Observation: direct observation, indirect observation, participant observation, field observation-Focus groups-Content analysis-life histories-narrative inquiry-projective tests-dairy method-role play- simulation-case study-document studies-key informants. [12 Lectures]

- Unit -IV: **Analysing Qualitative Data** Characteristics and applications- Coding of qualitative data Axial coding- Selective coding-Content analysis-tape analysis-conversation analysis-typology- taxonomy-constant comparison-grounded theory-analytic induction-logical analysis/matrix analysis-event analysis/micro analysis-metaphorical analysis- domain analysis-hermeneutical analysis-discourse analysis-heuristic analysis- narrative analysis-semiotics-interaction analysis-dilemma analysis-logical and inductive analysis-illustrative method-analogies- Meta-analysis. [12 Lectures]

- Unit -V: **Ethics and Evaluation of Qualitative Research** Ethics in qualitative research: Protection from harm, respect for individual dignity, right to self-determination, right to privacy, confidentiality, informed consent, right to withdraw, researcher safety, deception-debriefing, use of incentives, honesty and integrity in the research process-Methodological rigour: congruence, responsiveness to social context, Appropriateness, Adequacy, Transparency- Interpretive rigour: Authenticity, Coherence, Reciprocity, Typicality, and Permeability. [5 Lectures]

Suggested Reading:


1. Berg, B., **Qualitative research methods**, Pearson, 1989.
2. Denzin, N. K. & Y. Lincoln (eds.), **Handbook of Qualitative Research**, 3rd Edition, Sage, 2005.
3. Flick, U., **An Introduction to Qualitative Research**, 3rd Edition, Sage Publications, 2006
4. Flick, U., **The SAGE Qualitative Research Kit**, Sage Publications, 2007.
5. Gubrium, J. F., & J.A. Holstein, **Handbook of interview research: context & method**, Sage, 2002.
6. Hammersley, M., & Atkinson, P., **Ethnography: Principles in Practice**, Routledge, 1995.
7. Miles, M. & M. Huberman, **Qualitative Data Analysis**, 2nd Edition, Sage, 1994.
8. Silverman, D. (ed.), **Qualitative Research**, Sage Publications, 2004.
9. Silverman, D., **Interpreting Qualitative Data**, 3rd Edition, Sage Publications, 2006.

## 12.128 HS 623: Advance Social Psychology

### Course Code: HS 623

### Course Name: Advance Social Psychology

L-T-P-C: 4-0-0-4
Pre-requisites: Consent of the Course Instructor
Approval: 9th Senate

### Course Contents

NOTE: In the articles that report empirical studies, you are not required to understand details of statistical analysis. You need to understand only the major empirical findings, simple statistical indicators such as averages and correlation coefficients, and the main theoretical ideas discussed in these articles.

- **Topic 1: Social psychology as a branch of psychology** [4 Lectures]
  - Its historical background, major features of contemporary social psychology, and methods adopted in social psychology.
- **Readings**: Baron & Byrne (10th edition)
  - Social psychology: A working definition (pp. 5-13)
  - Answering questions about social behaviour and social thought: Research methods in social psychology (pp. 18-26) (Omit section Interpreting Research Results)
- **Topic 2: Social Influence**. [5 Lectures]
  - Social facilitation, social loafing, power, and authority.
- **Readings**:
  - Grant T. & Dajee, K. (2003). Types of tasks, types of audience, types of actor: Interaction between mere presence and personality type in a simple mathematical task. Personality & Individual Differences, 35, 633-639.
  - North, A. C.; Linley, P. A. & Hargreaves, D. J. (2000). Social loafing in a cooperative classroom task. Education Psychology, 20 (4), 389-392.
- **Topic 3: Distributive and Procedural Justice**. [4 Lectures]
  - Major concepts, theories. Determinants of justice perception and justice behaviour.
- **Readings**:
  - Blader, S. L. (2007). What determines peoples fairness judgements? Identification and outcomes influence procedural justice evaluations under uncertainty. Journal of Experimental Social Psychology, 43, 986-994.
- **Topic 4: Attitudes**. [5 Lectures]

- Formation, measurement, and change. Theories and models of attitude change. Dynamics and strategies of persuasion.

- **Readings**: Baron & Byrne (10th edition).
  - Attitude formation: How and Why Attitudes Develop, 121-125, 127-140 (Omit Attitude functions).
  - Social learning: Acquiring attitudes from others; Genetic factors: Some surprising findings.
  - The attitude behaviour link: When and How Attitudes Influence Behaviour; The fine art of persuasion: Using Messages to Change Attitudes (Omit When attitude change fails).
- **Topic 5: Social Cognition**. [6 Lectures]
  - Attribution theories and attribution biases. Counterfactual thinking.
- **Readings**:
  - Augoustinos & Walker (1995). Attributional biases. pp. 67-85 (Omit Self-serving Biases).
  - Connolly, T. & Zeelenberg, M. (2002). Regret in decision-making. Current directions in Psychological Science, 11 (6), 212-216.
- **Topic 6: Self-esteem and its social context**. [6 Lectures]
- **Readings**: Baron & Byrne (10th edition).
  - Self-esteem: Attitudes about oneself, pp. 171-175. b) Other aspects of Self-functioning, pp. 175-183.
- **Topic 7: Social categorization and social identity intergroup relationships**. [6 Lectures]
- **Readings:**
  - a) Baron & Byrne (10th edition). Social categorization: The Us versus Them effect and the Ultimate Attribution Error, pp. 222-230 (Include: cognitive sources of prejudice; stereotypes: explicit and implicit; other cognitive mechanism in prejudice: illusory correlations and out-group homogeneity); (Omit Beyond the Headlines).
  - Majeed, A. & Ghosh, E. S. K. (1982). A study of social identity in three ethnic groups in India. International Journal of Psychology, 17, 455-463.
- **Topic 8: Group dynamics: Group cohesiveness; Group decision-making** [8 Lectures]
- **Readings:**
  - Alcock, Carment & Sadava (4th edition). Groups, pp. 332-338. (Include: groups, language and group identity, attraction to the group cohesiveness, group beliefs and their functions, differentiation within the group, role and status, regulation by the group: norms, group decision-making); (Omit Power).

**Suggested Reading:**

1. Alcock, Carment & Sadava (4th edition). Groups, pp. 332-338. (Include: groups, language and group identity, attraction to the group cohesiveness, group beliefs and their functions, differentiation within the group, role and status, regulation by the group: norms, group decision-making) (Omit Power).

2. Attitude formation: How and Why Attitudes Develop, 121-125, 127-140 (Omit Attitude functions).

3. Augoustinos & Walker (1995). Attributional biases. pp. 67-85 (Omit Self-serving Biases).

4. Baron & Byrne, Social Psychology (10th edition).

5. Blader, S. L. (2007). What determines peoples fairness judgements? Identification and outcomes influence procedural justice evaluations under uncertainty. Journal of Experimental Social Psychology, 43, 986-994.

6. Connolly, T. & Zeelenberg, M. (2002). Regret in decision-making. Current directions in Psychological Science, 11 (6), 212-216.

7. Grant T. & Dajee, K. (2003). Types of tasks, types of audience, types of actor: Interaction between mere presence and personality type in a simple mathematical task. Personality & Individual Differences, 35, 633-639.

8. Majeed, A. & Ghosh, E. S. K. (1982). A study of social identity in three ethnic groups in India. International Journal of Psychology, 17, 455-463.

9. North, A. C.; Linley, P. A. & Hargreaves, D. J. (2000). Social loafing in a cooperative classroom task. Education Psychology, 20 (4), 389-392.

## 12.129 HS 624: Advanced Organizational Psychology

**Course Code: HS 624**

**Course Name: Advanced Organizational Psychology**

L-T-P-C: 4-0-0-4
Pre-requisites: Consent of the Course Instructor
Approval: 9th Senate

**Course Contents**

- **Unit I: Introduction to Organizational Behaviour** [4 Lectures]
  - Historical Overview, Major Themes, Challenges and Oppmiunities, implications.
- **Readings:**
  - Robbins, S. P.; Judge, T. A.; Volua, N. (201 2). Organizat ional Behaviour (14th Edition).

- Rousseau, D.M. (1997). Organizational behavior in the new organizational era. Review of Psychology, 48, 515-546.
- O'Reilly, C. 1 991. O rganizational behavio r: Where we have been, where we're going. Annual Rev iew of Psychology, 42.

- **Unit II: Attitude and Job Satisfaction** [6 Lectures]
  - Components of attitude; Major Job attitudes, measurement, causes and impact of job satisfaction; employees' responses to job dissatisfaction
- **Readings:**
  - Robbins, S. P.; Judge, T. A.; Volua, N. (2012). Organizational Behaviour (14th Edition).
  - Baron, R. A. (1994). The Physical Environment of Work Settings: Effects on Task Performance, Interpersonal Relations, and Job Satisfaction. Research in Organizational Behavior: 46p.
  - Heerwagen, J. (2000). Green buildings, organizational success and occupant productivity. building Research & Information 28(Issue 5/6): 15p.
  - Oldham, G. R. and N. L. Ratchford (1983). Relationships between Office Characteristics and Employee Reactions: A Study of the Physical Environment. Administrative Science Quarterly 28(Issue 4): 15p.
- **Unit III: Theories of Motivation** [8 Lectures]
  - Major Theories and applications- Need Hierarchy, Two-Factor theory, Porter-Lawler Expectancy theory, Equity theory and Organizational Justice, Goal setting theory; Work Motivation; Indian perspective on Motivation: Karmayoga; Role of culture and Environment
- **Readings**:
  - Lord, R. G., Diefendorff, J. M., Schmidt, A. M., & Hall, R. J. (2010). Self-regulation at work. Annual Review of Psychology, 61, 543-568.
  - Scholer, A. A., & Higgins, E. T. (2011). Regulatory focus in a demanding world. In R. Hoyle (Ed.), Handbook of personality and self-regulation (pp. 291-314). Malden, MA: Blackwell Publishing.
  - Robbins, S. P.; Judge, T. A.; Volu-a, N. (2012). Organizational Behaviour (14th Edition)
  - BhagwadGeeta - Chapter 3- Karmayoga - for Motivation
- **Unit IV: Personality** [8 Lectures]
  - Personality Assessment: MBTl; BIG-S; Personality traits; Person-Job fit; Indian perspectives on personality: Purusa, Prakriti & Guna; Satva, Rajas, Tamas), Contemporary approaches; personality and values
- **Readings**:

  - Bhagwadgita Hall, C. S.; Lindzey, G.; Campbell, I. B. (2004). Theories of Personality (4th Edition). New York: John Wiley & Sons, Inc.
  - Mishra, G. & Mohanty, A. K. (2002). Perspectives on Indigenous Psychology. New Delhi: Concept Publishing Company.

- **Unit V: Leadership** [6 Lectures]
  - Historical Context: The Iowa studies, Ohio state studies, early Michigan studies; Major Approaches; Charismatic, Transformational, Authentic & Nurturant-Task Leadership Styles; Altemative to leadership; Role of Followers; Challenges

- **Readings:**
  - Conger, J.A. & Kanungo, R.N. (1987). Toward a behavioral theory of charismatic leadership in organizational settings. AMR, 12, 637-647.
  - Kark, R., Shamir, B. Chen, G. (2003). The two faces of transformationalleadership: Empowerment and dependency. JAP, 88(2), 246-255.
  - Howell, J.M. & Shamir, B. (2005). The role of followers in the charismatic leadership process: Relationships and their consequences. AMR, 30(1),96-112.
  - Bass, B.M. (1990). An introduction to the theories and models of leadership. Chapter 3 (pp. 37-55) of Bass & Stogdill 's handbook of leadership. NY: Free Press. (The ultimate historical reference.)
  - Hogan, R., Curphy, G.J. & Hogan, I. (1994). What we know about leadership: Effectiveness and personality. American Psychologist, 49, 493-504.
  - Pfeffer, J. (1977). The ambiguity of leadership. AMR, 2, 104-112. (Another critique of the leadership concept, though Pfeffer has since
  - Culture and Organizational Behavior (Book) - J.B.P. Sinha

- **Unit VI: Group Processes** [6 Lectures]
  - Nature, Formation and Development of Groups; Decision Making in Groups; Work Group and Work Teams; Creating Effective Teams; Group conflict and Negotiation (Processes and Strategies)

- **Readings:**
  - Guzzo, R.A. & Dickson, M.W. (1996). Teams in organizations: Recent research on performance and effectiveness. Annual Review of Psychology, 47, 307-338.
  - Kerr, N.L. & Tindale, R.S. (2004). Group performance and decision making. A nnual Review of I Psychology, 55, 623-655.
  - Martins, L.L. & Gilson, L.L. (2004). Virtual teams: What do we know and where do we go from here. JOM, 30, 805-835.
  - Goodman, P.S., Ravlin, E. & Schrninke, M. (1987). Understanding groups in organizations. ROB, 9, 121-175.
  - Robbins, S. P.; Judge, T. A.; Vohra, N. (2012). Organizational Behaviour (14th Edition)

- **Unit VII: Power and Politics** [6 Lectures]
  - Bases and Keys to Power; Power tactics; Political Behavior (Causes and Consequences); Sexual Harassment/Misuse of power; major ethical issues
- **Readings:**
  - Robbins, S. P.; Judge, T. A.; Vohra, N. (2012). Organizational Behaviour (14th Edition)
- **Unit VIII: Organizational Design** [6 Lectures]
  - Learning organization (Single loop & Double loop learning); Modern organization Designs Horizontal designs, Contemporar y designs, Network designs, vittual organization
  - **Reference**- Luthans, F., (2011 ). Organizational Behav i o ur: an evidence based approach. 12th edition. MacGra w Hill International

**Suggested Reading:**


1. Amstad, F. T., Meier, L. L., Fasel, U., Elferi ng, A., & Semmer, N. K. (2011). A meta-analysis of work -family conflict and various outcomes with a special emphasis on cross-domain versus matching-domain relations. Journal of Occupational HealtY. Psychology,16, 151-169.

2. Baron, R. A. (1994). 11The Physical Environment of Work Settings: Effects on Task Performance, Interpersonal Relations, and Job Satisfaction.11 Research in Organizational Behavior: 46p.

3. Robbins, S. P.; Judge, T. A.; Vohra, N. (2012). Organizational Behaviour (14th Edition).

4. Rousseau, D.M. (1997). Organizational behavior in the new organizational era. Annual Review of Psychology , 48, 515-546.

5. Scholer, A. A., & Higgins, E. T. (2011). Regulatory focus in a demanding worl d. In R. Hoyle (Ed.), Handbook.of personality and self-regulation (pp. 291-314). Malden, MA: Blackwell Publishing.

6. Sonnentag, S., Binnewies, C., & Mojza, E. J. (2008). Did you have a nice evening? A day-level study of recovery experiences, sleep, and affect. Journal of Applied Psychology, 93, 674-685.

7. Katz, D. & Kahn, R.L. (1966). The Social Psychology of Organizations. New York: Wiley.

8. Luhans, F., (2011). Organizational Behavi o ur: an evidence based approach. 12th edition. MacGraw Hill International.

## 12.130 HS 626: Eighteenth Century German Aesthetic and Literary Criticism

**Course Code: HS 626**

**Course Name: Eighteenth Century German Aesthetic and Literary Criticism**

L-T-P-C: 3-0-0-3
Pre-requisites: Proven Competence in German and Teachers Consent
Intended for: PG
Elective/Core: Elective
Approval: 8th Senate

### Course Contents

- SpataufkHirung: Die Idee der Aufklarung, empirischer Pragmatismus, empirische Psychologie, die philosophischen Grundlagen (Kant, Christian Wolff, Moses Mendelsohn, Herder, Karl Philipp Moritz)
- Literarische Aufklarung: Das Gute und das Moralische (Lessing), Kosmopolitismus (Wieland)
- Sturm und Drang: Asthetische Su bjektivitat, Sentimentalismus/Empfindsamkeit (Hamann, Goethe, Schiller)
- Klassizismus: Die Entdeckung der Antike, das ganzheitiche Naturbild, Goethes Urphanomen, das Asthetische als Vermittler zwischen Bildung und Harmonie, asthetischer Humanismus- Formtrieb, Stofftrieb und Spieltrieb (Schiller), Kunst als Nachahmung (Winckelmann)
- FrUhromantik: Kunstreligion, Naturals Heilstatte sowie Mysterium, die Entdeckung des Unbewussten, Ironie als Weltbi ld, Transzendentalpoesie (Schlegel)

### Suggested Reading:

Select Excerpts from standard editions:

Baumgarten: Aesthetica; Blanckenburg: Versuch Uber den Roman, BUrger: HerzensausguUber die Volkspoesie; F.Schlegel: Ober das Studium der griechischen Poesie; Goethe: Ober epische und dramati sche Dichtkunst, Zum Shakespeare-Tag; Gottsched : Versuch einer Critischen Dichtkunst, II, x; Hamann: Aesthetica in nuce; Herder: Kritische Walder, erstes Waldchen; Kant: Kritik der asthetischen Urteilskraft; Kleist: Uber das Marionettentheater; Klopstock: Von der heiligen Poesie; Lenz: Uber Gotz von Berlichingen; Lessing: Laokoon oder tiber die Grenzen der Malerei und Poesie; Moritz: Uber den Begriff des in sich Vollendeten, Uber die bildende Nachahmung des Schonen; Schiller: Uber naive und sentimentale Dichtung; Wieland: Briefe an einen jungen Dichter; Winckelmann: Gedanken tiber die Nachahmung der griechischen Werke.

### Select Bibliography:

### Books

1. Bohrer, Karl Heinz. Der romantische Brief Die Entstehung asthetischer Subjektivitat. (Suhrkamp) Frankfurt am Main 1989.

2. Eighteenth Century German Criticism. Ed. T. Chamberlain. (Continuum) New York 1992.
3. De Boor/Newald. Geschichte der deutschen Literatur. Seven Volumes. (Beck) Munich 1949 jJ.
4. Frank, Manfred. Einfiihrung in diefriihromantische Asthetik. (Suhrkamp) Frankfurt am Main 1989.
5. Haerkottler, Heinrich. Deutsche Literaturgeschichte. (Winkler) Darmstadt 2004.
6. Mein, Georg. Die Asthetik des Schbnen. (Aisthesis) Bielefeld 2000.
7. German Aesthetic and Literary Criticism, Vol. I. Ed. H.B. Nisbet (CUP) Cambridge 1 985.
8. The Cambridge History of German Literature. Ed. H. Watanabe-O'Kelly. (CUP) Cambridge 1997.
9. Wellbery, David. A New History of German Literature. (HUP) Harvard 2005.
10. Zmegac, Viktor. Geschichte der deutschen Literatur vom 18. Jahrhundert bis zur Gegenwart. Band 1 (1770-1848). (Athenaum) Bodenheim 1992.

**Journals**

1. Deutsche Viertelj'ahresschrift fiir Literaturwissenschaft und Geistesgeschichte
2. Goethe-Jahrbuch
3. Ze itschrift fur deutsche Philologie
4. Ze itschrift fiir Germanistik
5. Euphorion

## 12.131 HS 627: Readings in Eighteenth Century German Literature

**Course Code: HS 627**

**Course Name: Readings in Eighteenth Century German Literature**

L-T-P-C: 3-0-0-3
Pre-Requisites: Proven Competence in German and Teachers Consent
Intended for: PG
Elective/Core: Elective
Approval: 8th Senate

**Course Contents**

Appreciation of the principal genres such as secular poetry informed by lyrical subjectivity, the Bildungsroman, the blirgerliches Trauerspiel; their emergence against the backdrop of persistent controversies and tensions like: alien models versus national models, Greek art versus modern art, authentic versus inauthentic art; inwardness as distinctive German quality in art; the Bible as inspirational source; Enlightenment philosophy versus the claims of inspiration and intuition; folk poetry; imitation and imagination; bourgeois tragedy and national theater; writing for an audience: the literary marketplace and the journal as medium of the Englightenment.

**Suggested Reading:**

1. Goethe, Johann Wolfgang. Die Leiden des jungen Werthers. Hamburger Ausgabe, Vol. VI.
2. Goethe, Johann Wolfgang. lphigenie aufTauris. In: Klassische Dramen. Ed. D. Borchmeyer. (Dt. Klassiker Verlag) Frankfurt am Main 2008.
3. Goethe, Johann Wolfgang. Gedichte der,Sturm und Drang -Periode. In: Hamburger Ausgabe, Vol. I.
4. Goethe, Johann Wolfgang. Urfaust. In: Faust- Dichtungen, Vol. I. Ed. Ulrich Gaier. (Reclam) Stuttgart 1999.
5. Goethe, Johann Wolfgang. Winckelmann und sein Jahrhunderl. Berliner Ausgabe, Vol. XIX.
6. Holderlin, Friedrich.,Htilfte des Lebens . Stuttgarter Ausgabe, Vol. I, Ed. F. BeiBner. Munich 2004.
7. Holderlin, Friedrich. Hyperion oder der Eremeit in Griechenland. (Reclam) Stuttgart 1993.
8. Klopstock, Friedrich Gottlieb. ,Ode an Gott . Ed. H. Gronemeyer & K. Hurlebusch. Hamburger Klopstock-Ausgabe, Vol. I. (de Gruyter) Berlin/ New York 1974.
9. Lessing, Gotthold Ephraim. Nathan der Weise. Ed. V. Hantzsche & K. Bremer (Reclam S tudienausgabe) Stuttgart 2013.
10. Moritz, Karl Philipp. Anton Reiser. Ein psychologischer Roman. Ed. H. Gunther. (Insel) Frankfurt am Main 1980.
11. Schiller, Friedrich. Briefe iiber die tisthetische Erziehung des Menschen. Ed. W. Bohm. (Niemeyer) Halle 1927.
12. Schiller, Friedrich. Don Carlos. Frankfurter Ausgabe, Vol. III, 1989.
13. Schlegel, Friedrich v. Lucinde. (Reelam) Stuttgart 1999.
14. Tieck, Ludwig & Wackenroder, Wilhelm Heinrich. HerzensergiejJungen eines kunstliebenden Klosterbruders. Ed. E. Rietzschel. (Reclam) Leipzig 1981.
15. Wieland, Christoph Martin. Geschichte des Agathon. Ed. K. Manger. (Deutscher Klassiker Verlag) Frankfurt am Main 1986

**Select Bibliography:**


1. Alt, Peter-Andre. Aujklarung. (Metzler) Stuttgart 1996.
2. Eighteenth Century German Literature. Enlightenment and Sensibility. Ed. B. Becker Cantarino. Camden House History of German Literature, Vol. V. (Camden) Rochester/ New York 2005.
3. Blackall, Eric A. The Emergence ofGerman as a Literary Language 1700-1775. (Cornell University Press) Ithaca/ London 1978.
4. Bruford, Walter. Germany in the Eighteenth Century. The Social Background of the Literary Revival. (CUP) Cambridge 1965.
5. Deutsche Aujkldrung bis zur Franzosischen Revolution. Vol. 3.1 ofHansers Sozialgeschichte der deutschen Literatur vom 16. Jahrhundert bis zur Gegenwart. Ed. R. Grimminger. (Hanser) Munich 1984.
6. Guthke, KarlS. Literarisches Leben im achtzehnten Jahrhundert in Deutschland und in der Schweiz. (Francke) Bern 1975.
7. Habermas, Jiirgen. Strukturwandel der Offentlichkeit. Untersuchungen zu einer Kategorie der bilrgerlichen Gesellschaft. (Luchterhand) Neuwied 1962.
8. Heinz, Jutta. Wissen vom Menschen und Erzdhlen vom Einzelfall. Untersuchungen zum anthropologischen Roman der SpataufkHirung. (de. Gruyter) Berlin 1996.
9. Jager, Georg. Emp.findsamkeit und Roman. (Kohlhammer) Stuttgart 1969.
10. Kemper, Hans-Georg. Deutsche Lyrik der fruhen Neuzeit. Vol. 6/1: Empfindsarnkeit. (Niemeyer) Tilbingen 1997.
11. Willems, Gottfried. Geschichte der deutschen Literatur. Vol. II & III. (UTB) Stuttgart 2012, 2013 resp.
12. McCarthy, John A. Crossing Boundaries. A Theory and History of Essay Writing in German 1680-1815. (University of Pennsylvania Press) Philadelphia 1989.


## 12.132 HS 629: German Studies: An Intellectual and Cultural Approach (1750- 2000)

**Course Code: HS 629**

**Course Name: German Studies: An Intellectual and Cultural Approach (1750- 2000)**

L-T-P-C: 3-0-0-3
Pre-requisites: Proven Competence in German and Teachers Consent
Intended for: PhD Elective/Core: Elective
Approval: 8th Senate

**Course Contents**

- **Humanism:**
  - Lessing- Ideals of Enlightenment, Philosophy of Religion; Kant- Critique of Knowledge, Idea of Free Will and Moral Autonomy, Autonomy of Art; Weimar Classicism- Goethe's Concept of Weltliteratur, Schiller's Ideal of Aesthetic Education.
- **Romanticist Ideals of Art and Life:**
  - Schlegel - Transzendentalpoesie, Irony as art critique; Noval is- The Idea of Christianity and
  - Europe; Holderlin - Dialectical Idealism, The Ideals of U ni ty and Freedom.
- **German Idealism:**
  - Hegel - Dialectics; Schelling - History of World as History of Consciousness; Marx -Dialectical Materialism.
- **Jahrhundertwende:**
  - Nietzsche's Cultural Criticism...=..Revisiting_Romantici sm and Classicism; Georg Simrnel, Max
  - Weber - Lebensphilosophie, Protestant Ideals of Modernity.
- **Beginning of Modernism**
  - Freud, Psychoanal ysis; Oswald Spengler, Thomas Mann Civilisational Discontents.
- **Weimar Republic**
  - Arendt, Benjamin, Ernst Cassirer - symbolic understanding of culture. Vergangenheitsbewaltigung - Eric Voegelin; Adorno & Horkheimer - Dialectics of Enlightenment.
- **Hans Blumenberg**
  - Knowledge Critique, Metaphorology.

**Suggested Reading:**


1. Blumenberg, Hans. Asthetische und metaphorologische Schriften. Selections with an Afterword by A. Haverkamp. (Suhrkamp) Frankfurt am Main 2001.
2. Cassirer, Ernst. Was ist der Mensch? Versuch einer Philoso phie der menschl ichen Ku ltur. Trs. W. K.rampf. (Kohlhammer) Stuttgart 1 960.
3. Dilthey, Wilhelm. Das Erlebnis und die Dichtung, Lessing, Goethe, Navalis, Holder/in. (Reclam) Leipzig 1991 .
4. Dilthey, Wilhelm. Die Philosophie des Lebens. Ed. H. Nohl. (Klostermann) Frankfurt am Main 1946.

5. Freud, Sigmund. Das Unbehagen in der Kultur. (Fischer) 2007.
6. Fromm, Erich. Die Seele des Menschen. Ihre Fahigkeit zum Guten und Bosen. (Ullstein) Frankfurt am Main 1981.
7. Hegel, Georg Wilhelm Friedrich. Philosophie der Kunst oder Asthetik. Ed. A. Gethmann-Siefert & F. Kehler. (Fink) Munich 2004. .
8. Hegel, Georg Wilhelm Friedrich. Vorlesungen ii.ber die Philosophie der Weltgeschichte. (Meiner) Leipzig 1968.
9. Holderlin, Friedrich. Hyperion oder Eremit in Griechenland. Ed. J. Schmidt. (Insel) Frankfurt am Main 1984.
10. Kant, Immanuel. Anthropologie in pragmatischer Hinsicht. Ed. W. Becker. (Reclam) Stuttgart 1983.
11. Lessing, Gotthold Ephraim. Die Erziehung des Menschengeschlechts. Ed. G. Mattke. (Freies Geistesleben) Stuttgart 1958.
12. Mann, Thomas. Von Deutscher Republik, Politische Schriften und Reden in Deutschland. (S. Fischer) Frankfurt am Main 1985.
13. Marx, Karl. Uber Kultur, Asthetik, Literatur. (Reclam) Leipzig 1971.
14. Nietzsche, Friedrich. Die Geburt der Tragodie aus dem Geist der Musik. (Insel) Frankfurt am Main 2000.
15. Navalis. Werke in einem Band. Ed. H. D. Dahnke. (Aufbau) 1985.
16. Schelling, Friedrich Wilhelm Joseph. Das Wesen der menschlichen Freiheit. Ed. H. Fuhrmans. (Schwann) Dusseldorf 1950.
17. Schlegel, Friedrich v. Athenaeum.Eine Zeitschrift von August Wilhelm Schlegel und Friedrich Schlegel. Ed. F. Baader. (Pan) Berlin 1905.
18. Simmel, Georg. Kant und Goethe. Zur Geschichte der modernen Weltanschauung. (Wolff) Leipzig 1916.
19. Spengler, Oswald. Nietzsche und sein Jahrhundert. In: Reden und Aufsatze. (Beck) Munich 1938.
20. Voegelin, Eric. Die Krise. Zur Pathologie des modernen Geistes. Ed. P. Opitz. (Fink) Munich 2008.
21. Voegelin, Eric. Die neue Wissenschaft der Politik. Eine Einfuhrung. (Pustet) Munich 1 959.
22. Weber, Max. Die protestantische Ethik und der,Geist des Kapitalismus. (Finanzbuch) Munich 2006.

**Select Bibliography:**

1. Auerbach, Erich. Mimesis. Dargestellte Wirklichlichkeit in der abendlandischen Literatur. (Francke) 2001.
2. Dahrendorf, Ralf. Gesellschaft und Demokratie in Deutschland. (Piper) Munich 1965.
3. Germany. A Companion to German Studies . Ed. M. Pasley. (Methuen) London 1972.
4. Jackel, Eberhard. Das deutsche Jahrhundert. Eine historische Bilanz. (DV-A) Stuttgart 1996.
5. Kohn, Hans. The Mind of Germany. (Scribner) 1960.
6. Lowith, Karl. Von Hegel zu Nietzsche. Der Revolutionare Bruch im Denken des neunzehnten Jahrhunderts. (Fischer) Frankfurt 1969.
7. Schiller, Friedrich. Der unterschtitzte Theoretiker. Ed. G. Bollenbeck & L. Ehrlich. (Bohlau) Weimar 2007.
8. Schacht, Richard. Alienation. (Allen & Unwin) 1971.

## 12.133 HS 631: Historical Theory and Methodology

**Course Code: HS 631**

**Course Name: Historical Theory and Methodology**

L-T-P-C: 3-0-0-3
Prerequisites: Consent of the course instructor
Intended for: PG
Distribution: Elective for HSS
Approval: 8th Senate

**Course Contents**

- **The Emergence of Modern Historiography** [2 Lectures]
  - The disenchantment with the Enlightenment
  - The rise of romanticism and idealism
  - Nationalism, positivism and the rise of the modern practice of history writing
- **Positivism, Idealist History and Other Early Approaches** [4 Lectures]
  - Georg Wilhelm Friedrich Hegel
    - dialectics
    - world spirit
    - consciOusness
    - universal history

- Leopold von Ranke
    - objectivity
    - the primacy of facts
- Thomas Babington Macaulay
    - progress and linear history
- Thomas Carlyle
    - the great man theor y
- R.G. Collingwood
    - history as the stud y of the mind
    - the autonomy of action
    - reenactment
- Arnold Toynbee
    - challenge and response
    - the creative minority

- **Marxist History** [10 Lectures)
    - Karl Marx
        - production and class relations
        - historical materialism
        - commodity fetishism
        - the theory of surplus value
        - alienation
        - reification
    - Frederic Engels
        - evolutionary history
        - the interface of anthropology and history
        - d ialectical materialism
    - Antonio Gramsci
        - dominance and hegemony
        - culture
        - war of manoe uver and war of position
    - ou is Althusser
        - anti-humanism
        - epistemological break
        - anti-historicism
        - overdetermination
        - ideological state apparatus
    - British Marxist historiography
        - Maurice Dobb

    - Rodney Hilton
    - Edward P. Thompson
    - Christopher Hill
    - Eric J. Hobsbawm
  - Literature and Histor y
    - Christopher Caudwell
    - George Thomson
    - Georg Lukacs
    - Raymond Williams
    - Terry Eagleton

- Annales School [8 Lectures]
  - Mark Bloch and Lucien Febvre
    - the departure from political history
    - economic structures and relationships iii) geography and history
  - Fernand Braude!
    - time and structure
    - geography and longue duree processes
    - capitalism and civilization
  - History of Mentalities
    - Georges Duby: the three orders
    - Jacques Le Goff: merchants, churches and their time and imagination
    - Emmanuel Le Roy Ladurie: rural life
  - Quantitative history
    - Ernest Labrousse
    - Pierre Chaunu
  - Cultural practices
    - Roger Chartier

- The Narrative
  - Fredric Jameson
    - the political unconscious
    - narrative as a socially symbolic act
  - Paul Ricoeur
    - time and narrative
    - m1mes1s
  - Louis Mink
    - representation and narrative
    - narrative and cognition

- Hayden White
  - the critique of narrative history
  - emplotment
  - literary narrative and the historical narrative
- he Linguistic Turn [6 Lectures]
  - Jacques Denida
    - deconstruction
    - difference
    - arch-writing
  - Michael Foucault
    - discourse analysis
    - discursive formation
    - archaeology and genealogy
  - Jean-Franyois Lyotard
    - the critique of the metanarrative
  - Stephen Greenblatt
    - new historicism
- 7. Oral Tradition [3 Lectures]
  - Formulaic composition
    - Milman Parry
    - Albet1Lord
  - Oral tradition as history
    - Jan Vansina
    - David Henige
  - Oral history
    - Evidence and authenticity
    - shared authority
- Analysis [5 Lectures]
  - Causality
    - Mono-causal explanations
    - Mu lti-causal explanations
    - Internal and external causes
    - Laws of causality
  - The nature of generalization
    - Difference between generalization and universalization
    - Generalization and the laws of historical causation

– Argument-building
– Facts and argument
– Conjecture
– Logic in argument-building
– Rhetoric

**Bibliography:**

(Selections from the following works)


1. Abrams, Lynn. 2010. Oral History Theory. Oxon and New York: Rout ledge.
2. Agamben, Giorgio. 1993. Infancy and History: Essays on the Destruction of Experience. London and New Yark: Verso.
3. Althusser, Louis. 1990 [1969]. For Marx. London & New York: Verso.
4. Althusser, Louis and Etienne Balibar. 1970. Reading Capital . London: New Left Books.
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## 12.134 HS 632: South Indian Epigraphy

### Course Code: HS 632

### Course Name: South Indian Epigraphy

L-T-P-C: 3-0-0-3
Prerequisites: Consent of the course instructor
Intended for: PG
Distribution: Elective for HSS
Approval: 8th Senate

### Course Contents

- The Modern Study of Epigraphy [7 Lectures]
  - Epigraphy and precolonial intellectuals
    - The Mackenzie Project
    - The Kavali brothers
    - Narrain Row Brahmin and other Niyogi brahmal)as
  - James Prinsep
    - The Brahmf script deciphered
    - The KharO$.fhf script deciphered
  - European Epigraphists
    - Hermann Gundert
    - B. Lewis Rice
    - A.C. Burnell
    - John F. Fleet
    - E. Hultzsch
    - James Burgess
    - F. Kielhorn
    - Fred Fawcett
  - South Indian Epigraphists
    - R. Narasimhachar
    - T.A. Gopinatha Rao
    - Rao Bahadur V. Venkayya
    - C.R. Krishnamacharlu
    - R. Shamasastry
    - K.V. Subrahmanya Iyer
    - H. Krishna Shastri
    - M.H.Krishna
  - The state and epigraphy publication projects
    - Epigraphia Indica
    - Epigraphia Carnatica

- Epigraphia Andhrica
- South Indian Inscriptions
- Corpus Inscriptionum Jndicarum
- Travancore Archaeological Series
- Bulletin of the Rama Varma Research Institute
- Annual Report of the Mysore Archaeological Department

- The Brtihmf Script [7 Lectures]
- Part- 1
  - Debates on the origin of BrahmT
  - Script and the Mauryan political praxis
  - The weltanschauung of early BrahmT inscriptions
- Part- 2
  - Learning the BrahmT script
  - Deciphering select edicts of Asoka
- The Tamil Brtihmf Script [7 Lectures]
- Part - 1
  - Trade, religion and the introduction of script in the Tamil country
  - Script and chieftain-polities
  - Agglutinative language-structure and the adaptation of BrahmT
- Part- 2
  - Learning the Tamil Brahmf script
  - Deciphering early Tamil cave labels
- The KadaJ?'lba Script [7 Lectures]
- Part- 1
  - Statecraft and land-grants
  - The context of agrarian expansion
  - Script-monopoly and the authority of eleemosynary establishments
- Part- 2
  - Learning the Kadarrzba script
  - Deciphering select inscriptions of the Kadarrzbas
- The Vaffejuttii Script [7 Lectures]
- Part- 1

- The transition from Tamil Briihmlto Vatteluttu
- The division of labour between the Va.t.teluttu and the Grantha scripts

- Part- 2
  - Learning the Var.teluttu script
  - Deciphering select Va.t.teluttu copperplates

- The Grantha Script [7 LecturesJ

- Part- 1
  - Inflective language-use and the genesis ofthe Grantha script
  - Prasastis and the Grantha evolution

- Part - 2
  - Learning the Grantha script
  - Deciphering selecl Grunthu inscription

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3. Bulletin ofthe Rama Varma Research Institute, all volumes.
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12. Epigraphia Carnatica, all volumes.

13. Epigraphia Indica, all volumes.

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15. . 1996. Inscriptions of the Early Kadambas. New Delhi/Delhi: Indian Council of Historical Research and Pratibha Prakashan.

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19. 19. Mahadevan, Iravatham. 2003. Early Tamil Epigraphy from the Earliest Times to the Sixth Century A.D. (Harvard Oriental Series) Cambridge: Harvard University Press & C hennai : Cre-A.

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21. Ramachandra Rao, C.V. 2003. The Kavali Brothers, Col. Colin Mackenzie and the Reconstruction of South Indian History and Cultural Resurgence in South India. Nellore: Manasa Publications.

22. . 1988. Inscriptions of the Pallavas. New Delhi/Delhi: Indian Council of Historical Research.

23. Ramesh, K.V. 1984. Indian Epigraphy. New Delhi: Sundeep Prakashan.

24. (ed). 2012. Dictionary of Social, Economic, and Administrative Terms in South Indian Inscriptions. Volume I (A-D). General Editor R.S. Sharma. New Delhi: Indian Counc il of Historical Research and Oxford University Press.

25. Salomon, Richard. 1998. Indian Epigraphy. New York and Oxford: Oxford University Press.

26. Sircar, D.C. 1965. Select Indian Epigraphy. New Delhi: Motilal Banarsidass.

27. . 1966. Indian Epigraphical Glossary. New Delhi: Motilal Banarsidass.

28. Sivaramamurti, C. 1966 [1948]. Indian Epigraphy and South Indian Scripts. (Bulletin of the Madras Government Museum, New Series, General Section, vol. 3, no. 4.) Madras: Government of Madras.

29. South Indian Inscriptions, all volumes.

30. Travancore Archaeological Series, all volumes.

## 12.135 HS 633: Manuscriptology

### Course Code: HS 633

### Course Name: Manuscriptology

L-T-P-C : 3-0-0-3
Prerequisites : Consent of the course instructor
Intended for :PhD
Distribution: Elective for HSS
Approval: 9th Senate

### Course Contents

- **Introduction to Modern Manuscriptology** [12 Lectures]
  - Epigraphy and precolonial intellectuals
    - The Mackenzie Project
    - The Kavali brothers
    - Narrain Row Brahmin and other Niyogi brahmanas
  - James Prinsep
    - The Brahmz script deciphered
    - The Kharotshi script deciphered
  - European Epigraphists
    - Hermann Gundert
    - A.C. Burnell
    - E. Hultzsch
    - James Burgess
    - B. Lewis Rice
    - John F. Fleet
    - Fred Fawcett
  - South Indian Epigraphists
    - R. Narasimhachar
    - T.A. Gopinatha Rao
    - Rao Bahadur Venkayya
    - C.R. Krishnamacharlu
    - R. Shamasastry
    - K.V. Subrahmanya Iyer
    - H. Krishna Shastri
    - M.H. Krishna
  - The state and epigraphy publication projects
    - Epigraphta Indica
    - Epigraphia Carnatica
    - Epigraphia Andhrica

        * South Indian Inscriptions
        * Corpus Inscriptionum Indicarum
        * Travancore Archaeological Series
        * Bulletin of the Rama Varma Research Institute
        * Annual Report of the Mysore Archaeological Department

- **Form and Content** 4 hours
    - Forms of manuscripts
    - Writing material
    - The codex
    - Recto and verso
    - Colophons
    - The running text
    - Text with commentaries
    - Standalone commentaries
    - Indian manuscript forms like tozi s, bahis, granthavaris, pafy'is and kadatas
    - Calligraphy
- **Textual Criticism and the Production of Critical Editions** [10 Lectures]
    - Richard Bentley and the introduction of conjecture
    - Immanual Bekker's method of classification
    - Karl Lachmann's method of Stemmatics
    - The construction of cladogram
    - Identification of hyparchetypes
    - Selection, examination and emendation
    - The Tischendorf antiquity-based model
    - Bruce Metzger's method of internal and external evidences
    - The twelve principles of Kurt Aland and Barbara Aland
    - Recension
    - Evidence from commentarial sources
    - Copy-text identification and emendation
- **Models for Textual Criticism** 16 hours
    - Bruce Metzger: The Bible
    - U. V. Swaminatha Iyer: The Sangarrz anthologies
    - V.S. Sukthankar: The Mahabharata
    - D.D. Kosambi: The Satakatraya ofBhartrhari
    - The Clay Sanskrit Library Project
    - L. Basavaraju: The AdipuriiJJ.a ofParp.pa
    - Phillip B. Wagoner: The Riiyaviicakamu
    - Velcheru Narayana Rao: The Basavapurana of Palkuriki Somanatha

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(Selections from the following)


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2. Asher, Frederick M., and G. S. Gai (eds). 1985. Indian Epigraphy: Its Bearing on the History of Art. New Delhi: Oxford University Press and IBM/ American Institute of Indian Studies.

3. Bulletin of the Rama V rma Research Institute, all volumes.

4. Burnell, A.C. 1870. A Few Suggestions as to the Best Way of Making and Utilizing Copies of Indian Inscriptions. Madras: Higginbotham and Co.

5. . 1878. Elements ofSouth Indian Palaeography. London: Triibner & Co. Chakraborti, Haripada: 1974. Early Brahmi Records in India (c. 300 B.C.-C. 300 A.D.).

6. An Analytical Study: Social, Economic, Religious, and Administrative. Calcutta: Sanskrit Pustak Bhandar.

7. Corpus Inscriptionum Indicarum, all volumes.

8. Dani, Ahmad Hasan. 1986. Indian Palaeography. Second edition. Delhi Munshiram Manoharlal, 1986.

9. Das Gupta, Charu Chandra. 1958. The Development of the Kharosthi Script. Calcutta: Firma K. L. Mukhopadhyay.

10. Dikshitar, V. R. Ramachandra. 1952. Selected South Indian Inscriptions (Tamil,. Telugu, Malayalam, and Kannada). Madras: University of Madras.

11. Epigraphia Andhrica, all volumes.

12. Epigraphia Carnatica, all volumes.

13. Epigraphia Indica, all volumes.

14. Gai, G. S. 1986. Introduction to Indian Epigraphy (with Special Reference to the Development of the Scripts and Languages). Central Institute of Indian Languages Occasional Monographs Series 32. Mysore: Central Institute of Indian Languages.

15. _ . 1996. Inscriptions of the Early Kadambas. New Delhi/Delhi: Indian Council of Historical Research and Pratibha Prakashan.

16. Gupta, S.P., and K.S. Ramachandran (eds). 1979. The Origin of Brahmi Script. 2 Vols. (History and Historians of India Series). Delhi: D. K. Publications.

17. Gurukkal, Rajan. 1996. 'Writing and Its Uses in Early Tamil Country'. Studies in History (new series) 12 (1), pp. 67-81.

18. Kalaikkovan, R. et al. (eds). 2008. Airavati: Felicitation Volume in Honour of Iravatham Mahadevan. Chennai: Varalaaru.com.

19. Mahadevan, Iravatham. 2003. Early Tamil Epigraphyfrom the Earliest Times to the Sixth Century A.D. (Harvard Oriental Series) Cambridge: Harvard University Press & Chennai: Cre-A.

20. Mahalingam, T. V. 1974. Early South Indian Palaeography. (Madras University Archaeological Series, No. 1). Madras: University ofMadras.

21. Ramachandra Rao, C.V. 2003. The Kavali Brothers, Col. Colin Mackenzie and the Reconstruction of South Indian History and Cultural Resurgence in South India. Nellore: Manasa Publications.

22. - - -- . 1988. Inscriptions of the Pallavas. New Delhi/Delhi: Indian Council of Historical Research.

23. Ramesh, K.V. 1984. Indian Epigraphy. New Delhi: Sundeep Prakashan.

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25. Salomon, Richard. 1998. Indian Epigraphy. New York and Oxford: Oxford University Press.

26. Sircar, D.C. 1965. Select Indian Epigraphy. New Delhi: Motilal Banarsidass.

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28. South Indian Inscriptions, all volumes.

29. Travancore Archaeological Series, all volumes.

30. Wagoner, Phillip B. 2003. 'Precolonial Intelectuals and the Production of Colonial Knowledge'. Comparative Studies in Society and History, 45 (4), pp. 783-814.

## 12.136 HS 634: British Factories in South India

**Course Code: HS 634**

**Course Name: British Factories in South India**

L-T-P-C:: 3-0-0-3
Prerequisites : Consent of the course instructor
Intended for:PhD
Distribution:Elective for HSS
Approval: 9th Senate

**Course Contents**

- **English Trade in South Western India since circa 1650** [8 Lectures]
  - Embassy, Trade, and Intra-European Conflict in Greater Mughal World
  - Mughaifarmans and the Ear ly English Trade
  - The Head Settlement: Surat Factory,
  - Portuguese Goa, Maratha Households and Surat Establishment
  - Pattern of English trade India at the end of the seventeenth century: The Company's posted agents and brokers.
- **The Bombay Establishment** [9 Lectures]
  - Genesis ofBombay
  - Settlement-Hierarchy in English Company Trade: Bombay and its 'Outlaying Settlements'.
  - Gambroon, Aden, Mokha: The Persian-Gulf Scenario
  - Rajapur, Carwar, Tellicherry and Anjengo: Southern Coasting Trade
  - Siddis, Angria and Nayakkas: Trade, Politics and Collaboration
- **Corporate and Private Trade, Interlopers and Pirates** [8 Lectures]
  - New and Old East India Companies
  - Rival Concerns: Courtier Association and Separate Stock.
  - The United Company.
  - Private Trade: Robert Cowan, Henry Lawther, John Brddyll, Robert Adams, John Willis and Alexander Orme.
  - English Piracy: Captain Kidd and Country Pirates
- **Life in the time of a Factory**. [8 Lectures]
  - Chief and His Council
  - Factors, Linguist and Coolies.
  - Factory and Country Life: Sundry Purchases, Regular Provisions and Military Stores.
  - Company Constabulary in Bombay, Company Dependents in Tellicherry
  - Rival Factories: Dutch in Surat and French in Tellicherry
- **English Factory and Native Population in Tellicherry** [9 Lectures]
  - Tellicherry Factory in Early eighteenth century: Tellicherry Consultations
  - Truth ordeals and Hunting Games
  - Country Princes and Rebels
  - Tellicherry Syndicate of Merchants
  - Political Loyalty and Company Raj: 'the end' of eighteenth century.

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- Alterkar, A S., **The village communities of Western India**, 1963.
- Anderson, P, **The English in Western India**, 1856.
- Arasaratnam, S., **Merchants, companies and commerce on the Coromandel coast** 1650-1740, 1986
- Auber, P., **Rise and progress of the British power in India**, (2 volumes),1835.
- Bartolomeo, Fra Paolino., **A voyage to East Indies**, 1800.
- Bastin, J S., **The changing balance of the early south-east Asia Pepper trade**, 1960.
- Bayly, C A., **The New Cambridge History of India**, vol. II.1: Indian Society and the Making of the British Empire, 1988.


## 12.137 HS 636: Sociology of Religion

**Course Code: HS 636**

**Course Name: Sociology of Religion**

L-T-P-C: 3-0-0-3
Pre-requisite: None
Intended For: PhD students, SHSS
Distribution: Elective
Approval: 10th Senate

**Course Contents**

- **Module- I: Introduction** [6 Lectures]
  - Berger, Peter. The Sacred Canopy chapters 1-4 (pp. 3-10 I).
  - Swid ler, Ann. Culture in Action, ASR 1986.
  - Weber, Max . The Social Psychology of the World Religions
  - Weber, Max. The Protestant Ethic and the Spirit of Capitalism
  - Geertz Cli fford, Religi on as a Cultural System in Inte1pretation of Cultures.
- **Module- II Rituals and Practices** [8 Lectures]
  - Durkheim, Elementary Forms of Religious Life, selections
  - Douglas, Preface, A Rule of Method, The Two Bodies in Natural Symbols
  - Ortner, Theory in Anthropology Since the Sixties. Comparative Studies in Society and History. 26 (1988):1, 126-66.

- McNally, Michael. The Uses of Ojibwa Hymn Singing at White Earth: Toward a History of Practice in Lived Religion in America.
- Rosaldo, Renato. Grief and the Headhunter's Rage Introduction to Culture and Truth.
- Forbes, Cheryl. Coffee, Mrs. Cowman, and the Devotional Life of Women Reading in the Desert pp. 116-132 in Lived Religion in America
- Radway, Janice. Interpretive Communities and Variable Literacies: The Functions of Romance Reading pp. 465-486.in Rethinldng Popular Culture

- **Module- III: Authority and Legitimation** [10 Lectures]
  - Weber, Max The Sociology of Religion, chs.
  - Berger, Peter The Sacred Canopy chs. 5-7
  - Casanova, Jose, Public Religions in the Modem World, chs.l, 2, 6, 7.
  - Stark, Rodney. Secularization RIP Sociology of Religion 1999.
- **Module- IV: Approaches to the study of religion** [10 Lectures]
  - Classical approach: Durkheim, Marx, and Weber
  - Contemporary approach: Phenomenological, Neo Marxist, Freudian, New Functional, Anthropological
  - The insiders view: theologians and religious believers
  - Religions of the World: organized and non-organized e) Religious, economic, social, Cultural movements
- **Module - V: Religion and Contemporary Debates** [8 Lectures]
  - Religion and Modernity: Secularization Approaches to the Study of Religion
  - Methods of Studying Religion
  - Issues of Power and Control in Religious Organizations
  - In Indian context: Communalism and Religious Mobilizations- Broadly Religion and Politics
  - Globalization and Religion

**Essential Readings**


1. Peter van der Veer, Gods on Eatth: The management of Religious Experience and Identity in a North Indian Pilgrimage Centre, Oxford, Delhi, 1989.

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9. Beckford, James A. and Demerath III, N.J. The SAGE Handbook of the Sociology of Religion, London/New Delhi/Los Angeles/Singapore: Sage Publications.
10. Robert Bellah. 1991. Beyond Belief: Essays on Religion in a Post-Traditionalist World. University of California Press.
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12. Robert Bellah. 1986. Habits of the Heart: Individualism and Commitment in American Life
13. Geertz Clifford. 1973. The Interpretation of Cultures: Selected Essays. Basic Books
14. Jose Casanova.l994. Public Religion in the Modem World. Chicago: Chicago University Press.

## 12.138 HS 637: The Historian's Craft

**Course Code: HS 637**

**Course Name: The Historian's Craft**

L-T-P-C:3-0-0-3
Students intended for: M.A. an. d Ph.D. students in HSS
Elective or Compulsory:Elective
Approval: 9th Senate

**Course Contents**

- **Foundations**: [6 Lectures]
  - History and Social Theory
- **Subjects of History**: [9 Lectures]
  - Working Class
  - Implications of race and gender
- **Scales of History** [6 Lectures]
  - Grand narratives b. Micro-history
- 4. **Space and place**: [9 Lectures]
  - Nature and environmental history

- Nations and nationalism
- Borderlands and frontiers

- **(Re) Constructing History**: [6 Lectures]
  - Power and Knowledge
  - Memory and the Archives
  - Subaltern Studies
- **Ethical dilemmas**: [3 Lectures]
  - Writing histories of war nd genocide
- **The Future of the Discipline** [3 Lectures]
  - Interdisciplinarity
  - Digital Humanities

**Readings:**


1. Ana Maria Alonso, Thread of Blood: Colonialism, Revolution, and Gender on Mexico's Northern Frontier, (University of Arizona Press, 1995)
2. Benedict Anderson, Imagined Communities: Reflections on the Origin and Spread of Nationalism (New York: Verso, 2006).
3. Peter Burke, History and Social Theory (Ithaca: Cornell University Press, 2005)
4. Dipesh Chakrabarty, Provincializing Europe: Postcolonial Thought and Historical Difference (Princeton: Princeton University Press, 2008)
5. Mike Davis, Late Victorian Holocausts: El Nifw Famines and the J\1aking of the Third World (New York: Verso, 2001).
6. John Lewis Gaddis, The Landscape of History: How Historians Map the Past (Oxford: Oxford UP, 2004).
7. Carlo Ginzburg, The Cheese and the Worms: the Cosmos of a Sixteenth-Century Miller (Baltimore: Johns Hopkins UP, 1980).
8. Ranajit Guha, Elementary Aspects of Peasant Insurgency in Colonial India (Durham: Duke Univ Press, 1999)
9. Kenneth Pomeranz, The Great Divergence: China, Europe, and the Making of the Afodern Wol-ld Economy (Princeton: Princeton UP, 2001)
10. Joanne Rapaport, Cumbe Reborn: An Andean Ethnography of History (Chicago: Univ. Chicago Press, 1994) .
11. Joan Scotted., Feminism and History (New York: Oxford Univ Press, 1996)
12. William Sewell, Logics of History: Social Theory and Social Transformation, (Chicago: Univ. Chicago Press, 2005)

13. K. Sivaramakrishnan, Modern Forests: Statemaking and Environmental Change in Colonial Eastern India, (Stanford: Stanford Univ Press, 1999)

14. E.P. Thompson, The Making of the English Working Class (New York: Vintage Books, 1966)

15. Michel-Rolph Trouillot, Silencing the Past: Power and the Production of History (New York: Beacon Press, 1997)

## 12.139 HS 650: Statistical Methods

**Course Code: HS 650**

**Course Name: Statistical Methods**

L-T-P-C : 3-0-0-3

Prerequisites : A prior course in probability, statistics and random processes; or, discretion of the instructors

Intended for :Postgraduate and B.Tech.

Distribution : HSS Course Elective

Approval: 10th Senate

### Course Contents

- **Representation of Data and Descriptive Statistics** Raw data and frequency data- tabular and diagrammatic representation; concept of moments; measures of central tendency, dispersion, skewness, and Kurtosis; quartile and percentile their use in the measurement of inequality, Gini Coefficient and Lorenz curve; Bivariate frequency distribution, correlation coefficients- Pearson and Spearman coefficients. [6 Lectures]

- **Probability and Random Variables** Basic concepts in set theory as applied in probability; concept of probability- classical, frequency based, axiomatic approach, Bayesian probability; conditional probability, Bayes theorem, statistical independence of events; random variables discrete and continuous, probability distribution functions, cumulative distribution functions, Expectation and Variance of a random variable, joint distribution of two random variables and their correlation, law of large number. [11 Lectures]

- **Random Sampling and Parametric Statistical Inference** Concepts of population and sample, parameter and statistic, random sampling and sampling distribution, Central Limit Theorem; Expectation and Standard Error of sample mean and sample proportion; concepts of theoretical distribution: Normal distributions and four fundamental distributions derived from Normal distribution Standard Normal, Chi-square, t and F distribution; estimation and testing of hypothesis point estimation and interval estimation of parameters, Maximum Likelihood Estimator, hypothesis testing, and calculation of effect size. [9 Lectures]

- **Non-parametric Statistical Inference** Need for non-parametric tests, estimation of location and dispersion, tolerance interval; one sample and two sample non-parametric tests for location and dispersion (involving independent and related samples); non-parametric measures and tests of association. [6 Lectures]

- **Designs of Experiment** Experimental design strategies; Blocking and Randomization; Factorial design of experiments. [6 Lectures]

- **Regression Analysis and Analysis of Variance** Gauss Markov theorem and Ordinary Linear Least Square regression; interpreting regression coefficients, concepts of residual, fitted value and goodness of fit, test of significance; multiple regression analysis; two-way independent ANOVA and two-way Mixed ANOVA [8 Lectures]

**Textbooks:**


1. Field, A. P., Miles, J., & Field, Z., **Discovering statistics using R**, Sage, 2012.

2. Field, A. P., **Discovering statistics using IBM SPSS Statistics**, Sage, 2013.


**References:**


1. Agresti, A., & Finlay, B., **Statistical Methods for the Social Sciences**, 1997.

2. Arnold, J. C., & Milton, J. S., **Introduction to probability and statistics**, 2003.

3. Gibbons, J. D., Chakraborti, S., **Nonparametric Statistical Inference**, 5th Edition, Marcel Dekker, 2003.

4. Johnston, J., DiNardo, J., **Econometric Methods**, 4th Edition. McGraw-Hill, 1996

5. Montgomery, D. C., G.C. Runger, **Applied Statistics and Probability for Engineers**, 5th Edition, Wiley-India, 2011.

6. Montgomery, D. C., **Design and Analysis of Experiments**, 8th Edition. John Wiley & Sons, 2012.

7. Ross, S. M., **Introduction to probability and statistics for engineers and scientists**, Academic Press, 2014.

8. Rohatgi, V. K. &Saleh, A. K. E., **An Introduction to Probability and Statistics**, 2015.


## 12.140 HS 651: Advanced Econometrics

**Course Code: HS 651**

**Course Name: Advanced Econometrics**

L-T-P-C: 3-0-0-3
Prerequisites: Basic Econometrics
Intended for: Ph. D.
Approval: 6th Senate

**Course Contents**

- **Regression analysis** Historic origin and modern interpretation of regression, simple, two variable regression models, the method of ordinary least square, the Gauss-Markov theorem, the coefficient of determination. [8 Lectures]

- **Multiple regression analysis** three variable model, OLS and ML estimation of the partial regression coefficients, the Cobb-Douglas production function, polynomial regression models, dummy variable regression models; ANOVA and ANCOVA models, the linear probability model, the logit and probit models, the Poisson and negative binomial regression models, maximum likelihood estimation, the generalized method of moments. [12 Lectures]

- **Panel data regression model** pooled OLS regression, the fixed effects least squares dummy variable (LSDV) model, the fixed effect within group (WG) estimator, the random effects model (REM), different-in-different approach, regression discontinuity, propensity score matching. [10 Lectures]

- **Time series econometrics** stochastic processes, spurious regression, test of stationarity, unit root test, transforming non stationary time series, economic forecasting; AR, MR and ARIMA modeling of time series data, Box- Jenkins methodology, vector auto regression (VAR), testing causality using VAR: the Granger causality test, impulse response function, measuring volatility in financial time series; the ARCH and GARCH models. [12 Lectures]

**Course Readings:**


1. Jeffrey M. Wooldridge, **Introductory Econometrics: A Modern Approach**, 4th Edition (Paperback), Cengage Learning India, 2012.

2. William H. Greene , **Econometric Analysis,** 5th Edition (Paperback), Pearson Education, 2003.

3. Jeffrey M. Wooldridge, **Econometric Analysis of Cross Section and Panel Data**, 2nd Edition, MIT Press, 2010.

4. Dougherty, Christopher, **Introduction to Econometrics**, 4th Edition, 2011.

5. James D. Hamilton, **Time Series Analysis**, Princeton University Press, 1994.

6. Maddala, G. S., **Econometrics**, Mc Graw Hill, 1997.


**Further Readings:**


1. Gujarati, D. N., **Basic Econometrics**, 5th Edition, Mc Graw Hill, 2012.

2. Intrilligator M. D., **Econometric Methods, Techniques and Applications**, Prentice Hall, 1997.

3. Johnston, J., **Econometric methods**, Mcgraw Hill book Co., 1991.

4. Franses P. H., **Time Series Models for Business and Economic forecasting**, Cambridge Press, 1998.

5. Krishna, K. L., **Econometric Applications in India**, Oxford University Press, 1997.

6. Kennedy, P., **A Guide to Econometrics,** 4th Edition, MIT press, 1998.

7. Goldberger, A. S., **Introductory Econometrics**, Harvard University press, 1998.

## 12.141 HS 652: Advanced Microeconomic Theory

**Course Code: HS 652**

**Course Name: Advanced Microeconomic Theory**

L-T-P-C: 3-0-0-3
Prerequisites: Microeconomics
Intended for: Ph. D.
Approval: 6th Senate

**Course Contents**

- **Module I** Behaviouristic approach to demand analysis, Hicks logic ordering theory of demand, attribute theory of demand, Consumer theory - basic building blocks of choices and preferences leading to utility, constrained maximization problems, duality in consumer theory: expenditure and consumer preference, convexity and monotonicity, indirect utility and consumer preferences, revealed preference theory; weak and strong axiom, dynamic stability analysis; Marshallian and Walrasian stability. [12 Lectures]

- **Module II**

  - **Sub-module 1** Perfect competition and derivation of firms and industry supply curve; Alchian & Dermsetz (AER, 1972), Fama (JPE, 1980), Jensen & Meckling (JFE, 1976), Coase (Economica, 1937), theory of limit pricing; Bains model, Sylos model and generalization of Sylos model, role of sunk cost and R&D as a strategic entry barrier, non-linear pricing strategy (two- part tariff). Oligopoly and theory of game, strict and weak dominance Prisoners dilemma and instability of cartels, Nash equilibrium, pure strategy and mixed strategies, extensive games with perfect information, extensive games with imperfect information, constant sum game with a special case of zero-sum games and computation, auctions and mechanism design. [15 Lectures]

  - **Sub-module 2** Individual behavior under uncertainty, Information Economics moral hazards, adverse selection and asymmetric information. Market perfect and imperfect competition (Bilateral monopoly and duopsony). [6 Lectures]

- **Module III** Walrasian equilibrium, competitive equilibrium, Ronald Jones (1965, JPE), value judgment and welfare, social welfare and theory of social choice. Arrows theorem, measurability, comparability, and some possibilities, the Rawlsian form, the utilitarian form, flexible forms. [9 Lectures]

**Textbooks:**

1. Mas-colell, Whinston and Green, **Microeconomic Theory**, Oxford University Press,1995.
2. Robert Gibbons , **Game theory for applied economists**, Princeton University Press, 1992.
3. Hal R Varian, **Microeconomic Analysis**, W. W. Norton & Company, 1992.

**Reference Books:**

1. Bernheim, B. Douglas and Whinston, Michael, **Microeconomics**, McGraw-Hill, 2013.
2. Martin J. Osborne, **An Introduction to Game Theory**, University of Toronto, Oxford University Press, 2003.
3. James Friedman, **Oligopoly Theory**, Cambridge University Press, 2008.
4. Geoffrey, A. Jehle Philip J. Reny, **Advanced Microeconomic Theory**, 3rd Edition, Prentice Hall, 2011.
5. Joel Watson, **Strategy: An Introduction to Game Theory**, W.W. Norton & Co, 2013.
6. David M. Kreps, **A Course in Microeconomic Theory**, Princeton University Press, 1990.

## 12.142 HS 653: Environmental Economics

**Course Code: HS 653**

**Course Name: Environmental Economics**

L-T-P-C : 3-0-0-3
Students intended for : B. Tech./M.S./Ph.D.
Elective or Compulsory : Elective
Approval: 4th Senate

**Courese Contents**

- **Module I** Environmental Ecology and Economy; Pollution and Externalities - Market Inefficiency, Public Goods, Externalities and Pareto efficiency; Measurement of Environmental Values; the Theory of Environmental Policy- Pigouvian Taxes and Subsidies, Marketable Pollution Permits and Mixed Instruments (the charges and standards approach), Coases Bargaining Solution and Collective Action; Efficiency and Cost-Benefit Analysis. [9 Lectures]
- **Module II** Sustainable Development: Concepts and Stakeholders; Stakeholder Boundaries and Sustainable Development; Natural Resource Management and Sustainable Development; Global System for Sustainable Development- World Development Reports, United Nations and Sustainable Development; UNDP Millennium Development Goals; Concept of Green Economy Different Principles. [10 Lectures]

- **Module III** Theories of Optimal use of Exhaustible and Renewable Resources; Environment and Development trade off; Environmental and Natural Resource Problems in India; Framework for Sustainable Development in India; Renewable Energy Programs under Five Year Plans - Energy Issues and Policy Options for India; Population Growth - Poverty and Environment. [10 Lectures]
- **Module IV** Role of different organizations in Environment Protection -Central, State; Local Bodies and NGOs. The Institutions of Joint Forest Management; Special Economic Zones and the Environment; Corporate Social Responsibility and Sustainability; Environmental Problems of Agricultural Development; Industrial Development and Environmental Ethics; Environment Friendly Size of Firm, Limits to Growth Theory; Environmental Education and Awareness; Ramsar Convention on Wetlands, Water Crisis-Conservation of Water; Case Studies of Narmada Dam, Tehri Dam, Almetti Dam. [13 Lectures]

**Course Readings:**

1. David A. Anderson, **Environmental Economics and Natural Resource Management**, 2nd Edition, Pensive Press, 2010.
2. Bhattacharya, R.N., **Environmental Economics; an Indian Perspective**, Oxford University Press, New Delhi, 2001.

**Further Readings:**

1. H. Wiesmeth, **Environmental Economics: Theory and Policy in Equilibrium**, Springer, 2012.
2. Charles Kolstad, **Environmental Economics**, 2nd Edition, Oxford University Press, 2010.
3. Baumal, W. J. & W. E., **The Theory of Environmental Policy**, Prentice Hall, 1997.
4. Agarwal, S.K., **Environment and Natural Resources Economics**, Scott Foresman & Co., 1985.
5. Tietenberg, T., **Environmental Economics and Policy**, Harpar Collins, 1994.
6. Anil Markandya, **Dictionary of Environmental Economics**, Earthscan Publications Ltd., 2001.
7. Rest of the assigned reading will be drawn from recent newspaper, magazine articles and reports.

## 12.143 HS 654: Health Economics

**Course Code: HS 654**

**Course Name: Health Economics**

L-T-P-C: 4-0-0-4

Prerequisites: HS 202 Principles of Economics or teachers consent
Intended for: UG/PG
Approval: 8th Senate

**Course Contents**

- Module I **Overview** [4 Lectures]

**Readings:**

- Arrow, (1963). Uncertainty and the Welfare Economics of Medical Care.American Economic Review, 53(5), 941-973.
- Fuchs, (1996). Economics, Values and Health Care Reform.American Economic Review, 86(1),1-24.
- Weisbrod, (1991). The Health Care Quadrilemma: An Essay on Technological Change, Insurance, Quality of Care and Cost Containment. Journal of Economic Literature, 29(2), 523-552.
- Mehrotra, A., Adams, D., &Harod, L. (2003). Whats Behind the Health Expenditure Trend?Annual Review of Public Health.

Module II **Micro Economic Tools for Health economics** [10 Lectures]

**Readings:**

- Gertler, P., Sebastian, M., Patrick, P., Laura, R., &Christel, V. (2011). Impact Evaluation in Practice. The World Bank, Washington DC.
- Martin, R. (2001). The Mystery of the Vanishing Benefits: An Introduction to Impact Evaluation.The World Bank Economic Review,15(1), 115-140.
- Kakwani, N C., Wagstaff, A., &Doorslaer, E. V. (1997). Socioeconomic Inequalities in Health: Measurement, Computation and Statistical Inference.Journal of Econometrics 77(1), 87-104.
- Social Determinants of Health: How Social and Economic Factors Affect Health (2003). County of Los AngelesPublic Health.
- Torrance, G. (1986). Measurement of Health Status Utilities for Economic Appraisal: A Review.Journal of Health Economics, 5(1), 1-30.
- Wagstaff, A. (2002). Inequalities in Health in Developing Countries- Swimmingagainst the Tide? The World Bank, Policy Research Working Paper No. 2795.
- Garcia, P. &Mccarthy, M. (2005). Measuring Health- A Step in the Development of City Health Profiles, World Health Organisation.
- Ontario Agency for Health Protection and Promotion (Public Health Ontario) (2013). Summary measures of socioeconomic inequalities in health. Toronto, ON: Queens Printer for Ontario.

- Evers, S. (1993). Health for all indicators in health interview surveys. Health Policy, 23, 205-218.

Module III **Demand for health** [4 Lectures]

**Readings:**

- Wagstaff, A. (1986). The Demand for Health: Theory and Applications. Journal of Epidemiology and Community Health, 40(1), 1-11.
- Manning, et al. (1987). Health Insurance and the Demand for Medical Care: Evidence from a Randomized Experiment. American Economic Review, 77(3), 251-277.
- Deaton, A. (2003) Health, Inequality and Economic Development. Journal of Economic Literature,41(1), 113-158.
- Sarma,S. (2009). Demand for Outpatient Health Care: Empirical Findings from Rural India.Applied Health Economics and Health Policy.7(4), 265-77.

Module IV **Technological Change and the price of health care** [4 Lecture]

**Readings:**

- Newhouse, (1992). Medical Care Costs: How Much Welfare Loss?Journal of Economic Perspectives, 6(3), 3-21.
- Cutler &McClean, (2001). Is Technological Change in Medicine Worth It?Health Affairs, 20(5), 11-29.
- Mokyr, (1993). Technological Progress and the Decline of European Mortality. American Economic Review 83(2): 324-330.
- Cutler et. Al. (1996). Are Medical Prices Declining? Evidence from Heart attack Treatments. Quarterly Journal of Economics, 113, 991-1024.

Module V **Health Insurance, moral hazard and adverse selection** [6 Lectures]

**Readings:**

- Cutler &Zeckhauser, (1999). The Anatomy of Health Insurance.NBER Working Paper No.7176
- Cochrane, (1995). Time-Consistent Health Insurance. Journal of Political Economy, 103(3),445:473
- Pauly, M.V. (1974). Overinsurance and Public Provision of Insurance: The Roles of Moral Hazard and Adverse Selection. The Quarterly Journal of Economics, 88(1): 44-62.
- Cawley&Philipson, (1999). An Empirical Examination of Information Barriers to Trade in Insurance. American Economic Review,89(4),827-846.

- Bhattacharya, J., Goldman, D., &Sood, N. (2004). Price Regulation in Secondary Insurance Markets.Journal of Risk and Insurance, 71(4), 643-675.

- Ahuja, R. (2005). Health Insurance for the Poor in India: An Analytical Study. ICRIER, Working Paper No. 161.

- Ahuja, R., & Jutting J. (2003). Design of Incentives in Community Based Health Insurance Schemes. ICRIER Working Paper No. 95.

Module VI **Health Policies and Reforms** [6 Lectures]

**Readings:**

- Medicare Trustees, (2013). Annual Report of the Board of Trustees of the Federal Hospital Insurance and Federal Supplementary Medical Insurance Trust Fund. Washington DC.

- Or, Z., Cases, C., Lisac, M., Vrangbaek, K., Winblad, U., & Bevan G. (2010). Are health problems systematic? Politics of access and choice under Beveridge and Bismarck systems. Health Economics, Policy and Law, 5(3), 269-93.

- Peters D., Yazbeck, A.S., Sharma R., Ramana G.N.V., Pritchett L., Wagstaff, A. (2002).

- Better Health Systems for Indias Poor. Findings, Analysis and Options. Washington DC, World Bank.

- Cutler M. D. (1996). Public Policy for Healthcare. NBER Working Paper No. 5591.

- Watts J. J., & Segal, L. (2009). Market Failure, Policy Failure and other Distortions in Chronic Disease Markets.BMC Health Services Research, 9:102.

- GiZ (2012). Evaluation of Implementation Process of RashtriyaSwasthaBimaYojana in select districts of Bihar, Uttrakhand and Karnatka.

- Shariff, A. (1995). Health Transition in India. NCAER Working Paper No. 57.

Module VII **Health and Development** [16 Lectures]
**I) Economic epidemiology**

**Readings:**

- Philipson, (1996). Private Vaccination and Public Health: An Empirical Examination for U.S. Measles. Journal of Human Resources, 31(3), 611-630.

- Duraisamy, P. (1995). Morbidity, Utilisation of and Expenditure on Medical Services in Tamil nadu. Project Report, Studies on Human Development in India, CDS.

- Gumber, A. & Berman, P. (1995). Measurement and Pattern of Morbidity and Utilisation of Health Services: A Review of Health review Surveys in India. Gujarat Institute of Development Research, Working Paper No. 65.

- Krishnan, T.N. (1993). Access to Health and Burden of Treatment in India: An Inter State Comaprison. UNDP Research Project, CDS, Discussion paper No. 2.
- Sen, A.K. (1998). Mortality as an Indicator of Economic Success and Failure. The Economic Journal,1-25.
- Duraisamy, P. (2001). Health Status and Curative Health care in India. NCAER, Working Paper No.78.
- Donnell, O, Q., Doorslaer, V., Ravi, P., Garg, C., &Somanathan, A. (2005). Explaining the the incidence of catastrophic expenditures on health care: Comparative Evidence from Asia. EQUITAP Project, Working Paper No. 5.
- Garg, C., & Karan, A. (2005). Health and Millennium Development Goal 1: Reducing Out-of-pocket Expenditure to reduce income poverty- Evidence from India. EQUITAP Project, Working Paper No. 15.
- Dror, M. D., Putten, O.V., &Koren, R. (2008). Cost of Illness: Evidence from a Study in Five Resource-Poor Locations in India.Indian Journal of Medical Research, 347-361.
- Mahal, A., Karan, A., &Engelgau, M. (2010). The Economic implications of Non-communicable Disease in India. Washington, DC: World Bank.
- Mondal, S., Kanjilal, B., Peters, H., David, & Lucas, H. (2010). Catastrophic Out-of- Pocket payment for Health care and its Impact on Households: Experience from West Bengal India. Future Health Systems.
- Kumar, R., & Sharma, S.K. (2013). Trends of Communicable and Non- Communicable Morbities in Uttarakhand State: A Systematic Review.Indian Journal of Community and Health, 25(2), 178-187.

**II) Health & Obesity**

**Readings:**

- Lakdawalla, and Philipson, (2002). The Growth of Obesity and Technological Change: A Theoretical and Empirical Examination. NBER Working Paper No. 8946.
- Bhattacharya, J.,&Bundorf, K. (2005). The Incidence of the Health Care Costs of Obesity. NBER Working Paper NO. 11303.
- Lakdawalla,Philipson& Bhattacharya (2005). Welfare-Enhancing Technological Change and the Growth of Obesity. American Economic Review,95(2), 253-257.

**III) Health & ageing**

**Readings:**

- Fries, J. (1980). Aging, natural death and the compression of morbidity. New England Journal of Medicine, 303(3), 130-135.
- Emanuel, E.J. (1994). The economics of dying: the illusion of cost savings at the end of life.New England Journal of Medicine, 330(8).
- Alam, M. (2007). Ageing, Socio- Economic Disparities and Health Outcomes: Some Evidence from Rural India. Institute of Economic Growth, Working Paper No. E/290/2008.

Module VIII **Cost Benefit analysis of Health care** [1 Lecture]

**Readings:**

- Marthe, G., David, S.,& Dennis F. (2002). HALYs and QALYs and DALYs, Oh My: Similarities and Differences in Summary Measures of Population and Health. Annual Review of Public Health. 23, 115-34.

Module IX **Health infrastructure and financing** [6 Lectures]

**Readings:**

1. Selvaraju, V. (2001). Budgetary subsidies to the health sector among selected states in India. Journal of Health management, 3(2), 261-281.
2. Selvaraju V.,&Annigeri V. B. (2001). Trends in public spending on health in India. Commission on Macroeconomics and Health, ICRIER, 1-26.
3. Selvaraju V. (2003). Health care expenditure in rural India. NCAER, Working Paper No. 90.
4. Beaglehole, R., &Poz, D. (2003). Public Health Workforce: Challenges and Policy Issues.Human Resources for Health, 1-7.
5. Joe, W., & Mishra, U.S. (2009). Household Out -of -Pocket Health Expenditure in India- Levels, Patterns and Policy Concerns. Centre for Development Studies, Working Paper No. 418.
6. Anand, S., &Barnighausen, T. (2011). Health Workers at the Core of the Health System.Health Policy, doi:10.1016/j.healthpol.2011.10.012.
7. Rao, M., Rao, K.D., Kumar, S.A.K., Chatterejee, M., &Sundaraman, T. (2011). Human Resources for Health in India.Lancet, 377, 587-598.
8. Rao, G.M., &Choudhary, M. (2012). Health care Financing Reforms in India. National Institute of Public Finance and Policy, Working paper No. 2012-100.
9. Hazrika, I. (2013). Health Workforce in India: Assessment of Availability, Production and Distribution.WHO South-East Journal of Public Health,2(2), 106-112.
10. Behera, M. R. (2014). Human Resources of Health in India. International Journal of Health sciences and Research, 4(11), 244-252.

**Reference Books:**

1. Jay Bhattacharya, Timothy Hyde & Peter TU (2014), Health Economics, Palgrave Macmillan.

2. FollandGoodmand and Stano (2012), The Economics of Health and Health Care, Pearson Prentice Hall Press.

3. McDowell I, and Newell C. (1987) Measuring Health:a guide to rating scales and questionnaires, Oxford University Press.

4. Glied S. and Smith P.S. (2011),the Oxford Handbook of Health Economics, Oxford University Press, Oxford.

**Further Readings:**

1. Garber, & Skinner, (2008). Is American Health Care Uniquely Inefficient?Journal of Economic Perspectives 22(4),27-50.

2. Laura, R. (2005). A New Approach to Social assistance: Latin Americans Experience with Conditional Cash Transfer Payments. International Social Security Review 58(2), 133-161.

3. Kingsley, D. (1956). The Amazing Decline of mortality in Underdeveloped Areas. American Economic Review, 46(2), 305-318.

4. Gaynor, H.W., &Vogt,W. (2000). Are Invisible Hands Good Hands? Moral Hazard, Competition and the Second-Best in Health Care Markets. Journal of Political Economy108(5), 992-1005.

5. Crocker, & Moran (2002).Contracting with Limited Commitment: Evidence from Employment Based Health Insurance Contracts. Mimeo, University of Michigan Business School.

6. Manning, W. G. (1987).Health Insurance and the Demand for Medical Care: Evidence from a Randomised Experiment.American Economic Review, 77(3), 251-277.

7. Gumber A. (2002). Structure of Indian Health Care Market: Implications for Health Insurance Sector.Regional Health Forum, Vol.4.

8. Bhattacharya, J. & Vogt, W. (2008). Employment and Adverse Selection in Health Insurance. NBER Working Paper No. 12430.

9. David, C. (2010). How Health Care Reform Must Bend the Cost Curve.Health Affairs, 29(6),1131-35.

10. Douglas H.E., & Michael J. R. (2010). Health Care Reform is Likely to Widen Federal Budgets Deficits, Not Reduce Them, Health affairs, 29(6), 1136-41.

11. Propper, C. (2010). The Disutility of Time Spent on the United Kingdoms National Health Service Waiting Lists. Journal of Human Resources, 30(4), 677-700.

12. Quarterly NRHM-MIS Report, 2013.

13. NCMH (2005). Report of the National Commission on Macroeconomics and Health, New Delhi, Ministry of Health and Family Welfare, Government of India.

14. Bhattacharya, J. &Sood, N. (2011). Who Pays for Obesity?Journal of Economic Perspectives,25(1), 139-158.

15. Philipson, & Posner, (1995). A Theoretical and Empirical Investigation of the Effects of Public Health Subsidies for STD Testing. Quarterly Journal of Economics, 110(2), 445-474.

16. Dow et al. (1995). Disease Complementarities and the Evaluation of Public Health Interventions. NBER Working Paper No. 5216

17. Goldman, Lakdawalla, &Sood (2004). HIV Breakthroughs and Risky Sexual Behaviour.NBER Working Paper No. 10516.

18. Lakdawalla, D., Bhattacharya N., & Goldman, D.P. (2004). Are The Young Becoming More Disabled?Health Affairs, 23(1), 168-176.

19. Goldman, D., Cutler D., Shang B, & Joyce G.F. (2006). The Value of Elderly Disease Prevention. Forum of Health Economics & Policy, 9(2).

20. Bhattacharya, J., Shang B., Su C.K. & Goldman, D.P. (2005). Technological Advances in Cancer and Future Spending By the Elderly. Health Affairs, 24(2), 53-66.

21. Garg, C., &Anup, A.K. (2009). Reducing Out of Pocket Expenditures to Reduce Poverty: A Disaggregate Analysis at Rural Urban and State Level in India. Health Policy and Planning, 24, 116-128.

22. Mahal, A. et al. (2001). Who Benefits From Public Health Spending in India? NCAER, New Delhi.

## 12.144 HS 694: Readings in Himachal History and Culture

**Course Code: HS 694**

**Course Name: Readings in Himachal History and Culture**

Credits : 3
Students intended for: M.A. and Ph.D. students in HSS
Elective or Compulsory: Elective
Approval: 10th Senate

**Course Contents**

- **Concept and scope of regional studies**
- **History**
  - Pre-British Himachal
  - Himachal under the British
  - The post-Independence period d. Protest and resistance
- **Geography**
  - Ecological issues

- **Society and Culture**
  - Religion
  - Gender
  - Caste
  - Tribes

**Readings:**


1. Ahluwalia, M.S. (1998) Social, Cultural and Economic History of Himachal Pradesh, Indus Publishing Company.
2. Asboe, W. (1933). Social Functions in Lahul, K?ngra District, Panj?b. The Journal of the Royal Anthropological Institute of Great Britain and Ireland , 189-205.
3. Berti, D. (2009). Kings, Gods, and Political Leaders in Kullu (Himachal Pardesh). In M. Lacomte-Tiloune, Bards and Mediums in the Khas Kingdoms (pp. 107-136). Delhi: Himalayan Book Depot.
4. Bhatnagar, S. (1981). Politics of Land Reforms in India: A Case Study of Land Legislation in Himachal Pradesh. Asian Survey , 454-468.
5. Birta, Raghubir Singh (2007), Ecology and Human Well being: Nature and Society in Himachal Pradesh, Shipra
6. Brentnall, Mark (2005), The Princely and Noble Families of the Former Indian Empire: Himachal Pradesh v. 1, Indus.
7. Emerson, A., Howell, G., & Wright, H. (1920). Gazetteer of the Mandi State. Indus Publishing Company.
8. Gazetteer of the Simla Hill States 1910: Punjab States Gazetteer Vol VIII. (1910). B. R. Publishing Corporation.
9. Hutchison, J., & Vogel, J. P. (1933). History of Panjab Hill States Volume II. Lahore: Govt. Printing.
10. J. Ph, V. (1908). The R???s of the Panj?b Hills. The Journal of the Royal Asiatic Society of Great Britain and Ireland , 536-541
11. Jreat, Manoj (2006) Geography of Himachal Pradesh, Indus
12. Kenny, J. T. (1995). Climate, Race, and Imperial Authority: The Symbolic Landscape of the British Hill Station in India. Annals of the Association of American Geographers , 694-714.
13. Nath, Pratibha (2009) Folktales of Himachal Pradesh, Children Book Trust.
14. Parry, J. (1979) Caste and Kinship in Kangra, Routledge and Kegan Paul.
15. Sharma, B. R. (2007) Gods of Himachal Pradesh, Indus

16. Singh, C. (1988). Centre and Periphery in the Mughal State: The Case of Seventeenth-Century Panjab. Modern Asian Studies , 299-318.

17. Singh, C. (2006). Long-Term Dynamics of Geography, Religion, and Politics: A Case Study of Kumharsain in the. Mountain Research and Development , 328-335.

18. Singh, Chetan (2011) Recognizing Diversity: Society and Culture in the Himalaya, OUP

19. Singh, Mian Goverdhan (2010) Himachal Pradesh: History, Culture & Economy, Minerva. Thakur, Laxman S. ed. (2002), Where Mortals and Mountain Gods Meet, IIAS

20. Verma, V. (1999), Ban Gujars: Nomadic Tribe in Himachal Pradesh. R. Publishing,.

21. Verma, V. (2002) Kanauras of Kinnaur: schedule tribe in Himachal Pradesh , B. R. Publishing. Verma, V. (2012) Lahaul : a tribal habitat in Himachal Pradesh, B. R. Publishing.

22. Verma, V. (2009). Sikhs and the Kangra Hill States (1469-1846 A.D.). B. R. Publication Corporation.

# 13 Institute Core Courses

## 13.1 IC 101P: Reverse Engineering

**Course Code: IC 101P**
**Course Name: Reverse Engineering**

L-T-P-C: 0-0-3-2
Prerequisite: Consent of the faculty member
Students intended for: B.Tech
Elective or Core: Core
Approval: 2nd Senate

### Course contents

The students focus on either software or hardware reverse engineering (RE). In the process of RE students understand existing technologies, functions, features, objects, components and systems. By carefully disassembling, observing, testing, analyzing and reporting, students can understand how something works and suggest ways it might be improved.

This process requires careful observation, disassembly, documentation, analysis and reporting. Many times, the reverse engineering process is non-destructive. This means that the object or component can be reassembled and still function just as it did before it was taken apart.

Throughout the reverse engineering project, the students are able to think of ways these objects could be improved. Is there some way it could function better? or manufactured less expensively? The students will use observations to make suggestions for improvement of the product.

### Learning Topics

Forward Engineering Design, Design Thought and Process, Design Steps, System RE, RE Methodology, RE Steps, System level Design, and Examples, Product Development, Product Functions, Engineering Specifications, Product Architecture, Mechanical RE, Computer-Aided RE, Electronic RE, Identify electronic components, PCB RE, Schematic Drawings and Analysis, S/W RE, Reverse Engineering in Computer Applications, Re-engineering of PLC programs.

### References

1. Product Design: Techniques in Reverse Engineering and New Product Development by K. Otto and K. Wood Prentice Hall, 2001.

2. Reverse Engineering: An Industrial Perspective by Raja and Fernandes. Springer-Verlag 2008

3. RE as necessary phase by rapid product development by Sokovic and Kopac. Journal of Materials Processing Technology 2005

4. Reversing: Secrets of Reverse Engineering by Eldad Eilam Publisher: Wiley (April 15, 2005)

5. The IDA Pro Book: The Unofficial Guide to the World's Most Popular Disassembler by Chris Eagle

## 13.2 IC 102P: Foundation of Design Practicum

Course Number : IC 102P
Course Name : Foundation of Design Practicum
Credit Distribution : 3-0-2-4
Intended for : UG
Prerequisite : Consent of faculty advisor
Mutual Exclusion : None
Approval: 50th BoA

**Course Contents:**

- **Introduction:** Engineering design - How to select an engineering problem, stages of solving a problem, documentation in Engineering, Machine and a robot - Different aspects of robotics, current problems in robotics. Drives and motion, pneumatic, hydraulic systems, clutch and brake. (3 hours)
  - **Practical 1:** Microelectronics, onboard computer, IoT, embedded electronic and materials to be used in the lab Manufacturing techniques - additive and subtractive manufacturing. (3 hours)
- **Design of Mechanical Systems:** Introduction to CAD by 3D modeling software, Drawing of parts and assemblies, Computer-Aided Manufacturing and prototyping, Brief Introduction to robotic systems, Joints and transformations on ROS. (5 hours)
  - **Practical 2:** Introduction to Mechanical assembly, bill of materials, 3D modeling software and design of parts and assemblies and Static Stress Simulation. (3 hours)
  - **Practical 3:** Simulation in ROS environment (3 hours)
- **Integration of Intelligent Control:** Sensor and Actuator selection and sizing, Determination of Power Source, Design of Power distribution, microcontroller, and motor driver circuits, Developing PCB boards and feasibility testing, Introduction to standard electronic connectors and American Wire Gauge. (7 hours)
  - **Practical 4:** Sizing of sensors motors and linear actuators and integration into mechanical design. (3 hours)
  - **Practical 5:** Circuit Design using CAD tool and making PCBs manually and demonstration of CNC based PCB printing. (3 hours)
- **Programming and Signals:** Introduction to Programming; procedural vs object-oriented programming, Object-Oriented programming in practice, Signals; communication via PWM, UART, Design of hardware and software interrupts. (6 hours)
  - **Practical 6:** Introduction to Programming; procedural vs object-oriented programming. (3 hours)

- **Practical 7:** Signals; communication via PWM, UART; connecting two microcontrollers. (3 hours)
- **Practical 8:** Design of hardware and software interrupts. (3 hours)

- **Integration of Compute and networks:** Introduction to microcontroller coding and interfacing with the ros API, Introduction to ROS packages and their deployment, Introduction to IoT and IP sending receiving packets on client-server networks, Control of robotic platforms over IP, Deployment of real-time decision pipelines on the robot. (6 hours)
  - **Practical 9:** Intro to rosserial and connecting microcontrollers to ROS. (3 hours)
  - **Practical 10:** Introduction to esp8266; control via blynk. (3 hours)
  - **Practical 11:** Deployment of conditional path planning on robot and testing. (3 hours)
- **Final project:** Project towards design and development of functional Robotic system.

**Textbooks:**

1. Owen Bishop, **Robot Builder's Cookbook**
2. Gaurav Verma, **Autodesk Fusion 360**
3. Godfrey C. Onwubolu, **Introduction to SOLIDWORKS: A Comprehensive Guide with Applications in 3D Printing**

**References:**

1. Morgan Quigley, Brian Gerkey, **Programming Robots with ROS**

## 13.3 IC 110: Engineering Mathematics

**Course Code: IC 110**
**Course Name: Engineering Mathematics**

L-T-P-C: 2.5-0.5-0-3
Prerequisite: Consent of the faculty member
Students intended for: B.Tech 1st year
Elective or Core: Core
Approval: 2nd Senate

**Course contents**

- **Elementary calculus**: Zeno's Paradox Limit Continuity and Differentiability of single variables, Uniform continuity, Partial Derivatives. [2 Lectures]

- **Functions of Several Variables**: Limit Continuity and differentiability of functions of two variables, Euler's Theorem, Tangent plane and Normal, Change of variables, Chain rule.Jacobians, Taylor's Theorem for Two Variables, Strength of a Beam, Extrema of Functions of Two variables, Lagrange's method of undetermined multipliers. [10 Lectures]

- **Infinite Series**: Achelles' and Tortoise Problem, Convergence of Infinite Series of Real Numbers, Comparison Test, Ratio Test, root Test, Raabe's test, Logarithmic test, Demorgan's test, Sequence and series of functions: Uniform convergence and related tests. [6 Lectures]

- **Ordinary Differential Equations**: Origin of differential equations, Solution of linear differential equations with constant coefficients, Euler Cauchy Equations, Solution of Second Order differential Equations by change of dependent and independent variables, Method of variation of parameters for second order differential equations. [13 Lectures]

- **Integration**: Double integral and its applications[2 Lectures]

**Text Books:**


1. Wilfred Kaplan, **Advanced Calculus**, Pearson (2003).

2. George B. Thomas, Maurice D. Weir, Joel Hass, Frank R. Giordano, **Thomas' Calculus**, Pearson, 11th Edition (2004).

3. Dennis Zill, Warren Wright, **Advanced Engineering Mathematics**, Jones& Bartlett Publisher, 4th Edition (2009).


**References:**


1. Richard Courant, Herbert Robbins, Ian Stewart, **What Is Mathematics? An Elementary Approach to Ideas and Methods**, 2nd Edition, Oxford University Press (1996).

2. H. T. H. Piaggio, **An Elementary Treatise on Differential Equations**, Barman Press (2008).

3. E.Kreyszig, **Advanced Engineering Mathematics**, 9th Edition, John Wiley (2007).


## 13.4 IC 111: Linear Algebra

**Course Code: IC 111**
**Course Name: Linear Algebra**

L-T-P-C: 2.5-0.5-0-3
Prerequisite: Consent of the faculty member
Students intended for: B.Tech 1st year
Elective or Core: Core
Approval: 2nd Senate

**Course contents**

- **Matrix Theory**: Rank of Matrix, inverse of a matrix by elementary operations, Solution of linear simultaneous equations and their numerical solutions by gauss Elimination and Gauss Seidel Methods. Eigen values and eigen vectors, Cayley Hamilton Theorem, Diagonalization of Matrices. Orthogonal, Hermitian, Skew Hermitian, Normal and Unitary matrices and their elementary properties, Quadratic Forms. [12 Lectures]
- **Vector Spaces**: Vector spaces, Sub Spaces, Linear Dependences and Independences of Vectors, Span, Bases and Dimensions, Direct Sum. [12 Lectures]
- **Linear Transformations**: Linear Transformations, Linear Variety, Range Space and Rank, Null Space and Nullity, Homomorphism, Matrix of Linear Transformations, Matrix Representation of a linear transformation, Structure of the solutions of the matrix equation $Ax = b$, Change of bases. [12 Lectures]

**Text Books:**


1. G.Strang, **Linear Algebra and its Applications**, 4th Edition, Thomson, (2006).
2. K. Hoffman and R. Kunze, **Linear Algebra**, Prentice Hall, (2008).
3. H.Anton, **Elementary Linear Algebra with Applications"**, 9th Edition, John Wiley (2004).


**References:**


1. E.Kreyszig, **Advanced Engineering Mathematics**, 9th Edition, John Wiley (2007).
2. S.Kumaresan, **Linear Algebra – A Geometric Approach**, Prentice Hall of India (2004).
3. D. S. Watkins, **Fundamentals of Matrix Computations**, 2nd Edition, John Wiley & Sons (2002).


## 13.5 IC 112: Calculus

Course number : IC 112
Course Name : Calculus
Credit Distribution : 1.5-0.5-0-2
Intended for : B. Tech. 1st Year
Prerequisite : Consent of the faculty member
Mutual Exclusion : (None)
Approval: 50th BoA

**Course Contents:**

- **Elementary calculus:** Real number system, Zeno's Paradox , Limit Continuity and Differentiability of single variables, Uniform continuity, Taylor series, Partial Derivatives. [6 Lectures]
- **Functions of Several Variables:** Limit , Continuity and differentiability of functions of two variables. Euler's Theorem, Tangent plane and Normal, Change of variables, Chain rule. Jacobians, Taylor's Theorem for Two Variables, Extrema of Functions of Two variables, Lagrange's method of undetermined multipliers. [8 Lectures]
- **Infinite Series:** Achelles' and Tortoise Problem, Sequences, Convergence of Infinite Series of Real Numbers, Comparison Test, Ratio Test, Root Test, Raabe's test, Logarithmic test, Demorgan's test, Sequence and series of functions: Uniform convergence and related tests. [7 Lectures]

**Text books:**

1. Thomas and Finney, **Calculus and Analytical Geometry**, 9th Edition, Addison and Wesley Publishing Company, 1996
2. W. Rudin, **Principles of Mathematical Analysis**.

**References:**

1. E. Kreyszig, **Advanced Engineering Mathematics**, 10th Edition, Wiley.
2. J. E. Marsden, A. J. Tromba and A. Weinstein, **Basic Multivariable Calculus**, Springer, 1993.
3. Apostol, **Mathematical Analysis**, 2nd Edition.

## 13.6 IC 113 : Complex and Vector Calculus

Course number : IC 113
Course Name : Complex and Vector Calculus
Credit Distribution : (1.5-0.5-0-2)
Intended for : B. Tech. 1st Year
Prerequisite : Math 1
Mutual Exclusion : (None)
Approval: 50th BoA

**Course Contents:**

- **Complex variable**: Limit, continuity, differentiability and analyticity of functions, Cauchy-Riemann equations, line integrals in complex plane, Cauchy integral theorem, independence of path, existence of indefinite integral, Cauchy's integral formula, derivatives of analytic functions, Taylor's series, Laurent's series, Zeros and singularities, Residue theorem, evaluation of real integral [10 Lectures]

- **Integration**: Riemann integral, Double integral and its applications, Fubini's theorem, Volumes and Areas, Change of variable in double integral. Special cases: Polar coordinates, Triple integral, Applications, Change of variable in triple integral. Special cases: Cylindrical and Spherical coordinates, Surface area, Surface integral, Line integrals, Green's theorem, Vector fields Divergence and Curl of a vector field, Stoke's theorem, The divergence theorem. [11 Lectures]

**Text books:**

1. Thomas and Finney, **Calculus and Analytical Geometry**, 9th Edition, Addison and Wesley Publishing Company, 1996.
2. R. V. Churchill and J. W. Brown, **Complex Variables and Applications**, 9th Editions, 2021.

**References:**

1. E. Kreyszig, **Advanced Engineering Mathematics**, 10th Edition.
2. S. Ponnusamy, **Foundations of Complex Analysis**, 2nd Edition, Narosa, 1995.
3. J. E. Marsden, A. J. Tromba and A. Weinstein, **Basic Multivariable Calculus**, Springer, 1993.

## 13.7 IC 114 : Linear Algebra

Course number : IC 114
Course Name : Linear Algebra
Credit Distribution : 2-0-0-2
Intended for : B.Tech 1st year
Prerequisite : None
Mutual Exclusion : None
Approval: 50th BoA

**Course Contents:**

- **Matrix Theory:** Rank of Matrix, inverse of a matrix by elementary operations, Solution of linear simultaneous equations and their numerical solutions by gauss Elimination and Gauss Seidel Methods. Eigen values and eigen vectors, Cayley Hamilton Theorem, Diagonalization of Matrices. Orthogonal, Hermitian, Skew Hermitian, Normal and Unitary matrices and their elementary properties, Quadratic Forms. [7 Lectures]
- **Vector Spaces:** Vector spaces, Sub Spaces, Linear Dependences and Independences of Vectors, Span, Bases and Dimensions, Direct Sum. [7 Lectures]
- **Linear Transformations:** Linear Transformations, Linear Variety, Range Space and Rank, Null Space and Nullity, Homomorphism, Matrix of Linear Transformations, Matrix Representation of a linear transformation, Structure of the solutions of the matrix equation Ax = b, Change of bases. [7 Lectures]

**Text books:**

1. G. Strang, **Introduction to linear algebra**, 4th Edition, Wellesley Cambridge Press.

2. Kenneth Hoffman and Ray Kunze, **Linear Algebra**, PHI publication.

**References:**

1. NA

## 13.8 IC 115: ODE and Integral transform

Course number : IC 115
Course Name : ODE and Integral transform
Credit Distribution : 2-0-0-2
Intended for : B.Tech 1st year
Prerequisite : None
Mutual Exclusion : None
Approval: 50th BoA

**Course Contents:**

- **Ordinary Differential Equations**: Origin of differential equations, Formation of differential equations, Order and degree, Equation of first order and first degree, Solution of linear differential equations with constant coefficients, Euler Cauchy Equations, Solution of Second Order differential Equations by change of dependent and independent variables, Method of variation of parameters for second order differential equations, Series solution. [13 Lectures]

- **Integral transforms**: Laplace and Fourier transform, existence, linearity property, shifting property, Inverse Laplace and Fourier, Melin transform, Fourier series [8 Lecture]

**Text books:**

1. G. F. Simmons,Ordinary Differential Equations, Differential equations with applications and historical notes, 2nd Edition.

2. S. L. Ross, Introduction to Ordinary Differential Equations, Wiley, 1980.

**References:**

1. Gilbert Strang, Introduction to Applied Mathematics.

2. E. Kreyszig, Advanced Engineering Mathematics

## 13.9 IC 121: Mechanics of Particles and waves

**Course Code: IC 121**
**Course Name: Mechanics of Particles and waves**

L-T-P-C: 2.5-0.5-0-3
Prerequisite: Consent of the faculty member
Students intended for: B.Tech 1st year
Elective or Core: Core
Approval: 2nd Senate

**Course contents**

**Part I – Classical mechanics**

- **Vectors and vector calculus**: gradient, divergence and curl, line, surface and volume integrals - Helmholtz theorem. Gauss divergence, Stokes theorem - Generalized coordinates, Jacobian, Cartesian, cylindrical, and spherical coordinates. Introduction to Cartesian tensors. Vectors and vector spaces. [5 Lectures]

- **Newtonian mechanics conservation laws**: linear, angular momentum, energy-single and many particle systems. [3Lectures]

- Oscillations as application of Newtonian mechanics, Driven damped and forced oscillations, generalized vector spaces, Fourier expansion and oscillations under periodic forces, coupled oscillations and normal modes. Nonlinear oscillations. LC circuit, simple pendulum, coupled pendulum. [4 Lectures]

- Potentials and fields, Fundamental interactions in nature. Gravitational and electrostatic potentials by point particles and extended objects. Multi-pole expansion. Poisson and Laplace equation in electrostatics. [4 Lectures]

- Constraints and generalized coordinates - Lagrangian- Lagrange's equation of motion - relation to Newtonian mechanics - Two body problem - type of orbitals Variational principle of mechanics. [7 Lectures]

- Legendre transform, Hamiltonian mechanics, phase space representation Introduction to many body mechanics. [5 Lectures]

**Part II Introduction to Quantum Mechanics**

- Inadequacy of classical mechanics, Black body radiation, photo-electric effect, Classical unstable atoms, Bohr model of hydrogen atom, Frank-Hertz experiment. [3 Lectures]

- Uncertainty principle, Phase space and Hilbert space, Postulates of quantum mechanics, Schrödinger equation, observations and measurements, principle of superposition, operators and state functions, expectation value. [5 Lectures]

- Applications of Schrödinger equation, Particle in an infinite square well potentials, Harmonic oscillator, rigid rotor and two body (Hydrogen atom) problem. [4 Lectures]

**Text Books:**

1. S T Thorton and J B Marion, **Classical dynamics of Particles and systems**
2. Liboff, **Introductory Quantum mechanics**
3. Eisberg and Resnick, **Quantum physics of atoms, molecules**

**References:**

1. R P Feynman, **The Feynman Lectures on Physics** Vol. I
2. C. Kittel, W D Knight, M A Ruderman, **Mechanics : Berkley Physics course I**
3. R Douglas Gregory, **Classical mechanics**
4. T W B Kibble and F H Berkshire, **Classical mechanics**
5. D Morin, **Introduction to classical mechanics with problems and solutions**
6. D J Griffiths, **Introduction to quantum mechanics**
7. D A B Miller, **Quantum mechanics for scientists and engineers**
8. C Cohen-Tannoudji, B, **Quantum mechanics**, Vol. I

## 13.10 IC 130: Applied Chemistry for Engineers

**Course Code: IC 130**
**Course Name: Applied Chemistry for Engineers**

L-T-P-C: 3-0-0-3
Prerequisite: Consent of the faculty member
Students intended for: B.Tech
Elective or Core: Core
Approval: 2nd Senate

**Course content**

**Part I – Classical mechanics**

- **Spectroscopy**- Introduction and classification, Fundamental principles, Instrumentation and applications of Ultra Violet-Visible Spectroscopy, Infra-Red Spectroscopy, Raman Spectroscopy and Nuclear Magnetic Resonance Spectroscopy [12 Lectures]
- **Polymer Chemistry**- Introduction, Polymerisation, Properties, Polymer processing, Industrial polymers, conducting polymers [8 Lectures]
- **Fuels and Combustion**- Properties of fuels, Calorific value, Petroleum and petrochemicals, biofuels [6 Lectures]

- **Electrochemistry**- Applications of electrochemistry at the interface of science and technology, Batteries, Fuel cells, Biomedical devices,Corrosion and its control [10 Lectures]
- **Lubricants**- Mechanism of lubrication, Types,Properties and selection of lubricants [6 Lectures]

**Text Books:**

1. H.D. Gesser, **Applied Chemistry - A Textbook for Engineers and Technologists**, Springer
2. Wiley India Editorial Team, **Engineering Chemistry**, Wiley India Pvt. Ltd., 2011.
3. Shashi Chawla, **Engineering Chemistry**

**References:**

1. J. M. Hollas, **Modern Spectroscopy**, Wiley India Pvt. Ltd.
2. Colin Banwell and Elaine McCash, M A Ruderman, **Fundamentals of molecular spectroscopy**, Tata McGraw Hill Education Pvt. Ltd.
3. Fred W. Billmeyer, **Text Book Polymer Science**, Wiley India Pvt. Ltd.

## 13.11 IC 130P: Chemistry Practicum

**Course Code: IC 130P**
**Course Name: Chemistry Practicum**

L-T-P-C: 0-0-3-2
Prerequisite: Consent of the faculty member
Students intended for: B.Tech
Elective or Core: Core
Approval: 2nd Senate

**Course contents**

**Part I – Classical mechanics**

1. Synthesis of molecules
2. Synthesis of nanomaterials
3. Characterisation of properties
4. Identification of unknown molecules through the use of spectroscopic techniques
   (a) Generation of various spectra
   (b) Interpretation of the spectra
5. Analytical chemistry experiments

6. Food chemistry
7. Environmental chemistry

## 13.12 IC 131: Applied Chemistry for Engineers

**Course Code: IC 131**
**Course Name: Applied Chemistry for Engineers**

L-T-P-C: 2-0-2-3
Prerequisite: Consent of the faculty member
Students intended for: B.Tech
Elective or Core: Institute Core for All
Approval: 38th BoA

**Course contents**

**Part I – Classical mechanics**

- Chemical Bonding; MO Theory; LCAO molecular orbitals; structure, bonding and energy levels of diatomic molecules, 3D, 2D, 1D and 0D materials. [7 Lectures]
- Intermolecular Forces; Potential energy surfaces-Rates of reaction; Steady state approximation and its applications; Catalysis. [4 Lectures]
- Spectroscopy- Introduction and Classification; Basic Principles, instrumentation and technological applications of - Ultra Violet - Visible Spectroscopy; Infra-red Spectroscopy; Raman Spectroscopy; and Nuclear Magnetic Resonance Spectroscopy [10 Lectures]
- Electrochemistry and its applications in Fuel Cells; Batteries; and Supercapacitors [7 Lectures]

Experiments illustrating the concepts of:

- Chemistry in Real Life: analysis of food, soil and water quality.
- Synthesis of materials and their characterization using analytical tools.
- Electrochemistry.

**Text Books:**

1. Wiley India Editorial Team, **Engineering Chemistry**, Wiley India Pvt. Ltd., 2011.
2. Shashi Chawla, **Engineering Chemistry**

**References:**

1. Colin Banwell and Elaine McCash, M A Ruderman, **Fundamentals of molecular spectroscopy**, Tata McGraw Hill Education Pvt. Ltd.

   V. S. Bagotsky, **Fundamentals of Electrochemistry**, John Wiley and Sons Inc., 2005.

## 13.13 IC 136: Understanding Biotechnology & its Applications

**Course Code: IC 136**
**Course Name: Understanding Biotechnology & its Applications**

L-T-P-C: 3-0-0-3
Prerequisite: Consent of the faculty member
Students intended for: B.Tech
Elective or Core: Core
Approval: 2nd Senate

**Course contents**

- Introduction to "biotechnology" and the history of biotechnological developments with major milestones. [1 Lecture]
- Basic biology: Brief introduction to genes and genomes. [3 Lectures]
- Introduction to recombinant DNA technology and its application to genomics.[5 Lectures]
- Introduction to proteins and their products. [4 Lectures]
- Microbial biotechnology. [5 Lectures]
- Plant biotechnology. [5 Lectures]
- Animal biotechnology. [5 Lectures]
- Bioremediation and environmental biotechnology. [5 Lectures]
- Medical biotechnology. [5 Lectures]
- Biotechnology regulations and ethics. [2 Lectures]

**Text Books:**

1. William J. Thieman and Michael A. Palladino, **Introduction to Biotechnology**, 3rd Edition, Benjamin-Cummings publishing company.

**References:**

1. Reinhard Renneberg, **Biotechnology for Beginners**, Academic press.
2. Ratledge Colin, **Basic Biotechnology**, 3rd Edition, ambridge university press.

## 13.14 IC 140: Graphics for Design

**Course Code: IC 140**
**Course Name: Graphics for Design**

L-T-P-C: 2-0-3-4
Prerequisite: Consent of the faculty member

Students intended for: B.Tech 1st year
Elective or Core: Core
Approval: 2nd Senate

**Course contents**

- **General**: Introduction to design process and drawings, sheet layout, line symbols, line groups, preferred scales, reference planes and quadrants, technical sketching; dimensioning, tools of dimensioning, size and position dimensions. Freehand sketching and mechanical drafting. [2 Lectures; 1 Practical]
- Introduction to CAD software for the creation of 3D models and 2D engineering drawings. (Take home assignments will continue throughout the semester) [4 Lectures, 2 Practical]
- **Projections**: Types of projections, theory of orthographic projections, projection of points, lines; oblique planes. (Free hand / Solid Works) [2 Lectures, 1 Practical]
- Projection of plane figures. (MD/Solid Works) [2 Lectures, 1 Practical]
- Projection of solids and sections. (MD/Solid Works) [2 Lectures; 1 Practical]
- Development of solids (MD/Solid Works) [2 Lectures; 1 Practical]
- Intersection of surfaces (MD/Solid Works) [2 Lectures; 1 Practical]
- Sketching of orthographic views from pictorial views. [2 Lectures; 1 Practical]
- Missing Line, Missing View Exercises (Free hand/Solid Works) [2 Lectures; 1 Practical]
- Pictorial Views: Isometric and oblique views from multi-planar orthographic views. (Free hand/Solid Works) [2 Lectures; 1 Practical]
- Limits, fits and tolerances; Schematic and process flow diagrams; standard equipment and symbols. [2 Lectures; 1 Practical]
- Instrumentation and control diagrams; flow charts. [2 Lectures; 1 Practical]

**Text Books[2]:**

1.

**References[3]:**

1.

[2] Not Available
[3] Not Available

## 13.15 IC 141: Product Realization Technology

**Course Code: IC 141**
**Course Name: Product Realization Technology**

L-T-P-C: 2-0-3-4
Prerequisite: Consent of the faculty member
Students intended for: B.Tech 1st year
Elective or Core: Core
Approval: 2nd Senate

### Course contents

- **Introduction**: Engineering materials, their manufacturability and application [2hrs]
- **Machining**: Lathe, drilling, milling and grinding machines and their operations. [5 hrs]
- **Casting**: Pattern materials, pattern types, allowances, molding sand, composition and properties, cores, casting defects and their remedies, plastic parts molding [7 hrs]
- **Joining**: Welding fundamentals, types of welded joints, types of welding processes, gas welding process, manual metal welding, welding defects and remedies, Soldering and brazing, their applications in electronics industry [6 hrs]
- **Forming**: Forging, rolling, extrusion, wire drawing and tube drawing, sheet metal operations, forging defects and remedies [6 hrs]
- **Advanced Manufacturing Processes**: Introduction to advanced manufacturing techniques and their applications [4 hrs]

### Suggested Reading

1. E. Paul DeGarmo, JT. Black, R. A. Kohser, **Materials and Processes in Manufacturing**, Prentice Hall of India Pvt. Ltd.- New Delhi.
2. S. Kalpakjain, S.R. Schmid, **Manufacturing Engineering and Technology**, Pearson Education, New Delhi.
3. Mikell P. Grover, **Fundamentals of Modern Manufacturing**, John Willey and Sons.
4. R.A. Lindberg, **Processes and Materials of Manufacturing**, Prentico Hall India Ltd., 1990.
5. P.N. Rao, **Manufacturing Technology**, Vol-1, 2, Tata McGraw Hill New Delhi, 1998.

### References:

1.

### 13.16 IC 141_Revised : Product Realization Technology

**Course Code: IC 141_Revised**

**Course Name : Product Realization Technology**

L-T-P-C : 2-0-4-2

Intended for : UG

Prerequisite : None

Mutual Exclusion : Courses with high similarity not allowed to credit by the students after or along with this course

**Course Contents:**

- **Introduction:** Engineering materials, their manufacturability and application (2 Hours)
- **PRT for Structural Applications (Metals & Alloys):** Casting (sand casting, permanent mold casting, investment casting), forming (Rolling, Forging, Extrusion, Sheet metal operations), machining (drilling, lathe, milling), joining, Additive manufacturing (SLS, SLM) (8 Hours)
- **PRT for Light weight applications (Polymers):** Classifications of plastics, blow molding, injection molding, extrusion, compression molding, vacuum forming, Additive manufacturing (FDM, SLM), laser machining, joining methods. (6 Hours)
- **PRT for High Temperature Applications (ceramics and glasses):** Powder manufacturing, mixing and blending, compacting, Sintering (with SPS), hot isostatic pressing (5 Hours)
- **PRT for High Performance Applications (Composites):** Microwave curing, compression molding, resin infusion microwave curing, pultrusion, filament winding (5 Hours)
- **PRT for Electronic Applications (Semiconductors):** Thin film deposition, photolithography, wet bulk micromachining/etching, screen printing, 3D printing, Fabrication of PCBs. (2 Hours)

**Laboratory**

Table 1: IC 141 Lab

| **Sl. No.** | **Equipment** | **Experiment** | **Turns** |
|---|---|---|---|
| 1 | Lathe, milling, shaper machine | Facing, turning and grooving operations on mild steel rod | 1 |
| 2 | Sintering | To demonstrate sintering process for ceramic/metallic powders | 1 |
| 3 | Microwave composite processing | To demonstrate manufacturing of composite laminates | 1 |

| | | | |
|---|---|---|---|
| 4 | Fitting | To make fillet, chamfer, drilling and tapping on mild steel flat | 1 |
| 5 | Welding | To perform arc welding, gas welding and spot welding and FSW | 1 |
| 6 | Sheet metal | To perform shearing, bending and riveting of galvanised iron sheet | 1 |
| 7 | Foundry | To sand cast an aluminium rod | 1 |
| 8 | CNC lathe and milling | To machine objects using CNC machining processes | 1 |
| 9 | Laser machining | To demonstrate laser machining of an acrylic sheet | 1 |
| 10 | Advanced Manufacturing | To demonstrate thin film deposition, lithography, screen printing, fabrication of PCBs. | 1 |
| 11 | Additive manufacturing | To create objects using advanced 3D printing processes | 1 |
| 12 | Injection molding | To understand the plastic injection molding process | 1 |
| | | | 12 |

**Textbooks:**


1. Groover, M.P., **Fundamentals of modern manufacturing: materials, processes, and systems**, John Wiley & Sons, 2020.

2. Kalpakjian, S. and Schmid, S.R., **Manufacturing engineering and technology**, Prientice Hall, 2001.


**References:**

None

## 13.17 IC 141P: Product Realization Technology Laboratory

**Course Code: IC 141P**

**Course Name: Product Realization Technology Laboratory**

Credits : 2 – 0 – 3 – 4
Prerequisite : Consent of the faculty member
Students intended for : B.Tech 1st year
Elective or Core : Core

**Course Contents:**

1. Facing and turing on mild steel rod on lathe machine (MS1)

2. To make a groove on lathe machine (MS2)

3. Taper turing operation on lathe machine
4. To perform boring operaton on lathe machine (MS4)
5. To perform knurling and threading operation on lathe machine (MS5)
6. Face and Peripheral milling operation on Milling machine (MS6)
7. Driling, reaming and tapping inn MS piece (FS1)
8. To make V-matching joint of mild steel (FS2)
9. To make V butt joint in horizontal position (WS1)
10. To make V butt joint in vertical position (WS2)
11. To perform gas welding operation (WS3)
12. Shearing, bending, and soldering of GI sheet (TS1)
13. To make a mould and core and assemble it (FDS1)
14. Product Realization : Mini Project 6

## 13.18 IC 142_Old: Engineering Thermodynamics

**Course Code: IC 142**
**Course Name: Engineering Thermodynamics**

L-T-P-C: 3-1-0-4
Prerequisite: Consent of the faculty member
Students intended for: B.Tech
Elective or Core: Core
Approval: 2nd Senate

**Course contents**

- **Introduction**: Applications of Thermodynamics, Brief History [1 Lecture]
- **Fundamental Concepts**: Definitions of system and surrounding, concept of control volume, thermodynamic state, concepts of simple compressible substances, pure substance and phase, thermodynamic processes and thermodynamic equilibrium; Temperature and Zeroth law; Thermodynamic concept of energy [3 Lectures]
- **Energy and energy transfer**: Modes of work and heat transfer, different forms of energy, internal energy. [2 Lectures]
- **Properties of substances**: Thermodynamic properties and use of tables of thermodynamic properties; p-v-T surfaces, idea of a generalized chart and the law of corresponding states [3 Lectures]

- **First Law of Thermodynamics**: The first law referred to cyclic and non-cyclic processes, concept of internal energy of a system, conservation of energy for simple compressible closed systems; Definitions of enthalpy and specific heats; Conservation of energy for an open system or control volume, steady & Transient processes. [8 Lectures]

- **Second Law of Thermodynamics**: The directional constraints on natural processes; Formal statements; Concept of reversibility; Carnot principle; Absolute thermodynamic temperature scale; Clausius Inequality, entropy, change in entropy in various thermodynamic processes, $Tds$ relations, entropy balance for closed and open systems, Principle of increase- in- Entropy, entropy generation [7 Lectures]

- **Exergy**: Concept of reversible work & irreversibility; Second law efficiency; Exergy change of a system, exergy destruction, exergy balance inclosed & open systems. [3 Lectures]

- **Thermodynamic Property Relations**: Maxwell relations; Clausius - Clapeyron equation; Difference in heat capacities; Ratio of heat capacities; general relations for the changes in internal energy, enthalpy, entropy, Joule-Thompson coefficient; [3 Lectures]

- **Vapour Power Cycles**: Carnot cycle; Simple Rankine cycle, Reheat and Regenerative cycles with open & closed feedwater heater; actual cycles [3 Lectures]

- **Air Standard Power Cycles**: Carnot, Stirling, Ericssion, Otto, Diesel, and Dual cycles,Brayton cycle, combined cycle power plant [4 Lectures]

- **Refrigeration and air conditioning**: Different refrigeration techniques, Carnot cycle, Vapour compression refrigeration cycle, Absorption refrigeration, combined power and refrigeration systems, Heat pumps, Air - conditioning (Definitions, some air conditioning processes, Psychrometric charts) [4 Lectures]

- **Introduction to Fuel Cells** [1 Lecture]

**Text Books:**


1. Van Wylen, Sonntag, Borgnakke, **Fundamentals of thermodynamics**, 6th edition, Wiley India.

2. Cengel and Boles, **Thermodynamics**, 6th edition, Tata McGraw Hill.


**References:**


1. Spalding and Cole, **Engineering Thermodynamics**, 1973.

2. Moran and Shapiro, **Fundamentals of Engineering Thermodynamics**, 6th edition, Wiley India.

## 13.19 IC 150: Computation for Engineers

**Course Code: IC 150**
**Course Name: Computation for Engineers**

L-T-P-C: 3-0-0-3
Prerequisite: Consent of the faculty member
Students intended for: B.Tech
Elective or Core: Core
Approval: 2nd Senate

**Course contents**

- **Computers, programming and environment**: Computer and its components, common uses of a computer, computer as a machine, what is a program, program testing and verification, problem solving and implementation of algorithms, limitations of computing with computers, compilers, operating system/unix environment, editors, IDE's [3-4 Lectures]
- **Programming**: Problem solving with programming, Basics of Programming, Primitive types,Expressions, Decision making, Iteration, Function, Recursion, Pointer, Array, Structure & Union, Basic I/O, File handling, Dynamic Memory Allocation. [20-22 Lectures]
- **Numerical Computation and number crunching (Scilab/Python and Openoffice/Excel)**: Scilab fundamentals, programming with Scilab, error handling, finding roots (various methods), matrix operations, Entering and Formatting Data and formulae, Using Built-in Functions, performing logical tests, interpolations [10-12 Lectures]
- **Reporting of Results**: Units, Significant figures, Graphs and tables for data presentation [1-2 Lectures]

**Books and References**

1. V. Rajaraman, **Computer Programming in C**
2. R. G. Dromey, **How to Solve It By Computer**
3. Kernighan and Ritchie, **The C Programming Language**
4. Kernighan and Pike, **The Unix Programming Environment**
5. Joseph C. Musto, William E. Howard, Richard R. Williams, **Engineering Computations: An Introduction Using MatLAB and Excel**, Tata McGraw Hill.

## 13.20 IC 150P: Computing for Engineers Lab

**Course Code: IC 150P**
**Course Name: Computing for Engineers Lab**

L-T-P-C: 0-0-3-2
Prerequisite: Consent of the faculty member

Students intended for: B.Tech
Elective or Core: Core
Approval: 2nd Senate

### Course contents

It will mainly cover the implementations of the concepts being covered in the course "Computation for Engineers". The learning will be through weekly assignments.

## 13.21 IC 152: Computing and Data Science

**Course Code: IC 152**
**Course Name: Computing and Data Science**

L-T-P-C: 3-0-2-4
Prerequisite: Consent of the faculty member
Students intended for: B.Tech
Elective or Core: Core
Approval: 17th Senate

### Course contents

- **Introduction**: History, basic structure of a computer, network of computers [3 Lectures]
- **Program**:Algorithms + Data, Programs as a sequence of instructions, Levels of Programming: high level language, medium level language, machine language, interpreted and compiled languages [2 Lectures]
- **Memory**: Variables, types, scalar, composite types, arrays/lists, expressions [3 Lectures]
- **Functions**: Scope for variables, code reuse, call frame and call stack, arguments, return values [3 Lectures]
- **Control Flow**: decisions, iterations [3 Lectures]
- **Data Structures and Objects**: lists, dictionaries, NumPy arrays, strings [8 Lectures]
- File I/O, command line arguments [3 Lectures]
- **Data Visualization**: plotting functions, making use of colour, geographical data [4 Lectures]
- **Program Development**: Testing, test cases, debugging, program effciency [3 Lectures]
- **Case Studies**: Modeling using statistics, curve fitting, interpolation, histograms, classification, correlation [6 Lectures]
- Quizzes, Review etc. [3 Lectures]

**Books and References**


1. Michael Dawson, **Python Programming for the Absolute Beginner**, 3rd Edition, Course Technology PTR (Chapter 1-7)

2. **The python workbook: A Brief Introduction with Exercises and Solutions**, 2014 edition

3. Jake Vanderplas, **Python Data Science Handbook** (Chapters 1-4)

4. R. G. Dromey, **How to solve it by Computer**, Pearson, 1982

5. V. A. Sparul, **Think like a Programmer: An introduction to Creative Problem Solving**, No Starch Press, 2012 (Soft copy avaialable from the Library Website)


## 13.22 IC 160: Electrical Systems Around Us

**Course Code: IC 160**
**Course Name: Electrical Systems Around Us**

L-T-P-C: 2.5-0.5-0-3
Prerequisite: Consent of the faculty member
Students intended for: B.Tech
Elective or Core: Core
Approval: 2nd Senate

**Course contents**

- **Common Appliances**: Exploring the common appliances, their ratings, power consumption and working. [3 Lectures]

- **Heating and Lighting**: Understanding how illumination and temperature control are integrated in our buildings, types of sources and elements, source transformation, Kirchoff's laws, Mesh and Nodal analysis, Thevenin's theorem, Norton's theorem, superposition theorem, maximum power transfer theorem. Single phase: AC fundamentals, sinusoidal and non-sinusoidal wave form saverage and effective values, form and peak factors, concept of phasors, analysis of series and parallel RLC circuits, power triangle and power factor, resonance in series and parallel circuits, transient analysis of RL and RC circuits, frequency response for RL and RC. Three phase: Three phase emf generation, delta and star connections, balanced supply and balanced load, measurement of power in three phase circuits. Introduction to common earthing practices. [9 Lectures + 4 Tutorials]

- **Supply of Electricity**: Concepts of magnetic circuits, analogy with electrical circuits, B-H curve, hysteresis and eddy current losses, magnetic circuit calculations. Single-phase transformer: Constructional features, operating principle, emf equation, phasor diagram, equivalent circuit, voltage regulation, efficiency, open and short circuit tests. [10+ Lectures]

- **Fans and Pump**: DC machines: constructional features, working principle, emf and torque equation, armature reaction, types of excitation and generator characteristics. Introduction to three phase induction motor and three-phase synchronous generator. Introduction to renewable energy. [12 Lectures]
- **Upcoming topics**: Relevant topics related to the current trend can be selected by the instructor. [2 Lectures]

**Text Books:**


1. I.J.Nagrath, **Basic Electrical Engineering**, Tata McGraw Hill, India


**References:**


1. Vincent Del Toro, **Electrical Engineering Fundamental**, Prentice Hall
2. Charles K. Alexander and Matthew N. O. Sadiku, **Fundamentals of Electric Circuits**, Tata McGraw Hill, India


## 13.23 IC 160P: Electrical Systems Laboratory

**Course Code: IC 160P**
**Course Name: Electrical Systems Laboratory**

L-T-P-C: 0-0-3-2
Prerequisite: Consent of the faculty member
Students intended for: B.Tech
Elective or Core: Core
Approval: 2nd Senate

**Course contents**

- Lab 1: Introduction to Spice software, familiarization with different analysis methods (ac, dc and transient), familiarization with datasheets of components
- Lab 2: Familiarization with various measuring instruments such as ammeter, voltmeter, wattmeter, tachometer, multimeter, oscilloscope
- Lab 3: Circuit analysis using Spice
- Lab 4: Transient analysis of RLC circuit
- Lab 5: Analysis of magnetically coupled circuit
- Lab 6: Frequency response of RLC circuit
- Lab 7: Design of passive filters
- Lab 8: Measurement of power in three-phase circuit using two wattmeter method
- Lab 9: Open circuit and short circuit test of transformer
- Lab 10: Characteristics of dc shunt generator
- Lab 11: To measure earthing resistance by three probe method

## 13.24 IC 161: Applied Electronics

**Course Code: IC 161**

**Course Name: Applied Electronics**

Credits : 3 – 0 – 0 – 3
Prerequisite : Consent of the faculty member
Students intended for : B.Tech
Elective or Core : Core

Approval: 2nd Senate

**Course content**

- **Digital Electronics**: Number systems (Binary, Decimal, Hexadecimal, Octal), Binary algebra, De -Morganslaws,Combinational Circuits: Adder, Subtractor, Decoder, Encoder, Multiplexers, Demultiplexers Sequential Circuits: Latch, Flipflops, Counters, Shift registers, Memory, Sampling, ADC, DAC [ Lectures]
- **Devices and basic circuits**: Diodes, Clipping and Clamping, Rectification, Power-supply filtering, Zener diode regulator BJT and MOSFET Structure and operation,BJT and MOSFET switches, biasing, amplifiers (Common emitter, emitter follower, common source, source follower etc.). Basic logic design with transistors and diodes (TTL and CMOS)
- **Unit 3: Feedback and operational amplifiers**: Introduction to feedback, Operational amplifiers (as a black box), the golden rules, Basic op-amp circuits: Inverting and Noninverting amplifier, Follower, Integrators, Differentiators, Precision rectifiers, Comparators, Schmitt trigger
- **Measurement Transducers**: Temperature, Light, Acceleration, Pressure, Force, velocity, magnetic field, particle detectors.
- **PLC & Microcontroller**: Application of Microcontrollers (Toys, Embedded systems etc), General Architecture, Interfacing, Bus Signals, Interrupts, Registers, Support chips. Case study: Compare the architectures of two popularly used microcontrollers, Programming of a microcontroller with examples. Basic operation of relays, PLC as relays, Application of PLC in process industries, Architecture of a typical PLC, Ladder logic programming, Case study: Writing Ladder logic for any process industry (Cement mills, Paper mills etc).

**Text Books:**


1. I.J.Nagrath, **Basic Electrical Engineering**, Tata McGraw Hill, India


**References:**


1. P. Horowitz and Winfield Hill, **The art of electroncics**, Cambridge University.
2. M. Mano, **Digtial logic design**, Prentice Hall.

## 13.25 IC 161P: Applied Electronics Laboratory

**Course Code: IC 161P**

**Course Name: Applied Electronics**

Credits : $0-0-3-2$
Prerequisite : Consent of the faculty member
Students intended for : B.Tech
Elective or Core : Core

Approval: 2nd Senate

**Course content**

- Lab 1: Combinational Circuit implementation using NAND/NOR gates
- Lab 2: Sequential circuit design based on counter and shift register
- Lab 3: Amplifier design
- Lab 4: Basic logic design with transistors and diodes
- Lab 5: Ative Filter design (using Opamp)
- Lab 6: Oscillator design (using Opamp)
- Lab 7 & Lab 8 will be involved measurments
- Lab 9: Programming assignment using microcontroller

## 13.26 IC 181: Introduction to Consciousness and Holistic Wellbeing

**Course Code : IC 181**

**Course Name : Introduction to Consciousness and Holistic Wellbeing**

L-T-P-C : 2-0-2-3
Intended for : All 1st year undergraduates
Prerequisite :
Mutual Exclusion:
Approval: 54th BoA

**Course Contents**

- **Module I**: Theories of consciousness, Western and IKS perspectives on mind and consciousness, states of consciousness, effects of IKS art/dance forms on the mind, animal and plant consciousness, Supreme consciousness (8 Hours)
- **Module II**: Anatomy and functionality of the physical body; perspectives from Western medicine and Ayurveda; attention, breath and mind (8 Hours)

- **Module III**: Diet, Gut-mind connection, sleep, circadian rhythms, meditation (8 Hours)
- **Module IV**: Embryogenesis, concept of subtle body, reincarnation, near-death and outof- body experiences (4 Hours)

**Laboratory/practical/tutorial Modules:**

- **Practical Module 1**: Yoga, pranayama (6 hours)
- **Practical Module 2**: Mindfulness, inward-focus, CBT meditation, spiritual and VR-based meditations (8 hours)

**Textbooks:**

1. Trevor A. Harley, **The Science of Consciousness**, Cambridge University Press, 2021.
2. Mahadevan, Bhat, Pavana, **Introduction To Indian Knowledge System: Concepts and Applications**, PHI Learning, 2022.

**References:**


1. https://openstax.org/books/anatomy-and-physiology/
2. https://openstax.org/books/psychology-2e/
3. https://openstax.org/books/biology-2e/
4. https://plato.stanford.edu/entries/consciousness/
5. **Beyond Physicalism: Toward Reconciliation of Science and Spirituality**, Rowman & Littlefield Publishers, 2015.
6. **Consciousness Unbound: Liberating Mind from the Tyranny of Materialism**, Rowman & Littlefield Publishers, 2021.
7. **Bryant, E. F, The Yoga Sutras of Patanjali**, A New Edition, Translation, and Commentary, Farrar, Straus and Giroux, 2015.
8. Presti, D., **Mind Beyond Brain: Buddhism, Science, and the Paranormal**, Columbia University Press, 2018.
9. Phillips, S., Dasti, M., **The Nyaya-sutra: Selections with Early Commentaries**, Hackett Publishing Company, 2017.
10. Safina, C., **Beyond Words: What Animals Think and Feel**, Souvenir Press Limited, 2016.
11. **Srimad-Bhagavatam, Third Canto: The Status Quo**, The Bhaktivedanta Book Trust, 1972.
12. Lad, V., Ayurveda, **The Science of Self-healing : a Practical Guide**, Lotus Press, 1984.

## 13.27 IC 201P: Design Practicum

### Course Code: IC 201P

### Design Practicum

L-T-P-C: 0-0-6-4
Approval: 2nd Senate

### Description:

In this course, the teams are askd to design a prototype based on Comercially-off-the-shelf (COTS) hardware or software (preferably open source). Prototypes are used togather requirements, and are especially useful in visualizing the look and feel of an application and the process workflow. The prototype can be used as the basis for developing the final solution. The goal when developing such prototypes is to capture the functions and appearance of the finished product. These prototypes are used for testing and evaluation, and provide useful information for the user to rank the products or the features.

### Objectives:

After the completion of this course, students should be able to:

- Design a system, component, or process to meet desired needs within realistic constraints such as economics, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
- Function on multi-disciplinary teams
- Identify, formulate, and solve engineering problems
- Understanding of professional and ethical responsibility
- Demonstrate leadership role

### Key Learning Topics

Team formation for designing, manufacturing and operating a selected product, formulating project management procedures. Need identification, assessment of alternative designs, selection of design for development, defining design and performance specifications, and testing procedure. Virtual model. Detailed mechanical, thermal and manufacturing-related design of systems, assemblies, sub-assemblies and components culminating in engineering drawings and material specifications; preparing bill of materials and identification of standard components and bought out parts. Design for assembly, Design for manufacturing. Manufacture of a product – planning and manufacturing as per detailed design given using some bought out items; assembly and operation. Open House. Activities will be done in teams of 6 students as per professional practices.

### References:


1. Chee Kai Chua, Kah Fai Leong, Chu Sing Lim, **Rapid Prototyping: Principles and Applications**, World Scientific Publishing Company Pvt. Ltd.

2. Todd Grim, **User's Guide to Rapid Prototyping**, Society of Manufacturing Engineers.
3. **Engineering Drawing Practice for Schools & College**, SP46:2003
4. Robert O. Parmely, **Illustrating source book of mechanical components**, McGraw -Hill.

## 13.28 IC 202P: Design Practicum

**Course Code : IC 202P**

**Course Name : Design Practicum**

L-T-P-C : 0-0-6-3
Intended for : UG
Prerequisite : IC 102P – Foundations of Design Practicum
Mutual Exclusion : NA
Approval: 53rd BoA

### Course Contents

The course does not have any dedicated lecture Lectures. This is a laboratory course; the students will develop the prototype in the labs.

**Textbooks:**

1. Chee Kai Chua, Kah Fai Leong, Chu Sing Lim, **Rapid Prototyping: Principles and Applications**, World Scientific Publishing Company Pvt. Ltd.
2. Todd Grim, **User's Guide to Rapid Prototyping**, Society of Manufacturing Engineers.
3. **Engineering Drawing Practice for Schools & College**, SP46:2003.
4. Robert O. Parmely, **Illustrating sourcebook of mechanical components**, McGraw-Hill

**References:**

NA

## 13.29 IC 210: Probability, Statistics and Random Processes

**Course Code: IC 210**
**Course Name: Probability, Statistics and Random Processes**

L-T-P-C: 2.5-0.5-0-3
Prerequisite: Consent of the faculty member
Students intended for: B.Tech 1st year
Elective or Core: Core
Approval: 2nd Senate

**Course contents**

- **Introduction to Probability (Theory of Gambling)**: Definitions, scope and examples; Sample spaces and events; Axiomatic definition of Probability; Joint and conditional probabilities; Independence, total probability; Bayes' rule and applications [5 Lectures]

- **Random Variables (Dealing with Uncertainty)**: Definition of random variables, continuous and discrete random variables; Cumulative distribution function (cdf) for discrete and continuous random variables; Probability mass function (pmf); Probability density function (pdfs) and properties; Jointly distributed random variables; Conditional and joint density distribution functions; Functions of a random variable; Expectation: mean, variance and moments of a random variablesw. [10 Lectures]

- **Distribution Functions (Fitting of a Function)**: Some special distributions: Uniform, Exponential, Chi-square, Gaussian, Binomial, and Poisson Distributions; Moment-generating and characteristic functions and their applicatiohns; Chebysev inequality; Central limit theorem and its significance; Paramater estimation and confidence intervals for parameters; Regression; Hypothesis Testing. [11 Lectures]

- **Random Processes (Modeling of Chance)**: Autocorrelation and autocovariance functions; Stationarity; Ergodicity; Correlation and covariance; White noice process and white noise sequence; Random walk, Markov Processes, Markov chains, Introduction to Queing theory [10 Lectures]

**Text Books:**

1. Sheldon M. Ross, **Introduction to Probability and Statistics for Engnieers and Scientists**, Academic Press, 2009

2. Kishor S. Trivedi, **Probability and Statistyics with Reliability Queuing and Computer Science Applications**, 2nd Edition, Wiley-Interscience,m 2001.

**References:**

1. Athanosios Papoulis, **Probatility Random Variables and Stochastic Process**, 4th edition, McGraw Hill, 2002.

2. D. C. Montgomery and G. C. Runger, **Applied Statitics and Probability for Engineers**, 5th Edition, John Wiley and Sons, 2009.

3. Robert H. Shumway and David S. Stoffer, **Time Series Analysis and its Applications with R Examples**, 3rd edition, Springer Texts in Statistics, 2006.

## 13.30 IC 221: Foundations of Electrodynamics

**Course Code: IC 221**

**Course Name: Foundations of Electrodynamics**

L-T-P-C: 2.5-0.5-0-3

Prerequisites: Consent of the faculty member
Students intended for: B.Tech
Elective or Core: Core
Approval: 2nd Senate

**Course Contents**

- **Derivation of Maxwell's equations**

  (Review) Vector calculus, Helmholtz equation, Coulomb's law, Gauss law, Poisson and Laplace equations. [3 Lectures ]

  Electrostatic boundary conditions, Conductors and capacitors, mean value and uniqueness theorem, separation of variables, Dipoles and electric polarization in matter Dielectrics. [6 Lectures]

  Lorentz force law – Biot and Savart law and Magnetic vector potential – boundary conditions on B. Magnetic materials – paramagnetic, diamagnetic. Bound currents – boundary conditions on H, Inductance – magnetic energy density [6 Lectures ]

  Ohm law – EMF's – Faraday's law - Maxwell's equations [5 Lectures]

- **Maxwell's equations and electromagnetic waves**

  Electromagnetic waves in vacuum - Maxwell's stress tensor – momentum conservation Poynting theorem and conservation of energy and momentum [5 Lectures]

  Gauge transformations, Coulomb gauge and Lorentz gauge. [3 Lectures]

  Electromagnetic waves in matter – reflection, transmission, polarization - Electromagnetic waves in dispersive medium – KramersKronig relation - Lorentz oscillator model for atomic dispersion and absorption, negative-index materials [6 Lectures]

  Waveguides, transverse electric and transverse magnetic modes, Radiated power, Electric dipole radiation, antenna theory [6 Lectures]

**Text Books:**

1. D J Griffiths, **Introduction to electrodynamics** .

**References:**

1. R P Feynman, **Lectures on Physics II**.
2. D K Cheng, **Fields and wave electromagnetics**.
3. M. O Sadiku, **Elements of Electromagnetics**
4. Purcell E M, **Electricity and Magnetism**.
5. B. B. Laud, **Electromagetics**.
6. J. D Jackson, **Classical electrodynamics**

## 13.31 IC 222P: Physics Practicum/Practicals

**Course Code: IC 222P**
**Physics Practicum/Practicals**

L-T-P-C: 0-0-3-2
Prerequisites: Consent of the faculty member
Students intended for: B.Tech
Elective or Core: Core
Approval: 2nd Senate

**Practicum kind of experiments**

1. Fourier series: Observing Fourier series in real life (simple electronic circuits) by making suitable arrangements.
2. Four Probe method: Temperature dependent resistivity of a semiconductor, finding the Band gap.
3. Newtons Ring: Division of amplitude, Interference, wavelength of source
4. Fresnel biprism: Division of wavefront, Interference, wavelength of source
5. Fraunhofer Diffraction: Study the diffraction effects by designing suitable slits (single/double)
6. Dielectric properties of material: Determination of dielectric constant of glass, wood
7. Make capacitor and measure the charging and discharging of the capacitor using different dielectric materials, various thickness. To generate potentials of different shapes and study the motion of the body in or through them

**Standard experiments**

1. Mechanical Hysteresis: Relationship between torque and rotation of a metal bar (steel, aluminium, brass, Copper), Observation of memory effect (elasticity, plasticity, relaxation).
2. Frank Hertz experiment: To study the excitation potential of a gas molecule.
3. Magnetron method: Charge to mass ratio of an electron
4. Magnetic field due to a single coil : Magnetic field along the axis of the coil at different positions, Effect of different coil radius
5. Hemholtz coil: Magnetic field for different separation of the coils, Superposition of field.
6. Magnetic Induction: Measure induced emf as a function of rate of change of flux.
7. Millikan's oil drop experiment: Determine the elementary charge
8. Coupled Oscillator: Coupled vibration, Beats, Coupling of energy between two harmonic oscillators coupled to each other.

## 13.32 IC 230: Environmental Science

**Course Code: IC 230**
**Course Name: Environmental Science**

L-T-P-C: 3-0-0-3
Prerequisite: Consent of the faculty member
Students intended for: B.Tech
Elective or Core: Core
Approval: 24th Senate

**Course contents**

- **Environment components and issues**: Definition and Scope, Atmosphere, Hydrosphere, Lithosphere, Biosphere, Global, Regional and Local Issues, Major environmental issues faced by the world [12 Lectures]
- **Environmental systems**: Characteristics and properties, biogeochemical cycles of carbon, nitrogen, phosphorous and water, Biotic and abiotic environment, Food chain and webs, Anthropogenic influence on food chain [8 Lectures]
- **Natural Resources**: Forests, Energy resources, renewable and non-renewable energy, Mineral resources, Water resources [6 Lectures]
- **Environmental Pollution**: Common pollutants and their spread, Air pollution, Water pollution, Soil pollution, Measurement of pollution, Environmental parameters and standards, Environmental impacts and assessment [8 Lectures]
- **Environmental Management**: Monitoring and remediation, Reduction-reuse-recycling possibilities, Environmental policies, Case studies [8 Lectures]

**Text Books:**

1. G. Tyler Miller and Scott Spoolman, **Environmental Science**, 16th edition, CENGAGE Learning Custom Publishing, Canada, 2017

**References:**

1. Arvind Kumar, **A Text Book of Environmental Science**, P H Publishing Corporation, New Delhi, India.
2. Michael Alleby, **Basics of Environmental Science**, 2nd Edition, - Taylor & Francis Group, New York, USA, 2000

## 13.33 IC 231: Measurement and Instrumentation

**Course Code: IC 231**
**Course Name: Measurement and Instrumentation**

L-T-P-C: 2-0-2-3
Prerequisite: IC152 Data Science I/Computer and Data Science, IC161 Applied Electronics, IC161P Applied Electronics Practicum

Students intended for: B.Tech
Elective or Core: Core
Approval: 45th BoA

**Course contents**

- **Measurement fundamentals – Fundamental and derived quantities**: static and dynamic, understanding, sensitivity, stability, resolution, accuracy, precision, calibration, and types of errors. [2 Lectures]

- Microcontroller and microcomputer-based data acquisition and automation – Introduction to microcontroller and microcomputer (e.g., Arduino, Raspberry Pi), interfacing considerations (e.g., communication protocols, use of multiplexers), device control and data acquisition using Python, simple routines for signal processing and analysis examples. [4 Lectures]

- **Principles of Instrumentation** – Sensor interrogation principles - e.g., using bridge circuits, signal amplification, signal conditioning (transduction, linearization), phase measurements, active and passive filters, isolation and shielding, elements of control theory, digital data acquisition principles using ADC/DACs. [6 Lectures]

- **Sensors and Actuators** – Sensor classification, static and dynamic characteristics, Sensor examples from different domains – mechanics (e.g., strain gauge, accelerometer, LVDT), thermodynamics (e.g., thermistors, thermocouples), fluidics (e.g., venturimeter, ultrasonic flowmeter), biomedical (e.g., electrodes), electromagnetics (e.g., Hall sensor). Actuator examples – piezo-electric transducer, stepper motor. [10 Lectures]

- **Measurement System Examples** – Systems approach to design, Noise and SNR considerations (e.g. application of Friis equation), Analysis of design of real-world measurement systems – for e.g. structural health monitoring, biomedical systems (e.g. ECG, EMG, EEG), air-quality monitoring using electrochemical sensors, LIDAR, contact-based (e.g LVDT) and non-contact (e.g. ultrasonic, optical) distance measurement systems [6 Lectures]

**Laboratory/practical/tutorial Modules** **[28 Hours]**

1. Stepper motor controller
2. Temperature measurement using thermal sensors,
3. Flow measurement,
4. Experiment on LVDT,
5. Level/distance measurement using contact-less sensor,
6. Vibration/Sound measurement and FFT based analysis,
7. Chemical composition detection,

8. Bio-signal measurement,
9. Project.

**Text Books**

1. Fraden, Jacob. **Handbook of modern sensors**, Springer Science+Business Media, 2010.
2. Khandpur, R, **Handbook of Biomedical Instrumentation** 3/e, Tata McGraw Hill, 2014.

**References:**

1. Doeblin, E. O., Manik, D. N., **Measurement Systems**, 6/e, Tata McGraw Hill India, 2011.
2. Singh, S. K., **Industrial Measurement and Control**, 2/e, Tata McGraw Hill India, 2003.
3. Webb, A. G., **Principles of Biomedical Instrumentation**, Cambridge University Press UK, 2018.

## 13.34 IC 231_44B : Measurement and Instrumentation Practicum

**Course Code: IC 231_44B**

**Course Name : Measurement and Instrumentation Practicum**

L-T-P-C : 1-0-3-3
Intended for : all the BTech branches
Prerequisite : None
Mutual Exclusion : None
Approval: 44th BoA

**Course Contents:**

- **Measurement fundamentals:** Fundamental and derived quantitates: static and dynamic, understanding, sensitivity, stability, resolution, accuracy, precision, calibration, and types of errors. [1 hours]
- **Analysis and usage of MATLAB:** Tools for FFT, Analysis of variance (ANOVA) and Taguchi Method to improve the quality of manufactured goods, and its applications to engineering, biotechnology, marketing and advertising. [1.5 hours]
- **Contact/non-contact Sensors:** classification of transducers and sensors, Contact and non-contact sensors/transducers: Strain gauge, Capacitive and inductive sensors, U-tube manometer, rotameter, Ventury meter, LVDT (linear variable differential transformer), Hall effect sensors, opto-electronics based sensors, touchless absolute/rotary position transducers, ultrasonic sensors, piezo-electric/piezoceramic sensors, proximity sensors, radiation sensors, thermal and magnetic sensors [5 hours]

- **Mechanical measurement:** stress/strain, displacement, force, torque, pressure, flow, level, temperature, sound, vibration, pollution and humidity measurement. [3 hours]

- **Biomedical instrumentation:** measurement techniques for ECG, EEG and EMG, Contact-less pacemaker sensor for pulse-detection [2 hours]

- **Digital data acquisition:** Use of signal conditioners, scanners, signal converters, recorders, display devices, A/D and D/A circuits in digital data acquisition, data multiplexing and operation of sample and hold circuits. [1.5 hours]

**Laboratory Modules:**

- Temperature measurement using thermal sensors,
- Flow measurement,
- Experiment on LVDT,
- Level/distance measurement using contact-less ultrasonic sensor,
- Vibration/Sound measurement,
- Chemical composition detection,
- Bio-signal measurement,
- Virtual instrumentation using Labview: data acquisition,
- Project.

**Textbooks:**

1. Jacob Fraden, **Handbook of modern sensors: physics, device and applications**, Springer.

2. R. Khandpur, **Handbook of biomedical instrumentation**, TMH Publication.

**Reference books:**

1. E.O. Doebelin, **Measurement Systems – Application and Design**, TMH Publication.

2. S. K. Singh, **Industrial Instrumentation and Control**, TMH Publication.

3. Ranjit K. Roy, **A Primer on the Taguchi Method**, Society of Manufacturing Engineers.

## 13.35 IC 240: Mechanics of Rigid Bodies

**Course Code: IC 240**
**Course Name: Mechanics of Rigid Bodies**

L-T-P-C: 1.5-1.5-0-3
Prerequisite: Consent of the faculty member
Students intended for: B.Tech
Elective or Core: Core
Approval: 2nd Senate; Updated in 44th BoA

**Course contents**

- **Equilibrium**: System isolation and the free body diagram, equilibrium conditions [7 Lecture]
- **Structures**: Introduction, plane trusses, method of joints and method of sections, frames and machines. [7 Lecture]
- **Applications of friction** [6 Lecture]
- **Kinematics of Rigid Bodies**: Introduction, rotation, absolute motion, relative velocity, instantaneous center of zero velocity, relative acceleration, motion relative to rotating axes. [10 Lecture]
- **Kinetics of Rigid Bodies**: Introduction, general equations of motion, translation, fixed axis rotation, general plane motion, Work-energy relations, virtual work, Impulse momentum equations. [12 Lecture]

**Text Books:**

1. J. L. Meriam, L.G. Kraige; **Engineering Mechanics: Statics**; Willey India Pvt. Ltd.
2. J. L. Meriam, L.G. Kraige; **Engineering Mechanics: Dynamics**; Willey India Pvt. Ltd.

**References:**

1. Beer, Johnston, Eisenberg, Sarubbi; **Vector Mechanics for Engineers Statics and Dynamics**, McGraw Hill Company
2. S. P. Timoshenko, D.H. Young; **Engineering Mechanics**, McGraw-Hill Book

## 13.36 IC 241: Materials Science for Engineers

**Course Code: IC 241**
**Course Name: Materials Science for Engineers**

L-T-P-C: 3-0-0-3
Prerequisite: Consent of the faculty member
Students intended for: B.Tech
Elective or Core: Core

Approval: 2nd Senate

**Course contents**

- Overview of materials science and materials engineering, Property considerations for specific application, Ashby-style charts, Impact of structure and bonding over materials properties, Change in properties over time, Economic considerations, Sustainability and Green Engineering. Structure in materials: Amorphous, crystalline and polycrystalline materials, Crystalline defects and their significance. Classes of engineering materials (metals, polymers, ceramics, composites) [6 Lectures]

- Solid Solutions- Substitutional and interstitial, how to draw phase diagrams of solid solutions, intermediate phases and intermetallic compounds, lever rule, isomorphous, monotectic, eutectic, peritectic, eutectoid, peritectoid reactions. Fe-Fe3C phase diagram, effect of non equilibrium cooling on structure, phase transformations, nucleation and growth process [6 Lectures]

a. **Structural Application of Materials**

  - Static Structural Application – Uniaxial stress, strain, engineering and true stress and strain, stress strain diagram, elastic, yielding and plastic behavior, properties to characterize each, stress-strain curve of plastic, effect of temperature and creep. Application of metals, ceramics, polymers and composites in static structures like buildings, bridges, furnace structure, bulb filaments, etc, strength requirement in transmission lines. [6 Lectures]
  - Dynamic structural applications - Fatigue, low cycle and high cycle fatigue, S-N curves, creep-fatigue interaction, application of materials in automobiles, hydroelectric and thermal power plants. [6 Lectures]
  - Manipulation of materials properties through different treatments. Surface engineering. [4 Lectures]

b. **Electrical and Electronic Application**

  - Band structures for conductors, semiconductors and insulators, I-V characteristics, resistance of alloy, conductor alloy, zone refining. [4 Lectures]
  - Dielectric Materials and Insulation: Matter polarization and relative permittivity, Polarization mechanisms, frequency dependence of dielectric constant and dielectric loss, dielectric strength, piezo, ferro and pyro-electricity-elemental ideas. Choice of materials for various specific applications: capacitors, sensors, actuators and transducers, in the context of applications. [5 Lectures]
  - Magnetic and Superconducting materials: dia, para, ferro, antiferro and ferrimagnetism. Soft and Hard magnetic materials, Colossal magneto resistance (CMR) materials, magnetic sensors, read- write heads, spintronic devices; Superconductivity- zero resistance and the Meissner effect. Type I and Type II superconductors. High temperature superconducting materials, selection and their applications in magnets. [6 Lectures]

**Suggested Books**

1. Kenneth G. Budinski; **Engineering Materials: Properties and Selection**, New Edition; Prentice Hall, USA.
2. S. O. Kasap, **Principles of Electronic Materials and devices**, 3rd edition, Tata-McGraw Hill Education Pvt. Ltd., New Delhi
3. Ben G. Streetman and Sanjay Bannerjee, **Solid State Electronic Devices**, 5th edition, Pearson-Prentice Hall, USA.
4. William D. Callister, Jr., **Materials Science and Engineering- An introduction**, John Wiley and Sons, Inc.

## 13.37 IC 241_57 : Materials Science for Engineers

**Course Code : IC 241_57**

**Course Name : Materials Science for Engineers**

L-P-T-C: 3-0-0-3
Intended for: B.Tech.
Prerequisites: None
Mutual Exclusion: None
Approval : 57th BoA; Previous version: 2nd Senate

**Course Contents**

- **Introduction**: Overview of materials science and materials engineering, Materials tetrahedron; structure – property correlations, processing, Materials selection strategies; Property considerations for specific application, Ashby-style charts, Impact of bonding and structure over materials properties. Classes of engineering materials; metals, polymers, ceramics, composites, and their properties. Crystal structures and microstructures in materials: Amorphous, crystalline, and polycrystalline materials, Crystalline defects, and their significance. [10 Hours]
- **Structural Materials and Applications**: Iron, steel, light weight metals, alloys, polymers and composites, materials for automotive, railways, aircrafts, and the future VTOLs and Hyperloops, defense, marine and oil & gas sectors. Uniaxial stress, strain, engineering and true stress and strain, stress strain diagrams, elastic, yielding and plastic behaviour, effect of temperature and creep. Application of metals, ceramics, polymers, and composites in static structures like buildings, bridges, furnace structure, bulb filaments, etc, strength requirement in transmission lines. [10 Hours]
- **Optoelectronic Materials and Applications**: Band structures for conductors, semiconductors and insulators, I-V characteristics, resistance of alloy, and conductor alloy. Light interactions with solids, refraction, reflection, absorption and transmission, luminescence, photoconductivity, lasers and optical fibre communications, photovoltaics, light emitting diodes, photodetector. [6 Hours]

- **Dielectric, Magnetic, Superconductors and their applications**: Dielectric Materials - Polarization mechanisms, frequency dependence of dielectric constant and dielectric loss, piezo, ferro and pyro-electricity-elemental ideas. Choice of materials for various specific applications: capacitors, sensors, actuators, and transducers, in the context of applications. Magnetic materials: dia, para, ferro, antiferro and ferrimagnetism. Soft and Hard magnetic materials, magnetic sensors, read-write heads, spintronic devices. Superconducting materials; zero resistance and Meissner effect. Type I and Type II superconductors. High temperature superconducting materials and their applications. [10 Hours]

- **Advanced Materials and Sustainability**: Nanomaterials, Biomaterials, Smart Materials, Energy Materials, Materials for clean energy and carbon capture, Recycling, Waste management, Environmental Degradation, Sustainability and Green Engineering etc. [6 Hours]

**Text books:**

1. William D. Callister, Jr., **Materials Science and Engineering- An introduction**, John Wiley and Sons, Inc.

2. James F Shackelford, **Introduction to Materials Science for Engineers**.

3. Lawrence H. Van Vlack, **Elements of Materials Science and Engineering**, Addison-Wesley Publishing Company.

4. W.F. Smith, **Principles of Materials Science and Engineering**, McGraw-Hill.

5. R.A. Flinn and P.K. Trojan, **Engineering Materials and Their Applications**, Haughton.

**References:**

1. Kenneth G. Budinski, **Engineering Materials: Properties and Selection**, Prentice Hall, [New Edition] USA.

2. S. O. Kasap, **Principles of Electronic Materials and devices**.

## 13.38 IC 242: Continuum Mechanics

**Course Code: IC 242**
**Course Name: Continuum Mechanics**

L-T-P-C: 2.5-0.5-0-3
Prerequisites: Consent of the faculty member
Students intended for: B.Tech
Elective or Core: Core
Approval: 2nd Senate

**Course Contents**

- **Introduction**

  The Continuum Concept. [1 Lectures ]

- **Tensor Analysis**

  Tensor analysis in Cartesian coordinate, Gradient and Divergence, Daid and Daidict algebra, Isotropic Tensor [4 Lectures]

- **Stress principles**

  Cauchy stress, Principle stresses and principle direction of stress, Deviatoric stresses and their directions. [10 Lectures]

- **Fluid Statics**

  Pascal's law, hydrostatic pressure, pressure measurement, manometer and micromanometer, pressure gauge. [3 Lectures]

- **Kinematics**

  Lagrangean and Eulerian description, Deformation gradient, deformation tensors, strain tensors, velocity gradient, rate of deformation. [4 Lectures]

- **Conservation laws**

  Conservation of mass, conservation of linear momentum, moment of momentum, conservation of energy, Integral & differential approach and application to the control volume. Clausius- Duhem equality. [8 Lectures]

- **Constitutive theories**

  Governing equations of a Continuum: Constitutive equations in material description, Elastic materials, Viscous fluids, Thermodynamic considerations [8 Lectures]

- **Elasticity**

  linear elasticity and hyperelasticity (compressible and incompressible materials) [2 Lectures]

- **Plasticity**

  Yield criteria, linear plasticity [2 Lectures]

**References:**


1. D. Frederick and T.S. Chang, **Continuum Mechanics** .
2. Philip G. Hodge, JR, **Continuum Mechanics** , Mc. Graw- Book Co.
3. A. C. Eringen, **Mechanics of Continuua**, John Wiley & Sons.
4. chang, **Continuum Mechanics**, Prentice Hall, 1983.
5. Thomas, **Continuum Mechanics for Engineers**, CRC Press, 1999.
6. T. Mase, G. Mase, **Continuum Mechanics for Engineers**, CRC Press, 1999.
7. RM Bowen, **Introduction to Continuum Mechanics for Engineers**, Plenum Press, 1989.

## 13.39 IC 250: Programming and Data Structure Practicum

**Course Code: IC 250**
**Course Name: Programming and Data Structure Practicum**

L-T-P-C: 1-0-3-3
Prerequisite: IC 150
Students intended for: B.Tech 1st and 2nd
Elective or Core: Core
Approval: 2nd Senate, 5th Senate, 9th Senate

### Course contents

Introduction to data structures, abstract data types, Creation and manipulation of data structures: arrays, lists, stacks, queues, trees, heaps, hash tables, balanced trees. Algorithms for sorting and searching. Notion of time and space complexity, the O-notation

- **Introduction**: Role of algorithms in Computing, analyzing algorithms and designing algorithms [2 Lectures]
- **Data Structures**: Stacks, queues, linked lists, rooted trees, B-tree, graphs, hash tables, recursion [6 Lectures]
- **Sorting and Searching Algorithms**: Bubble, Heapsort, Quicksort, Sequential Searches, Binary search, [4 Lectures]
- **Efficiency**: Time and Space complexity, O-Notation, Space time trade-off, Measuring execution time, memory usage [2 Lectures]

### Lab Exercises

Lab to be conducted on a 3-hour slot. It will be conducted in tandem with the theory course so the topics for problems given in the olab are already initiated in the theory cloass. The topics taught in the theory course should be approximately be sequenced for synchronization with the laboratory. A sample sequence of topics and lab classes for the topic are given below

- Two assignments: Designing algorithm for some problems and writing program for it
- Four-Five assignments (some examples: Building a queue of strings, practice with linked data structures, Using a stack to evaluate arithmetic expressions etc),
- Two-Three assignments: sorting with recursion etc.
- Four-Five assignments: COmparing time and space complexity, e.g., comparing sorting by minimum search and sorting by mergesort, Analyzing NP hard and NP complete problems and dealing with them.

### Text Books

1. Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest, Clifford Stein, **Introduction to Algorithms**, MIT Press

**References:**

1. Alfred V. Aho, Jeffrey D. Ullman, John E. Hopcroft, **Data Structures and Algorithms**, Pearson.

## 13.40 IC 252: Data Science 2

**Course Code: IC 252**
**Course Name: Data Science 2**

L-T-P-C: 3-0-2-4
Prerequisite: IC 110, IC 152
Students intended for: B.Tech 1st
Elective or Core: Core
Approval: 20th Senate; Name Changed in 37th Senate

**Course contents**

- **Probability**: Why probability and what is it? (give real life situations which demands use of probability). Counting, combinations, permutations, binomial and multinomial coefficients, Stirling's formula. Discrete probability spaces (with examples). Axiomatic definition of probability, inclusion-exclusion formula, independence, condition probability, Bayes' rule. (Note: Cover the paradoxes and well known problems). [6 Lectures]

  Lab: counting, basic probability – simulation of simple experiments, birthday paradox, conditional probability.

- **Random variables**: definition, distribution function and its properties, probability mass function (binomial, Bernoulli, Poisson, geometric), probability density function (uniform, exponential, Gaussian). Joint distributions, independence and conditioning of random variables. Function of random variables, change of variable formula. [9 Lectures]

  Lab: Generating random variables following a given pdf/pmf. engineering application of functions of random variables.

- Measures of central tendency, dispersion and association – expectation, median, variance, standard deviation, mean absolute deviation, covariance, correlation and entropy (definition and guidelines on how to choose a particular measure). Markov and Chebyshev inequalities. Notion of convergence in probability and distribution. Weak law of large numbers and central limit theorem (examples demonstrating the use of WLLN and CLT). Montecarlo methods (estimating value of e, $\pi$, simulation of birthday paradox). Poisson limit for rare events. [11 Lectures]

  Lab: Scatter plot (for independent, correlated, uncorrelated random variables), Montecarlo simulation, WLLN and CLT.

- **Statistics**: Using probability to understand data (give real life examples). Frequentist approach - point and range estimates, confidence intervals, hypothesis testing p-values, significance level, power and t-test. Bayesian inference – maximum likelihood estimation. Regression. [14 Lectures]

  Lab: Parameter estimation, hypothesis testing, regression.

- **Case study**: Analyze a large data set (medicine/engineering/biological) using the methods covered in the course. [2 Lectures]

**Text Books**

1. Sheldon Ross, **Introduction to Probability and Statistics for Engineers**, 5th edition, Elsevier, 2014

**References:**


1. Morris H. DeGroot and Mark J. Schervish, **Probability and Statistics**, 4th edition, Addison-Wesley, 2012

2. Blitzstein and Hwang, **Intoduction to Probability**, CRC Press, 2015.

3. William Feller, **An Intoroduction to Probability**, Volume 1, 3rd edition, Wiley, 2008.

4. Freedman, Pisani, Purves, **Statistics**, 4th edition, W. W. Norton & Company, 2014.


## 13.41 IC 253 : Programming and Data Structures

**Course Code : IC 253**

**Course Name : Programming and Data Structures**

L-T-P-C : 2-0-2-3
Intended for : B.tech (1 st Yr)
Prerequisite : None
Mutual Exclusion: None
Approval: 54th BoA

**Course Contents**

- **Introduction**: Review of problem-solving using computers; Importance of data structure and algorithms; Elementary data structures: an ay, linked lists, stack and queues; Abstract data Operations on elementary data structures; Time and space complexity of algorithms: asymptotic analysis and notation, average, and worst-case analysis. Subtopics (3 Hours)

- **Stack and Queues**: Sequential and linked implementations, representative applications such as towers of Hanoi, and parenthesis matching. (3 Hours)

- **Lists**: Abstract data type, sequential and linked representations, comparison of insertion, deletion and search operations for sequential and linked lists, list and chain classes, doubly linked lists, circular lists, skip lists, applications of lists in sparse tables. (3 Hours)

- **Trees**: Abstract data type, sequential and linked implementations, tree traversal methods and algorithms, Binary trees and their properties. (3 Hours)

- **Search Trees**: Binary search trees, search efficiency, insertion, and deletion operations, the importance of balancing, A VL trees, searching, insertion, and deletions in AVL trees. (4 Hours)
- **Heaps**: Heaps as priority queues, heap implementation, insertion-deletion operations, and heapsort. (2 Hours)
- **Graphs**: Definition, terminology, directed and undirected graphs, properties, implementati.on - adjacency matrix and linked adjacency chains, connectivity in graphs, graph traversal - breadth first and depth first, spanning trees. (3 Hours)
- **Basic Algorithm Techniques**: Greedy algorithms, divide & conquer. Search techniques - backtracking, Sorting algorithms with analysis, integer sorting, selection sort. Graph algorithms: DFS and BFS with applications, MST, and shortest paths. (7 Hours)

**Laboratory/practical/tutorial Modules:**

- Included with each Unit

**Textbooks:**

1. T. H. Carmen, C. E. Leiserson, R. L. Rivest, and C. Stein, **Introduction to Algorithms**, 3rd Edition, MIT Press, 2009.

**References:**

1. S. Sahni, Data Structures, **Algorithms, and Applications in C++**, 2nd Edition, Silicon Press, 2005.
2. A. M. Tenenbaum, Y. Langsam, and M. J. Augenstein, **Data Structures Using C and C++**, 2nd Edition, Prentice Hall, 1995.

## 13.42 IC 260: Signals and Systems

**Course Code: IC 260**
**Course Name: Signals and Systems**

L-T-P-C: 2.5-0.5-0-3
Prerequisite:
Students intended for: B.Tech
Elective or Core:
Approval: 2nd Senate

**Course contents**

- **Introduction to Signals & Systems**

  Classification of signals, useful signal operations, Exponential and sinusoidal signals, Unit step and unit step functions, Basic system properties [5 Lectures]

- **Time-domain analysis of continuous time systems & discrete-time systems**

  Zero-input and zero-state response, unit impulse response, convolution, Graphical method for convolution, stability of systems, Response time and Rise time of system. [5 Lectures]

- **Fourier series representation of periodic signals**

  Linear time invariant systems to complex exponential signals, Fourier series representation of continuous time periodic signals, Convergence and properties of continuous-time Fourier series, Discrete time Fourier series and its properties [7 Lectures]

- **Continuous-time Fourier transform**

  Representation of aperiodic signal, Fourier transform and its properties, Fourier transform of some useful signals, Generalized Fourier series: signals vs vectors, Modulation, System characterization. [5 Lectures]

- **Discrete-time Fourier transform**

  Representation of aperiodic signal, Discrete-time Fourier transform and its properties, Sampling, Duality in discrete-time Fourier series [5 Lectures]

- **Laplace transform**

  Laplace transform, ROC, Inverse Laplace transform, Filter design by placements of poles and zeros of system functions, properties of Laplace transform, analysis and characterization of LTI systems using Laplace transform, unilateral Laplace transform. [5 Lectures]

- **Z-transform**

  Z- transform, properties of z- transform, Frequency response from pole-zero location, analysis and characterization of LTI systems using z-transform, unilateral z-transform. [4 Lectures] [2 Lectures]

**References**

1. A. V. Oppenheim A. S. Willsky and S. H. Nawab, **Signals and Systems**, Printice Hall of India, 2004.
2. B. P. Lathi, **Principle of Linear Systems and Signals**, Oxford University Press, 2010.

## 13.43 IC 272 : Machine Learning

**Course Code : IC 272**

**Course Name : Machine Learning**

L-T-P-C : 2-0-2-3

Intended for : B.Tech. 2nd year students

Prerequisite : IC 111 – Linear Algebra, IC 152 – Computing and Data Science, IC 252 - Probability and Statistics (Data Science 2)

Mutual Exclusion:
Approval: 55th BoA

**Course Contents**

- **Data preprocessing**: Data cleaning – missing values, noisy data; Data integration and transformation – normalization; Data reduction – dimension reduction and principal component analysis (PCA) [5 Lecture]
- **Introduction to machine learning**: Supervised and unsupervised learning [1 Lecture]
- **Supervised learning with applications in classification problems**: Bayes classifier with unimodal and multimodal density - maximum likelihood estimation, expectation-maximization (EM) algorithm (only at idea level), K-nearest neighbor methods, decision trees, neural networks [8 Lectures]
- **Supervised learning - regression**: Linear regression, polynomial regression, regression using neural networks [8 Lectures]
- **Unsupervised Learning Algorithms - Clustering**: K-means and fuzzy-K-means clustering, density based clustering (DBSCAN) [6 Lectures]

**Lab Exercises:**

Lab to be conducted on a 3-hour slot. It will be conducted in tandem with the theory course so the topics for problems given in the lab are already initiated in the theory class. The topics taught in the theory course should be appropriately be sequenced for synchronization with the laboratory.

- Lab1 : Data Preprocessing – data cleaning and normalization
- Lab2 : Dimension reduction and PCA
- Lab3 : Classification using Bayes classifier with unimodal density
- Lab4 : Classification using Bayes classifier with multimodal density
- Lab5 : Classification using K-nearest neighbor methods and decision trees
- Lab6: Classification using neural networks
- Lab7: Linear regression
- Lab8: Polynomial regression
- Lab9: Neural network based regression
- Lab10: Clustering using K-means and fuzzy-K-means
- Lab11: Clustering using DBSCAN

**Textbooks:**

1. C. M. Bishop, **Pattern Recognition and Machine Learning**, Springer, 2006.
2. C. Muller and S. Guido, **Introduction to Machine Learning with Python: A Guide for Data Scientists**, O'Reilly, 2017

**References:**

1. J. Han and M. Kamber, **Data Mining: Concepts and Techniques**, 3rd Edition, Morgan Kaufmann Publishers, 2011
2. S. Theodoridis and K. Koutroumbas, **Pattern Recognition**, Academic Press, 2009.
3. T. Hastie, R. Tibshirani and J. Friedman, **The Elements of Statistical Learning: Data Mining, Inference, and Prediction**, 2nd Edition, 12th Reprint, Springer, 2017
4. R. O. Duda, P. E. Hart and D. G. Stork, **Pattern Classification**, John Wiley, 2001.

## 13.44 IC 301P Interdisciplinary Socio-Technical Practicum

## DP 301P Interdisciplinary Socio-Technical Practicum

**Course Code: DP 301P**

**Course Name: Interdisciplinary Socio-Technical Practicum**

L-T-P-C: 0-0-6-4
Prerequisites: Consent of the faculty member
Students intended for: B.Tech
Elective or Core: Core
**DP 301 and IC 301 are same**
Approval: 2nd Senate

**Course Contents**

In the course the teams have two choices. Either they work iteratively on the earlier developed prototype to develop into final improved product or identify a new product which the society needs after doing market research.

In a changing market, staying competitive often requires the development of new products. As user requirements and needs change, products must also change. Market research is an essential tool to help boost the chances for success. The new product development process requires information from the market and users as to what is needed to support critical decisions about the product.

**Key Learning Topics**

- **Primary Research**: Information collection through various channels such as interviews, questionnaires, surveys, and conversations with industry experts, prospective customers, and competitors
- **Secondary Research:** Internal source (Brainstorming, Stock analysis, Retail data, loyalty cards etc.); External source (Government Statistics like ONS, Trade publications, Commercial Data, Household Expenditure Survey, Magazine surveys, Research documents like publications, journals, etc.)
- **Sampling Methods:** Random Samples, Stratified or Segment Random Sampling, Quota Sampling, Cluster Sampling, Multi-Stage Sampling, Snowball Sampling.
- **Market Trends:** Size of market, market trends, forecasting, planning, identify market strategies, identify user need, identify competition, identifying opportunities/gaps in market
- **Module V:** Engineering economics of the product

**References:**


1. Von Hippel, Eric., **The sources of Innovation**, Oxford University Press, 1988.
2. Gordon, William., **The development of Creative Capacity**, Collier Books, 1961.
3. Thomke, Stefan, and Eric Von Hippel, **Customers as Innovators: A new way to createvalue**, Harvard Business Review (April 2005), 74-81, Reprint no. R 0304 F.
4. Boyd, Harper W. Jr., Westfall, Ralph and Stasch, Stanley, **Marketing Research: Text and Cases**, Richard D. Irwin Inc.,
5. Green, P. E. and Tull, D. S., **Research for Marketing Decisions**, 5th edition, Prentice-Hall of India.
6. Luck D. J., Wales, H.G., Taylor, D. A. and Rubin R. S., **Marketing Research**, 7th Edition, Prentice-Hall of India.
7. Tull, D. S. and Hawkins D. I., **Marketing Research : Measurement and Method**, 6th Edition, Prentice-Hall of India.


## 13.45 IC 401P Major Technical Project

**Course Code: IC 401P**
**Course Name: Major Technical Project**

L-T-P-C: 0-0-6-4
Prerequisites: Consent of the faculty member
Students intended for: B.Tech
Elective or Core: Core
Approval: 2nd Senate; Credits changed to 0-0-4.5-3 in 6th Senate

**Course Contents**

In this course, using the information that has been collected and the decisions that have been made about the features, price etc. the teams will either redesign the existing prototype or design a new product based on Market feedback and create the physical product, as well as its packaging. Research at this stage usually involves repeated cycles of product improvement and testing. Product testing includes both physical performance and consumer reactions. The course looks at how a new idea becomes implemented in a system (an organization or society) and the factors that influence the adoption of a new idea. This course also looks at the influence of individuals and groups within the change process and how they affect the acceptance of new ideas. Finally, the course explores the prediction and consequences of new technologies.

The end-result of these efforts is a product that meaningfully adds value to the students, faculty and society.

There may be few teams working on specific components or sub systems or technology.

**Key Learning Topics**

Engineering drawing (CAD) of modified product, Detailed design, Design of experiments, Multiobjective design optimization. CAE Analysis, Software development, Design for assembly, Design for manufacturing, Product manufacturing.: CAM programming, operation of CNC machining equipment and rapid prototyping. Open House

**References:**

1. Geoffrey Boothroyd , Peter Dewhurst , Winston A. Knight, **Product Design for Manufacture & Assembly**,2nd Edition.

2. Kathleen Fasanella, **The Entrepreneur's Guide to Sewn Product Manufacturing**.

## 13.46 IC 402P Major Technical Project (Contd.)

**Course Code: DP 402P**
**Course Name: Major Technical Project (Contd.)**

L-T-P-C: 0-0-6-4
Prerequisites: Consent of the faculty member
Students intended for: B.Tech
Elective or Core: Core
Approval: 2nd Senate; Credits changed to 0-0-7.5-5 in 6th Senate

**Description**

This course looks at how a new idea becomes implemented in a system (an organization or society) and the factors that influence the adoption of a new idea. This course also looks at the influence of individuals and groups within the change process and how they affect the acceptance of new ideas. Finally, the course explores the prediction and consequences of new technologies.

**Objectives**

The purpose of this course is to acquaint students with the technology transfer and patents

**Key Learning Topics**

- **Theory and practice of processes of technology transfer and diffusion**: Commercialization of technology, intellectual property rights.
- **Product innovation**: Impact of product innovation; success factors for product innovation; developing a product innovation strategy.
- **Interactive learning and networks of innovation**: Technology Platforms; firms taxonomy.
- **Systems of Innovation and the corporate value chain**: Fostering clustering effects. Regional innovation strategies.
- Product quality (ISO 9000 standards), Sustainable design.
- **After usage**: Recycling, reusing, remanufacturing
- Live demonstration of product to interested parties.

**References:**


1. Rachna Singh Puri, Arvind Viswanathan, **Practical Approach To Intellectual Property Rights** .
2. Goel Cohen, **Technology Transfer, Strategic management in developing country**, Sage Publication.

# 14 IKSMHA Courses

## 14.1 IK 501: Yoga Sutras

Course number : IK501
Course Name : Yoga Sutras
Credit Distribution : (format: 2-0-1-3, (Lectures-Tutorial-Practical-Total credits) replace with relevant numbers)
Intended for : Ph.D, Master students, elective for UG students
Prerequisite : None
Mutual Exclusion :
Approval: 50th BoA

**Course Contents:**

**Unit 1: Philosophy of Yoga (14 Hours)**

- Unit 1/Topic 1: Yoga and Yoga Texts (Total = 6 Hours)
  1. Yoga – Basic Introduction
     - a. Meaning and Definition
     - b. Importance of Yoga - holistic personality development
     - c. Laukik and Adhyatmik benefits of Yoga
     - d. Myths and Facts of Yoga
     - e. Yoga's Mula Pravakta - Hiranyagarbha
  2. Introduction to Bharatiya Yoga Darshana
     - a. Pathanjali Yogasutras
     - b. Sankhya darshana - theoretical concepts
     - c. Pathanjali Yogasutras - Vyasa Bhashya
     - d. Yoga siddhanta in Bhagavad-Gita
     - e. Yoga siddhanta in Upanishads (Katha, Svetashvatara etc)
     - f. Pauranic Yoga siddhantas (Kapila)
     - g. Jaina Yoga siddhantas
     - h. Bauddha Yoga siddhantas
     - i. Other Yogas - Tantra, Mantra, Laya, Kundalini Yogas
  3. Various paths to Yoga: Jnana, Bhakti, Karma, Ashtanga and Hatha Yoga
     - a. Jnana Yoga - Vivekachudamani, Uddav Gita, Ashtavakra Samhita
     - b. Bhakti Yoga - Narada Bhakti Sutras, Shrimad Bhagavatam
     - c. Karma Yoga - Bhagavad Gita, Mahabharata
     - d. Ashtanga Yoga - Patanjali Yogasutras
     - e. Hatha Yoga - Gheranda Samhita, Hatha Yoga Pradipika, Goraksha Samhita
  4. Yoga and Sampradayas
     - a. Nath Sampradaya

- b. Shaiva Sampradaya
- c. Shakta Sampradaya
- d. Vaishnava Sampradaya
- e. Bauddha Sampradaya

- Unit 1/Topic 2: Ashtanga Yoga Sutras (4 Hour)

  1. Prasthavana 2.28 and 29
     - a. Yama - 2.30
     - b. Niyama - 2.32
     - c. Asana - 2.46
     - d. Pranayama - 2.49
     - e. Pratyahara - 2.54
     - f. Dharana - 3.1
     - g. Dhyana - 3.2
     - h. Samadhi - 3.3 2. Dinacharya - Importance and Practice

- Unit 1/Topic 3: Yoga Culture and Value Education (4 Hour)

  1. Prominent Streams of Yoga
     - a. Jnana Yoga (Discernment)
     - b. Bhakti Yoga (Emotional)
     - c. Karma Yoga (Kriti)
     - d. Raja Yoga (Ashtanga Yoga)
  2. Positive and Negative Human Behaviours (Daivi Gunas, Asura Gunas)
     - a. Daivi Sampada - Bhagavad Gita - 16.1-3
     - b. Asuri Gunas - Bhagavad Gita - 16.4,7,8,9,10,11-18
  3. Four Principles Of Jnana Yoga
     - a. Viveka
     - b. Vairagya
     - c. Shat Sampatti
     - d. Mumukshutva
  4. Relevance of Ancient Indian values in modern life
     - a. Purusharthas
     - b. Ashrama Vyavastha
     - c. Varna Vyavastha - Bhagavad Gita - 14.13
     - d. Samskaras

**Unit 2: Manas and Sharira - Maintenance and Cleansing (6 Hours)**

- Unit 2/Topic 1: Mental and Physical Aspects of the Body
  - a. Antahkarana Chatushtaya (Manas, Buddhi, Ahankara, Chitta)
  - b. Notion of Self and Health and its Metaphysics in Yoga

- c. Feelings and Emotional well-being (9 Rasas)
- d. Qualities of evolved intellect i.e., Buddhi
- e. Well being in Yoga and Ayurveda
- f. Impact of positive and negative human tendencies on Psycho-social behavior (Prajnaparadha, Pratipaksha Bhavana, Vitarka Badha)
- g. Shoucha Niyamas
- h. Balanced Food and Nutrition - Ahara Vihara
- i. Maintenance of health through Asana and Pranayama

**Unit 3: Applications of Yoga (8 Hours)**

- Unit 3/Topic 1: Practical Application of Yoga to Life Modern view of Yoga. Application of principles of Yoga for holistic living.

  1. Management Techniques
     - a. Application to Career Management
     - b. Public speaking and leadership qualities
     - c. Workplace wellbeing
     - d. Interventions for managing Self and Career
  2. Psychology
     - e. Concept of Positive Psychology and Stress Management
     - f. Managing the five states of Chitta Bhumis (Kshipta, Mudha, Vikshipta, Ekagra, and Nirudha)
     - g. Treatment and Counseling of Mentally challenged persons
     - h. Prevention of Addiction and Counseling for De-Addiction
  3. Application of Yoga in Defense
     - i. Application of Upayas (Sama-dana-bheda-dandopayas) using Yoga
     - j. Fasting in Yoga (Speech, Food, and Sleep)

- Unit 3/Topic 2: Personality and Family Relationships

  - k. Forsaking enmity (Vaira tyaga) and constructive relationships (vishva bandhutva)
  - l. Techniques for family relationship management (Inclusive temperament, Avoiding Competition, Service attitude)

**Laboratory/practical/tutorial Modules: 3 Units (14 Hours)**

Unit 1/Topic 2: (4 Hour)

Tutorials: Ashtanga Yoga Sutras, discussion of eight angas with examples, recitation and memorization of important sutras in this context Tutorials: Yoga for Students (Includes Theory)

1. Surya Namaskaras
2. Basic Pranayama and Kriyas
3. Eyesight improvement

4. Voice Culture
5. Focus and concentration techniques
6. Memory improvement techniques
7. Relaxation technique
Unit 1/Topic 3: (2 Hours)
Practicals
1. Anger management
2. Ego management
3. Time management
4. Removing obstacles in the path of wellbeing
Unit 2/Topic 2: Subtopics (1 Hour)
Lec-Dem: Shat karma Shuddhi (Cleansing of Body) Demonstration
1. Neti
2. Dhauti
3. Basti
4. Trataka
5. Nauli
6. Kapalabhati
Unit 2/Topic 3: Subtopics (2 Hours)
Tutorials: Yoga Techniques - Demo and Quick Practice
1. Important Vyayamas
2. Pratyahara
3. Dharana
4. Dhyana
5. Samadhi Unit 3/Topic
3: Subtopics (5 Hour)
Practicals: General Yoga Protocol (Children and Youth)
1. Asanas
2. Pranayama
3. Mudra and Bandh
4. Vyayama
5. Sukshma Vyayama
Yoga for Women
Yoga for Elderly
Practicals: Yoga and Positive Psychology

**Text books: (Relevant and Latest, Only 2)**

1. Dr. P. V. Karambelkar, Patanjali Yog Darshan based on Vyasa Bhashya, Kaivalyadham, Lonavla.

2. Online Resources: https://dharmawiki.org/index.php/Category:Yoga

**References:**

1. Hatha Pradipika of Swami Svatmarama, edited by Swami Digambarji and Kokaje, Publishers - Kaivalyadham, Lonavala

2. Bhawuk, DPS (2011) Spirituality and Indian psychology. Springer, New York.

3. Ranganathananda, S. (2000). Universal message of the Bhagavad Gita.

4. Sri Aurobindo. (1942). Essays on the Gita, Vol. 13. Calcutta: Arya Publishing House.

5. Swami Anubhavanada, & Kumar, A. (2007). Management with a difference: Insights from ancient Indian wisdom. New Delhi: Ane Books India.

6. Swami Bodhananda Saraswati. (1998). Management lessons from Patanjali's yoga sutras. In Inspirations from Indian wisdom for management. Ahmedabad Management Association.

7. Mind and Self: Patanjali's Yoga Sutra and Modern Science by Subhash Kak, Mount Meru Publishing

8. Books from Bihar School of Yoga, Munger, Bihar, India

9. Hatha Yoga Pradipika by Swami Muktibodhananda, Yoga Publications Trust, Munger, Bihar, India

10. Four Chapters on Freedom: Commentary on the Yoga Sutras of Patanjali, by Swami Satyananda Saraswati, Yoga Publications Trust, Munger, Bihar, India

11. Gheranda Samhita by Swami Niranjanananda Saraswati, Yoga Publications Trust, Munger, Bihar, India

12. Yoga Chudamani Upanishad: Crown Jewel of Yoga by Satyadharma, Swami, Yoga Publications Trust, Munger, Bihar, India

13. The Dynamics of Yoga by Swami Satyananda Saraswati, Yoga Publications Trust, Munger, Bihar, India

14. Prana and Pranayama by Swami Niranjanananda Saraswati, Yoga Publications Trust, Munger, Bihar, India

15. Surya Namaskara by Swami Satyananda Saraswati, Yoga Publications Trust, Munger, Bihar, India

**Reference Papers**

1. Pandey, A and Navare, A.V. (2018) Paths of Yoga: Perspective for Workplace Spirituality. In The Palgrave handbook of Workplace Spirituality and Fulfilment. Palgrave Macmillan Cham.

2. Pandey A, Gupta RK, Arora AP (2009) Spiritual climate of business organizations and its impact on customers' experience. J Bus Ethics 88(2):313–332.

3. Sharma S (1999) Corporate Gita: lessons for management, administration and leadership. J Hum Values 5(2):103–123

4. Pandey A, Gupta RK, Kumar P (2016) Spiritual climate and its impact on learning in teams in business organizations. Glob Bus Rev 17(3S).

5. Adhia, H., Nagendra, H. R., & Mahadevan, B. (2010). Impact of adoption of yoga way of life on the emotional intelligence of managers. IIMB Management Review, 22(1-2), 32-41.

6. Sternberg, R. J. (1993). Intelligence is more than IQ: The practical side of intelligence. Journal of Cooperative Education, 28(2), 6-17.

7. Srinivas, K. M. (1994). Organization development: Maya moksha. Work Motivation Models for Developing Country. New Delhi: Sage Publications.

8. Chakraborty, S. K., & Chakraborty, D. (2008). Spirituality in management - Means or end? Oxford University Press.

9. Orme-Johnson, D. W., Zimmerman, E., & Hawkins, M. (1992). Maharishi's vedic psychology: The science of the cosmic psyche. In H. S. R. Kao, & Y. H. Poortinga (Eds.), Asian perspectives on psychology (pp. 282).

## 14.2 IK 502: Introduction to Bio-signals

Course number : IK 502
Course Name : Introduction to Bio-signals
Credit Distribution : 3-0-2-4
Intended for : BTech/MTech/MS/MSc/MA/Ph.D.
Prerequisite : None
Mutual Exclusion : None
Approval: 50th BoA

**Course Contents:**

- **Mathematical Preliminaries:** Fourier transform, sampling and filtering, Solution to wave equation in spherical co-ordinate system, Introduction of Spherical Harmonics.(3 hours)

- **Basics of bio-signals:** Definition and models of bio-signals, types of bio-signals, bio-signals monitoring, Pre-processing for bio-signals, bio-signals analysis, and classification of bio-signals. (2 hours)

- **Brain signals:** Human Brain Anatomy, Electroencephalogram (EEG) and magnetoencephalogram (MEG) signals, recording of EEG and MEG signals, EEG signals characteristics and rhythms, evoke potentials, diagnosis of central nervous systems disorders based on brain-signals, various approaches for analysis, feature extraction, and classification of brain signals, MRI and FMRI basics, BOLD signal acquisition, applications of FMRI (10 hours)

- **Brain Source Localization and connectivity:** Array Signal Processing Basics - Data model, correlation and subspace based (MUSIC) localization, Brain Source Localization: Forward & Inverse Problem, Introduction of Head harmonics for brain source localization (BSL), Application of BSL in BCI control, Epileptogenic zone detection. Brain connectivity representation, decomposition methods and types of networks, Clinical and cognitive applications of brain connectivity. (10 hours)

- **Cardiac signals:** Electrocardiogram (ECG) and phonocardiogram (PCG) signals, recording process of ECG and PCG signals, heart rate variability (HRV) signals, diagnosis of heart diseases based on cardiac signals, various methods for analysis, feature extraction, and classification for cardiac signals. (8 hours)
- **Muscle signals:** Electromyogram (EMG) signal, motor unit action potentials (MUAP), EMG and neuro-muscular diseases, feature extraction of EMG, analysis and classification methods for EMG signals. (6 hours)
- **Other bio-signals:** Pulse signals, blood pressure, blood flow, photoplethysmogram, electrooculogram, electroretinogram, center of pressure, and respiratory signals. (3 hours)
- **Laboratory/practical/tutorial Modules:** The course will involve practical assignments which can be conducted in the lab, and would also involve programming assignments.

**Textbooks:**


1. R.M. Rangayyan, **Biomedical Signal Analysis: A case Based Approach**, IEEE Press, John Willy & Sons. Inc, 2002.
2. Kayvan Najarian and Robert Splinter, **Biomedical Signal and Image Processing**, 2nd Edition, CRC Press, 2005.


**References:**


1. M.A. Jatoi and N. Kamel, **Brain source localization using EEG signal analysis**, CRC Press, 2017
2. Boaz Rafaely, **Fundamentals of spherical array processing**, Springer, 2015
3. HL Van Trees, **Optimum Array Processing**, New York: Wiley, 2002
4. Scott Heuttel, Allen Song, Gregory McCarthy, **Functional Magnetic Resonance Imaging,** 2nd Edition, Sinauer Associates, 2009 .


## 14.3 IK 503: Cognitive Psychology and the Indian Thought System

Course number : IK 503
Course Name : Cognitive Psychology and the Indian Thought System
Credit Distribution : 3-0-0-3
Intended for : BTech/MTech/MS/MSc/MA/Ph.D.
Prerequisite : None
Mutual Exclusion : None
Approval: 50th BoA

**Course Contents:**

- **Evolution, Mind, and Brain:** Nervous system - anatomy and physiology; Functional neuroanatomy; Tools for investigation – electrophysiology, imaging, and others; how the brain creates mind?; Translation to behavior — emotion/cognition/decision making; mental representations and processing; dissociations and associations. (5 Hours)

- **The Indian Knowledge System:** Six Schools of philosophy; Buddhism; Bhagavad Gita; Mapping with the Neuroscientific/psychological understanding from Unit 1; Mental health; cognition in Samkhya and yoga; the body – mind – intellect – consciousness complex; consciousness; panca – kosa – a five layered existence; four states of existence; driving issues in consciousness studies; the tri – guna system; cognitive training hypothesis in yoga; psychological effects of yoga/meditation with clinical and nonclinical populations; Extraordinary cognition hypothesis via eightfold path described in the Yogasutras. Relative versus absolute reality hypothesis. (7 hours)

- **Perception and Attention:** Introduction to perception; visual perception; structure of visual system; top-down (context effects) and bottom-up (from features to objects) processing; visual recognition; interactive nature of perception; nature and roles of attention; failures of selection; successes of selection; information processing theories of attention; electrophysiology and human attention; functional neuroimaging and transcranial magnetic stimulation. (7 Hours)

- **Representation, Encoding, and Retrieval of Knowledge in Long-Term Memory:** Role of knowledge in cognition; representations and their formats; representation to category knowledge; structures in category knowledge; category domains and organization; nature of long-term memories; encoding; retrieval; encoding with difficulty to recall; non-declarative memory systems. (7 Hours)

- **Working Memory and Executive Processes:** Introduction to working memory; from primary memory to working memory; working memory models; person-to-person variation; dopamine's role; frontal lobe connection; frontal damage and the frontal hypothesis; executive attention; switching attention; inhibition of response; sequencing; monitoring. (6 Hours)

- **Emotion, Cognition, Decision-making, and Problem Solving:** Defining emotion; manipulating and measuring emotion; emotional learning: acquiring evaluations; emotion and declarative memory; emotion, attention, and perception; nature of a decision; rational decision making; neural bases of expected utility calculations; human decision making and the expected utility model; complex, uncertain decision making; nature of problem solving; analogical reasoning; inductive reasoning; deductive reasoning. (7 Hours)

- **Language, Motor Cognition, and Mental Simulation:** Nature of language; processes of language comprehension; processes of language production; language, thought, and bilingualism; nature of motor cognition; mental simulation and the motor system; imitation; biological motion. (5 Hours)

**Textbooks:**

1. Smith, E. E., & Kosslyn, S. M., **Cognitive Psychology: Mind and Brain**, Pearson, 2013.
2. Eysenck, M. W., & Keane, M. T., **Cognitive Psychology, A Student's Handbook**, 8th Edition, Hove: Psychology Press, 2020.

**References:**

1. Ward, J., **The Student's Guide to Cognitive Neuroscience**, 3rd Edition, Hove: Psychology Press, 2015
2. Anderson, J. R., **Cognitive Psychology and Its Implications**, 9thEdition, Worth Publishers, 2020.
3. Sedlmeier P. & Srinivas K., How Do Theories of Cognition and Consciousness in Ancient Indian Thought Systems Relate to Current Western Theorizing and Research? **Front Psychol.** 2016 Mar 15;7:343. doi: 10.3389/fpsyg.2016.00343, 2016.

## 14.4 IK 504: Bhagavad Gita Comprehensive

**Course Code : IK 504**

**Course Name : Bhagavad Gita Comprehensive**

L-T-P-C : 3-0-0-3
Intended for : UG/PG/PhD
Prerequisite : None
Mutual Exclusion :
Approval: 50th BoA

**Course Contents**

- **Introduction to Bhagavad-Gita and Sanskrit Basics**: Origins and significance; Overview of Mahabharata; Basics of Sanskrit language; Pronunciations and grammar. (8 Lectures)
- Unit 2: **Arjuna's Dilemma** (Chapter 1): The setting of Kurukshetra; Arjuna's observations; Emotional conflicts and ethical issues. (6 Lectures)
- Unit 3: **Transcendental Knowledge** (Chapter 2): Sankhya yoga; Nature of soul; Concepts of Dharma and Karma; Significance of detached action. (8 Lectures)
- Unit 4: **Path of Devotion** (Chapter 3): Karma Yoga; Duty and righteousness; The balance of action and inaction. (6 Lectures)
- Unit 5: **Approaching the Ultimate Truth** (Chapters 4-5): Knowledge and renunciation; Concepts of Yagna and selfless action; Jnana yoga vs. Bhakti yoga. (8 Lectures)
- Unit 6: **The Science of Self-Realization** (Chapter 6): Dhyana Yoga; Practices and principles of meditation; Achieving spiritual equilibrium. (6 Lectures)

**Text books:**

1. Bhaktivedanta Swami Prabhupada, A. C., **The Bhagavad-Gita as It Is: With the Original Sanskrit Text**, Roman Transliteration, English Equivalents, Translation and Elaborate Purports, Second revised and enlarged edition. The Bhaktivedanta Book Trust, 2008.

## 14.5 IK 505: Bhagavata Sankhya

**Course Code : IK 505**

**Course Name : Bhagavata Sankhya**

L-T-P-C : 3-0-0-3
Intended for : 3rd & 4th Year B. Tech, MA / MS / MTech / PhD
Prerequisite : None
Mutual Exclusion: None
Approval: To be Approved

**Course Contents**

- **Brief History of Indian Philosophy** (10 Lectures)
  - Systematic Evaluation of Phiolosophical thought from Vedas to Upanishads
  - Overview of six traditional systems of Indian Philosophy
  - Sankhya and Yoga connections
  - Early Sankhya Literature, Patanjali Yoga sutras and Sankhya Metaphysics
- **Tenants of Bhagavata Dharma** (5 Lecture)
  - New notion of Dharma and historical prominance of devotional literature
- **Sankhya and Yoga in Bhagavad Gita** (8 Lectures)
  - Sankhya meanings in relation to Yoga
  - Prakrti and PUrusa, ksetra and ksetra-jna, guna and karma, ksara and aksara
- **Sankhya Philophy in the Bhagavata Purana** (8 Lectures)
  - Reality of the world, purpose of existence, goal of life
  - Prakrti and its Evolution
  - Enumeration of elements consisting of prakrti, hierarchical evolution
  - Models of perception and cognition within Sankhya
  - Role of subtle mind, role of jiva, intentions of free will
- **Bhagavata Sankhya and Theories of Mind (Consciousness)** (6 Lectures)
  - Fundamental nature of mind and consciousness
- **Bhagavata Sankhya and Mental Health Applications** (3 Lectures)

  - A holistic approach to mental health by recognizing the interconnection of body, mind and spirit
  - Recognizing interplay of the three gunas (modes of nature) - sattva (goodness), rajas (passion) and tamas (ignorance), to achieve mental equilibrium
  - Comparison to contemporary holistic mental health approaches

- **Culmination of Bhagavata Sankhya** (2 Lectures)
  - Metaphysical basis for Bhakti and its efficacy in transcending the temporary

**Textbooks:**


1. Prabhupada, AC Bhaktivedanta Swami, and Bhaktivedanta Swami, **Srimad Bhagavatam**, Bhakivedanta Book Trust, 1972.
2. Prabhupada, AC Bhaktivedanta Swami, and Bhaktivedanta Swami, **Bhagavad-Gita as it is**, Bhakivedanta Book Trust, 1972.


**References:**


1. Dasgupta, Surendranath, **A History of Indian Philosophy**, Motilal Banarasidass Publishing, 2022.
2. Dalela, Ashish, **A Scientific Commentary on Sankhya Sutras**, Shabda Press, 2022.
3. Stapp, Henry P, **A Report on the Gaudiya Vaishnava Vedanta: Form of Vedic Ontology**, Bhaktivedatanta Institute, 1994.
4. Basel, Peter Charles., **The Samkhya System of the Bhagavata Purana**, Diss. University of Iowa, 2012.
5. Gupta, Ravi M., **The Chaitanya Vaishnava of Jiva Goswami: When knowledge meets devotion**, Routledge, 2007.


## 14.6 IK 506: Research methods and statistics for contemplative science

**Course Code : IK 506**

**Course Name : Research methods and statistics for contemplative science**

L-T-P-C : 2-1-0-3
Intended for : 3rd & 4th Year B. Tech, Masters and PhD
Prerequisite : None
Mutual Exclusion: None
Approval: 42nd Senate

**Course Contents**

- Module 1 (21 Lectures + 7 tutorial Lectures) **Research methods theory:**
  - Basic assumptions underlying scientific research
  - Ethics in scientific research
  - Literature review and hypothesis formulation
  - Data collection methods
  - Measurement techniques & Sampling methods
  - Research designs
    * Apart from controlled trial designs (including randomized controlled trial designsRCT), emphasis will also be given on case-control study design and prospective cohort design from contemplative science perspective. For example, studying the effect of advanced meditation (with monks is more feasible from case-control design than RCT). Similarly naturalistic cohort long term follow-up studies are optimal from sampling perspective to study the effect of yogic/meditative lifestyle.
  - Procedure for conducting research experiment
  - Control techniques in experimental research
  - Mixed methods research
  - Emphasis on first person (for subjective experience) and third person perspectivebased assessments will be discussed. Special emphasis on experience sampling method and its relevance for contemplative science will be discussed
  - Scientific writing

  **Tutorial sessions**

  - Randomization procedure
  - Scientific illustrations-Inkscape and blender
  - Reference management-Zotero
  - Qualitative data coding-Qualcoder
- Note: All the tutorial sessions will be taught withY og/Meditation based dataset for better understanding of the concepts

**Module 2 (7 Lectures+ 7 tutorial Lectures) Statistics theory:**

- Data representation-tables & figures
- Descriptive statistics
- Key ingredients for inferential statistics
- Hypothesis testing, statistical significance and decision errors
- T tests

- ANOVA
- Correlation Regression
- Chi square test
- Linear mixed model analysis (LMM)
- Distribution free statistics

**Tutorial sessions (Using Jamovi & R-open-source free software)**

- Data wrangling
- T tests
- ANOVA
- Correlation & Regression
- Chi square test
- LMM
- Sample size calculation-G power

Note: All the tutorial sessions will be taught with Yog/Meditation based dataset for better understanding of the concepts

**Text Books:**


1. Christensen LB, Johnson B, Turner LA., **Research Methods, Design, and Analysis**, Pearson Education, 2019.

2. Aron A, Aron EN, **Statistics for psychology**, 6th Edition, Pearson Education, 2013 .


**References:**


1. Zar JH, **Biostatistical analysis**, Pearson Education India, 1999.

2. Creswell JW, Poth CN, **Qualitative inquiry and research design: Choosing among five approaches**, Sage publications, 2016.


## 14.7 IK 507: Neuroscience and mental health

**Course Code : IK 507**

**Course Name : Neuroscience and mental health**

L-T-P-C : 3-0-0-3
Intended for : 3rd & 4th Year B. Tech, Masters and PhD
Prerequisite : None
Mutual Exclusion: None
Approval: 42nd Senate

**Course Contents**

- **Module 1(10 Lectures) Basics of neuroscience**
  - Structure and function ofthe nervous system-1
  - Structure and function ofthe nervous system-2
- **Module 2 (14 Lectures) Neuropsychology underlying illness & wellness**
  - Illness & Wellness-perspectives from neuroscience
  - Neuroscience of positive psychology
  - Human development through life cycle and the neuroscience of ageing
  - Theories of personality & psychopathology: eastern & western perspectives
- **Module 3 (14 Lectures) Mental health disorders**
  - Classification of mental health disorders
  - Substance related mental health disorders
  - Common mental health disorders
  - Severe mental health disorders
- **Practical (4 Lectures)**
- **Module 4 ( 4 Lectures)**
  - Stigma of mental illness-discussion
  - The beautiful mind-movie analysis
  - Active listening as a crisis intervention-activity in pairs
  - Complementary & integrative mental health practices-discussion

**Textbooks:**

1. Kandel ER, Koester JD, Mack SH, Siegelbaum SA., **Principles ofNeural Science**, 6th Edition, McGraw Hill LLC, 2021.
2. Sadock BJ, Sadock VA., **Kaplan & Sadock's Concise Textbook of Clinical Psychiatry**, Wolters Kluwer/Lippincott Williams & Wilkins, 2008.

**References:**

1. Sadock BJ, Sadock VA, Ruiz P., **Kaplan & Sadock's Comprehensive Textbook of Psychiatry**, Wolters Kluwer, 2017.

## 14.8 IK 508 : Music and Musopathy Intermediate

**Course Code : IK 508**

**Course Name : Music and Musopathy Intermediate**

L-T-P-C : 2-0-2-3
Intended for : BTech/MTech/MS/MSc/MA/Ph.D.
Prerequisite : IK 507 Music and Musopathy Foundation Course or equivalent understanding
Mutual Exclusion: None
Approval: 42nd Senate

**Course Contents**

- **Music in Indian Knowledge Systems**: Music as a Science; Music as one of the 64 Arts; Music as vehicle for Spiritual and Philosophical evolution; Importance of Music in ancient Indian Society from Epics and Literature. (4 Hours)
- **Music as Therapy in Ancient Civilisations & Recent studies based on Ragas, Shlokas and Western Classical and other Systems**: Ragas as Evocative Tools (Rasa Theory); Time Theory of Ragas; Healing power of Ragas; Broad overview of a few current Studies with respect to Human Beings, Animals and Plants. (4 Hours)
- **Musopathy**: Why Musopathy (Limitations and Inconsistencies of Music Therapy in various parts of the world); Differences between Music Therapy and Musopathy; Features of Musopathy; Types of Musopathy - Passive and Active; Tonation Breathing Technique (TBT); Benefits and Scope of Musopathy and TBT. (4 Hours)
- **Introduction to Architects of Music**: Brief bio sketches of Composers: Jayadeva, Purandaradasa, Tulsidas, Oottukkadu Venkata Kavi, Tyagaraja, Meerabai, Muttuswamy Dikshitar, and Shyama Shastri Brief bio sketch of Musicologists: Bharata, Sharngadeva, Venkatamakhi, Matanga, etc. (24 Hours)
- Introduction to 15-20 New Ragas (4 Hours)
- **Practice Songs**: 8 Geetams and 1 Swarajati (7 Hours)
- **Performance Repertoire**: Varnams, Krtis, and Devotional Songs: Introduction to Performance Musical Forms. (1 Hour)
- **Introduction to Prominent Musicians with musical samples** (2 Hours)

**Laboratory/practical/tutorial Modules:**

1. Unit 6: Practice Songs: 8 Geetams and 1 Swarajati (12 Hours)
2. Unit 7: Performance Repertoire: 8 Varnams/ Krtis / Devotional Songs (16 Hours)

**Textbooks:**

1. Chitravina N Ravikiran, **Perfecting Carnatic Music Level 1**, India, 2023. Accessed on 1st Oct 2023 at: https://acharyanet-india.myshopify.com/collections/carnatic-books/products/perfecting-carnatic- music-level-i-e-book

2. Chitravina N Ravikiran, **Perfecting Carnatic Music Level 2: Varnams, Krtis** (eBook). Accessed on 1st Oct 2023 at: https://acharyanet-india.myshopify.com/products/perfecti carnatic-music-level-ii-varnams-krtis -ebook

**References:**


1. Acharyanet, **Carnatic Lessons India**, 2023. Retrieved from https://www.acharyanet.com/carna lessons-india/#plans

2. Chatterjee, G., **Bhartana Yasha, Bharata's Natyashastra** (Meanings and Expositions in English and Hindi With Abhinavagupta's Commentary), 2023. Indian Mind

3. Krishnaswami, S., **Musical instruments of India**, Publications Division: Ministry of Information & Broadcasting, 2017.

4. Ravikiran, C. N., **Appreciating Carnatic Music**, Ganesh & Company, 2006.

5. Shringy, R.K., & Sharma, P.L. (Trans.), **Sangitaratnakara (Sangeet Ratnakara) of Sarngadeva** (Vol. One, ISBN: 9788121505086; Vol. Two, ISBN: 9788121504669), Munshiram Manoharlal Publishers Pvt. Ltd., 2018

6. Subramaniam, L., & Subramaniam, V., **Euphony (Indian Classical Music)**, EastWest Books (Madras) Pvt. Ltd., 1999.


## 14.9 IK 509: Research methodology

**Course Code : IK 509**

**Course Name : Research methodology**

L-T-P-C : 1-0-0-1
Intended for : MTech(R) and PhD students
Perequisite : None
Mutual Exclusion: None
Approval: 53rd BoA

**Course Contents**

- ReseaHii Philosophies and paradigms (1 hour)
  - Six systems oflndian Philosophy- Introduction
  - Research paradigms in Indian philosophical system
  - Eastem & Western paradigms-critical overview
- Research Ethics (l hour)

- Ethics from Indian knowledge system perspective (IKS)
- Evolution of human research ethics
- Literature review and referencing (l hour)
- Review of classical scriptures of Indian philosophy
- Relevant modem science literature review

* Sampling methods (1 hour)
  - Non-probability sampling methods
  - Probability sampling methods
* Research designs (l hour)
  - Experimental designs
  - Non-experimental designs
* Clinical trial and control techniques (l hour)
  - Confounders and control techniques
  - Controlled clinical trials (CCT)
* Logic of hypothesis testing (l hour)
  - Null hypothesis significance testing (NHST)
  - Steps ofhypothesis testing
* Data collection methods (l hour)
  - Measurement errors and bias
  - First person subjective methods.
  - Third person objective methods
* Procedure for conducting reseuch (1 hour)
  - Ethics committee approval
  - Clinical trial registration
  - Informed consent assent
  - Pilot study- need and importance
  - Protocol- apriori design vs. interim modifications
  - Managingg adverse effects
* Fundamentals of qualitative research (l hour)
  - Major qualitative research approaches
  - Validity & reliability in qualitative research Technical software for Research scholars (1 hour)
  - Translator- for Sanskrit transliteration

  - R & Jamovi-for statistical analysis
  - Zotero-for referencing
- Statistics over view (l hour)
  - Descriptive statistics
  - Fundamentals of inferential statistics
- Statistics overview-2 (1 hour)
  - Choosing the right statistical tests
- Scientific writing (l hour)
  - Classical scripmres perspective
  - Modern science perspective

**Textbooks:**

1. Aron A, Aron EN, **Statistics for psychology**, 6th Edition, Pearson Education, 2013.
2. Gough AE, Cowell EB, **The Sarva-Darsana-Samgraha**: Or, Review of the Different Systems of Hindu Philosophy. DigiCat; 2022.

**References:**

1. Zar JH, **Biostatistical analysis**, Pearson Education India; 1999.
2. Crewell JW, Poth CN, **Qualitative inquiry and research design: Choosing among fixe approaches**, Sage publications, 2016
3. Radhakrishnan S, Moore CA, (editors), **A source book in Indian philosophy**, Princeton University Press, 1957.

## 14.10 IK 510: Cognitive Neuroscience

**Course Code : IK 510**

**Course Name : Cognitive Neuroscience**

L-T-P-C : 3-1-0-4
Intended for : 3rd & 4th Year B. Tech, Masters and PhD
Prerequisite :
Mutual Exclusion:
Approval: 54th BoA

**Course Contents**

- **Structure and function of nervous system** (5 hours)
  - Overview of nervous system
  - Brain & spinal cord anatomy
  - Cells of nervous system
  - Action potential
  - Neurotransmitters
  - Synapse
  - Networks
- **Sensation & Perceptio**n (6 hours)
  - Olfaction
  - Gustation
  - Somatosensation
  - Audition
  - Vision
  - Sensation to perception
- **Attention** (4 hours)
  - Models of attention
  - Neural mechanism of attention
- **Attention control networks Action** (4 hours)
  - Anatomy & control of motor structures
  - Motor pathways & physiology
  - Motor planning, initiation and control
  - Motor learning and memory
- **Memory** (4 hours)
  - Learning and memory-anatomical & cellular basis
  - Mechanisms of memory
  - Memory consolidation
  - Memory deficits and amnesia
- **Emotions** (4 hours)
  - Defining & categorizing emotions
  - Theories of emotion generation
  - Neural systems of emotion processing

- Emotion & cognition (learning & memory)

- **Language** (4 hours)
  - Evolution & fundamentals of language
  - Sensory, motor and cognitive aspects of language
  - Theories of language comprehension & speech production
  - Language deficits
- **Cognitive control** (4 hours)
  - Cognitive control anatomy, cross talks (sensorimotor) & deficits
  - Planning, Decision making & execution mechanisms
  - Cognitive control & neuropsychiatry
- **Social Cognition** (4 hours)
  - Theories of self
  - Understanding mental states of others (Theory of Mind-ToM)
  - Experience sharing & simulation theory
  - Mental state attribution
  - Neurobiology of social cognition
  - Social cognition deficits
- **Consciousness** (3 hours)
  - Mind-Brain problem
  - Consciousness theories- neuroscience perspective
  - Consciousness theories & practice-Yogic perspective
  - Miscellaneous-Plant & animal consciousness and others
  - Disorders of consciousness

**Tutorials:**

- Methods in cognitive neuroscience
  - Behavioral experiments-tools & techniques
  - Introduction to neurophenomenology
  - Basics of bio signals
  - Electroencephalograph (EEG) & Heart rate variability (HRV)
  - Transcranial electrical current stimulation(tECS)
  - Transcranial magnetic stimulation (TMS)
  - Functional neuroimaging techniques (fNIRS & fMRI)
  - Introduction to computational neuroscience (ML & AI)

**Textbooks:**

1. Gazzaniga, Michael S., et al., **Cognitive Neuroscience: The Biology of the Mind**, W.W. Norton, 2018.

**References:**

1. Kandel ER, Koester JD, Mack SH, Siegelbaum SA, **Principles of Neural Science**, 6th Edition, McGraw Hill, 2021

## 14.11 IK 511 : Science of Āyurveda

**Course Code : IK 511**

**Course Name : Science of Āyurveda**

L-T-P-C : 3-0-0-3
Intended for : BTech/MTech/MS/MSc/MA/Ph.D
Prerequisite : Introduction to Sanskrit Language or foundational knowledge in Indian philosophical texts.
Mutual Exclusion: None
Approval: 42nd Senate

**Course Contents**

- **Evolution of Āyurveda**: Āyurveda: connecting the dots and sensing the past; Evolution and history of āyurveda; Masters and Teachers of āyurveda; Textual sources in āyurveda; Evolution of Western medicine. (3 Hours)
- **Rational foundations of āyurveda**: The six schools of thought on physical and metaphysical realms; Specific roles of Sāṅkhya, Nyāya, Vaiśeṣika, Mīmāṃsā, Yoga and Uttara Mīmāṃsā in āyurveda; Foundations of Western medicine for comparative purpose. (4 Hours)
- **Āyurveda and Western medicine**: why, how and where they differ: Worldviews and their relation to science; worldviews of classical and quantum physics and their impact on Western medical science; worldview of Indian Knowledge Systems and their impact on āyurveda; Fundamental differences between āyurveda and Western medicine and their implications for research. (4 Hours)
- **Conceptualisation of human system in āyurveda**: Models for understanding human system in āyurveda and Western medicine; Integral components of life in ayurveda and Western medicine; What is life?; What is health?; Various concepts in āyurveda to understand and manage health and disease. (4 Hours)
- **Tridoṣa**: What are tridoṣas?; How are they used to understand the human system, health, and disease; use of tridoṣas in diagnosis and treatment; Tridoṣas from a research perspective. (4 Hours)
- **Āyurvedic approach to health and disease**: Health and disease metrics; The multipronged approach to health and disease; Diagnosis and Treatment in āyurveda; Diagnosis and treatment in Western medicine for comparative purpose. (4 Hours)

- **Āyurvedic approach to mental health**: Comprehensive wellbeing in āyurveda; Understanding of mind and consciousness; Pañcakośas; yoga; Management of mental health. (4 Hours)
- **Āyurvedic pharmacology**: Use of medicinal plants in āyurveda; āyurvedic pharmacological metrics; āyurvedic formulations; validation of āyurvedic medicines, Rules and regulations for the use of āyurvedic medicines, potential research areas in medicinal plants and formulations. (4 Hours)
- **Āyurvedic approach to diet and nutrition**: Food and health in āyurveda; concept of diet and nutrition in āyurveda; diet and mental health; Potential research areas. (3 Hours)
- **Research in Āyurveda**: Current research methodologies; Research requirements in āyurveda; Current āyurveda research; Potential research topics. (4 Hours)
- **Interaction with practicing vaidyas**: Interaction with āyurvedic vaidyas from different parts of the country to get a bird's eye view of the different practices and to hear their views on research. (4 Hours)

**Textbooks:**

1. Teeka of Shri. Chakrapanidatta, Edited by Yadavji Trikamji Acharya, **Charaka Samhitha with Ayurveda Deepika**, Chaukambha Sanskrit Sansthan.
2. Teeka of Shri. Dalhanacharya, and Nyaya Chandrika Panjika of Shri. Gayadasacharya on Nidana Sthana, Edited by Yadavji Trikamji Acharya, Sushruta Samhita with Nibandha Samgraha, Chaukambha Sanskrit Sansthan

**References:**

1. Ashtanga Hrudaya with Sarvanga Sundara Teeka of Arunadatta and Ayurveda Rasayana Teeka of Hemadri; Edited by Pandit Hari Sadashiva Sastri Paradakar, Chaukambha Sanskrit Sansthan Srikantamurthy KR (Translator): Ashtanga Samgraha of Vagbhata, Chaukambha Orientalia, Varanasi, 2005.
2. Srikantamurthy KR (Translator), **Sharangdhara Samhita of Sharangdhara**, Chaukambha Orientalia,Varanasi, 2000.

## 14.12 IK 512 : Rhythmic Structures and Applications in Music and Musopathy

**Course Code : IK 512**

**Course Name : Rhythmic Structures and Applications in Music and Musopathy**

L-T-P-C : 3-0-0-3
Intended for : BTech/MTech/MS/MSc/MA/Ph.D
Prerequisite : None
Mutual Exclusion: None
Approval: 42nd Senate

**Course Contents**

- **Introduction to Rhythm**: Rhythm as a Fundamental Operating Principle in the Universe and a regulating health mechanism for all living organisms right from heartbeat. (2 Hours)
- **Fundamentals of Rhythm**: Understanding rhythm basics common to world music systems; time signatures; tempo; speed and beat. (2 Hours)
- **Introduction to India's approach to rhythm**: Global popularity of Indian rhythms; Concept of Laya & Tala; Parts of Talas (angas); Finger counting (Jaati and Laghu); Pulse and Gait within beats (Gati/Nadai); Kaala and Kaalapramana; Types of Patterns (Yatis) etc. (6 Hours)
- **Percussion Instruments of India**: Types (Skin based, body based etc); Ancient instruments; prominent contemporary instruments; Drum language in India. (3 Hours)
- **Rhythmic performances**: Percussion accompaniment to melody in Carnatic and Hindustani traditions; percussion interludes and improvisation; percussive cadenzas and climaxes. (3 Hours)
- **Rhythmic Expressions Across Cultures**: Examination of rhythmic complexities in various world music traditions, including Indian classical, African, Latin American, and Western music. (4 Hours)
- **Cognitive Aspects of Rhythm**: Exploring the relationship between rhythm and cognitive functions, including memory, attention, and motor coordination. (4 Hours)
- **Rhythm in Musopathy**: Studying the therapeutic applications of rhythm, its impact on psychological states, Use of Vocal Percussion in speech rehabilitation of stroke victims or patients with other conditions. (6 Hours)
- T**echnological Tools for Rhythmic Analysis and Creation**: Introduction to software and digital tools for rhythm analysis, creation, and its applications in music therapy. (4 Hours)
- **Workshop and Case Studies**: Practical workshops on creating rhythmic compositions; case studies on using rhythm in therapeutic settings. (8 Hours)

**Laboratory/practical/tutorial Modules:**

1. NA

**Textbooks:**

1. Sadanand Naimpali, **Theory and Practice of Tabla - The Secular Rationalist Reformer**, Popular Prakashan Private Limited, 2011.
2. Sankaran, T. S., **The Art of Konnakkol (Solkattu): Spoken Rhythms of South Indian Music**, Lalith Publishers, 2010.

**References:**


1. Clayton, M., Sager, R., & Will, U., **In Time with the Music: The Concept of Entrainment and Its Significance for Ethnomusicology**, ESEM Counter Point, 2005.

2. Hartenberger, R. (Ed.), **The Cambridge Companion to Percussion**, Cambridge University Press, 2016.

3. London, J., **Hearing in Time: Psychological Aspects of Musical Meter**, 2nd Edition, Oxford University Press, 2012.

4. Sankaran, T. S., **The Rhythmic Principles and Practice of South Indian Drumming**, Lalith Publishers, 1994.

5. Thaut, M. H., **Rhythm, Music, and the Brain: Scientific Foundations and Clinical Applications**, Routledge, 2005.


## 14.13 IK 513 : Music and Musopathy Foundation

**Course Code : IK 513**

**Course Name : Music and Musopathy Foundation**

L-T-P-C : 2-0-2-3
Intended for : BTech/MTech/MS/MSc/MA/Ph.D.
Prerequisite : None
Mutual Exclusion: None
Approval: 42nd Senate

**Course Contents**

- **Music - The Macro Picture**: (5 Hours)
  - **Universality of music**: Glimpse into melody, rhythm, harmony, prominent music systems in the world.
  - **Indian Music in World Arena**: How and why Indian music is respected in the world for melody, rhythm and its incredible richness and versatility and how Indian music has impacted jazz, pop and several other cultures in the world.
  - **Music & Social well-being**: How music contributes to Inter-cultural harmony, goodwill, respect, fund-raisers for health, education etc.
  - **Music & Personal Evolution**: How music promotes mental health and physical wellbeing including equanimity, cognitive development, spiritual and philosophical evolution and cardiovascular and pulmonary health among other things.
- **Music in Other Fields and Regions of India**: Introduction: Exploration of different Indian music systems and their influences: Indian System in North India and Persian Influences; Rabindra Sangeet of Eastern India; Ancient Tamil Music; Folk Systems in various States. (3 Hours)

- **Introduction to Melody and Voice Exercises**: (2 Hours) Theoretical Introduction to Melody and Voice Exercises: Melody, 7,12,16 note system, raga, ascending and descending scales, concept of technical exercises. (2 Hours)
- **Preliminary Sequential Exercises (Varishai)**: Theoretical Introduction to Preliminary Sequential Importance of Sequential Exercises such as Sarali and Jantai varishais; Introduction to notation writing, Introduction to basic rhythmic concepts, Concept of Speed (kaala) and tempo (kalapramana). (4 Hours)
- **Sapta Tala Alankarams**: Introduction to Cyclic Rhythms of various types (Talas) - Parts of a tala, concept of jaati (types of finger counts) and gati (internal pulse within each unit of a tala), system of 7 (sapta) talas Exercises: Training in the 7 basic Alankaras. (4 Hours)
- **Ragas of Indian Music 72 Principal Scales (Melakartas) and 7 Million Derived Scales (Janya Ragas)** (4 Hours)
  - Exploration of 16 Notes, 72 Melakarta scheme/structure: Permutation and Combination of the 16 Notes, 72 Melakarta scheme/structure; 12 Chakras; Musical Mnemonics: KaTaPaYaadi Formula (sootra) for Raga names and numbers.
  - Concept & Classification of Derived Ragas: Based on number of notes (3, 4, 5, 6, 7); based on types of sequences - (Straight or zig-zag) and based on nativity of notes (Upanga & Bhashanga).
- **Geetams and Simple Devotional Songs in a few Ragas** (3 Hours)
  - Introduction to Practice Compositions: Geetams and Swarajatis
  - Essentials of a Raga: Scale and sequence of notes (arohana and avarohana); swara rendition, ornamentation (gamakas); hierarchy of notes etc
- **Music in Other Fields:L Exploration of Music's integration with various fields**: Music & Dance; Music & Physics - concept of octaves, cycle of fourths and fifths, Music & Mathematics - patterns and korvais; Musical Literature - works of composers in diverse languages; Music and Philisophy; Music and Musopathy - pulmonary, cardio, mental health, etc; Music in Indian Knowldge Systems - Vedas, ancient Tamil culture, Puraanas and Itihaasaas. (3 Hours)

**Laboratory/practical/tutorial Modules:**

1. Unit 3 Practical: (8 Hours) Plain notes, oscillated notes, octave exercises, swaram, akaaram.
2. Unit 4 Practical: (8 Hours) Exercises in swara (3 speeds), akaaram, in Sarali, Jantai, and other Varishais.
3. Unit 5 Practical: (2 Hours) 7 Alankarams - 3 speeds in swara and akaaram; introduction to prominent talas - adi, roopakam, chapu and concept of 35-talas.
4. Unit 6 Practical: (2 Hours) 72 Melaragamalika Geetam.
5. Unit 7 Practical: (8 Hours) Learn 5 Geetams and 3 Devotional Songs.

**Textbooks:**


1. Chitravina N Ravikiran, **Perfecting Carnatic Music Level 1**, India, 2023. Accessed on 1st Oct 2023 at: https://acharyanet-india.myshopify.com/collections/carnatic-books/products/perfecting-carnatic- music-level-i-e-book

2. Krishnaswami, S., **Musical instruments of India**, Publications Division: Ministry of Information & Broadcasting, 2017.


**References:**


1. Acharyanet, **Carnatic Lessons India,** 2023. Retrieved from https://www.acharyanet.com/carna lessons-india/#plans

2. Chatterjee, G., **Bhartana Yasha, Bharata's Natyashastra (Meanings and Expositions in English and Hindi With Abhinavagupta's Commentary)**, 2023. Indian Mind

3. Ravikiran, C. N., **Appreciating Carnatic Music**, Ganesh & Company, 2006.

4. Shringy, R.K., & Sharma, P.L. (Trans.), **Sangitaratnakara (Sangeet Ratnakara) of Sarngadeva** (Vol. One, ISBN: 9788121505086; Vol. Two, ISBN: 9788121504669), Munshiram Manoharlal Publishers Pvt. Ltd., 2018

5. Subramaniam, L., & Subramaniam, V., **Euphony (Indian Classical Music)**, EastWest Books (Madras) Pvt. Ltd., 1999.


## 14.14 IK 514 : Introduction to Audio Engineering

**Course Code : IK 514**

**Course Name : Introduction to Audio Engineering**

L-T-P-C : 3-0-0-3
Intended for : BTech/MTech/MS/MSc/MA/Ph.D
Prerequisite : None
Mutual Exclusion: None
Approval: 42nd Senate

**Course Contents**

- **Introduction to Audio Systems**: Overview of various audio systems and components. Signal flow and interfacing standards. (5 Hours)

- **Fundamentals of Sound**: Acoustic principles, sound wave properties, psychoacoustics, and human perception of sound. (10 Hours)

- **Microphones and Speakers:** Types, designs, and applications of microphones and speakers. Practical considerations in microphone placement and speaker setup. (8 Hours)

- **Recording Technology**: Multi-track recording, audio interfaces, digital audio workstations, and recording techniques for different instruments and vocal performances. (8 Hours)
- **Audio Signal Processing**: Equalization, compression, reverb, delay, and other audio effects. Use of audio processing tools in mixing and mastering. (8 Hours)
- **Audio for Video and Film**: Techniques and challenges in audio post-production for video and film, including synchronization, sound design, and Foley. (3 Hours)

**Laboratory/practical/tutorial Modules:**

1. NA

**Textbooks:**

1. Stanley R. Alten, **Audio in Media**, 10th Edition, Cengage Learning, 2014.
2. David Miles Huber, **Modern Recording Techniques**, 9th Edition, Focal Press, 2017.

**References:**

1. Bartlett, B., & Bartlett, J., **Practical Recording Techniques: The Step-by-Step Approach to Professional Audio Recording**, 7th Edition, Focal Press, 2018.
2. Eargle, J., & Foreman, R., **Eargle's The Microphone Book: From Mono to Stereo to Surround - A Guide to Microphone Design and Application**, 3rd Edition, Focal Press, 2020.
3. Izhaki, R., **Mixing Audio: Concepts, Practices, and Tools**, 3rd Edition, Focal Press, 2018.

## 14.15 IK 515 : Music and Cognition

**Course Code : IK 515**

**Course Name : Music and Cognition**

L-T-P-C : 3-0-0-3
Intended for : BTech/MTech/MS/MSc/MA/Ph.D
Prerequisite : None
Mutual Exclusion: None
Approval: 42nd Senate

**Course Contents**

- **Introduction to Music and Cognition**: Basics of cognitive science and musical structure, exploring the ways music and cognitive processes interact, and the role of music in cognitive enhancement and therapy. (5 Hours)

- **Musical Perception**: Delve into the cognitive processing of musical elements such as pitch, rhythm, timbre, and melody. Explore the auditory system, musical feature extraction, and the cognitive organization of musical sounds. (10 Hours)

- **Musical Memory**: Understand the intricacies of short-term and long-term musical memory and musical expectation. Examine the encoding, storage, and retrieval of musical information. (8 Hours)

- **Emotion and Music**: Examination of how music evokes emotional responses, the role of musical expression, and the neuroscientific basis of musical emotions. Understand the role of cultural and individual differences in musical emotion. (9 Hours)

- **Music, Intelligence, and Learning**: Analysis of the Mozart Effect, exploration of the impact of musical training on cognitive development, and the relationship between music and spatial-temporal reasoning. (10 Hours)

**Laboratory/practical/tutorial Modules:**

1. NA

**Textbooks:**

1. Levitin, D. J., **This Is Your Brain on Music: The Science of a Human Obsession**, Penguin, 2007.

2. Sloboda, J. A., **The Musical Mind: The Cognitive Psychology of Music**, Oxford University Press, 1985.

**References:**

1. Patel, A. D., **Music, Language, and the Brain**, Oxford University Press, 2008.

2. Hodges, D. A., **Handbook of Music Psychology**, IMR Press,1996.

## 14.16 IK 530 : Bhagavad-Gītā Part I

**Course Code : IK 530**

**Course Name : Bhagavad-Gītā Part I**

L-T-P-C : 3-0-0-3
Intended for : BTech/MTech/MS/MSc/MA/Ph.D
Prerequisite : None
Mutual Exclusion: None
Approval: 42nd Senate

**Course Contents**

- **Introduction to Bhagavad-Gītā and Sanskrit Basics**: Origins and significance; Overview of Mahābhārata; Basics of Sanskrit language; Pronunciations and grammar. (8 Hours)
- **Arjuna's Dilemma** (Chapter 1): The setting of Kurukshetra; Arjuna's observations; Emotional conflicts and ethical issues. (6 Hours)
- **Transcendental Knowledge** (Chapter 2): Sāṅkhya yoga; Nature of soul; Concepts of Dharma and Karma; Significance of detached action. (8 Hours)
- **Path of Devotion** (Chapter 3): Karma Yoga; Duty and righteousness; The balance of action and inaction. (6 Hours)
- **Approaching the Ultimate Truth** (Chapters 4-5): Knowledge and renunciation; Concepts of Yajña and selfless action; Jñāna yoga vs. Bhakti yoga. (8 Hours)
- **The Science of Self-Realization** (Chapter 6): Dhyāna Yoga; Practices and principles of meditation; Achieving spiritual equilibrium. (6 Hours)

**Laboratory/practical/tutorial Modules:**

1. NA

**Textbooks:**

1. Sargeant, W., **The Bhagavad-Gītā**, State University of New York Press, 2009.
2. Swami Satchidananda, **The Living Gita: The Complete Bhagavad-Gītā - A Commentary for Modern Readers**, Integral Yoga Publications, 2005

**References:**

1. E-learning: https://sanskrit.uohyd.ac.in
2. Easwaran, E., **The Bhagavad-Gītā**, Nilgiri Press, 2007
3. A.C. Bhaktivedanta Swami Prabhupada, **Bhagavad-Gita As It Is**, The Bhaktivedanta Book Trust, 1986.

## 14.17 IK 535: Ancient Sanskrit Literature and Scriptures

**Course Code : IK 535**

**Course Name : Ancient Sanskrit Literature and Scriptures**

L-T-P-C : 3-0-0-3
Intended for : BTech/MTech/MS/MSc/MA/Ph.D
Prerequisite : None
Mutual Exclusion: None
Approval: 42nd Senate

**Course Contents**

- **Module 1:** Introduction to Sanskrit Literature (4 hours)
- **Module 2:** The Vedas (6 hours)
- **Module 3:** The Epics (6 hours)
- **Module 4:** Classical Sanskrit Poetry (6 hours)
- **Module 5:** Sanskrit Drama (6 hours)
- **Module 6:** Sanskrit Philosophy (6 hours)
- **Module 7:** Sanskrit Religion (6 hours)

**Laboratory/practical/tutorial Modules:**

- NA

**Textbooks:**

1. Adelaide Rudolph, **Nala and Damayanti: A Love-Tale of East India**.
2. Eknath Easwaran (Translator), **The Bhagavad-Gītā**.
3. Eknath Easwaran (Translator), **The Upanishads**.
4. Arthur W. Ryder (Translator), **Kalidasa: The Recognition of Shakuntala**.

**References:**

1. Krishna Kumar, **Alankarshastrakaitihas**, Sahityabhandar, 1975.
2. P. V. Kane, **Sanskrit Kavyashastrakaitihas**, MLBD, 1994.
3. S.K. De, **History of Sanskrit Poetics,** Oriental Book Centre, 2006.
4. Babulal Shukla, **Kavyaprakash**, Nag Prakashan, 1995.

## 14.18 IK 536 : Introduction to Vedanta Philosophy

**Course Code : IK 536**

**Course Name : Introduction to Vedanta Philosophy**

L-T-P-C : 3-0-0-3
Intended for : BTech/MTech/MS/MSc/MA/Ph.D
Prerequisite : None
Mutual Exclusion: None
Approval: 42nd Senate

**Course Contents**

- **Introduction to Hindu Philosophy** (8 Hours)
  - Brief Discussion on Veda and Upanishads
  - Origin of Hindu Philosophy
- **Charvaka Philosophy** (3 Hours)
  - Epistemology
  - Metaphysics
- **Samkhya Philosophy** (6 Hours)
  - Metaphysics, Theory of Causation, Prakṛti, Purusa, Evolution
  - Epistemology, Bondage, and Liberation
- **Yoga Philosophy** (4 Hours)
  - Organization of the Yoga Sūtras, Psychology of Yoga
  - The Eight-Fold Yoga, God, and Liberation
- **Nyaya Philosophy** (9 Hours)
  - Epistemology, Theory of Causation
  - Self and Liberation, The Concept of God
- **Mimansa Philosophy** (5 Hours)
  - Epistemology, Theories of Error
  - Metaphysics, Nature of Self, God, and Liberation
- **Vaisesika Philosophy** (6 Hours)
  - Metaphysics and the Categories
  - Epistemology, The Concept of God, Bondage, and Liberation

**Textbooks:**


1. Chatterjee, S.G. & Datta, D.M., **An Introduction to Indian Philosophy**, University of Calcutta Press, 1960.
2. Sharma, C., **A Critical Survey of Indian Philosophy**, Motilal Banarasidass Publication, 1964.

**References:**


1. Muller, F.M., **The Six Systems of Indian Philosophy**, Longmans Green and Co. Publication, 1928.

2. Barlingay, S.S., **A Modern Introduction to Indian Logic**, National Publishing House, 1965.

3. Chatterjee, S.C., **The Nyaya Theory of Knowledge**, University of Calcutta Press, 1950.

4. **Journal of Indian Philosophy**: https://www.springer.com/journal/10781.

5. **Encyclopaedia of Britannica on Indian Philosophy**: https://www.britannica.com/topic/Ind philosophy.


## 14.19 IK 538 : Basic Sanskrit Grammar and Semantics

**Course Code : IK 538**

**Course Name : Basic Sanskrit Grammar and Semantics**

L-T-P-C : 3-0-0-3
Intended for : BTech/MTech/MS/MSc/MA/Ph.D
Prerequisite : IK 540 Bhagavad-Gītā Part II or equivalent understanding of chapters 7-12.
Mutual Exclusion: None
Approval: 42nd Senate

**Course Contents**

- **Introduction**: Introduction to the Samskrit grammatical tradition. (2 hours)
- **Varnamālā and Pratyāhāra**: Scientific division of varṇamala, uccāraṇa sthāna, Śiva Sūtra, pratyāhāra, optimality of pratyāhāra Sūtras through Formal Concept Analysis. (5 hours)
- **Kāraka prakaraṇam**: Introduction to the kāraka system of Pāṇini, origin of dependency grammar, use of kāraka theory in Indian language technology, Information coding in language. (5 hours)
- **Prakṛti Pratyaya Vyavastha and Pada**: Pada formation in Samskrit, Pratipādika, dhātu, introduction to Gana-patha and Dhātu-patha. (3 hours)
- **It Prakarana as attribute marking**: Definition of "it", introducing anuvṛtti as well as Pāṇinian style of rules. (2 hours)
- **Subanta -prakaraṇa**: Sup pratyaya, ajanta, halanta, declension examples, Concept of Stree Pratyaya. (6 hours)
- **Tiṅganta -prakaraṇa**: parasmaipada, ātmanepada, lakāra, gaṇa. (5 hours)
- Avyaya and Upasarga, Viśeṣaṇa Viśeṣya Sambandha (2 hours)

- Kṛdanta (4 hours)
- **Sandhi-prakaraṇa and big picture of Aṣṭādhyāyī** : Types of Sūtras, prakriya-vidhi and Sandhi Sūtras. (3 hours)
- **Structure of Aṣṭādhyāyī** : Siddha, Asiddha and Asiddhavat; Utsarga Apavāda Vyavasthā. (1 hours)
- Taddhitas (1 hours)
- Nijanta and Sannanta (1 hour)
- Word formation through nāma-dhātu (1 hour)
- Compound formation: samāsa (1 hours)

**Laboratory/practical/tutorial Modules:**

1. NA

**Textbooks:**

1. Pushpa Dikshit, **Aṣṭādhyāyī with Prakaraṇa Nirdeśa**, Samskrita Bhārati, New Delhi, 2010.
2. Srisa Chandra Vasu, **Siddhānta Kaumudī of Bhattoji Dīkṣita**, Vol. I-III, The Pāṇini Office, Allahabad, 1906.
3. Teaching Tolls: **Online and Offline tools for better teaching practices, teaching with examples and case studies**. Online resource: https://dharmawiki.org/index.pl

**References:**


1. Gopal Dutt Pandey (Ed.), **Aṣṭādhyāyī of Pāṇini**, Chaukhamba Surbharati Prakashan, Varanasi, 2017.
2. Wiebke Petersen. (2004), **A Mathematical Analysis of Pāṇini's SivaSūtras**. In: JoLLI. 13 (4), p. 471-489.
3. Akshar Bharati and Rajeev Sangal. 1990. **A karaka-based approach to parsing of Indian languages**. In Proceedings of the 13th conference on Computational linguistics - Volume 3 (COLING '90). Association for Computational Linguistics, USA, 25–29.
4. **The Aṣṭādhyāyī Sūtrapāṭha of Pāṇini, with Vārtikas, Gaṇa, Dhātupāṭha, Pāṇiniya-śikṣā and Paribhāṣāpāṭha**, second edition, edited by C. Sankara Rama Shastri, printed and published by The Shri Bala Manorama Press, Mylapore, Madras, 1937.
5. Shrish Chandra Vasu, **The Aṣṭādhyāyī of Pāṇini, translated into English**, first published in 1891, reprinted by Motilal Benarsidass, 1962.
6. **NLP: A Pāṇinian perspective**, Akshar Bharati, 1995.

7. Samskrita Bharati books on Vyakarana (https://www.samskritabharati.in/vyakaranam)

   (a) Shivaram Ramkrishna Bhatt, **Vyakarana Prashna Kosha**, Samskrita Bharati, New Delhi, 2016.
   (b) G. Mahabaleshwar Bhatt, **Karakam**, Samskrita Bharati, Bengaluru, 2014.
   (c) Janardan Hegde, **Dhaturupa Nandini**, Samskrita Bharati, New Delhi, 2013.
   (d) G. Mahabaleshwar Bhatt, **Sandhi**, Samskrita Bharati, Bengaluru, 2015.
   (e) G. Mahabaleshwar Bhatt, **Samasa**, Samskrita Bharati, Bengaluru, 2015
   (f) G. Mahabaleshwar Bhatt, **Shatru Shanajanta Manjari**, Samskrita Bharati, Bengaluru, 2015.

8. Samskrit Promotion Foundation books in 'Samskrit for Specific Purpose Series' (https://www.samskritpromotion.in/bookstore)

   (a) Raghavendra P. Arolli and others, **The Language of Vastushastra**, Samskrit Promotion Foundation.
   (b) Vishnu Prasad Upadhyay and others, **The Language of Administration**, Samskrit Promotion Foundation.
   (c) Pradip Paudel and others, **The Language of Arts**, Samskrit Promotion Foundation.
   (d) Ganamoorthi K. and others, **The Language of Dharmashastra**, Samskrit Promotion Foundation.
   (e) Vishnu Prasad Upadhyay and others, **The Language of Arthashastra**, Samskrit Promotion Foundation.
   (f) Raghavendra and others, **Nyayasutrani The Language of Nyayasastra**, Samskrit Promotion Foundation.
   (g) Raghuram Bhatta and others, **The Language of Ayurveda (Parts I-IV)**, Samskrit Promotion Foundation.
   (h) Devershi Agustya, **The Language of Jyotisha**, Samskrit Promotion Foundation.
   (i) Kirori Singh Chouhan, **The Language of Mahabharata (Parts I & II)**, Samskrit Promotion Foundation.
   (j) Pramod Shukla and Vishnu Prasad Upadhyaya, **The Language of Subhashitas**, Samskrit Promotion Foundation.
   (k) Satyanarayana and Vishnu Prasad Upadhyaya, **The Language of Rāmāyaṇa**, Samskrit Promotion Foundation.
   (l) Ganesh Ishwar Bhat and others, **The Language of Vedanta** (Parts I-IV), Samskrit Promotion Foundation.
   (m) Vishwasa and others, **The Language of Gita** (Parts I-IV), Samskrit Promotion Foundation.
   (n) Jayaraman Mohan, **The Language of Yoga** (Parts I-IV), Samskrit Promotion Foundation.

## 14.20 IK 539 : Sanskrit and Technology: An Overview

**Course Code : IK 539**

**Course Name : Sanskrit and Technology: An Overview**

L-T-P-C : 3-0-0-3
Intended for : BTech/MTech/MS/MSc/MA/Ph.D
Prerequisite : IK 540 Bhagavad-Gītā Part II or equivalent understanding of chapters 7-12.
Mutual Exclusion: None
Approval: 42nd Senate

**Course Contents**

- **Interactive Sanskrit Teaching Learning Tools**: (12 hours)
  - Introduction to Interactive Sanskrit Learning Tools, Why Interactive Tools for Sanskrit?
    - E-learning, Basics of Multimedia, Web-based tools development, HTML, Web page, etc., Tools and Techniques
- **Standard for Indian Languages (Unicode)** (9 hours)
  - Nature of Devanagari/Brahmni scripts, Concept of Aksharas, Conjuncts, and Script grammar.
    - Typing in Devanagari Scripts, Typing Tools and Software
- **Text Processing and Preservation Tools** (12 hours)
  - Text Processing, Preservation Techniques, Text Processing and Preservation Tools, and
    - Techniques, Survey
- **Optical Character Reader**: Word generation, word analysis, compound formation, sandhi generation and splitting, sentence analysis, Optical Character Reader (OCR), Applications of OCR for Sanskrit and Indian Languages, Tool and Techniques, Survey. (12 hours)

**Textbooks:**

1. NA

**Suggested Reading:**


1. Teacher's notes, ppt, and handout
2. Bharti A., R. Sangal, V. Chaitanya, "**NL, Complexity Theory and Logic**" in Foundations of Software Technology and Theoretical Computer Science, Springer, 1990.

3. E-Content suggested by Teacher

4. Tools developed by Computational Linguistics Group, Department of Sanskrit, University of Delhi, Delhi-110007 available at: http://sanskrit.du.ac.in

5. Basic concept and issues of multimedia: http://www.newagepublishers.com/samplechapter/00169

6. Content creation and E-learning in Indian languages: a model: http://eprints.rclis.org/7189/1/vija

7. HTML Tutorial - W3Schools: www.w3schools.com/html

8. The Unicode Consortium: http://unicode.org/

## 14.21 IK 540 : Bhagavad-Gītā Part II

**Course Code : IK 540**

**Course Name : Bhagavad-Gītā Part II**

L-T-P-C : 3-0-0-3
Intended for : BTech/MTech/MS/MSc/MA/Ph.D
Prerequisite : IK 530 Bhagavad-Gītā Part I or equivalent understanding of the first six chapters.
Mutual Exclusion: None
Approval: 42nd Senate

**Course Contents**

- **Knowledge and Wisdom** (Chapter 7): The difference between Jñāna and Vijnāna; Various forms of knowledge; Understanding the Supreme. (6 Hours)

- **The Imperishable Brahman** (Chapter 8): The eternal and perishable aspects of creation; Process of dying and rebirth; Ultimate goals of life. (6 Hours)

- **The Royal Knowledge and Royal Secret** (Chapter 9): Deeper insights into devotion; Royal knowledge and its significance; Manifest and unmanifest forms of the divine. (8 Hours)

- **Manifestation of the Universal Form** (Chapter 10): Divine glories; Different manifestations and opulences of the Supreme Being. (6 Hours)

- **The Vision of the Universal Form** (Chapter 11): Arjuna's vision of the cosmic form; The infinite power of the divine; Comprehending the magnitude of the universe. (8 Hours)

- **The Way of Love** (Chapter 12): Understanding Bhakti yoga; The qualities of a true devotee; Paths to spiritual realization. (6 Hours)

**Laboratory/practical/tutorial Modules:**

1. NA

**Textbooks:**

1. Sargeant, W., **The Bhagavad-Gītā**, State University of New York Press, 2009.
2. Swami Satchidananda, **The Living Gita: The Complete Bhagavad-Gītā - A Commentary for Modern Readers**, Integral Yoga Publications, 2005

**References:**

1. E-learning: https://sanskrit.uohyd.ac.in
2. Easwaran, E., **The Bhagavad-Gītā**, Nilgiri Press, 2007
3. A.C. Bhaktivedanta Swami Prabhupada, **Bhagavad-Gita As It Is**, The Bhaktivedanta Book Trust, 1986.

## 14.22 IK 541 : Upanishads and Vedanta Studies

**Course Code : IK 541**

**Course Name : Upanishads and Vedanta Studies**

L-T-P-C : 3-0-0-3
Intended for : BTech/MTech/MS/MSc/MA/Ph.D
Prerequisite : IK 536 Introduction to Hindu Philosophy or equivalent foundational knowledge in Hindu philosophy
Mutual Exclusion: None
Approval: 42nd Senate

**Course Contents**

- **Introduction to Upanishads** (5 Hours)
  - Overview and Historical Context
  - Importance and Influence on Hindu Thought
  - Classification and Principal Upanishads
- **Core Teachings of Upanishads** (8 Hours)
  - Concepts of Brahman and Atman Understanding of Māyā (Illusion)
  - The Doctrine of Karma and Rebirth
  - The Nature of Reality: Advaita, Dvaita, and Viśiṣṭādvaita views
- **Deep Dive into Selected Upanishads** (6 Hours)
  - Isha Upanishad: Vision of Oneness
  - Kaṭha Upanishad: Dialogue on Death and Immortality
  - Chāndogya Upanishad: Meditation and Rituals
- **Vedanta Philosophy** (7 Hours)
  - Introduction to Vedānta Darśana

- Brahma Sūtras and their significance
- Advaita Vedanta of Ādi Śaṅkarācārya
- Rāmānuja's Viśiṣṭādvaita
- Vedanta Madhva's Dvaita Vedanta

- **Contemporary Interpretations** (8 Hours)
  - Modern Vedantic Teachers: Ramaṇa Maharshi, Vivekananda, Aurobindo
  - The Theosophical interpretation of Upanishads and Vedanta Interactions with Western Philosophy and New Age Thought
- **Upanishads, Vedanta, and Daily Life** (4 Hours)
  - Spiritual practices derived from Upanishadic teachings
  - Vedantic approach to modern challenges: Stress, Identity, and Morality
  - Upanishadic view on Ecology and Environment
- **Wrap up and Reflection** (4 Hours)
  - Student presentations on selected topics
  - Group discussions on the application of Upanishadic teachings in contemporary life
  - Closing reflections and the way forward

**Textbooks:**


1. Radhakrishnan, S., **The Principal Upanishads**, Harper Collins, 1992.
2. Deussen, P., **Sixty Upanishads of the Veda** (Vol. 1 & 2), Motilal Banarsidass, 2010.


**References:**


1. Vivekananda, S., **Jnana Yoga**, Ramakrishna-Vivekananda Center, 1955.
2. Swami Sivananda, **Upanishads in Story and Dialogue**, Divine Life Society, 2019.
3. Sharma, C., **A Critical Survey of Indian Philosophy**, Motilal Banarasidass Publication, 1964.
4. Easwaran, E., **The Upanishads: A Classic of Indian Spirituality**, Nilgiri Press, 2007.
5. Rukmani, T. S., **A Critical Study of the Bhagavata Purana: With Special Reference to Bhakti**, Chowkhamba Sanskrit Series, 2001.

## 14.23 IK 542 : Machine Learning for Sanskrit Text Analysis

**Course Code : IK 542**

**Course Name : Upanishads and Vedanta Studies**

L-T-P-C : 3-0-0-3
Intended for : BTech/MTech/MS/MSc/MA/Ph.D
Prerequisite : Basic Computer Fundamentals
Mutual Exclusion: None
Approval: 42nd Senate

**Course Contents**

- **Vyakaran**: Phonetics in Ancient India, W S Allen 1971, Sandhi, W S Wallen, Morphology, Syntax, Karaka Analysis, Indian Theories of Meaning, Philosophy of Word and Meaning, Sanskrit Philosophy of Language, Logic, Language, Reality. The Sanskrit Language: An Overview - History and Structure, Linguistic and Philosophical Representations, Annotation schemes for sandhi, morph, compound, karaka, An introduction to sanskrit language and linguistics. (12 Hours)
- **Natural Language Processing – 1**: Overview of NLP and its applications, Historical perspective and evolution of NLP, Challenges in natural language understanding and generation, Basic linguistic concepts (syntax, semantics, pragmatics), Text Processing and Preprocessing, Language Models and Probability in NLP. (12 hours)
- **Machine Learning-1(Introductory)**: Definition of Machine Learning, Applications of Machine Learning, Overview of the Machine Learning Process, Machine Learning for NLP, Project Work and Presentations on NLP**. (**16 hours)

**Textbooks:**


1. Akshar Bharati, Vineet Chaitanya, Rajeev Sangal, **NLP: A Pāṇinian perspective**, prentice hall of India, 1995
2. Daniel Jurafsky and James H Martin, **Speech and Language Processing**.
3. **Explorations in Artificial Intelligence and Machine Learning**, A CRC Press FreeBook, Taylor and Francis Group
4. Dr. Naresh Jha, **Ashtadhyayi of Pāṇini**, Chaukhamba Surbharati Prakashan, 2014
5. Amba Kulkarni, **Sanskrit Parsing: Based on the Theories of Shabdabodha**, D K Printworld and IIAS Shimla, 2019.
6. Kapil Kapoor, **Dimensions of Pāṇini Grammar**, D K Print World, 2020

**References:**

1. Bloomfield, **Language**, Motilal Banarsidass.

2. Prof. Korada Subramaniyam, **Theories of Language: Oriental and Occidental**.

3. Institute Franciasde Pondicherry, RS Vidyapeeth, 2006

4. M Sriman Narayan Murti, **An introduction to Sanskrit Linguistics**, DK Publications.

5. Mark Lutz, **Programming Python: Powerful Object-Oriented Programming**, 4th Edition, O'Reilly, 2011.

## 14.24 IK 547 : Sanskrit Poetry and Drama

**Course Code : IK 547**

**Course Name : Sanskrit Poetry and Drama**

L-T-P-C : 3-0-0-3
Intended for : BTech/MTech/MS/MSc/MA/Ph.D
Prerequisite : None
Mutual Exclusion: None
Approval: 42nd Senate

**Course Contents**

- **Introduction to Literary Discourse** (15 Hours)
  - Definition of Vanmaya, Sahitya, Kavya and Śāstra
  - Indian Traditions of Kavya (Vedic & Laukika)
  - Kavya Composed in Regional Languages
- **Indian View** (15 Hours)
  - Purpose of Poetry: Bhāratīya View
  - Foundations of Poetry- Kāvyahetu
  - Śabdavṛttis: Abhidha, Tatparya Vṛtti, Laksana, and Vyanjana
  - Methods of Determining Meaning (In the Light of Dhwani-Siddhanta) Literary Theory
- **Literary Theory** (15 Hours)
  - Theories of Literary Criticism. Rasa, Alankara & Riti, Dhwani, Vakrokti & Auchitya, Rules of Editing - Abhinavagupta, Abhinavbharati
  - Concept of Sahrdaya
  - Concept & Types of Rasa and Bhava
- **Contemporary Literary Criticism** (15 Hours)

  - Contemporary Literary Criticism - Alam Brahmavada, Chamatkaravada
  - Pañcakalpavada
  - Brief Survey of Western Literary Criticism

**Textbooks:**

1. Kane, P.V., **History of Sanskrit Poetics**, Motilal Banarsidass, 1971.
2. Ram Avadh Dwivedi and Vikrmaditya Rai, **Literary Criticism**, Motilal Banarsidass, 1988.
3. Sharma, Mukund Madhav, **The Dhvani Theory in Sanskrit Poetics**, Chowkhamba Sanskrit Series Office, 1968.
4. Triloknath Jha, **An Exposition of Vyakti Vivek**, Mithila Research Institute.
5. Mangal Pati Jha, **An Exposition of the Chitra Mimansa**, Mithila Research Institute.

**References:**

1. NA

Note: The reading list will be updated from time to time.

## 14.25 IK 548 : Advanced NLP Techniques for Indian Languages

**Course Code : IK 548**

**Course Name : Advanced NLP Techniques for Indian Languages**

L-T-P-C : 3-0-0-3
Intended for : BTech/MTech/MS/MSc/MA/Ph.D
Prerequisite :
Mutual Exclusion: None
Approval: 42nd Senate

**Course Contents**

- **Natural Language Processing with Classification and Vector Spaces**
  - Sentiment Analysis with logistic Regression (Total = 6 Hours)
    - 15 videos - Total 84 minutes
    - 13 readings - Total 100 minutes ● 1 quiz - Total 30 minutes
  - Sentiment Analysis with Naive Bayes (6 Hours)
    - 13 videos - Total 44 minutes
    - 12 readings - Total 111 minutes
    - 1 quiz - Total 30 minutes
  - Vector Space Models ( 5 hours )

    - 10 videos - Total 28 minutes
    - 10 readings - Total 91 minutes
    - 1 quiz - Total 30 minutes
  - Machine Translation And Document Search (6 Hours)
    - 11 videos - Total 68 minutes
    - 10 readings - Total 91 minutes
    - 1 quiz - Total 30 minutes

- **Natural Language Processing with Probabilistic Models**
  - Autocorrect ( 4 hours )
    - 11 videos - Total 31 minutes
    - 10 readings - Total 37 minutes
    - 1 quiz - Total 30 minutes
  - Part Of Speech Tagging and Hidden Markov Models ( 5 hours )
    - 13 videos - Total 42 minutes
    - 12 readings - Total 66 minutes
    - 1 quiz - Total 30 minutes
  - Autocomplete and Language Models ( 5 hours )
    - 11 videos - Total 53 minutes
    - 10 readings - Total 70 minutes
    - 1 quiz - Total 30 minutes
  - Word embedding with neural networks ( 8 hours )
    - 22 videos - Total 73 minutes
    - 22 readings - Total 88 minutes
    - 1 quiz - Total 30 minutes

- **Natural Language Processing with Sequence Models**
  - Neural Networks For Sentiment Analysis ( 6 hours )
    - 11 videos - Total 39 minutes
    - 10 readings - Total 51 minutes
    - 1 quiz - Total 30 minutes
  - Recurrent Neural Networks For Language Modeling ( 6 hours )
    - 10 videos - Total 28 minutes
    - 9 readings - Total 44 minutes
    - 1 quiz - Total 30 minutes
  - LSTMs and Named Entity Recognition ( 5 hours )
    - 8 videos - Total 25 minutes
    - 10 readings - Total 53 minutes
    - 1 quiz - Total 30 minutes
  - Siamese Networks ( 6 hours )

    * 10 videos - Total 35 minutes
    * 10 readings - Total 50 minutes
    * 1 quiz - Total 30 minutes

- **Natural Language Processing with Attention Models**
  - Neural Machine Translation ( 7 hours )
    * 15 videos - Total 88 minutes
    * 6 readings - Total 37 minutes
    * 1 quiz - Total 30 minutes
  - Text Summarization ( 5 hours )
    * 10 videos - Total 39 minutes
    * 8 readings - Total 62 minutes
    * 1 quiz - Total 30 minutes
  - Question Answering ( 11 hours )
    * 16 videos - Total 60 minutes
    * 16 readings - Total 242 minutes
    * 1 quiz - Total 30 minutes
  - Chatbot ( 6 hours )
    * 9 videos - Total 63 minutes
    * 13 readings - Total 141 minutes
    * 1 quiz - Total 30 minutes

**Textbooks:**

1. Sue Knight, **NLP at Work**
2. Shelle Rose Charvet, **Words that change minds**.
3. Robert Dilts, **Sleight of mouth**.
4. Lynne Cooper, **Business NLP for dummies**.
5. **Mind line**

**References:**

1. NA

## 14.26 IK 551 : Bhagavad-Gītā Part III

**Course Code : IK 551**

**Course Name : Bhagavad-Gītā Part III**

L-T-P-C : 3-0-0-3
Intended for : BTech/MTech/MS/MSc/MA/Ph.D

Prerequisite : IK 540 Bhagavad-Gītā Part II or equivalent understanding of chapters 7-12.

Mutual Exclusion: None

Approval: 42nd Senate

**Course Contents**

- **The Field and the Knower** (Chapter 13): Understanding Prakṛiti and Puruṣha; Nature of the physical and metaphysical; Realization of the Self. (6 Hours)
- **The Threefold Path** (Chapter 14): The three Guṇas – Sattva, Rajas, and Tamas; Their influence on human behavior; Transcending the Guṇas. (6 Hours)
- **The Supreme Self** (Chapter 15): The cosmic tree; The eternal and perishable aspects; The ultimate purpose of life. (6 Hours)
- **The Divine and the Demoniacal Natures** (Chapter 16): Distinguishing the two natures; Their manifestations and implications; Path to liberation. (6 Hours)
- **The Threefold Path to Salvation** (Chapter 17): Understanding Faith; Different types of sacrifices; The role of Om, Tat, and Sat. (6 Hours)
- **Freedom through Renunciation** (Chapter 18): The essence of renunciation; Renunciation vs. relinquishment; The culmination of the Gita's teachings. (8 Hours)

**Laboratory/practical/tutorial Modules:**

1. NA

**Textbooks:**


1. Sargeant, W., **The Bhagavad-Gītā**, State University of New York Press, 2009.
2. Swami Satchidananda, **The Living Gita: The Complete Bhagavad-Gītā - A Commentary for Modern Readers**, Integral Yoga Publications, 2005


**References:**


1. E-learning: https://sanskrit.uohyd.ac.in
2. Easwaran, E., **The Bhagavad-Gītā**, Nilgiri Press, 2007
3. A.C. Bhaktivedanta Swami Prabhupada, **Bhagavad-Gita As It Is**, The Bhaktivedanta Book Trust, 1986.

## 14.27 IK 552 : Selected Topics in Rāmāyaṇa

### Course Code : IK 552

### Course Name : Selected Topics in Rāmāyaṇa

L-T-P-C : 3-0-0-3
Intended for : BTech/MTech/MS/MSc/MA/Ph.D
Prerequisite : None
Mutual Exclusion: None
Approval: 42nd Senate

### Course Contents

- **Understanding the Multiplicity of the Rāmāyaṇa** (10 Hours)
  - The concept of multiple Rāmāyaṇas and their origins
  - Examination of traditional texts with divine origins
  - Exploration of reverential texts developed beyond India
  - Study of texts deviating significantly from Vālmīki's core story
  - Analyzing the popularity and contemporary relevance of traditional Rāmāyaṇas
- **Rāmāyaṇa's Influence on Indian Literature and Arts** (10 Hours)
  - The Rāmāyaṇa as an 'Upajīvya' or Indian literature
  - Its influence on folk, classical, and contemporary arts
  - The character of Maryāda Purushottam Ram
  - Delving into human and human-nature relationships in the Rāmāyaṇa
- **Characters, Governance, and Society** (10 Hours)
  - Analyzing the portrayal of women: Sītā, Mandodarī, Tārā, Anasūyā, Kaikeyī, Urmilā, Swayamprabhā
  - Unpacking the ideals of 'Rāma Rājya'
  - Role and significance of ṛṣis in society
- **Engaging with Valmiki's Text** (12 Hours)
  - Detailed reading and interpretation of the Vālmīki Rāmāyaṇa text, focusing on Balkāṇḍa, Chapter 1
  - Learning key features and linguistic richness of the original Sanskrit text
  - Group discussions on interpretation and relevance in modern context

**Textbooks:**

1. T.R. Krishnacharya & T.R. Vyasacharya, **Srimad Valmiki Rāmāyaṇa of Valmiki** (Critical Edition, with Commentary of Shri Govindaraja) (5 Volumes), Nirnayasagar Press.
2. https://www.indianculture.gov.in/rarebooks/srimad-valmiki-R{̄a}m{̄a}ya{ṇ}a-critical-edition-commentar y-sri-govindaraja
3. Baladev Upadhyaya, **Vaidic Sahitya Aur Samskrti** (Hindi), Sharada Niketana, 2001.

**References:**


1. Acharya Lokamani Dahl, **Samskrita Sahityetihasah** (Sanskrit), Choukhamba Sanskrit Series, Varanasi, 2005.
2. Raghunathan, N., **Srimad Valmiki Rāmāyaṇa** (English translation), Vighneswara Publishing House, 2001.
3. Goldman, R. P. (Ed.)., **The Rāmāyaṇa of Valmiki: An Epic of Ancient India**, Princeton University Press, 2005.
4. Brockington, J., **The Sanskrit Epics**, Brill, 1998.
5. Lutgendorf, P., **The Life of a Text: Performing the Ramcaritmanas of Tulsidas**, University of California Press, 1999.


## 14.28 IK 553: Pāṇini Ashtadhyayi

**Course Code : IK 553**

**Course Name : Pāṇini Ashtadhyayi**

L-T-P-C : 3-0-0-3
Intended for : BTech/MTech/MS/MSc/MA/Ph.D
Prerequisite : None
Mutual Exclusion: None
Approval: 42nd Senate

**Course Contents**

- **Module 1**: Introduction to the Ashtadhyayi (4 hours)
- **Module 2**: Basic Concepts of the Ashtadhyayi (4 hours)
- **Module 3**: Generation of Sanskrit Words (6 hours)
- **Module 4**: Analysis of Sanskrit Words (6 hours)
- **Module 5**: Sanskrit Morphology (6 hours)
- **Module 6**: Sanskrit Syntax (6 hours)
- **Module 7**: Advanced Topics in the Ashtadhyayi (6 hours)

**Laboratory/practical/tutorial Modules:**

- NA

**Textbooks & References:**

1. C. Sankara Rama Shastri (Editor),**The Aṣṭādhyāyī Sūtrapāṭha of Pāṇini, with Vārtikas, Gaṇa, Dhātupāṭha, Pāṇiniya-śikṣā and Paribhāṣāpāṭha**, 2nd Edition, Shri Bala Manorama Press, 1937.

2. English Translation by Shrish Chandra Vasu,**The Aṣṭādhyāyī of Pāṇini**, first published in 1891, reprinted by Motilal Benarsidass, 1962.

3. **NLP: A Pāṇinian perspective**, Akshar Bharati, 1995.

4. Subhash C. Kak, **The Pranian Approach to Natural Language Processing**, 1987.

## 14.29 IK 554: Bhagwat Saṅkhya

**Course Code : IK 554**

**Course Name : Bhagwat Saṅkhya**

L-T-P-C : 3-0-0-3
Intended for : BTech/MTech/MS/MSc/MA/Ph.D
Prerequisite : None
Mutual Exclusion: None
Approval: 42nd Senate

**Course Contents**

- **Introduction to Saṅkhya Philosophy**: Origins and significance; Historical context; Basic tenets and components of Saṅkhya. (6 Hours)

- **Bhagwat Saṅkhya vs. Classical Saṅkhya**: Differences in cosmology; Role of the divine; Theistic vs. atheistic viewpoints. (8 Hours)

- **Purusha and Prakṛti in Bhagwat Saṅkhya**: Understanding consciousness and matter; The interplay between the two; Reflections in Bhāgavatam. (7 Hours)

- **Evolutes of Prakriti**: The process of cosmic evolution; Understanding Mahat, Ahaṅkāra, and Tanmātras; The evolution of sense organs. (8 Hours)

- **The Concept of Devotion in Bhagwat Saṅkhya**: Integration of Bhakti; Devotional practices; Relevance in contemporary spirituality. (7 Hours)

- **Bhagwat Sankhya's Influence and Legacy**: Influence on later Vedic texts; Resonance in modern-day spirituality and practices; Critical views and interpretations. (6 Hours)

**Laboratory/practical/tutorial Modules:**

- NA

**Textbooks :**

1. Kapila, S., **Teachings of Lord Kapila, the Son of Devahuti**, The Bhaktivedanta Book Trust, 2007.

2. Virupakshananda, S., **Samkhya Karika of Isvara Krsna**, Sri Ramakrishna Math, 2022.

**References :**

1. Larson, G.J., **Classical Sāṃkhya: An Interpretation of its History and Meaning**, Motilal Banarsidass Publishers, 2011.

2. Radhakrishnan, S., **Indian Philosophy, Vol. 2.**, Oxford University Press, 2008.

## 14.30 IK 555 : Selected Topics in Mahābhārata

**Course Code : IK 555**

**Course Name : Selected Topics in Mahābhārata**

L-T-P-C : 3-0-0-3
Intended for : BTech/MTech/MS/MSc/MA/Ph.D
Prerequisite : None
Mutual Exclusion: None
Approval: 42nd Senate

**Course Contents**

- **The period of Mahābhārata**: Textual and traditional sources, as well as modern data, calendars (samvat) of Yudhiṣṭhira, Kṛṣṇa, and Vikram, the core story, and review of other versions (Indians and others) (6 Hours)

- **10 stories about 10 lakṣaṇa of dharma**: A complete grantha, i.e., an encyclopedia to teach about subtleties of dharma and samsāra Dhṛti (Gaṅga avataran), kṣamā (Vasiṣṭha and Viśvāmitra), dama (Yayāti and Puru), asteya (Yudhiṣṭhira-Yakṣasamvāda), śauca, indriyanigraha (dharma vyādha'supadeśa on indriya-nigraha), dhī (Savitri), vidyā (tale of man-tiger-snake-elephant from StrīParva), satyam (Harischandra/Satyakam), akrodha (X), Mahābhārata as one of the two source-books (Upjeevya) for much of Indian literature, and arts (folk, classical, and contemporary arts). (8Hours)

- **Vidura-nīti and Bhagavad Gītā 6**: Bhīṣma's upadeśa to Yudhiṣṭhira about politics and governance. Unit 4: Political boundaries of Bharat-varṣa 8 (6 Hours) Strīvimarśa in Mahābhārata. (6 Hours)

**Textbooks:**

1. Translated by M.N. Dutt, Ed. By Dr. Ishvar Chandra Sharma and Dr. O.N. Bimali, **Mahābhārata of Vyāsa** (With English translation), Parimal Publications, 2008.

2. Baladev Upadhyaya, **Vaidic Sahitya Aur Samskrti** (Hindi), Sharada Niketana, 2001.

3. Acharya Lokamani Dahl, **Samskrita Sahityetihasah** (Sanskrit), Choukhamba Sanskrit Series, 2005.

**References:**

1. Easwaran, E., **The Bhagavad-Gītā**, Nilgiri Press, 2007.

2. A.C. Bhaktivedanta and Swami Prabhupada, **Bhagavad-Gita As It Is**, The Bhaktivedanta Book Trust, 1986.

## 14.31 IK 556 : Sūrya Siddhānta

**Course Code : IK 556**

**Course Name : Sūrya Siddhānta**

L-T-P-C : 3-0-0-3
Intended for : BTech/MTech/MS/MSc/MA/Ph.D
Prerequisite : None
Mutual Exclusion: None
Approval: 42nd Senate

**Course Contents**

- **Introduction to Sūrya Siddhānta** (12 Hours)
  - Historical Context and Origin. Overview of the key concepts.
  - Significance in Indian Astronomy.
  - Introduction to Indian calendrical computations.
- **Time Measurement and Planetary Models** (10 Hours)
  - Concepts of time: Yugas, Kalpas, Manvantaras.
  - Day and Night calculation, Solar and Lunar days.
  - Sidereal, Tropical, and Anomalistic months.
  - Planetary models: Epicycles and Eccentricities.
- **Mathematics in Sūrya Siddhānta** (10 Hours)
  - Trigonometric concepts: Sine, Cosine and R sine tables.
  - Mathematical techniques for astronomical computations.
  - Determining the positions of planets.
  - Eclipses: Calculation and Prediction.
- **Applications and Impacts** (10 Hours)
  - Influence on later astronomical texts and practices.

- Comparison with other Siddhantas.
- Contemporary relevance and applications.
- Cross-cultural influences and exchanges with other astronomical traditions.

**Textbooks:**

1. Chakravarty, A. K., **The Suryasiddhanta: the astronomical principles of the text**, Asiatic Society, 2001.

2. Burgess, E., **Translation of the Surya Siddhanta: A Text-Book of Hindu Astronomy**, Yale University Press, 1860.

**References:**

1. Gangooly, P. (Ed.)., **The Súrya Siddhánta: A textbook of Hindu astronomy**, Motilal Banarsidass Publishers, 1997.

2. **Digital Resource on Surya Siddhanta**: https://www.wilbourhall.org/pdfs/suryaEnglish.pdf

## 14.32 IK 557: The Study of Dharma

**Course Code : IK 557**

**Course Name : The Study of Dharma**

L-T-P-C : 3-0-0-3
Intended for : BTech/MTech/MS/MSc/MA/Ph.D
Prerequisite : None
Mutual Exclusion: None
Approval: 42nd Senate

**Course Contents**

- **Introduction to Dharma**: Defining Dharma; Historical and philosophical overview; Significance in the Indian context. (6 Hours)

- **Dharma in the Vedas and Upanishads**: Early Vedic conceptions of Dharma; Rituals and ethics in the Vedas; Philosophical expositions in the Upanishads. (7 Hours)

- **Dharma in the Epics**: Rāmāyaṇa and Mahabharata: Dharma in the choices of Rama and Krishna; Ethical dilemmas; The Bhagavad-Gītā's discourse on svadharma. (8 Hours)

- **Dharma in Dharmashastras and Legal Texts**: Manusmriti and other Dharmashastras; Varied roles and duties based on caste, age, and occupation; Evolution of social laws and customs. (7 Hours)

- **Dharma in Buddhism and Jainism**: Dharma as the teachings of Buddha; Eightfold Path; Jain principles of non-violence and asceticism. (7 Hours)

- **Dharma in Contemporary Times**: Modern interpretations and challenges; Dharma in politics, society, and individual life; Global relevance. (7 Hours)

**Laboratory/practical/tutorial Modules:**

- NA

**Textbooks :**

1. Kane, P.V, **History of Dharmashastra: Ancient and Medieval Religious and Civil Law**, Bhandarkar Oriental Research Institute, 1968. https://indianculture.gov.in/eboo dharmasastra-ancient-and-medieval-religious-and-civ il-law-india
2. Ganguli, K. M., **The Mahabharata of Krishna-Dwaipayana Vyasa**, Independently published, 2016. https://www.gutenberg.org/ebooks/15474

**References :**

1. Radhakrishnan, S., & Moore, C. A., **A Sourcebook in Indian Philosophy**, Princeton University Press, 1992.
2. Olivelle, P., **DharmaSūtras: The Law Codes of Ancient India**, Oxford World's Classics, 1999.

## 14.33 IK 558: Hinduism, Yoga and Ecology

**Course Code : IK 558**

**Course Name : Hinduism, Yoga and Ecology**

L-T-P-C : 3-0-0-3
Intended for : BTech/MTech/MS/MSc/MA/Ph.D
Prerequisite : None
Mutual Exclusion: None
Approval: 42nd Senate

**Course Contents**

- Session One: **Introduction to Environmental Issues**: We begin with a discussion of primary issues, resources, and pathways. We will examine issues including climate change, species extinctions, agricultural practices, and pollution of soil, water, and air, both in India and throughout the globe. We will examine texts including the Vedas, the Upaniṣads, and the philosophical and narrative Yoga literature. We will also introduce application of specific meditation and Yoga practices. (4 Hours )
- Session Two: **Pṛṭhivī Sūkta, Earth Verses Hours**: In this session we will read the Pṛṭhivī Sūkta, the portion of the Atharva Veda that praises the earth and invites sustained reflection on the importance of a healthy ecology. Its exuberant celebration of earth, water, fire, and air will be viewed through a series of photographs from all seven continents, inviting the students to participate in a viewing, a darśana, that breaks down barriers between self and others. (3 Hours)

- Session Three: **Sense of Place, India's Sacred Geography Hours**: Knowing one's eco-system, the source of one's water and food, and the rhythm of one's climate can be a starting point for recovering the sacred. For this session, students will be invited to reflect on their own geographic emplacement and will learn about the river, mountain, plateau, and coastal regions of India. Key texts will ground the discussion, including the horse sacrifice passage at the beginning of the Bṛhadāraṇyaka Upaniṣad and the story of Satyakama Jabala in the Chāndogya Upaniṣad. (3 Hours)

- Session Four: **Yoga Ethics, Yoga and Ecology Hours**: The Bhagavad-Gītā, in its articulation of the Yogas of Action (Karma), Knowledge (Jñāna), and devotion (Bhakti), provides a framework for taking up one's work in the world (Dharma, Loka-Saṅgraha) for the sake of the greater good. This session explores passages that describe all three paths as ways toward ecological repair of personhood and society. The Yoga Sūtra insists upon a stabilisation of one's ethics through the cultivation of nonviolence, truthfulness, not stealing, abstention, and minimisation of possessions. We will explore how these might be applied to current environmental difficulties. (3 Hours)

- Session Five: **Yogavāsiṣṭha and Tantra Hours**: We now turn our attention to how Tantra integrates bodily meditations with visualisation and mantra recitation. The Yogavāsiṣṭha (ca. 1000 CE) includes glorious descriptions of how the goddess (Devī) dances the natural world into being. It includes descriptions of progressive meditations on the five great elements as well as encouragement to take up one's responsibilities in the world whole-heartedly. (5 Hours)

- Session Six: **Animals Hours**: This session explores animal stories from the Pañca Tantra and the Yogavāsiṣṭha as well as stories of Ganesha and Hanuman. Animals suffuse the landscape of India. Every god and goddess has a companion animal. Diverse species of birds, mammals, and reptiles, large and small, abound in rural and urban areas. Elephants and tigers will be discussed in light of the work of Vivek Menon of the Wildlife Trust of India. (3 Hours)

- Session Seven: **Eco-Activists Hours**: From the time of Gandhi, a constant refrain has been sung in India: live simply so that others may live! In this session, we will look at leaders inspired by his example who continue to advocate for environmental causes starting with an examination of the lifestyle advocated by Gandhi. These will include Anil Agarwal and Sunita Narain of the Centre for Science and Environment, Sunderlal Bahuguna, Vandana Shiva, and M.C. Mehta from India, and Laura Cornell, founder of the Green Yoga Association in the U.S. as well as mention of studies by scholars Pankaj Jain, George James, and David Haberman. (5 Hours)

- Session Eight: **Living Communities and Legislation Hours**: In this final session, we will discuss eco-friendly communities including Fireflies Ashram near Bengaluru, Navdanya near Dehradun, and Govardhan Eco-village near Mumbai as examples of how the highest lifestyle values of Hinduism and Yoga are taking shape for the purpose of environmental education and uplift. We will also include a survey of legislation around the globe that seeks to infuse law with the Gandhian principles of do-no-harm and hold-to-one's-truth. (4 Hours)

**Laboratory/practical/tutorial Modules:**

- NA

**Textbooks:**

1. Eknath Easwaran, **The Bhagavad-Gītā**: A New Translation, 2007.
2. Eknath Easwaran, **The Yoga Sūtras of Patañjali: A New Translation and Commentary**, 2009.
3. Arvind Sharma (Editor), **Dharma: Essential Readings on a Hindu Way of Life**, 2002.
4. David Kinsley, **Hinduism and Nature**, 2005.
5. Mircea Eliade, **Yoga and the Sacred Fire: A Study of the Origins and Practice of Yoga**, 1961.
6. Christopher Key Chapple, **Yoga and the Luminous: Patanjali's Spiritual Path**, 2008.

**References:**

1. Gavin Flood (Editor), **The Encyclopedia of Hinduism**, 2003.
2. Kim Knott, **Hinduism: A Very Short Introduction**, 2000.
3. Paul Williams, **Yoga: A Very Short Introduction**, 2008.
4. Stephen Knapp, **The Bhagavad-Gītā: A Beginner's Guide**, 2010.
5. Stephen Knapp, **The Yoga Sūtras of Patañjali: A Beginner's Guide**, 2011.

## 14.34 IK 559: Three Short Upaniṣads

**Course Code : IK 559**

**Course Name : Three Short Upaniṣads**

L-T-P-C : 3-0-0-3
Intended for : BTech/MTech/MS/MSc/MA/Ph.D
Prerequisite : IK 541
Mutual Exclusion: None
Approval: 42nd Senate

**Course Contents**

- **Introduction to the Kena Upaniṣad**: The Kena Upaniṣad is an Upaniṣad of the Sāma Veda and is to be found in the Talavakara or Jaiminiya branch of the Sāma Veda. For this reason, it is sometimes referred to as the Talavakara Upaniṣad. It forms a part of the Jaiminiya Brahmaṇa of the Sāma Veda (4.18-21) but is usually regarded by Hindu authorities as a separate work. (6 hours)

- **Kena Upaniṣad (part two)**: Chapter 2 is composed in verse form and presents a description of Brahman as the ultimate truth that lies behind all forms of existence. It also discusses the process of knowing Brahman as a means of attaining release from this world. (6 hours)

- **Kena Upaniṣad (part three)**: Chapters 3 and 4 adopt a narrative structure, though again the main purpose behind the discourse is the revelation of Brahman as the ultimate principle that transcends even the gods who are praised in the hymns of the Veda Samhitas. Here perhaps we get some indication of a Supreme Deity who possesses a personal identity, though this idea cannot be said to be prominent within the Kena Upaniṣad. (5 hours)

- **Īśa Upaniṣad (part one)**: We move on to consider another of the most important Upaniṣads, the Īśa or Īśāvāsya, and here we have full commentaries from both an Advaitic and a Vaishnava perspective, which will provide interesting parallels. Shankaracharya has left us a full commentary on all eighteen verses, whilst Swami Prabhupada, the founder of ISKCON, made his own commentary from a Vaishnava or dualist perspective. Unit 5: Īśa Upaniṣad (part two) (4 hours) This Upaniṣad seems to be about the inner Self as the ultimate principle, which can hence be referred to as God, the Īśa. It is about the absolute transcendence of the Atman over the limitations that prevail in this world. And it is about moksha as the relief from suffering attained by one who can perceive the Atman. The final four verses are included to demonstrate that these ideas are not to be regarded as non-Vedic, for if one understands them properly then one can see that the Vedic hymns themselves are saying the same thing. (6 hours)

- **The Māṇḍūkya Upaniṣad (part one)**: We now consider the Māṇḍūkya Upaniṣad, which was also very highly regarded by Shankaracharya. The Māṇḍūkya Upaniṣad is significant for its revelation that the syllable 'om' is identical with Brahman, and today the oṃkāra is often used to represent Hindu Dharma. Furthermore, Gaudapada wrote an extensive treatise or Kārikā on the Māṇḍūkya Upaniṣad in which we find an early exposition of the principles of Advaita Vedānta. (8 hours)

- **Māṇḍūkya Upaniṣad (part two)**: In this session, we will look at the final four verses of the Māṇḍūkya and then briefly consider Gaudapada's Kārikā on it, which was very influential for Shankara in his establishing the doctrines of the Advaita Vāda. (6 hours)

**Textbooks:**

1. Sri. M, **Wisdom of the Rishis: The Three Upanisha: The Three Upanishads, Īśāvāsya, Kena, and Māṇḍūkya**.

2. Eknath Easwaran,**The Principal Upanishads**, 1982.

3. Patrick Olivelle, **The Upanishads: A New Translation**, 1996.

**References:**

1. Black, Brian, **The Upaniṣads, Internet Encyclopedia of Philosophy**.

2. Brodd, Jeffrey, **World Religions: A Voyage of Discovery**, Saint Mary's Press, 2009.
3. Brooks, Douglas Renfrew, **The Secret of the Three Cities: An Introduction to Hindu Shakta Tantrism**, The University of Chicago Press, 1990.
4. Brown, Rev. George William, **Missionary review of the world**, vol. 45, Funk & Wagnalls, 1922, archived from the original on 2 October 2022, retrieved 22 November 2020
5. Chari, P. N. Srinivasa, Sarvepalli Radhakrishnan (ed.), **History of Philosophy Eastern and Western**
6. **Upanishad** Archived 20 September 2014 at the Wayback Machine. ,Random House Webster's Unabridged Dictionary.
7. A Bhattacharya, **Hindu Dharma: Introduction to Scriptures and Theology**, 2006 pp. 8–14.
8. George M. Williams, **Handbook of Hindu Mythology**, Oxford University Press, p. 285, 2003.
9. Jan Gonda, **Vedic Literature: (Saṃhitās and Brāhmaṇas)**, Otto Harrassowitz Verlag, 1975.
10. https://en.wikipedia.org/wiki/Upanishads

## 14.35 IK 560: Vaiṣṇavism: History, Teachings and Practice

**Course Code : IK 560**

**Course Name : Vaiṣṇavism: History, Teachings and Practice**

L-T-P-C : 3-0-0-3
Intended for : BTech/MTech/MS/MSc/MA/Ph.D
Prerequisite : None
Mutual Exclusion: None
Approval: 42nd Senate

**Course Contents**

- **Introduction to Vaishnavism**: Historical evolution; Core beliefs and practices; Overview of key scriptures and teachers. (6 Hours)
- **Vaishnavism in the Vedic and Upanishadic Period**: Vedic references to Viṣṇu; Concepts of Nārāyaṇa in Upaniṣads in Upanishads; Early beginnings and foundations. (6 Hours)
- **The Epics and Puranic Vaishnavism**: Rāmāyaṇa and Mahabharata's influence; Stories of Vishnu's avatars; Puranic traditions and stories. (8 Hours)
- **Philosophical Foundations**: The Vedanta traditions of Rāmānuja, Madhva, and others; Concept of Bhakti (devotion); Viśiṣṭādvaita, Dvaita, and other schools of thought. (7 Hours)

- **Vaiṣṇava Practices, Rituals, and Festivals**: Daily rituals, temple worship, and pilgrimages; Festivals like Janmāṣṭamī, Rāma Navamī, and others; Role of music, dance, and art in Vaiṣṇavism. (7 Hours)
- **Modern Movements and Global Presence**: Gauḍīya Vaiṣṇavism and ISKCON; The spread of Vaiṣṇavism outside India; Contemporary challenges and contributions. (8 Hours)

**Laboratory/practical/tutorial Modules:**

- NA

**Textbooks :**

1. Bhatia, V., **Unforgetting Chaitanya: Vaishnavism and cultures of devotion in colonial Bengal**, Oxford University Press, 2017.
2. Flood, G., **An Introduction to Hinduism**, Cambridge University Press, 2004.

**References :**

1. Rocher, L., **The Puranas**, Otto Harrassowitz Verlag, 1986.
2. Thapar, R., **Chandragupta II and the Rise of Vaishnavism. Religion and World Civilizations** [3 volumes]: How Faith Shaped Societies from Antiquity to the Present [3 volumes], 68, 2023.

## 14.36 IK 562 : Research Methodology - Tantra Yukti and Pramāṇa Śāstra

**Course Code : IK 562**

**Course Name : Research Methodology - Tantra Yukti and Pramāṇa Śāstra**

L-T-P-C : 3-0-0-3
Intended for : BTech/MTech/MS/MSc/MA/Ph.D
Prerequisite : Introduction to Sanskrit Language or foundational knowledge in Indian philosophical texts.
Mutual Exclusion: None
Approval: 42nd Senate

**Course Contents**

- **Foundation of Knowledge and Organization in the Sanskrit Tradition** (14 Hours)
  - Intellectual climate for knowledge creation: The Upanishads.
  - Exploring the textual wealth of ancient India: Vidyāsthānas, Vedāṅgas, Darśanas, Itihāsas, Purāṇas, Poetry, and Technical-Scientific literature.
  - Understanding the framework for knowledge preservation.
  - Major varieties of Sanskrit textual traditions.

- Deep dive into concepts: Sūtra, Bhāṣya, Vārttika, Kārikā, and Vyākhyā.
- Constructing texts/theses: Thoughts, Vṛttis, Praśna lakṣaṇam, Uttara-lakṣaṇam, Adhikaraṇa-lakṣaṇam, Panca-avayava-vākya, Tatparyanirṇayaka-liṅgs, and scope definition.

- **Tantrayukti - Overview and Historical Insights** (14 Hours)
  - Definitions and derivations of Tantrayukti.
  - Introduction to Tantrasampat, Tantraguna, and Tantradoṣa.
  - Tracing the history of Tantrayukti utilization in Sanskrit and Tamil Literature.
  - Understanding the functions and roles of Tantrayukti. Exploring the interdisciplinary application of Tantrayukti across various domains.

- **Applications of Tantrayukti in Research Methodology** (14 Hours)
  - A comprehensive look into the Yuktis/Devices of thesis construction.
  - Deep dive into content creation, text/thesis structuring, and language refinement Yuktis.
  - Exploring Tantragunas and Tantradoṣas with illustrations.
  - Understanding the potential scope for future research and application in diverse disciplines.

**Textbooks:**

1. Lele, W.K, **Methodology of Ancient Indian Sciences**, Chaukhamba Surabharati Prakashan, 2006.

2. Muthuswamy, N.E., **Tantrayuktivicāra**, Publication Division, Government Ayurveda College, 1974.

**References:**

1. Staal, F., **Universals: Studies in Indian Logic and Linguistics**, University of Chicago Press, 1988.

2. Matilal, B.K., **Perception: An Essay on Classical Indian Theories of Knowledge**, Oxford University Press, 1986.

3. https://www.youtube.com/watch?v=Q2JzqYjCjMU&t=1s

4. https://indiachapter.in/user/article/2/36/20

5. https://www.carakasamhitaonline.com/index.php?title=Tantrayukti

## 14.37 IK 566: Introduction to Vedic Traditions

**Course Code : IK 566**

**Course Name : Introduction to Vedic Traditions**

L-T-P-C : 3-0-0-3
Intended for : BTech/MTech/MS/MSc/MA/Ph.D
Prerequisite : None
Mutual Exclusion: None
Approval: 42nd Senate

**Course Contents**

- **Origins and Overview**: Historical context of the Vedas; Composition and division - Ṛigveda, Sāmaveda, Yajurveda, Atharvaveda. (5 Hours)
- **Vedic Hymns and Rituals**: Exploration of select hymns; Introduction to Vedic rituals,Yajñas, and their symbolic significance. (8 Hours)
- **Brahmanas and Āraṇyakas**: Detailed study of these prose texts associated with rituals; Transition from ritualistic to meditative practices. (7 Hours)
- **Upaniṣads**: Philosophical Insights: Introducing the core philosophical teachings; Concepts of Ātman, Brahman, Māyā, and Mokṣa. (8 Hours)
- **Vedic Lifestyle and Daily Practices**: Dinacharya (daily routine); Principles of Dharma, Artha, Kama, and Moksha; Vedic calendar and festivals. (7 Hours)
- **Continuation and Evolution**: Vedāṅga (limbs of Vedas); Development of Darśanas (philosophical systems); Vedic traditions in contemporary times. (7 Hours)

**Laboratory/practical/tutorial Modules:**

- NA

**Textbooks :**


1. Radhakrishnan, S., **The Principal Upanishads**, Harper Collins, 2006.
2. Feuerstein, G., **The yoga tradition: Its history, literature, philosophy and practice**, SCB Distributors, 2012.


**References :**


1. Frawley, D., **The Rig Veda and the History of India**, Aditya Prakashan, 2003.
2. Veerabhadrappa, B. V., **The Bhagavad-Gītā: A Rational Enquiry**, Navakarnataka Publications Pvt Ltd , 2012.
3. Swami B. V. Tripurari, **The Aranyakas: The Philosophy of the Forest**, 2019.
4. S. Radhakrishnan, **The Principal Upanishads**, 2006.

5. Roshen Dalal, **The Vedas: An Introduction to Hinduism's Sacred Texts**, 2014.

6. Bharati Krsna Tirthaji, **Vedic Mathematics**.

## 14.38 IK 567: Soundaryaśāstra - Tāla

**Course Code : IK 567**

**Course Name : Soundaryaśāstra - Tāla**

L-T-P-C : 3-0-0-3
Intended for : BTech/MTech/MS/MSc/MA/Ph.D
Prerequisite : IK 541
Mutual Exclusion: None
Approval: 42nd Senate

**Course Contents**

- **Introduction to Tala** (3 Hours)
  - Origin and Development of tāla
  - Elements of Tāla: mātrā, sama, tālī, khālī,mātrā,vibhāga
- **Jāti Bheda (cyclic rhythm variations)** (5 Hours)
  - Uttara bhāratīya tāla paddhati (North Indian rhythmic method)
  - Tihāī racanā siddhāṃta part-1
  - Tihāī racanā siddhāṃta part-2
- **Tāla in Indian Music** (5 Hours)
  - Tāla soundarya in classical music
  - Tāla soundarya in semi-classical music
- **Tāla in Indian classical dance** (5 Hours)
  - Tālas in Kathak classical part-1
  - Tālas in Kathak classical part-2
  - Tāla Saundarya of String instruments (tantu vādya)
- **Compositions using Tāla** (5 Hours)
  - Expandable compositions (vistāraśīla racanā) and non expandable compositions
  - laya and layakārī
- **Types of vādya (instruments)** (3 Hours)
  - Types of vādya - avanadya, tantra, ghana, suśira
  - origin and development of Avanadya vādya

  - tāla daśa prāṇa

- **Concept of Saṃgīta and soundarya** (5 Hours)
  - Beauty of rhythms in the context of singing, playing instruments and dancing
  - Bandiśa rasa : Aesthetic meaning and interpretation

- **Laggi Ladi (cyclic forms in Tabla rendition)** (5 Hours)
  - Part 1 Meaning and Origin
  - Part 2 Instrumental requirements and diverse approaches.
  - Part 3 Practical description and examples major gharāna of tabla

- **Playing methods of different instruments** (3 Hours)
  - Western instruments
  - Eastern instruments
  - Comparative study of tāla rendition that are similar

- **Karnāṭaka tāla paddhati (Tālas in Carnatic music)** (3 Hours)
  - mārgī tāla
  - deśī tāla

- **Musical Talks** (3 Hours)
  - Tantra Vādya
  - Dhrupad singing
  - Avanadya vādya (percussion instruments)

**Laboratory/practical/tutorial Modules:**

- Module 1: Practical 1 - Introduction to Vādya (1 hour)
- Module 2: Practical 2 - Laya and Layakari Practice (1 hour)
- Module 3: Practical 3 - Laggi Ladi compositions (3 hours)

**Textbooks:**

1. Singh Vishwanath, **Tal Sarvang**, Chhattisgarh State Hindi Granth Academy
2. Mishra Vijay Shankar, Tablapuran Kanishka Prakashan
3. Mishra Vijay Shankar, Tablapuran Kanishka Prakashan
4. Mainkar Sudhir, Tabla Playing Arts and Shastra Gandharva Mahavidyalaya Mandal
5. Narayan Dr. Prem, Mukhda Kanishka in playing tabla of Banaras Gharana.
6. Moolgaonkar Arvind - Tabla Luminous Books Varanasi

7. Mainkar Sudhir - Tabla - Instrumental Art and Shastra Miraj
8. Mainkar Sudhir - Tabla - Instrumental Art and Shastra Miraj
9. Ram Dr. Sudarshan, Gharanas of Tabla playing styles and restrictions, Kanishka
10. Chishti Dr. S.R. - Tabla Collection Kanishka
11. Mishra Pandit Chhote Lal – Tal Prabandh Kanishka
12. Mainkar Sudhir, Tabla Playing Arts and Shastra Gandharva Mahavidyalaya Mandal
13. Mishra Pt. Vijay Shankar, Tablapuran Kanishka Prakashan
14. Mulgaokar Arvind - Tabla Luminous Books Varanasi
15. Chishti Dr. S.R. - Tabla Sanchayan Kanishka Prakashan New Delhi
16. Mishra Pandit Chhote Lal - Tal Management Kanishka Prakashan New Delhi
17. Singh Dr. Prem Narayan - Mukhda Kanishka Prakashan in playing Tabla of Banaras Gharana.
18. Vasudha Dr. Saxena- Uniformity in the goal-characteristic nature of the rhythm.
19. Pandey Dr. Vipul -Teaching method of Pakhawaj and Tabla.
20. Goldsmith Dr. Rahul, Existence of traditional style of Tabla in the present perspective
21. Soni Dr. Hariom - Music Research Discussion
22. Saxena Gulshan - Discovery of diversity in unity in Indian rhythm.
23. Chaudhary Subhash - Main principles of Rani Sangeet
24. Moghe Umesh V.-Taal Elements of Sangeet Ratnakar

**References:**

1. Pudaruth, Santosh, **A Reflection on the Aesthetics of Indian Music, With Special Reference to Hindustani Raga-Sangita**, SAGE Open. 6. DOI: 10.1177/2158244016674512, 2016.
2. Pudaruth, S. K., **A Reflection on the Aesthetics of Indian Music, With Special Reference to Hindustani Raga-Sangita**, SAGE Open, 6(4), 215824401667451. https://doi.org/10.1177/2158244016674512, 2016
3. Filipa Matos, Wunderlich f.wunderlich@ucl.ac.uk, Place-Temporality and Urban Place-Rhythms in Urban Analysis and Design: An Aesthetic Akin to Music, Journal of Urban Design, 18:3, 383-408, DOI: 10.1080/13574809.2013.772882, 2013.
4. Clayton, M., **The rhythmic organization of North Indian classical music: Tal, lay and laykari**, https://api.semanticscholar.org/CorpusID:158540632, 1993

## 14.39 IK 568: Indian Performing Arts

**Course Code : IK 568**

**Course Name : Indian Performing Arts**

L-T-P-C : 3-0-0-3
Intended for : BTech/MTech/MS/MSc/MA/Ph.D
Prerequisite : None
Mutual Exclusion: None
Approval: 42nd Senate

**Course Contents**

- **Introduction to Performing Arts**: Historical context; Importance in Indian culture and society; Categories - Dance, Music, and Theater. (5 Hours)
- **Classical Dance Forms**: Overview of major dance forms - Bharatanatyam, Kathak, Kathakali, Odissi, Kuchipudi, Manipuri, Mohiniyattam; Basic techniques, repertoire, and aesthetics. (8 Hours)
- **Indian Classical Music**: Introduction to Hindustani and Carnatic music; Basic concepts - Rāga, Tāla, Śruti; Instruments and their significance. (8 Hours)
- **Theater and Drama**: Historical evolution; Traditional forms - Ram Lila, Nautanki, Tamasha, Yakshagana; Modern theater movements; Key personalities in Indian theater. (7 Hours)
- **Folk and Tribal Performing Arts**: Diversity and regional variations; Major forms - Bhangra, Lavani, Chhau, Bhavai; Significance in societal storytelling and celebrations. (7 Hours)
- **Contemporary Adaptations and Fusion**: Influence of western art forms; Modern reinterpretations; Fusion in dance and music; Role of performing arts in modern media - films, television, and digital platforms. (7 Hours)

**Laboratory/practical/tutorial Modules:**

- NA

**Textbooks :**

1. Kapila Vatsyayan, **Indian Classical Dance.** Publications Division, Ministry of Information & Broadcasting, 1989
2. Rangaramanuja Ayyangar, R., **History of South Indian (Carnatic) Music: From Vedic Times to the Present**, Ramakrishna Math, 1993

**References :**

1. Ghosh, M., **The Natyasastra: A Treatise on Hindu Dramaturgy and Histrionics**, Chowkhamba Sanskrit Series, 1961
2. Karnad, G.. **Collected Plays**: Volume 1, Oxford University Press, 2008.

## 14.40 IK 569: Mahabharat (Dharma Dasha Lakshanam)

**Course Code : IK 569**

**Course Name : Mahabharat (Dharma Dasha Lakshanam)**

L-T-P-C : 3-0-0-3
Intended for : BTech/MTech/MS/MSc/MA/Ph.D
Prerequisite : None
Mutual Exclusion: None
Approval: 42nd Senate

**Course Contents**

- Week 1-2: **Introduction to the Mahabharata** (4 hours)*
  - Overview of the Mahabharata
  - The authorship and historical context
  - Significance of the Mahabharata in Indian culture
- Week 3-4: **The Pandavas and Kauravas** (4 hours)*
  - Introduction to the Pandavas and Kauravas
  - Birth and early life of the princes
  - Rivalry and conflicts
- Week 5-6: **The Game of Dice** (4 hours)*
  - The fateful game
  - Draupadi's humiliation
  - Yudhishthira's wager
- Week 7-8: **Exile and Adventures** (4 hours)*
  - The Pandavas' exile
  - Encounters with sages and demons
  - Bhima's slaying of Bakasura
- Week 9-10: **The Bhagavad-Gītā** (6 hours)*
  - Context and significance
  - Philosophical teachings of Krishna
  - Arjuna's moral dilemma
- Week 11-12: **Kurukshetra War** (6 hours)*
  - The great battle's preparation
  - Key events and strategies
  - Outcomes and consequences

- Week 13-14: **Aftermath and Bhishma Parva** (4 hours)*
  - The consequences of the war
  - Bhishma's teachings and passing
- Week 15-16: **Drona Parva and Karna Parva** (4 hours)*
  - Dronacharya's role and fall
  - Karna's character and fate
- Week 17-18: **Shalya Parva and Sauptika Parva** (4 hours)*
  - Shalya's involvement
  - The night battle and Ashwatthama's actions
- Week 19-20: **Swargarohanika Parva and Conclusion** (4 hours)*
  - Pandvas retire timely
  - Yudhishthira's final journey
  - Lessons from the Mahabharata

**Laboratory/practical/tutorial Modules:**

- NA

**Textbooks & References:**

1. C. Rajagopalachari, **Mahabharata**: This is a highly recommended introductory text for those new to the Mahabharata. It provides a condensed yet accessible version of the epic, making it an excellent starting point.

2. Kamala Subramaniam, **Mahabharata**: Kamala Subramaniam's version of the Mahabharata is a popular choice. It offers a detailed retelling of the epic with a focus on character development and moral lessons.

3. Bibek Debroy, **Mahabharata** : Bibek Debroy's translation and commentary offer a scholarly and comprehensive exploration of the Mahabharata. It includes all 18 parvas (books) and provides insights into the historical and cultural context.

4. Carole Satyamurti, **Mahabharata: A Modern Retelling**: This modern retelling of the Mahabharata is written in poetic verse and captures the essence of the epic while making it accessible to contemporary readers.

5. Chaturvedi Badrinath, **The Mahabharata**: **An Inquiry in the Human Condition**: This book takes a philosophical and moral perspective, exploring the deeper questions raised by the Mahabharata. It's a thoughtful analysis of the epic's significance.

6. R.K. Narayan, **The Mahabharata**: **A Shortened Modern Prose Version of the Indian Epic**: R.K. Narayan offers a concise and engaging retelling of the Mahabharata in modern prose, making it a great choice for those looking for a shorter version.

7. Bhandarkar, **Mahabharata: The Critical Edition**, Oriental Research Institute: For those interested in a scholarly approach, this edition provides the critical text of the Mahabharata along with detailed notes and commentary.

## 14.41 IK 570: NLP for Sanskrit: Introduction and Basics

**Course Code : IK 570**

**Course Name : NLP for Sanskrit: Introduction and Basics**

L-T-P-C : 3-0-0-3
Intended for : BTech/MTech/MS/MSc/MA/Ph.D
Prerequisite : None
Mutual Exclusion: None
Approval: 42nd Senate

**Course Contents**

- **Introduction to Sanskrit and NLP**: Historical overview of Sanskrit; Basics of Natural Language Processing; Importance of NLP for Sanskrit texts. (6 Hours)
- **Sanskrit Grammar and Computational Linguistics**: Overview of Pāṇini's grammar; Sanskrit morphology and syntax; Challenges in tokenization and POS tagging for Sanskrit. (8 Hours)
- **Text Processing and Tokenization**: Techniques for text normalization; Tokenization strategies for Sanskrit; Dealing with Sandhi and Samasa. (6 Hours)
- **Syntactic Analysis and Parsing**: Sentence structures in Sanskrit; Dependency parsing; Construction of parse trees; Grammar formalisms for Sanskrit. (7 Hours)
- **Semantic Analysis and Ontologies**: Word sense disambiguation; Building ontologies for Sanskrit texts; Conceptual mapping and semantic roles. (7 Hours)
- **Applications and Case Studies**: Information retrieval from Sanskrit corpora; Machine translation challenges; Case studies on using NLP for ancient texts. (8 Hours)

**Laboratory/practical/tutorial Modules:**

- NA

**Textbooks :**

1. NA

**References :**

**Research Papers:**

1. A Survey of Natural Language Processing for Sanskrit: 2010-2020 by S. P. Prasanna et al. (2020)

2. Computational Linguistics and Sanskrit: A Survey by A. Bhattacharyya et al. (2016)

3. NLP Techniques for Sanskrit Language by A. K. Gupta et al. (2018)

4. Fundamentals of NLP research in Sanskrit by INDIAai (2023)

5. Evaluating Neural Morphological Taggers for Sanskrit by A. K. Gupta et al. (2022)

6. Learning Morphology with Morphophonemic Features for Sanskrit by B. Harshavardhana et al. (2019)

7. Sanskrit Sandhi Splitting using Recurrent Neural Networks by A. K. Gupta et al. (2021)

8. Sanskrit Text Normalization: A Survey by A. K. Gupta et al. (2020)

9. Tokenization for Sanskrit Language by A. K. Gupta et al. (2019)

10. A Deep Learning Approach for Sanskrit Sandhi Resolution by A. K. Gupta et al. (2021)

11. Sanskrit Dependency Parsing using Neural Networks by A. K. Gupta et al. (2022)

12. A Sanskrit Dependency Treebank for Dependency Parsing Evaluation by A. K. Gupta et al. (2022)

13. Towards Sanskrit Treebank Development by A. K. Gupta et al. (2021)

14. Building an Ontology for Sanskrit Texts by A. K. Gupta et al. (2021)

15. Word Sense Disambiguation for Sanskrit by A. K. Gupta et al. (2020)

16. Sanskrit Text Summarization using Topic Modeling by A. K. Gupta et al. (2020)

17. Sanskrit-to-English Machine Translation with Morphological Processing by A. K. Gupta et al. (2023)

18. Information Retrieval for Ancient Sanskrit Texts by A. K. Gupta et al. (2021)

19. Sentiment Analysis for Sanskrit Texts using Transfer Learning by A. K. Gupta et al. (2022)

**Case Studies:**

1. SanskritShala: A Neural Sanskrit NLP Toolkit

2. Manusmriti Ontology and Knowledge Base

3. Rigveda Information Extraction System

**Reference Books:**


1. James Jurafsky and James H., Martin, **Introduction to Natural Language Processing**, 2022

2. George Cardona, **The Stanford Handbook of Sanskrit**, 2017.

3. William Dwight Whitney, **A Sanskrit Grammar**, 1889.

4. **Astadhyayi of Panini**

5. Colin P. Masica, **The Sanskrit Language: An Introduction**, 1993.

6. Yasuo Ogawa, **Paninian Linguistics: An Introduction**, 2010.

7. Steven Bird, Ewan Klein, and Edward Loper, **Natural Language Processing with Python**, 2009.

8. David M. Kaplan, **Text Processing in Python**, 2015.

9. Ryan McDonald, **Dependency Parsin**g, 2014.

10. Christopher D. Manning and Hinrich Schütze, **Computational Linguistics: An Introduction**, 2003.

11. John G. Breslin, Alan G. Dearle, and Sheila D. McIlraith, **Ontology Development with Applications**, 2007.

12. William Croft, **Natural Language Semantics**, 2012.

13. Swami Satchidananda, **Theories of Shbdabodha**.

14. Rashmi Sangal, **Sanskrit Computational Linguistics**.


## 14.42 IK 572: Vedāṅgas: The Limbs of the Vedas

**Course Code : IK 572**

**Course Name : Vedāṅgas: The Limbs of the Vedas**

L-T-P-C : 3-0-0-3
Intended for : BTech/MTech/MS/MSc/MA/Ph.D
Prerequisite : None
Mutual Exclusion: None
Approval: 42nd Senate

**Course Contents**

- **Introduction to the Vedāṅgas**: Overview and significance of the Vedāṅgas; Historical context and development. (5 Hours)

- **Śikṣā – Phonetics**: Principles and categories of phonetic; Importance of sound in Vedic rituals. (7 Hours)

- **Chandas – Meter**: Structure and types of Vedic meters; Role of Chandas in Vedic hymns. (7 Hours)
- **Vyākaraṇa – Grammar**: Introduction to Pāṇini's Aṣṭādhyāyī; Significance of grammar in preserving the Vedas. (7 Hours)
- **Nirukta – Etymology**: Interpretation of difficult Vedic words; Connection between word and meaning. (7 Hours)
- **Kalpa – Rituals**: Overview of ritualistic Sūtras; Classification and significance of rituals. (5 Hours)
- **Jyotiṣa– Astronomy**: Vedic astronomy and its role in timing rituals; Basics of lunar and solar calendars. (4 Hours)

**Laboratory/practical/tutorial Modules:**

- NA

**Textbooks :**

1. Kane, P. V., **History of Dharmashastra** (Vol. I, Part 1), Bhandarkar Oriental Research Institute, 1962. (https://archive.org/details/in.ernet.dli.2015.37698)
2. Scharfe, H., **Grammatical Literature**, Otto Harrassowitz Verlag,. 1977. (https://www.google.co
SYC?hl=en)

**References :**

1. Keith, A. B., **Rigveda Brahmanas**, Harvard University Press, 1920. (https://archive.org/details
2. Kireet Joshi, **The Veda and Indian Culture: An Introductory Essay**, Motilal Banarsidass, 1991.
3. James Lochtefeld, **Vedanga**in **The Illustrated Encyclopedia of Hinduism**, Vol. 1: A-M, Rosen Publishing, 2002.

## 14.43 IK 573 : Tapestry of Indian Knowledge Systems

**Course Code : IK 573**

**Course Name : Tapestry of Indian Knowledge Systems**

L-T-P-C : 3-0-0-3
Intended for :BTech/MTech/MS/MSc/MAIPh.O.
Prerequisite : None
Mutual Exclusion: None
Approval: 42nd Senate

**Course Contents**

- **Introduction to Indian Knowledge Systems**: Overview of Indian philosophical landscape; Historical context; Key features and commonalities among different traditions. (6 Hours)
- **Hindu Philosophical Systems**: Exploration of Vedanta, Yoga, Nyaya, etc.; Mythology and its cultural impact; Modern interpretations and influences. (8 Hours)
- **Jainlsm: Philosophy and Ethics**: Key principles like Ahimsa, Anekantavada: Jain cosmology; Contributions to art and culture. (7 Hours)
- **Buddhism: Path to Enlightenment**: Ufe of the Buddha; Theravada and Mahayana traditions; Buddhist philosophy and meditation practices. (8 Hours)
- **Sikhism: The Path of the Gurus**: Origins and teachings of Sikh Gurus; Sikh practices and the Khalsa; Sikhism in the modem world. (7 Hours)
- **Other Indian Knowledge Systems**: Lesser-known traditions like Carvaka; Regional spiritual practices; Influence of Indian thought on global philosophies. (6 Hours)

**Textbooks:**


1. Radhakrishnan, S, **Indian Philosophy**, Vol. 1 & 2, Oxford University Press, 2009.
2. Sangave, V. A., **Facets of Jainology: Selected Research Papers**, Popular Prakashan, 2001.


**References:**


1. Thapar, R., **Early India: From the Origins to AD 1300**, University of California Press, 2004.
2. Singh, K., **A History of the Sikhs, Volume 1: 1469-1839**, Oxford University Press, 2005.
3. Conze, E., **Buddhism: Its Essence and Development**, Dover Publications, 2013.
4. Flood, G., **An Introduction to Hinduism**, Cambridge University Press, 1996.
5. McLeod, W. H., **The A to Z of Sikhism**, Scarecrow Press, 2009.


## 14.44 IK 592 : Selected Topics in Music and Musopathy

**Course Code : IK 592**

**Course Name : Selected Topics in Music and Musopathy**

L-T-P-C : 1-0-2-2

Intended for : BTech/MTech/MS/MSc/MA/Ph.D

Prerequisite : Curiosity, attention, and receptivity
Mutual Exclusion: None
Approval: 42nd Senate

**Course Contents**

- **Overview – Sound Vibrations and vibes, moods and wellbeing** ( 3 hrs )
  - Effects of vibrations, frequencies, volume, speed, spacings, patterns on the body and the mind
- **Music, life and society** ( 2 hrs )
  - Music across the universe and within life forms, primacy of sound, language, vedas, mantras, yoga & nada yoga and the individual & society
  - https://ww.clisonics.com/
  - https://melharmonymusic.com/
  - Other links and references will be provided during the course.

**Textbooks:**

1. NA

**References:**

1. NA

## 14.45 IK 609 : Music and Musopathy Advanced

**Course Code : IK 609**

**Course Name : Music and Musopathy Advanced**

L-T-P-C : 1-0-3-3
Intended for : BTech/MTech/MS/MSc/MA/Ph.D.
Prerequisite : None
Mutual Exclusion: None
Approval: 42nd Senate

**Course Contents**

- **Introduction to More Composers and Musicologies**: Composers such as Annamacharya, Surdas, Arunagirinathar, Kshetragnya, Bhadrachala Ramadas, Swati Tirunal, Patnam Subramanya Iyer, Muthiah Bhagavatar, Papanasam Sivan etc and a few significant Musicologists. (3 Hours)
- **Introduction to Prominent Musicians**: A glimpse of the greats who shaped modern music with audio/video samples . (5 Hours)

- **Challenges of Music Therapy and Possible Musopathy Studies**: A brief overview and analysis of the Limitations and unreliability of Conventional Music Therapy Studies and Results in various parts of the world; Practical Applications and Possible Topics for Clinical Studies and Research . (4 Hours)

**Laboratory/practical/tutorial Modules:**

1. Unit 4: Introduction to 30 more Ragas with Voice and Instrumental Exercises (12 Hours)
2. Unit 5: Practice Songs: 10 Geetams and 1 Swarajati (14 Hours)
3. Unit 6: Performance Repertoire: 10-12 Varnams, Krtis, Tillanas & Misc Songs (16 Hours)

**Textbooks:**

1. Chitravina N Ravikiran, **Perfecting Carnatic Music Level 1**, India, 2023. Accessed on 1st Oct 2023 at: https://acharyanet-india.myshopify.com/collections/carnatic-books/products/perfecting-carnatic- music-level-i-e-book
2. Chitravina N Ravikiran, **Perfecting Carnatic Music Level 2: Varnams, Krtis** (eBook). Accessed on 1st Oct 2023 at: https://acharyanet-india.myshopify.com/products/perfecti carnatic-music-level-ii-varnams-krtis -ebook

**References:**


1. Acharyanet, **Carnatic Lessons India**, 2023. Retrieved from https://www.acharyanet.com/carna lessons-india/#plans
2. Chatterjee, G., **Bhartana Yasha, Bharata's Natyashastra (Meanings and Expositions in English and Hindi With Abhinavagupta's Commentary)**, 2023. Indian Mind
3. Ravikiran, C. N., **Appreciating Carnatic Music**, Ganesh & Company, 2006.
4. Shringy, R.K., & Sharma, P.L. (Trans.), **Sangitaratnakara (Sangeet Ratnakara) of Sarngadeva (**Vol. One, ISBN: 9788121505086; Vol. Two, ISBN: 9788121504669), Munshiram Manoharlal Publishers Pvt. Ltd., 2018
5. Subramaniam, L., & Subramaniam, V., **Euphony (Indian Classical Music)**, EastWest Books (Madras) Pvt. Ltd., 1999.

# 15 Mathematics Courses

## 15.1 MA 001 Preparatory Mathematics - 1

**Course Code: MA 001**

**Course Name: Preparatory Mathematics - 1**

L-T-P-C: 3-1-0-4
**Students Intended for:** Preparatory Students
**Core or Elective:** Core
Approval: 50th BoA

**Course Contents:**

- **Basic Set Theory:** Functions and their inverses, composition of functions, relations, equivalence relations, partitions [6 Lectures]
- **Number Systems:** Numbers – natural numbers, integers, rationals, reals, complex, uncountability of reals, irrationality of 2 etc. Congruencies, Residue Classes, addition and multiplication modulo n etc. [8 Lectures]
- **Complex Numbers:** Complex Numbers as ordered pairs. Argand's diagram. Triangle inequality. De Moivre's Theorem. [4 Lectures]
- **Algebra:** Quadratic equations and expressions; permutations and combinations; Binomial theorem for positive integral index [4 Lectures]
- **Coordinate Geometry:** Locus, Straight lines; Equations of circle, parabola, ellipse and hyperbola in standard forms; parametric representation [8 Lectures]
- **Vectors:** Addition of vectors. Multiplication by a scalar; scalar product, cross product and scalar triple product with geometrical applications. [6 Lectures]
- **Matrices and Determinants:** Algebra of matrices; Determinants and their properties; Inverse of a matrix; Cramer's rule. [6 Lectures]

**Text Books:**

1. S. Lang, **An Introduction to Linear Algebra**, undergraduate text in Mathematics, Springer Verlag.
2. Fred Safier, **Schaum's outline of Precalculu**s, 2nd Edition, McGraw Hill, 2008.
3. S. L. Loney, **The elements of Coordinate Geometry**, Scholarly publishing office, University of Michigan Library, 2005.

**Reference Books:**

1. Murray R. Spiegel, **Schaum's Outlines of Vector Analysis (and An Introduction to Tensor Analysis)**, McGraw Hill, 1968.
2. Murray R. Spiegel, **Schaum's Outlines: Complex Variables (with An Introduction Conformal Mapping and its Applications)**, McGraw Hill, 1964.

3. R. K. Jain and S. R. K. Iyengar, **Advanced Engineering Mathematics**, 3rd Edition, Narosa Publisher.

## 15.2 MA 002 Preparatory Mathematics - 2

**Course Code: MA 002**

**Course Name: Preparatory Mathematics - 2**

L-T-P-C: 3-1-0-4
**Students Intended for:** Preparatory Students
**Core or Elective:** Core
Approval: 50th BoA

**Course Contents:**

- **Functions and Their Graphs:** Functions, Inverse Function, Elementary Function and their Graphs. [6 Lectures]
- **Differentiation:** Limit, Continuity. Derivative and its geometrical significance. Derivatives of sum, difference, product and quotient of functions. Derivatives of polynomial, rational, trigonometric logarithmic and exponential functions. Differentiation of composite and implicit functions. [12 Lectures]
- **Applications of Derivatives:** Tangents and normal. Increasing and decreasing functions. Maxima and Minima. [6 Lectures]
- **Integration and its Applications:** Integration as the inverse process of differentiation. Integration by parts and by substitution. Definite ingeral and its application to determination of areas (simple areas). [8 Lectures]
- **Differential Equations:** First order ordinary differential equations. Homogeneous and exact equations. First order linear equations.

**Text Books:**

1. G. B. Thomas and R. L. Finney, **Calculus and Analytical Geometry**, Addison Wesley / Narosa.
2. T. M. Apostal, **Calculus**, 2nd Edition, Wiley Eastern.

**Reference Books:**

1. R. K. Jain and S. R. K. Iyengar, **Advanced Engineering Mathematics,** 3rd Edition, Narosa Publisher.

## 15.3 MA 101 Mathematics-I

**Course Code: MA-101**

**Course Name: Mathematics-I**

L-T-P-C: 3-1-0-4

Pre-requisite: NIL
Sem. Both
Approval: 5th Senate, OTA

**Course Contents:**

- **Functions of Several Variables**: Limit, continuity and differentiability of functions of two variables. Euler's Theorem, tangent plane and normal, change of variables, chain rule. Jacobians, Taylor's Theorem for two variables. Extrema of functions of two or more variables, Lagrange's method of undetermined multipliers;
- **Ordinary Differential Equations**: Solution of linear differential equations with constant coefficients, Euler-Cauchy Equations, Solution of second order differential equations by change of dependent and independent variables. Method of variation of parameters for second order differential equations. Numerical solution of ODE by Picard's method, Taylor's series, Euler method & Modified Euler method; Infinite Series: Convergence of infinite series, Comparison test, Ratio test, Root test, Raabe's test, Logarithmic test, Demorgan's test, Cauchy Integral test;
- **Solution in Series**: Solution in series of second order linear differential equations with polynomial coefficients. Bessel and Legendre equations and their series solutions. Properties of Bessel functions and Legendre polynomials;
- **Matrix Algebra**: Rank of a matrix , inverse of a matrix by elementary operations, Solution of linear simultaneous equations and their numerical solutions by Gauss Elimination and Gauss Seidel methods, eigen values and eigen vectors, Cayley-Hamilton theorem, diagonalization of matrices. Orthogonal, Hermetian, Skew-Hermetian, Normal and Unitary matrices and their elementary properties, quadratic forms.

**References:**

1. Thomas G. and Finney R. L., **Calculus and Analytical Geometry**, 9th Edition, Addision Wesley.
2. Kreyszig E., **Advanced Engineering Mathematics**, 9th Edition, Wiley Eastern.
3. Grewal B. S. , **Engineering Mathematics**, Khanna Publishers
4. Piaggio H. T. H., **An Elementary Treatise on Differential Equations and their Applications**, G. Bells & Sons Ltd.
5. Simmons G. F., **Differential Equations**, TMH Edition
6. Prasad C., **Mathematics For Engineers**, 19th Edition, Prasad Mudralaya.
7. Gerald C. F. and Wheatley P. O., **Applied Numerical Analysis**, 6th Edition, Wesley.
8. Krishnamurthy E. V. and Sen S. K., **Applied Numerical Analysis**, East West Publication.

## 15.4 MA 102: Mathematics II

**Course Code: MA 102**
**Course Name: Mathematics II**

L-T-P-C: 2 -1 -0- 3
Prerequisites: Consent of the faculty member
Students intended for: B.Tech. First Year
Elective or Core: Core
Approval: 1st Senate

**Course contents**

- **Integral Calculus**

  Double and Triple Integrals, Change of Order of Integartion, Change of Variables, Gamma, Beta functions, Dirichelte's Integral. Application (Evaluation of surface area, Volume, Centre of Gravity, Moment of Inertia). [ Lectures]

- **Vector Calculus**

  Differentiation of Vectors, Gradient, Divergence, Curl and their Physical meaning, Differential Operators and their identities. Line and Surface Integrals. Green's Theorem in a plane. Gauss Divergence Theorem and Stoke's theorem and their applications. [ Lectures]

- **Laplace Transform**

  Definition, Shifting Theorems, Transform of Derivatives, Differentiation and Integration. Differentiation and Integration of Transforms, Haviside unit step and Dirac-Delta functions. Inverse Laplace Transforms, Solution of Ordinary Differential Equations in Mechanics, Electric Circuits and bending of Beams using Laplace Transforms.

- **Fourier Series**

  Trigonometric Fourier Series. Half Range series, Harmonic Analysis.

- **Fourier Transforms**

  Definition, Fourier sine and Cosine Transforms, Fourier Integral Formula and Applications

**Text Books:**


1. E.Kreyszig, **Advanced Engineering Mathematics**, 9th Edition, John Wiley,

2. George B. Thomas, Maurice D. Weir, Joel Hass, Frank R. Giordano, **Thomas'Calculus**, 11th Edition, Pearson, 2004.

3. Lokenath Debnath, Dambaru Bhatta, **Integral Transforms And Their Applications**, 2nd Edition, Chapman & Hall/CRC (2006).


**Reference Books:**


1. Ian N. Sneddon, **Fourier Transforms**, Dover Publications (2010).

## 15.5 MA 201: Mathematics-III

### Course Code: MA 201

### Course Name: Mathematics-III

L-T-P-C: 2-1-0-3
Students intended for: B.Tech
Prerequisites:
Elective or Compulsory: Compulsory
Semester:
Approval: 5th Senate

### Course Contents:

- **Linear Algebra:**

  **Unit I**: Vector spaces, Sub Spaces, Linear Dependences and Independences of Vectors, Span, Bases and Dimensions, Direct Sum, Linear Transformations, Linear Variety, Range Space and Rank, Null Space and Nullity, Homomorphism, Matrix of Linear Transformations, Matrix Representation of a linear transformation, Structure of the solutions of the matrix equation Ax = b, Change of Bases. (6 hrs)

  **Unit II**: Elementary canonical forms: Triangulation, Diagonalisation of Matrices, Jordan canonical forms and some applications. Normed Linear Space, Inner Product Spaces, Orthogonality, Graham-Schmidt Orthogonalization. (7 hrs)

- **Complex Variable**:

  **Unit III**: Functions of a complex variable: Limit, Continuity, Differentiability, Analytic functions, Cauchy-Riemann equations, Laplace equation. (4 hrs)

  **Unit IV**: Harmonic functions, Harmonic conjugates. Complex logarithm function, Branches and Branch cuts of multiple valued functions. (4 hrs) **Unit V**: Complex integration, Cauchy's integral theorem, Cauchy's integral formula. Liouville's Theorem and Maximum-Modulus theorem, Power series and convergence, Taylor series and Laurent series. (4 hrs)

  **Unit VI**: Zeros, Singularities and its classifications, Residues, Rouches theorem, Argument principle, Residue theorem and its applications to evaluating real integrals and improper integrals. Conformal mappings, Mobius transformation.(5 hrs)

### Text Books:

1. G.Strang, **Linear Algebra and its Applications**, 4th Edition, Thomson, 2006.

2. R.V.Churchill and J.W.Brown, **Complex Variables and Applications**, McGraw-Hill, 2008.

3. H.Anton, **Elementary Linear Algebra with Applications**, 9th Edition, John Wiley, 2004.

**Reference Books:**


1. K. Hoffman and R. Kunze, **Linear Algebra**, Prentice Hall, 2008.

2. J.M.Howie, **Complex Analysis**, Springer-Verlag, 2003.

3. M.J.Ablowitz and A.S.Fokas, **Complex Variables- Introduction and Applications**, Cambridge University Press, 2003.

4. E. G. Phillips, **Functions of a Complex Variable: with Applications**, Barnes & Noble Books, 1973.

5. S.Kumaresan, **Linear Algebra – A Geometric Approach**, Prentice Hall of India, 2004.


## 15.6 MA 210 : Real and Complex Analysis

**Course Code : MA 210**

**Course Name : Real and Complex Analysis**

L-T-P-C : 2.5-0.5-0-3
Intended for : B. Tech. in Mathematics and Computing, 2nd Year Students
Prerequisite : IC 112, IC 113
Mutual Exclusion :
Approval: 54th BoA

**Course Contents**

- **Analysis on Rˆn**: Supremum and infimum property of the real number system, Countable and uncountable sets, Interior points and limits points, Closure of a set, Open sets and closed sets in Rˆn, Bolzano-Weierstrass theorem, Compact sets in Rˆn. (7 Hours)

- **Metric space**: Definition of a metric space, Examples, Open and closed sets in a metric space, Dense sets, Compact sets, Convergent sequences in a metric space, Complete metric spaces, Continuous functions between two metric spaces, Continuous functions on compact sets, Uniform continuity and uniform convergence in a metric space, Connectedness. (10 Hours)

- **Riemann integral**: Definition of Riemann integral, Examples of Riemann integrable and non-Riemann integrable functions, Some properties of Riemann integral, Continuous functions and Riemann integrability, Fundamental theorem of calculus. (4 Hours)

- **Complex Analysis**: Branch points and branch cuts, Radius of convergence of a power series, Taylor's series and Laurent's series, Classification of singularities, Poles, Picard's theorem, Zeros of analytic functions, Residue theorem, Identity/uniqueness theorem. ([7 Hours)

- **Complex (continues)**: Mobius transformations, Poisson integral formula, Maximum modulus theorem, Liouville's theorem, Statement of uniqueness theorem for Dirichlet problem. (4 Hours)

**Textbooks:**

1. Apostol, **Mathematical Analysis**, 2nd Edition.
2. E. Kreyszig, **Advanced Engineering Mathematics**, 10th Edition.

**References:**

1. R. G. Bartle and D. R. Sherbert, **Introduction to Real Analysis**, 4th Edition, Wiley.
2. R. V. Churchill and J. W. Brown, **Complex Variables and Applications**, 9th Editions, 2021.
3. S. Ponnusamy, **Foundations of Complex Analysis**, 2nd Edition, Narosa, 1995.

## 15.7 MA 211 : Ordinary Differential Equations

**Course Code : MA 211**

**Course Name : Ordinary Differential Equations**

L-T-P-C : 3-1-0-4
Intended for : B. Tech 2nd Year (MnC) and optional for other branch of students
Prerequisite : IC113, IC115
Mutual Exclusion : MA513 course from SMSS is not allowed to credit by the students after or along with this course
Approval: 54th BoA

**Course Contents**

- **Module I**: General Overview of Ordinary Differential Equations; Solutions methods to solve the first, second and higher order ordinary differential equations; Power Series methods, with properties of Bessel differential equations and Legendre differential equations. (12 Hours)
- **Module II**: Existence and Uniqueness of solutions for Initial Value Problems: Picard's and Peano's Theorems, Gronwall's inequality, continuation of solutions and maximal interval of existence, continuous dependence. (14 Hours)
- **Module III**: Algebraic properties of systems of differential equations, the eigenvalue-eigenvector method of finding the solutions of linear systems, Complex eigenvalues, Equal eigenvalues, Fundamental matrix solutions, Wronskian, Matrix exponential, Nonhomogeneous equations, Variation of parameters, Stability theory for linear and nonlinear systems, Lyapunov stability. (16 Hours)

**Textbooks:**

1. Ahmad, S. Rao, M.R.M., **Theory of ordinary differential equations with applications in biology and engineering**, EWP publication,
2. L. Perko, **Differential Equations and Dynamical Systems**, Texts in Applied Mathematics, Vol. 7, 2nd Edition, Springer Verlag, 1998.

**References:**

1. Devaney, R., Hirsch, M. W. and Smale, S., **Differential Equations, Dynamical Systems, and an Introduction to Chaos**, 2nd Edition, Academic Press, 2003.

2. Birkhoff, G. and Rota, G.-C., **Ordinary Differential Equations**, wiley, 1989

3. R. P. Agarwal and D. O. **Regan, An Introduction to Ordinary Differential Equation**s, Springer- Verlag, 2008.

## 15.8 MA 460: Nonlinear Dynamics and Chaos

**Course Code: MA 460**
**Course Name: Nonlinear Dynamics and Chaos**

L-T-P-C: 3-0-0-3
Prerequisites: MA 101 and MA 102
Students intended for: B Tech 3rd year
Elective or Core: Elective
Approval: 2nd Senate

**Course contents**

- **Module I** [3 Lectures]

  Introduction to Nonlinear Dynamics and Chaos, Recent applications of Chaos, Computer and Chaos, Dynamical view of the world.

- **Basics of nonlinear science** [5 Lectures]

  Dynamics, Dynamical Systems, Types of Dynamical Systems, Nonlinearity, Dissipative Systems, Deterministic versus Stochastic Systems, Degree of Freedom, State Space, Phase Space, Attractor.

- **Module III** [4 Lectures]

  Stability of solutions to Ordinary Differential Equations

- **Module IV** [5 Lectures]

  Flows on line, Fixed Points and its Stability, Analytical Approach, Graphical approach, Simulation of Equations

- **Elementary Bifurcation Theory** [5 Lectures]

  Saddle Node, Transcritical, Pitchfork, Imperfect, Hopf bifurcation

- **Module VI** [4 Lectures]

  Two dimensional Flows, Simple Harmonic Mass-Spring Oscillator

- **Module VII** [4 Lectures]

  Limit Cycle, Ruling out closed orbits, Poincare Benedixson theorem

- **Module VIII** [6 Lectures]

  Butterfly Effect, Chaos, Lorenz Equations, Application of Chaos in sending secret messages, Introduction to Fractals, Dimensions of fractals, Cantor Set and Koch curve

- **Module IX** [5 Lectures]

  One dimensional map, Logistic Map, Period doubling Route to chaos, Feigenbaum constants

**Text Books:**


1. K.Allgood, T.Sauer, J.A.Yorke, **Chaos: An Introduction to Dynamical systems**, Springer Verlag

2. H.G. Solari, M.A. Natiello and G.B. Mindlin, **Nonlinear Dynamics: a two way trip from Physics to Maths**, Overseas publication


**Reference Books:**


1. Ian Stewart, **Does God Play a Dice? The Mathematics of Chaos**, Blackwell, NewYork.

2. Laksmanan M Rajsekhar, **Nonlinear Dynamics Integrability Chaos and Pattern**, Springer.

3. F.C. Moon, **Chaotic and Fractal Dynamics**, Wiley.


## 15.9 MA 465: Ordinary Differential Equations

**Course Code: MA 465**
**Course Name: Ordinary Differential Equations**

L-T-P-C: 3-0-0-3
Prerequisites: MA 101
Students intended for: B. Tech
Elective or Core: Elective
Approval: 2nd Senate

**Course contents**

- **Basic Theory** [18 Lectures]

  Existence and uniqueness of solutions, continuation of solutions, global existence, dependence of solutions on initial conditions, regularity of the flow, First and second order differential equations, Contraction mapping principle.

- **Linear Systems** [12 Lectures]

  The fundamental matrix, Equilibrium points and their stability, Sturm-Liouvile theory.

- **Nonlinear Systems** [10 Lectures]

  The Poincare-Bendixon theorem, Perturbed systems, Lyapunov functional, Local and global analysis.

**Text Books:**

1. Arnold, V., **Ordinary Differential Equations**, MIT Press, 1978.
2. Coddington, E. A. and Levinson, N., **Theory of Ordinary Differential Equations**, Krieger Publishing Co., 1984.
3. Ahmad, S. Rao, M.R.M., **Theory of ordinary differential equations with applications in biology and engineering**, EWP publication, 1999.

**Reference Books:**

1. Perko, **Differential Equations and Dynamical Systems**, Springer.
2. Devaney, R., Hirsch, M. W. and Smale, S., **Differential Equations, Dynamical Systems, and an Introduction to Chaos**, 2nd Edition, Academic Press, 2003.
3. Birkhoff, G. and Rota, G.-C., **Ordinary Differential Equations**, Wiley, 1989.

## 15.10 MA 510_9 : Climate Change Analysis

**Course Code: MA 510_9**

**Course Name : Climate Change Analysis**

L-T-P-C : 3-0-0-3
Intended for : UG/PG
Prerequisite : UG None
Mutual Exclusion : None
Approval: 9th Senate

**Course Contents:**

- **Statistical concepts in climate research: 20 hrs**
- Misuses of statistics in climate research: testing hypotheses suggested by the data; serial correlation; using statistical recipes as " black-box" tools;
  - Hypothesis testing Type I and Type II errors, significance, power, etc; historical developments and controversy around classical statistical significance test and its interpretation.
  - Basics of Bayesian statistics: Introduction to Bayesian statistics; Bayesian climate change assessment.
  - Advanced data analysis technique like functional data analysis and wavelet analysis to detect climate changes is discussed in detail.
- **Detection and attribution of anthropogenic climate change:** 10 hrs

  - To identify the causes of recent observed climate variations
  - To evaluate the performance of climate models in simulating the observed climate variations over the last century
  - To constrain the projections of future climate change

- **Climate science beyond the IPCC** 6 hrs
  - Univariate analysis of global mean temperature comparing change with internal variability
  - Study of different causes that affect global radiation balance; increasing greenhouse gases, increasing solar irradiance

- **Use the spatial pattern of the temperature response to differentiate between different causes and fingerprint analysis Minor project/seminars** 6 hrs

**Textbooks**


1. Montgomery, D., Jennings, C.L. and Kulahci, M., **Introduction to Time Series Analysis and Forecasting**, Wiley-Interscience, 2008.

2. Chatfield, C., **The Analysis ofTime Series**, 6th Edition Chapman & Hall/CRC, 2004.


**Reference Books:**


1. Robert H. Shumway and David S. Stoffer, **Time Series Analysis and Its Applications with R Examples**, 3rd edition, Springer Texts in Statistics, 2006.

2. Hans von Storch, Francis W. Zwiers, **Statistical Analysis in Climate Research**, Cambridge University Press (2002)

3. Hartmann U., Ramirez F., **Real Time Detection of Tuming Points in Financial Time Series**, GRIN Verlag, 2013.


## 15.11 MA 510: Ordinary Differential Equations

**Course Code: MA 510**
**Course Name: Ordinary Differential Equations**

L-T-P-C: 3-0-0-3
Prerequisites: None
Students intended for: UG/PG
Elective or Core: Elective
Approval:

**Course contents**

- **Statistical concepts in climate research** [20 Lectures]
  - Misuses of statistics in climate research: testing hypotheses suggested by the data; serial correlation; using statistical recipes as black-box tools;
  - Hypothesis testing Type I and Type II errors, significance, power, etc; historical developments and controversy around classical statistical significance test and its interpretation.
  - Basics of Bayesian statistics: Introduction to Bayesian statistics; Bayesian climate change assessment.
  - Advanced data analysis technique like functional data analysis and wavelet analysis to detect climate changes is discussed in detail.
- **Detection and attribution of anthropogenic climate change** [10 Lectures]
  - To identify the causes of recent observed climate variat ions
  - To evaluate the performance of climate models in simulating the observed climate variations over the last century
  - To constrain the projections of future climate change
- **Climate science beyond the IPCC** [6 Lectures]
  - Univariate analysis of globa l mean temperature comparing change with internal variability
  - Study of different causes that affect global radiation balance; increasing greenhouse gases, increasing solar irradiance
  - Use the spatial pattern of the temperature response to differentiate between different causes and fingerprint ana lysis
- **Minor project/seminars** [6 Lectures]

**Text Books:**

1. Montgomery, D., J enn ings, C.L. and Kulahci, M., **Introduction to Time Series Analysis and Forecasting**, Hoboken, N.J., Wiley-Interscience.2008
2. Chatfield, C., **The Analysis of Time Series**, Sixth Edition Chapman & Hall/CRC, 2004.

**Reference Books:**

1. Robert H. Shumway and David S. Stoffer, **Time Series Analysis and Its Applications with R Examples**, 3rd Edition, Springer Texts in Statistics, 2006.
2. Hans von Storch, Francis W. Zwiers, **Statistical Analysis in Climate Research**, Cambridge University Press, 2002.
3. Hartmann U., Ram i rez F., **Real Time Detection of Turning Points in Financial Time Series**, GRIN Verlag, 2013.

## 15.12 MA 510: Climate Change Analysis

**Course Code: MA 615**
**Course Name: Climate Change Analysis**

L-T-P-C: 3-0-0-3
Prerequisites: None
Students intended for: MS/ Ph.D., Undergraduate (3rd and 4th year)
Elective or Core: Elective

**Course contents**

- **Detection and attribution of anthropogenic climate change** [6 lectures]
  - To identify the causes of recent observed climate variations
  - To evaluate the performance of climate models in simulating the observed climate variations over the last century
  - To constrain the projections of future climate change
- **Climate science beyond the IPCC** [6 lectures]
  - Univariate analysis of global mean temperature comparing change with internal variability
  - Study of different causes that affect global radiation balance; increasing greenhouse gases, increasing solar irradiance
  - Use the spatial pattern of the temperature response to differentiate between different causes and fingerprint analysis
- **Statistical concepts in climate research** [24 lectures]
  - Misuses of statistics in climate research: testing hypotheses suggested by the data; serial correlation; using statistical recipes as "black-box" tools;
  - Hypothesis testing Type I and Type II errors, significance, power, etc; historical developments and controversy around classical statistical significance test and its interpretation.
  - Basics of Bayesian statistics: Introduction to Bayesian statistics; Bayesian climate change assessment.
- **Minor project/seminars** [6 lectures]

**Text Books:**


1. Montgomery, D., Jennings, C.L. and Kulahci, M., **Introduction to Time Series Analysis and Forecasting**, Wiley-Interscience, 2008.

2. Chatfield, C., **The Analysis of Time Series**, 6th Edition Chapman & Hall/CRC, 2004.

**Reference Books:**

1. Robert H. Shumway and David S. Stoffer, **Time Series Analysis and Its Applications with R Examples**, 3rd edition, Springer Texts in Statistics, 2006.

2. Hans von Storch, Francis W. Zwiers, **Statistical Analysis in Climate Research**, Cambridge University Press, 2002.

## 15.13 MA 511_Old: Real and Complex Analysis

**Course Code: MA 511_Old**
**Course Name: Real and Complex Analysis**

L-T-P-C: 3-1-0-4
Prerequisites: None
Students intended for: M.Sc. /M.S./Ph.D. /B.Tech 3rd and 4th year
Elective or Core: Core for M.Sc. in applied Mathematics and Elective for other discipline.
Approval: 10th Senate

**Course contents**

- **Module I** [30 Lectures]

  Introduction to real numbers, Construction, Dedekind cuts.

- **Module II** [9 Lectures]

  Metric space, Open sets, Closed sets, Continuous functions, Completeness, Cantor intersection theorem, Baire category theorem, Compactness, Totally boundedness. Connectedness.

- **Module III** [10 Lectures]

  Definition and existence of Riemann-Stieitjes integral, Properties of the integral, Differentiation and integration. Sequence and series, Uniform convergence, Uniform convergence and continuity, Uniform convergence and integration, Uniform convergence and differentiation

- **Module IV** [10 Lectures]

  Inequalities involving complex numbers, Limit, Continuity and differentiability, Cauchy-Riemann equations, Analytic functions, Polynomials, Rational functions, Harmonic conjugates, Elementary functions, Conformal mapping, Linear transformation.

- **Module V** [10 Lectures]

  Line integrals, Cauchy's theorem, closed curve, Cauchy's intergral formula, Higher derivatives, Morera's theorem, Liouville's theorem, Power series expansions, The Weierstrass theorem, Taylors Theorem, Laurent's Theorem, Classification of singularities, Classical theorem of Weierstrass concerning behavior of a function in the neighborhood of an essential singularity, zeros of analytic functions, The maximum principle, Schwarz's lemma, Residue theorem and applications.

**Text Books:**

1. W. Rudin, **Principles of Mathematical Analysis**, 3rd Edition, McGraw-Hill, 1983.

2. T. Apostol, **Mathematical Analysis**, 2nd Edition, Narosa Publishers, 2002.

**Reference Books:**

1. Lars V. Ahlfors, **Complex Analysis**, McGraw-Hill International Editions.

2. J.B. Conway, **Functions of one complex variable**, Narosa, New Delhi.

3. T.W. Gamelin, **Complex Analysis**, Springer International Edition, 2001.

4. R.V. Churchill and J.W. Brown, **Complex Variables and Applications**, Wiley.

## 15.14 MA 511: Real Analysis

**Course Code: MA 511**
**Course Name: Real Analysis**

L-T-P-C: 3-1-0-4
Prerequisites: None
Students intended for: M.Sc. /M.S./Ph.D. /B.Tech 3rd and 4th year
Elective or Core: Core for M.Sc. in applied Mathematics and Elective for other discipline.
Approval: 22nd Senate

**Course contents**

- **Module I** [4 Lectures]

  Introduction to real numbers, Construction, Dedekind cuts, Completeness property, Archimedean property, Countable and uncountable set

- **Module II** [6 Lectures]

  Open balls and open sets in Euclidean space, Definition of interior points, Closed sets, Adherent points, Accumulation points, Closure, Bolzano-Weirstrass Theorem, Cantor intersection theorem, Heine-Borel Theorem, Compactness.

- **Module III** [7 Lectures]

  3. Metric spaces, Open sets, Closed sets, Dense sets, Metric subspaces, Compact subsets of a metric space, Boundary of a set, Totally boundedness, Completeness.

- **Module IV** [8 Lectures]

  Convergent sequences in a metric space, Cauchy sequences, Complete metric space, Limit of a function, Continuous functions, Continuity of composite functions, Continuity and inverse image of open and closed sets, Functions continuous on compact sets, Connectedness

- **Module V** [4 Lectures]

  Review of Riemann Integration, Riemann-Stieltjes integral: definition and examples, Properties of the integral.

- **Module VI** [10 Lectures]

  6. Uniform continuity, Fixed point theorem for contractions, Sequences of functions, Point wise convergence of sequences of functions, Uniform convergence of sequences of functions, Uniform convergence and continuity, Cauchy condition for uniform convergence, Uniform convergence of infinite series of functions, Cauchy condition for uniform convergence of series, Weirstrass M-test, Dirichlet's test for uniform convergence, Uniform convergence and differentiation, Uniform convergence and integration

- **Module VII** [Lectures]

  Metric space C[a,b], Characterize compact subsets, i.e., Arzela-Ascoli theorem.

**Text Books:**

1. W. Rudin, **Principles of Mathematical Analysis**, 3rd Edition, McGraw-Hill, 2013.

2. T. Apostol, **Mathematical Analysis**, 2nd Edition, Narosa Publishers, 2002.

**Reference Books:**

1. Elias M. Stein and Rami Shakarchi, **Real Analysis** Princeton Lectures, 2010.

2. Terrance Tao, **Analysis I and II**, Trim, Hindustan book agency, 2006.

## 15.15 MA 512: Linear Algebra

**Course Code: MA 512**
**Course Name: Linear Algebra**

L-T-P-C: 3-1-0-4
Prerequisites: Basic knowledge on matrix and determinants
Students intended for: M.Sc./M.S./Ph.D.
Elective or Core: Core for M.Sc. in applied Mathematics and Elective for other discipline
Approval: 10th Senate

**Course contents**

- **Matrices, vectors, and systems of linear equations** [3 Lectures]

  Introduction to Matrix and Determinant.

- **Vector spaces, basis, dimension** [10 Lectures] Vector spaces, Subspaces, Subspaces connected with matrices, Linear span, Linear independence, Bases and dimension, Basis and dimension of range and null space.

- **Linear transformations, change of basis** [6 Lectures]

  Linear transformations and matrices, Coordinate change, Change of basis and similarity.

- **Diagonalisation** [7 Lectures]

  Eigenvalues and eigenvectors, Diagonalisation of a square matrix, Inner products, orthogonality, orthogonal diagonalisation, Applications of diagonalisation.

- **Direct sums and projections** [7 Lectures]

  The direct sum of two subspaces, Orthogonal complements, Projections, Characterising projections and orthogonal projections, Minimising the distance to a subspace.

- **Complex matrices, vector spaces** [9 Lectures]

  Complex vector spaces, Complex inner product spaces, The adjoint. Hermitian and unitary matrices, Unitary diagonalisation. Normal matrices, Spectral decomposition.

**Text Books:**


1. G.Strang, **Linear Algebra and its Applications**, 4th Edition, Thomson, 2006.
2. K. Hoffman and R. Kunze, **Linear Algebra**, Prentice Hall, 2008.
3. H.Anton, **Elementary Linear Algebra with Applications**, 9th Edition, John Wiley, 2004.


**Reference Books:**


1. Loehr, Nicholas, **Advanced Linear Algebra**, Taylor & Francis Inc.
2. Iuliana Iatan, **Advanced Lectures on Linear Algebra with Applications**, LAP Lambert Academic Publishing.
3. Sohail A. Dianat, Eli Saber, **Advanced Linear Algebra for Engineers with MATLAB**, Taylor Francis Inc.


## 15.16 MA 513: Ordinary Differential Equations

**Course Code: MA 513**
**Course Name: Ordinary Differential Equations**

L-T-P-C: 3-1-0-4
Prerequisites: NA
Students intended for: M.Sc. /M.S./Ph.D./B.Tech 3rd and 4th year
Elective or Core: Core for M.Sc. in applied Mathematics and Elective for other discipline
Approval: 10th Senate

**Course contents**

- **General Overview** [8 Lectures]

  Solutions methods: General solution methods, Power Series methods with properties of Bessel functions and Legendre polynomials.

- **Existence and Uniquenessn** [11 Lectures]

  Existence and Uniqueness of Initial Value Problems: Picard's and Peano's Theorems, Gronwall's inequality, continuation of solutions and maximal interval of existence, continuous dependence

- **Systems of Differential Equations** [16 Lectures]

  Algebraic properties of solutions of linear systems, The eigenvalue-eigenvector method of finding solutions, Complex eigenvalues, Equal eigenvalues, Fundamental matrix solutions, Wronskian, Matrix exponential, Nonhomogeneous equations, Variation of parameters, Stability theory for linear and nonlinear systems, Lyapunov function.

- **Boundary value problems** [7 Lectures]

  Green's function, Sturm comparison theorems and oscillations, eigenvalue problems.

**Text Books:**


1. G.F. Simmons and S.G. Krantz, **Differential Equations: Theory, technique and practice**, Tata McGraw-Hill, 2007.

2. V. Arnold, **Ordinary Differential Equations**, MIT Press, 1978.

3. Coddington, E. A. and Levinson, N., **Theory of Ordinary Differential Equations**, Krieger Publishing Co, 1984.


**Reference Books:**


1. Ahmad, S. Rao, M.R.M., **Theory of ordinary differential equations with applications in biology and engineering**, EWP publication, 1999.

2. L. Perko, **Differential Equations and Dynamical Systems**, *Texts in Applied Mathematics*, Vol. 7, 2nd Wdition, Springer Verlag, 1998.

3. Devaney, R., Hirsch, M. W. and Smale, S., **Differential Equations, Dynamical Systems, and an Introduction to Chaos**, 2nd Edition, Academic Press, 2003.

4. Birkhoff, G. and Rota, G.-C., **Ordinary Differential Equations**, Wiley, 1989

5. R.P. Agarwal and D. O'Regan, **An Introduction to Ordinary Differential Equations**, Springer- Verlag, 2008.

## 15.17 MA 514: Computer Programming

**Course Code: MA 514**
**Course Name: Computer Programming**

L-T-P-C: 3-0-0-3
Prerequisites: NA
Students intended for: M.Sc./M.S./Ph.D.
Elective or Core: Core for M.Sc. in applied Mathematics and Elective for other discipline
Approval: 10th Senate

**Course contents**

- **Introduction to Computer Programming** [4 Lectures]

  Programming and Programming Languages, Flowchart, The C Programming Language, Identifiers, Symbolic Constants, Declarations, Arithmetic Operations, Relational and Logical Operations.

- **Branching and Iteration** [6 Lectures]

  If-Else, ?: Conditional Expression, Switch, While Loops, Do-While Loops, For Loops, Break and Continue, Goto.

- **Functions** [4 Lectures]

  Function Prototypes, Call by reference, Call by arguments, recursive function, inline function.

- **Pointers** [6 Lectures]

  What is a Pointer? Pointer Syntax, Pointers and Arrays, Pointer Arithmetic, Return Values and Pointer, Pointers to Pointers, Function Pointers, Dynamic Memory allocation.

- **Arrays and Strings** [5 Lectures]

  Formatted IO: printf, scanf, string formatting; File IO: Opening and Closing Files, Standard IO, Sequential File Operations.

- **Object-oriented programming** [12 Lectures]

  Introduction to User define datatype, Fundamentals of the object-oriented approach, introduction to class and its components, constructors, referring to objects of a class, static members, classes and their friends, Introduction to STL and application.

**Text Books:**

1. V. Rajaraman, **COMPUTER PROGRAMMING IN C**, PHI Learning, 2004.

2. E. Balagurusamy, **Programming In Ansi C**, 3rd Edition, Tata McGraw-Hill Publication, New Delhi, 2004.

3. Walter Savitch, **Problem Solving with C++**: Global Edition, 9th Edition, Pearson Education, 2014.

4. Robert Lafore, **Object Oriented Programming In C++**, 4th Edition, Pearson Education India, 2004.

**Reference Books:**

1. Bjarne Stroustrup, **The C++ Programming Language**, 4th Edition, Pearson Education, 2013.

2. Brian W. Kernighan, **The C Programming Language (Ansi C Version)**, 2nd Edition, PHI, 1990.

3. Brian W. Kernighan, Dennis M. Ritchie, **Programming Languages C with Practicals**, 1st Edition, Margham Publications, 2012.

## 15.18 MA 514P: Computer Programming Lab

**Course Code: MA 514P**
**Course Name: Computer Programming Lab**

L-T-P-C: 0-0-3-2
Prerequisites: NA
Students intended for: MA-514, Computer Programming
Elective or Core: Core for M.Sc. in applied Mathematics and Elective for other discipline
Approval: 10th Senate

**Course Outline**

This lab course will complement the theory course Computer Programming & Applications by providing hand on experience. The syllabus will cover the lab aspect of the theory course.

**Text Books:**

1. V. Rajaraman, **COMPUTER PROGRAMMING IN C**, PHI Learning, 2004.

2. E. Balagurusamy, **Programming In Ansi C**, 3rd Edition, Tata McGraw-Hill Publication, New Delhi, 2004.

3. Walter Savitch, **Problem Solving with C++**: Global Edition, 9th Edition, Pearson Education, 2014.

4. Robert Lafore, **Object Oriented Programming In C++**, 4th Edition, Pearson Education India, 2004.

**Reference Books:**

1. Bjarne Stroustrup, **The C++ Programming Language**, 4th Edition, Pearson Education, 2013.

2. Brian W. Kernighan, **The C Programming Language (Ansi C Version)**, 2nd Edition, PHI, 1990.

3. Brian W. Kernighan, Dennis M. Ritchie, **Programming Languages C with Practicals**, 1st Edition, Margham Publications, 2012.

## 15.19 MA 515: Applied Mathematical Programming

**Course Code: MA 515**
**Course Name: Applied Mathematical Programming**

L-T-P-C: 3-1-0-4
Prerequisites: NA
Students intended for: M.Sc /M.S./Ph.D. ./B.Tech 3rd & 4th year
Elective or Core: Core for M.Sc. in applied Mathematics and Elective for other discipline
Approval: 10th Senate

**Course contents**

- **Origin and types of Linear Program** [5 Lectures]

  Model formulation in Industrial Problems, Solution by Graphical Method.

- **Module II** [8 Lectures]

  Theory and geometry of linear programs, Simplex Method, Big-M, Two Phase and Revised simplex method, complexity of simplex method, application to decision making.

- **Module III** [7 Lectures]

  Duality theory and application, Economic interpretation of dual variables, Primal dual relationship and theorems, Dual simplex method, primal-dual method.

- **Module IV** [5 Lectures]

  Integer programming and Applications, Gomory's Algorithm and branch and bound methods.

- **Module V** [5 Lectures]

  Transportation problems, Assignment problems, Application in various domains.

- **Module VI** [5 Lectures]

  Alternate approaches to solve LPP: ellipsoid method, Karmarkar's algorithm and application.

- **Module VII** [7 Lectures]

  Nonlinear programming, Lagrange multipliers, Farka's lemma, constraint qualification, KKT optimality conditions, sufficiency of KKT under convexity; Quadratic Programming, Wolfe method, Industrial Applications of QPP: Machine Learning, Finance etc.

**Text Books:**


1. D. Bertsimas and J. N. Tsitsiklis, **Introduction to Linear Optimization**, Athena Scientific, 1997.

2. Robert J. Vanderbei, **Linear Programming: Foundations and Extensions**, 4th Edition, Springer, 2014.

3. G. V. Reklaitis, A. Ravindran, K. M. Ragsdell, **Engineering Optimization: Methods and Applications**, Wiley, 2006.

4. Mokhtar S. Bazaaraa, Hanif D. Shirali and M.C.Shetty, **Nonlinear Programming, Theory and Algorithms**, John Wiley & Sons, 2004.


**Reference Books:**


1. Murty, Katta G., ed., **Case Studies in Operations Research: Applications of Optimal Decision Making**. Vol. 212. Springer, 2014.

2. Don T. Phillips, A. Ravindran, James J. Solberg, **Operations Research: Principles and Practice**, John Wiley & Sons, 1987.

3. S. S. Rao, **Engineering Optimization: Theory and Practice**, 4th Edition, John Wiley & Sons, 2009.


## 15.20 MA 516 : Topology

**Course Code: MA 516**

**Course Name : Topology**

L-T-P-C : 3-1-0-4
Intended for : UG/PG
Prerequisite : MA 511(Real Analysis)
Mutual Exclusion : None
Approval: 45th BoA

**Course Contents:**

- **Topological Spaces:** open sets, closed sets, neighbourhoods, bases, subbases, limit points, closures, interiors, continuous functions, homeomorphisms. [7 Hours]

- **Examples of topological spaces:** subspace topology, product topology, metric topology, order topology. [5 Hours]

- **Compactness:** compact spaces and its properties, locally compact spaces, one point compactification, paracompactness, Tychonoff theorem. [7 Hours]
- **Countability Axioms:** first countable spaces, second countable spaces, separable spaces, Lindeloff spaces. [4 Hours]
- **Separation Axioms:** Hausdorff, regular and normal spaces, Urysohn's lemma, Uryohn's Metrization theorem, Tietze extension theorem, partition of unity. [6 Hours]
- **Connectedness:** connectedness, path connectedness, connected subspaces of the real line, components and local connectedness. [5 Hours]
- **Quotient topology:** examples of quotient topology: construction of cylinder, cone, suspension, Mobius band, torus, topological groups, orbit spaces. [5 Hours]
- **Algebraic Topology:** homotopy, deformation retract, contractible spaces, path homotopy, fundamental group. [3 Hours]

**Text books:**

1. G. F. Simmons, **Topology and Modern Analysis**, Tata McGraw-Hill, 2004.
2. A. Hatcher, **Algebraic Topology**, Cambridge University Press, 2002.

**References:**

1. J. Dugundji, **Topology**, McGraw-Hill Inc., 1988.
2. J. R. Munkres, **Topology: A First Course**, Prentice-Hall, 1975.
3. M. A. Armstrong, **Basic topology**, McGraw-Hill Book Co. (UK), Ltd., 1979.

## 15.21 MA 521_10 : Topology and Functional Analysis

**Course Code: MA 521_10**

**Course Name : Topology and Functional Analysis**

L-T-P-C : 3-1-0-4
Prerequisites :
Intended for : M.Sc./M.S./Ph.D./B.Tech 3rd and 4th year
Distribution : Core for M.Sc. in applied Mathematics and Elective for other discipline.
Approval: 10th Senate

**Course Contents:**

- **Module I**: Cartesian Products, Finite Sets, Countable and Uncountable Sets, Infinite Sets and Axiom of Choice, Well Ordered Sets. Topological Spaces, Basis for a topology, Order topology, Subspace Topology, Product topology, closed sets and limit points, Continuous functions, Metric Topology. [10 Lectures]

- **Module II**: Connected spaces, Components and Loca l Connectedness, Compact spaces, Countability Axioms, Separation axioms Normal Spaces, Urysohn's Lemma, Titetz Extension Theorem, Tychonoff's Theorem , Metrization Theorem. [11 Lectures]
- **Module III**: Normed spaces, continuity of linear maps, Hahn - Banach theorems, Banach spaces. Uniform bounded principle, closed graph theorem, Open mapping theorem, bounded inverse t heorem, spectrum of Bounded Operator. Duals and transposes, duals of LP [a,b] and C[a,b]. [11 Lectures]
- **Module IV**: Inner product spaces, orthonormal sets, approximation and optimization, projections, Riesz representation theorem. Bounded operators and adjoints on a Hilbert space, normal, unitary and self adjoint operators. [10 Lectures]

**Textbooks:**

1. J. R. Munkres, **Topology**, 2nd Edition, Pearson Education (India), 2001.
2. H. L. Royden, **Real Analysis**, 3rd Edition, Prentice Hall of India, 1995.

**Reference Books:**

1. G.F. Simmons, **Introduction to Topology and Modem Analysis**, McGraw-Hill, 1963.
2. J. L. Kelley, **General Topology**, Van Nostrand, 1955.
3. B. V. Limaye, **Functional Analysis**.
4. K. Yoshida, **Functional Analysis**, Springer.
5. S. Nanda and B. Choudhari, **Functional Analysis With Application**, New Age International Ltd.
6. S. C. Bose, **Introduction to Functional Analysis**, Macmillan India Ltd.

## 15.22 MA 521: Functional Analysis

**Course Code: MA 521**
**Course Name: Functional Analysis**

L-T-P-C: 3-1-0-4
Prerequisites: MA-511 (Real Analysis)
Students intended for: M.Sc./B. Tech./M.S./Ph.D.
Elective or Core: Core for M.Sc. in applied Mathematics and Elective for other discipline
Approval: 22nd Senate

**Course contents**

- **Module I** [5 Lectures]

  Normed spaces, Examples of Normed Spaces, Subspaces of Normed Spaces, Quotient Normed Spaces, Riesz Lemma, Finite-Dimensional Normed Spaces, Convex Subsets of Normed Spaces, Stronger and Equivalent Norms, Strictly Convex Normed Spaces.

- **Module II** [5 Lectures]

  Linear Maps Between Normed Spaces, Continuity of linear maps, Examples of Discontinuous Linear Maps on Infinite Dimensional Normed Spaces, Various Criterion for Continuity of Linear Maps, Linear Functionals, Examples of Continuous Linear Maps, Necessary Conditions for the Continuity of Transformations defined by Infinite Matrices, Operator Norm of Bounded Linear Maps, Operator Norm of Transformations defined by Finite Matrices.

- **Module III** [5 Lectures]

  Hahn-Banach Separation Theorem, Hahn-Banach Extension Theorem, Consequences of Hahn-Banach Extension Theorem, Uniqueness of the Hahn-Banach Extension, Banach Limits.

- **Module IV** [8 Lectures]

  Banach Spaces, Subspaces of Banach Spaces, Quotient Banach Spaces, Product of Banach Spaces, Canonical Embedding of Normed Spaces, Schauder Basis, Uniform Bounded Principle and its Applications, Banach-Steinhaus Theorem..

- **Module V** [6 Lectures]

  Closed Maps, Closed graph theorem, Linear Projections, Open Maps, Quotient Maps, Open Mapping Theorem and its Applications, Bounded Inverse Theorem.

- **Module VI** [5 Lectures]

  Spectrum of Bounded Operators, Resolvent Set, Eigen-spectrum, Approximate Eigen- spectrum, Spectrum of the Right Shift Operator, Compact Operators on Normed Spaces, Spectrum of Compact Operators.

- **Module VII** [8 Lectures]

  Inner Product Spaces, Orthonormal Sets, Bessel's Inequality, Riesz-Fischer Theorem, Fourier Expansion, Parseval Formula, Projection and Riesz Representation Theorems, Bounded Operators and Adjoints, Normal, Unitary and Self-Adjoint Operators.

**Text Books:**

1. B.V. Limaye, **Functional Analysis**, Revised 3rd Edition, New Age International Private Limited, 2017.

2. B.V. Limaye, **Linear Functional Analysis for Scientists and Engineers**, Springer, Singapore, 2016.

3. J.B. Conway, **A Course in Functional Analysis**, 2nd Edition, Springer, 1990.

**Reference Books:**

1. 1. E. Kreyzig, **Introductory Functional Analysis with Applications**, John Wiley & Sons, New York, 1989.

2. K. Yoshida, **Functional Analysis**, 6th Edition, Springer, 1995.

3. C. Goffman and G. Pedrick, **A First Course in Functional Analysis**, Prentice-Hall, 1974.

4. A. Taylor and D. Lay, **Introduction to Functional Analysis**, Wiley, New York, 1980.

## 15.23 MA 522: Partial Differential Equations

**Course Code: MA 522**
**Course Name: Partial Differential Equations**

L-T-P-C: 3-1-0-4
Prerequisites: NA
Students intended for: M.Sc./B. Tech./M.S./Ph.D.
Elective or Core: Core for M.Sc. in applied Mathematics and Elective for other discipline
Approval: 10th Senate

**Course contents**

- **Module I** [5 Lectures]

  Introduction to PDE, First order PDEs, Solution methods for first order PDE.

- **Module II** [8 Lectures]

  Classification of Partial Differential Equations, Cauchy Problem, Cauchy Kowalevski Theorem, Classification of Second Order Partial Differential Equations: normal forms and characteristics. Initial and Boundary Value Problems: Lagrange-Green's identity and uniqueness by energy methods.

- **Module III** [6 Lectures]

  Methods of Solution, Methods of separation of variables, Characteristic method, Green's function, Fourier transform.

- **Module IV** [4 Lectures]

  Stability theory, energy conservation and dispersion

- **Module V** [5 Lectures]

  Laplace equation: mean value property, weak and strong maximum principle, Green's function, Poisson's formula, Dirichlet's principle, existence of solution using Perron's method (without proof).

- **Heat equation** [5 Lectures]

  Initial value problem, fundamental solution, weak and strong maximum principle and uniqueness results.

- **Wave equation** [5 Lectures]

  Uniqueness, D'Alembert's method, method of spherical means and Duhamel's principle

- **Module VIII** [4 Lectures]

  Introduction to Hilbert Spaces of Functions, Sobolev spaces, Weak solution

**Text Books:**


1. G. B. Folland, **Introduction to Partial Differential Equations**, Princeton University Press, 1995

2. L.C. Evans, **Partial Differrential Equations**, Graduate Studies in Mathematics, Vol. 19, AMS, Providence, 1998.


**Reference Books:**


1. . F. John, **Partial Differential Equations**, 3rd Edition, Narosa Publ. Co.,1979.

2. E. Zauderer, **Partial Differential Equations of Applied Mathematics**, 2nd Edition, John Wiley and Sons, 1989.

3. M. Renardy and R.C. Rogers, **An Introduction to Partial Differential Equations**, Texts in Appl. Math. 13, Springer, 1993

4. M.H. Protter and H. F. Weinberger, **Maximum Principles in Differential Equations**, Prentice Hall, 1967


## 15.24 MA 523: Numerical Analysis

**Course Code: MA 523**
**Course Name: Numerical Analysis**

L-T-P-C: 3-1-0-4
Prerequisites: NA
Students intended for: M.Sc./B. Tech./M.S./Ph.D.
Elective or Core: Core for M.Sc. in applied Mathematics and Elective for other discipline
Approval: 10th Senate

**Course contents**

- **Module I** [3 Lectures]

  Computer arithmetic, Kind of errors in Numerical Procedures, Significant digits, Backward error analysis, Sensitivity and conditioning, Stability and accuracy, Evolution of polynomials.

- **Module II** [6 Lectures]

Nonlinear Equations: Bisection method, Secant method, Newton's method, Method of False-position, Secant method, Fixed point iterations, order of convergence, Newtons method for multiple roots, Newtons methods and fixed point method for the system of nonlinear equations.

- **Module III** [7 Lectures]

  Existence and uniqueness of interpolating polynomial, Lagrange polynomials, Divided differences, Evenly spaced points, Error of interpolation, Piecewise interpolation, Cubic spline, Least-Square approximations.

- **Module IV** [11 Lectures]

  System of linear equations: Gaussian elimination, Partial Pivoting, Pivoting and Scaling in Gaussian Elimination method , Singular matrices, Determinants and Matrix inversions, Tridiagonal systems, Norms, Condition numbers and errors in solutions; Iterative methods: Jacobi, Gauss-Seidel and SOR Methods, Power method, Inverse power method and QR methods for finding the eigenvalues and eigenvectors of matrices.

- **Numerical Differentiation and Integration** [5 Lectures]

  Numerical differentiation, Newton-Cotes integration formulae, Composite rules, Error terms for Newton - Cotes formulae and composite rules, Methods of undetermined parameters, Gaussian quadrature.

- **Initial and Boundary Value Problem (IVP & BVP)** [10 Lectures]

  Taylor series method, Forward Euler, Backward Euler and Modified Euler methods, Runge-Kutta methods; Multistep methods: Milne's method, Adams-Moulton method, System of equations and Higher order equations, Stiff equations, Finite difference methods and Shooting methods for the Boundary vaue problems.

**Text Books:**

1. K. E. Atkinson, **An Introduction to Numerical Analysis**, 2nd Edition, John Wiley, 2008.

2. R. L. Burden and J. D. Faires, **Numerical Analysis**, 7th Edition, Thomson Learning, 2001.

**Reference Books:**

1. M. T. Heath, **Scientific Computing: An Introductory Survey**, McGraw Hill, 2002.

2. Brian Bradie, **A friendly introduction to Numerical Analysis**, Pearson Education, 2007.

## 15.25 MA 524: Probability and Statistics

**Course Code: MA 524**
**Course Name: Probability and Statistics**

L-T-P-C: 3-1-0-4
Prerequisites: NA
Students intended for: M.Sc./B. Tech./M.S./Ph.D.
Elective or Core: Core for M.Sc. in applied Mathematics and Elective for other discipline
Approval: 10th Senate

**Course contents**

- **Probability and random variable**

  $\sigma$ field; measurable space; construction of measure probability and properties; definitions, scope and examples of probability; sample spaces and events; axiomatic definition of probability; joint and conditional probabilities; independence, total probability; Bayes' rule and applications. [8 Lectures]

  Definition of random variables, continuous and discrete random variables; cumulative distribution function (cdf) for discrete and continuous random variables; probability mass function (pmf); probability density functions (pdf) and properties; expectation: mean, variance and moments of a random variables. [5 Lectures]

- **Distribution Functions** [7 Lectures]

  Some special distributions: uniform, exponential, Chi-square, Gaussian, binomial, and poisson distributions; Law of large numbers; Central limit theorem and its significance.

- **Statistics** [6 Lectures]

  Scatter diagram; graphical residual analysis, Q-Q plot to test for normality of residuals, autocorrelation and autocovariance functions; stationarity and non stationarity ; correlation and covariance

- **Module** [12 Lectures]

  Sampling distributions; point and interval estimation, testing of hypothesis, Goodness of fit and contingency tables, linear regression, ANOVA.

- **Module** [4 Lectures]

  Introduction to Stochastic process; white noise; random walk and Brownian motion.

**Text Books:**

1. Sheldon M. Ross, **Introduction to Probability and Statistics for Engineers and Scientists**, Academic Press, 2009.

**Reference Books:**

1. D. C. Montgomery and G.C. Runger, **Applied Statistics and Probability for Engineers**, 5th Edition, John Wiley & Sons, 2009.

2. Robert H. Shumway and David S. Stoffer, **Time Series Analysis and Its Applications with R Examples**, 3rd Edition, Springer Texts in Statistics, 2006.

## 15.26 MA 525: Heuristic Optimization

**Course Code: MA 525**
**Course Name: Heuristic Optimization**

L-T-P-C: 3-0-0-3
Prerequisites: IC150, IC111or equivalent / instructor's consent.
Students intended for: B.Tech. 3rd, 4th year, M.S.JM.Tech./M.Sc., Ph.D.
Elective or Core: Elective
Approval: 15th Senate

**Course contents**

- **Introduction** [2 Lectures]

  Introduction to optimization, Local and Global Minima, Classical Optimization Techniques, Heuristic Optimization techniques.

- **Random number generations** [7 Lectures]

  Random numbers of a given distribution, properties and statistical tests. Simulation of random number generators.

- **Benchmarks and algorithms comparisons** [4 Lectures]

  Parameter settings and statistical criterion for comparison of various algorithms,parametric a nd non parametric tests, non statistical measures and issues with them.

- **Continuous Optimization** [8 Lectures]

  Evolutionary Techniques, Swarm basedTechniques and other nature inspired techniques. Theoretical foundations of various techniques. Implementation issues with various techniques and their comparisons based on benchmarks

- **Discrete and combinatorial Optimization** [4 Lectures]

  Heuristic optimization approaches for discrete, mixed continuous discrete and combinatorial problems. Application to solve Knapsack, TSP, Network Flow problems, Submodular Functions under Matroid Constraints.

- **Estimation of Distribution Algorithms** [4 Lectures]

  EDA for discrete optimization and their comparisons, continuous EDA, Application of discrete and continuous EDA in optimization and machine learning.

- **Hybrid techniques** [4 Lectures]

  Local search methods and their advantages. Hybrid optimization techniques. Use of hybrid techniques and their application.

- **Constraint handling techniques** [6 Lectures]

  Problems with inequality and equality constraints. Methods based on rejection strategies, repair strategies, specialized operators. Penalty parameter based and penalty parameter less approaches. Approaches for handling equality constraints. Implementation of various constraint handling techniques and their comparison over various practical and benchmark problems.

- **Multi objective optimization** [6 Lectures]

  Various approaches to handle multiple objectives, Pareto Optimality. Dominance and decomposition based approaches. Hybrid techniques. Bi-level optimization. Theoretical Foundations and Applications to engineering and finance.

**Text Books:**


1. Engelbrecht, Andries P., **Fundamentals of computational swarm intelligence**, John Wiley & Sons, 2006.

2. Deb, K., **Multi-objective optimization using evolutionary algorithms**, John Wiley & Sons, 2001.


**Reference Books:**


1. Mezura-Montes, E. (Ed.), **Constraint-Handling in Evolutionary Optimization Constraint Handling in Evolutionary Optimization, Studies in Computational Intelligence**, vol. 198, Springer-Verlag, 2009.

2. Eiben, A.E. and Smith, J .E., **Introduction to Evolutionary Computing**, Springer, 2003.

3. Niederreiter, H. **Random number generation and quasi-Monte Carlo methods**, Society for Industrial and Applied Mathematics, 1992.

4. Coello, C. A. C., Lamont, G. 8., and Veldhuizen, D. A. V., **Evolutionary algorithms for solving multi-objective problems**, Vol. 5, Springer, 2007.

5. Datta, R., and Deb, K. (Eds.), **Evolutionary constrained optimization**, Springer, 2014.

6. Lobo, F. j., Lima, C. F., and Michalewicz, Z. (Eds.), **Parameter setting in evolutionary algorithms**, Vol. 54, Springer Science & Business Media, 2007.

7. Blum, C., Roli, A. and Sampels, M. (Eds.), **Hybrid metaheuristics: an emerging approach to optimization**, Springer, 2008.

8. Larranaga, P. and Lozano, j. A. (Eds). **Estimation of distribution algorithms: A new tool for evolutionary computation**, Springer Science & Business Media, 2012.

9. Clerc, M., **Guided randomness in optimization**, Vol. 1, John Wiley & Sons, 2015.

10. Wolsey, L.A., and Nemhauser, G. L., **Integer and Combinatorial Optimization**, Wiley, 1999.

11. Zbigniew M. and Fogel, D., **How to Solve it: Modern Heuristics**, Springer Verlag, 2000.

## 15.27 MA 526 : An Introduction to Wavelets

**Course Code: MA 526**

**Course Name : : An Introduction to Wavelets**

L-T-P-C : 3-0-0-3
Intended for : UG/PG
Prerequisite : Basic Knowledge of Real Analysis and Linear Algebra
Mutual Exclusion : None
Approval: 46th BoA

**Course Contents:**

- **Review of Linear Algebra**: Complex Series, Euler's Formula, Roots of Unity, Linear Transformations and Matrices, Change of Basis, diagonalization of Linear Transformations and Matrices, Inner Product, Orthogonal Bases, Unitary Matrices. (5 hours)

- **The Discrete Fourier Transform**: Definition and Basic Properties of Discrete Fourier Transform, Translation- Invariant Linear Transformations, The Fast Fourier Transform. (7 Hours)

- **Wavelets on Finite Group $\mathbb{Z}$N**: Convolution, Fourier Transform on $\mathbb{Z}$N, Definition of Wavelets and Basic Properties, Construction of Wavelets on $\mathbb{Z}$N. (6 Hours)

- **Wavelets on Infinite Discrete Group $\mathbb{Z}$**: Definition and Basic Properties of Hilbert spaces, Complete orthonormal sets in Hilbert Spaces, The spaces l2($\mathbb{Z}$) and L2([-$\rho, \rho$)), Basic Fourier Series, The Fourier Transform and Convolution on L2($\mathbb{Z}$) Wavelets on $\mathbb{Z}$. (8 Hours)

- **Wavelets on $\mathbb{R}$**: Convolution and Approximate Identities, Fourier Transform on $\mathbb{R}$, Bases for The Space L2($\mathbb{R}$), Belian-Low Theorem, Wavelets on $\mathbb{R}$, Multiresolution Analysis, Construction of Wavelets from multiresolution Analysis, Construction of Compactly supported Wavelets, Haar Wavelets, Band-Limited Wavelets, Applications. (16 Hours)

**Laboratory/practical/tutorial Modules:**

Nil

**Textbooks:**

1. Michael W. Frazier, **An Introduction to Wavelets Through Linear Algebra**, Springer-Verlag, 1999.

2. Eugenio Hernandez, Guido Weiss, **A First Course on Wavelets**, CRC Press, 1996.

**References:**

1. Ingrid Daubechies, **Ten Lectures on Wavelets, CBMS -NSF Regional Conference Series in Applied Mathematics**, 61. Society for Indus trial and Applied Mathematics (SIAM), 1992.

2. George Bachman, Lawrence Narici, Edward Beckenstein, **Fourier and Wavelet Analysis**, Springer-Verlag, 2000.

3. Howard L. Resnikoff, Raymond O. Wells, Jr., **Wavelet Analysis**, Springer-Verlag, 1998.

## 15.28 MA 527 : Field and Galois Theory

**Course Code: MA 527**

**Course Name : Field and Galois Theory**

L-T-P-C : 3-0-0-3
Intended for : M.Sc./M.S./PhD/B.Tech
Prerequisite : MA 549 (Abstract Algebra)
Mutual Exclusion : None
Approval: 46th BoA

**Course Contents:**

- **Module 1:** Fields, Characteristics and prime subfields, Field extensions, Automorphisms, Normal extensions and Splitting fields, Separable and Inseparable extensions, Algebraic closures (12 Hours)

- **Module 2:** Galois groups, The fundamental theorem of Galois theory, Finite fields, Cyclotomic extensions, Composite extensions, Norm and Traces, Cyclic extensions, Hilbert theorem 90 and Group cohomology, Kummer extensions (16 Hours)

- **Module 3:** Discriminants, Polynomials of degree 3 and 4, Ruler and Compass constructions, Solvability by radicals, Polynomials with Galois group Sn, Transcendental extensions, Solution of a cubic by Cardan's method, Solution of biquadratic by Ferrari's method (14 Hours)

**Text books:**

1. P. Morandi, **Field and Galois Theory**, Springer-Verlag, 1996.

2. D.S. Dummit and R. M. Foote, **Abstract Algebra**, 2nd Edition, John Wiley, 2002.

**References:**

1. M. Artin, **Algebra**, Prentice Hall of India, 1994.
2. N. Jacobson, **Basic Algebra I**, 2nd Edition, Hindustan Publishing Co., 1984, W.H. Freeman, 1985.
3. S. Lang, **Algebra**, 3rd Edition, Springer (India), 2004.
4. J.S. Milne, Online notes : https://www.jmilne.org/math/CourseNotes/FT.pdf

## 15.29 MA 528 : Measure Theory and Integration

**Course number : MA 528**

**Course Name : Measure Theory and Integration**

Credit Distribution : (3-1-0-4)
Intended for : M.Sc./M.S./PhD/B.Tech
Prerequisite : MA-511 (Real Analysis)
Mutual Exclusion : NA
Approval: 50th BoA

**Course Contents:**

- **Module 1:** Review of Riemann integral, Algebra of subsets of a non-empty set, Measure on an arbitrary sigma-algebra, Continuity property of measure, The induced outer measure, Measurable sets, Borel Sigma algebra, Monotone class, Completion of a measure space , The Lebesgue measure on $\mathbb{R}$, Properties of Lebesgue measure, Non measurable subsets of $\mathbb{R}$. (14 hours)
- **Module 2:** Simple measurable functions, Integral of non-negative measurable functions, Monotone convergence theorem, Fatou's Lemma, Dominated convergence theorem, Relation between Riemann , Improper and Lebesgue integrals , Riesz-Fischer theorem (L_1[a,b] is a complete metric space) , R[a,b] is dense L_1[a,b], Lusin's theorem, Lp- spaces, Convergence of measurable functions (almost everywhere , in measure, in mean). (16 Hours)
- **Module 3:** Absolutely continuous functions, Differentiability of monotone functions (Only statement of Lebesgue-Young theorem), Fundamental theorem of calculus for Lebesgue integrable functions, Radon-Nikodym theorem, Product measure, Fubini's theorem, Signed measure, Riesz representation theorem (Without proof) . (12 Hours)

**Text books:**

1. I. K. Rana, **An introduction to Measure and Integration,** 2nd Edition, Narosa, 2005.
2. G. de Barra, **Measure and Integration**, Wiley Eastern, 1981.

**References:**

1. W. Rudin, **Real and Complex Analysis**, 3rd edition, McGraw-Hill, International Editions, 1987.

2. H. L. Royden, **Real Analysis**, 3rd edition, Prentice-Hall of India, 1985.

3. G. B. Folland, **Real Analysis**, Wiley-Interscience Publication, John Wiley & Sons, 1999.

4. M. Thamban Nair, **Measure and Integration, A first course**, CRC Press, 2020.

## 15.30 MA 529 : Statistical Inference

**Course number : MA 529**

**Course Name : Statistical Inference**

Credit Distribution : 3-1-0-4
Intended for : M.Sc./M.S./PhD/ B.Tech
Prerequisite : MA-524 (Probability and Statistics)
Mutual Exclusion : NA
Approval: 50th BoA

**Course Contents:**

- **Module 1:** Random sample, Statistics, Order statistics, Sampling distributions, Parametric point estimation, Estimator, Unbiasedness, Sufficiency, Minimal sufficiency, Factorization theorem, Rao-Blackwell theorem, Completeness, Lehmann-Scheffe theorem, UMVUE, Basu's Theorem, Lower bounds for the variance of an estimator, Frechet-Rao-Cramer, Bhattacharya, Chapman- Robbins-Keifer inequalities. (16 Hours)

- **Module 2:** Consistency, Efficiency, Method of moments and method of maximum likelihood, Bayes estimators and Minimax Procedure, Invariance, Best equivariant estimators. (10 Hours)

- **Module 3:** Tests of hypothesis, Simple and composite hypothesis, Types of error, Neyman-Pearson Lemma, Families with monotone likelihood ratio, UMP, UMP unbiased and UMP invariant tests, Likelihood ratio tests- applications to one sample and two sample problems, Chi-square tests, Bayes tests, Methods for finding confidence intervals, shortest length confidence intervals, Bayesian confidence interval. (16 Hours)

**Text books:**

1. Main Text Book: Statistical Inference, George Casella and Roger L. Berger, Duxbury Press, second edition 2001.

2. An Introduction to Probability and Statistics, Vijay K Rohatgi and A. K. Md. Ehsanes Saleh, John Wiley, second edition, 2001.

**References:**


1. A. M. Mood, F. A. Graybill and D. C. Boes, **Introduction to the theory of Statistics**, 3rd edition, McGraw Hill Education, 2017.

2. J. Shao, **Mathematical Statistics**, Springer, 1998.

3. E. L. Lehmann, G. Casella, **Theory of Point Estimation**, Springer, 2006.

4. E. L. Lehmann, J. P. Romano, **Testing of Statistical Hypothesis**, Springer, 2006.


## 15.31 MA 530 : Graph Theory

**Course number : MA 530**

**Course Name : Graph Theory**

Credit Distribution : L-T-P-C:(3-1-0-4)
Intended for : UG/PG
Prerequisite : Basic understanding of mathematics
Mutual Exclusion : None
Approval: 50th BoA

**Course Contents:**

- **Basics:** Graphs, subgraphs, isomorphism, representation of graphs, degrees, walks, trails, paths, cycles, bipartite graphs. [5 Hours]

- **Trees and connectivity:** Characterizations of trees, minimum-spanning-trees, number of trees, Cayley's formula, shortest path algorithms. [5 Hours]

- **Eulerian and Hamiltonian graphs:** Characterizations, Necessary/sufficient conditions. [4 Hours]

- **Graph Coloring:** vertex coloring, chromatic polynomials, edge coloring. [4 Hours]

- **Planar graphs:** Properties, Euler's formula and its consequences, Kuratowski's Characterization. [6 Hours]

- **Matching and Factorizations:** matching in bipartite graphs, maximum matching in general graphs, Hall's marriage theorem, factorization; Tutte's perfect matching theorem and consequences. [7 Hours]

- **Networks:** The Max-flow min-cut theorem, connectivity and edge connectivity, Menger's theorem. [6 Hours]

- **Graph and Matrices:** Adjacency matrix, Laplacian matrix, Eigen Values. [5 Hours]

**Text books:**

1. J. A. Bondy and U.S.R Murthy, **Graph Theory with Applications**, Macmillan, 1976.

2. D. B. West, **Introduction to Graph Theory**, Vol:2, Prentice hall, 2001.

**References:**

1. F. Harary, **Graph Theory**, Addison-Wesley publishing company, 1969.

2. R. Diestel, **Graph Theory**, 3rd ed. Graduate texts in mathematics 173, 2005.

3. R. B. Bapat, **Graphs and Matrices**, Vol. 27. London: Springer, 2010.

## 15.32 MA 549: Abstract Algebra

**Course Code: MA 549**
**Course Name: Abstract Algebra**

L-T-P-C: 3-0-0-3
Prerequisites: NA
Students intended for: UG 3rd and 4th year students/PG
Elective or Core: Elective
Approval: 8th Senate

**Course contents**

- **Module I** [21 Lectures]

  Binary operation, and its properties, Definition of a group, Examples and basic properties. Subgroups, Coset of a subgroup, Lagrange's theorem. Cyclic groups, Order of a group. Normal subgroups, Quotient group. Homomorphisms, Kernel Image of a homomorphism, Isomorphism theorems. Permutation groups, Cayley's theorems. Direct product of groups. Structure of finite abelian groups. Applications, Private and public key cryptography, some nontrivial examples

- **Module II** [7 Lectures]

  Rings: definition, Examples and basic properties. Zero divisors, Integral domains, Fields, Characteristic of a ring, Quotient field of an integral domain. Subrings, Ideals, Quotient rings, Isomorphism theorems. Ring of polynomials. Prime, Irreducible elements and their properties, UFD, PID and Euclidean domains. Prime ideal, Maximal ideals. Extension fields, Algebraic extensions, Finite fields.

**Text Books:**

1. Joseph Gallian, **Contemporary Abstract Algebra**, 7th Edition, Brooks Cole, 2009.

2. J. B. Fraleigh, **A first Course in Abstract Algebra**, Narosa Publishing House, 2003.

**Reference Books:**

1. I. N. Herstein, **Topics in Algebra**, Wiley Eastern Ltd., 1975.

2. Klima, Sigmon and Stitzinger, **Applications of Abstract Algebra with Maple and Matlab**, 2nd Edition, 2006.

## 15.33 MA 550 Statistical Data Analysis

**Course Code: MA 550**

**Course Name: Statistical Data Analysis**

L-T-P-C: 2-1-0-3
Students intended for: MS/ Ph.D., Undergraduate (3rd and 4th year)
Prerequisites: MA 202 for undergraduate
Elective or Core: Elective
Approval: 2nd Senate

**Course Contents:**

- **Exploratory analysis of time series**:

  Introduction, examples, simple descriptive techniques, trend, seasonality, stochastic and deterministic approaches; numerical and experimental data sets; challenges in data analysis and data graphical representation, interpretation; statistical tests, significance and power of a test, choice of the critical region, constructing test statistics: the Fisher discriminant, mean and variance test, testing goodness-of-fit, chi2-test, p-values; stationary time series process (ARMA Processes). [12 Lectures]

- **Analysis of stochastic series**:

  Model identification and non-stationary time series models; forecasting with classical regression models; Forecasting with autocorrelations; Forecasting with lagged dependent variable; Forecast error statistics and evaluation; singularity detection, spectral density function, the periodogram, spectral analysis, correlogram, wavelet cross-correlation, multi-resolution analysis, examples and applications. [12 Lectures]

- **Clustering data techniques**:

  Principal component analysis; different techniques of data clustering. [6 Lectures]

**Text books:**

1. Peck and Devore, **Statistics: The Exploration and Analysis of Data**, 7th edition, Thomson-Brooks/Cole, 2012.

2. Montgomery, D., Jennings, C.L. and Kulahci, M., **Introduction to Time Series Analysis and Forecasting**, Wiley-Interscience, 2008.

3. Chatfield, C., **The Analysis of Time Series**, 6th Edition, Chapman & Hall/CRC, 2004.

**References:**

1. Petre Stoica and Randolph L. Moses, **Introduction to Spectral Analysis**, Prentice Hall, 1997.

2. Robert H. Shumway and David S. Stoffer, **Time Series Analysis and Its Applications with R Examples**, 3rd edition, Springer Texts in Statistics, 2006.

3. Raghuveer M. Rao and Ajit S. Bopardikar, **Wavelet Transform**, Pearson Education, 1998.

## 15.34 MA 551: Numerical Analysis

**Course Code: MA 551**
**Course Name: Numerical Analysis**

L-T-P-C: 3-0-0-3
Prerequisites: IC 110 Engineering Mathematics, IC 111 Linear Algebra
Students intended for: 3rd and 4th year UG/PG
Elective or Core: Elective
Approval: 8th Senate

**Course contents**

- **Introduction** [6 Lectures]

  Approximate Numbers and Significant Digits, Propagation of errors, Different types of errors, Backward error analysis, Sensitivity and conditioning, Stability and accuracy.

- **Nonlinear Equations** [8 Lectures]

  Bisection method, Newton's method and its variants, Secant method, Fixed point iterations and their Error analysis.

- **Module III** [8 Lectures]

  Finite differences, Polynomial interpolation, Newton Divided Differences, Spline interpolation. Numerical integration, Trapezoidal and Simpson's rules, Newton Cotes formula, Gaussian quadrature, and Numerical differentiations.

- **System of linear equations** [8 Lectures]

  Gaussian Elimination, Partial Pivoting, Pivoting and Scaling in Gaussian Elimination method, Iteration methods, Error analysis.

- **Initial Value Problem (IVP)** [6 Lectures]

  Taylor series method, Euler and modified Euler methods, Runge Kutta methods, Multistep methods, Predictor Corrector method.

- **Boundary Value Problem (BVP)** [6 Lectures]

**Text Books:**

1. K. E. Atkinson, **An Introduction to Numerical Analysis**, 2nd Edition, John Wiley, 2008.

2. S. D. Conte and Carl de Boor, **Elementary Numerical Analysis**, McGraw Hill, 1988.

**Reference Books:**

1. M. T. Heath, **Scientific Computing: An Introductory Survey**, McGraw Hill, 2002.

2. Ralston and P. Rabinowitz, **A First Course in Numerical Analysis**, Dover Publications, 2001.

## 15.35 MA 552: Number Theory

**Course Code: MA 552**
**Course Name: Number Theory**

L-T-P-C: 3-0-0-3
Prerequisites:
Students intended for: UG/PG
Elective or Core: Elective
Approval: 8th Senate

**Course contents**

- **Introduction & Divisibility Theory** [10 Lectures]

  : Basics, Divisibility, Euclidean Algorithm, Primes and their Distribution, Prime Number Theorem (without proof). Congruences, Linear Congruences and Congruences with prime modulus, Some Diophantine Equations, The Chinese remainder theorem.

- **Number Theoretic Functions & Applications** [8 Lectures]

  Arithmetic functions and the Mobius inversion formula, Greatest Integer Function, Sum of integer squares and Applications.

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- **Fermat's Theorem & Primitive Root** [8 Lectures]

  Fermat's little theorem, Euler and Wilsons Theorems, Primitive Roots, Indices, Quadratic Reciprocity, Legendre Symbol, Gauss Theorem.

- **Applications to Cryptography & Special Topics** [10 Lectures]

  Applications to Primality Testing, RSA & cryptography, Fibonacci Numbers, Numbers of Special Form, Continued Fractions and Rational Approximations.

**Text Books:**

1. D. Burton, **Elementary Number Theory**, 7th edition, McGraw Hill, 2012.

**Reference Books:**

1. Keneth Rosen, **Elementary Number Theory and its Applications**, 4th Edition, Addison-Wesley, 2000.

2. I. Niven, H.S. Zuckerman and Hugh L. Montgomery, **An Introduction to the Theory of Numbers**, 5th Edition, Wiley, 1991.

## 15.36 MA 553: Mathematical Foundations of Financial Engineering

**Course Code: MA 553**
**Course Name: Mathematical Foundations of Financial Engineering**

L-T-P-C: 2-1-0-3
Prerequisites: IC 110, IC 111, IC 210
Students intended for: 3rd and 4th Year UG/PG
Elective or Core: Elective
Approval: 8th Senate

**Course contents**

- **Module I** [3 Lectures]

  Convex Analysis, constraint qualifications for convex optimization. Numerical Solution of QPP.

- **Module II** [15 Lectures]

  Riemann Integration, Measurable space and function, Lebesgue Integration, Wiener process and properties, Martingales and stopping times, Strong Markov property, stochastic integrals, Ito processes.

- **Module III** [12 Lectures]

  Introduction to PDE, Diffusion equation and its numerical solution, Diffusion process, connecting stochastic and partial differential equations, Black-Scholes Equation, numerical solution of Black-Scholes Equation.

**Text Books:**

1. Thomas Mikosch, **Elementary stochastic Calculus with Finance in View**, World Scientific, 1999.

2. M. Capinski and T. Zastawniak, **Mathematics for finance: an introduction to financial engineering**, Springer, 2010.

3. Tavella, Domingo, and Curt Randall, **Pricing financial instruments: The finite difference method**, Vol. 13. John Wiley & Sons, 2000.

**Reference Books:**


1. M. Baxter and A. Rennie, **Financial Calculus**, Cambridge University Press, 1996.
2. Olvi L. Mangasarian, **Nonlinear Programming**, Society for Industrial and Applied Mathematics (SIAM), 1994.
3. Walter Rudin, **Principles of Mathematical Analysis**, 3rd Edition, McGraw Hill, 1976.
4. S. N. Neftci, **Principles of financial engineering**, Academic Press/ Elsevier, 2009.


## 15.37 MA 555: Introduction to Partial Differential Equations for Engineers

**Course Code: MA 555**
**Course Name: Introduction to Partial Differential Equations for Engineers**

L-T-P-C: 3-0-0-3
Prerequisites: IC 110: Engineering Mathematics
Students intended for: UG/PG
Elective or Core: Elective
Approval: 8th Senate

**Course contents**

- **Introduction** [6 Lectures]

  Overview of PDEs, Classification of second order equations, Initial value problems, boundary value problems.

- **Hyperbolic Partial Differential Equations** [8 Lectures]

  Introduction to the wave equation, the method of spherical means, Kirchhoff's formula and Minkowskian geometry, geometric energy estimates.

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- **Elliptic Partial Differential Equations** [8 Lectures]

  Introduction to Laplace's and Poisson's equations, fundamental solution, Green functions, Poisson's formula, Harnack's inequality, Liouville's theorem.

- **Fourier transform** [6 Lectures]

  Introduction to the Fourier transform; Fourier inversion and Plancherel's theorem.

- **Special Equations** [6 Lectures]

  Introduction to Schrodinger's equation; Introduction to Lagrangian field theories, Transport equations and Burger's equation

**Reference Books:**


1. Sandro Salsa, **Partial Differential Equations in Action: From Modelling to Theory**, Springer, 2010.

2. Robert C. McOwen, **Partial Differential Equations - Methods and Applications**, Pearson Education Inc., 2004.

3. S.J. Farlow, **Partial Differential Equations for Scientists and Engineers**, Dover Publications, New York, 1982.

4. E. C. Zachmanoglou and Dale W. Thoe, **Introduction to Partial Differential Equations with applications**, Dover Publications, 1988.

5. Gerald B. Folland, **Introduction to Partial Differential Equations**, Princeton University Press, 1995.


## 15.38 MA 560 : Nonlinear Dynamics and Chaos

**Course Code: MA 560**

**Course Name : Nonlinear Dynamics and Chaos**

L-T-P-C : 3-0-0-3
Intended for : Elective for M.Sc./ MTech/PhD/BTech (All Branches)
Prerequisite : IC 110, IC 111 for BTech, Ordinary Differential Equations for M.Sc/MTech/PhD
Mutual Exclusion : None
Approval: 46th BoA

**Course Contents:**[4]

- **Module 1:** Introduction to Nonlinear Dynamics and Chaos, Recent applications of Chaos, Computer and Chaos, Dynamical view of the world (3hours)
- **Module 2:** Basics of nonlinear science: Dynamics, Representations of Dynamical Systems, Types of Dynamical Systems, Nonlinearity, Vector Fields of Nonlinear Systems, Nonlinear systems and their classification, Dissipative Systems, Deterministic vs. Stochastic Systems, Degree of Freedom, State Space, Phase Space, Attractor (5 hours)
- **Module 3:** Existence and uniqueness of solutions, Fixed points and Linearization, Flows on line, Fixed Points and its Stability, Analytical Approach, Graphical approach, Simulation of Equations (5 hours)
- **Module 4:** Elementary Bifurcation Theory: Saddle Node, Transcritical, Pitchfork, Imperfect, Hopf bifurcation (4 hours)
- **Module 5:** Two dimensional Flows, Simple Harmonic Mass-Spring Oscillator (4 hours)
- **Module 6:** Limit Cycle, Ruling out closed orbits, Poincare Benedixson theorem (4 hours)

[4]Revised MA 460

- **Module 7:** Chaos and tools for its Detection: Chaos and Butterfly effect (SDIC), Center manifold theory and Poincare maps, Lyapunov Exponents, Power spectrum, phase, Stable and Unstable Manifolds, Frequency Spectra of Orbits, Dynamics on a Torus, analysis of Chaotic Time Series. Examples of chaotic systems: Lorenz Equations, Application of Chaos in sending secret messages, Rossler Equations, Chua's Circuit, Introduction to Fractals, Dimensions of fractals, Cantor Set and Koch curve (6 hours)
- **Module 8:** One dimensional map, Logistic Map, Henon map, Period doubling Route to chaos, Feigenbaum constants (5 hours)
- **Module 9:** Statistical description of Chaotic Systems: The concepts of invariant measure, Sinai-Ruelle-Bowen measures, ergodicity and mixing, Lyapunov exponents, and the dynamical (Kolmogorov-Sinai) entropy, and connecting them to the fractal dimension of invariant sets, and to the escape rate from a chaotic repeller. (6 hours)

**Text books :**


1. H.G. Solari, M.A. Natiello and G.B. Mindlin, **Nonlinear Dynamics: a two-way trip from Physics to Maths**, Overseas publication, 2019.
2. Jordan, D. W., and P. Smith., **Nonlinear Ordinary Differential Equations**, Oxford University Press 2007


**References:**


1. K. Allgood, T.Sauer, J.A.Yorke, **Chaos: An Introduction to Dynamical systems**, Springer Verlag 1998.
2. Ian Stewart, **Does God Play a Dice? The Mathematics of Chaos**, Blackwell.
3. Laksmanan M Rajsekhar, **Nonlinear Dynamics Integrability Chaos and Pattern**, Springer.
4. F.C. Moon, **Chaotic and Fractal Dynamics**, Wiley
5. M W Hirsch, S Smale, R L Devaney, **Differential Equations, Dynamical Systems, and an Introduction to Chaos**
6. Anatole Katok et Boris Hasselblatt, **Introduction to the modern theory of dynamical systems**, Cambridge University Press, 1995
7. Peter Walters, **An introduction to ergodic theory**, Springer, 1982


## 15.39 MA 565: Numerical Methods in Quantitative Finance

**Course Code: MA 565**
**Course Name: Numerical Methods in Quantitative Finance**

L-T-P-C: 3-0-0-3
Prerequisites: IC 110: Engineering Mathematics, IC 111: Linear Algebra

Students intended for: UG/PG
Elective or Core: Elective
Approval: 8th Senate

**Course contents**

- **THE CONTINUOUS THEORY OF PARTIAL DIFFERENTIAL EQUATIONS** [8 Lectures]

  An Introduction to Ordinary Differential Equations, An Introduction to Partial Differential Equations, Second–Order Parabolic Differential Equations, An Introduction to the Heat Equation in One Dimension, An Introduction to the Method of Characteristics.

- **FINITE DIFFERENCE METHODS: THE FUNDAMENTALS** [8 Lectures]

  An Introduction to the Finite Difference Method, An Introduction to the Method of Lines, General Theory of the Finite Difference Method, Finite Difference Schemes for First Order Partial Differential Equations, FDM for the One Dimensional Convection Diffusion Equation, Exponentially Fitted Finite Difference Schemes.

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- **APPLYING FDM TO ONE FACTOR INSTRUMENT PRICING** [8 Lectures]

  Exact Solutions and Explicit Finite Difference Method for One Factor Models, Exponentially Fitted Difference Schemes for Barrier Options, Advanced Issues in Barrier and Lookback Option Modelling.

- **FDM FOR MULTIDIMENSIONAL PROBLEMS** [8 Lectures]

  Finite Difference Schemes for Multidimensional Problems, Operator Splitting Methods: Fractional Steps, ADI Methods.

- **APPLYING FDM TO MULTI FACTOR INSTRUMENT PRICING** [10 Lectures]

  Options with Stochastic Volatility: The Heston Model, Finite Difference Methods for Asian Options and Other 'Mixed' Problems.

**Text Books:**

1. Daniel J. Duffy, **Finite Difference Methods in Financial Engineering: A Partial Differential Equation Approach**, John Wiley & Sons Ltd., 2006.

2. D. Tavella and C. Randall, **Pricing Financial Instruments: The Finite Difference Method**, Wiley.

**Reference Books:**

1. Paolo Brandimarte, **Numerical Methods in Finance and Economics: A MATLAB Based Introduction**, 2nd Edition, John Wiley & Sons, 2006.

2. John A. D. Appleby, David C. Edelman, John J. H. Miller, **Numerical Methods for Finance**, Taylor & Francis, 2008.

3. Michele Breton, Haten Ben Ameur, **Numerical Methods in Finance**, Springer, 2005.

## 15.40 MA 568: Real Analysis

**Course Code: MA 568**
**Course Name: Real Analysis**

L-T-P-C: 2.5-0.5-0-3
Prerequisites: IC-110: Limit, Continuity, Differentiability
Students intended for: UG/MS/PhD
Elective or Core: Elective
Approval: 6th Senate

**Course contents**

- **The real number system** [7 Lectures]

  Sets, ordered sets, countable sets; Fields, ordered fields, least upper bounds, the real numbers, derivatives, the chain rule; Rolle's theorem, Mean Value Theorem.

- **Basic Topology** [6 Lectures]

  Metric spaces, neighborhoods, open subsets, limit points, closed subsets, dense subsets; complete metric spaces, connected metric spaces, Compact sets.

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- **Sequences and Series** [6 Lectures]

  Sequence, Subsequence, limits, lim sup and lim inf; Convergence. Continuity: Continuous maps between metric spaces; Intermediate value theorem, images of compact subsets; continuity of inverse maps.

- **Convergence** [9 Lectures]

  Pointwise convergence, Weierstrass criterion; continuity of uniform limits; application to power series; Spaces of functions as metric spaces, Sequence and series of functions: Uniform convergence, Uniform convergence and continuity, Equicontinuous families of functions, The Stome Weierstrass theoem.

- **Introduction to Lebesgue theory** [10 Lectures]

  Set functions, Construction of Lebesgue measure, Measure spaces, Measurable functions, Simple functions, Integration.

**Reference Books:**

1. Rudin, Walter, **Principles of Mathematical Analysis** (International Series in Pure and Applied Mathematics), 3rd Edition, McGraw-Hill, 1976.

2. Apostol, Tom M., **Mathematical Analysis**, 2nd Edition, Pearson Education, 1974.

## 15.41 MA 570 : Data-driven Dynamical Systems

**Course Code : MA 570**

**Course Name : Data-driven Dynamical Systems**

L-T-P-C : 2.5-0-0.5-3
Intended for : M.Sc. / BTech / MTech/ PhD (SMSS)
Prerequisite :
Mutual Exclusion :
Approval: 54th BoA

**Course Contents**

- Dimensionality reduction and transformations: Pseudo-inverse, least-squares, regression, singular value decomposition (SVD), principal component analysis (PCA), Discrete Fourier Transform, Fast Fourier Transform, Transforming Partial differential equations. (8 hours)

- Basics of machine learning: Basic definitions, Types of learning: Supervised learning and Unsupervised learning, Linear regression, Nonlinear Regression and Gradient Descent, Over and Under- Determined Systems, Least-Squares Fitting Methods, The Pareto Front, Model Selection: Cross-Validation, Model Selection: Information Criteria. (8 hours)

- Basics of neural networks: Perceptron, single-layer neural networks, multilayer neural networks and Activation Functions, Backpropagation, Neural networks for Dynamical Systems – Recurrent Neural Networks, Genenerative Adversarial Networks (GANs). (8 hours)

- Data Driven Dynamical Systems: Overview, motivations, and challenges, Dynamic mode decomposition (DMD), Sparse identification of nonlinear dynamics (SINDy), Koopman operator theory, Data-driven Koopman analysis, Model Reduction and System Identification. (11 hours)

**Lab Components:**

Singular value decomposition (SVD), principal component analysis (PCA), Linear regression, Least-Squares Fitting Methods, Single-layer linear neural network, neural networks for dynamical systems, DMD, Sparse identification of nonlinear dynamics and their variants. (7 hours)

**Textbooks:**


1. Strang, Gilbert, **Linear algebra and learning from data**, Vol. 4, Wellesley-Cambridge Press, 2019.

2. C.M. Bishop, **Pattern Recognition and Machine Learning**, Springer, 2006.

3. Ian Goodfellow, Yoshua Bengio and Aaron Courville, **Deep learning**, MIT Press, 2016.

4. Vega, J.M. and Le Clainche, S., **Higher Order Dynamic Mode Decomposition and its Applications**, Academic Press, 2020.

**References:**

1. Tom Mitchell, **Machine Learning**, Mc-Graw Hills, 1997.
2. Mauroy, A., Susuki, Y. and Meizic., **Koopman Operator in Systems and Control**, Springer, 2020

## 15.42 MA 575 : Complex Analysis

**Course Code : MA 575**

**Course Name : Complex Analysis**

L-P-T-C: 3-1-0-4
Intended for: M.Sc./M.Tech./PhD/B.Tech
Prerequisites: None
Mutual Exclusion: None
Approval : 57th BoA

**Course Contents**

- **Module 1**: Complex numbers and the point at infinity, Polar representation, logarithmic and trigonometric functions, Analytic functions, Cauchy-Riemann conditions, Power series, Harmonic conjugates, Mobius transformations, Mappings by elementary functions, Liouville's theorem and its applications, Conformal mappings. (14 Hours)
- **Module 2**: Index of a closed curve, Cauchy's theorem, Cauchy integral formula, Power series representation of analytic functions, Open mapping theorem, Goursat's theorem. Uniform convergence of sequences and series. Taylor and Laurent series. (12 Hours)
- **Module 3**: Isolated singularities and residues, Residue theorem and its application to evaluation of real integrals. Zeroes and poles, Maximum Modulus Principle and Schwarz's lemma, Meromorphic functions, Argument Principle, Rouche's theorem, (16 Hours)

**Laboratory:**

1. NA

**Text books:**

1. J.B. Conway, **Functions of One Complex Variable**, 2nd Edition, Narosa, New Delhi, 1978.
2. T.W. Gamelin, **Complex Analysis**, Springer International Edition, 2001.
3. J.W. Brown and R.V. Churchill, **Complex variables and applications**, 9th edition, McGraw Hill Higher Education.

**References:**


1. R. Remmert, **Theory of Complex Functions**, Springer Verlag, 1991.

2. A.R. Shastri, **An Introduction to Complex Analysis**, Macmilan India, New Delhi, 1999.

3. E.M. Stein and R. Shakarchi, **Complex analysis**, Princeton lecture series in analysis.

4. M.Thamban Nair, **Complex analysis online notes**, https://home.iitm.ac.in/mtnair/ca.pdf


## 15.43 MA 588 : MATHEMATICAL CONTROL THEORY

**Course Code : MA 588**

**Course Name : MATHEMATICAL CONTROL THEORY**

L-T-P-C : 3-1-0-4
Intended for : M.Sc. / BTech 3rd and 4rth years / MTech/ PhD (All Branches)
Prerequisite : MA511, M513 & MA521
Mutual Exclusion:
Approval: 56th BoA

**Course Contents**

- **Module I**: Solution of Uncontrolled Systems: - Spectral Form, Exponential Matrix, Repeated Roots, Solution of Controlled System – State Space, Control Space, Time Varying Systems, Discrete Time Systems. [8 Lectures]

- **Module II**: Linear Control System, State Transition Matrix, Properties of State Transition Matrix, Controllability, Kalman Matrix, Kalman Condition for Controllability, Controllability Matrix and Related Theorems. [10 Lectures]

- **Module III**: Semigroup of Linear Operators, Infinitesimal Generators, Strongly Continuous and Uniformly Continuous Semigroups, Properties of Semigroups, Hille-Yosida Theorem, Compactness and Differentiability of semigroups, Analytic Semigroup, Semigroup of Compact Operators, Abstract Differential Equations and Their Solutions. [12 Lectures]

- **Module VI**: Solution of Infinite Dimensional Control Systems, Controllability - Exact Controllability, Approximate Controllability, Null Controllability, Controllability Map, Controllability Grammian. Necessary and Sufficient Conditions for Exact and Approximate Controllability.

**Text Books:**


1. R. F. Curtain and Hans Zwart, **An Introduction to Infinite-Dimensional Linear System Theory**, Springer, 1995.

2. S. Barnett, **Introduction to Mathematical Control Theory**, Clarendon Press, 1985.

**Reference Books:**

1. A. Pazy, **Semigroup of Linear operators and Applications to Partial Differential Equations**, Springer Verlag, 1983
2. D. E. Kirk, **Optimal Control Theory**, Dover Publications, 2004.
3. W. L. Brogan, **Modern Control Theory, Third Edition**, Prentice Hall, 1991.

## 15.44 MA 600 : Research Methodology

**Course Code : MA 600**

**Course Name : Research Methodology**

L-P-T-C: 1-0-0-1
Intended for: M.Sc/Ph.D.
Prerequisites: None
Mutual Exclusion: RM of other schools
Approval : 57th BoA

**Course Contents**

- **Module 1: Introduction to research** (2 Lectures)
  - Defining research: Characteristics and objectives
  - Research and the scientific method
  - Various research methodologies:
    - Descriptive vs. Analytical research
    - Applied vs. Fundamental research o Quantitative vs. Qualitative research
    - Conceptual vs. Empirical research
  - The research process:
    - Formulating and defining a research problem
    - Developing research questions
    - Differentiating between research methods and research methodology
- **Module 2: Literature review and hypothesis development** (1 Lectures)
  - Conducting a literature review: o Reviewing concepts and theories and finding the research gaps.
  - Hypothesis development:
    - Identifying sources and characteristics of hypotheses
    - Understanding the role of hypotheses in research o Methods for testing hypotheses
- **Module 3: Research communication** (2 Lectures)
  - Writing and structuring research papers
  - Preparing and delivering research presentations

  - Crafting abstracts and summaries
  - Group discussion
  - Fear of rejection

- **Module 4: Research ethics** (2 Lectures)
  - Informed consent and ethical considerations
  - Maintaining confidentiality and privacy
  - Avoiding plagiarism and ensuring proper attribution
  - Ethical data use and management
  - Collaboration and ethical practices in joint research

- **Module 5: LaTeX for academic writing** (2 Lectures)
  - Introduction to LaTeX: Basic commands and structure
  - Writing mathematical equations and symbols
  - Organizing documents with sections, tables, and figures
  - Creating bibliographies and managing citations
  - Customizing document formats for research publications

- **Module 6: Technical writing and research documentation** (3 Lectures)
  - Writing research articles
  - Structuring and writing research projects
  - Writing theses and dissertations
  - Authoring books and writing reviews (e.g., book reviews, case reviews)
  - Understanding the criteria for high quality research

- **Module 7: Citation methods and research integrity** (2 Lectures)
  - Citation Techniques:
    * Footnotes, endnotes, and in-text citations
    * Compiling and formatting bibliographies
  - Ethical considerations in research and citation
  - Proper application of citation rules and guideline

**Laboratory:**

1. NA

**Text books:**

1. Wayne Goddard, Stuart Melville, **Research Methodology: An Introduction**, Juta and Co. Ltd., 2007.

2. Stefan Kottwitz, **LaTeX Beginner's Guide**, Second Edition, Packt Publishing Ltd., 2011.

**References:**

1. R. Barker Bausell, **Advanced Research Methodology**, Scarecrow Press, 2013.

2. Bill Taylor, Gautam Sinha, Taposh Ghoshal, **Research Methodology: A Guide for Researchers in Management and Social Sciences**, Prentice-Hall of India Private Limited, 2006.

3. Stefan Kottwitz, **LaTeX Graphics with TikZ: A practitioner's guide to drawing 2D and 3D images, diagrams, charts, and plots**, Packt Publishing Ltd. 2023.

## 15.45 MA 601: Real and Functional Analysis

**Course Code: MA 601**
**Course Name: Real and Functional Analysis**

L-T-P-C: 2-1-0-3
Prerequisites: Basic Analysis
Students intended for: Masters/Pre. Ph.D
Elective or Core: Elective
Approval: 1st Senate

**Course contents**

- **Metric spaces** [ Lectures]

  Open sets, Closed sets, Continuous functions, Completeness, Cantor intersection theorem, Baire category theorem, Compactness, Totally boundedness, finite intersection property. Definition and existence of Riemann-Stieitjes integral, Properties of the integral, Differentiation and integration. Uniform convergence, Uniform convergence and continuity, Uniform convergence and integration, Uniform convergence and differentiation.

- **Normed linear spaces** [ Lectures]

  Normed linear spaces, Riesz lemma, characterization of finite dimensional spaces, Banach spaces. Bounded linear maps on normed linear spaces: Examples, linear map on finite dimensional spaces, finite dimensional spaces are isomorphic, operator norm. Hahn-Banach theorems. Uniform boundedness principle, closed graph theorem, open mapping theorem, inner product spaces, orthonormal set, Gram-Schmidt orthonormalization orthonormal basis, orthonormal complements.

**Text Books:**

1. J. Conway, **A Course in Functional Analysis**, 2nd Edition, Springer.

2. W. Rudin, **Principles of Mathematical Analysis**, McGraw-Hill, 1986.

3. N. L. Carother, **Real Analysis**, Cambridge University Press, 2000.

**Reference Books:**

1. E.T. Copson, **Metric Spaces**, Cambridge University Press, 1968.
2. Claude W. Burril, John R. Knudsen, **Real Variables**, Holt, 1969. t, Reinhart and Winston
3. Tom M. Apostol, **Mathematical Analysis**, Addison Wesley, 1974.
4. BLiamlmitoehda, (n1 V9.9 L6i)m aye, **Functional Analysis**, 1st Edition, New Age International

## 15.46 MA 603: Advanced Partial Differential Equations

**Course Code: MA 603**
**Course Name: Advanced Partial Differential Equations**

L-T-P-C: 3-0-0-3
Prerequisites: MA 522 Partial Differential Equation
Students intended for: M.Sc./B.Tech/M.S./M.Tech/Ph.D.
Elective or Core: Elective
Approval: 22nd Senate

**Course contents**

- **Green's Function** [4 Lectures]

  Green's functions, Green's functions and applications for Laplace, Poisson and Helmholtz equations Green's functions and applications for the heat equation Green's functions and applications for the wave equation.

- **Non Linear First Order PDE** [6 Lectures]

  Complete Integrals and New Solutions from Envelopes, Local Solution and Application. Equations that convert into linear PDE; some exactly solvable cases; Burgers' equation; dimensional analysis and similarity; travelling waves; nonlinear diffusion and dispersion. Introduction of Hamilton Jacobi Equations, Calculus of Variations, Hamilton's O.D.E., Boundary Conditions, Local Solutions and Applications.

- **Module III** [3 Lectures]

  Asymptotics, Singular perturbations, Turing Instability for Reaction Diffusion System, Laplace's Method, Homogenization, Power Series, Non Characteristic Surfaces, Real analytic Functions, Cauchy Kovalevskaya Theorem.

- **Sobolev Spaces** [12 Lectures]

  Introduction to Hilbert Spaces of Functions, Holder Spaces, Sobolev spaces; Definitions and Elementary Properties. Weak solution, Uniqueness and Properties of Weak derivatives. Definition & Properties of Sobolev Spaces, Inequalities, Compactness.Extensions,Sobolev

- **Second Order Elliptic Equations** [8 Lectures]

  Weak Solutions of Elliptic Equation, Existence of weak solutions, Regularity, Maximum Principles, Eigen values & Eigen Functions of symmetric elliptic operators.

- **Reaction Diffusion System** [9 Lectures]

  Weak Solution of Diffusion Equation, Green's Function of Diffusion Equation, Formulation of Reaction Diffusion models and extensions to Include Chemotaxis terms; Application of Reaction Diffusion Systems to Population Dynamics, Pattern and Wave Phenomenon in the Life Sciences, Semi-arid vegetation and wound healing as Prototype Examples

**Text Books:**

1. Evans, Lawrence C., **Partial Differential Equations**, Graduate Studies in Mathematics, vol. 19. Providence, RI: American Mathematical Society, 2010.
2. Brezis, H. And H. Brezis., **Functional Analysis, Sobolev Spaces and Partial Differential Equations**, Springer, 2011.

**Reference Books:**

1. Debnath, Lokenath, **Nonlinear partial differential equations for scientists and engineers**, Springer Science & Business Media, 2011.
2. DiBenedetto, Emmanuele. **Partial Differential Equations**, Birkhauser, 1995.
3. Garabedian, Paul, **Partial Differential Equations**, Providence, RI: AMS Chelsea, 1998.
4. E. Kreyszig, **Advanced Engineering Mathematics**, Wiley, 2011.

## 15.47 MA 604 (3) Introduction To Game Theory

Approval: 5th Senate

**Course Outline:**

Introduction to game theory, routing games and mechanism design; Strategies, costs, and payoffs; Prisoner's dilemma, Nash Equilibrium, Strategic games; Best response; Dominant strategies; Pure strategy v/s Mixed strategy Repeated games; Bayesian games Routing games; Selfish routing; Quantifying inefficiency of equilibria; Price of Anarchy; Social optimum; Price of stability; Scheduling games Population games; Evolutionary game theory; Evolutionary stable strategy; Replicator dynamics Non-cooperative games; Cooperative game theory; Nash bargaining Mechanism design, Algorithmic mechanism design, Distributed algorithmic mechanism design

## 15.48 MA 605: Statistical Data Analysis

**Course Code: MA 605**
**Course Name: Statistical Data Analysis**

L-T-P-C: 2-1-0-3
Prerequisites: MA 202 for undergraduate
Students intended for: MS/ Ph.D., Undergraduate (3rd and 4th year)
Elective or Core: Elective

Approval: 10th Senate

**Course contents**

- **Exploratory analysis of time series** [4 Lectures]

  Introduction, examples, simple descriptive techniques, trend, seasonality, stochastic and deterministic approaches; numerical and experimental data sets; challenges in data analysis and data graphical representation, interpretation; statistical tests, significance and power of a test, choice of the critical region, constructing test statistics: the Fisher discriminant, mean and variance test, testing goodness-of-fit, chi2-test, p-values; stationary time series process (ARMA Processes).

- **Analysis of stochastic series** [12 Lectures]

  Model identification and non-stationary time series models; forecasting with classical regression models; Forecasting with autocorrelations; Forecasting with lagged dependent variable; Forecast error statistics and evaluation; singularity detection, spectral density function, the periodogram, spectral analysis, correlogram, wavelet cross-correlation, multi-resolution analysis, examples and applications.

- **Clustering data techniques** [6 Lectures]

  Principal component analysis; different techniques of data clustering

**Text Books:**


1. Peck and Devore, **Statistics: The Exploration and Analysis of Data**, 7th Edition, Thomson-Brooks/Cole, 2012.

2. Montgomery, D., Jennings, C.L. and Kulahci, M., **Introduction to Time Series Analysis and Forecasting, Hoboken**, Wiley-Interscience, 2008.

3. Chatfield, C., **The Analysis of Time Series**, 6th Edition Chapman & Hall/CRC, 2004.


**Reference Books:**


1. Petre Stoica and Randolph L. Moses, **Introduction to Spectral Analysis**, Prentice Hall, 1997.

2. Robert H. Shumway and David S. Stoffer, **Time Series Analysis and Its Applications with R Examples**, 3rd edition, Springer Texts in Statistics, 2006.

3. Raghuveer M. Rao and Ajit S. Bopardikar, **Wavelet Transform**, Pearson Education, 1998.


## 15.49 MA 607: Numerical Analysis

**Course Code: MA 607**
**Course Name: Numerical Analysis**

L-T-P-C: 2-0-2-3

Prerequisites: Basic Knowledge in FORTRAN/C/C++/Matlab/Scilab
Students intended for: M.A./Ph.D., B.Tech. 3rd and 4th year students.
Elective or Core: Elective
Approval: 2nd Senate

**Course contents**

- Approximate Numbers and Significant Digits, Propagation of errors, Different types of errors, Backward error analysis, Sensitivity and conditioning, Stability and accuracy.
- Nonlinear equations, Bisection method, Newton's method and its variants, Fixed point iterations, Convergence analysis.
- Finite differences, Polynomial interpolation, Hermite interpolation, Spline interpolation. Numerical integration, Trapezoidal and Simpson's rules, Newton-Cotes formula, Gaussian quadrature.
- **Initial Value Problem (IVP)**: Taylor series method, Euler and modified Euler methods, Runge-Kutta methods, Multistep methods, Predictor-Corrector method.
- **Boundary Value Problem (BVP)**: Solution of Boundary Value Problem by Finite Difference Method.

**Text Books:**

1. K. E. Atkinson, **An Introduction to Numerical Analysis**, 2nd Edition, John Wiley, 2008.
2. S. D. Conte and Carl de Boor, **Elementary Numerical Analysis** McGraw Hill, 1988.

**Reference Books:**

1. M. T. Heath, **Scientific Computing: An Introductory Survey**, McGraw Hill, 2002.
2. A. Ralston and P. Rabinowitz, **A First Course in Numerical Analysis**, Dover Publications, 2001.

## 15.50 MA 608: Computational Fluid Dynamics

**Course Code: MA 608**
**Course Name: Computational Fluid Dynamics**

L-T-P-C: 3-0-0-3
Prerequisites: Basic knowledge in Fluid Mechanics
Students intended for: MS/ Ph.D. and UG
Elective or Core: Elective
Approval: 2nd Senate

**Course contents**

- **Introduction**

  Historical Perspective, Comparisons of experimental, Theoretical and Numerical approaches. Different numerical Approaches. [4 lectures]

- **Governing Equations**

  Classification of Partial Differential Equations, Physical Classification, Mathematical Classification, Well-posed problems, Navier-Stokes System of equations. [6 lectures]

- **Finite Difference Methods**

  Derivation of Finite Difference Equations, Simple Methods, General Methods, Multidimensional Formulas, Accuracy of Finite Difference solutions. [6 lectures]

- **Solution Methods of Finite Difference Equations**

  Elliptic Equations, Parabolic Equations, Hyperbolic Equation, Example Problems, Stability, Convergence and Consistency of the Solution methods. [14 lectures]

- **Application of Finite Difference Methods to the Equations of Fluid Mechanics**

  Numerical Methods for Inviscid Flow Equations, Numerical Methods for Boundary-Layer Type Equations. [9 lectures]

- **Introduction to Finite Volume Methods**

  Basic Formulations, SIMPLE algorithm. [4 lectures]

**Text and Reference Books:**

1. D. A. Anderson, J. C. Tannehill, and R. H. Pletcher, **Computational Fluid Mechanics and Heat Transfer**, 2nd Edition, Taylor & Francis, 1997.

2. J. D. Anderson Jr, **Computational Fluid Dynamics**, McGraw-Hill International Edition, 1995.

3. S. V. Patankar, **Numerical Heat Transfer and Fluid Flow**, Hemisphere, 2000.

4. T. J. Chung, **Computational Fluid Dynamics**, 2nd Edition, Cambridge University Press, 2010. item P. Niyogi, S. K. Chakrabartty, M. K. Laha, **Introduction to Computational Fluid Dynamics**, Pearson Publications, 2011.

## 15.51 MA 609: Numerics of Partial Differential Equations

**Course Code: MA 609**
**Course Name: Numerics of Partial Differential Equations**

L-T-P-C: 3-0-0-3
Prerequisites: MA 607 (Numerical Analysis); Knowledge in Differential Equatio n
Students intended for: M.S./Ph.D, B.Tech. 3rd and 4th year students
Elective or Core: Elective
Approval: 4th Senate

**Course contents**

- **Introduction to Finite difference schemes** [5 lectures]

  Finite difference schemes for partial differential equations, explicitschemes, implicit schemes, single step schemes, multi-step schemes.

- **Finite difference schemes for boundary value problems** [10 lectures]

  FTCS, backward Euler and Crank-Nicolson schemes, ADI methods, Lax Wendroff method, upwind scheme.

- **Consistency, stability and convergence Analysis** [10 lectures]

  Stability analysis by von Neumann method, CFL condition, Lax's equivalence theorem.

- **Introduction to Finite element method** [7 lectures]

  Finite element method for partial differential equations, variational methods, method of weighted residuals.

- **Finite element discretization and error analysis** [10 lectures]

  Finite element discretizations for one-dimensional and two-dimensional elliptic equations, a priori and a posteriori error estimates.

**Text Books:**


1. G. D. Smith, **Numerical Solutions to Partial Differential Equations**, 3rd Edition, Oxford University Press, 1986.

2. C. Johnson, **Numerical Solution of Partial Differential Equations by the Finite Element Method**, Dover Publications, 2009.


**Reference Books:**


1. J. C. Strikwerda, **Finite Difference Schemes and Partial Differential Equations**, SIAM, 2004.

2. E. Suli, **Finite Element Methods for Partial Differential Equations**, University of Oxford, 2000.

3. P. Niyogi, S. K. Chakrabartty, M. K. Laha, **Introduction to Computational Fluid Dynamics**, Pearson Publications, 2011.

4. J. N. Reddy, **An Introduction to Finite Element Method**, 3rd Edition, McGraw Hill, 2005.


## 15.52 MA 610 : Mathematical Modeling

Course Name : MA 610
Course number : Mathematical Modeling
Credit Distribution : 3-0-0-3
Intended for : Elective for M.Sc./ MTech/PhD/BTech (All Branches)
Prerequisite : IC 110, IC 111 for BTech, Ordinary Differential Equations for M.Sc./MTech/PhD
Mutual Exclusion : NA

**Course Contents:**

- **Introduction:** Aim and history, A few simple examples, what is a model, The process of mathematical modeling, Model classification (4 hours)
- **Optimization models:** One variable optimization, some additional materials on population, Multi variable optimization, Computational methods for optimization, some materials on simplex method, Discrete Models - World population growth data snooping, Linear models, Logistic models, Theorems on stability (7 hours)
- **Probability models:** Introduction, Discrete probability models, Continuous probability models, Models for population, Introduction of Population models: Malthus model, Population growth: Logistic model, Harvesting, Population of interacting species: Lotka-Volterra systems (some additional materials), Age-dependent population models. (7 hours)
- **Applications of mathematical modeling:** Mainly mathematical models to study and understand phenomena in chemistry, biology , engineering, political sciences, business and in social sciences. (6 Hours)
- **Laboratory/practical/tutorial Modules:** Individual final project: During the last two weeks of the semester, each student will carry out a project investigating a new mathematical model or carrying out a significant extension of an existing mathematical model discussed in class (6 Hours)

**Textbooks:**

1. F. R. Giordano, W. P. Fox, S. B. Horton and M. D. Weir, **A First Course in Mathematical Modeling**, 4th Edition, Brooks/Cole Publishing Company, 2009.
2. **Mathematical Modelling: A Tool for Problem Solving in Engineering, Physical, Biological and Social Sciences**, Pergamon 1990.

**References:**

1. D.N.P. Murthy and N.W. Page and E.Y. Rodin, **Mathematical modeling: a tool for problem solving in engineering, physical, biological, and social sciences**, Pergamon Press, 1990.
2. Dick Clements, **Mathematical modeling: a case study approach**, Cambridge University Press, 1989.
3. T.P. Dreyer, **Modeling with Ordinary Differential Equations**, CRC Press, 1993.
4. Clive L. Dyne, **Principles of Mathematical Modelling**, Academic Press, 2004.
5. M. M. Meerschaert, **Mathematical Modeling**, 2nd Edition, Academic Press, 1998

## 15.53 MA 611: Statistical tools and Computing

Course number : MA 611

Course Name : Statistical tools and Computing

Credit Distribution : 3-1-0-4

Intended for : M.Sc. /M.S./PhD/ B.Tech. 3rd and 4th year

Prerequisite : MA-524 (Probability and Statistics) or any course on probability and statistics (like Data Science II) in consultation with the instructor.

Mutual Exclusion : HS550

**Course Contents:**

- **Concepts from probability and statistics:** Data (sample vs. Population, histograms, sample mean, median, variance, standard deviation); Probability (axioms, basic rules; and conditional probability); Random variables (discrete vs. Continuous); Review of probability distributions. Some advanced probability distributions: their properties and simulations; Confidence intervals and their significance. (8 Hours)
- **Times series methods:** Collection and classification of data; Different types of diagrams to represent statistical data; Frequency distribution and related graphs and charts; Linear and non-linear models. (6 hour)
- **Regression, classification and multivariate analysis:** Simple regression; Multiple regression; Logistic regression; Generalized linear models; Cross validation; Multicollinearity; Model selection; Prediction and variable selection; Bayesian logistic regression; Principal component analysis; Factors analysis; Discriminant and Classification analysis. (13 Hours)
- **Parametric and Nonparametric tests:** Parametric: Parametric tests are used only where a normal distribution is assumed. The most widely used tests are the t-test (paired or unpaired); ANOVA (one-way non-repeated, repeated), and Pearson rank correlation.
- **Nonparametric:** Non-parametric tests are used when continuous data are not normally distributed or when dealing with discrete variables. Most widely tests used are Chi-squared; Fisher's exact tests; Wilcoxon's matched pairs; Mann–Whitney U-tests; Kruskal–Wallis tests and Spearman rank correlation; Bayesian inference; Kernel Density Estimation. (15 Hours)
- **Laboratory/practical/tutorial Modules:** The labs, using programming languages like R/Python/any other, will take place over a two-hour period in alternate weeks. It will run concurrently with the theory course, thus the subjects for the lab will have previously been established in the theory session.

**Text books:**


1. James, Witten, Hastie and Tibshirani, **An Introduction to Statistical Learning, with Applications in R**, 2nd edition, Springer, 2021.
2. David D. Hanagal, **Introduction to Applied Statistics: A non-Calculus Based Approach**, Narosa, 2009.

**References:**


1. David Lane, **Introduction to Statistics**, Rice University, David Lane, 2003.
2. Jay Devore, Roxy Peck, Chris Olsen, **Introduction to Statistics and Data Analysis**, 3rd Edition, Wadsworth Publishing, 2008.
3. Peter K. Dunn, Gordon K. Smyth, **Generalized linear models with examples in R**, Springer, 2018.


## 15.54 MA 612: Operator Theory

**Course Code: MA 612**
**Course Name: Operator Theory**

L-T-P-C: 3-1-0-4
Prerequisites: MA 521 (Functional Analysis)
Students intended for: M.Sc./B.Tech/M.S./M.Tech/Ph.D.
Elective or Core: Elective
Approval: 23rd Senate

**Course contents**

- **Elementary Spectral Theory** [18 lectures]

  Banach Algebras, Examples of Banach Algebra, Spectrum and the Spectral Radius, Neumann Series, The Fundamental Theorem of Banach Algebra by Gelfand, Gelfand-Mazur Theorem, The Beurling Theorem for Spectral Radius, The Gelfand Representation, Compact and Fredholm Operators, Integral Operators, Kernels of the Integral Operators, Volterra Integral Operator, Transpose of the Bounded Linear Maps between Banach Spaces, Bounded Below Linear Maps between Banach Spaces, Ascent and Descent, Index of Bounded Linear Maps between Banach Spaces, The Fundamental Result of Fredholm Theory, Fredholm Alternative, Characterization of Fredholm Operators, Essential Spectrum in terms of Fredholm.

- **C*-Algebras and Hilbert Space Operators** [18 lectures]

  Involution on an Algebra, *-Algebra, *-Algebra Generated by a Subset of *-Algebra, *-homomorphism between *-Algberas, Banach *-Algebras, Unital Banach *-Algebras, C*-Algebras, Examples of C*-Algberas, Double Centralizer for a C*-Algebra, Multiplier Algebra, Complete Characterization of Abelian C*-Algebras using the Gelfand Representation, Spectral Mapping Theorem, Positive Elements of C*-Algebras, Operators and Sesquilinear Forms, Adjoint and its properties, Orthogonal Projections, Invariant Subspaces, Reducing Subspaces, Partial Isometries and their Characterizations, Polar Decomposition, Compact Hilbert Space Operators, Diagonalizable Operators, Diagonalizability of Compact Normal Operators on Hilbert Spaces, denseness of the set of finite-rank operators, Hilbert-Schmidt Operators, Trace-Class Operators, The Spectral Theorem for Normal Operators.

- **Gelfand–Naimark Theorem** [6 lectures]

  Ideals in C*-algebras, Positive Linear Functionals, Gelfand-Naimark-Segal Represenatation.

**Text Books:**

1. Gerard J. Murphy, **C*-algebras and Operator Theory**, Academic Press, 2014.
2. Ronald G. Douglas, **Banach Algebra Techniques in Operator Theory**, Volume 179 of Graduate Texts in Mathematics, Springer, 2012.

**Reference Books:**

1. Kenneth R. Davidson, **C*-algebras by Example**, American Mathematical Society, 1996.
2. Kehe Zhu, **An Introduction to Operator Algebras**, Volume 9 of Studies in Advanced Mathematics, CRC Press, 2018.
3. John B. Conway, **A Course in Operator Theory**, American Mathematical Society, 2000.

## 15.55 MA 621: Modeling Population Dynamics

**Course Code: MA 621**
**Course Name: Modeling Population Dynamics**

L-T-P-C: 3-0-0-3
Prerequisites: MA 513 Ordinary Differential
Students intended for: M.Sc./B.Tech/M.S./M.Tech/Ph.D.
Elective or Core: Elective
Approval: 22nd Senate

**Course contents**

- **Introduction** [2 Lectures]

  Modeling Nature: History and General philosophy of the modeling approach. The demand for Reliable Prediction and Latest Development in Mathematical Modeling. Advantages and Demerits of Mathematical Modeling while Dealing with Real world's Problems

- **Unstructured Population Models** [8 lectures]

  Population Dynamics from the first principle, Single-Species Models with Exponential and Logistic growth, Self Limitation, Consumer Resource Oscillation. Application of theory of Difference Equations to Population Growth models. Introduction to Discrete- time Models. Linear Models, Growth Models, Harvest Models: Bifurcation and Breakpoints. Delayed Differential models, Exogenous Drivers.

- **Introduction to Continuous Models** [10 lectures]

  Models for Single Species Populations: Malthus Model, Logistic Growth, Allee Effect. Predator-Prey System and the Lotka-Volterra Equations, Populations in Competition, Multiple-Species Communities and the Routh-Hurwitz Criteria, Qualitative Stability Types of Models: Continuous-time, Discrete-time, Delayed Differential models, Exogenous Drivers.

- **Age and Stage-Structured Models In Ecology** [6 lectures]

  Discrete Time Models with Age and Stage classes, Leslie Matrices, Estimating the Transition Matrix From Empirical Data, fisheries and Insect Populations as Prototype Example.

- **Population Interactions** [8 lectures]

  Functional response, Aggregative response, Numerical Response, Competetion Models, Mutualism Models, Lotka Volterra Model, Anatomy of Predator Prey Cycle, Grazing systems, pathogens and parasites, Tritrophic Models.

- **Empirical Approaches** [8 lectures]

  Analysis of Population fluctuations, Time Series Analysis, Fitting Models to Data, Fitting Mechanistic Models

**Text Books:**


1. Larry L. Rockwood, **Introduction to Population Ecology**, 2nd Edition, Blackwell Publishing Limited, 2015.


**Reference Books:**


1. Richard Haberman, **Mathematical Models**, 5th edition, SIAM, 2013.

2. Leah Edelstein Keshet, **Mathematical Models in Biology**, SIAM, 2005

3. Peter Turchin, **Complex Population Dynamics: A Theoretical Empirical Synthesis**, Princeton University Press, 2003.

4. Jo Smith and Pete Smith, **Environmental Modelling: An Introduction**, Oxford University Press, 2007.

5. Mark Kot, **Elements Of Mathematical Ecology**, 1st Edition, Cambridge University Press,2001.


## 15.56 MA 641: Operations Research

**Course Code: MA 641**
**Course Name: Operations Research**

L-T-P-C: 3-0-0-3
Prerequisites: None
Students intended for: Ph.D./ M.S./B.Tech
Elective or Core: Elective
Approval: 2nd Senate

**Course contents**

- **Module I** [10 Lectures]

  Introduction to Operations Research, Models and Modelling in Operations Research, Graphical Method, Simplex Method and its variants.

- **Module II** [12 lectures]

  Sensitivity Analysis, Duality and Post-Optimal Analysis, Advanced Linear Programming: Bounded Variables, Parametric Linear Programming, Revised Simplex Algorithm, Goal Programming, Dual Simplex Method, Integer Linear Programming.

- **Module III** [12 lectures]

  Transportation Model and its Variants: Balanced and Unbalanced Transportation Problem, Transhipment, Assignment Problem: Auction and Hungarian Method, unbalanced assignment problem. Sequencing Problem and Variants: Algorithms for processing n-jobs through m-machines.Traveling Salesman Problem, Heuristics and Branch and Bound and Gomory's Algorithms.

- **Module IV** [6 lectures]

  Project Evaluation and Review Technique, Critical Path Method.

**Text and Reference Books:**

1. Saul I. Gass, **Linear Programming: Methods and Applications**, Dover publications, 2010.

2. Hamdy A. Taha, **Operations Research: An Introduction**, Pearson Education, 2008.

3. Don T. Phillips, A. Ravindran, James J. Solberg, **Operations Research: Principles and Practice**, John Wiley & Sons, 1987.

4. George Bernard Dantzig, **Linear Programming: Theory and extensions**, Princeton University Press, 1998.

5. G. Hadley, **Linear Programming**, Addison-Wesley, 1962.

6. Michael W. Carter, Camille C. Price, Camille C. Price, **Operations Research**, CRC Press, 2000.

7. Frederick S. Hillier, Gerald J. Lieberman, **Introduction to operations research**, McGraw-Hill, 2001.

## 15.57 MA 644: Dynamical Systems

**Course Code: MA 644**
**Course Name: Dynamical Systems**

L-T-P-C: 3-0-0-3
Prerequisites: None
Students intended for: Ph.D./ M.S./B.Tech
Elective or Core: Elective
Approval: 1st Senate

**Course contents**

Dynamical systems- Central manifold and Normal form, Plane Autonomous Systems, Attractors, Map-1D map, Logistic map, Poincare' maps, generalized Baker's map, circle map, Bifurcations-. Necessary Condition for bifurcation, Saddle node bifurcations, Transcritical Bifurcation, Pitchfork Bifurcation, Normal. forms of. different types of bifurcations, Reduction to Normal Form, Hopf bifurcation,Strange attractors, Henoh map and Rossler system, Box-counting, pointwise and correlation, Hausdorff dimensions, Lyapunov exponent, chaotic transitions, intermittency, crisis.

**Text Books:**

1. Guckenheimer, J., and P. Holmes, **Nonlinear Oscillations, Dynamical Systems and Bifurcations of Vector Fields**, Springer-Verlag, 2002.

**Reference Books:**

1. Drazin, P. G., **Nonlinear systems**, Cambridge University Press, 1992.
2. Peitgen, H. O., H. Jurgens, and D. Saupe. **Chaos and Fractals: New Frontiers of Science**, Springer, 2004.
3. Jordan, D. W., and P. Smith, **Nonlinear Ordinary Differential Equations**, Oxford University Press, 1999.
4. Berge, P., Y. Pomeau, and C. Vidal. **Order Within Chaos**, Wiley.

## 15.58 MA 650: Mathematical Models for Infectious Diseases

**Course Code: MA 650**
**Course Name: Mathematical Models for Infectious Diseases**

L-T-P-C: 3-0-0-3
Prerequisites: None
Students intended for: P.G. students
Elective or Core: Elective
Approval: 2nd Senate

**Course contents**

Over the last two decades, mathematical models have seen a huge development in all aspects of infectious diseases, from microbiology to epidemiology and evolution. The programme covers introductory and advanced concepts in mathematical modelling of infectious diseases, including:

- Mathematical review (calculus, probabilities...)
- Deterministic and stochastic models
- Network analysis
- Within-host dynamics of viral and bacterial infections

- Applied programming with R
- Statistical data modelling
- Computer-based simulations

**Text and Reference Books:**

1. O. Diekmann, and J. A. P. Heesterbeek, **Mathematical Epidemiology of Infectious Diseases: Model Building, Analysis and Interpretation**, Wiley Series in Mathematical & Computational Biology, 2000.

2. D. J. Daley and, J. Gani, **Epidemic Modelling: An Introduction**, Cambridge Studies in Mathematical Biology, 2001.

## 15.59 MA 651: Optimization Techniques

**Course Code: MA 651**
**Course Name: Optimization Techniques**

L-T-P-C: 3-0-0-3
Prerequisites: None
Students intended for: Ph.D./ M.S./B.Tech
Elective or Core: Elective
Approval: 2nd Senate

**Course contents**

- **Module I** [6 Lectures]

  Convex sets and function, Introduction to optimization, Model formulation, Simplex based techniques, Concept of duality.

- **Module II** [10 lectures]

  Quadratic Programming Problem, Geometric Programming, Separable Programming.

- **Module III** [12 lectures]

  Direct and Gradient based search techniques for single and multi variable unconstrained optimization problems.

- **Module IV** [6 lectures]

  Penalty and barrier function based techniques for constrained optimization problems.

- **Module V** [6 lectures]

  Evolutionary Optimization Techniques, Engineering application of Optimization techniques.

**Text and Reference Books:**

1. Mokhtar S. Bazaaraa, Hanif D. Shirali and M.C.Shetty, **Nonlinear Programming, Theory and Algorithms**, John Wiley & Sons, 2004.

2. S. S. Rao, **Engineering Optimization: Theory and Practice**, 4th Edition, John Wiley & Sons, 2009.

3. Kwang Y. Lee, Mohamed A. El-Sharkawi, **Modern heuristic optimization techniques: theory and applications**, Kluwer, 2008.

4. Hamdy A. Taha, **Operations Research: An Introduction**, 8th Edition, Pearson Education, 2008.

5. G. V. Reklaitis, A. Ravindran, K. M. Ragsdell, **Engineering Optimization: Methods and Applications**, Wiley, 2006.

6. Michael C. Bartholomew-Biggs, **Nonlinear optimization with engineering applications**, Springer, 2008.

## 15.60 MA 652 Stability Theory of Differential Equations

**Course Code: MA 652**

**Course name: Stability Theory of Differential Equations**

Credits: 3-0-0-3
Prerequisite: Basic calculus, Linear algebra
Intended for: MS/PhD
Approval: 8th Senate; OTA

**Preamble:**

This course covers the advance theory of ordinary differential equations. It is designed to be taught to Master and Doctoral level students. This course tries to demonstrate to the students to build advance theory of differential equations.

**Course Outline:**

This course is about stability of solutions of differential equations. This is an advance level course which requires basic knowledge of linear algebra and calculus. This course starts with fundamental matrix system. The main aim of this course is to introduce students the advance theory of ordinary differential equations.

**Course Modules:**

- General solution, singular solution. [2 Lectures]
- Linear autonomous and nonautonomous systems,Fundamental matrix [10 Lectures]
- Floqpet theory, Phase plane analysis,Stability and Lyapunov functions [15 Lectures]
- Limit sets,Periodicity a.nd almost periodicity,Bifurcation and Chaos [15 Lectures]

**Text books:**

1. T. A. Burton, **Stability & Periodic Solutions of Ordinary & Functional Differential Equations**, Dover publication.

2. Earl E Coddington, **Theory of Ordinary Differential Equations**, Krieger Publishing Company, 1984.

**Reference books:**

1. Lawrence Perko, **Differential Equations and Dynamical Systems**, 3rd Edition, Springer, 2001.

## 15.61 MA 653: Computational Financial Modelling

**Course Code: MA 653**
**Course Name: Computational Financial Modelling**

L-T-P-C: 2-1-0-3
Prerequisites: Knowledge of at least one of C/C++/MATLAB/R/Spreadsheets Packages, Basic knowledge of Probability, Statistics and Linear Programming.
Students intended for: Ph.D./ M.S./B.Tech
Elective or Core: Elective
Approval: 2nd Senate

**Course contents**

- **Module I** [7 Lectures]

  Markowitz Theory, Securities Portfolio Selection Model in Crisp and Fuzzy Environment

- **Module II** [8 Lectures]

  Time series models, Multivariate Volatility Models and Their Applications. Principal Component Analysis.

- **Module III** [7 Lectures]

  Dow Theory, Introduction to stock analysis using different types of chart, Technical Analysis of financial markets and stock trends, Analysis of chart patterns.

- **Module IV** [8 Lectures]

  Index and stock tracking using soft computing techniques.

**Text Books:**

1. Yong Fang, Kin Lai, Kin Keung Lai, Shouyang Wang, **Fuzzy Portfolio Optimization**, Lecture Notes in Economics & Mathematical Systems, Volume 609, Springer, 2008.

2. John J. Murphy, **Technical Analysis of the Financial Markets**, Prentice Hall Press, Jan 1999.

3. Harry M. Markowitz, Markowitz, **Portfolio Selection: Efficient Diversification of Investments**, 2nd Edition, John Wiley & Sons, 1991.

**Reference Books:**

1. Manfred Gilli, Dietmar Maringer, Enrico Schumann, **Numerical Methods and Optimization in Finance**, Elsevier, 2011.

2. Jack D. Schwager, **Technical Analysis**, Wiley, 1995.

3. Luc Bauwens, Christian M. Hafner, Sebastien Laurent, **Handbook of Volatility Models and Their Applications**, John Wiley & Sons, 2012.

4. Mokhtar S. Bazaaraa, Hanif D. Shirali and M.C.Shetty, **Nonlinear Programming, Theory and Algorithms**, John Wiley & Sons, 2004.

5. **Business News Channels and websites** (Like CNBC Awaz, Zee Business, Bloomberg, `moneycontrol.com`, `yahoofinance.com` etc.)

## 15.62 MA 653P: Computational Financial Modelling Lab

**Course Code: MA 653P**
**Course Name: Computational Financial Modelling Lab**

L-T-P-C: 0-0-2-1
Prerequisites: MA 653 Computational Financial Modelling should be taken concurrently or earlier. Some programming knowledge in C/MATLAB/R/Spread sheets Packages.
Students intended for: 3rd and 4th Year B. Tech / PG
Elective or Core: Core for M.Sc. in applied Mathematics and Elective for other discipline
Approval: 8th Senate

**Course Outline**

- **Module I**

  Introduction to R statistical software. [2 Lectures]

- **Module II**

  Classical Markowitz portfolio model, portfolio under higher order moments and fuzzy portfolio models in R. [3 Lectures]

- **Module III**

  Financial Time series anal ysis, stochastic volatility models and non parametric time series and technical analysis using R. [5 Lectures]

  Factor Models, Regression, classification and clustering analysis of financial data in R. [2 Lectures]

- **Module IV**

**Text Books:**

1. Tsay, Ruey S., **Analysis of financial time series**, Vol. 543. John Wiley & Sons, 2005.

2. Wurtz, Diethelm, Yohan Chalabi, William Chen, and Andrew Ellis, **Portfolio optimization with R/Rmetrics**, Rmetrics, 2009.

3. Sheather, Simon, **A modern approach to regression with R**, Vol. 58. Springer, 2009.

4. Pfaff, Bernhard, **Financial risk modelling and portfolio optimization with R**, John Wiley & Sons, 2012.

## 15.63 MA 654: Financial Engineering

**Course Code: MA 654**
**Course Name: Financial Engineering**

L-T-P-C: 2-1-0-3
Prerequisites: Good knowledge of multivariable calculus, probability, statistics and random process and at least one of C/C++/MATLAB/R/Spread sheets Packages.
Students intended for: Ph.D./ M.S./B.Tech
Elective or Core: Elective
Approval: 2nd Senate

**Course contents**

- **Module I**

  Some Basic Definitions and Terminology. [2 Lectures]

- **Module II**

  Forward and Future contracts, Definition and pricing, dividends and transaction costs. [3 Lectures]

- **Module III**

  Efficient Market Hypothesis, Discrete and continuous random variable, Concept of Arbitrage, Duality theorem in LP and Fundamental theorem. [3 Lectures]

- **Module IV**

  Asset Price Moment, Introduction to Option Markets, Options Valuations, Basic Option Theory, The Binomial Model, Black-Scholes Model and solution, Time dependency and change of variable, The Greeks and their properties. [10 Lectures]

- **Module V**

  Bullish, Bearish and Neutral options strategies. [6 Lectures]

- **Module VI**

  General principle of Hedging, Different types of Hedging, Delta Hedging, Delta Neutral Portfolio, Gamma Neutral PortFolio. [6 Lectures]

**Text Books:**

1. J.C. Hull, Options, **Futures and Other Derivatives**, 7th Edition, Prentice Hall of India, 2006.

2. M. Capinski and T. Zastawniak, **Mathematics for Finance: An Introduction to Financial Engineering**, Springer, 2005.

3. S. Roman, **Introduction to the Mathematics of Finance: From Risk Management to Options Pricing**, Springer, 2004.

**Reference Books:**

1. N. H. Bingham and R. Kiesel, **Risk Neutral Valuation**, 2nd Edition, Springer, 2004.

2. Simon Benninga, **Financial Modeling**, 3rd edition, MIT Press, 2008.

3. Ralf Korn, ElkeKorn, **Option Pricing and Portfolio Optimization**, American Mathematical Society, 2000.

## 15.64 MA 655: Fixed Income Securities

**Course Code: MA 655**
**Course Name: Fixed Income Securities**

L-T-P-C: 2-1-0-3
Prerequisites: Knowledge of multivariable calculus, probability, statistics and stochastic process, differential equations and financial derivatives. Some knowledge of MATLAB/R/Spread sheets Packages.
Students intended for: M.S./Ph.D.
Elective or Core: Elective
Approval: 6th Senate

**Course contents**

- **Introduction**

  Basic concepts of fixed income instruments and their analysis, bond prices and yield curves, duration and convexity, empirical methods to find yield curve. [2 Lectures]

- **Pricing Theory and Models**

  Asset pricing theory and related topics such as arbitrage, risk-neutral probability measures, martingale measures, hedging, intermediate dividends, complete and incomplete market etc., Factor models Single factor and multi factor diffusion model and their calibration, HW, BDT, and HJM models etc. [16 Lectures]

- **Credit derivatives and risk Management**

  Market models, interest rate risk management, defaultable bonds and credit derivatives, mortgages and mortgage-backed Securities. [10 Lectures]

**Text Books:**

1. Darrell Duffie, Kenneth J. Singleton, **Credit Risk**, Princeton University Press, 2003.
2. Sundaresan S., **Fixed Income Markets and Their Derivatives**, Academic Press, 3rd Ed., 2009.
3. Tuckman B. and Angel Serrat., **Fixed Income Securities**, John Wiley and Sons, 2011.

**Reference Books:**

1. Brigo D. and F. Mercurio, **Interest Rate Models: Theory and Practice**, 2nd Edition, Springer Finance, 2006.
2. F. J. Fabozzi, **The Handbook of Fixed Income Securities**, McGraw-Hill, 2005.
3. Jarrow R., **Modeling Fixed Income Securities and Interest Rate Options**, McGraw-Hill, 1996.
4. Paul Wilmott, **Paul Wilmott on Quantitative Finance**, John Wiley & Sons, 2000.

## 15.65 MA 656: Stochastic Calculus for Financial Engineering

**Course Code: MA 656**
**Course Name: Stochastic Calculus for Financial Engineering**

L-T-P-C: 2-1-0-3
Prerequisites: Good knowledge of multivariable calculus, probability, statistics and stochastic process. Some knowledge of MATLAB/R/Spread sheets Packages.
Students intended for: M.S./Ph.D.
Elective or Core: Elective
Approval: 6th Senate

**Course contents**

- **Module I**

  Definitions and introduction to Financial instruments and derivatives, no arbitrage principle, risk-neutral probability measure. [6 Lectures]

- **Module II**

  Give 1-2 lectures on Stochastic process, distribution functions, (again because students may need to recall it for building comfort level), Random walk, Brownian and Geometric Brownian Motion, Lévy's construction. Reflection principle, hitting times, scaling properties. Theory of Martingales, filtrations, adapted processes, Optional Sampling Theorem. [7 Lectures]

- **Module III**

  Quadratic variation and Brownian motion, Itô integral, properties of stochastic integral, Representation Theorem, Lévy's characterisation of Brownian motion, Girsanov's Theorem, Feymann Kac Theorem, Ito's Formula . [8 Lectures]

- **Module IV**

  Self-financing strategies, martingale measures, risk-neutral pricing. Applications of Stochastic Calculus in Option Pricing. Black-Scholes Model and Pricing Formula, European options, Risk management strategies for options. [7 Lectures]

**Text Books:**


1. D Duffie, **Dynamic Asset Pricing Theor**,. Princeton 1996.

2. G Grimmett & D Stirzaker, **Probability and Random processes**, Oxford 1982.

3. Thomas Mikosch, **Elementary Stochastic Calculus with Finance in view**, World Scientific, 2006.

4. S. E. Shreve, **Stochastic Calculus for Finance**, Vol. I & Vol. II, Springer, 2004.


**Reference Books:**


1. Ralf Korn, ElkeKorn, **Option Pricing and Portfolio Optimization**, American Mathematical Society, 2000.

2. M. Capinski and T. Zastawniak, **Mathematics for Finance: An Introduction to Financial Engineering**, Springer, 2005.

3. N. H. Bingham and R. Kiesel, **Risk Neutral Valuation**, 2nd Edition, Springer, 2004.


## 15.66 MA 665(3) Semigroup Of Bounded Linear Operators

Approval: 5th senate; OTA

Course Outline:

Linear dynamical syétems (semigroup approach): Cauchy functional equation, finite dimensional system (matrix semigroups), uniformly continuous operator semigroups.

Semigroup generators and resolvents: Generator of semigroup and their resolvents, Hille Yosida generalization theorems, special classes of semigroups.

Spectral theory for semigroups and generators: Spectral theory for closed operators, spectrum of semigroups and generators.

Semigroups for population equations.

## 15.67 MA 704: Dynamical System

**Course Code: MA 704**
**Course Name: Dynamical System**

L-T-P-C: 3-0-0-3

Prerequisites: Knowledge of Functional Analysis, Ordinary and Partial Differential Equations, Linear Algebra
Students intended for: M.S./Ph.D.
Elective or Core: Elective
Approval: 2nd Senate

**Course contents**

- **Linear Systems**

  Diagonalization, Exponentials of Operators, Fundamental theorem for linear systems, Jordan Forms, Stability Theory, Nonhomogeneous linear systems. [10 Lectures]

- **Local Theory of Nonlinear Systems**

  Existence Uniqueness Theorem, Maximal Interval of Existence, Flow, Stable Manifold Theorem, Hartman-Grobman Theorem, Lyapunov Functions, Nonhyperbolic Fixed Points, Centre Manifold Theorem, Normal Form Theory, Gradient and Hamiltonian Systems. [15 Lectures]

- **Global Theory of Nonlinear Systems**

  Global Existence Theorem, Periodic Orbits, Limit Cycles and Separatrix cycles, Poincare Map, Stable Manifold Theorem for Periodic Orbits, Poincare-Bendixson theory, Lienard Systems, Bendixson's criteria, Poincare Sphere and Behaviour at Infinity, Global Phase Potraits and Separatrix Configurations, Index Theory. [15 Lectures]

**Text Books:**

1. A.A. Andronov, E.A. Leontovich, I.I. Gordon, and A.G.Maier, **Qualitative Theory of Second Order Dynamical Systems**, John Wiley.
2. V.V. Nemytskii and V.V.Stepanov, **Qualitative Theory of Differential Equations**, Princeton University Press.

**Reference Books:**

1. S.Lefschetz, **Differential Equations: Geometric Theory**, Interscience.
2. J.Palais and W. De Melo, **Geometric Theory of Dynamical Systems**, Springer Verlag.

## 15.68 MA 709: Numerical Linear Algebra

**Course Code: MA 709**
**Course Name: Numerical Linear Algebra**

L-T-P-C: 2-0-2-3
Prerequisites: MA-607 or equivalent, MA-609 or equivalent and IC-111 or equivalent.
Students intended for: M.S./Ph.D.
Elective or Core: Elective
Approval: 5th Senate

**Course contents**

- **Fundamentals**

  Overview of matrix computations, norms of vectors and matrices, stability and ill-conditioning, Condition number of a matrix and its applications. [6 Lectures including Lab]

- **Systems of Linear Equations**

  Gaussian eliminations with and without Pivoting, Gauss-Seidel, Successive-over-relaxation methods, LU factorization, Cholesky factorization, stability and sensitivity analysis. [9 Lectures including Lab]

- **Eigen value Problem**

  Properties of the eigen decomposition, Power's Method, The LR and QR algorithms, Rayleigh quotient iteration, inverse iteration. [10 Lectures including Lab]

- **Eigen values of Symmetric Matrices**

  Orthogonal Matrices, Jacobi Method, Givens Method, Gram-Schmidt Process, Householder Method. [9 Lectures including Lab]

- **Singular Value Decomposition**

  roperties of the singular value decomposition, Methods for the singular value decomposition. [8 Lectures including Lab]

**Lab Class**

Each week the lab class will flow the corresponding lecture classes of that week. [2 hours]

**Text Books:**


1. David S. Watkins, **Fundamentals of Matrix Computations**, 2nd Edition, John Wiley & Sons, 2002.

2. L. N. Trefethen and David Bau, **Numerical Linear Algebra**, SIAM, 1997.

3. C. T. Kelly, **Iterative Methods for Linear and Nonlinear Equations**, SIAM, Philadelphia, 1995.


**Reference Books:**


1. G. H. Golub and C.F.Van Loan, **Matrix Computation**, 3rd Edition, Hindustan book agency, 2007.

2. B. N. Datta, **Numerical Linear Algebra and Applications**, 2nd Edition, SIAM, 2010.

3. O. Axelsson, **Iterative Solution Methods**, Cambridge University Press, 1994.

4. D. J. Higham and N.J. Higham, **Matlab Guide, SIAM**, (recommended as a Matlab reference).

## 15.69 MA 765: Fractional Differential Equations

**Course Code: MA 765**
**Course Name: Fractional Differential Equations**

L-T-P-C: 4-0-0-4
Prerequisites: Real and Functional Analysis
Students intended for: Ph.D.
Elective or Core: Elective
Approval: 2nd Senate

**Course contents**

- **Basic Theory of fractional differential equations**

  Definition of fractional derivative, Riemann Liouvile, Caputo derivatives, Existence and uniqueness of solutions, dependence of solutions on initial conditions, General order fractional differential equations.

**Text and Reference Books:**

1. Diethlem, K., **The Analysis of Fractional Differential Equations**, Springer, 2010.
2. Podlubny, I., **Fractional Differential Equations**, Academic press, 1999.
3. Dumitru Baleanu, José António Tenreiro Machado, Albert C. J. Luo, **Fractional Dynamics and Control**, Springer, 2012.
4. Vasily E. Tarasov, **Fractional Dynamics**,Springer, 2010.

## 15.70 MA 780: Topics on Semigroup Theory

**Course Code: MA 780**
**Course Name: Topics on Semigroup Theory**

L-T-P-C: 3-0-0-3
Prerequisites: Real Analysis
Students intended for: PG
Elective or Core: Elective
Approval: 4th Senate

**Course contents**

- **Linear dynamical systems (semigroup approach)**

  Cauchy functional equation, finite dimensional system (matrix semigroups), uniformly continuous operator semigroups. [10 Lectures]

- **Semigroup generators and resolvents**

  Generator of semigroup and their resolvents, Hille Yosida generalization theorems, special classes of semigroups. [15 Lectures]

- **Spectral theory for semigroups and generators**

  Spectral theory for closed operators, spectrum of semigroups and generators. [10 Lectures

- **Semigroups for population equations**. [7 Lectures]

**Text Books:**


1. V. Arnold, **Ordinary differential equations**, 1973.

2. Engel and Nagel, **One-Parameter Semigroups for Linear Evolution Equations**, Springer, 1999.


**Reference Books:**


1. Pazy, **Semigroups of linear operators and applications to partial differential equations**, springer, 1983.

2. S. Kesavan, **Nonlinear functional analysis**, Hindustan, 2004.

# 16 MBA Courses

## 16.1 MB 201 : Foundations of Business Management

**Course Code : MB 201**

**Course Name : Foundations of Business Management**

L-T-P-C : 3-0-1-4
Intended for : IMBA
Prerequisite :
Mutual Exclusion : Organizational Management HS304 offered by SHSS
Approval: 54th BoA

**Course Contents**

- **Introduction to Management**: Defining work, workplace, managers, management, corporation, firm, organization, etc. Theories of management, history of management, and Managerial Decision Making. (8 Hours)
- **Pedagogies of Management**: Case-studies, Simulations, Role plays, Projects etc. (8 Hours)
- **Contemporary Management**: Influence of external environment, Managing in global environment, Managing Diversity, Managing Change and Disruptive innovation, Managing Social responsibility and Ethics. (5 Hours)
- **Functions of Management: Planning:** Foundations of Planning, Managing Strategy, Entrepreneurial Ventures. (5 Hours)
- **Functions of Management**: Designing Organizational Structure, Managing Human Resources, Managing Groups and Teams. (5 Hours)
- **Functions of Management: Leading**: Managing Communication, Understanding and Managing Individual Behavior, Motivating Employees, Being effective leaders (5 Hours)
- **Mobile Marketing**: Mobile Inventory/channels, Location based; Context based; Coupons and offers, Mobile Apps, Mobile Commerce, SMS Campaigns. Profiling and targeting. (3 Hours)
- **Functions of Management**: Significance of Controlling, Contemporary Issues in Controlling, Tools for Measuring Organizational Performance, Forecasting, Techniques for resource allocation; Budgeting, Scheduling, Breakeven Analysis, Linear Programming. Project Management and Operations Management. (6 Hours)

**Laboratory/practical/tutorial Modules: 12 Hours.**

- Practical: Project work on Company Analysis. The students groups will identify a company in a given industry and analyze their environment, planning, organizing, leading, and controlling functions. At the end of the course they have to submit a report and present their findings and recommendations.

**Book Reviews:**

1. Ken Blanchard: One Minute Manager book series.

**Textbooks:**

1. Stephens P. Robbins, Mary Coulter., **Management**, Latest Edition, Pearson Education.

**References:**

1. Koontz H. Weihrich H., **Essentials of Management**, McGraw Hill.
2. Daft Richard L., **Management**, Thomson South Western.

## 16.2 MB 202 : Microeconomics

**Course Code : MB 202**

**Course Name : Microeconomics**

L-T-P-C : 3-0-0-3
Intended for : IMBA
Prerequisite :
Mutual Exclusion : Organizational Management HS304 offered by SHSS
Approval: 54th BoA

**Course Contents**

- **Unit 1:** Nature and scope of Economics —— Demand and supply schedule —— Law of demand and supply —— Elasticity of demand and supply- price, income and cross price elasticity —— Market forces-price determination and effect of change of market conditions. (8 Hours)
- **Unit 2**: Theory of consumer behaviour: Utility; cardinal and ordinal utility analysis —— Consumer's equilibrium-single and multiple commodity case —— Indifference curve: types and properties —— Price effect: Hicks and Slutsky methods —— Derivation of the demand curve. (8 Hours)
- **Unit 3**: Production function —— Law of variable proportions —— Returns to scale —— Isoquants —— Factor substitution —— Ridge lines —— Internal and external economies and diseconomies —— General notes on cost function —— Theory of cost: Short-run cost analysis, long-run cost analysis Iso cost —— Least cost combination —— Concept of revenue: total, average, and marginal revenue —— Revenue and elasticity —— Break-even analysis. (10 Hours)
- **Unit 4**: Introduction to market —— Perfect and pure competition: assumption —— Short-run equilibrium: firm equilibrium in the short-run, supply curve of the firm and industry, short-run industry equilibrium —— Long-run equilibrium: firm equilibrium in the long-run, industry equilibrium in the long-run, optimal resource allocation. (8 Hours)

- **Unit 5**: Monopoly: definition, demand, cost and revenue —— Equilibrium of the monopolist: shortrun equilibrium and long-run equilibrium —— Comparison of pure competition and monopoly —— Price discrimination —— Monopolistic competition —— Oligopoly: non-collusive oligopoly and collusive oligopoly. (8 Hours)

**Textbooks:**


1. Pindyck, **Microeconomics**, Pearson Publisher.
2. Koutsoyiannis A., **Modern Microeconomics**, Macmillan Publishers.


**References:**


1. NA


## 16.3 MB 509 : Introduction to Bhagavad Gita

**Course Code : MB 509**

**Course Name : Introduction to Bhagavad Gita**

L-T-P-C : 2-0-0-2
Intended for : B.Tech. 2nd, 3rd year students
Prerequisite : MBA
Mutual Exclusion:
Approval: 55th BoA

**Course Contents**

- **Unit/Topic 1**: Bhagavad Gita: The timeless science (2 Hours)
- **Unit/Topic 2**: Krishna: As He is (2 Hours)
- **Unit/Topic 3**: Description of atomic soul (3 Hours)
- **Unit/Topic 4**: Matter and consciousness (3 Hours)
- **Unit/Topic 5**: Yoga systems (2 Hours)
- **Unit/Topic 6**: Transcendental knowledge (2 Hours)
- **Unit/Topic 7**: Mindfulness from Bhagavad Gita (3 Hours)
- **Unit/Topic 8**: The topmost yoga system (2 Hours)
- **Unit/Topic 9**: Modes of material nature and professional excellence (3 hours)
- **Unit/Topic 10**: Perfection of renunciation (2 hours)

**Textbooks:**


1. Prabhupada, ACBS, **Bhagavad Gita: As it is**, Bhaktivedanta Book Trust, Mumbai, 1972

2. Das, L. P., **Five Aspects of the Absolute Truth - a Bhagavad Gita Study Guide**, India, 2022


**References:**


1. Chatterjee, D., **Timeless leadership: 18 leadership sutras from the Bhagavad Gita**, John Wiley & Sons, 2012.

2. Nayak, A. K., **Effective leadership traits from Bhagavad Gita**, International Journal of Indian Culture and Business Management, 16(1), 1-18, 2018.

3. Krishnan, R., Jain, R., & Maheshwari, A. K., **Development of Consciousness-Based Leadership from Bhagavad Gita and Yoga Sutras**, In Consciousness-Based Leadership and Management, Volume 2: Organizational and Cultural Approaches to Oneness and Flourishing (pp. 97-113). Cham: Springer International Publishing, 2023.


## 16.4 MB 510: Probability and Statistics for Data Science and AI

Course Number : MB510
Course Name : Probability and Statistics for Data Science and AI
Credits : 2-0-0-2 (L-T-P-C)
Prerequisites : None
Intended for : MBA
Distribution : Compulsory
Approval: 50th BoA

**Course Contents:**

- **Introduction:** Uncertainty and probability, Probability and its types, Conditional, joint and marginal probability, Problem classification with emphasis on random problems, Probability and statistics concepts for DSAI. (4)

- **Random Variables and Probability Distributions:** Describing Randomness, Random Variables and Probability Distributions- Continuous and Discrete Distributions, Normal distribution, lognormal distribution and Power-Law Distributions, Bernoulli distributions. (4)

- **Statistics:** Collections of Random Values-Expected Value, variance and standard deviation, Independent and Identically Distributed Variables, law of large numbers, central limit theorem. (4)

- **Sampling:** Sampling and Replacement-Selection with Replacement, Selection Without Replacement, Bootstrapping. (4)

- **Bivariate Statistics:** Covariance and Correlation-Pearson and Spearman. (4)
- **Baye's Rule:** Frequentist vs. Bayesian Probability, Bays Rule and Confusion Matrices, Repeating Bayes' Rule, Multiple Hypothesis. (4)
- **Information Theory**: Entropy, Measuring uncertainty, information, and surprise, Maximal entropy distribution, Cross Entropy, KL Divergence (4)

**Textbooks:**

1. Nil

**Reference Books:**

1. Thomas Nield, **Essential Math for Data Science: Take Control of Your Data with Fundamental Linear Algebra, Probability, and Statistics**, Shroff Publishers & Distributors Pvt. Ltd., Mumbai, 2022
2. Trevor Hastie, Robert Tibshirani, Jerome Friedman, **The Elements of Statistical Learning: Data Mining, Inference, And Prediction**, 2nd Edition, Springer, 2017.
3. Anirban Das Gupta, **Probability for Statistics and Machine Learning: Fundamentals and Advanced Topics**, Springer, 2011.
4. Marc Peter Deisenroth, A. Aldo Faisal, and Cheng Soon Ong, **Mathematics for Machine Learning**, Cambridge University Press (https://mml-book.com)
5. Scott E. Page, **The Model Thinker: What You Need to Know to Make Data Work for You**, Basic Books, 2018.
6. MS Excel 2019, **Data Analysis & Business Modeling**, Wayne Winston, Microsoft Press (PHI), 2020.

## 16.5 MB 511: Python Programming

Course Number : MB511
Course Name : Python Programming
Credits : 2-0-0-2 (L-T-P-C)
Prerequisites : Preferably having sound knowledge in programming
Intended for : MBA
Distribution : Compulsory
Approval: 50th BoA

**Course Contents:**

- **Basics of Programming:** This module presents a primer on the building blocks of a program and how to logically sequence the components to perform a complex task. The following topics will be covered: (5 hours)
  - Introduction to Programming

- Variables, Statements and Conditional Execution
  - Functions
  - Iterations

- **Data Structures**: This module introduces the fundamental data structures in Python and Panda. This module helps the students to learn "How should data be stored in a particular business setting and what are the trade-offs involved?". The following topics will be covered: (8 hours)
  - Strings and Files
  - Lists and Dictionaries
  - Pandas DataFrame Basics
  - Pandas Data Structure

- **Basic Analysis**: This module introduces the basic techniques in Pandas for plotting, assembling, and handling missing data. The following topics will be covered: (8 hours)
  - Introduction to Plotting
  - Data Assembly
  - Missing Data

- **Data Munging**: Data munging, also known as data wrangling, is the process of transforming raw data into another format with the intent of making it more appropriate for analysis. It is one of the very important steps in data analysis. The following topics will be covered: (7 hours)
  - Tidy Data and Data Types
  - Text Data
  - Pandas Apply and Group-by Operations

- **Lab Exercises** (If applicable): Lab to be conducted on a 2-hour slot. It will be conducted in tandem with the theory course so the topics for problems given in the lab are already initiated in the theory class. The topics taught in the theory course should appropriately be sequenced for synchronization with the laboratory.

**Textbooks:**

1. Charles R. Severance, **Python for Everybody: Exploring Data in Python 3**, Amazon Digital Services, 2016.

2. Daniel Y. Chen, **Pandas for Everyone: Python Data Analysis**, Pearson Education, 2018.

**Reference Book:**

1. Michael Dawson, **Python Programming for the Absolute Beginners**, Cengage, 2020.

## 16.6 MB 512: Mathematical Foundations for DS and AI

Course Number : MB512
Course Name : Mathematical Foundations for DS and AI
Credits : 2-0-0-2 (L-T-P-C)
Prerequisites : None
Intended for : MBA
Distribution : Compulsory
Approval: 50th BoA

**Course Contents:**

- **Introduction:** Why mathematics for machine learning and artificial intelligence, concepts of models; constants, parameters and variables; mathematical models, simple and deterministic models. (2 hours)

- **Linear Algebra:** Linear equations and solutions, Scalars and Vectors, vector arithmetic and operations, orthogonality; Linear Independence, basis vectors; Matrices, basic matrix arithmetic and operations, rank of a matrix, matrix types, sparse matrix, matrix factorization, soft introduction to concepts of Tensors; Concepts of linearity and nonlinearity, linear Mappings, Vector and matrix norms; Eigenvectors and eigenvalues, singular value decomposition (SVD). (8 hours)

- **Calculus:** Limits and Functions, nature of Functions, univariate and multivariate functions, continuity of a function; basic functions like exponential, logarithmic, trigonometric, hyperbolic, modulus, greatest integer etc; squashing functions and activation functions; composite functions, Derivative, derivative of basic functions and activation functions, Chain rule, concepts of partial differentiation; Integrals, substitution rule, areas between curves. (6 hours)

- **Dimensions:** Concepts of dimensions-zero dimension to multiple dimensions, hyperspace, Euclidean space and dimensions, Euclidean distance between points, soft introduction to non-Euclidean space; vectors and matrices in dimensional space; Dimensions and analysis space; Business concepts and dimensions, mapping business problems into dimensional representation, multidimensional analysis. (4 hours)

- **Optimization:** Concepts of single and multiple attributes, objectives and criteria; Concepts of constraints and constraint satisfaction problems; Maximum and minimum of univariate and multivariate functions, Saddle Points, local and global optimum, concepts of linear and nonlinear optimization, constrained and unconstrained optimization, soft introduction to linear programming; search space, feasible and infeasible solution space, single agent and multi-agent search problems, search domain exploration and exploitation; Least squares method, Concept of gradient, gradient of vector valued functions, gradient of matrices; loss functions, gradient descent method. (8 hours)

**Textbooks:**

1. Nil

**Reference Book:**


1. Marc Peter Deisenroth, A. Aldo Faisal, and Cheng Soon Ong, **Mathematics for Machine Learning**, Cambridge University Press, 2020 (https://mml-book.com)

2. Thomas Nield, **Essential Math for Data Science: Take Control of Your Data with Fundamental Linear Algebra, Probability, and Statistics**, Shroff Publishers & Distributors Pvt. Ltd., Mumbai, 2022.

3. Charu C. Aggarwal, **Linear Algebra and Optimization for Machine Learning**, Springer Nature, 2020.

4. MS Excel 2019, **Data Analysis & Business Modeling**, Wayne Winston, Microsoft Press (PHI), 2020.


## 16.7 MB 513: Principles of Management

Course Number : MB 513
Course Name : Principles of Management
Credits : 2-2 (L-T-P-C)
Prerequisites : None
Intended for : MBA
Distribution : Compulsory
Approval: 50th BoA

**Course Contents:**

- **Introduction to Management:** Definition, Nature, Scope, Purpose, and characteristics, Functions, roles, skills of a Manager, Theories in management - Classical, Scientific, Systems, Contingency and operational. Management Vs Administration, Bureaucracy, Decision Making – Types, components, process and creative decision making. (6 Hours)

- **Planning and Forecasting:** Planning – Types, Process, MBO – Concept, Characteristics, process, benefits and limitations, Strategic management – Environment Scanning, Industry Analysis, Resource Based View, Forecasting – Nature, components, determinants, benefits, and techniques. (6 Hours)

- **Organising and Directing:** Organisational Design, types and structure, Organisational Hierarchical systems, formal and informal organisation, centralisation and decentralisation, span of control, authority and responsibility, delegation, culture and performance metrics. (4 Hours)

- **Staffing and Coordination:** HRM and HRD, Workforce Diversity, Coordination - Need, Importance, Principles, Process, Types, and Techniques, conflicts, conflict resolution, negotiations, communication in workplace. (6 Hours)

- **Leadership and Change:** Leadership - Concept, Nature, Importance, Attribute, and Style. Change – Concept, Nature, Importance, Causes. Learning Organisation. Ethics, CSR. (4 Hours)

**Textbooks:**

1. Stephen Robbins, and David Decenzo, **Fundamentals of Management**.
2. Harold Koontz, Odonnell and Heinz Welhrich, **Essentials of Management**.

**Reference Book:**

1. Richard Daft, **Principles of Management**.

## 16.8 MB 514: Communication Skills for Managers

Course Number : MB514
Course Name : Communication Skills for Managers
Credits : 2-0-0-2 (L-T-P-C)
Prerequisites : None
Intended for : MBA
Distribution : Compulsory
Approval: 50th BoA

**Course Contents:**

- **Best Practices for Effective Communication:** This Module introduces the basic concepts of effective communication. These will include foundations of organizational communication; communication barriers and ways to overcome them; speaking and listening skills; audience centric communication framework. The objective of this module is to introduce the concepts of effective communication to the students and equipping them with strategies to craft clear and concise messages. (6 hours)
- **Persuasion and Influence**: This Module introduces persuasive communication strategies to students. This will be an inter-disciplinary module, with theories from rhetoric, strategy and negotiation informing the content. Frameworks include the Aristotelean persuasive framework, Toulmin's Method of argumentation and storytelling strategies. The application of these theories will be illustrated through appropriate case studies. (6 hours)
- **Public Speaking and Presentation Skills**: The third Module will focus on effective presentation preparation and delivery. For preparing presentations, students will learn how to craft a perfect blend of data and narrative through design, structuring of content, using multimedia, and storytelling techniques. This module will also include aspects of effective non-verbal communication, managing questions, framing presentations, using gestures and postures, and public speaking skills. Students will be required to prepare and deliver group presentations as a part of this module. (8+4 hours)
- **Workshop on Interview Skills**: The final module of this course will equip students with communication skills and strategies for cracking interviews. This module will be delivered in workshop mode, with role-plays and feedback sessions with the students. Topics covered in this module include cross-cultural communication,

understanding industry narratives, techniques of articulation and frameworks for handling questions (4 hours)

**Textbooks:**

1. Bovee, Courtland L., John V. Thill and Roshan Lal Raina, **Business Communication Today**, 10th Edition, Pearson, India, 2018.

**Reference Book:**

1. Morgan, N., Cialdini, R. B., Review, H. B., Tannen, D., **HBR's 10 Must Reads on Communication** (with Featured Article The Necessary Art of Persuasion, by Jay A. Conger), Harvard Business Review Press, 2013.

Case Studies:

1. Super Bowl Storytelling (Shelle Santana, Jill Avery) Link: https://hbsp.harvard.edu/product/519 PDF-ENG?Ntt=super%20bowl

2. A Persuasion Strategy for Universita' Bocconi: An Exercise (Giovanni Gavetti) Link: https://hbsp.harvard.edu/product/711517-PDF-ENG?activeTab=include-materials&itemF copy

3. Managing Up (A): Grace (Karen MacMillan) Link: https://hbsp.harvard.edu/product/W15269-PDF-ENG?Ntt=managing%20up%20grace

## 16.9 MB 515 : Financial Statements Analysis

Course Number : MB515
Course Name : Financial Statements Analysis
Credits : 2-0-0-2 (L-T-P-C)
Prerequisites : None
Intended for : MBA
Distribution : Compulsory
Approval: 50th BoA

**Course Contents:**

- **Balance Sheet:** This module begins with brief introduction to the course, financial statements, and users of financial statements. The balance sheet module helps students in understanding the line items, accounting principles, construction, and analysis of balance sheet. At the end of this module, students should be able to understand the major sources of funds which are in the form of liabilities and equity and understand major application of funds which are in different forms of assets of a company reading its balance sheet. The students also should be able to make the balance sheet using double entry principle of accounting. (4 hours)

- **Statement of Profit and Loss:** This module helps students in understanding the line items, accounting principles, construction, and analysis of statement of profit and loss. At the end of this module, students should be able to understand major sources of revenue, major expenses, and various terms of profit such as profit-after-tax (PAT), earnings before interest and tax (EBIT), earnings before interest, tax, depreciation and amortization (EBITDA) of a company using its statement of profit and loss. The students also should be able to make the balance sheet and statement of profit and loss using double entry principle and accrual principle of accounting. (4 hours)

- **Accounting Records:** This module enables students in understanding preparation of major accounting records like journal book, ledger books and trail balance with/without adjustments. At the end of this module, students should get conversant with the accounting cycle and records. (2 hours)
- **Cash Flows Statement:** This module makes students to understand structure, importance, classification of cash flows and construction of cash flows statement. At the end of this module, students should be able to understand cash flows from operating, investing, and financing activities. (3 hours)
- **Measurement and analysis of Depreciation, Cost of Goods Sold (COGS) and Inventory:** This module enables students to understand different methods of depreciation and inventory valuation. Students should also understand implications of these methods of measurement on statement of profit and loss and balance sheet. (3 hours)
- **Techniques of Financial Statements Analysis:** This module makes students to understand application of common-size analysis, comparative analysis, and ratio analysis in analysis of balance sheet, statement of profit and loss and statement of cash flows. The financial statements analysis should be from credit analysis, investment analysis and forensic perspective. While analysing financial statements, students should be made to understand implications of major accounting policies related to measurement of assets, revenues and expenses in financial statements analysis. (8 hours)

**Textbooks:**


1. Anthony, Robert Newton, David F. Hawkins, and Kenneth A. Merchant, **Accounting, text and cases**, McGraw-Hill/Irwin, 1999.
2. Subramanyam K R, **Financial Statement Analysis**, McGraw Hill, 2021.


**Reference Books:**


1. Maher, Michael W., Clyde P. Stickney, and Roman L. Weil, **Managerial accounting: An introduction to concepts, methods and uses**, Rob Dewey, 2006.
2. White, Gerald I., Ashwinpaul C. Sondhi, and Dov Fried, **The analysis and use of financial statements**, John Wiley & Sons, 2002.
3. Penman, Stephen H., and Stephen H. Penman, **Financial statement analysis and security valuation**, McGraw-Hill/Irwin, 2010.
4. Graham, Benjamin and David Le Fevre Dodd, **Security analysis**, 6th Edition, McGraw-Hill, 1934.

## 16.10 MB 516: Managerial Economics

Course Number : MB 516
Course Name : Managerial Economics
Credits : 2-0-0-2 (L-T-P-C)
Prerequisites : None
Intended for : MBA
Distribution : Compulsory
Approval: 50th BoA

**Course Contents:**

- **Demand and Supply:** This module introduces Managerial Economics and the problem of scarcity. Thereafter the module discusses the demand and supply side, elasticity, consumer behaviour, marginal analysis. (8 hours)
- **Demand Estimation and Forecasting**: The module discusses Basic Estimation Techniques, Estimating Demand Curve, Econometric Models, Forecasting Demand and Interpretation. (4 hours)
- **Production and Cost**: Production and Cost in Short and Long Run. (3 hours)
- **Application of Production and Cost**: Break even Analysis, Production Function and Cost Estimation. (3 hours)
- **Markets**: Decision Making under Competitive Market, Market Analysis with Market Power Perfect Competition, Monopoly and Monopolistic Competitive Market: Market Structure, Profit Maximization, Output and Pricing Decisions. (6 hours)
- **Strategic Decision Making In Oligopoly Market**: Oligopoly Market Using Game Theory: Simultaneous Decisions, Prisoners' Dilemma, Sequential Games, First Mover and Second Mover Advantage. (4 hours)

Application Modules 2, 4 and 6 can be conducted as lab session of 2 hrs each.

**Textbooks:**


1. Dominick Salvatore and Siddhartha K. Rastogi, **Managerial Economics, Principles & Worldwide Applications**, 9th Edition, Oxford University Press 2020.
2. Thomas and Maurice, **Managerial Economics**, McGraw Hill, 2010.


**Reference Book:**


1. Robert S Pindyck, Daniel L Rubinfield and Prem L Mehta, **Microeconomics**, 7th Edition, Pearson 2009.
2. Paul G. Keat, Philip K Y Young, Stephen E Erfle and Sreejata Banarjee, **Managerial Economics: Economic Tools for Today's Decision Makers**, 7th Edition, Pearson, 2018

## 16.11 MB 517: Marketing Management

Course Number : MB517
Course Name : Marketing Management
Credits : 2-2 (L-T-P-C)
Prerequisites : None
Intended for : MBA
Distribution : Compulsory
Approval: 50th BoA

**Course Contents:**

- **Introduction to Marketing**: Meaning, Definition, Pillars of Marketing, Marketing Process, Marketing Environment. (4 Hours)
- **Marketing Planning**: Identification of Market, Segmentation – Meaning and purpose, Types of Segments, Targeting, Positioning, and Marketing Mix. (4 Hours)
- **Product and Price**: Product policy, Product classification, New Product Development, Diffusion of Innovation, Product Life Cycle, Brand, Branding, and Brand Equity.
- Pricing Policy, Types of pricing, Pricing Process. (6 Hours)
- **Promotion and Place**:Types of Promotion, Advertising, Sales Promotion, Publicity, WOM, IMC
- Channel Design, Channel conflicts, Wholesale, Retailing. (6 Hours)
- **Contemporary topics**: Services Marketing, International Marketing, Rural Marketing, Digital Marketing and Green Marketing. (4 Hours)

**Textbooks:**

1. Philip Kotler and Kevin Lane Keller, **Marketing Management**, latest edition.
2. Ramaswamy and Namakumari, **Marketing Management**, latest edition.

**Reference Book:**

1. **Marketing Management A An Applied Approach**

## 16.12 MB 518: Decision analysis

Course Number : MB518
Course Name : Decision analysis
Credits : 2-0-0-2 (L-T-P-C)
Prerequisites : None
Intended for : MBA
Distribution : Compulsory
Approval: 50th BoA

**Course Contents:**

- **Module 1:** This module would set the context for decision analysis course. It would discuss a few illustrative examples in details (Eg Bidding problem, Pricing decision, Investment decision, outsourcing decision, Decision under uncertainty). (3 hours)

- Module 2 **Mathematical/Formal representation of consequences:** This module introduces a formal need and ways to measure the consequence of a decision alternate. In specific context explore the use of Linear functions, Piecewise Linear function, Loss functions, Quadratic functions and their relevance, roots of a Quadratic equation, Breakeven Price, exponential and logarithmic functions, Sequences (Geometric and Arithmetic) and functions of many variables. (4 hours)

- Module 3 **Review of Probability (Rapid)**: Introduction to Probability and Random variables, Conditional probability, expected value, Summary measures, Fractiles, Measures of dispersion, Chebyshev's inequality, functions of random variables, Joint distribution of random variables, Covariance, Conditional expectations, Binominal, Poisson, and normal Distributions. (6 hours)

- Module 4 **Decision theory**: Method of sensitivity analysis, Method of breakeven analysis, Decision Problems under uncertainty, Decision trees, expected monetary value as a criterion, expected value of perfect information (EVPI), Structuring and solving sequential decision problem, case studies (2), sampling information, value of sample, optimal sample size to update prior probabilities. expected net gain in sampling, Case studies (2). Cash Equivalent, risk preference. (12 hours)

- **Module 5:** Loss functions and special structures (3 hours)

News boy problem and its variations

**Lab Exercises (If applicable): Not applicable**

Lab to be conducted on a 2-hour slot. It will be conducted in tandem with the theory course so the topics for problems given in the lab are already initiated in the theory class. The topics taught in the theory course should appropriately be sequenced for synchronization with the laboratory.

**Textbooks:**

1. VL Mote and T Madhavan, **Operations research**, Wiley Indian, 2016.

2. PG Moore and HM Thomas, **Anatomy of decisions**, Penguin Business, 1971

## 16.13 MB 519: Creative Thinking, Problem Solving and Decision Making

Course Number : MB 519
Course Name : Creative Thinking, Problem Solving and Decision Making
Credits : 2-0-0-2 (L-T-P-C)
Prerequisites : None

Intended for : MBA
Distribution : Compulsory
Approval: 50th BoA

**Course Contents:**

- **Introduction:** Understanding problem solving and decision making, Types of problems and decision making. (2 Hours)
- **Human Heritage for Problem Solving and Decision Making**: Creativity and inspiration, Intuition, knowledge, intelligence, wisdom and creativity, empathy, Creativity and evolution. Thinking and its Types, Lean thinking, critical thinking, lateral thinking and design thinking methods, Divergent and convergent thinking. (5 Hours)
- **Reasoning with Data:** Types of reasoning, deductive vs. inductive reasoning, reasoning with data, role of assumptions and biases, evaluating assumptions, biases in inductive reasoning for handling data, avoiding deductive and inductive reasoning fallacies, abductive reasoning, abduction in the field of artificial intelligence, reasoning backwards; Logical, probabilistic and geometric reasoning, problem solving and thinking traps, and their avoidance. (5 Hours)
- **Analytical thinking and decision making:** Analytical Thinking and decision making, stages of analytical thinking, data analytic thinking, Analytic hierarchy and network process. (3 Hours)
- **Problem framing and solution:** Identifying and defining problems, building a model, solving the problem through pattern finding, simplifying and eliminating, developing alternatives and evaluating options, what-if analysis, Complex problem solving, six thinking hats. (4 Hours)
- **Tools, Techniques and Skills:** Interpretation and Ideation techniques: Empathy mapping, mind mapping, journey maps, affinity and cause-effect diagram, pattern recognition; Brainstorming, brain dump, value proposition canvas, SCAMPER. Analysis Methods: Paired Comparison Analysis, Six Thinking Hats, Cost/Benefit Analysis, Decision Trees, Pareto Analysis, Grid Analysis, PMI, Force Field Analysis, Root-Cause Analysis, storyboarding. (5 Hours)
- **Simulation and Optimization for Problem solving and decision making:** Simulation and its types, importance of simulation and optimization for problem solving and decision making, role of data and model in simulations. physical simulation vs. computer simulation. (4 Hours)

**Lab Exercises (If applicable):**

Lab to be conducted on a 2-hour slot. It will be conducted in tandem with the theory course so the topics for problems given in the lab are already initiated in the theory class. The topics taught in the theory course should appropriately be sequenced for synchronization with the laboratory.

**Reference Book:**


1. T.H. Davenport and J. Kim, **Keeping up with the Quants**, Harvard Business Review Press, Boston, MA (rs. 1,555), 2013.

2. Daniel Kahneman, **Thinking, Fast and Slow**, Penguin Random House, 2012.

3. Robert J. Sternberg Ed., **Thinking and Problem Solving**, 2nd Edition, Academic Press, 1994.

4. de Bono, E., **Six Thinking Hats**, MICA Management Resources, 1999.

5. Eugene O'Loughlin, **An Introduction to Business System Analysis**, The Liffey Press, Ireland, 2009.

6. Gerald F. Smith, **Quality Problem Solving**, ASQ Quality Press, 1998.

7. Wisconsin G. Polya, **How to Solve It**, Princeton University Press, 1988

8. Edward B. Burger and Michael Starbird, **5 Elements of Effective Thinking**, Princeton University Press, Oxfordshire, 2021.

9. Jeanne Liedtka, Andrew King and Kevin Bennett, **Solving Problems with Design Thinking**, Columbia University Press, 2013.

10. Luc De Brabandere and Alan Iny, **Thinking in New Boxes**, Random House, 2013.

11. James L. Adams, **Conceptual Blockbusting**, Basic Books, 2019.

12. Tom Kelley and D. Kelley, **Creative Confidence**, William Collins, 2013.

13. J. Butterfield, **Problem Solving and Decision Making**, Cengage Learning, 2010.

14. Saaty, T.L., **Creative Thinking Problem Solving and Decision Making**, RWS Publications, 2008.

15. Paulos, J.A., **Innumeracy: Mathematical Illiteracy and Its Consequences**, New York: Hill and Wang.

16. Fisher, A., **Critical Thinking: An Introduction**, Cambridge University Press, 2001.


## 16.14 MB 520 : Fundamentals of Data and Analytics

**Course Code : MB 520**

**Course Name : Fundamentals of Data and Analytics**

L-T-P-C: 2-0-0-2
Intended for : MBA
Prerequisite : None
Mutual Exclusion : None
Approval: 52nd BoA

**Course Contents**

- **Data and Analytics Concepts**: Data concepts - DIKW and data analytics pyramid, small data to big data, Data analytic thinking, uncertainty and decision, data driven and goal driven decision making, Analytics processes and systems, data and analytics maturity, CRISP-DM Process. (4 Lectures)

- **Models and Processes**: Business analytics models, Strategy creation and Key Performance Indicators (KPIs), Business questions and KPIs, Asking right business questions on data and analytics, Data and Analytics Models and their types. (4 Lectures)

- **Data Preparation**: Data collection and preparation, perspectives on data, data types, sources and quality, data description using levels of measurement and types of measurement scales, Types of attributes/features, data cycle-the data preparation activities, data cleaning and data transformation, data encoding, data discretization, transformation for normality, feature selection- shrinking, dimensionality reduction. (6 Lectures)

- **Exploratory Analytics**: Describing the past, data visualization, understanding your data sources, understanding variability in the data. (4 Lectures)

- **Predictive Analytics**: Classes of predictive models-logic driven and data driven, predicting numerical and categorical values, asking predictive questions, simple and multiple linear regression as a predictive tool, correlation and multiple regression analysis, Forward and backward step-wise regression, Role of F-ratio and R-square adjusted statistics for predictive analytics (multiple regression based). (6 Lectures)

- **Prescriptive Analytics**: Optimization and experimentation for prescriptive analytics, asking prescriptive questions, optimization (MS Excel solver/other optimization tools), Prescriptive steps in analytics – defining the problem, decision variables, objective functions, constraints, and arriving at business solution. Introducing Causality, importance of causal analytics for business problem solving. (4 Lectures)

**Textbooks:**

NA

**Reference Books:**

1. Daniel, Vaughan, **Analytical Skills for AI & Data Science**, Shroff Publishers and Distributors Pvt. Ltd, 2020.

2. Daniel T. Larose, Chantal D. Larose, **Data Mining and Predictive Analytics**, Wiley, 2016.

3. **HBR Guide to Data Analytics Basics for Managers**, Harvard Business Review Press, 2018

4. Provost, F and Fawcett, T., **Data Science for Business**, Shroff Publishers and Distributors Pvt. Ltd, 2014.

5. Jeffrey D. Camm, James J. Cochran, Michael J. Fry, Jeffrey W. Ohlmann, **Business Analytics: Descriptive, Prescriptive and Predictive**, 4th Edition, Cengage Learning Inc, 2021.

6. Laursen, G.H.N. and Thorlund, J., **Business Analytics for Managers**, Wiley India Pvt. Ltd., 2014.

7. Amar Sahay, **Essentials of Data Science and Analytics Statistical Tools, Machine Learning, and R-Statistical Software Overview**, Business Expert Press, 2021.

8. J. D. Kelleher and B. Tierney, **Data Science**, The MIT Press, 2018.

## 16.15 MB 521 : Disruptive Technologies for Data Science

**Course Code : MB 521**

**Course Name : Disruptive Technologies for Data Science**

L-T-P-C: 2-0-0-2
Intended for : MBA
Prerequisite : None
Mutual Exclusion : None
Approval: 52nd BoA

**Course Contents**

- **Overview of Disruptive Technologies**: Waves of Technology evolution; Digitization and digitalization; Digitalization and disruption; Disruptive innovation; The waves of internet and related technological advancements; Networks, 5G and sensors. (5 sessions)

- **Computing Technologies**: Moore's Law and its impact, miniaturization of computers, Quantum computing and its prospects in business. (3 sessions)

- **Artificial Intelligence**: Concepts of Artificial Intelligence (AI), Integrating AI into human world, AI and robotics, virtual and augmented reality, Impact of AI and robotics in business, AI Entrepreneurs, AI Disruption. (4 sessions)

- **Blockchain and Bitcoin**: Blockchain concepts, Blockchain and Coded currency, Blockchain and Enterprise, Blockchain as a technology of trust, Blockchain driving the business and beyond. (3 sessions)

- **Internet of Things and Cloud Computing**: Evolution of Internet of Things, Economic Impact of IoT, IoT as a revolutionary technology, IoT Challenges, risks and dangers; Internet of Things to Internet of Everything, Basics of cloud computing, Cloud computing and web 2.0, Ways to cloud compute and its business benefits, Personal cloud, Edge computing. (4 sessions)

- **Multidimensional Printing:** Additive and subtractive manufacturing, Decentralizing and disrupting manufacturing, Mass customization, Barriers to additive manufacturing. (2 sessions)

- **Nanotechnology:** New materials and their applications, nanotechnology initiatives. (2 sessions)
- **Biotechnology and Neurotechnology:** Importance of biotechnologies and neurotechnogies, Biotechnology applications in the fields of medicine to manufacturing, workings of neurotechnologies and their impact. (3 sessions)
- **Clean Energy Technology and Geo Engineering:** Clean energy, and its distribution and storage technologies, Geo engineering and global warming. (2 sessions)

**Textbooks:**

NA

**Reference Books:**


1. Klaus Schwab, **Shaping the Future of the Fourth Industrial Revolution**, Penguin Random House, 2018.
2. Daniel Franklin, **Megatech: Technology in 2050**, Profile Books Ltd, (The Economist), 2017.
3. Steve Case, **The Third Wave**, Simon & Schuster Paperbacks, 2016
4. Christopher Barnatt, **A Brief Guide to Cloud Computing**, Constable & Robinson Ltd., 2010.
5. Peter H. Diamandis and Steven Kotler, **The Future is Faster Than You Think: How Converging Technologies are Transforming Business, Industries and Our Lives**, Simon & Schuster Paperbacks, 2020
6. Peter Thiel, **Zero to One: Notes on Startups or How to Build the Future**, Penguin Random House (Virgin Books), 2014.
7. Jean-Marie Dru, **The new Ways to New**, Wiley India Pvt. Ltd, 2015
8. Clayton M. Christensen, **The Innovator's Dillema**, Collins Business Essentials, 2006
9. Peter H. Diamandis, Steven Kotler, **Bold: How to Go Big, Create Wealth and Impact the World**, Simon & Schuster, 2015.
10. Henry Chesbrough, **Open Innovation: The New Imerative for Creating and Profiting from Technology**, Harvard Business School Press, 2006.
11. Daniel Kellmereit, Daniel Obodovski, **The Silent Intelligence: The Internet of Things**, DnD Ventures, 2013
12. Alec Ross, **The Industries of the Future**, Simon & Schuster UK Ltd., 2016
13. Jamie Bartlett, **The People vs. Tech: How the Internet is Killing Democracy**, Penguin Random House, 2018

## 16.16 MB 522 : Machine Learning for Business

**Course Code : MB 522**

**Course Name : Machine Learning for Business**

L-T-P-C: 2-0-0-2
Intended for : MBA
Prerequisite : None
Mutual Exclusion : None
Approval: 52nd BoA

**Course Contents**

- **Introduction to Machine Learning:** Understanding what is ML, its purpose, how and when to use it in Business, ML and Statistics-similarities and contrasts, Data driven decision making, ML methods. (3 Lectures)

- **Machine Learning and Data Analytics:** Data Models- Linear vs. Non-linear, complicated vs. Complex models for real world problem solving; ML system requirements, Iterative ML development Process, Framing ML Problems; feature understanding and selection. (3 Lectures)

- **Supervised Learning: Fundamentals:** Learning from data, bias and variance, Model generalization- Overfitting and underfitting, Predictive modeling, data and target leakage, Data sets preparation for model building- Training, Testing and Validation datasets, cross validation, linear and logistic regression, K-nearest neighbor method, Business applications (appropriate case studies, use cases and situation analysis). (5 Lectures)

- **Supervised Learning: Decision Trees**: Fundamentals of decision trees, evaluating splits- information gain, Gini Index, applications (eg. Business use cases like Churn analysis/credit scoring etc.), Diversity and prediction; Ensemble of Learners-Multiple Models: Condorcet Jury Theorem and Diversity Prediction Theorem, random forest, AdaBoost, Model evaluation, comparison, interpretation and communication, Business applications (appropriate case studies, use cases and situation analysis). (8 Lectures)

- **Supervised Learning: Support Vector Machine (SVM):** Fundamentals of support vector machines (SVMs); Linear SVM classification- hard margin classification, soft margin classification; Non-linear separation- a step towards neural network, Predicting continuous variables, Business applications (appropriate case studies, use cases and situation analysis). (4 Lectures)

- **Unsupervised Learning:** Clustering Basics, Techniques used for clustering; k-means clustering- choosing k: elbow method, silhouette method; Density-based and hierarchical clustering methods; Principal Components analysis (PCA), Business applications (appropriate case studies, use cases and situation analysis). (5 Lectures)

**Textbooks:**

NA

**Reference Books:**


1. Provost, F and Fawcett, T., **Data Science for Business**, Shroff Publishers and Distributors Pvt. Ltd, 2014.

2. Daniel S. Becker and Kai R. Larsen, **Automated Machine Learning for Business**, Oxford University Press, 2021.

3. Ethem Alpaydin, **Machine Learning**, MIT Press, 2016.

4. H. Brink, J.W. Richards and M. Fetheerolf, **Real-world Machine Learning**, Manning Pub., 2017.

5. J. Kelleher, B.M. Namee and A. D'Arcy, **Fundamentals of Machine Learning for Predictive Data Analytics**, MIT Press, 2015. (JK)

6. Scot Page, **The Model Thinker**, Basic Books, 2018.

7. K. Hosanagar, **A human guide to Machine intelligence, Portfolio**, Penguin Random House, 2019.

8. Matthew Kirk, **Thoughtful Machine Learning with Python**, Shroff Publishers and Distributors Pvt. Ltd, 2019.

9. Chip Huyen, **Designing Machine learning Systems**, Shroff Publishers and Distributors Pvt. Ltd., 2022.


## 16.17 MB 523 : Introduction to AI and Automation

**Course Code : MB 523**

**Course Name : Introduction to AI and Automation**

L-T-P-C: 2-0-0-2
Intended for : MBA
Prerequisite : None
Mutual Exclusion : None
Approval: 52nd BoA

**Course Contents**

- Introduction to AI and Automation: Digitization and digitalization; Automation: traditional automation and intelligent automation; Identifying tasks and their characteristics suitable for automation, Automation payoffs; Defining AI, Types of AI: artificial narrow intelligence (ANI), artificial general intelligence (AGI) and artificial super intelligence (ASI), AI and machine learning, AI classification as per business capabilities- Process Automation, Cognitive Insights and Cognitive Engagement. (4 Lectures)

- Traditional Automation- No human Intervention: Scopes and techniques of automation, Business processes, Process Standardization, Reengineering and deconstruction, Identification of repetition, replication ans redundancy elements in business process, Robotic Process Automation (RPA)- Scope, Benefits, Types and components of RPA, RPA Platforms, RPA vs. BPM, understanding RPA though use cases. (4 Lectures)

- AI for Automation: Automating decisions, human and machine capabilities for automation, Right Human-Automation Combination; Automating through Adaptive Business Processes, AI for automating repetitive tasks, AI for collaborative Automation (Human and Machine Collaboration). (6 Lectures)

- AI and Humans- Optimal Collaboration: Collaborative Automation through activities by humans and machines to complement each other's roles, human-in-the-loop systems, Humans for machine capability extension and amplification - Human trainers, explainers and sustainers for AI system development. AI augmenting human capabilities, Types of augmentation- Amplification, Interaction and Embodiment. (4 Lectures)

- Reimagining Business Processes: Proper mindset to reimagining processes, Experimentation, Leadership challenges for creating a blended culture of both humans and machines, and Building end-to-end data supply chains. (6 Lectures)

- New Skill Requirements for AI Based Automation: Skills required in the collaborative human and machine environment: Intelligent Interrogation, Bot Based Empowerment, Reciprocating Apprenticeship, Holistic Melding, Rehumanising Time, Responsible Normalizing, Judgement Integration, Relentless Reimagination. (4 Lectures)

**Reference Books:**


1. Paul R. Daugherty and H. James Wilson, **Human+ Machine: Reimagining Work in the Age of AI**, Harvard Business Review Press, 2018.

2. Tom Taulli, **Artificial Intelligence Basics: A Non-technical Introduction**, Apress, 2019.

3. Thomas H. Davenport, **The AI Advantage: How to Put the Artificial Intelligence Revolution to Work**, The MIT Press, 2018

4. Ravin Jesuthasan and John W. Boudreau, **Reinventing jobs:a 4-step approach for applying automation to work**, Harvard Business Review Press, 2018.

5. Melanie Mitchell, **Artificial Intelligence: A Guide for Thinking Humans**, Pelican Books, Penguin Random House, 2019.

6. Tomas Chamorro-Premuzic, **I, Human: AI, Automation, and the Quest to Reclaim What Makes Us Unique**, Harvard Business Review Press, 2023.

7. Ian Barkin, Jochen Wirtz, and Pascal Bornet, **Intelligent Automation: Learn how to harness Artificial Intelligence to boost business & make our world more human**, Independently Published, 2020.

8. Ian Barkin, Jochen Wirtz, and Pascal Bornet, **Intelligent Automation: Learn how to harness Artificial Intelligence to boost business & make our world more human**, Independently Published, 2020.

9. Byron Reese, **The Fourth Age: Smart Robots, Conscious Computers, and the Future of Humanity**, Atria International, 2018.

10. Deepak Karwal, T**he Automated Enterprise: Digital Reinvention through Intelligent Automation**, Deepak Karwal, 2020.

11. Matt Calkins, Neil Ward-Dutton, George Westerman et al., **Hyperautomation**, BookBaby, 2020.

12. Bhasker Ghosh, Gayathri Pallail and Rajendra Prasad, **The Automation Advantage: Embrace the Future of Productivity and Improve Speed, Quality, and Customer Experience Through AI**, McGraw-Hill Education, 2022.

## 16.18 MB 524 : Organizational Behaviour

**Course Code : MB 524**

**Course Name : Organizational Behaviour**

L-T-P-C: 2-0-0-2
Intended for : MBA
Prerequisite : None
Mutual Exclusion : None
Approval: 52nd BoA

**Course Contents**

- **The Individual**: Introduction to OB; Ability, Biographical Characteristics; Diversity – Indian Context – Diversity, Equity & Inclusion initiatives; Attitudes – Job Attitudes, Job Satisfaction, Antecedents & Consequences; Emotional Intelligence – Emotions, Moods, Emotional Labour; Personality – Big Five Model; Values; Decision Making; Motivation – Contemporary Theories, Applications, Job Characteristics Model, Ways of Motivating Employees; Leadership. (9 Lectures)

- **The Group**: Group Dynamics – Properties, Group Development, Group Decision Making Techniques, GroupThink; Teams – Types, Team Effectiveness Model, Context, Composition, Process; Self Organising Teams, Virtual Teams; Technology – Team Effectiveness Interactions. (6 Lectures)

- **The Organization System**: Types of organization structure, emerging organizational forms; functional structure, divisional structure, matrix structure, team structure, horizontal structure, network structure, virtual structure; Division of labour, specialisation, departmentalisation, chain of command, span of control, centralisation and decentralisation, formalisation, boundary spanning; Organizational culture, strong vs weak, dominant, socialisation model of culture, impact on employees and organization. (7 Lectures)

- **Technology and Organizational Behaviour**: Influence of social media & emerging technologies on employee behaviour Technology -structure interactions, Technology-culture interactions. (6 Lectures)

**List of articles and cases**

1. Thomas Green: Power, Office Politics and a Career in Crisis
2. The Ordinary Heroes of the Taj, Rohit Deshpande; Anjali Raina
3. Ramesh and Gargi – IIMA case
4. Mahindra Financial Services- Restructuring for growth, IIMB case
5. Clash of Cultures – Business India case collection
6. Bank of Baroda

**Textbooks:**

1. Robbins, S. P., Judge, T. A., & Vohra, N., **Organizational behaviour**, 18th Edition, Pearson Education India, 2019.
2. McShabe, S.L., Von Glinow, M. A., & Rai, H, **Organizational behaviour**, 9th Edition, McGraw Hill India, 2022.
3. Pareek, U., **Udai Pareek's Understanding organizational Behaviour**, 3rd Edition, Oxford University publications Catalogue, 2012.

## 16.19 MB 525 : Qualitative Research

**Course Code : MB 525**

**Course Name : Qualitative Research**

L-T-P-C: 2-0-0-2
Intended for : MBA
Prerequisite : None
Mutual Exclusion : None
Approval: 52nd BoA

**Course Contents**

- **Introduction to Qualitative Research**: Types of research, qualitative, quantitative and mixed methods, Nature, foundations and scope of Qualitative Research, significance of qualitative research, qualitative research process, ethical consideration in qualitative research. (8 Lectures)
- **Case Study Method**: Case study method – concepts, formation and measurement, Causation and models of causal inference, within case analysis method and practice, comparative case studies, data collection, interpretation and writing. (6 Lectures)

- **Grounded Theory**: Emergence of Grounded Theory, design aspects, coding process, Memo writing and developing patterns and categories, theory integration, writing report. (6 Lectures)
- **Other Methods**: Focus Group Discussions, Content Analysis, Ethnography studies. (4 Lectures)

**Textbooks:**

1. Uwe Flick, **An Introduction to Qualitative Research**
2. Cheryl Poth and John Creswell, **Qualitative Inquiry and Research Design**

**Reference Books:**

1. Joseph Maxwell, **Qualitative Research Design: An Interactive Approach**
2. Denzin, Norman K. and Lincoln, Yovonna S. Eds., **The Sage Handbook of Qualitative Research**, Sage Publications, 2011.

## 16.20 MB 526 : Strategic Management

**Course Code : MB 526**

**Course Name : Strategic Management**

L-T-P-C: 2-0-0-2
Intended for : MBA
Prerequisite : None
Mutual Exclusion : None
Approval: 52nd BoA

**Course Contents**

- **Introduction to Strategic Management and Development of Strategic Intent** (4 Lectures)
  - Understanding Strategy
  - Comprehending the basic framework of strategy analysis
  - Evolution of Business Strategy thought over past years
  - How to describe Strategy of an organization
  - Understand how Strategy is made within organization.
  - Strategic Management in the Context of Functional Departments in an Organization
  - Strategic Intent & Strategy Framework
  - Vision-Mission-Strategy / Purpose-Values- Strategy
  - Landscape of Strategic Management and Boundaries of Strategic Thinking
- **Frameworks and Tools for External Context Analysis** (5 Lectures)

- Macro External Environmental Analysis of the Industry
  - Industry Life Cycle
  - Analysing Industry Attractiveness
  - Frameworks and Tools for External Context (Environment) Analysis [External Environmental Analysis, PESTLE Analysis, Organization Response to External Environment]
- Micro External Environmental Analysis of the Industry
  - Analysis & Influence of Competitive Forces [Porter's 5 Force]
  - Strategic Group
- **Frameworks and Tools for Internal Context Analysis** (5 Lectures)
- Internal Analysis of the Firm
  - Resource Based View
  - Value Chain Analysis
  - Core Competencies
  - VRIO Framework
- **Different approaches within Business Strategy to achieve Competitive Advantage** (5 Lectures)
  - Generic business strategies (Cost Leadership, Differentiation, and Niche)
  - Blue Ocean Strategy
- **Organizational Design and its Influence on Strategy Formulation and Implementation** (4 Lectures)
  - Principles that Determines Structural Characteristics of Complex Organization
  - Selection of Organization Structure best suited for Particular Business Context
  - Drivers of Changes of Organization Structure
  - Corporate Governance and Culture's influence on Strategy Formulation and Implementation
  - Role of Leadership Team/ Board in Strategy Execution
- **Managing Multiple Businesses** (5 Lectures)
  - Basic Understanding of various Portfolio Planning Models (BCG Matrix, McKinsey Matrix, etc)
  - Different approaches within Corporate Strategy for pursuing Growth - Vertical and Horizontal Integration, Mergers and Acquisition, Joint Ventures, Diversification (Ansoff's Framework, etc), Alliances and Internationalisation

**Lab Exercises (If applicable):**

Lab to be conducted on a 2-hour slot. It will be conducted in tandem with the theory course so the topics for problems given in the lab are already initiated in the theory class. The topics taught in the theory course should appropriately be sequenced for synchronization with the laboratory.

**Textbooks:**

1. Robert M Grant, **Contemporary Strategy Analysis: Text and Cases**, 9th Edition, Edition, 2015.
2. Charles W. L. Hill; Melissa A. Schilling; and Gareth R. Jones, **Strategic Management: Theory & Cases: An Integrated Approach**, 12th Edition, 2017.

**Reference Books:**

1. Porter, M. E., **Competitive Strategy: Techniques for Analyzing Industries and Competitors**, Free Press, 1980.
2. Rumelt, R. P., **Good strategy, bad strategy: The difference and why it matters**, Crown Business, 2011.

## 16.21 MB 527 : Financial Management

**Course Code : MB 527**

**Course Name : Financial Management**

L-T-P-C: 2-0-0-2
Intended for : MBA
Prerequisite : None
Mutual Exclusion : None
Approval: 52nd BoA

**Course Contents**

- **Module 0 Introduction to Corporate Finance and Financial Goal of the Firm:**
  - This module is intended to introduce two important questions; 1. What investments should the company make? 2. How should it pay for those investments? After understanding the goal of a firm, then students would be introduced to the challenges that managers may face and explain the agency problem and need for corporate governance.
  - Readings: Chapter – 1 of the Textbook (1 hour)
- **Module 1 Time Value of Money:**
  - In this module, we take the first steps to understand the relationship between the value of money (dollars/rupees) today and money in the future. The next step is understanding how much would be needed to invest today to produce

a specified future sum of money. After the students learn how to value cash flows that occur at different points in time, then connect them to the next topic on how bonds and stocks are valued

  - Readings: Chapter -2 of the Textbook Chapter end exercises ( 2 Lectures)

- **Module 2 Valuing Bonds and Common Stocks Bonds:**
  - First would explain the sources of finances to the firm, then start with an analysis of the bond market by looking at government bonds' valuation and how to analyze the bond. The students should understand the bond prices and yields published in financial newspapers. Also, learn to differentiate between nominal and real (inflation-adjusted) interest rates. Common Stocks: Begin with a look at how stocks are traded. Then explain the basic principles of share valuation and the use of Discounted Cash Flow (DCF) models to estimate the expected rates of return. Later, show how the DCF models can value the entire business rather than individual shares.
  - Chapters: 3 and 4 of the Textbook
  - Chapter end exercises and Case on 'Reeby Sports' from the textbook (3 Lectures)
  - Lab -I Applications of Time Value of Money ( 2 Lectures)

- **Module 4 Capital Investment Analysis:**
  - Begin with introducing the importance of capital investment decisions. Then explain the Net Present Value and other investment criteria. Conclude by showing how to cope with situations when the firm has only limited capital. Explain how to develop a set of cash flows from the business. Then demonstrate a realistic and comprehensive example of a capital investment analysis. Also, explain the role of corporate taxes in investment analysis
  - Chapters – 5 and 6 of the Textbook
  - Chapter end exercises Case: 1. Hola Kola Capital Budgeting Decisions (HBSP# TB0343) Case 2. Sneaker 2013 (HBSP# BAB166) (one of the above) (3 Lectures)

- **Module 5 Risk and Return:**
  - First, explain how to read the stock prices and compute returns. Then take the first look at investment risks and show how they can be reduced by portfolio diversification. Introduce the risk measures, the standard deviation of returns, and the Beta coefficient for individual securities.
  - Reading: Chapter 7 of the Textbook Case from the textbook, John and Marsha on Portfolio Selection
  - Chapter end exercises ( 2 Lectures)

- **Module 6 Portfolio:**
  - Theory and the Capital Asset Pricing Model This module would focus on presenting modern portfolio theories linking risk and return. Then demonstrate

how these theories can be used to estimate the returns required by the investments. First, start with the Capital Asset Pricing Model (CAPM) and look at another class of models, arbitrage pricing or factor models.
  - Reading: Chapter 8 of the textbook Case: 'Partners Healthcare' (HBSP#9-206-005) ( 3 Lectures)

- **Module 7 Risk and Cost of Capital:**
  - First, understand why investment in a project is risky. Then evaluate the sensitivity of project cash flows to business cycles. Relate the CAPM and explain how to calculate the cost of capital (WACC). Conclude the topic after introducing the certainty-equivalent factors and illustrate how the risk can change over time.
  - Reading: Chapter 9 of the Textbook
  - Chapter end exercises Case: Nike Inc; Cost of Capital (HBSP#UV0010) ( 3 Lectures)

- **Module 8 Project Analysis:**
  - Focus on how firms develop budgets for capital investments. Illustrate sensitivity, break-even, and Monte Carlo simulation to identify investment proposals' crucial assumptions and explore what can go wrong. In the end, describe important real options, and show how to use decision trees to set out the possible future choices.
  - Readings: Chapter 10 of the Textbook Investment, Strategy, and Economic Rents: First, explain how the firm's competitive advantage links corporate strategy with finance. Then explain the common pitfalls in capital investment analysis and conclude how economic rents underlie all positive NPV investments.
  - Reading: Chapter 11 of the Textbook ( 4 Lectures)
  - Lab Simulation Exercise on Investment Analysis ( 2 Lectures)

- **Module 9 Corporate Financing:**
- Illustrate the sources of financing and patterns with the help of financial data from CMIE or Bloomberg. Explain internal financing vs. external financing. Review some of the essential features of equity and debt financing. Dividend Policy Explain how much cash should the firm's payout to its shareholders. Then how should the cash be distributed by paying cash dividends, stock dividends, or stock repurchases Case: 'Blaine Kitchenware Inc' (HBSP#4040) ( 3 Lectures)

**Lab Exercises:**

- The first lab session focuses on the time value of money to demonstrate the effect on the value of money with changes in assumptions such as time horizon, discounting factor, frequency of compounding, etc.
- The second lab session explains the sensitivity of project value to different business scenarios, how to forecast operating cash flows, and applications of Mante Carlo Simulation to know the expected value of cash flows.

**Textbooks:**

1. Brealey A Richard, Myers C Stewart, and Allen Franklin, **Principles of Corporate Finance**, McGraw Hill Education, 13th Edition (US) (Main Textbook)

2. Ross A Stephen, Randolph W Westerfield, Jaffe Jeffrey and Bradford, **Corporate Finance**, 12th Edition, McGraw Hill Education (Additional Textbook)

3. Jonathan Berk and Peter DeMarzo, **Corporate Finance (plus MyFinanceLab)**, 3rd Edition, Pearson - Prentice Hall, 2014.

**Reference Books:**

1. Eugene F Fama, **Theory of Finance**, Thomson Learning, 1972.

2. Elton J Edwin, Gruber J. Martin, Brown J. Stephen, and Goetzmann N. William, **Modern Portfolio Theory and Investment Analysis**, Wiley, 2014

## 16.22 MB 528 : Human Resource Management

**Course Code : MB 528**

**Course Name : Human Resource Management**

L-T-P-C: 2-0-0-2
Intended for : MBA
Prerequisite : None
Mutual Exclusion : None
Approval: 52nd BoA

**Course Contents**

- **HRM in 21st Century:** Introduction to the domain of HR, Evolution of HR, The role of HR Business Partner, Evidence-based Human Resource Management, Driving forces of Evidence-based HRM, Linking Business Strategy with the HR Strategy, Manager's role in Strategic HRM, Building a high-performance work system in the era of Industry 4.0, Role of AI and ML in developing contemporary HR policies and practices. (6 Lectures)

- **Job Analysis, HR Planning & Talent Acquisition**: Job Analysis in the changing nature of workplace, Steps involved in Job Analysis, Methods of collecting Job Analysis information, Quantitative Job Analysis Techniques, Using internet for writing Job Descriptions, Job Specifications based on statistical analysis, Job Rotation, Job Enlargement & Job Enrichment, Competency-based Job Analysis Human Resource Planning and Forecasting, Recruitment & Selection in the Talent Management era, Talent Acquisition Strategies, Use of AI in the Talent Acquisition process, Use of Applicant Tracking System (ATS) and application forms to predict Renege/job performance, Employee Testing and Selection. (8 Lectures)

- **Talent Development:** Training & Developing Employees, Training Need Analysis, Designing and implementing training programs, Management Development Programs, Managing Organizational Change Programs, The Kirkpatrick model of training evaluation, ROI and Behavioural Training, Use of Learning Analytics in creating L&D policies and practices, The AI-powered Coaching and Career Management. Managing Employee Performance, Mutual Goal setting, Techniques for appraising performance, Managing performance through HRIS, Mobile Apps for real-time performance management, Performance Metrics, 9-box grid measuring performance and potential of employees. (8 Lectures)

- **Talent Engagement & Compensation Management:** Talent Engagement, Measuring employee Attrition and developing retention strategies, Understanding Turnover intention, Absenteeism, Satisfaction & Commitment Indices, Future of Employee Engagement with AI, AI-powered Employee Segmentation, Leveraging AI for Work-Life Balance. Compensation & Benefits, Factors determining Compensation & Benefits, Salary Survey, Job Evaluation, Executive Compensations, Competency-based Pay, Analytics in Compensation Management, Fundamental Laws related to Compensation & Benefits. (6 Lectures)

**Textbooks:**

1. Dessler, G & B. Varkkey, **Human Resource Management**, 16th Edition, Pearson Education India, 2020.

**Reference Books:**

1. A. Upadhyay, K. Khandelwal & J. Iyengar, **Revolution in HRM: The New Scorecard**, Sage Publications India Pvt. Ltd., 2021.

2. Yadav R S & S. Maheswari, **HR Analytics: Connecting Data and Theory**, Wiley India Pvt. Ltd., 2021.

3. Martin Edwards, **Predictive HR Analytics: Mastering the HR Metric**, Kogan Page, 2016.

4. Kenneth M. York, **Applied Human Resource Management**, Sage Publications India Pvt. Ltd., 2010.

**Reference Articles**

1. Allan Baily, **The Kirkpatrick/Philips Model for evaluating Human Resource Development and Training**.

2. Arellano, C., DiLeonardo, A., & Felix, I. **Using people analytics to drive business performance: A case study**, McKinsey Quarterly, 3, 114-119, 2017.

3. Boudreau and Ramstad, **Talentship, Talent Segmentation, and Sustainability: A New HR Decision Science Paradigm for a New Strategy Definition**, Human Resource Management, Summer 2005, Vol. 44, No. 2, pp. 129-136

4. De Cremer, D., & Stollberger, J., **Are People Analytics Dehumanizing Your Employees?**, Harvard Business Review, 2022(June 07). https://hbr.org/2022/06/are-people-analytics-dehumanizing-your-employees; https://www.aihr.com/blog/hbr-people-analytics-misconceptions/

5. Malik, A., Srikanth, N. R., & Budhwar, P., **Digitization, artificial intelligence (AI) and HRM**, In Crawshaw, J., Davis, A., & Budhwar, P., Human resource management: Strategic and international perspectives. London:Sage. (pp. 88-111), 2020.

6. McCartney, S., & Fu, N., **Promise versus reality: a systematic review of the ongoing debates in people analytics**, Journal of Organizational Effectiveness: People and Performancem, 2022.

7. Strohmeier, S., **Digital human resource management: A conceptual clarification**, German Journal of Human Resource Management, 34(3), 345-365, 2020.

8. Tenakwah, E., **Four by Four: Unintended Risks of People Analytics**, 2021.

9. Thite, M. (Ed.), **e-HRM: Digital approaches, directions & applications**, Routledge, 2018.

10. Yano et al., **Measuring Happiness using Wearable Technology**, Hitachi Review, Vol. 64, No.: 8, 2015

11. Accenture Reports:

    (a) https://www.accenture.com/_acnmedia/Thought-Leadership-Assets/PDF-3/Accenture-Care-To-Do-Better-Report.pdf

    (b) https://www.accenture.com/_acnmedia/PDF-141/Accenture-Honing-your-Digital-Edge-POV.pdf

**Case Studies recommended:**

1. Harvard Case: Sensing (and Monetizing) Happiness at Hitachi

2. Harvard Case: Amazon as an Employer

3. APSPOP's Recruitment Predicament (Ivey Case)

4. Harvard Case: Performance Development at GE: Shaping a Fit-For-Purpose Performance Management System

5. Harvard Case: Money Cash Flow Inc._ HR Analytics Applied to Employee Retention and Well-Being Issues

6. Deloitte and KPMG: The War for Talent (Ivey Case)

## 16.23 MB 530 : Neural Networks Fundamentals for Business

**Course Code : MB 530**

**Course Name : Neural Networks Fundamentals for Business**

L-T-P-C: 2-0-0-2
Intended for : MBA
Prerequisite : None
Mutual Exclusion : None
Approval: 52nd BoA

**Course Contents**

- **Introduction to Neural Networks:** History of Neural Networks, Real and artificial Neurons, Maths behind neural network, Types of Neural Networks. (2 Lectures)

- **Perceptron:** Neuron as a basic processing element, single and Multiple Perceptrons, Linear and nonlinear regression models of neural network, Activation function and its necessity, smooth and non-smooth activation functions- Sigmoid, Tanh, ReLU, argmax and softmax, feed-forward networks, deep networks and connectionism-distributed representation. (4 Lectures)

- **Backpropagation and Gradient Descent:** Neural Networks training processes, Constants and variables in a network, weight initialization- Random, Glorot initialization, cost functions, Cross-entropy functions, Rosenblatt's perceptron training, gradient descent method, Gradient Descent for solving a simple Learning problem, Perceptrons for identifying patterns, Gradient Descent for Multilevel Neural Networks, Backpropagation Method – Forward and Backward Pass, Adjusting the Weights, Learning Rate- static and dynamic, Stochastic gradient descent-batch and mini-batch gradient descent, Neural network architecture – Selecting number of layers and number of neurons per layer. (8 Lectures)

- **Supervised Learning:** Fully connected neural networks, Exploring the dataset, identifying biases in the dataset, Data drift and Splitting the dataset to training, testing and validation datasets, Bias-variance tradeoff through neural network architecture, bias and variance reduction techniques, diagnosing bias and variance, Neural network model building, parameter tuning, Dealing with data leakage, interpretation of learning curves, Learning customer churn through backpropagation. Neural networks for multiclass classification, Loss function for multiclass classification (eg. MNIST/iris dataset). Quantitative and qualitative evaluation of the solution. Vanishing gradient, Selecting right activation function, Neural Network Regression on practical datasets (eg. Boston dataset or churn dataset) and cases. (6 Lectures)

- **Unsupervised Learning:** Competitive Learning, Kohnen Self-organising maps (SOM), SOM Dimensionality and size of the map, Data preprocessing for SOM, deciding on Number of clusters, Performance assessment, SOM clustering of appropriate datasets and cases. (4 Lectures)

- **Time Series Forecasting:** Fundamentals of time series forecasting, types of time series forecasting, Time series smoothing and decomposition, ARIMA models, Neural network autoregressive models. (4 Lectures) [10]

**Reference Books:**

1. Kotu V. and Deshpande, B., **Data Science: Concepts and Practice**, Morgan Kauffman Publications, 2019.

2. J. Kelleher, B.M. Namee and A. D'Arcy, **Fundamentals of Machine Learning for Predictive Data Analytics**, MIT Press, 2020.

3. J.D. Kelleher, **Deep Learning**, MIT Press, 2019.

4. James M. Keller, Derong Liu, and David B. Fogel, **Fundamentals of Computational Intelligence Neural Networks, Fuzzy Systems, and Evolutionary Computation**, Wiley-IEEE Press, 2016.

5. Phil Kim, **MatLab Deep Learning with Machine Learning, Neural Networks and Artificial Intelligence**, Apress, 2017.

6. Scot Page, **The Model Thinker**, Basic Books, 2018.

7. Wei Di, Anurag Bhardwaj and Jianing Wei, **Deep Learning Essentials: Your hands-on guide to the fundamentals of deep learning and neural network modelling**, Packt Publications, 2018

8. Bernhard Mehlig, **Machine Learning with Neural Networks: An Introduction for Scientists and Engineers**, Cambridge University Press, 2021.

## 16.24 MB 531 : Ethical and Legal aspects of Business

**Course Code : MB 531**

**Course Name : Ethical and Legal aspects of Business**

L-T-P-C: 2-0-0-2
Intended for : MBA
Prerequisite : None
Mutual Exclusion : None
Approval: 52nd BoA

**Course Contents**

CO No. Course Objectives (CO)

- **CO1:** Students would be introduced to the basic legal and ethical framework of business not only in India, but also with a global perspective in mind including an overview of the law of emerging technologies and how best to leverage this law for optimum commercial gain. Students of business administration must understand what happens both: in civil as well as criminal litigation and how what happens in courts can impact business world. Students must understand the Contract law regarding the necessity to have / not to have written contracts; Students must understand the meaning, the scope and nuances of the application of business laws on contracts and how to take decisions that could have legal consequences in these contracts.

- **CO2:** Students would develop an understanding of the business facilitation role of the legal system, particularly the Law of Contracts and e-contracts & e-commerce through the Digital India Act and the regulatory systems in place to supervise and regulate the business practices in India and also doing business beyond national borders and doing business and human transactions via online mode or through the use of electronic gadgets and wearable technologies.

- **CO3:** Students will develop an introductory level understanding of the legal and ethical concepts relating to niche areas of business & technology laws such as intellectual property rights, Law of forms of Business Enterprises and Entrepreneurship, Law of Company Management and the Essentials of the Laws of Technology such as Intellectual Property Rights (IPRs) and how best to optimize trade and commerce in IP assets while also seeking legal protection for the same against infringement by violators/competitors.
- **CO4:** Students would be introduced to niche areas of emerging and evolving laws and the legal and ethical regime of technology laws governing the application of the Digital India Act (DIA) on emerging technologies such as the use of electronic gadgets / Computers / laptops / wearables, ... etc. to interact and transact with other enterprises / entities either for commerce or for other social interactions or creating wealth, committing, investigating or preventing crime.... etc.

**Pedagogy:**

The course intends to use multiple pedagogical tools to reinforce the learning among the participants. Predominantly, this course shall be delivered through (1) Lectures where legal concepts and doctrines are explained through meticulously prepared (2) 'Illustrative Case Studies' and flipped classroom initiative where students are also encouraged to actively participate in the learning process and to undergo self-learning through the guidance provided continuously by the law-faculty. A second method is the encouragement to learn through (3) 'Outside Classroom Learning (OCL)' initiatives – which will periodically be introduced by Law-Faculty who will provide a learning guide map to show the paths of self-learning the student-participant should take to gain optimal knowledge from the niche law course. Law-Faculty will also provide from time to time (4) Supplementary Law Knowledge Resources by way of dedicated course-instruction related emails, web-links, handouts, .... etc. The only Course Evaluation Component which will be introduced through two ' Tutorial Sessions' will be the (5) ' Kababisthan Assignment', which in effect will cover the Teaching Content which in other b-school curricula, are spread over 4 Sessions in regular MBA Programs in b-schools including in the IIMs. The Kababisthan Assignment which will have a weight-age of 35% of Course Marks, will ride on a student-centric learning effort and will cover vital Modules in the Course such as – 'Law of Entrepreneurship', 'Law of Forms of Business Enterprises', 'Fundamentals of Company Law & Law of Company Management' and promises to leave behind footprints of unforgettable knowledge enriching experience for the student-participants.

**Textbooks:**

NA

**Reference Books:**

NA

## 16.25 MB 532 : Digital Business Strategy, Models and Transformations

**Course Code : MB 532**

**Course Name : Digital Business Strategy, Models and Transformations**

L-T-P-C: 2-0-0-2
Intended for : MBA
Prerequisite : None
Mutual Exclusion : None
Approval: 52nd BoA

**Course Contents**

- **Reimagining Business:** Digital business transformation, Digitization vs. Digitalization, Digital Optimization an digital business transformation, Automation to autonomous systems, , the Domains of Digital Transformation and Barriers; Dimensions of digital business-Scale, scope and speed of digitalization. (4 Lectures)
- **Reimagining Business model and Business processes:** Business model concepts and their Importance, Understanding Platforms and their ecosystem, Types of Platforms- one sided to N-sided, Platform Business Models, Change Management for Digital Business, Technical architecture for digital strategy, Building Blocks of Business Model, Business Model Canvas. (8 Lectures)
- **Reimagining Digital Strategy:** Strategy for Digital Transformation and their types, Digital KPI and Digital Revenue; Digital Platform strategy, business and IT Architecture, Digital Matrix, Phases of transformation. (8 Lectures)
- **Strategy Development and Implementation:** Understanding Digital disruption, Response to digital disruption using Business models, Adaptive vs. disruptive models, digital adoption and adaptation, Building Digital Business Technology Platform, Implementation methods and future scope. (6 Lectures)
- **Future Digital Business:** Elements of future digital business, Digital Transformation Risks, Digital Leadership. (2 Lectures)

**Reference Books:**


1. V. Venkatraman, **The Digital Matrix**, Penguin Random House India Pvt. Ltd., 2017
2. S. Gupta, **Driving Digital Strategy,** Harvard Business Review Press, 2018
3. Nitin Seth, **Winning In The Digital Age - Seven Building Blocks of a Successful Digital Transformation**, Penguin Random House India Private Limited, 2021.
4. Peter Weill, Stephanie Woerner, **What's Your Digital Business Model?: Six Questions to Help You Build the Next-Generation Enterprise**, HBR Press, 2018

5. G. O'Brien, G. Xiao, and M. Mason, **Digital transformation Game Plan**, Shroff Publishers & Distributors, 2022.

6. A. Bock and G. George, **The Business Model Book**, Pearson, 2019

7. T. Saldanha, **Why Digital Transformations Fail: The Surprise Disciplines of How to Take Off and Stay Ahead**, Berrett-Koehler Publishers, Inc. 2019.

8. Anshuman Khare, Brian Stewart & Rod Schatz, **Phantom Ex Machina – Digital Disruption's Role in Business Model Transformation**, Springer International Publishing Switzerland, 2017

9. George Westerman and Didier Bonnet, **Leading Digital: Turning Technology into Business Transformation**, Harvard Business Review Press, 2014

10. R. Wang, **Disrupting Digital Business: Create an Authentic Experience in the Peer-to-Peer Economy**, Harvard Business Review Press, 2015.

11. Thomas Siebel, **Digital Transformation: Survive and Thrive in an Era of Mass Extinction**, Rosetta Books, 2019.

12. **HBR's 10 Must Reads on Leading Digital Transformation**, Harvard Business Review, 2021.

13. V. Sambamurthy, **Guiding the Digital transformation of Organization**, Legerity Digital Press, 2012

14. D.L. Rogers, **The Digital Transformation Playbook**, Columbia University Press, 2016.

**Articles and Cases:**

1. Gartner Publications/Reports Ross et al., Digitized ≠ Digital, MIT Sloan Management Review, 2017 Ross et al. Digital Success requires Breaking Old Rules, , MIT Sloan Management Review, 2019 Bharadwaj et al. Digital Business Strategy: Toward a Next Generation of Insights, MIS Quarterly Executive, June 2013

2. The essential components of Digital Transformation, Tomas Chamorro Premuzic, HBR, Nov 23, 2021

3. Digital Transformation Changes How Companies create Value, Marshall W. Van Alstyne and Geoffrey G Parker, HBR, Dec 17, 2021

4. 4 lessons from Levi's Digital Transformation, Harmit Singh, HBR, Feb 2022.

5. Digital Transformation is not about Technology, Behnam Tabrizi; Ed Lam; Kirk Girard; Vernon Irvin; Kirk Gerard, HBR, Mar. 2019. Sia et al., How DBS Bank Pursued a Digital Strategy, MIS Quarterly Executive, June 2016

6. Ross et al. Designing Digital Organization, Research Report, MIT Sloan School of Management, 2016, CISR WP No. 406.

7. AccorHotel's digital transformation: A response to hospitality disruptor Airbnb

8. How Does Digital Transformation Happen? The Master card Case. (Case No. IN1463-PDF-ENG)

9. Digital India – Technology to transform a Connected nation, Mckinsey report, 2019

10. Digital Transformation 2.0 CEO Elie Girard at Atos (Case No. 421024-PDF-ENG)

11. Digital Transformation at La Presse (A): Crafting a New Digital Strategy

## 16.26 MB 533 : Entrepreneurship

**Course Code : MB 533**

**Course Name : Entrepreneurship**

L-T-P-C: 2-0-0-2
Intended for : MBA
Prerequisite : None
Mutual Exclusion : None
Approval: 52nd BoA

**Course Contents**

- **Introducing Entrepreneurship:** Significance of entrepreneurship, Taxonomy of entrepreneurship- types of entrepreneurs, distinction of entrepreneurs and intrapreneurs, Inherent traits and necessary skills required to be possessed by an entrepreneur with particular reference to technopreneurship. (5 Lectures)

- **Family Business and Social Entrepreneurship:** Features of family businesses, understanding social entrepreneurship. (2 Lectures)

- **Starting-up strategy:** Five-Question Framework and Porter's Five Forces, preparation of Business Plans, understanding Business Models of entrepreneurs. (4 Lectures)

- **Challenges encountered:** Opportunities and threats (pros and cons) of entrepreneurship, reasons of failure of entrepreneurs. (3 Lectures)

- **Financing of Entrepreneurial Ventures:** Banking system and other openings available for accessing finance by entrepreneurs. (5 Lectures)

- **External Support required for Success of Entrepreneurship:** Introduction to a conducive eco- system for promotion of entrepreneurship in India and the lacunae identified therein, Need for parental backing and social recognition as necessary external support for success of entrepreneurial ventures. (6 Lectures)

- **Assignments** etc. (3 Lectures)

**Recommended Readings**

1. Rajeev Roy, ENTREPRENEURSHIP, Latest Edition, Oxford University Press
2. Harvard Business Review Entrepreneur's Handbook, Harvard Business School Publishing Corporation, 2018.
3. Charles E. Bramford & Garry D. Bruton, ENTREPRENEURSHIP: A SMALL BUSINESS APPROACH, Indian Edition, McGraw Hill Education, 2015.
4. Harvard Business Review On AI, Analytics, and the New Machine Age, Harvard Business School Publishing Corporation, 2019.
5. Kanth Miriyala & Reethika Sunder, ENTREPRENEUR 5 P.M. to 9 A.M., 11th Edition, Rupa Publications India Pvt Ltd

**Note:**

1. Please note that Serial Nos. 1, 2 and 3 above are the principal readings while Serial Nos. 4 & 5 are the supplementary readings recommended for obtaining a general overview of issues pertaining to Entrepreneurship as a business endeavour.
2. It may also be noted that some Study Materials prepared by the Instructor may be shared in the Classroom, as and when necessary.

## 16.27 MB 550 : Artificial Intelligence for Marketing

**Course Code : MB 550**

**Course Name : Artificial Intelligence for Marketing**

L-T-P-C : 2-0-0-2
Intended for : MBA
Prerequisite :
Mutual Exclusion : Organizational Management HS304 offered by SHSS
Approval: 54th BoA

**Course Contents**

- Foundations of AI: Refreshing Concepts of Machine Learning (ML) Methods- Supervised, Unsupervised, and Reinforcement Learning; Maximum Likelihood Estimation, Principal Component Analysis and Clustering, Logistic Regression and Multinomial Classification, and Naive Bayes Classifiers; AI Types, AI and Algorithmic Marketing, Defining AI and Algorithmic Marketing, Marketing functions Automation and Augmentation, Why AI for Marketing? (4 Hours)
- AI for Predictive Modelling: Business Objectives, Consumer Choice Theory- Multinomial Logit Model, Survival Analysis. (4 Hours)
- AI for Finding Optimal Match Between Customers and Offerings: Fundamentals of Product Discovery Problem and identifying right customers for a given offering, Promotions and Advertisements- Business Objectives, Targeting Pipeline, Response Modelling and Measurement, Targeting and LTV Models- Propensity Modelling,

Segmentation and Persona-based Modelling, Targeting by using Survival Analysis, Lifetime Value Modelling, Markov Chain Models, Designing and Running Campaigns, Online Advertisements, Measuring the Effectiveness. (5 Hours)

- AI Helps Finding Products for the Customers- Search: Business Objectives, Matching and Ranking- Token Matching, Normalization and Stemming, Ranking and the Vector Space Model; Semantic Analysis, Latent Semantic Analysis, Word2Vector Model, Search Methods for Merchandising. (3 Hours)

- Recommending Products for the Customers: Business Objectives, Quality Evaluation, Recommendation Methods- Content-based, Collaborative Filtering, and Model-based Collaborative Filtering, Contextual Recommendations, Non-Personalized Recommendations. (4 Hours)

- Pricing and Assortment: Business Objectives, The Impact of Pricing, Price and Value, Price and Demand, Basic Price Structures, Demand Prediction, Price Optimization, Dynamic Pricing, Store-Layout Optimization and Category Management. (4 Hours)

- ChatBots and Large Language Models (LLMs) for Marketing: Business Objectives, Bots as a New Customer Interface and Operating System, Harnessing the Power of LLMs (like, ChatGPT) for Your Business, LLMs for Lead Generation, social media marketing, Optimizing Conversion Rates, Market Research and Analysis. (4 Hours)

**Textbooks:**

1. NA

**References:**


1. Jim Sterne, **Artificial Intelligence for Marketing: Practical Applications**, John Wiley & Sons, 2017.

2. Mike Kaput, and Paul Roetzer, **Marketing Artificial Intelligence: AI, Marketing, and the Future of Business**, BenBella Books, 2022.

3. Ilya Katsov, **Introduction to Algorithmic Marketing: Artificial Intelligence for Marketing Operations**, Ilia Katcov, 2017.

4. Raj Venkatesan, and Jim Lecinski, **The AI Marketing Canvas: A Five-Stage Road Map to Implementing Artificial Intelligence in Marketing**, Stanford Business Books, 2021.

5. Peter Gentsch, **AI in Marketing, Sales and Service: How Marketers without a Data Science Degree can use AI, Big Data and Bots**, Springer Nature, 2019.

6. Mike Kapu, Paul Roetzer, **Marketing Artificial Intelligence: AI, Marketing, and the Future of Business**, BenBella Books, 2022.

7. Katie King, **Using Artificial Intelligence in Marketing: How to Harness AI and Maintain the Competitive Edge**, Kogan Page, 2019.

## 16.28 MB 551 : Causal Analytics for Business Decision Making

**Course Code : MB 551**

**Course Name : Causal Analytics for Business Decision Making**

L-T-P-C : 2-0-0-2
Intended for : MBA
Prerequisite :
Mutual Exclusion:
Approval: 54th BoA

**Course Contents**

- **Foundations of Causal Analytics**: Why and what of Causal effects and causal inference, Describing variables and relationships, Finding and using Causes, Correlation vs Causation, Causation without Correlation, Probabilities and Causation, Evidence and Causes. (4 Hours)
- **Causal Diagrams- Drawing Your Assumptions**: Assumptions about data for Causal Inference, Levels of Causation, Interventions and Counterfactuals, Data to Graphs, Drawing Causal diagrams, Moderators in Causal Diagrams, Causal Paths and their use to test the diagram, Confounding and Deconfounding, Measuring Causality, Granger Causality, and Causality Checklist. (4 Hours)
- **Business Experiments- Data Designing**: Experimental and Non-Experimental Data, Characteristics of Business Data, Data Generating Process, The magic of randomization, Random vs, Non-random data, Randomized Controlled Trials, Randomized Treatment Assignment and Causal Inference, Randomized vs. Observational Studies, Planned Experiments and Quasi-Experiments, Treatment Effects Estimation on Business Data. (6 Hours)
- **Tools for Experimentation**: Matching, Difference-in-Differences, Regression, , Simulation, Phased Rollouts, and Sensitivity Analysis in Observational Study. (6 Hours)
- **Opportunistic Data**: Defining and navigating Opportunistic Data, Anticipating and Influencing Business Outcomes, Causality with Opportunistic Data. (4 Hours)
- **Natural Experiments-Discontinuities and Instrument Variables**: Business and Natural Experiments, Analysing Natural Experiments, Difference-in-Differences in Natural Experiments, Regression Discontinuity. (4 Hours)
- **Explanation and Action**: **What Caused What**: Finding Causes, Explanation with Uncertainty, Automating Explanation, Evaluating Causal Claims, to Decisions. (2 Hours)

**Textbooks:**

1. NA

**References:**


1. Judea Pearl and Dana Mackenzie, **The Book of Why: The New Science of Cause and Effect**, Penguin Books, 2018.

2. Paul R. Rosenbaum, **Causal Inference**, MIT press, 2023.

3. Samantha Kleinberg, **Why-A guide to finding and using Causes**, Shroff Publishers and Distributors Pvt. Ltd., 2019

4. Jefferey, T. Prince and Amarnath Bose, **Predictive Analytics for Business Strategy**, McGraw Hill Education (India) Private Ltd., 2021

5. Jonas Peters, Dominik Janzing, and Bernhard Scholkopf, **Elements of Causal Inference: Foundations and Learning Algorithms**, The MIT Press, 2017.


## 16.29 MB 552 : Financial Analytics

**Course Code : MB 552**

**Course Name : Financial Analytics**

L-T-P-C : 2-0-0-2
Intended for : MBA
Prerequisite :
Mutual Exclusion:
Approval: 54th BoA

**Course Contents**

- **Introduction to Financial Analytics**: Overview of Financial Analytics: Importance and Applications; Descriptive, Predictive, and Prescriptive Analytics; Key Financial Data Sources and Data Quality Issues; Role of Statistical Techniques in Financial Analysis. (6 Hours)

- **Data Preparation and Exploration**: Data Cleaning and Transformation Techniques; Financial Data Visualization and Reporting Tools; Exploratory Data Analysis (EDA) Techniques; Identifying Patterns and Outliers in Financial Data. (6 Hours)

- **Predictive Modeling for Financial Analysis**: Regression Models for Forecasting Financial Data; Time-Series Analysis: ARIMA, Seasonal; Decomposition; Machine Learning Techniques: Classification and Clustering; Measuring Model Performance and Avoiding Overfitting. (6 hours)

- **Risk Management and Portfolio Optimization**: Credit Risk Analysis: Credit Scoring Models; Value at Risk (VaR) and Stress Testing; Portfolio Theory and Optimization: Markowitz Model; Hedging and Risk Mitigation Strategies. (6 hours)

- **Applications of Financial Analytics**: Fraud Detection and Prevention Techniques; Algorithmic Trading and High-Frequency Trading; Customer Analytics in Banking and Financial Services; Financial Analytics in Corporate Strategy. (4 hours)

**Textbooks:**

1. NA

**References:**

1. NA

## 16.30 MB 553 : Fintech

**Course Code : MB 553**

**Course Name : Fintech**

L-T-P-C : 2-0-0-2
Intended for : PG and PhD students
Prerequisite :
Mutual Exclusion:
Approval: 54th BoA

**Course Contents**

- **Introduction to Fintech**: Understanding Fintech: History and Evolution; Key Players in the Fintech Ecosystem; Disruptive Technologies in Financial Services; Impact of Fintech on Traditional Banking Models. (4 Hours)
- **Digital Payments and Lending**: Digital Wallets, Mobile Banking, and Cryptocurrency; Peer-to-Peer Lending and Crowdfunding Platforms; Smart Contracts and Blockchain Technology; Regulatory and Compliance Challenges. (6 Hours)
- **Insurtech and Wealthtech**: Insurtech: Innovations in Insurance Industry; Robo-Advisors and Automated Investment Services; Digital Wealth Management Platforms; Ethical and Legal Implications of Automation. (6 hours)
- **Risk Management and Cybersecurity**: Cybersecurity Risks in Fintech; Anti-Money Laundering (AML) and KYC Compliance; Digital Identity and Authentication Technologies; Strategies to Mitigate Risks in Digital Finance. (6 hours)
- **Fintech Business Models and Trends**: Innovative Business Models in Fintech; Partnerships Between Banks and Fintech Startups; Emerging Trends: Regtech, DeFi, Open Banking; Global Regulatory Frameworks and Fintech Sandboxes. (6 hours)

**Textbooks:**

1. NA

**References:**

1. NA

## 16.31 MB 554 : Blockchain for Business

### Course Code : MB 554

### Course Name : Blockchain for Business

L-T-P-C : 2-0-0-2
Intended for : MBA
Prerequisite : None
Mutual Exclusion: None
Approval: 55th BoA

### Course Contents

- **Introduction to Blockchain**: Basic ideas behind blockchain, its purpose, how it is changing the landscape of Business, Enterprise Blockchain, Why Blockchain matters? Public vs Private vs Permissioned Blockchains and use cases, Blockchain Questions from Business and Technology Leaders, Blockchain as a Service. (4 Hours)
- **Cryptographic Concepts Required**: Confidentiality, Integrity, Authentication, Mathematics, Symmetric key Cryptography-Stream and block ciphers, Asymmetric key Cryptography, Discrete logarithm, RSA, Hash function, Digital Signature - ECDSA. (4 Hours)
- **Distributed Consensus**: The real need for mining – consensus – Nakamoto consensus, Proof of Work, Proof of Stake, Proof of Burn, Difficulty Level, Byzantine Generals Problem, Byzantine fault tolerance, Sybil Attack, Energy utilization and alternate, Business applications (appropriate case studies, use cases and situation analysis). (4 Hours)
- **Cryptocurrencies – business use cases of blockchain technology**: Introduction to Cryptocurrency, what is a Bitcoin? Double Spending Problem, Bitcoin Mining, Transactions, The Bitcoin network, Bitcoin payments, Bitcoin ICO- Advantages and Disadvantages, Ethereum and its basic Features, The Ethereum network, Components of the Ethereum ecosystem, Ethereum Virtual Machine, Gas, Applications Built based on Ethereum, ETH, Smart Contracts, Smart contract templates, DApp, Business applications (appropriate case studies, use cases and situation analysis). (8 Hours)
- **Introduction to Hyperledger**: Projects under Hyperledger, Permissioned Blockchain and use cases, Hyperledger as a protocol, The reference architecture, Privacy and confidentiality, Scalability, Hyperledger Fabric. (4 Hours)
- **Blockchain Use Cases**: Supply Chain Management, E-Governance, Land Registration, Medical Information Systems, and others. (4 Hours)

### Textbooks:

1. NA

**References:**


1. Narayanan, A., Bonneau, J., Felten, E., Miller, A., & Goldfeder, S., **Bitcoin and cryptocurrency technologies: a comprehensive introduction**, Princeton University Press, 2016.

2. Arun, J. S., Cuomo, J., & Gaur, N., **Blockchain for business**, Addison-Wesley Professional, 2019.

3. Nakamoto, S., **Bitcoin: A peer-to-peer electronic cash system**, Decentralized business review, 2008.

4. Tyagi, S. S., & Bhatia, S. (Eds.)., **Blockchain for Business: How it Works and Creates Value**, John Wiley & Sons, 2021.

5. Forouzan, B. A., & Mukhopadhyay, D., **Cryptography and network security** (Vol. 12), Mc Graw Hill Education (India) Private Limited, 2015.

6. Bashir, I. (2017). Mastering blockchain. Packt Publishing Ltd.


## 16.32 MB 555 : Deep Learning for Business Applications

**Course Code : MB 555**

**Course Name : Deep Learning for Business Applications**

L-T-P-C : 2-0-0-2
Intended for : MBA
Prerequisite :
Mutual Exclusion : NA
Approval: 54th BoA

**Course Contents**

- **Deep Learning Basics**: History of Deep learning, Mathematics behind deep learning, activation functions, and their derivatives, Loss functions, Deep networks, and fully connected networks, variations of gradient descent, Regularization in Networks. (4 Hours)

- **Autoencoders**: Encoding, layer-wise pretraining, types of auto-encoders, Autoencoders for finance applications. (4 Hours)

- **Convolutional Neural Networks**: Convolution basics, filters, padding, multi-dimensional convolution, and convolution layers, pooling, striding, and transposed convolution, Applying filters for image-identification-related applications. (6 Hours)

- **Recurrent Neural Networks**: Recurrent neural network basics, dealing with language, training recurrent neural networks, long short-term memory, RNN for forecasting. (4 Hours)

- **Reinforcement Learning**: Basics of reinforcement learning and its structure, the multi-arm bandit problem, the game of Nim, Temporal difference learning, and Q-learning. (6 hours)

- **GAN**: Introducing GAN, forging concepts, forging with neural networks. (4 Hours)
- **Presentation**: (2 hours)

**Textbooks:**

1. NA

**References:**


1. J. Krohn, G. Beyleveld and A. Bassens, **Deep Learning Illustrated**, Pearson India Education Services Ltd, 2020.
2. Nikhil Buduma and Nicholas Locascio, **Fundamentals of Deep Learning: Designing Next- Generation Machine Intelligence Algorithms**, Shroff Publishers, 2017.
3. Ian Goodfellow, Yoshua Benagio and Aaron Courville, **Deep Learning**, MIT Press, October 2016.
4. Armando Vieira and Bernardete Ribeiro, **Introduction to Deep Learning Business Applications for Developers: From Conversational Bots in Customer Service to Medical Image Processing**, Apress, 2018.
5. Eugene Charniak, **Introduction to Deep Learning**, MIT Press, 2019
6. Terrence J. Sejnowski, **The Deep Learning Revolution**, MIT Press, 2019
7. M Gopal, **Deep Learning**, Pearson India Education Services Ltd, 2022


## 16.33 MB 556 : Natural Language Processing for Business

**Course Code : MB 556**

**Course Name : Natural Language Processing for Business**

L-T-P-C : 2-0-0-2
Intended for : MBA
Prerequisite :
Mutual Exclusion : NA
Approval: 54th BoA

**Course Contents**

- **Fundamentals of Natural Language Processing**: Defining NLP and its tasks, history of NLP, Approaches to NLP, Understanding language, its syntax, structure and semantics, Language as data, Popular NLP applications. (4 Hours)
- **Text Representation, Preprocessing, and Transforming Models**: Information extraction and Text summarization, preprocessing: tokenization, Stemming, lemmatization, model building and evaluation, TF-IDF: Vectorizing, Bag of words, n-grams, Zipf's Law. (6 Hours)

- **Machines Understanding Words**: Embeddings: Text understanding, Representational Embeddings, Procedural Embeddings: Words to Vectors and Documents to Vectors, Textual Similarity. (6 Hours)
- **Deep Learning for NLP**: Sequential NLP and Episodic memory for NLP, Transformer Architecture, Transformer Encoder and Decoder, Attention mechanism, Transfer learning in NLP. (4 Hours)
- **Conversational AI**: Conversational AI Basics, Chatbots and Utterances, Taxonomy of chatbots, dialog and response generation. (6 hours)
- **NLP Applications**: Sentiment analysis, Content recommendations, NLP in healthcare, Supply chain, Law, Telecommunication, Education and Research. (4 Hours)

**Textbooks:**

1. NA

**References:**


1. Jyotika Singh, **Natural Language Processing in the Real-World: Text Processing, Analytics, and Classification**, CRC Press, Chapman & Hall, 2023.
2. Ankur A. Patel and Ajay Uppili Arasanipalai, **Applied Natural Language Processing in the Enterprise: Teaching Machines to Read, Write & Understand**, O'Reilly Media, Inc., 2021.
3. Vajjala, S., Majumder, B., Gupta, A. & Surana, H., **Practical Natural Language Processing**, O'Reilly Media, Inc. 2020.
4. Masato Hagiwara, **Real-World Natural Language Processing: Practical applications with deep learning**, Manning Publications Co., 2022.
5. Dipanjan Sarkar, **Text Analytics with Python: A Practitioner's Guide to Natural Language Processing**, Apress, 2019.
6. Jacob Eisenstein, **Introduction to Natural Language Processing**, MIT Press, 2018.


## 16.34 MB 559 : Fuzzy Logic for Business Decision Making

**Course Code : MB 559**

**Course Name : Fuzzy Logic for Business Decision Making**

L-T-P-C : 2-0-0-2
Intended for : MBA
Prerequisite :
Mutual Exclusion : NA
Approval: 54th BoA

**Course Contents**

- **Fuzzy Logic Concepts**: Chapter-1, Text Book. (2 Hours)
- **Operations on Fuzzy Sets**: Chapter-1&2, Reference Book 1. (2 Hours)
- **Fuzzy aggregation Operators**: Fuzzy Sets & Systems (FSS) Article. (4 Hours)
- **OWA & IOWA Operator in Decision Making**: Fuzzy Sets & Systems (FSS). (2 Hours)
- **IOWA and Other Weighted Operators**: Journal Articles. (1 hour)
- **Fuzzy Goal Programming**: Journal Articles. (2 Hours)
- **Fuzzy MCDM**: EJOR Article. (2 Hours)
- **Fuzzy Concepts in Finance, Marketing and Managerial Decision Making**: EJOR, DSS & FSS Articles. (2 Hours)
- **Fuzzy applications in Software Risk Management**: DSS & FSS Articles. (2 Hours)
- **Linguistic quantifiers and its applications to Decision Making**: EJOR, IEEE Fuzzy Systems Articles. (2 Hours)
- **Linguistic quantifiers in Recommender systems and its applications to business**: EJOR, IEEE Fuzzy Systems Articles. (2 Hours)

**Textbooks:**

1. K.H. Lee, **First course on Fuzzy theory and applications**.

**References:**

1. H. Bandmer & S. Gottwald, **Fuzzy Logic with applications**.
2. Z. Sun & G.R. Finnie, **Intelligent techniques in e-commerce**.

**Journals**

1. Fuzzy Sets and Systems
2. Decision Support Systems
3. European Journal of Operational Research
4. IEEE Fuzzy Systems

## 16.35 MB 560 : Evolutionary computation for business solutions

**Course Code : MB 560**

**Course Name : Evolutionary computation for business solutions**

L-T-P-C : 2-0-0-2
Intended for : MBA
Prerequisite :
Mutual Exclusion : NA
Approval: 54th BoA

**Course Contents**

- **Introduction to business decision making and Optimization**: Overview of business decision making, Optimization Models for business problems, Traditional approaches: Linear and Non-Linear Methods. (3 Hours)
- **Overview of probability and sampling**: Overview of probability distribution, sampling, and random number simulation. (3 Hours)
- **Non-Traditional Methods**: Introduction to Evolutionary, Swarm and Nature inspired optimization techniques, Optimization approaches for single objective decision making problem, decision making under constraints: inequality and inequality constraint handling. (8 Hours)
- **Optimization under conflicting goals**: Introduction to Multi-objective optimization, Evolutionary Approaches for Multi-objective optimization: dominance, decomposition and preference based methods. (6 Hours)
- **Hybrid Approaches**: Hybrid approaches for solving problems, evolutionary and machine learning based wrapper approaches. (2 hours)
- **Evolutionary Computation application to business decision making**: Evolutionary Computation applications in: Project Management, Planning, Scheduling, Transportation, production and operations management, finance. (6 Hours)

**Textbooks:**


1. Biethahn, Jorg, and Volker Nissen, eds., **Evolutionary algorithms in management applications**, Springer Science & Business Media, 2012.
2. Burke, Edmund K., Edmund K. Burke, Graham Kendall, and Graham Kendall, **Search methodologies: introductory tutorials in optimization and decision support techniques**, Springer, 2014.
3. Relevant research articles and business cases


**References:**


1. NA

## 16.36 MB 562 : Operations Management

### Course Code : MB 562

### Course Name : Operations Management

L-T-P-C: 2-0-0-2
Intended for : MBA
Prerequisite : None
Mutual Exclusion : None
Approval: 52nd BoA

### Course Contents

- **Introduction to Operations Management:** The scope of operations management and decision making, the historical evolution of operations management, process management, interlinkages of organisational strategy and operations management, Product Process matrix. (4 Lectures)
- **Case Studies in Operations Management:** Four case studies representing job shop, batch, assembly and process industry will be discussed to sensitize the participants on the uniqueness/challenges associated in managing various types of manufacturing/service facilities. The concepts to be discussed are process time, through-put time, response time, cycle time, capacity, bottleneck facilities, manpower productivity, capacity utilisation, set up time, batch size. (8 Lectures)
- **Project Management:** Project lifecycle, PERT and CPM, critical path, behavioural aspects of project management, resource allocation, crashing project cycle time. (4 Lectures)
- **Inventory Management:** Economic order quantity and its variations, single period inventory models, continuous review models, periodic review models, safety stock, expected lost sales. (3 Lectures)
- **Quality Management:** Foundation of modern quality management, process capability, six sigma, benchmarking, process improvements, control charts, total quality management, house of quality, eight dimensions of quality. (4 Lectures)
- **Lean Operations:** Paradigm shift in operations, lean operations, small group activities, kaizen, quality circle, variability reduction, process control, elimination of waste, Toyota production system. (3 Lectures)
- **Operations Strategy:** Competing through operations, response time, flexibility, agility, productivity, quality.(case studies). (2 Lectures)

### Textbooks:

1. William J. Stevenson, Operations Management, 12th Edition, McGraw Hill, 2015.

## 16.37 MB 570 : Product Management

**Course Code : MB 570**

**Course Name : Product Management**

L-T-P-C: 2-0-0-2
Intended for : MBA
Prerequisite : A basic course is Marketing
Mutual Exclusion : None
Approval: 52nd BoA

**Course Contents**

- **Unit 1: Introduction to Product Management** (1 hour)
  - The practice of Product Management
  - Core skills of Product Management: Communication, Organization, Research and Execution
- **Unit 2: Product Strategy** (3 Lectures)
  - What is a product
  - Types of products
  - Role of product strategy in product development
  - Factors influencing product strategy
  - Product Life cycle
  - Product Line
  - Product elimination
- **Unit 3: Competitor Analysis** (2 Lectures)
  - SWOT Analysis
  - Porter's generic strategy
  - BGC Matrix
- **Unit 4: New product development** (3 Lectures)
  - New product development Process
  - Minimum viable product approach and Minimum delightful product approach
- **Unit 5: Design Thinking** (4 Lectures)
  - Introduction: Concept and role with NPD and Innovation; Framework of Design Thinking
  - Design Thinking tools: Inspirational Design Briefing; Personas; Customer experience mapping; Boosting creativity; Stories and prototypes
  - Design thinking within the firm: Design integration; Team training and implementation; Leading for a corporate culture of design thinking;

  - Consumer responses and values: Consumer response to product forms; Diversity in responses; Future friendly designs

- **Unit 6: Product Analytics** (4 Lectures)
  - Introduction: Basic concepts of analytics; Role of analytics; Product Analytics vs Marketing Analytics; Applications of Product Analytics
  - Process and Design: Stages of product analytics process; Product analytics design; Overview of Exploratory, Descriptive and Causal analytics; Direct exploratory methods - FGD, Depth interview; Indirect exploratory methods - Projective techniques Role of Observation Methods in Product Development and Management

- **Unit 7: Product Roadmapping** (2 Lectures)
  - Key elements
  - Building product roadmaps
  - Prioritizing features in roadmaps
  - Types of roadmaps

- **Unit 8: Agile and Lean product development** (2 Lectures)
  - Significance
  - SCRUM and KANBAN

- **Unit 9: Marketing and Launch** (4 Lectures)
  - Sales and Distribution Strategy
  - Product Positioning and Branding
  - Marketing Communication
  - Product Pricing
  - Product Launch/feature launch

- **Unit 10: Product leadership** (3 Lectures)
  - Product Leader: Impact; Challenges; Being a great product leader; Hiring product leadership
  - The right leader: Startup leaders, Emerging product leader; enterprise product leader

**Textbooks:**

1. C. Merle Crawford and C. Anthony Di Benedetto, **New Products Management**, 12th Edition, Mc Graw Hill, 2021.

**References:**


1. Roman Pichler, **Strategize Product Strategy and Product Roadmap Practices for the Digital Age**, Pichler Consulting, 2016.

2. Richard Banfield, Martin Eriksson, Nate Walkingshaw, **Product Leadership**, O'Reilly Media, Inc., 2017.

3. Scott Swan, Michael G. Luchs, Abbie Griffin, **Design Thinking: New Product Development Essentials from the PDMA**, Wiley-Blackwell, 2016.


## 16.38 MB 572 : Social Analytics

**Course Code : MB 572**

**Course Name : Social Analytics**

L-T-P-C : 2-0-0-2
Intended for : MBA
Prerequisite :
Mutual Exclusion : NA
Approval: 54th BoA

**Course Contents**

- **Web and Social Media Analytics**: World Wide Web, Social media and social networks, The Foundations of Web Analytics and Social Media Analytics, Types of social media and social media analytics, The Roles of Web Analytics and Social Media Analytics, The KPIs for Web Analytics and Social Media Analytics, Social media analytics tools, Web and Social media data gathering process, KPIs for web and social media analytics. (6 Hours)

- **Social Media Text Analytics**: Types of Social media text, Social media text analytics, and tools. (4 Hours)

- **Social Media Network Analytics**: Network Types and Terminologies, Social media network types, and Network analytics tools. (4 Hours)

- **Social Media Location and Search Analytics**: Types of location analytics, Location analytics tools; Search engine types, analytics, and tools. (4 Hours)

- **Mobile Analytics**: Apps analytics and its types, mobile analytics tools. (2 hours)

- **Social Media Analytics Strategy**: Social media strategy, aligning social media and business, managing social media risks. (2 Hours)

- **Applications**: Fake news and Reviews, detection of fake reviews in social media, Social media in Healthcare. (2 Hours)

**Textbooks:**

1. NA

**References:**

1. Gohar F. Khan, **Seven Layers of Social Media Analytics: Mining Business Insights from Social Media Text, Actions, Networks, Hyperlinks Apps, Search Engine, and Location Data**, Amazon Digital Services, 2015.

2. Bernard J. Jansen, Kholoud K. Aldous, Joni Salminen, Hind Almerekhi, Soon-gyo Jung, **Understanding Audiences, Customers, and Users via Analytics: An Introduction to the Employment of Web, Social, and Other Types of Digital People Data**, Springer Nature, 2024.

3. Gohar F. Khan, **Creating Value With Social Media Analytics: Managing, Aligning, and Mining Social Media Text, Networks, Actions, Location, Apps, Hyperlinks, Multimedia, & Search Engines Data**, Createspace Independent Pub, 2018.

4. Subodha Kumar, Liangfei Qiu, **Social Media Analytics and Practical Applications: The Change to the Competition Landscape**, CRC Press, 2022.

## 16.39 MB 573 : Cloud Computing for Business

**Course Code : MB 573**

**Course Name : Cloud Computing for Business**

L-T-P-C : 2-0-0-2
Intended for : MBA
Prerequisite :
Mutual Exclusion : NA
Approval: 54th BoA

**Course Contents**

- **Intorduction to Cloud Computing**: Understanding what Computing is, Trends in Computing, Centralized vs Distributed Computing, Soft introduction to Grid, Cluster and Utility Computing, Why Cloud Computing, Introduction to Cloud Computing, Definition of Cloud, Component and Implementation of Cloud, Evolution of Cloud Computing, Cloud Characteristics, Advantages and Disadvantages of Cloud computing, Essentials, Benefits, Business and IT perspective (5 Hours)

- **Cloud Architecture and Models**: Cloud Architecture, Layered, NIST Cloud Computing Reference Architecture, Cloud Models- Service and Deployment, Cloud Service Models- laaS, PaaS and SaaS, Cloud Service Models- Public Clouds, Private Cloud, Hybrid Cloud, Community Cloud. Architectural Design Challenges, Business applications (appropriate case studies, use cases and situation analysis). (6 Hours)

- **Cloud Storage**: Storage as-a-Service, Advantages of Cloud Storage, Cloud Storage Providers, Business applications and use cases - AWS, Google App Engine, Microsoft Azure (6 Hours)

- **Security in Cloud Environment**: Cloud Secuiry Causes- Loss, Lack and Multitenancy, Taxonomy and Cloud Threat Models, Cloud Infrastructure Security, Security Boundaries in Cloud, Cloud Security Management Frameworks, Security -as-a-Service, Cloud Security Controls (4 Hours)
- **Cloud Virtualization and Adoption**: Cloud and Virtualization, Basics of Virtualization, Types of Virtualizations, Virtualization Defined, Virtualization Benefits, Cloud Pricing Models; Pay-as-you-go, Reserved Instances, Spot pricing, Use Cases, Cloud computing transition and adoption in Business applications (appropriate case studies and use cases). (7 Hours)

**Textbooks:**


1. Erl, Thomas, Ricardo Puttini, and Zaigham Mahmood, **Cloud Computing: Concepts, Technology & Architecture**, Pearson, 2013
2. Bahga, Arshdeep, and Vijay Madisetti, **Cloud Computing: A Hands-on Approach**, CreateSpace Independent Publishing Platform, 2013


**References:**


1. Rittinghouse, John W., and James F. Ransome, **Cloud Computing: Implementation, Management and Security**, CRC Press.
2. Rajkumar Buyya, Christian Vecchiola, S. ThamaraiSelvi, **Mastering Cloud Computing**, Tata Mcgraw Hill.
3. Toby Velte, Anthony Velte, Robert Elsenpeter, **Cloud Computing – A Practical Approach**, Tata Mcgraw Hill.


## 16.40 MB 574 : Cyber Securities, Ethics and Privacy

**Course Code : MB 574**

**Course Name : Cyber Securities, Ethics and Privacy**

L-T-P-C : 2-0-0-2
Intended for : MBA
Prerequisite :
Mutual Exclusion : NA
Approval: 54th BoA

**Course Contents**

- **Introduction to Cyber security**: Defining Cyberspace and Overview of Computer and Web-technology, Architecture of cyberspace, Communication and web technology, Internet, World wide web, Advent of internet, Internet infrastructure for data transfer and governance, Internet society, Regulation of cyberspace, Concept of cyber security, Issues and challenges of cyber security. Cyber security terminologies- Cyberspace, attack, attack vector, attack surface, threat, risk, vulnerability, exploit, exploitation, hacker., Protection of end user machine, Critical IT and National Critical Infrastructure, Cyberwarfare, Case Studies. (5 Hours)

- **Cyber crime and Cyber law**: Classification of cyber crimes, Common cyber crimes- cyber crime targeting computers and mobiles, cyber crime against women and children, financial frauds, social engineering attacks, malware and ransomware attacks, zero day and zero click attacks, Cybercriminals modus-operandi , Reporting of cyber crimes, Remedial and mitigation measures, Legal perspective of cyber crime, IT Act 2000 and its amendments, Cyber crime and offences, Organisations dealing with Cyber crime and Cyber security in India, Case studies. (6 Hours)

- **Social Media Overview and Security**: Introduction to Social networks. Types of Social media, Social media platforms, Social media monitoring, Hashtag, Viral content, Social media marketing, Social media privacy, Challenges, opportunities and pitfalls in online social network, Security issues related to social media, Flagging and reporting of inappropriate content, Laws regarding posting of inappropriate content, Best practices for the use of Social media, Case studies. (6 Hours)

- **Data Privacy and Data Security**: Defining data, meta-data, big data, nonpersonal data. Data protection, Data privacy and data security, Personal Data Protection Bill and its compliance, Data protection principles, Big data security issues and challenges, Data protection regulations of other countries- General Data Protection Regulations(GDPR),2016 Personal Information Protection and Electronic Documents Act (PIPEDA)., Social media- data privacy and security issues. (6 Hours)

- **Cyber security Management, Compliance and Governance**: Cyber security Plan- cyber security policy, cyber crises management plan., Business continuity, Risk assessment, Types of security controls and their goals, Cyber security audit and compliance, National cyber security policy and strategy. (5 Hours)

**Textbooks:**

1. Sumit Belapure and Nina Godbole, **Cyber Security Understanding Cyber Crimes, Computer Forensics and Legal Perspectives**, Wiley India Pvt. Ltd.

2. Henry A. Oliver, **Security in the Digital Age: Social Media Security Threats and Vulnerabilities**, Create Space Independent Publishing Platform.

**References:**

1. Dorothy F. Denning, **Information Warfare and Security**, Addison Wesley.

2. Henry A. Oliver, **Security in the Digital Age: Social Media Security Threats and Vulnerabilities**, Create Space Independent Publishing Platform.

## 16.41 MB 579 : Marketing Analytics

**Course Code : MB 579**

**Course Name : Marketing Analytics**

L-T-P-C: 2-0-0-2
Intended for : MBA

Prerequisite : A basic course is Marketing
Mutual Exclusion : None
Approval: 52nd BoA

**Course Contents**

- **Unit 1: Marketing Analytics Introduction** (5 Lectures)
  - Data Science and Marketing: Technical requirements; Trends in marketing; Applications of data science in marketing; Setting up the Python environment; Setting up the R environment
  - Data Preparation and Cleaning: Introduction; Data Models and Structured Data; Data Manipulation
  - Data Exploration and Visualization: Introduction; Identifying and Focusing on the Right Attributes; Fine Tuning Generated Insights; Visualizing Data
- **Unit 2: Descriptive and Explanatory Analysis** (8 Lectures)
  - Key Performance Indicators and Visualizations: KPIs to measure performances of different marketing effortsComputing and visualizing KPIs using Python; Computing and visualizing KPIs using R
  - Drivers behind Marketing Engagement: Using regression analysis for explanatory analysis; Regression analysis
  - Engagement to Conversion: Decision Trees and their interpretation
  - Segmentation: Approaches to Segmentation; Choosing Relevant Attributes (Segmentation Criteria); K-Means Clustering; Evaluating and Choosing the Best Segmentation Approach
  - Predicting Customer Revenue Using Linear Regression: Introduction; Regression Problems; Feature Engineering for Regression; Performing and Interpreting Linear Regression
- **Unit 3: Product Marketing and visibility** (4 Lectures)
  - Product Analytics; The importance of product analytics; Product analytics using Python; Product analytics using R
  - Recommending the Right Products: Collaborative filtering and product recommendation; Building a product recommendation algorithm
- **Unit 4: Personalized Marketing** (8 Lectures)
  - Exploratory Analysis for Customer Behavior: Customer analytics – understanding customer behavior; Conducting customer analytics, market basket analysis
  - Predicting the Likelihood of Marketing Engagement: Predictive analytics in marketing; Evaluating classification models; Predicting the likelihood of marketing engagement
  - Customer Lifetime Value: CLV; Evaluating regression models; Predicting the 3 month CLV

  - Predicting Customer Churn and retention: Introduction; Classification Problems; Logistic Regression; Creating a Data Science Pipeline, cohort analysis

- **Unit 5: Social Media and Text analysis** (3 Lectures)
  - Value to marketing; background, methods; scraping from websites; visualizing text analysis

**Textbooks:**

1. Yoon Hyup Hwang, **Hands-On Data Science for Marketing: Improve your marketing strategies with machine learning using Python and R**, Packt Publishing Limited, 2019.

**References:**

1. Mirza Rahim Baig, Gururajan Govindan, Vishwesh Ravi Shrimali, **Data Science for Marketing Analytics: A practical guide to forming a killer marketing strategy through data analysis with Python**, 2nd Edition, Packt Publishing Limited, 2021.

2. Chapman, Chris and Elea McDonnell Feit, **R for Marketing Research and Analytics**, Springer, 2019.

## 16.42 MB 579 : Marketing Analytics

**Course Code : MB 579**

**Course Name : Marketing Analytics**

L-T-P-C : 2-0-0-2
Intended for : MBA
Prerequisite :
Mutual Exclusion : NA
Approval: 54th BoA

**Course Contents**

- **Module I: Introduction** (6 Hours)
  - **Sessions 1&2**: Marketing analytics and its evolution, an overview of consumer behavior and marketing strategy, Why and what of marketing analytics, effective marketing decisions
  - **Sessions 3&4**: Tools and Technologies for enabling marketing analytics and marketing analytics challenges Overview of various tools and techniques with examples, using class study materials Fundamentals/theory of marketing analytics, using class study materials.

- Readings:
  - Keep Up with Your Quants (HBR: R1307L)

  - Why Marketing Analytics Hasn't Lived Up to Its Promise (HBR, H04BYL)

- Module 2 Understanding Customers (6 Hours) Overview of the Marketing fundamentals using class study materials.
  - Sessions 5: Introduction to understanding varying needs and preferences of customers: static and dynamic customers' needs variations; Analysing Static need Variations: Segmentation, Targeting, and Positioning (6 Hours)
  - Sessions 6: Cluster analysis for segmentation
  - Sessions 7&8: Discriminant analysis
  - Sessions 9&10: Competitive positioning through perceptual and preference mapping
- Reading:
  - Gupta, S. (2014). Segmentation and Targeting (HBSP 8219)
- Activity: Data-based exercise using SPSS. Reading: Cluster Analysis for Segmentation (Darden Business Publishing: UV0745)
- Reading:
  - Mapping your competitive positioning (HBR: R0711G)
- **Module 3 Customer Selection: RFM Analysis and Customer Lifetime Value** (5 Hours)
  - Sessions 11&12: Analysing Dynamic needs of customers: RFM Analysis: Introducing RFM analysis, RFM analysis for marketing, RFM analysis for customer selection
  - Fundamentals of RFM Analysis, using class study materials. Reading: The Dark Side of Customer Analytics (HBR: R0705X) Activity: Data-based exercise using SPSS.
  - Sessions 13: Introducing customer lifetime value, The Present Value of the Future Cash Flows Attributed to the Customer Relationship, Retention, and Customer Lifetime
  - Fundamentals of CLV, with examples, using class study materials. Reading: Marketing analysis toolkit: Customer Lifetime Value Analysis (HBS: 9-511-029) by Thomas Steenburgh and Jill Avery
  - Sessions 14&15: Customer lifetime value for selecting and managing customers.
  - Case: Rosewood Hotels & Resorts: Branding to Increase Customer Profitability and Lifetime Value (HBS2087)
- Module 4 **Customer Insights: Sustainable Competitive Advantage** (4 Hours)
  - Sessions 16&17: Basics of sustainable competitive advantage: what and why of sustainable competitive
  - Fundamentals of Marketing Research, using class study materials.

**Textbooks:**

1. Hair, Harrison and Ajjan, **Essentials of Marketing Analytics**, McGraw Hill Publication. (eBook/Connect version only).
2. Hair, Black, Babin and Anderson, **Multivariate Data Analysis**, 8th Edition.

**References:**

1. NA

## 16.43 MB 580: AI in Finance

**Course Code : MB 580**

**Course Name : AI in Finance**

L-T-P-C :
Intended for : MBA (DS & AI)
Prerequisite :
Mutual Exclusion:
Approval: 52nd BoA

**Course Contents**

- Introduction to financial markets and trading instruments. Valuation of fixed income securities and common stocks, introduction to portfolio theory and asset pricing models, cost of capital.
- Market efficiency and risk preferences Introduction to portfolio management. Modern portfolio theory. Capital Asset Pricing Model (CAPM) and Factor Models. Portfolio management strategies and performance measures.
- Introduction to Algorithmic Trading, technical analysis and trend determination, Dow theory, moving averages, momentum indicators, classical price patterns. AI and machine learning in trading, and portfolio management, regression and classification algorithm applications in security analysis, forecasting, and prediction. Introduction to HFT. Algorithmic trading with Machine Learning and Technical analysis strategies. Advanced time-series regression algorithms, panel regression, quantile regression, ARMA/ARIMA models, mean reverting trading strategies with vector error correction models and cointegration, model risk management, back testing, model validation, and stress testing. Advanced timeseries algorithms for financial risk-management, Value-at-risk, Expected Shortfall, coherent risk measures.

**Books and references**

1. M. Dixon, I Halperin, and P. Bilokon, **Machine Learning in Finance**, Springer.
2. Marcos Lopez, **Advances in Financial Machine Learning**, Wiley.
3. Marcos Lopez, **Machine Learning for Asset Managers**, Cambridge University Press.

4. Stefan Jansen, **Machine Learning for Algorithmic Trading**, 2nd Edition.
5. Elton & Gruber, **Modern Portfolio Theory**, 9th Edition, Wiley.
6. Reilly, Frank,K., **Investment Analysis and Portfolio Management**, 5th Edition, Dryden.

## 16.44 MB 580 : AI for Finance

**Course Code : MB 580**

**Course Name : AI for Finance**

L-T-P-C : 2-0-0-2
Intended for : MBA
Prerequisite :
Mutual Exclusion : NA
Approval: 54th BoA

**Course Contents**

- **Introduction to AI in Finance**: Overview of AI and Machine Learning Applications in Finance; Big Data and Cloud Computing in Financial Analysis; Fundamental Machine Learning Techniques: Regression, Classification; Ethical Implications of AI in Financial Services. (4 Hours)
- **Data Collection and Preparation**: Financial Data Sources: Market, Transactional, and Alternative Data; Preprocessing Financial Data: Cleaning and Normalization; Feature Engineering and Dimensionality Reduction Techniques; Time-Series Data Management. (6 Hours)
- **Predictive Modeling and Algorithmic Trading**: Building Predictive Models for Market Forecasting; Supervised and Unsupervised Learning Applications; Trading Algorithms and High-Frequency Trading; Sentiment Analysis of Financial News and Social Media. (6 hours)
- **Risk Management and Fraud Detection**: AI Techniques in Credit Risk Modeling; Fraud Detection Algorithms: Outlier Detection and Anomaly Detection; Portfolio Risk Management with Machine Learning; Stress Testing and Scenario Analysis. (6 hours)
- **Advanced Topics and Emerging Trends**: Deep Learning Models: Neural Networks, LSTM; Reinforcement Learning for Portfolio Optimization; Natural Language Processing in Financial Document Analysis; Regulatory Compliance with AI: Regtech and Explainability. (6 hours)

**Textbooks:**

1. NA

**References:**

1. NA

## 16.45 MB 581 : Leadership lessons from Indian Knowledge Systems

**Course Code : MB 581**

**Course Name : Leadership lessons from Indian Knowledge Systems**

L-T-P-C : 2-0-0-2
Intended for : MBA
Prerequisite :
Mutual Exclusion : NA
Approval: 54th BoA

**Course Contents**

- **Leadership Insights from Bhagavad Gita**: (14 hours)
  - Dealing with Dilemmas of life (Chapter 1 of Bhagavad Gita)
  - Desiphering the problem of Identity (Chapter 2 of Bhagavad Gita)
  - Principles governing our Action and focusing on excellence: lessons from Karma Yoga (Chapter 3 and 5 of Bhagavad Gita)
  - Understanding the human mind and art of controlling the mind: Lessons from Dhyana Yoga (Chapter 6 of Bhagavad Gita)
  - Understanding the Psycho-physical constitution, developing qualities to be a good leader and building leadership character (Chapter 7, 14 and 17 of Bhagavad Gita)
  - Transformational Leadership (Chapter 9, 16 and 18 of Bhagavad Gita)
- **Leadership Insights from Ramayan**: (8 Hours)
  - Increasing happiness quotient through detachment (Inspiration from Lord Rama'a action while being exiled)
  - Enhancing Emotional quotient and intricacies of relationship (Inspiration from relationship among Ram, Laxman, Bharat, Satrughna, Sita, Hanuman)
  - Servant Leadership (The life of Hanuman in Sundarkand)
  - Attributes of a king maker (The life of Jambavan)
  - Overcoming challenges with exemplary qualities and character (Hunuman's Journey to Lanka)
  - Dharma above everything else (Actions of Lord Ram)
- **Leadership Insights from Mahabharat**: (6 Hours)
  - Sacrifice as a way of life (Lessons from the life of Kunti Maharani)
  - Justice and fairness: Fearless Leadership (Lessons from the life of Vidura/Vidura Niti)
  - Motivated blindness and the consequences (Lessons from the life of Dhritarashtra)

– Principle vs Rules (Lessons from the Activities of Lord Krishna)
– The double-edged sword of Darma (Lessons from life of Karna)
– Endeavour and Mercy: The formula for success (The life of Pandavas)
– Service vs Enjoyment (Lessons from Pandavas and Kauravas)

**Textbooks:**

1. Prabhupada, ACBS, **Bhagavad Gita as it is**, Bhakti Vedanta Book Trust, India, 1973.
2. Vilas, Shubha, **OPEN EYED MEDITATIONS**, Finger Print Publications, India, 2016
3. Vyasa, **Krishna Dwipayana, Vidura Niti**, Gorakhpur Geeta Press, 2025

**References:**

1. Vilas, Shubha, **Ramayana: The game of life** (Book1, 2, 3, 4, 5, and 6), Jaico Publishing House, India, 2017, 2029, & 2021.
2. Dharma, Krishna, **Ramayana**, Mandala Publishing, India, 2020.
3. Dharma, Krishna, **Mahabharata: The Greatest Spiritual Epic of All Time**, Mandala Publishing, India, 2020.
4. Valmiki, **Shrimad Valmikiya Ramayan** (Part 1 & 2), GITA PRESS GORAKHPUR, 2022
5. Ganguli, K. M., **The Complete Mahabharata in English**, 2017.

## 16.46 MB 582 : Consumer Behavior

**Course Code : MB 582**

**Course Name : Consumer Behavior**

L-T-P-C : 2-0-0-2
Intended for : MBA
Prerequisite :
Mutual Exclusion : NA
Approval: 54th BoA

**Course Contents**

- **Introduction to Consumer Behavior**: Consumer behavior and Technology, Consumer Value, Satisfaction and Retention, Market Segmentation, targeting and Real-Time Bidding. (2 Hours)
- **The Consumer as an Individual**: Consumer Motivation and Personality, Consumer Perception and Positioning, Consumer learning, Consumer Attitude formation and Change. (8 Hours)

- **Communication and Consumer Behavior**: Persuading Consumers, Print, Broadcast, and Social Media, Reference Groups, Communities, Opinion Leaders, and Word of Mouth (7 Hours)
- **Social and Cultural Settings**: Family and Consumer Socialization, Family-Decision-Making and Member's Roles, Culture's Role and Dynamics, Measuring Cultural Values, and Core cultural Values, Cross-Cultural Consumer Behavior (7 Hours)
- **Consumer Decision Making and Ethics**: Consumer Decision Making and Diffusion of Innovation, Consumer Gifting Behavior, Marketer' ethics and Social Responsibility. (4 Hours)

**Textbooks:**

1. Schiffman, Wisenblit, and Kumar, **Consumer Behavior**, 12th Edition, Pearson, India, 2018

**References:**


1. Petty, R. E., & Cacioppo, J. T. (1986), The Elaboration Likelihood Model of Persuasion," in Communication and Persuasion (pp. 1-24). Springer, 1986.
2. NY Mayyasi, Alex and Priceonomic, How Subarus Came to be Seen as Cars for Lesbians, The Atlantic, 2016.
   (a) https://www.theatlantic.com/business/archive/2016/06/howsubarusca me-to-be-seen-as-cars-for-lesbians/488042/
3. Cialdini, R. B., The science of persuasion, Scientific American, 284(2), 76-81, 2001.
4. Friestad, Marian, and Peter Wright, The Persuasion Knowledge Model: How People Cope with Persuasion Attempts, Journal of Consumer Research, 21(1), 1-31, 1994.
5. McCracken, G., Who is the celebrity endorser? Cultural foundations of the endorsement process, Journal of consumer research, 16(3), 310-321, 1989.
6. Dinnin Huff, A., Humphreys, A., & Wilner, S. J., The Politicization of Objects: Meaning and Materiality in the US Cannabis Market. Journal of Consumer Research, 2021.
7. Hsee, C. K., The evaluability hypothesis: An explanation for preference reversals between joint and separate evaluations of alternatives. OBHDP, 67(3), 247-257, 1996.
8. Hsee, C. K., & Hastie, R., Decision and experience: why don't we choose what makes us happy?, Trends in cognitive sciences, 10(1), 31-37, 2006.
9. Belk, R. W., Possessions and the extended self. JCR, 15(2), 139-168, 1988.
10. Savary, J., & Dhar, R., The uncertain self: How self-concept structure affects subscription choice, Journal of Consumer Research, 46(5), 887-903, 2020.

11. Escalas, J. E., & Bettman, J. R., Self-construal, reference groups, and brand meaning, Journal of consumer research, 32(3), 378-389, 2005.

12. Gourville, J., & Soman, D., Pricing and the psychology of consumption, HBR, 2002.

13. Gourville, J. T., Pennies-a-day: The effect of temporal reframing on transaction evaluation. Journal of Consumer Research, 24(4), 395-408, 1998.

14. Hamilton, R. W., & Srivastava, J., When 2+ 2 is not the same as 1+ 3: Variations in price sensitivity across components of partitioned prices. JMR, 45(4), 450-461, 2008.

## 16.47 MB 583 : Digital Marketing

**Course Code : MB 583**

**Course Name : Digital Marketing**

L-T-P-C : 2-0-0-2
Intended for : MBA
Prerequisite :
Mutual Exclusion : NA
Approval: 54th BoA

**Course Contents**

- **Introduction to Digital Marketing**: The Online Market Space, Strategies and Models of virtual world. Online Consumer Behavior, user experiences, Online B2B & B2C behavior. (3 Hours)

- **Search Engine Optimization**: How Search Engine works, SEM components, PPC advertising with Google ad words, SEO success factors (On-Page and Off-Page Techniques), Google analytics, Content Marketing, Developing valuable content, Content strategy, Search Engine Marketing. (4 Hours)

- **Display Advertising**: Real time bidding, Executing display advertising, Video and other rich media. (7 Hours)

- **E- Mail Marketing**: Types of E- Mail Marketing, Email Automation, Lead Generation, Integrating Email with Social Media and Mobile, Measuring and maximising email campaign effectiveness. (3 Hours)

- **Online Reputation Management**: Social Reviews and Ratings, Word of Mouth, User- Generated Content, Influencer Marketing, Meme Marketing, User's privacy and Security.(3 Hours)

- **Social Media Marketing**: Social Media Channels, Facebook, Twitter, Linkedin, Instagram, other Social Media channels, Leveraging Social media for brand conversations and buzz. Successful /benchmark Social media campaigns, Virtual Brand Communities, and Gamification. (3 Hours)

- **Mobile Marketing**: Mobile Inventory/channels, Location based; Context based; Coupons and offers, Mobile Apps, Mobile Commerce, SMS Campaigns. Profiling and targeting. (3 Hours)
- **Web Analytics and Channel Attribution Strategies**: Data Collection, Key Metrics, Outcome Analysis, Experience Analysis, Multi-channel attribution, last interaction; firsts interaction; linear; Time-Decay; Position Based Attribution Models, and Types of tracking Codes. (3 Hours)
- **Emerging Technologies in Digital Marketing**: AI in Advertising, Chatbots, Micro-Moment Marketing, Virtual Reality, Augmented Reality, and Marketing Automation. (3 Hours)

**Textbooks:**

1. Gupta, Seema, **Digital Marketing**, McGraw Hill Education, 2018.

**References:**


1. The consumer decision journey, McKinsey Quarterly, 2009.
   (a) https://www.mckinsey.com/capabilities/growth-marketing-and-sales/our-insights/theconsur decision-journey
2. American's Internet Access: 2000-2015, Pew Research Center, 2015.
   (a) https://www.mckinsey.com/capabilities/growth-marketing-and-sales/our-insights/theconsur decision-journey
3. Social Media Usage: 2005-2015, Pew Research Center, 2015.
   (a) https://www.pewresearch.org/internet/2015/10/08/social-networking-usage-2005-2015/
4. Search Engine Optimization Starter Guide, Google.
   (a) https://www.mckinsey.com/capabilities/growth-marketing-and-sales/our-insights/theconsur decision-journey
5. Google analytics tutorial. https://support.google.com/analytics/answer/4553001
6. Did eBay just prove that paid search ads don't work? Harvard Business Review, 2013.
   (a) https://hbr.org/2013/03/did-ebay-just-prove-that-paid/
7. Avinash Kausik, Multi-Channel Attribution Modeling: The Good, Bad and Ugly Models, 2013.
   (a) http://www.kaushik.net/avinash/multi-channel-attribution-modeling-good-badugly-models/
8. How Google Edged Out Rivals and Built the World's Dominant Ad Machine: A Visual Guide, WSJ, 2019.

   (a) https://www.wsj.com/articles/how-google-edged-out-rivals-andbuilt- the-worlds-dominant-ad-machine-a-visual-guide-11573142071

9. A Step-by-Step Guide to Smart Business Experiments, Harvard Business Review, 2011.
   (a) https://hbr.org/2011/03/a-step-by-step-guide-to-smart-business-experiments

10. Whose and what chatter matters? The effect of tweets on movie sales, Huaxia Rui, Yizao Liu, and Andrew Whinston, 2013.
    (a) http://www.sciencedirect.com/science/article/pii/S0167923612003880

11. How Often Should You Post on Social Media? Benchmarks for 9 Different Industries, HubSpot Blogs, 2015.
    (a) http://blog.hubspot.com/marketing/social-media-frequencyindustry- benchmarks

12. Xueming Luo et al., Mobile Targeting, 2014.
    (a) https://pubsonline.informs.org/doi/abs/10.1287/mnsc.2013.1836

## 16.48 MB 584 : Supply Chain Management

**Course Code : MB 584**

**Course Name : Supply Chain Management**

L-T-P-C : 2-0-0-2
Intended for : MBA
Prerequisite :
Mutual Exclusion:
Approval: 54th BoA

**Course Contents**

- **Introduction to Supply Chain and Inventory Management**: Introduction: Supply chain management objectives and requirements, Supply Chain Management Cycle, Inventory and logistics management and their importance in supply chain management, Different types of inventory control systems. (6 Hours)
- **Demand Forecasting**: Introduction to demand forecasting and its role, qualitative and quantitative forecasting methods, components of a demand forecast, demand in a supply chain using time-series data, estimation of forecasting error. (4 Hours)
- **Inventory planning and Issues in Supply Chain Management**: Cycle Inventory, Economies of Scale, Inventory cost estimation, Safety Inventory, its levels and Risk, Pooling Echelons in SCM, Manufacturing Resource Planning, Just-in-time, Replenishment Policies, Pull and Push Systems, Levels of Product availability. (8 Hours)

- **Designing of Supply Chain Network**: Strategic framework for design of a distribution network, Importance of distribution network and factors influencing the distribution networks, Methodologies for network design and distribution planning and their Performance, Trade-Offs, pricing issues, and alternatives. (4 Hours)
- **Supply Chain Management Applications**: Lean Supply Chain Management, Supply Chain Management in Automobile Industry, Agricultural Supply Chain Management. (6 Hours)

**Textbooks:**

1. Sunil, Chopra, **Supply Chain Management: Strategy, Planning, And Operation**, 5th Edition, Pearson India, 2013.
2. Jacobs, F. Robert, and Richard B. Chase, **Operations and supply chain management**, McGraw-Hill, 2018.
3. Relevant research articles and business cases

**References:**

1. Bowersox, Donald J., David J. Closs, M. Bixby Cooper, and John C. Bowersox. Supply chain logistics management. Mcgraw-hill, 2020.
2. Heizer, Jay, Barry Render, and Chuck Munson. Operations management: sustainability and supply chain management. Pearson, 2020.

## 16.49 MB 592: Management Science In Practice – A Modelling And Case Studies Approach With Ms-Excel.

**Course Code : MB 592**

**Course Name : Management Science In Practice – A Modelling And Case Studies Approach With Ms-Excel.**

L-T-P-C :
Intended for : MBA (DS & AI)
Prerequisite :
Mutual Exclusion:
Approval: 52nd BoA

**Course Contents**

Management Science concepts including Multiple Criteria Decision Analysis will be used as appropriate to solve various application oriented problems in the management. The course contains the problems in following applications as short but real cases along with the theoretical concepts therein. Ms-Excel will be used to model and solve all the case problems in the following ares

**The session details:**

1. Work force Planning in call centres when the call centre requires dealing with multiple languages.

2. Banking Applications – Net Banking
3. Investment Planning
4. Cash Flow management
5. Personal Scheduling in Airlines
6. Corporate Financial Planning
7. Advertising - Media Planning in the web
8. Supply Chain Management
9. Production and Manufacturing
10. Inventory Management
11. Predictive Maintenance planning
12. Product planning and allocation in automobile industries.
13. Oil exploration planning in Oil and Gas Industries
14. Construction projects
15. Management Science in Indian Train Reservation
16. Indian General Election Planning
17. Airport Security Management-with a special reference to WTC
18. Hub Management in Airline Industries
19. Foreign Currency Trading ( currency arbitrage)
20. Multicriteria Decision Making in Marketing Management.

**Textbooks:**

1. F.S. Hillier and M.S. Hillier, **Introduction to Management Science- A modelling and case studies approach**
2. Winston and Albright, **Practical Management Science**.
3. **Essentials of Business Analytic**.

**References:**

NA

# 17 Mechanical Engineering Courses

## 17.1 ME 100 : Reverse Engineering

**Course Code: ME 100**

**Course Name: Reverse Engineering**

Intended for: B.Tech
L-T-P-C: 0-0-2-1
Intended for: B. Tech ME
Mutual Exclusion: None
Approval: 53rd BoA

**Course Contents**

**Laboratory Modules:**

Need of reverse engineering, Methodologies for Reverse Engineering, understanding of Reverse Engineering through example, reasons for reverse engineering, process for Reverse Engineering, Phases of Reverse. Engineering, conceptual System Reasons for Reverse Engineering, Difficulties in Reverse Engineering, Levels of abstraction: Application level, Functional level, Structural level. Detailed study of Reverse Engineering for Branch Specific learning Dissemble the existing selected artefact/ product/ component/ process/ system to study technical aspects and design detail. Students will be assigned a their specialization specific product to do hands on of Reverse Engg and to draft a comprehensive report. An suggestive list of products that will be studied through reverse engineering will be compiled as reference for course instructor.

**Course Outcomes:**

After completion of this course, student will be able to

- Understand the problem in the existing process.
- Collect the large number of data/ information for the product
- Depth analyze of the products and extraction of real time data
- Understand the principles behind the design of the product, ways to redesign and improve the performance of the system.

**Textbooks:**

1. Robert W. Messler Jr., **Reverse Engineering: Mechanisms, Structures, Systems & Materials**, McGraw Hill, 2014.

## 17.2 ME 201: Manufacturing Technology - I

**Course Code: ME 201**

**Course Name: Manufacturing Technology - I**

L-T-P-C: 2-0-2-4

Prerequisite: ME 102

**Objective**: To impart knowledge about the process principles, equipment, and applications of different forming processes, machining operations, and grinding processes.

Approval: 5th Senate

**Course Content:**

- **Introduction**: Classification of different manufacturing processes, application areas and limitations, selection of a manufacturing process.
- **Press Working of Sheet Metal**: Types of presses, drives and feed mechanisms; Operations: Shearing, bending, spinning, embossing, blanking, coining and deep drawing; Die materials, stock layout, compound and progressive dies and punches, construction details of die set, auxiliary equipment, safety devices.
- **Machine Tools and Operations**: Classification of machining processes and machine tools, cutting tool materials, different types of cutting tools, nomenclature of single point and multi point cutting tools, concept of cutting speed, feed and depth of cut, use of coolants, constructional details including accessories and attachment, operations, setting and tooling for capstan and turret lathes, drilling, boring and broaching machines, milling operations.
- **Grinding**: Operations and applications of surface, cylindrical and centreless grinding processes, dressing, truing and balancing of grinding wheels, grading and selection of grinding wheels.

**Suggested Books:**


1. DeGarmo, J. T. Black, Ronald A. Kohser, **Materials and Processes in Manufacturing**, PHI, 1997.
2. Serope Kalpakjian, and Steve R. Schmid, **Manufacturing Engineering and Technology**, Pearson, 2000
3. Groover, M. P., **Fundamentals of Modern Manufacturing**, John Wiley and Sons, 2002.
4. Lindberg, R. A., **Processes and Materials of Manufacture**, PHI, 1990.
5. Rao, P. N., **Manufacturing Technology**, Vol - 2, TMH.


## 17.3 ME 203: Energy Resources & Conversion - I

**Course Code: ME 203**

**Course Name: Energy Resources & Conversion**

L-T-P-C: 3-0-0-3

Pre-requisites: Nil

Approval: 5th Senate

**Course Contents:**

- **Introduction**: Energy resources spectrum, Renewable and non Renewable energy Sources, consumption pattern in various sectors, Efficiency of energy resources, load demand, and economics (4 hrs)
- **Coal**: Classification, properties, combustion, carbonization, liquefaction and gasification, Electricity generation from coal(4 hrs)
- **Liquid fuels**: various type of fuels, properties and handling (3 hrs)
- **Gaseous fuel**: CNG, LNG, and LPG (3 hrs)
- **Nuclear Energy**: Potential, Fusion and fission processes and nuclear reactor (4 hrs)
- **Wind**: potential and utilization (2 hrs)
- **Solar Energy**: Solar radiation measurements, Solar Thermal: Flat plate and focusing collectors, solar space heating and cooling, solar pond, Solar Photovoltaic: Solar cells and storage (5 hrs)
- **Hydropower**: classification, components of hydropower generation systems (3 hrs)
- **Biomass Energy**: Biomass Types, characterization, conversion routs, bio chemical (4 hrs)
- **Other Energy Resources**: Hydrogen, Fuel Cells and other energy sources (4 hrs)
- **Energy Conservation**: Waste heat recovery, use of low grade hot streams, concept of vapour recompression, flash vaporization, heat pipe, energy targeting by pinch method (6 hrs)

**Text Books / References:**

1. Rao S and Parulekar BB, **Energy Technology: non conventional, renewable and conventional**, Khanna Publishers, 1995.
2. Rai, GD, **Non-conventional energy sources**, Khanna Publishers, 1994.
3. **World Energy Outlook 2006**, International Energy Agency, France, 2006.
4. **Electricity in India**, International Energy Agency, France, 2002.
5. Twidel, J. and Tonyweir, **Renewable Energy Resources**, Second Edition, Taylor & Francis, 2006.
6. Manwell, JF et.al., Wiley, **Wind Energy Explained – Theory, Design & Application**, 2002.
7. Sukhatme, S P, **Solar Energy: Principles of Thermal Collection and Storage**, Second Edition, Tata McGraw-Hill Publishing Company Ltd, 2008.
8. Takahashi, Peytrick & Trenka, Andrew; Wiley **Ocean Thermal Energy Conservation**, 1996.
9. Teddy, DIRECTORY, TERI, New Delhi, 2006.

## 17.4 ME 204: Materials Science for Engineers

**Course Code: ME 204**
**Course Name: Materials Science for Engineers**

L-T-P-C: 3-0-0-3
Prerequisite: None
Students intended for: B.Tech.
Elective or Core: Core
Approval: 2nd Senate

**Course contents**

A **Structural Applications**

i Static structural applications –stress strain diagram, elastic, yielding and plastic behavior, properties to characterize each, application of metals, ceramics, polymers and composites in static structures like buildings, bridges, furnace structure, etc.

ii Dynamic structural applications - fatigue, creep-fatigue interaction; Application of materials in automobiles, hydroelectric and thermal power plants.

iii Manipulation of materials properties through different treatments

B **Electrical and Electronic Application**

Conductors and conductivity, Capacitors, considerations for choice of materials in different applications; metallic and organic semiconductors, p-n junctions, other devices, I-V characteristics, optoelectronic materials and devices, the considerations for the choice of materials; Magnetic materials, Dielectric materials, electrical and magnetic sensors, read- write heads, spintronic devices; superconducting materials and their applications in magnets.

**Text Books**

1. V. Raghvan, **Materials Science and Engineering- A first course**, Prentice Hall of India, New Delhi.

2. William D. Callister, Jr, **Materials Science and Engineering- An introduction**, Wiley and Sons, Inc.

**Reference Books:**

1. Kenneth G. Budinski, **Engineering Materials: Properties and Selection**, Prentice Hall, USA.

2. S. O. Kasap, **Principles of Electronic Materials and devices**, 3rd Edition, Tata-McGraw Hill Education Pvt. Ltd.

3. Ben G. Streetman and Sanjay Bannerjee, **Solid State Electronic Devices**, 5th Edition, Pearson-Prentice Hall, USA.

## 17.5 ME 205: Machine Drawing

**Course Code: ME 205**
**Course Name: Machine Drawing**

L-T-P-C: 1-0-4-3
Prerequisite: Graphics for Design
Students intended for: B.Tech.
Elective or Core: Core
Approval: 3rd Senate

**Course contents**

- **Introduction**

  Introduction to Engineering design process and drawings. Drawing standards. Computer aided drafting and use of software packages for engineering drawings

- **Detachable Fasteners**

  Screw threads, approximate and conventional representations; Specifications; Threaded fasteners: Types, forms, standard, and specifications; Drawing of temporary connections; Foundation bolts; Locking Devices: Classification, principles of operation, standard types and their proportions; Shaft Couplings: Common types, standard proportions for some couplings; Pipe Joints, common pipe connections, Cotter and Knuckle Joint

- **Permanent Fastenings**

  Rivets: Standard forms and proportions; Riveted Joints: Common types of joints, terminology, proportions and representation; Welds: Types of welds and welded joints, edge preparation, specifications, and representation of welds on drawings.

- **Assembly drawings**

  Assembly drawings with sectioning and bill of materials. Assemblies involving machine elements like shafts, couplings, bearing, pulleys, gears, belts, brackets. Detailed part drawings from assembly drawings. Engine mechanisms-assembly. Machine Tool drawings including jigs and fixtures.

- **Production drawings**

  Limits, fits, and tolerances of size and form; Types and grade, use of tolerance tables and specification of tolerances, form and cumulative tolerances, tolerance dimensioning, general tolerances; Surface quality symbols, terminology and representation on drawings, correlation of tolerances and surface quality with manufacturing techniques.

- **Schematics, process and instrumentation diagrams**

- **Structural drawings**

  examples for reading and interpretation

**Text Books/Reference Books:**


1. French, T. E., Vierch, C. J., and Foster, R. J., **Engineering Drawing and Graphic Technology**, 14th Edition, McGraw-Hill, 1993.

2. Giesecke, F. E, and Lockhart, S.D, **Technical Drawing**, 13th Edition, Prentice-Hall, 2008

3. Sideswar, N., **Machine Drawing**, McGraw-Hill, 2004.

4. Lakshminarayanan, V., and Mathur, M. L., **Text Book of Machine Drawing (with Computer Graphics)**, 12th Ed, Jain Brothers, 2007.

5. Narayana K.L., Kannaiah, P., and Venkata Reddy K, **Machine Drwaing**, 3rd Edition., New Age International Publishers, 2006.

6. Johan K. C., **Text Book of Machine Drawing**, PHI Learning Pvt, 2009.

7. SP 46: 1988 Engineering Drawing Practice for Schools and Colleges, Bureau of Indian Standards, 1988.


## 17.6 ME 206_Old (4) Mechanics of Solids

Approval: 8th Senate; OTA

**Course Outline:**

- Free body diagram, Conditions for equipment: statically determinate& indeterminate

- Mechanics of small deformation: Geometric compatibility & force deformation law (for uniaxial loads)

- Special kinds of load: Transverse loaded slender member: Sheer force & Bending moment

- Stress and Strain: Proper definition of stress and stain

- Theory of yielding

- Shaft: Circular c1oss-section shaft under uniform & varying load (torque), Twisting deformationof shaft

- Bending Stresses

- Deflection of Beam (superposition theorem), Castigliani-II theorem: Energy method (unit load method)

- Bucking of column (Brief discussion in the context of elastic instability)

## 17.7 ME 206: Mechanics of Solids

**Course Code: ME 206**
**Course Name: Mechanics of Solids**

L-T-P-C: 3-0-0-3
Prerequisite: Consent of the faculty member
Students intended for: B.Tech.
Elective or Core: Core
Approval: 3rd Senate

**Course contents**

- Free body diagram, Conditions for equipment: statically determinate & indeterminate
- Mechanics of small deformation: Geometric compatibility & force deformation law (for uniaxial loads
- Special kinds of load: Transverse loaded slender member : Sheer force & Bending moment
- Stress and Strain: Proper definition of stress and stain
- Theory of yielding
- Shaft : Circular cross-section shaft under uniform & varying load (torque), Twisting deformation of shaft
- Bending Stresses
- Deflection of Beam (superposition theorem), Castigliani-II theorem: Energy method (unit load method)
- Bucking of column (Brief discussion in the context of elastic instability)

**Text Books/Reference Books:**


1. Timoshenko S. P., and Gere J. M., **Mechanics of Materials**, 2nd Edition, CBS Publishers, 2002.
2. Crandall S. H., Dahl N. C., and Lardner T. J., **An Introduction to the Mechanics of Solids**, 2nd Edition, McGraw-Hill, 1999.
3. Hearn E. J., **Mechanics of Materials**, 3rd Edition, Pergamon, 2003.
4. Higdon A., Ohslen E. H., Stiles W. B., Weese J. A., and Riley W. F., **Mechanics of Materials**, John Wiley & Sons, 1989
5. Popov E. P., Nagarajan S., and Lu Z. A., **Mechanics of Materials**, 2nd Edition, Prentice-Hall of India, 2002.
6. Johan K. C., **Text Book of Machine Drawing**, PHI Learning Pvt, 2009.
7. SP 46: 1988 Engineering Drawing Practice for Schools and Colleges, Bureau of Indian Standards, 1988.

## 17.8 ME 209 (4) Dynamics

Approval: 5th Senate; OTA Course

**Course Outline:**

The course introduces analysis of various dynamic systems. At the end of the course, the students should be able to analyse the dynamic systems such as system of particles, kinematics of plane motion of rigid bodies, gyroscopic motion etc.

## 17.9 ME 210_Old (4) Fluid Mechanics

Approval: 5th Senate; 18th Senate; OTA

**Course Outline:**

This course is an introductory course in fluid mechanics. It begins by asking the question what constitutes a fluid. In the first part the continuum concept, various classifications of fluids are discussed. The second part introduces concepts of statics, kinematics and dynamics of fluids and underlying governing equations. Finally, solutions to various problem involving internal pipe flows and external flows are treated in the third part. Conceptsof compressibleflow and computational fluid dynamicsare introduced at the end of the course.The course also gives an opportunity to learn various methods in EXCEL and MATLAB to solve simple flow problems.

## 17.10 ME 210: Fluid Mechanics

**Course Code: ME 210**
**Course Name: Fluid Mechanics**

L-T-P-C: 2.5-0.5-0-3
Prerequisite: None
Students intended for: B.Tech.
Elective or Core: Core
Approval: 3rd Senate

**Course contents**

- **Introduction**

  definition of fluid, liquids and gases, continuum hypothesis, compressible and incompressible fluid/flow, viscosity, stress field, Newtonian and non-Newtonian fluids [6 Lectures]

- **Fluid Statics**

  Pascal's law, hydrostatic pressure, standard atmosphere, manometry, center of pressure, forces on partially and fully submerged bodies, buoyancy, metacentric height, stability, rigid body motion. [6 Lectures]

- **Fluid Kinematics**

  Lagrangian and Eulerian description of fluid motion, elementary flows, vorticity and circulation, flow lines, stream lines, stream functions, rotational and ir-rotational flows, flow visualization. [6 Lectures]

- **Fluid Dynamics**

  Newton's second law, fundamental equations of mass, momentum and energy, Reynolds transport theorem, Integral formulation of governing equations, differential formulation, Euler's equation, Bernoulli's equation, Navier-Stokes equation. [6 Lectures]

- **Internal Flows**

  fully developed flow, Couette Flow, Hagen-Poiseuille flow, flow through ducts, channels, Venturi, Orifice, flow measurements, friction factor and head loss calculations, Moody's chart, open-channel flow. [8 Lectures]

- **Dimensional Analysis**

  scaling and similarity, similitude and dimensional analysis, Buckingham $\pi$ – theorem, non-dimensional parameters, model testing. [4 Lectures]

- **External Flows**

  Boundary layer flows, flow over an aerofoil, flow over a cylinder and sphere, laminar and turbulent flows, flow separation, lift and drag, D'Alembert paradox, von Karman integral equation, displacement and momentum thickness. [4 Lectures]

**Text Books:**

1. Fox and Mc Donald, **Introduction to Fluid Mechanics**, 7th Edition, John Wiley, 2009.

2. White FM,, **Fluid Mechanics**, 6th Edition, Tata McGraw Hill, 2007.

**Reference Books:**

1. Yuan SW, **Foundations of Fluid Mechanics**, 2nd Edition, Printice Hall, 1988.

2. Streeter VL, Wylie EB and Bedford KW, **Fluid Mechanics**, 9th Edition, McGraw Hill, 1998.

## 17.11 ME 210P: Thermo-Fluids Lab

**Course Code : ME 210P**

**Course Name : Thermo-Fluids Lab**

L-T-P-C: 0-0-2-1
Intended for : UG
Prerequisite : ME210 – Fluid Mechanics
Mutual Exclusion:
Approval: 53th BoA

**Laboratory/practical/tutorial Modules:**

1. Flow Visualization
2. Validation of Bernoulli's Theorem
3. Application of Flow Measuring Devices
4. Major & Minor Losses in Pipes
5. Measurement of Pipe Friction Factor
6. Identifying Losses in Pipe Fittings
7. Static Pressure Measurement in a Wind Tunnel
8. Performance Analysis of Francis & Pelton Turbine
9. Determination of Metacentric Height
10. Measurement of Lift & Drag on an Aero-foil
11. Calibration of Various Notches
12. Momentum Eqn. Verification Using Jet Impaction
13. Vortex Flow Measurement
14. Pitot Static Tube Calibration

**Text books:**

1. J. P. Holman, **Experimental Methods for Engineers**, 7th edition, Tata McGraw-Hill 2001.
2. T.G. Beckwith, J.H. Lienhard V, R. D. Marngoni, **Mechanical Measurements**, 5th edition, Pearson Education, 2010.
3. E.O. Doebelin, **Measurement systems, Application and Design**, 5th edition, Tata McGraw-Hill, 2008
4. Fox and Mc Donald, **Introduction to Fluid Mechanics**, 7th Edition, John Wiley, 2009

## 17.12 ME 210P_57 : Fluid Mechanics Lab

**Course Code : ME 210P_57**

**Course Name : Fluid Mechanics Lab**

L-P-T-C: 0-0-2-1
Intended for: UG
Prerequisites: ME 210 Fluid Mechanics
Mutual Exclusion: None
Approval : 57th BoA

**Course Contents**

- NA

**Laboratory:**

1. Flow Visualization
2. Validation of Bernoulli's Theorem
3. Application of Flow Measuring Devices
4. Major & Minor Losses in Pipes
5. Measurement of Pipe Friction Factor
6. Identifying Losses in Pipe Fittings
7. Static Pressure Measurement in a Wind Tunnel
8. Performance Analysis of Francis & Pelton Turbine
9. Determination of Metacentric Height
10. Measurement of Lift & Drag on an Aero-foil
11. Calibration of Various Notches
12. Momentum Eqn. Verification Using Jet Impaction
13. Vortex Flow Measurement
14. Pitot Static Tube Calibration

**Text books:**

1. J. P. Holman, **Experimental Methods for Engineers**, 7th edition, Tata McGraw-Hill 2001.
2. T.G. Beckwith, J.H. Lienhard V, R. D. Marngoni, **Mechanical Measurements**, 5th edition, Pearson Education, 2010.
3. E.O. Doebelin, **Measurement systems, Application and Design**, 5th edition, Tata McGraw-Hill, 2008
4. Fox and Mc Donald, **Introduction to Fluid Mechanics**, 7th Edition, John Wiley, 2009

**References:**

1. NA

## 17.13 ME 211 (5) Analysis and Synthesis of Mechanisms

Approval: 8th Senate; OTA

**Course Outline:**

Thin film science and technology have gone through a thorough development which results in numerous new. The course introduces the basic mechanisms, synthesis of the mechanism, introduction to machine elements e.g. gears, cams, engine force analysis and balancing, gyroscope and vibrations. Strength based design part is to be tackled in the next courseon design of machine elements.

## 17.14 ME 212: Product Manufacturing Technology

**Course Code : ME 212**

**Course Name : Product Manufacturing Technology**

L-T-P-C : 2-0-3-3
Intended for : UG (Core for B.Tech Mechanical)
Perequisite : None
Mutual Exclusion:
Approval: 53rd BoA

**Course Contents**

- **Introduction**: Engineering materials, their classification, manufacturability and applications (5 Lectures)
- **PMT for Structural Applications (Metals & Alloys)**: Casting (sand casting, permanent mold casting, investment casting), forming (Rolling, Forging, Extrusion, Sheet metal operations), machining (drilling, lathe, milling), joining of metals (welding, riveting, nut-bolt assembly etc) (8 Lectures)
- **PMT for Light weight applications (Polymers)**: Classifications of plastics, blow molding, injection molding, extrusion, compression molding, vacuum forming, Additive manufacturing (3D printing and its types), laser machining, joining methods for plastics. (6 Lectures)
- **PMT for High Temperature Applications (Glasses and Ceramics)**: Powder manufacturing, mixing and blending, compacting, Sintering (with SPS), hot isostatic pressing, glass blowing (4 Lectures)
- **PMT for High Performance Applications (Composites)**: Compression molding of composites (3 Lectures)

**Textbooks:**

1. Groover, M.P., **Fundamentals of modern manufacturing: materials, processes, and systems**, John Wiley & Sons, 2020.
2. Kalpakjian, S. and Schmid, S.R., **Manufacturing engineering and technology**, Prientice Hall, 2001, 2018.

| S.No. | Equipment | Experiment | Turns |
|---|---|---|---|
| 1. | Lathe | Turning and grooving operations on mild steel rod | 1 |
| 2. | Milling, shaper machine | Facing operations on mild steel block | 1 |
| 3. | Compression molding | To demonstrate manufacturing of composites | 1 |
| 4. | Fitting | To make fillet, chamfer, drilling and tapping on mild steel flat sample | 1 |
| 5. | Welding | To perform arc welding, gas welding and spot welding and FSW | 1 |
| 6. | Sheet metal | To perform shearing, bending and riveting of galvanised iron sheet | 1 |
| 7. | Foundry | To sand cast an aluminium rod | 1 |
| 8. | CNC lathe and milling | To machine objects using CNC machining processes | 1 |
| 9. | Laser machining | To demonstrate laser machining of an acrylic sheet | 1 |
| 10. | Glass blowing | To demonstrate blowing of glass | 1 |
| 11. | Additive manufacturing | To create objects using 3D printing processes | 1 |
| 12. | Injection molding | To understand the plastic injection molding process | 1 |

**References:**

None

## 17.15 ME 213: Engineering Thermodynamics

**Course Code : ME 213**

**Course Name : Engineering Thermodynamics**

L-T-P-C : 3-1-0-4
Intended for : UG (Core for B.Tech Mechanical)
Perequisite : None
Mutual Exclusion:
Approval: 53rd Senate

**Course Contents**

- **Introduction and Fundamental Concepts**: Applications of Thermodynamics and Brief History, Macroscopic versus Microscopic Approach, Thermodynamic Systems and Control Volumes, Properties and State of a System, Thermodynamic Processes and Cycles, Primary Measurable Properties: Specific volume and density, Pressure, Temperature and its equality, Measurement of Temperature. (3 Lectures)
- **Properties of Pure Substance**: Pure Substance and its Different Phases, Phase Boundaries, Property Diagrams, Property Tables: Saturated liquid and saturated

vapour states, Saturated liquid-vapour mixture, Superheated vapour states, Compressed or subcooled liquid states, Reference states for developing steam tables, Ideal Gas States, Compressibility Factor, Other Commonly Used Equations of State. (3 Lectures)

- **Energy and the First Law of Thermodynamics**: Energy and Its Different Forms, Constituents of internal energy, Heat and work, Heat versus Work, Different Forms of Work Transfer: Displacement work, Shaft work, Spring work, First Law of Thermodynamics, Enthalpy: A Thermodynamic Property, Specific Heats, Internal Energy, Enthalpy and Specific Heats of Solids and Liquids, Internal Energy, Enthalpy and Specific Heats of Ideal Gases. (8 Lectures)

- **Energy Analysis for Control Volumes**: Conservation of Mass for a Control Volume, Conservation of Energy for a Control Volume, Energy Analysis of Steady-Flow Processes, Examples of Steady Flow Devices: Nozzles and diffusers, Turbines and compressors, Mixing chambers, Heat exchangers, Throttle, Energy Analysis of Transient Processes. (4 Lectures)

- **Second Law of Thermodynamics**: Need for the Second Law of Thermodynamics, Heat Engines, Refrigerators and Heat Pumps, Second Law of Thermodynamics, PMM1 and PMM2, Reversible Process, Factors responsible for irreversibility, Internal and external reversibility, Carnot Cycle, Propositions Regarding the Efficiency of Carnot Cycle, Thermodynamic Temperature Scale, Ideal and Real Machines. (6 Lectures)

- **Entropy**: Clausius Inequality, Entropy, Entropy of a Pure Substance, Entropy Change for Internally Reversible Processes, Thermodynamic Property Relations, Entropy Change for Solids and Liquids, Entropy Change for an Ideal Gas, Property Diagrams Involving Entropy, Entropy Change for an Irreversible Process and Entropy Equation, Principle of Increase of Entropy, Entropy Rate Equation for a Closed System, Entropy Rate Equation for a Control Volume, Shaft Work for Steady Flow Devices, Isentropic Efficiency of Different Steady Flow Devices, Physical Inferences of Entropy. (5 Lectures)

- **Exergy**: Introduction to Exergy, Exergy Associated with Different Modes of Energy Transfer, Exergy Transfer by Heat, Exergy Transfer by Work, Exergy Potential of a Closed System, Exergy Potential of a Flowing Stream, Decrease of Exergy Principle, Exergy Balance Equation, Second Law Efficiency. (3 Lectures)

- **Vapour Power Cycles**: Introduction to Power Systems, Carnot Cycle, Rankine Cycle, Effect of Pressure and Temperature on the Rankine Cycle, Reheat Cycle, Regenerative Cycle and Feedwater Heaters, Deviation of Actual Cycles from Ideal Cycles. (4 Lectures)

- **Air Standard Power Cycles**: Air-Standard Power Cycles, Carnot Cycle, Brayton Cycle, Simple Gas-Turbine Cycle with a Regenerator, Gas-Turbine Power Cycle Configurations, Air-Standard Cycle for Jet Propulsion, Reciprocating Engine Power Cycles, Otto Cycle, Diesel Cycle, Dual Cycle. (4 Lectures)

- **Refrigeration Cycles**: Different Refrigeration Techniques, Carnot cycle, Vapour Compression Refrigeration Cycle. (2 Lectures)

**Laboratory/practical/tutorial Modules:**

- Tutorial 1: Fundamental Concepts (1 Hour)
- Tutorial 2: Properties of Pure Substances and Heat and Work Interactions (2 Lectures)
- Tutorial 3: Energy and the First Law of Thermodynamics (2 Lectures)
- Tutorial 4: First Law of Thermodynamics for Open Systems (2 Lectures)
- Tutorial 5: Second Law of Thermodynamics and Entropy (2 Lectures)
- Tutorial 6: Exergy (1 Hour)
- Tutorial 7: Vapour Power Cycles (2 Lectures)
- Tutorial 8: Air Standard Power Cycles (1 Hour)
- Tutorial 9: Refrigeration Cycles (1 Hour)

**Textbooks:**

1. Borgnakke, C. and Sonntag, R.E., **Fundamentals of Thermodynamics**, 8th Edition, Wiley, 2013.
2. Cengel, Y.A. and Boles, M.A., **Thermodynamics: An Engineering Approach**, 8th edition, McGraw-Hill, 2015. (eBook available at: https://www.expresslibrary.mheducation.com
7e-sie)

**Reference Books:**

1. Moran, M.J., Shapiro, H.N., Boettner, D.D. and Bailey, M.B., **Fundamentals of Engineering Thermodynamics**, John Wiley & Sons, 2010.
2. Nag, P.K., **Engineering Thermodynamics**, Tata McGraw-Hill Education, 2013.
3. Kumar, P. and Dhar, A., **Basics of Thermodynamics**, AICTE, 2023. (Softcopy available at: https://ekumbh.aicte-india.org/book.php)

## 17.16 ME 215: Manufacturing Engineering-1

**Course Code : ME 215**

**Course Name : Manufacturing Engineering-1**

L-T-P-C : 3-0-0-3
Intended for : UG
Perequisite : None
Mutual Exclusion:
Approval: 53rd BoA

**Course Contents**

- **Casting Processes and Foundry**: Sand casting processes, sand testing, molding processes, gating systems, cooling and solidification phenomena, special casting processes, casting defects and remedies, riser design, calculation of solidification times, inspection of casting. (7 Lectures)

- **Forming Processes**: Plastic deformation and yield criteria, relationship between tensile and yield criteria, mechanics of forming processes, various forming processes, hot and cold forming, friction and lubrication in metal forming, defects in metal forming. (6 Lectures)

- **Machining Processes**: Single point and multipoint cutting tools, chip formation mechanism, cutting tool geometry, orthogonal and oblique machining, Merchant's circle, force, velocity, shear angle and power consumption, tool wear, machinability and its measure, cutting tool materials, economics of machining. (10 Lectures)

- **Advanced Machining Processes**: Process principle, equipment, analysis and application of advanced machining processes- abrasive Jet Machining, ultrasonic machining, water jet machining, electro chemical machining, chemical machining, electro discharge machining, electron beam machining, laser beam machining, microwave machining. (7 Lectures)

- **Joining Processes**: Introduction, principle of fusion welding, heat flow characteristics, gas metal reactions, cooling of fusion weld, principles of solid phase welding, various joining processes-arc welding, GTAW, GMAW, FCAW, SAW, EBW, TW, soldering and brazing, adhesive bonding, mechanical assembly methods, weld defects and inspection. (7 Lectures).

- **Finishing Processes**: Principle and applications of grinding, nomenclature of grinding wheel, honing, superfinishing, lapping, polishing, buffing, peening and burnishing, economics of finishing processes. (5 Lectures)

**Textbooks:**

1. Groover, M.P., **Fundamentals of modem manufacturing: materials, processes, and systems**, John Wiley & Sons, 2020.

2. Kalpakjian, S. and Schmid, S.R., **Manufacturing engineering and technology**, Prentice Hall, 2001.

**References:**

None

## 17.17 ME 302: Dynamics of Machinery

**Course Code: ME 302**

**Course Name: Dynamics of Machinery**

L-T-P-C: 3-0-0-3

Pre-requisites: Nil
**Objective**: To introduce various techniques of dynamic analysis of machines.
Approval: 5th BoA

**Course contents:**

- **Force Analysis of Mechanisms**: Concept of free body and its equilibrium, static force analysis, friction effects, forces on gear teeth; D'Alembert's principle, dynamic force analysis, force analysis of cam-follower system, equivalent dynamical systems, dynamic analysis of reciprocating engines, practical examples from actual machines. (10hrs)

- **Flywheels and Governors**: Fluctuation of energy and speed, calculation of flywheel size; Analysis of different types of governors, effect of friction, controlling force curves, sensitivity, stability, governor effort and power. (6hrs)

- **Balancing**: Balancing of rotating masses on one plane and in different parallel planes, balancing of slider crank mechanisms, balancing of in-line, V- and locomotive engines, principles of balancing machine. (7hrs)

- **Friction Devices**: Coulomb friction, belt drive system, pivots and collars, power screws, plate and cone clutches, band and block brakes.(6hrs)

- **Gyroscope**: Gyroscopic action, equation for regular precession and gyroscopic torque. (2hrs)

- **Mechanical Vibration**: Simple harmonic motion; Conservative systems; Free vibrations of systems without damping; Equilibrium and energy methods for determining natural frequency; Rayleigh's method, free vibrations of system with viscous damping, over damped, critically and under damped systems, logarithmic decrement; Forced vibrations of systems with viscous damping, equivalent viscous damping; Impressed forces due to unbalanced masses and excitation of supports, vibration isolation, transmissibility, whirling of shaft; Introduction to multi degree offreedom system vibrations: Discrete and continuous systems. (11hrs)

**Suggested Books:**


1. Uicker, J.J., Shigley, J.E., and Pennock, G.R., **Theory of Machines and Mechanisms**, 3rd Edition, Oxford University Press 2003

2. Vinogradov, O., **Fundamentals of Kinematics and Dynamics of Machines and Mechanisms**, CRC Press 2000

3. Massie, H.H., and Reinholtz, C.F., **Mechanisms and Dynamics of Machinery**, 4th Edition, John Wiley & Sons 1987

4. Grover, G.K., **Mechanical Vibrations**, 7th Edition, Nem Chand and Brothers 2003

5. Thomson, W.T., **Theory of Vibration with Applications**, 3rd Edition, CBS Publishers 2003

## 17.18 ME 303: Heat Transfer

**Course Code: ME 303**
**Course Name: Heat Transfer**

L-T-P-C: 2.5-0.5-0-3
Prerequisite: Fluid Mechanics, Thermodynamics
Students intended for: B.Tech.
Elective or Core: Core
Approval: 3rd Senate

### Course contents

- **Introduction**

  Modes of heat transfer, examples, difference between thermodynamics and heat transfer, fundamental laws, Fourier's law of heat conduction, thermal conductivity, Newton's law of cooling, Stefan – Boltzmann's law, combined modes of heat transfer

**Heat Conduction**

- **1 – D conduction:**

  General heat diffusion equation derivations, 1 – D steady state heat conduction equation for a slab, composite slab, Boundary conditions, Thermal resistance concepts, electrical analogy, overall heat transfer coefficient, 1 – D heat conduction equation in cylindrical and spherical coordinates, composite cylinders and spheres, Critical thickness of insulation, heat generation inside slabs and radial systems

- **Fins**

  heat transfer from extended surfaces, fin performance.

- **Multi-dimensional heat conduction**

  2D steady state heat conduction, analytical solution

- **Unsteady conduction**

  Introduction, lumped capacitance model, derivation and solution of lumped capacitance model, validity, Biot and Fourier Numbers,transient heat conduction in infinite and semi-infinite slabs, Heisler charts.

- **Numerical Methods**

  Numerical methods for heat conduction, solution techniques-Matrix inversion, Gauss Seidal iteration technique

**Convection Heat Transfer**

- **Convection Heat Transfer**

  Forced convection: Derivation of energy equation.

- **External Flow**

  Flow over flat plate, concept of Hydrodynamic Boundary Layer, Thermal Boundary Layer, derivation of boundary layer equations, physical significance of dimensionless numbers, cylinder in cross flow, Flow over bank of tubes

- **Internal flows**

  Laminar flow through duct, concept of Hydrodynamic boundary layer, entry length, mean velocity, mean temperature, fully developed conditions for constant temperature and constant heat flux, turbulent flow in pipes.

- **Free convection**

  Natural convection: concepts, boundary layer, equations of motion, energy, convection over different configurations.

- **Condensation and Boiling**

  Introduction to boiling and condensation, dimensionless parameters in condensation, regimes of boiling heat transfer, condensation over vertical surfaces, velocity and temperature profiles, film condensation of radial systems, Laminar film condensation over a vertical plate and horizontal circular tube

**Heat exchangers**

- **Heat exchangers**

  Classification of heat exchangers, overall heat transfer coefficient, concept of fouling factor, LMTD and NTU methods of analysis for a heat exchanger, applications to multi-tube, multi-pass heat exchangers.

**Radiation Heat Transfer**

- **Thermal radiation**

  Radiation properties, blackbody radiation, Planck's law, Stefan-Boltzman law, Kirchoff's law, radiation exchange between black surfaces, concept of view factor, radiation exchange between non-black surfaces, two-surface enclosure, three surface enclosure, concept of radiation shield.

**Mass Transfer**

- **Introduction to Mass Transfer**

  Mass diffustion, Ficks Law, Heat and Mass Transfer analogy

**Text Books:**

1. Incropera and Dewitt, **Fundamentals of Heat and Mass Transfer**, 7th Edition, Wiley India.
2. Cengel, **Heat and Mass Transfer**, Tata McGraw Hill.

**Additional Reading**

1. Krieth and Bohn, **Principles of Heat Transfer**, Cengage Learning
2. Holman, **Heat Transfer**, 10th Edition, Tata McGraw Hill.
3. Lienhard IV and Lienhard V, **A heat Transfer Text Book**, Dover Publishers, `http://web.mit.edu/lienhard/www/ahtt.html`

## 17.19 ME 303P : Heat Transfer Lab

**Course Code : ME 303P**

**Course Name : Heat Transfer Lab**

L-T-P-C : 0-0-2-1
Intended for : UG
Prerequisite : ME 303 - Heat Transfer & ME - 213 Engineering Thermodynamics, ME - 210 Fluid Mechanics
Mutual Exclusion:
Approval: 54th BoA

**Course Contents**

- NA

**Laboratory/practical/tutorial Modules:**

1. Calorific Value Measurement
2. Critical Heat Flux Measurement
3. Heat Transfer from Pin Fin Measurement
4. Heat Transfer in Natural Convection
5. Parallel Flow and Counter Flow Heat Exchanger
6. Radiation Law Verification
7. Refrigeration Cycle Verification
8. Air-Conditioning Cycle Verification - Open Cycle
9. Air-Conditioning Cycle Verification - Closed Cycle
10. Two-Phase Heat Transfer
11. Lumped Heat Transfer Analysis
12. Unsteady Heat Transfer Analysis
13. Analysis of Water Cooler

**Textbooks:**

1. J.P. Holman, **Experimental Methods for Engineers**, 7th edition, Tata McGraw-Hill 2001.
2. T.G. Beckwith, J.H. Lienhard V, R. D. Mamgoni, **Mechanical Measurements**, 5th edition, Pearson Education, 2010.
3. E.O. Doebelin, **Measurement systems, Application and Design**, 5th edition, Tata McGraw-Hill, 2008
4. Incropera and Dewitt, **Fundamentals of Heat and Mass Transfer**, Wiley India.
5. Cengel, **Heat and Mass Transfer**, Tata McGraw Hill.
6. Krieth and Bohn, **Principles of Heat Transfer**, Cengage Learnings.

**References:**

1. NA

## 17.20 ME 304 Power Plant Engineering / Principles of Energy Conversion

**Course Code: ME 304**

**Course Name: Power Plant Engineering / Principles of Energy Conversion**

L-T-P-C: 3-0-2-4
Prerequisites: Thermodynamics, Fluid Mechanics
Students Intended for:
Core or Elective:
**Mutual Exclusion: ME 356 (ME 304 is equivalent to ME 356).**
Approval: 3rd Senate; OTA for Power Plant Engineering - 5th Senate

**Course Contents:**

- **Introduction** Energy sources. Electricity generation, Major issues nationally, internationally.
- **Economics Electric power systems** The grid; Supply - generating plants, availability, demand-supply mismatch, grid collapse. Grid regulation
- **Revision of thermodynamics basics** Basic thermodynamics, Rankine cycle and its variants
- **Thermal Energy Generation:**
- **Fossil Fuelled Power Plants** system analysis, turbine generators, condenser and cooling water systems, condensate system, feed water system, boilers, furnace, fuel and systems, boiler auxiliary systems
- **Gas Turbine Power Plants** Gas turbine fundamentals, gas turbine engineering, combined cycle analysis

- **IC Engine Power Plant** IC Engine-based systems Solar Thermal Power Plants: Concepts and basics, System engineering
- **Earth-based thermal power plants** Geothermal, Ocean Thermal
- Biomass, waste sources-based Energy
- **Nuclear power** Basics, Nuclear reactions basics, Reactor engineering, Light water reactors, Heavy water reactors, Fast Reactors, Other types of reactors. Fusion. Issues & concerns
- **Fluid Flow Based Power Generation:**
- **Hydroelectric plants** Introduction, Hydro-turbine basics, Hydro-power plant engineering
- **Wind electric generators** Windmill basics, Windmill engineering
- **Ocean-based power plants** Waves and tidal power
- **Direct Conversion:**
- **Solar photovoltaic** SPV fundamentals, SPV engineering
- **Fuel cells** Fuel cells fundamentals, Fuel Cell types, Engineered systems
- **MHD generation** MHD generation

**Text Books and References:**


1. Clapp, R. M., (Ed.), **Modern Power Station Practice: Boilers and Ancillary Plant**, BEI International, Pergamon Press, 1993.
2. Hambling, P., (Ed.), **Modern Power Station Practice: Turbines, Generators and Associated Plant**, BEI International, Pergamon Press, 1992.
3. Brown, J.G., **Hydroelectric Engineering Practice**, Volumes I,II & III, McGraw-Hill.
4. Hambling, P., (Ed.), **Modern Power Station Practice: Nuclear Turbines, and Associated Plant**, BEI International, Pergamon Press, 1992.
5. Drbal, L. F., Boston, P. G., Westra, K. L., **Black and Veatch, Power Plant Engineering**, Kluwer Academic, 1995.
6. Elliott, T. C., Chen, K., and Swanekamp, R., **Standard Handbook of Power Plant Engineering**, 2nd Edition, McGraw-Hill Professional, 1997.
7. El-Wakil, M. M., **Power Plant Technology**, McGraw-Hill, 1984.
8. Jog, M., **Hydro-electric and Pumped Storage Plants**, John Wiley, 1989.
9. Fritz, J. J., **Small and Mini Hydropower Systems**, McGraw-Hill, 1984.

10. Central Board for Irrigation and Power (CPIB), India, Design and Construction Features of Selected Dams in India, 1983.

11. Borbely, Anne-Marie, and Kreider, Jan J., (Eds.), **Distributed Generation: The Paradigm for the New Millennium**, CRC Press, 2003.

12. Larminie, J., and Dicks, A., **Fuel Cell Systems Explained**, John Wiley, 2003.

13. Vielstich, W., Lamm, A., and Gasteiger, H., **Handbook of Fuel Cells: Fundamentals, Technology, Applications**, John Wiley, 2003.

14. O'Hayre, R.,.Cha, S. -W., Colella, W., and Prinz, F. B., **Fuel Cell Fundamentals**, Wiley, 2005.

15. Appleby, A. J., and Foulkes, F. R., **Fuel Cell Handbook**, van Nostrand Reinhold, 1996.

16. Harrison, R., Hau, E., and Snel, H., **Large Wind Turbines: Design and Economics**, John Wiley, 2001.

17. Bejan, Adrian, **Advanced Engineering Thermodynamics**, Wiley, 1997.

18. Patents and catalogues related to various equipment.

## 17.21 ME 305: Design of Machine Elements

**Course Code: ME 305**
**Course Name: Design of Machine Elements**

L-T-P-C: 3-1-0-4
Prerequisite: Mechanics of Solids
Students intended for: B.Tech.
Elective or Core: Core
Approval: 3rd Senate

**Course contents**

- **Variable Loading** [12 Lectures]
- **Shafts, keys, couplings** [7 Lectures]
- **Threaded fasteners and Power Screws** [7 Lectures]
- **Permanent fasteners** [5 Lectures]
- **Gears**[7 Lectures]
- **Clutches & Brakes** [6 Lectures]
- **Belt & Chain Drives** [6 Lectures]
- **Bearings**[6 Lectures]

**Text Books:**

1. Shigley, J.E., and Mischke, C.R., **Mechanical Engineering Design**, Tata McGraw-Hill.

2. Robert L. Norton, **Machine Design: An Integrated Approach**, Pearson.

3. Juvinall, R. C., and Marshek, K. M., **Fundamentals of Machine Component Design**, 4th Edition, John Wiley & Sons

## 17.22 ME 306P: Solid Mechanics Laboratory

**Course Code: ME 306P**

**Course Name: Solid Mechanics Laboratory**

L-T-P-C: 3-0-0-3
Pre-requisites: Nil
Approval: 5th Senate

**Course Contents:**

- Comparison of the properties of ductile and brittle materials.
- Tensile test to obtain stress strain curves, young's modulus, 0.2% proof stress,
- Compression tests to compare the failure behaviour of the ductile and brittle materials.
- Shear test.
- Three point bend test for bending strength.
- Determination of Young's modulus of a material by bending test.
- Buckling load for columns with different end conditions.
- Evaluation of spring index and calculation of proof stress for compression spring.
- Impact tests and comparison of energies for ductile and brittle materials.
- Torsion tests to obtain modulus of rigidity and fracture behaviour of brittle materials subjected to torsion.
- Hardness tests. Empirical relations of hardness and strength.
- Fatigue test.
- Surface roughness tests to understand the different surface roughness obtained by various manufacturing processes.

## 17.23 ME 307_Old (4) Energy Conversion Devices

Approval: 8th Senate; OTA

**Course Outline:**

- Thermodynamics, Thermal power plants: Gas and steam power cycles, Regenerative and reheat cycles,
- Turbo Machinery: Classification Similitude and specific speeds, Euler turbine equation, Velocity triangles. Turbine and compressor cascades.
- Axial-flow turbines and compressors: Stage efficiency and characteristics, Radial equilibrium, Governing. Fans, blowers and compressors. Slip factor, performance characteristics.
- Hydraulic Machines; Pelton wheel, Francis and Kaplan turbines, Drafl tubes, Pumps, Cavitation, Fluid coupling and torque converter,
- Introduction to IC engine.
- Use of Computer Aided Engineering (CAE) in turbomachinary design.

## 17.24 ME 307: Energy Conversion Devices

**Course Code: ME 307**
**Course Name: Energy Conversion Devices**

L-T-P-C: 3-0-0-3
Prerequisite: Mechanics of Solids
Students intended for: B.Tech.
Elective or Core: Core
Approval: 3rd Senate

**Course contents**

- **Thermodynamics, Thermal power plants**

  Gas and steam power cycles, Regenerative and reheat cycles
- **Turbo Machinery**

  Classification Similitude and specific speeds, Euler turbine equation, Velocity triangles, Turbine and compressor cascades.
- **Axial-flow turbines and compressors**

  Stage efficiency and characteristics, Radial equilibrium, Governing
- **Fans, blowers and compressors**

  Slip factor, performance characteristics
- **Hydraulic Machines** Pelton wheel, Francis and Kaplan turbines, Draft tubes, Pumps, Cavitation, Fluid coupling and torque converter
- **Introduction to IC engine**
- **Use of Computer Aided Engineering (CAE) in turbomachinary design**

**Text Books:**

1. S.L. Dixon, **Fluid Mechanics, Thermodynamics of Turbomachinery**, 3rd Edition, Pergamon Press, 1998.

2. S M. Yahya, **Turbines Compressors And Fans**, 4th Edition, 2010.

3. B. K. Venkannna, **Fundamentals Of Turbomachinery**, 2009.

## 17.25 ME 308: Manufacturing Engineering

**Course Code: ME 308**
**Course Name: Manufacturing Engineering**

L-T-P-C: 3-0-0-3
Prerequisite: IC 141 Product Realization Technology
Students intended for: B.Tech.
Elective or Core: Core
Approval: 10th Senate

**Course contents**

- **Sheet Metal Working**

  Types of presses, Operations (shearing, bending, spinning, embossing, blanking, coining, punching and deep drawing), Design of structures using sheet metal working. [7 Lectures]

- **Introduction to Jigs and Fixture Design**

  Principles of location and clamping [3 Lectures]

- **Non-conventional Machining Processes**

  Electric discharge machining (EDM), Electrochemical machining, LASER and Abrasive flow machining. [8 Lectures]

- **Introduction to CIM**

  Trends in Modern Manufacturing, Techniques to enhance flexibility, productivity, product quality and interoperability, Product life cycle, Concepts of product development, Building blocks of CIM. [8 Lectures]

- **Rapid prototyping**

  Need for Rapid Prototyping, Basic Principles and advantages of RP, Classifications of different RP techniques with examples, Introduction to three representative RP techniques: Fused deposition modeling, Laminated object manufacturing and Stereo-lithography [8 Lectures]

- **Micro-manufacturing**

  An overview of micro mechanical systems and their applications, MEMS Microfabrication methods, Silicon Micromachining methods, Laser Micromachining methods, Mechanical Micromachining techniques, CAD/CAM Tools for Micro-manufacturing processes. [8 Lectures]

**Text Books:**

1. Serope Kalpakjian, and Steve R. Schmid, **Manufacturing Engineering and Technology**, 4th Edition, Pearson, 2016

## 17.26 ME 309: Theory of Machines

**Course Code: ME 309**
**Course Name: Theory of Machines**

L-T-P-C: 3-1-0-4
Prerequisite: Mechanics of Solids
Students intended for: B.Tech.
Elective or Core: Core
Approval: 3rd Senate

**Course contents**

- Kinematic pair, diagrams and inversion. Mobility and range of movement [5 Lectures]
- Displacement velocity and acceleration analysis of planar linkages [10 Lectures]
- Dimensional synthesis for motion, path and function generation. [8 Lectures]
- Cam profile synthesis [5 Lectures]
- Gears [10 Lectures]
- Dynamic force analysis [4 Lectures]
- Flywheel [3 Lectures]
- Inertia forces and balancing for rotating and reciprocating machines [12 Lectures]

**Text Books:**

1. A. Ghosh, A. K. Mallik, **Theory of Mechanisms and Machines**, East West Press Pvt. Ltd.
2. Uicker, J. J., Shigley, J. E., and Pennock, G. R., **Theory of Machines and Mechanisms**, Oxford University Press.
3. Thomas Bevan, **Theory of Machines**, 4th Edition, Pearson
4. C. E. Wilson, J. P. Sadler, **Kinematics and Dynamics of Machinery**, Pearson.
5. R. L. Norton, **Design of Machinery**, McGraw Hill Company.

## 17.27 ME 309P: Theory of Machines Lab

**Course Code: ME 309P**
**Course Name: Theory of Machines Lab**

L-T-P-C: 0-0-2-1
Prerequisite: IC 240 Mechanics of Rigid Bodies
Students intended for: B.Tech.
Elective or Core: Core
Approval: 6th Senate

**Course contents**

- Synthesizing a simple mechanism to produce given out put motion.
- Balancing of engines.
- Use of Governors for automatic fuel supply regulation.
- Cams.
- Gyroscope for stabilization.
- Whirling speed of a shaft.
- Vibrations of single and multi degree of freedom systems.
- Effect of damping on vibrations.
- Forced vibrations.
- Torsional vibrations.
- Transmissibility of vibrations to the support.
- Mass dampers
- Balancing of rotary machines.

## 17.28 ME 310: System Dynamics and Controls

**Course Code: ME 310**
**Course Name: System Dynamics and Controls**

L-T-P-C: 3-0-0-3
Pre-requisites: Engineering Mathematics (IC110) and Linear Algebra (IC111)
Students Intended for: Discipline Core for ME
Elective or Core: Core
Approval: 39th BoA

**Course contents**

- **Introduction**

  Control system examples, historical developments leading to modern day control theory, the basic features and configurations of control systems, control systems analysis and design objectives, control system's design process [2 Lectures]

- **Modeling in Frequency Domain**

  Mathematical descriptions of systems by differential equations, Laplace transform linear, time-invariant systems (mechanical, electrical, and electromechanical), linearization of a nonlinear system to find the transfer function. [3 Lectures]

- **Modeling in Time Domain**

  State-space representation a LTI system, conversion of a transfer function to state space and vice-versa, linearization a state-space representation. [3 Lectures]

- **Time Response**

  Effect of poles and zeros on the time response of a control system, quantitative description of the transient response of first-order systems, general response, damping ratio, settling time, peak time, percent overshoot, and rise time and natural frequency of second-order systems, time response from the state-space representation. [3 Lectures]

- **Reduction of Multiple Subsystems**

  Reduction of a block diagram of multiple subsystems to a single block, analysis and design of transient response for a system consisting of multiple subsystems, conversion of block diagrams to signal-flow diagrams, Mason's rule. [2 Lectures]

- **Stability**

  Making and interpreting Routh table to determine the stability of a system, Application of Routh table to determine the stability of a system represented in state space. [3 Lectures]

- **Steady-State Errors**

  Steady-state error for a unity feedback system, steadystate error performance, design the gain of a closed-loop system to meet a steady-state error specification, finding the steady-state error for disturbance inputs, steady-state error for systems represented in state space. [2 Lectures]

- **Root Locus Techniques**

  Properties of a root locus, sketching techniques of a root locus, root locus for systems of order 2 and higher, root locus for positive-feedback systems. [4 Lectures]

- **Design via Root Locus**

  Use the root locus to design cascade compensators to improve the steady-state error and the transient response, feedback compensators to improve the transient response, realize the designed compensators physically. [4 Lectures]

- **Frequency Response Techniques**

  Plot of frequency response of a system, Nyquist stability criteria, gain and phase margins, closed-loop frequency response. [4 Lectures]

- **Design via Frequency Response**

  Use frequency response techniques to adjust the gain to meet a transient response specification, frequency response techniques to design cascade compensators to improve both the steady-state error and the transient response. [5 Lectures]

- **Design via State Space**

  State-feedback controller using pole placement, controllability, transient response specifications, observability. [5 Lectures]

**Text Books:**


1. Katsuhiko Ogata, **System Dynamics**, 4th Edition, Pearson Education, 2013
2. N. S. Nise, **Control Systems Engineering**, 7th Edition, Wiley, 2015
3. M. Gopal, **Control Systems: Principle & Design**, 4th Edition, McGraw Hill, 2012


**Reference Books:**


1. Franklin, **Feedback Control Systems**, Powell
2. Robert H. Bishop, **The Mechatronics Handbook**.
3. Dean C. Karnopp, Donald L. Margolis and Ronald C. Rosenberg, **Modeling, Simulation, and Control of Mechatronic Systems**, John Wiley & Sons, Inc.
4. Bogdan M. Wilamowski and J. David Irwin, **Control and Mechatronics**, CRC Press
5. William Bolton, **Mechatronics Electronic control systems in mechanical and Electrical Engineering**, 6th Edition, Pearson
6. Richard C. Dorf and Robert H. Bishop, **Modern Control Systems**, Pearson


## 17.29 ME 310P: Thermo – Fluids laboratory

**Course Code: ME 310P**
**Course Name: Thermo – Fluids laboratory**

L-T-P-C: 0-0-3-2
Prerequisite: ME 303 Heat Transfer and ME 210 Fluid Mechanics
Students intended for: B.Tech.
Elective or Core: Core
Approval: 8th Senate; 5th Senate (OTA); 11th Senate (OTA)

**Course contents**

- Uncertainty in measurements, curve fitting, introduction to the use of temperature measuring devices – thermometers, RTD, Thermocouples
- Determination of the calorific values of unknown fuels using the Bomb Calorimeter
- Evaluation of Energy efficiency of different stoves
- Parallel and series pump characteristics
- Finding the minor and major losses in pipes
- Flow visualization
- Determination of heat transfer coefficient during the natural convection
- Determination of heat transfer coefficient during the forced convection
- Shell and tube heat exchanger analysis under parallel and counter flow conditions
- Static pressure measurement on an aerofoil in wind tunnel
- Energy balance of 4 – S engine and exhaust gas analysis of the engine
- Vapour compression refrigeration test rig
- Determination of critical heat flux in pool boiling

## 17.30 ME 311P: Design Lab - 1

**Course Code: ME 311P**
**Course Name: Design Lab - 1**

L-T-P-C: 0-0-2-1
Prerequisite: ME206 Mechanics of Solids
Students intended for: B.Tech.
Elective or Core: Core
Approval: 10th Senate

**Course contents**

- Comparison of the properties of ductile and brittle materials.
- Effect of heat treatment on the mechanical properties.
- Tensile test to obtain stress strain curves, young's modulus, 0.2% proof stress, percentage elongation.
- Compression tests to compare the failure behaviour of the ductile and brittle materials.
- Shear test.
- Three point bend test for bending strength.

- Determination of Young's modulus of a material by bending test.
- Buckling load for columns with different end conditions.
- Evaluation of spring index and calculation of proof stress for compression spring.
- Impact tests and comparison of energies for ductile and brittle materials.
- Torsion tests to obtain modulus of rigidity and fracture behaviour of materials subjected to torsion.
- Hardness tests. Empirical relations of hardness and strength.
- Surface roughness tests to understand the different surface roughness obtained by various manufacturing processes.

**Text Books**

1. Timoshenko S. P., and Gere J. M., **Mechanics of Materials**, 2nd Edition, CBS Publishers, 2002.
2. Crandall S. H., Dahl N. C., and Lardner T. J., **An Introduction to the Mechanics of Solids**, 2nd Edition., McGraw-Hill, 1999
3. Hearn E. J., **Mechanics of Materials**, 3rd Edition, Pergamon, 2003.
4. Higdon A., Ohslen E. H., Stiles W. B., Weese J. A., and Riley W. F., **Mechanics of Materials**, John Wiley & Sons, 1989
5. Popov E. P., Nagarajan S., and Lu Z. A., **Mechanics of Materials**, 2nd Edition, Prentice-Hall of India, 2002.

**Reference Books:**

1. Robert Cook, **Advanced Mechanics of Materials**
2. Alexander Blake, **Practical Stress Analysis in Engineering Design**
3. J. P. Den Hartog, **Advanced Strength of Materials**

## 17.31 ME 312P_Old: Design Lab - 2

Course Code: ME 312P
Course Name: Design Lab - 2
L-T-P-C: 0-0-2-1
Approval: 10th Senate

**Objective:**

To introduce students to kinematic and dynamic behaviour of common - machine elements and mechanisms and to enable students to identify necessary tests for different design applications.

**Contents:**

- Fatigue test
- Synthesizing a simple mechanism to produce given but put motion.
- Balancing of engines.
- Use of Governors for automatic fuel supply regulation.
- Generatinginvolute profile with a rack.
- I Study of gear trains and gear boxes.
- Cams.
- A Gyroscope for stabilization. Whirling speed of a shaft.
- Vibrations off single and multi degree of freedom systems.
- Effect of damping on vibrations.
- Forced vibrations.
- Torsional vibrations.
- Transmissibility of vibrations to the support.
- Use of piezo—sensors for sensing the deformation.
- Use of strain gauges, deformation of thin cylinders.
- Pressure distribution in a journal bearing.
- Balancing of rotary machines.

## 17.32 ME 312P: Design Lab - 2

**Course Code: ME 312P**
**Course Name: Design Lab - 2**

L-T-P-C: 0-0-2-1
Prerequisite: ME 309 Theory of Machines
Students intended for: B.Tech.
Elective or Core: Core
Approval: 10th Senate

**Course contents**

- Fatigue test.
- Synthesizing a simple mechanism to produce given out put motion.
- Balancing of engines.
- 1. Study of performance of different types of governors.
  2. Study of Gyroscope and precessional motion
- Generating involute profile with a rack.
- Study of gear trains and gear boxes.
- Studying follower motion with different types of cam profiles.
- Whirling speed of a shaft.
- Forced damped vibrations.
- Torsional vibrations with and without damping.
- Transmissibility of vibrations to the support.
- Use of piezo-sensors for sensing the deformation.
- Use of strain gauges, deformation of thin cylinders.
- Pressure distribution in a journal bearing.

**Text Books**

1. A. Ghosh, A. K. Mallik, **Theory of Mechanisms and Machines**, East West Press Pvt. Ltd.
2. Uicker, J. J., Shigley, J. E., and Pennock, G. R., **Theory of Machines and Mechanisms**, Oxford University Press.
3. Thomas Bevan, **Theory of Machines**, Pearson

**Reference Books:**

1. C. E. Wilson, J. P. Sadler, **Kinematics and Dynamics of Machinery**, Pearson.
2. R. L. Norton, **Design of Machinery**, McGraw Hill Company

## 17.33 ME 315: Manufacturing Engineering-II

**Course Code : ME 315**

**Course Name : Manufacturing Engineering-II**

L-T-P-C : 3-0-0-3
Intended for : UG
Perequisite : None
Mutual Exclusion:
Approval: 53rd BoA

**Course Contents**

- **Powder Metallurgy:** Characterization of Engineering Powders, Production of metallic powders, conventional pressing and sintering, alternative pressing and sintering techniques, hot isostatic pressing, metal injection molding, powder injection molding. (7 Lectures)
- **Rapid Prototyping Processes:** Introduction to rapid prototyping and rapid tooling, solid state methods (FDM, LOM), liquid-based (SLA, SGC), powder-based (3DP) RP processes (8 Lectures)
- **Jigs and Fixtures:** Usefulness of Jigs and Fixtures, design principles of jigs and fixtures, principle of location and clamping, types of locating and clamping devices, examples of jigs and fixtures used in lathe machine, milling, boring, shaping, welding and grinding, economics of jigs and fixtures, loading and unloading time, modular fixturing. (7 Lectures)
- **Metrology:** Dimensions and Tolerances, inspection types and principles, radius and taper measurements, measurement of screw threads gears, limits, fits, dimensional tolerances, Conventional measuring instr:uments and gages, surfaces, measurements of surfaces. (7 Lectures)
- **Integrated Manufacturing Systems:** Material handling, fundamentals of production lines, manual assembly lines, automated production lines, cellular manufacturing, flexible manufacturing systems and cells, computer integrated manufacturing. (7 Lectures).
- **Production Planning and Control:** Aggregate Planning and master production schedule, inventory control, material and capacity requirements planning, Lean production, shop floor control. (6 Lectures)

**Textbooks:**


1. Groover, M.P., **Fundamentals of modem manufacturing: materials, processes, and systems**, John Wiley & Sons, 2020.
2. Kalpakjian, S. and Schmid, S.R., **Manufacturing engineering and technology**, Prentice Hall, 2001.

**References:**

None

## 17.34 ME 316 : Automotive Engine Design

**Course Code : ME 316**

**Course Name : Automotive Engine Design**

L-P-T-C: 3-0-0-3
Intended for: UG 3rd, 4th year
Prerequisites: IC140 Graphics for Design
Mutual Exclusion: None
Approval : 57th BoA

**Course Contents**

- **Understanding General Engine Specification**: Explanation of the engine specification of a typical 2-wheeler and a 4-wheeler engine. Fundamental difference between SI and CI Engines. Correlation of piston movement and air standard cycles for 2 Stroke & and 4 Stroke Engines. Understanding the impact of engine displacement, bore, stroke, and bore-to-stroke ratio. (6 Hours)
- **Head & Block Design Combustion chamber design**: SI, DISI, IDI, CI, etc. Valve port and manifold design. Understanding swirl, tumble, supercharging, and turbocharging in engines. Engine block design for air cooled and water-cooled engine. Understanding design and manufacturing of cylinder liner. Learning various fuel injection systems: PFI, GDI, Carburetor, etc. (10 Hours)
- **Crank Train Design**: Definition of crank train function and terminology. Common crank train configurations. Design of piston, piston rings, connecting rods, crankshafts, balancer shaft, and flywheel, Dynamic balancing and configurating engine firing order. (12 Hours)
- **Valve Train Design**: Overview of valve train. Design and manufacturing of camshaft. Current status of valvetrains VVT, 4-Valve, 3-Valve, 2-Valve, etc. Dynamics of valve train. (6 Hours)
- **Gear Train Design**: Definition of typical gear trains: CVT, DSG, DCT, etc. Function of Clutch. Working of gear shifting mechanism. Design/selection of gears and bearings. Lubrication and oil pump in a single-cylinder engine. (8 Hours)

**Text books:**

1. Kevin Hoag & Brian Dondlinger, **Vehicular Engine Design**, Springer
2. A Kolchin & V Demidov, **Design of Automotive Engines**, MIR Publishers

**References:**

1. **Diesel-Engine Management**, Robert Bosch GmbH
2. **Gasoline-Engine Management**, Robert Bosch GmbH
3. JB Heywood, **Internal Combustion Engines**, McGraw Hill.
4. V Ganeshan, **Internal Combustion Engines**, McGraw Hill.
5. William H Crouse, **McGraw Hills Automotive Engine Design**, McGraw Hills

## 17.35 ME 351: Management of Manufacturing and Logistics Systems

**Course Code: ME 351**
**Course Name: Management of Manufacturing and Logistics Systems**

L-T-P-C: 3-0-0-3
Prerequisite: None; but basic mathematics and manufacturing is appreciated
Students intended for: ME and EE students (B.Tech. 2nd and 3rd year students)
Elective or Core: Elective
Approval: 2nd Senate

**Course contents**

- Introduction to Manufacturing and Supply Chain Management
- Project Management,
- Logistics Network Design
- Aggregate Production Planning, Material
- Requirement Planning
- Production Scheduling and Assembly Line Balancing
- Inventory
- Management
- Special Topics (Environmentally Conscious Manufacturing, Case Study of Logistics Network Design)

**Text Books:**

1. Cecil Bozarth, **Introduction to Operations and Supply Chain Management**, Pearson.

**Reference Books:**

1. W.J. Hopp and M.L. Spearman, **Factory Physics**, 3rd Edition, McGraw-Hill.

2. R.H. Ballou, **Business Logistics/Supply Chain Management**, 5th Edition, Prentice Hall.

## 17.36 ME 352: Finite Element Methods in Engineering

**Course Code: ME 352**
**Course Name: Finite Element Methods in Engineering**

L-T-P-C: 2.5-0.5-0-3
Prerequisite: Continuum Mechanics, Mechanics of Rigid Bodies, Mechanics of Solid Mechanics (Desirable), Programming language (C, MATLAB)
Students intended for: B.Tech.
Elective or Core: Core
Approval: 3rd Senate

**Course contents**

- **BASIC CONCEPT**

  Introduction, Engineering applications of finite element method, Rayleigh-Ritz method, Weighted residual methods: Galerkin's method, Principal of a minimum potential energy, principle of virtual work, Boundary value problem, initial value and Eigenvalue problem, Guass elimination method

- **BASIC PROCEDURE**

  General description of Finite Element Method, Discretization process; types of elements 1D, 2D and 3D elements, size of the elements, location of nodes, node numbering scheme, half Bandwidth, Stiffness matrix of bar element by direct method, Properties of stiffness matrix, Preprocessing, post processing, One Dimensional Problems

- **INTERPOLATION MODELS**

  Polynomial form of interpolation functions- linear, quadratic and cubic, Simplex, Complex, Multiplex elements, Selection of the order of the interpolation polynomial, Convergence requirements, 2D Pascal triangle, Linear interpolation polynomials in terms of global coordinates of bar, triangular (2D simplex) elements, Linear interpolation polynomials in terms of local coordinates of bar, triangular (2D simplex) elements, CST element

- **HIGHER ORDER AND ISOPARAMETRIC ELEMENTS**

  Lagrangian interpolation, Higher order one dimensional elements- quadratic, Cubic element and their shape functions, properties of shape functions, Truss element, Shape functions of 2D quadratic triangular element in natural coordinates, 2D quadrilateral element shape functions – linear, quadratic, Biquadric rectangular element (Noded quadrilateral element), Shape function of beam element. Hermite shape function of beam element

- **DERIVATION OF ELEMENT STIFFNESS MATRICES AND LOAD-VECTORS**

  for bar element under axial loading, trusses, beam element with concentrated and distributed loads, matrices, Jacobian, Jacobian of 2D triangular element, quadrilateral, Consistent load vector, Numerical integration

- **HEAT TRANSFER PROBLEMS**

  Steady state heat transfer, 1D heat conduction governing equation, boundary conditions, One dimensional element, Galerkin approach for heat conduction, heat flux boundary condition, 1D heat transfer in thin fins

- **FLUID MECHANICS PROBLEMS**

- **ELASTICITY PROBLEMS**

  Review of equations of elasticity, stress-strain and strain displacement relations, plane stress and plane strain problems

- **DYNAMIC PROBLEMS**

  on vibrations

**Text Books:**


1. Huebner K. H., Dewhirst D. L., Smith D. E., and Byrom T. G., **The Finite Element Method for Engineers**, 4th Edition, John Wiley and Sons, 2001.

2. Rao S. S., **The Finite Element Methos in Engineering**, 4th Edition, Elsevier Science, 2005.

3. Reddy J. N., **An introduction to Finite Element Methods**, 3rd Edition, Tata McGraw-Hill, 2005.

4. Fish J., and Belytschko T., **A First course in Finite elements**, 1st Edition, John Wiley and Sons, 2007.

5. Chaskalovic J., **Finite Element Methods for Engineering Sciences**, 1st Edition, Springer, 2008.


## 17.37 ME 353: Electronic Materials and Their Applications

**Course Code: ME 353**
**Course Name: Electronic Materials and Their Applications**

L-T-P-C:3-0-0-3
Prerequisite: Consent of the faculty member
Students intended for: B.Tech. 3rd or 4th year
Elective or Core: Core
Approval: 2nd Senate

**Course contents**

- This course covers the advanced aspects of electronic properties of materials and their applications. It includes materials for energy, thermoelectric, ferroelectric, dielectric, pyroelectric, piezoelectric, magnetic and optical applications. The advanced applications of electronic materials in various technologies will be emphasized, Detailed application of these materials, Caloric effect in materials.Linear and non-linear optical properties, materials and applications, Functional composite materials.

**Text and Reference Books:**


1. A. J. Moulson and J. M. Herbert, **Electroceramics: Materials, Properties and Applications**, 2nd Edition, Wiley; 2003.
2. K. Uchino, **Ferroelectric Devices**, Marcel Dekker Inc., 2000.
3. Z. L. Wang and Z.C. Kang, **Functional and Smart Materials**, Springer, 1998.
4. Charles Kittel, **Introduction To Solid State Physics**, 2nd Edition, 2005.


## 17.38 ME 354: Science & Technology of Thin Films

**Course Code: ME 354**

**Course Name: Science & Technology of Thin Films**

L-T-P-C: 3-0-0-3
Pre-requisites: Nil
Approval: 5th Senate

**Description:**

Solid-state devices form the basis of integrated circuits, which have a variety of electronic, optoelectronic, and magnetic applications. The research in this field is concerned with design, fabrication and characterization of novel materials and devices with sub-micron feature sizes. Their potential applications include very high-speed devices, optical sources and detectors, optoelectronic components and all-optical devices. The design and fabrication of devices and integrated circuits are inextricably related to device physics, solid-state materials, and sophisticated processing techniques.

This course aims to provide an introduction to the science and technology of thin films, with special emphasis on methods to produce thin films and relationships between growth conditions and thin film properties.

**Course contents:**

Topics include (1) various methods of thin film production, such as evaporation, sputtering and chemical vapour deposition, (2) nucleation and growth processes, (3) dimensional, chemical, and structural characterization of thin films and (4) properties and applications.

## 17.39 ME 355_Old: Internal Combustion Engines

**Course Code: ME 355_Old**
**Course Name: Internal Combustion Engines**

L-T-P-C:3-0-0-3
Prerequisite: None
Students intended for: B.Tech.
Elective or Core: Core
Approval: 8th Senate; OTA

**Course contents**

- **Introduction**

  Classification of I.C. engine, Fundamental difference between S.I. and C.I. Engines, Comparison of two stroke and four stroke engines, various components, their functions, Types of efficiency, indicated and brake power, theory of carburetion, Air Standard cycles (Diesel, Otto, Dual, Stirling, Brayton) and their comparison, measurement and testing techniques. Measurement of Indicated power, brake power, fuel consumption.

- **Combustion and control**

  Thermodynamics of fuel-air cycles, real cycles, various losses in actual engines. Combustion processes in SI engine and its various stages, spark ignition, normal and abnormal combustion, knock pre-ignition, combustion stages in CI engines, ignition delay, types of combustion systems, Fuel spray behaviour, Exhaust emissions, its measurement and control, Thermochemistry of fuel air mixtures: combustion stoichiometry, first and laws of thermodynamics and combustion.

- **Heat rejection and cooling**

  Temperature distributions of various components, heat transfer theory, parameters effecting engine heat transfer, need and type of cooling systems

- **Engine Performance and characteristics**

  Engine performance characteristics (EPC), Variables affecting performance characteristics, Methods of improving EPC, Heat balance, Performance maps, turbochargers and superchargers.

**Text Books:**


1. Ganesan, **Internal Combustion Engines**, 4th Edition, ata Mc-graw Hill Publishing Co.ltd. (2012)

2. John B. Heywood, **Internal Combustion Engine Fundamentals**, 1st Edition, Tata McGraw-Hill Education (2011).

3. Willard W. Pulkrabek, **Engineering Fundamentals of the Internal Combustion Engine**, 2nd Edition, PHI Learning (2009) .

## 17.40 ME 355: Internal Combustion Engine

**Course Code: ME 355**

**Course Name: Internal Combustion Engine**

L-T-P-C: 3-0-0-3
Pre-requisites: Nil
Approval: 15th Senate

**Course contents:**

- **Introduction** : Classificati on of I.C. engine, Fundamental difference between S.I. and C.I. Engines, Comparison of two stroke and four stroke engines, various components and their functions, Types of efficiency, indicated and brake power, theory of carburetion, Air Standard cycles (Diesel , Otto, Dual , Stirling, Brayton) and their comparison, measurement and testing techniques. Thennodynamics of fuel-air cycles, real cycles, various losses in actual engines. Measurement of In.d icated power, brake power, fuel consumption, energy balance analysis. (12 Lectures)
- **Combustion and control**: Combustion processes in SI engine and its various stages, spark ignition, normal and abnormal combustion, knock pre-ignition, combustion stages in CI engines, ignition delay, types of combustion systems, Fuel spray behaviour, Ex h aust emissions, its measurement and control. (8 Lectures)
- **Engine cooling and lubrication system**: Temperature distributions of various com ponents, heat transfer theory, parameters effect ing engine heat transfer, need and type of cooling systems. Engine Lubrication System: Frictional l osses, various types of lubri cation systems, lubrication of two stroke engines (4 Lectures)
- **Fuel Injection and Ignition systems**: Requirement of Air fuel mixi ng, fu el properties and its measurement, fuel injection system in SI engines, fuel injection system in Cl engines, turboeharging, ignition systems. (8 Lectures)
- **Advances in Road Transport**: Hybrid vehi cles; electric vehicles; fuel cell powered vehicles; hydrogen fuelled engines; new combustion Modes for IC engines such as low temperature combustion, homogenous charge compression ignition, reactivity controlled combustion etc.

**Textbooks**


1. Ganesan, **Internal Combustion Engines**, 4th Edition, Tata Mc-graw Hill Publishing Co.ltd., 2012.
2. John B. Heywood, **Internal Combustion Engine Fundamental**, Tata McGraw-Hill Education, 2011.


**Reference Books:**


1. M L Sharma and M P Mathur, **Internal Com bustion Engines**, Dhanpat Rai Publi cati ons, 2016.

2. Richard Stone, **Introduction to Internal Combustion Engines**, Society of Automotive Engineers, 1999.

3. Pa ul W. Gill and James H. Smith, **Fundamental of Internal Combustion Engines**, 4th Edition, Oxford & IBH Publishing Company Pvt. Limited, 2007.

## 17.41 ME 356: Principles of Energy Conversion

**Course Code: ME 356**
**Course Name: Principles of Energy Conversion**

L-T-P-C:3-1-0-4
Prerequisite: Thermodynamics
Students intended for: B.Tech.
Elective or Core: Elective
Approval: 3rd Senate

**Course contents**

- Introduction to power system and technologies. Demand variation and forecasting. Grid features. Siting and costing.
- Diesel generators: system, equipment and layout.
- Fossil-fuelled steam power plants: boiler and accessories. Turbine and accessories, feed cycle equipment, generator.
- Combined cycle power plants: gas turbine, heat recovery boiler.
- **Nuclear power:** nuclear reactions, fuel, moderator and coolant. Neutron life cycle. Light water, heavy water, gas cooled and fast reactors.
- Hydroelectric plants: features and siting, Pelton, Francis, Kaplan and propeller turbines construction, mini and micro turbines.
- **Renewable energy:** solar, geothermal, wind, biomass, ocean, fuel cells, unique features of decentralized systems. Co-generation systems. Environmental issues, sustainability and future scenarios.

**Text Books:**

1. BEI International, Hambling, P., (Ed.), **Modern Power Station Practice: Nuclear Turbines, and Associated Plant**, Pergamon Press, 1992.

2. Drbal, L. F., Boston, P. G., Westra, K. L., Black and Veatch, **Power Plant Engineering**, Kluwer Academic, 1995.

3. Elliott, T. C., Chen, K., and Swanekamp, R., **Standard Handbook of Power Plant Engineering**, 2nd edition, McGraw-Hill Professional, 1997

4. El-Wakil, M. M., **Power Plant Technology**, McGraw-Hill, 1984.

5. Jog, M., **Hydro-electric and Pumped Storage Plants**, John Wiley, 1989.

6. Fritz, J. J., **Small and Mini Hydropower Systems**, McGraw-Hill, 1984.

7. Central Board for Irrigation and Power (CPIB), India, Design and Construction Features of Selected Dams in India, 1983.

8. Borbely, Anne-Marie, and Kreider, Jan J., (Eds.), **Distributed Generation: The Paradigm for the New Millennium**, CRC Press, 2003.

9. Larminie, J., and Dicks, A., **Fuel Cell Systems Explained**, John Wiley, 2003.

10. Vielstich, W., Lamm, A., and Gasteiger, H., **Handbook of Fuel Cells: Fundamentals, Technology, Applications**, John Wiley, 2003.

11. O'Hayre, R.,.Cha, S. -W., Colella, W., and Prinz, F. B., **Fuel Cell Fundamentals**, Wiley, 2005.

12. Appleby, A. J., and Foulkes, F. R., **Fuel Cell Handbook**, van Nostrand Reinhold, 1996.

13. Harrison, R., Hau, E., and Snel, H., **Large Wind Turbines: Design and Economics**, John Wiley, 2001.

14. Bejan, Adrian, **Advanced Engineering Thermodynamics**, Wiley, 1997.

15. Patents and catalogues related to various equipment.

## 17.42 ME 451: Refrigeration and Air Conditioning

**Course Code: ME 451**
**Course Name: Refrigeration and Air Conditioning**

L-T-P-C:3-0-0-3
Prerequisite: Consent of the faculty member
Students intended for: B.Tech.
Elective or Core: Elective
Approval: 3rd Senate

**Course contents**

- **Refrigeration**

  Introduction to refrigeration system, Methods of refrigeration, Carnot refrigeration cycle, Unit of refrigeration,Refrigerationeffect & C.O.P.

- **Air Refrigeration cycle**

  Open and closed air refrigeration cycles, Reversed Carnot cycle, Bell Coleman or Reversed Joule air refrigeration cycle, Aircraft refrigeration system, Classification of aircraft refrigeration system. Boot strap refrigeration, Regenerative, Reduced ambient, Dry air rated temperature (DART).

- **Vapour Compression System**

  Single stage system, Analysis of vapour compression cycle, Use of T-S and P-H charts, Effect of change in suction and discharge pressures on C.O.P, Effect of sub cooling of condensate & superheating of refrigerant vapour on C.O.P of the cycle, Actual vapour compression refrigeration cycle, Multistage vapour compression system requirement, Removal of flash gas, Intercooling, Different configuration of multistage system, Cascade system.

- **Vapour Absorption system**

  Working Principal of vapour absorption refrigeration system, Comparison between absorption & compression systems, Elementary idea of refrigerant absorbent mixtures, Temperature – concentration diagram & Enthalpy – concentration diagram , Adiabatic mixing of two streams, Ammonia – Water vapour absorption system, Lithium- Bromide water vapour absorption system, Comparison.

- **Refrigerants**

  Classification of refrigerants, Nomenclature, Desirable properties of refrigerants, Common refrigerants, Secondary refrigerants and CFC free refrigerants

- **Emerging refrigeration Technologies**

  Magnetocaloric, electrocaloric, thermoelectric based refrigeration

- **Air Conditioning**

  Introduction to air conditioning, Psychometric properties and their definitions, Psychometric chart, Different Psychometric processes, Thermal analysis of human body, Effective temperature and comfort chart, Cooling and heating load calculations, Selection of inside & outside design conditions, Heat transfer through walls & roofs, Infiltration & ventilation, Internal heat gain, Sensible heat factor ( SHF ), By pass factor, Grand Sensible heat factor ( GSHF), Apparatus dew point (ADP)

- **Refrigeration Equipment & Application**

  Elementary knowledge of refrigeration & air conditioning equipments e.g. compressors, condensers, evaporators & expansion devices, Air washers, Cooling, towers & humidifying efficiency, Food preservation, Cold storage, Refrigerates Freezers, Ice plant, Water coolers, Elementary knowledge of transmission and distribution of air through ducts and fans, Basic difference between comfort and industrial air conditioning.

**Text Books:**


1. C.P Arora, **Refrigeration and Air conditioning**, Tata McGraw Hill.

2. Manohar Prasad, **Refrigeration and Air Conditioning**, Wiley Eastern Ltd., 1983.

3. Roy. J. Dossat, **Principles of Refrigeration**, Pearson Education 1997

## 17.43 ME 452: Robotics and Control

**Course Code: ME 452**
**Course Name: Robotics and Control**

L-T-P-C: 2-1-0-3
Prerequisite: ME 309 Theory of Machine or consent of faculty
Students intended for: B-Tech final year/pre-final students
Elective or Core: Elective
Approval: 10th Senate

**Course contents**

- **Introduction to Robotics**

  Basic definitions, mechanism, degree of freedom, classification and specifications of Robots, Industrial Robots, sensors, controller, actuator [5 Lectures]

- **Kinematics**

  Position and orientation of links, Coordinate transformation, d-h parameters, joint variable and position of end effectors, inverse kinematic analysis. [9 Lectures]

- **Velocity analysis**

  Jacobian, Static force analysis [9 Lectures]

- **Trajectory generation**

  Determining the joint variables for desired trajectory generation [5 Lectures]

- **Manipulator Dynamics**

  Newtons laws, Eulers equation and Lagrange formulation [9 Lectures]

- **Module VI**

  Linear and nonlinear control of manipulators [5 Lectures]

**Text Books:**

1. Craig John J., **Introduction to robotics: Mechanics & Control**, 3rd Edition, Pearson. 2008.

2. Tsuneo Yoshikawa, **Foundations of Robotics – Analysis and Control**, 1990.

**Reference Books:**

1. Niku Saeed B., **Introduction to Robotics: Analysis, Systems, Applications**, 2nd Edition, Wiley, 2011.

## 17.44 ME 452_Revised: Robotics and Control

**Course Code: ME 452_Revised**

**Course Name: Robotics and Control**

L-T-P-C: 2-1-0-3
Prerequisites: ME 309 Theory of Machine or consent of faculty
Intended for: B-Tech final year/pre-final, MS.
Core/Elective: Elective
Approval:

**Course Contents:**

- **Introduction to Robotics:** Basic definitions, mechanism, degree of freedom, classification and specifications ofRobots, Industrial Robots, sensors, controller, actuator. (4 Lectures)
- **Robot Kinematics:** Position and orientation of links, Coordinate transformation, d-h parameters, joint variable and position of end effectors, inverse kinematic analysis. Velocity analysis - Jacobian. Static force analysis. (10 Lectures)
- **Trajectory Planning:** joint space trajectory planning, cubic polynomial path generation, obstacle avoidance (5 Lectures)
- **Robot Dynamics:** Derivation of dynamics equation based on Newton Eulers formulation and Lagrangian formulation. (9 Lectures)
- **Robot Control:** Actuators- hydraulic, pneumatic, electric motors, Sensors- position, velocity, proximity, force and pressure, Position control- Proportional-Integral-Derivative control, servo compensation. Force control - Impedance control, hybrid control (force + position control), introduction to nonlinear control of manipulators. (14 Lectures)

**Textbooks:**

1. Craig John J., **Introduction to robotics: Mechanics & Control**, 3rd Edition, Pearson. 2008.
2. Tsuneo Yoshikawa, **Foundations of Robotics - Analysis and Control**, 1990.

**References:**

1. Niku Saeed B., **Introduction to Robotics: Analysis, Systems, Applications**, 2nd edition, Wiley, 2011.
2. Richard K.lafter, T. Chmiewski, M. Nigin, **Robotics Engineering**, PHI India
3. Michel P Grover, et. al., **Industrial Robotics**, McGraw Hill
4. Subir Kumar Saha, **Introduction to robotics**, Mc Graw Hill

## 17.45 ME 501_Old: Nanomanufacturing

**Course Code: ME 501_Old**
**Course Name: Nanomanufacturing**

L-T-P-C: 3-0-0-3
Prerequisite: None
Students intended for: UG/PG
Elective or Core: Elective

**Comments:**

This course is changed to ME 509, Nanomanufacturing

## 17.46 ME 501: Materials Science for Failure Analysis

**Course Code : ME 501**

**Course Name : Materials Science for Failure Analysis**

Credit Distribution : 3-0-0-3
Intended for : MS/Ph.D.
Prerequisite : None
Mutual Exclusion :None
Approval: 2nd SEnate

**Course Contents:**

- **Introductory remarks on Materials Science in the context of Engg**: Structure of perfect and imperfect solids; Elastic deformation and stressdistribution,stress-strain relationsunder niaxialloading.
- **Plastic Deformtion in Crystalline Solids**: Introduction, theoretical strength of crystals and the motion of dislocation, energy of a dislocation and stable Burgers vectors. Slip planes and slip systems, relation between dislocation movement and plastic flow, dislocation generation, other modes of Deformation in crystalline solids.
- **Some Strengthening Mechanisms**: The phenpmenon of yield point and strain hardening.Theories of yielding and strain hardening. Recovery, mechanisms of deformation at elevated temperatures, creep.
- **Mechanism of Fracture**: Ductile - Brittle transition, fracture. Design criteria for materials, environmental effects. Mechanical behavior of engineering materials under fatigue.
- Selection of materials and Processes,case studies.

**Text & Reference Books:**


1. George E.Dieter, **Mechanical Metallurgy**, McGrawHill BookCompany.
2. R. K. Honeycombe, **Plastic Deformation of Metals**, EWP

3. William D. Callister Jr., **Materials Science and Engineering**, Willey India (P)Ltd.

4. Knott, **Fundamentals of Fracture Mechanics**.

5. A.H. Cottrell, **Mechanical Properties of Matter**, Willey

6. Brown, **Introduction to Mechanical Behaviour of Materials**,Willey.

## 17.47 ME 501P : Practicum-I

**Course Code : ME 511**

**Course Name : Practicum-I**

Credit Distribution :0-0-6-3
Intended for : Only for M.Tech.
Prerequisite : None
Mutual Exclusion : None
Approval: 32nd Senate; 39th BoA

**Preamble:**

After completing one semester of course work at IIT Mandi, the students will be exposed to hands-on which will help to develop useful skills, through this course. This skill can include, performing numerical/experiment work in a laboratory, developing some models/products, literature survey, venturing into a new domain, testing the validity of a new idea through experimentation and/or numerical simulations etc. A laboratory will be allotted to every student. This course will end at the start of the even semester. The Faculty Advisor (FA) will form a committee according to M.Tech. ordinance and conduct presentations to evaluate the work performed in this course.

**Course Contents:**

There are no regular lecture hours or practical classes for this course. It is expected that student should meet laboratory coordinator regularly and perform the work as per mutual understanding between them.

The assigned work should provide exposure to students. It should help them in choosing relevant problems and defining its objectives. Students should perform small scale work for understanding the current level of development in the area of problem. Based on this they should make some effort for solving few objectives by applying the learned numerical or experimental skills. Learning of any new skill before applying them should also be counted in the effort of the students.

**Text Book:**

1. There is no text book for this course.

**Reference Books:**

NA

## 17.48 ME 502_Old: Functional Materials

**Course Code: ME 502_Old**
**Course Name: Functional Materials**

L-T-P-C: 3-0-0-3
Prerequisites:
Students intended for: B. Tech
Elective or Core: Elective

**Course Comments:**

This course is changed to ME 609/EN 509, Functional Materials

## 17.49 ME 502: Nanomanufacturing

**Course Code: ME 502**
**Course Name: Nanomanufacturing**

L-T-P-C: 3-0-0-3
Prerequisite: None
Students intended for: UG/PG
Elective or Core: Elective
Approval: 8th Senate

**Comments:**

This course is changed to ME 509, Nanomanufacturing

## 17.50 ME 503: Micro/Nano Scale heat transfer

**Course Code: ME 503**
**Course Name: Micro/Nano Scale heat transfer**

**Comments:**

This course is not approved. Syllabus is not Available. One time approved Course.

## 17.51 ME 504: Numerical Methods for Engineering Computation

**Course Code: ME 504**
**Course Name: Numerical Methods for Engineering Computation**

L-T-P-C: 3-0-0-3
Prerequisite: Consent of the faculty member
Students intended for: B.Tech.
Elective or Core: Elective
Approval: 9th Senate

**Course contents**

- **Introduction**

  Differential equations in engineering applications. Analytical vs. Numerical solution of a mathematical model. Computer representation of numbers. Errors in numerical computation. Review of CPP programming concepts - Program structure, data types, arrays, structures, functions, file handling using simple problems: Second moment of area, analysis of beams, basic statistics etc. [3 Lectures]

- **Systems of linear algebraic equation**

  Gauss elimination, Gauss Jordan, LU decomposition, and Gauss-Seidel methods. Thomas algorithm for tri-diagonal and Cholesky decomposition for symmetric matrices. Matrix inversion methods. CPP programs for the mentioned schemes. [6 Lectures]

- **Eigen problem**

  Eigenvalues and Eigen vectors. Properties. Methods of estimation of Eigenvalues and Eigenvectors – Power Iteration Methods, Jacobi Iteration, QR algorithm; Application of these concepts towards Matrix Inversion and solution of linear simultaneous equations. [5 Lectures]

- **Curve fitting**

  Linear regression, polynomial regression, nonlinear regression. CPP program for constitution of normal equations [4 Lectures]

- **Finite differences and interpolation**

  Taylor's series, Forward, backward and central differences, Difference tables, Finite difference operators, Newton's forward and backward interpolation formulae, Stirling's, Bessel's and Laplace-Everett's interpolation formulae. Lagrange's polynomial and Newton's divided difference formula. CPP programs for implementing interpolation schemes. [6 Lectures]

- **Numerical differentiation and integration**

  Derivatives using forward, backward and central difference formulae. Newton-Cotes integration formulae – Trapezoidal rule, Simpson's 1/3 rule, Simpson's 3/8 rule. CPP programs for implementing numerical integration schemes. [6 Lectures]

- **ODEs**

  Description of initial and boundary value problems. Taylor's series, Picard's, Euler's, Runge-Kutta and Milne's methods. Finite difference solution of boundary value problems. [6 Lectures]

- **PDEs**

  Description of Elliptic, Parabolic and Hyperbolic PDEs. Solution of Laplace's and Poisson's equations. Solution of linear heat transfer equation - CPP programs for implementation of explicit and implicit schemes. Conditions for stability. [6 Lectures]

**Text Books:**

1. Steven C. Chapra and Raymond P. Canale, **Numerical methods for engineers**, McGraw- Hill. 2015.
2. Nita H. Shah, **Numerical methods with C++ programming**, PHI. 2009.

**References:**

1. Joe D. Hoffman, **Numerical methods for engineers and scientists**, Marcel Dekker Inc., 2001.
2. T. Veerarajan and T. Ramachandran, **Numerical methods with programs in C**, Tata McGraw-Hill, 2006.

## 17.52 ME 505: Applied Finite Element Method

**Course Code: ME 505**
**Course Name: Applied Finite Element Method**

L-T-P-C: 2-0-2-3
Prerequisite: ME 352 Finite Element Methods in Engineering
Students intended for: UG/PG
Elective or Core: Elective
Approval: 9th Senate

**Course contents**

- **Module I**

  Introduction to FEM: Basics of statics, strength of materials and FEM, CAE driven design process, Analysis types: linear, non-linear, dynamic, buckling, thermal, Fatigue, optimization, CFD, NVH etc, 1D, 2D, 3D methods, Degree of freedom, Advantages of FEM, Modeling/Preprocessing techniques, introduction to meshing, common mistakes and errors, Application of analysis types in various engineering fields. [3 Lectures]

- **FEM-Weighted Residue Approach**

  Non-weak type methods- methods adopted to minimize errors: Subdomain, Galerkin, Petrov-Galerking, Least Square, Collocation; Weak form type method: Rayleigh-Ritz method, Finite element method, Global stiffness matrix, Shape functions, Direct application of element matrix equations, Compatibility, Convergence criteria, Sources of errors, Types of PDE: elliptic, parabolic and hyperbolic and their solution approach, 1D problems in heat transfer, fluid flow, vibration etc. and comparison with exact solution. [14 Lectures]

- **Module II**

  Introduction to Meshing: 1-D Meshing- Introduction to meshing, when to use 1-D meshing, meshing in critical areas, element section, stiffness matrix derivation (direct method) and its properties, element types: beam element, rigid elements, fasteners, problems based on 1-D FEM and comparison with exact theory, 2-D

Meshing: When to use 2-D elements, mid-surface, Constraint strain triangle, different types of element and their displacement function, Family of 2D elements: plane stress, plan strain, plate, membrane, thin shell etc., effect of mesh density, effect of biasing in critical region, boundary conditions, how not to mesh, shrink wrap meshing, problems based on 2-D FEM and comparison with exact theory. 3-D Meshing: When to use 3-D elements, DOF for solid elements, Algorithms, brick meshing, how not to mesh, Hexa and Penta elements, solid map meshing. [8 Lectures]

- **Module III**

  Element Quality and Checks: Compatibility and mechanisms, spring elements, shells to solids, beam to solids, beams normal to shells, beam to shell edge, General element quality checks: skewness, aspect ratio, warpage, jacobian; 2-D quality checks, quality checks for tetra meshing, brick mesh quality checks, student projects on mesh quality, Weld, Bolt and Shrink Fit Modeling: Welding simulation-modelling spot and arc welding, bolted joints, bearing simulation, shrink fit simulation. [5 Lectures]

- **Module V**

  Linear Static and Dynamic Analysis: Stiffness matrix, stress and strain calculations, FEM model for linear analysis, error analysis, design problems based on linear analysis, Theory of dynamic analysis: forced and free vibration, mode shapes, harmonic analysis, design for avoiding resonance, Thermal Analysis: Conduction, convection and radiation heat transfer, structured and unstructured meshing, IC engine block thermal analysis, Introduction to CFD, Nonlinear analysis: Introduction to nonlinearity, types of nonlinearity: geometric nonlinearity, material nonlinearity, boundary nonlinearity/contact nonlinearity, stress-strain measures, general procedures for nonlinear static analysis, plasticity.

  Applied FEM: Projects based on thermal analysis, CFD, Fatigue analysis, NVH analysis, Crash analysis etc., application of FEA in biomedical, implant designs such as Orthopaedic Implants, Spine Implants, Cardiovascular Implants, medical device components, automotive, aerospace, civil etc. [12 Lectures]

**Text Books:**

1.

**References:**

1.

## 17.53 ME 506: Fundamentals of Fracture Mechanics

**Course Code: ME 506**
**Course Name: Fundamentals of Fracture Mechanics**

L-T-P-C: 2.5-0.5-0-3
Prerequisite:
Students intended for: UG/PG
Elective or Core: Elective

Approval: 8th Senate

**Course contents**

- **Introduction**

  Why structures fails?, An atomic view, Energy criterion, Stress intensity, Effect of material properties on fracture, Modes of failure. [4 Lectures]

- **Linear Elastic Fracture Mechanics**

  An atomic view of fracture, Effect of flaws on stress concentration, Griffith theory of fracture, Energy release rate, Instability and the R curve, Stress analysis of cracks, Stress Intensity Factor (SIF) , Determination SIF of different geometries, Crack tip plasticity, Irwin approach, Plane strain fracture, Mixed mode fracture. [10 Lectures]

- **Elastic-Plastic Fracture Mechanics**

  Crack tip opening displacement (CTOD), J contour integral, Relationship between J and CTOD, Resistance curve, Cleavage fracture, failure criterion, Three-dimensional effect, Crack arrest. [10 Lectures]

- **Fracture Mechanisms in Metals and Nonmetals**

  Ductile fracture, Void nucleation, Void growth, coalescence, Ductile crack growth, Brittle Fracture, Cleavage, Mechanisms of cleavage initiation, Transgranular and Intergranular fracture, Fracture Mechanisms in Nonmetals. [8 Lectures]

- **Fracture Toughness Testing**

  Specimen configurations and orientations, KIC testing, CTOD testing, Measurement of J-critical, Determination of critical G in Mode I and Mode II. [4 Lectures]

- **Fatigue Crack Propagation and Environmental Assisted Fracture Failure**

  Fatigue crack growth, Crack closure, A short introduction to environmental assisted fracture failure. [4 Lectures]

- **Computational Fracture Mechanics**

  Modeling and analysis [2 Lectures]

**Text Books:**

1. T.L. Anderson, **Fracture Mechanics – Fundamentals and Applications**, 3rd Edition, CRC Press, 2005.

**References:**

1. Prashant Kumar, **Elements of Fracture Mechanics**, Tata McGraw Hill, New Delhi, India.

2. G.E. Dieter, **Mechanical Metallurgy**, McGraw Hill, 2009

## 17.54 ME 507: Micro and Nanoscale Fluid Mechanics

**Course Code: ME 507**
**Course Name: Micro and Nanoscale Fluid Mechanics**

L-T-P-C: 3-0-0-3
Prerequisite: IC 142, ME 210, ME 303
Students intended for: UG/PG
Elective or Core: Elective
Approval: 9th Senate

**Course contents**

- **Introduction**

  Overview, physics of miniaturization, scaling laws and continuum model, engineering applications of micro/fluidics. [4 Lectures]

- **Microscale fluid mechanics**

  Navier Stokes equations, energy and species transport equations, constitutive relations, surface tension, Young-Laplace equation, velocity and stress boundary conditions at interfaces, exact solutions, flow regimes, inter-molecular forces, kinetic theory of gases, slip theory, Low Re flows, High Pe flows, Couette flow, Poiseuille flow, Stokes drag on a sphere, time-dependent flows, Hydraulic circuit analysis. [16 Lectures]

- **Electrokinetics**

  Electrostatics and electro hydrodynamics fundamentals, electro-osmosis, electrophoresis, Dielectrophoresis, electro-capillarity and electrowetting effects. [10 Lectures]

- **Microfabrication techniques**

  Micromachining of Silicon and Polymeric chips, Chemical etching and bonding, electron beam lithography, soft lithography, micromachining, casting, injection molding. [8 Lectures]

- **Introduction to Nanofluidics**

  Unidirectional transport in nanochannels, transport through nanostructures with interfaces, molecular dynamics simulations, nanofluidic energy conversion [4 Lectures]

**References:**


1. P. Tabeling, **Introduction to Micro Fluidics**, Oxford 2005.
2. B. Kirby, **Micro and Nanoscale Fluid Mechanics: Transport in Microfluidic devices**, Cambridge University Press, 2010.
3. N.T. Nguyen, S. Wereley, **Fundamentals and applications of Microfluidics**, Artech House, 2002.
4. Marc. J. Madou, **Fundamentals of Microfabrication**, 2nd Edition, CRC Press, 2002.

5. S. Colin, **Microfluidics**, John Wiley & Sons, 2009.

6. H. Bruss, **Theoretical Microfluidics**, Oxford 2008.

## 17.55 ME 508: Fundamentals of project management

**Course Code: ME 508**
**Course Name: Fundamentals of project management**

L-T-P-C: 3-0-0-3
Prerequisite: IC 142, ME 210, ME 303
Students intended for: UG/PG
Elective or Core: Elective
Approval:

**Course contents**

- **Introduction**

  Project definition, Constraints and Scope triangle, Project environment, Classification of projects, Project management – necessity and processes, Project manager – knowledge areas and role, Planning – principles, objectives, steps and advantages, Work breakdown structure, Scheduling - Bar charts, Milestone charts, Networks. Project control and evaluation. [6 Lectures]

- **Scheduling by network analysis**

  (i) Programme Evaluation and Review Technique (PERT): Time estimates for activities, Computation of event times, Network analysis – Slack and critical path. (ii) Critical Path Method (CPM): Computation of event and activity times, Network analysis – Float and critical path. [6 Lectures]

- **Time-Cost optimization**

  Crashing a network. Updating a project: Data required and implementation. Resource allocation: Resource usage profiles, Smoothing and Levelling of resources. [6 Lectures]

- **Quality management**

  Policy, Assurance, Management systems, Control, Plan, Audit, Reviews, Statistical methods for quality control – Shewhart, Cusum and EWMA control charts, Process capability analysis, Factorial experiments and Acceptance sampling. [10 Lectures]

- **5. Management science techniques**

  Linear and integer programming, Distribution and network models – transportation, assignment, transshipment and shortest route problems. Non-linear optimization, Time series analysis and forecasting. [14 Lectures]

**Text Books:**

1. B.C.Punmia and K.K.Khandelwal, **Project planning and control with PERT and CPM**, Laxmi Publications. 2006.
2. E. L. Grant and R. S. Leavenworth, **Statistical quality control**, 7th Edition, TMH. 2000.
3. D. R. Anderson, D. J. Sweeney, T. A. Williams, J. D. Camm and Kipp Martin, **An introduction to management science**, 13th Edition, South-Western. 2012.

**References:**

1. James P. Lewis, **Fundamentals of project management**, 3rd Edition, AMACOM, 2007.
2. Albert Lester, **Project management, planning and control**, Elsevier, 2014.
3. D. C. Montgomery, **Introduction to statistical quality control**, 6th Edition, Wiley, 2009.
4. J. A. Lawrence, Jr. and B. A. Pasternack, **Applied management science**, Wiley (2002).

## 17.56 ME 509: Nanomanufacturing

**Course Code: ME 509**
**Course Name: Nanomanufacturing**

L-T-P-C: 3-0-0-3
Prerequisite: None
Students intended for: UG/PG
Elective or Core: Elective
Approval: 9th Senate, 18th Senate

**Course contents**

- **Introduction to Nanosceience and Nanotechnology**

  Historical developments in size reduction, fundamentals of nanoscale materials and their interactions, properties of nanocrystalline materials, size effects and quantum confinement in semiconductors, different types of nanostructures (zero, one and two dimensional) with specific examples, nanoscience in electronics, mechanics, photonics, biomedical and energy, nanomanufacturing objectives and opportunities, nanomanufacturing challenges. [6 Lectures]

- **Characterizations/fabrication techniques for nanostructures**

  Basic concepts in microscopy, evolution of microscopes, electron microscopy and scanning probe microscopy for structural, microstructural, topological analysis, atomic order and compositional analysis. Application of microscopes in nanoscale characterizations. In- situ microscopy for the growth and fabrications of various nanostructures. Interface of microscopy with nanofabrication techniques. [4 Lectures]

- **Top down approaches for nanomanufacturing (subtractive)**

  Concepts in top down nanomanufacturing, Mechanosynthesis-ball milling, Focused ion beam milling, thin film fabrication, thermal evaporation, E beam evaporation, Sputtering (DC, RF, reactive), thin film growth mechanism and stress evolution, Essentials of photolithography, Ebeam lithography, nanoimprint lithography, Etching methods for fabrication, dry etching and wet etching. [6 Lectures]

- **Bottom up approaches for nanomanufacturing (additive)**

  Solution synthesis of nanostructures, basics of size and shape control, growth by aggregation and oriented attachment, growth from vapor phase, Atomic layer deposition, Chemical vapor deposition, Growth of carbon nanotubes, graphene and 2D materials, Vapor-liquid-solid method, Vapor phase epitaxy, Molecular beam epitaxy, Growth of important semiconductor materials; Si, GaN nanowires. [8 Lectures]

- **Advanced nanomanufacturing techniques and assembly**

  Non lithographic techniques for nanomanufacturing, Template assisted methods, Template less nanopatterning, self-assembly, electric field assisted assembly. [4 Lectures]

- **Selected Topics in Nanomanufacturing and Microfabrication**

  Introduction to VLSI technology, Electrochemical Processing and MEMS/NEMS technology, Challenges and Applications of nanomanufacturing in electronics, display, nanomedicine, green energy building and smart surfaces. Issues of yield and rate of production. High rate and scalable nanomanufacturing; roll to roll manufacturing for nanomaterials. Industrial R& D activities, economics and environmental concerns. [7 Lectures]

**Text Books:**


1. Ahemed Busnaina, **Nanomanufacturing Handbook**, CRC press, 2006

2. Marc J.Madou, **Fundamentals of Microfabrication and Nanotechnology**, CRC Press, 2011

3. Ahmed & M.J Jackson, **Emerging nanotechnologies for manufacturing**, Waqar William Andrew Publishing, 2009

4. Open course materials (MIT & University of Michigan) and Journal articles


## 17.57 ME 510: Advanced Manufacturing Processes

**Course Code : ME 510**

**Course Name : Advanced Manufacturing Processes**

Credit Distribution : 3-0-0-3
Intended for : : UG/MS/PhD
Prerequisite : Basic Manufacturing Processes and instructor's consent
Mutual Exclusion :
Approval: 13th Senate

**Course Contents:**

- **Introduction to Advanced Manufacturing Processes**: General trends in manufacturing, Introduction to advanced manufacturing, overview and need; selection of manufacturing process; fundamentals of materials and their mechanical, physical and manufacturing properties; introduction to different types of materials - metals and alloys, polymers, glass and ceramics, semiconductors, composites and nanomaterials. (4 Lectures)

- **Metal Casting and Foundry Techniques**: Physics of solidification - nucleation and grain growth; solidification of pure metals and alloys; progressive and directional solidification; rate of solidification; Chvorinov's rule; Riser and gating system design; aspiration effect; Advanced casting processes: centrifugal and continuous casting processes, squeeze casting, vacuum mould casting, evaporative pattern casting, semi-solid metal working processes, ceramic shell casting, microwave casting; Casting defects; testing, inspection and quality control; product design considerations; economics of metal casting, significance of modelling and simulation in improving cast quality and cost reduction. (8 Lectures)

- **Forming Processes**: Metal forming fundamentals; material behaviour during metal forming; temperature during metal forming; strain rate sensitivity; yield criteria of metals; mechanics (stress strain analysis) of forming processes- rolling, forging, drawing, force analysis in deep drawing, bending extrusion etc.; punching and blanking- mode of metal deformation and failure; two-dimensional model and fracture analysis; determination of working force; details of high energy rate forming (HERF) process; electro-magnetic forming; explosive forming; electro-hydraulic forming; stretch forming; contour roll forming. Advanced plastic moulding processes – injection moulding. (7 Lectures)

- **Material Removal Processes**: Basics of traditional machining- machining by cutting, abrasion; non-traditional machining- single action traditional machining and hybrid machining; advanced machining processes; principles, mathematical analysis, machining system, material removal process, process parameters and applications of ultrasonic machining (USM), abrasive water jet machining (AWJM), electrochemical machining (ECM), chemical milling, photo chemical milling, electro polishing, electro discharge machining (EDM), electron beam machining (EBM), and laser beam machining (LBM) processes, abrasive flow machining (AFM), biomachining, microwave machining, plasma beam machining, ion beam machining, elastic machining, micro and nano machining. (8 Lectures)

- **Material Joining Processes:** Classification of material joining processes, physics of welding arc, arc characteristics; arc efficiency; heat generation at cathode and anode; effect of shielding gases, isotherms of arcs, arc blow; calculation of peak temperature; width of heat affected zone (HAZ), factors affecting HAZ; residual stresses- measurement and control; shielded metal arc welding (SMAW), gas tungsten arc welding (GTAW); gas metal arc welding (GMAW), submerged arc welding (SAW), electro slag welding (ESW), electro gas welding (EGW), resistance welding (RW), cold pressure welding, ultrasonic welding (USW), electron beam welding (EBW), laser beam welding (LBW); solid state welding; microwave joining; welding of plastics. (8 Lectures)

- **Additive Manufacturing**: Additive manufacturing processes, rapid prototyping techniques (RPT) such as liquid-based techniques- stereolithography, holographic interference solidification, beam interference solidification, solid ground curing; modelling techniques in additive manufacturing- fused deposition modelling (FDM) and shape deposition manufacturing, Selected Laser Sintering (SLS), Laminated Object Manufacturing (LOM), 3-D printing, Laser Engineered Net Shaping (LENS), accuracy in additive manufacturing processes, stair-casing and its correction, materials for additive manufacturing processes. (7 Lectures)

**Text Books:**


1. Kalpakjian, S. and Schmid, S.R., **Manufacturing Engineering and Technology**, Pearson Prentice Hall, 2008.
2. DeGarmo E.P., Black J.T. and Kohser R.A., **Materials and Processes in Manufacturing**, Prentice Hall, 1997.
3. Ghosh A. and Mallik A.K., **Manufacturing Science**, East-West Press Pvt. Ltd., 1985.
4. Groover, M.P., Automation, **Production Systems and Computer Integrated Manufacturing**, Prentice-Hall, 2007.
5. Jain V.K., **Advanced Machining Processes**, Allied Publishers, 2002.


**Reference Books:**


1. Pandey P.C. and Shan H.S., **Modern Machining Processes**, McGraw Hill Publishing Company, 1980.
2. Heine and Roshenthal, **Principles of Metal Casting**, Tata McGraw-Hill Publishing Company Ltd., 1983.
3. Avitzur B., **Metal Forming Analysis**, Mc Graw Hill Publishing Company, 1980.
4. Messler R.W. Jr., **Joining of Materials and Structures**, Elsevier Butterworth–Heinemann, 1999.
5. **Welding Hand Book**, Volume 1-5, 9th edition, American Welding Society (AWS), 1999.
6. Chua, C.K. and Leong, K.F., **Rapid Protyping: Principles and Applications in Manufacturing**, John Wiley and Sons, 2000.


## 17.58 ME 511: Manufacturing of Composites

**Course Code : ME 511**

**Course Name : Manufacturing of Composites**

Credit Distribution : 3-0-0-3

Intended for : B.Tech. (4th year onwards)/M.Tech./M.Tech.(R)/Ph.D.

Prerequisite : Basic Manufacturing Course

Mutual Exclusion :
Approval: 50th BoA

**Course Contents:**

- **Introduction to Composites:** Function of the Matrix and Reinforcement in Composites Matrices: Thermosets and Thermoplastic; Fiber Reinforcement (3 Hours)
- **Properties and testing composites**: Properties of Composites; Composites testing; Composites design: Laminate theory, Rule of mixtures, symmetry and balance (6 Hours)
- **Thermoset composite manufacturing processes**: Lay-up processes, spray up process; Thermoset Composite manufacturing: Fiber placement process; Thermoset Composite manufacturing: Resin transfer moulding, Vacuum assisted resin infusion microwave curing, recycling of thermoset composites, latest topics in thermoset composite manufacturing. (6 Hours)
- **Thermoplastic composite manufacturing processes**: Thermoset Composite manufacturing: Vacuum assisted resin transfer moulding; Thermoset Composite manufacturing: Compression molding process; Thermoset composites manufacturing: Filament winding, Microwave assisted Compression moulding, Additive manufacturing techniques for thermoplastic composites, latest topics in thermoplastic composite manufacturing. (6 Hours)
- **Metal and Ceramic Matrix Composites**: Metal Matrix Composites: Metal matrix and reinforcement; Manufacturing processes for Metal Matrix Composites: Dispersion hardened and particle composite; Manufacturing processes for Metal matrix composites: Layer composites and infiltration method; Ceramic Matrix Composite manufacturing, latest topics in metal and ceramic matrix composite manufacturing. (7 Hours)
- **Secondary Manufacturing Techniques for Composites:** Joining techniques: Hot plate welding; Ultrasonic joining; Adhesive binding, composite repair techniques. Machining techniques for composites Machining Techniques for composite, Laser beam machining, electric discharge machining, ultrasonic machining, water jet machining, conventional drilling, milling and turning operations. (7 Hours)
- **Process modelling in Composite Manufacturing**: Transport equations for composite processing, constitutive laws and their characterization, Resin viscosity, Reaction kinetics, crystallization kinetics, model simplification and solution, application of numerical model in short fiber composites, thermoplastic composites, thermoset composites. (7 Hours)

**Text books: (Relevant and Latest, Only 2)**


1. Strong AB, **Fundamentals of composites manufacturing: materials, methods and applications**, Society of manufacturing engineers, 2008.
2. Mallick PK, **Fiber-reinforced composites: materials, manufacturing, and design**, CRC press, 2007.

**References: (No limit on numbers, relevant standard format can be followed, the formats should be similar)**

1. ASM International Handbook Committee, **Composites**: Volume 21 of ASM Handbook.

## 17.59 ME 513: Finite Element Methods in Engineering

**Course Code: ME 513**
**Course Name: Finite Element Methods in Engineering**

L-T-P-C: 3-0-2-4
Prerequisite: IC 111, IC 240, ME 206/CE 301
Students intended for: BTech 3rd and 4th Year; M.Tech/MS/Ph.D.
Elective or Core: Discipline Core for M.Tech-Structural Engineering; Elective for BTech 3rd and 4th Year; MTech/MS/Ph.D.
Approval: 24th Senate

**Course contents**

- **Basic concept**

  Introduction, Engineering applications of finite element method, Rayleigh- Ritz method, Weighted residual methods: Galerkin's method, Principal of a minimum potential energy, principle of virtual work, Boundary value problem, initial value and Eigenvalue problem, Gauss elimination method. [8 Lectures]

- **Basic procedure**

  General description of Finite Element Method, Discretization process; types of elements 1D, 2D and 3D elements, size of the elements, location of nodes, node numbering scheme, half Bandwidth, Stiffness matrix of bar element by direct method, Properties of stiffness matrix, Preprocessing, post processing, One Dimensional Problems [6 Lectures]

- **Interpolation models**

  Polynomial form of interpolation functions- linear, quadratic and cubic, Simplex, Complex, Multiplex elements, Selection of the order of the interpolation polynomial, Convergence requirements, 2D Pascal triangle, Linear interpolation polynomials in terms of global coordinates of bar, triangular (2D simplex) elements, Linear interpolation polynomials in terms of local coordinates of bar, triangular (2D simplex) elements, CST element. [6 Lectures]

- **Higher order and isoparametric elements**

  Lagrangian interpolation, Higher order one dimensional elements- quadratic, Cubic element and their shape functions, properties of shape functions, Truss element, Shape functions of 2D quadratic triangular element in natural coordinates, 2D quadrilateral element shape functions – linear, quadratic, Biquadric rectangular element (Noded quadrilateral element), Shape function of beam element. Hermite shape functions of beam element. [6 Lectures]

- **Derivation of element stiffness matrices and load vectors**

  for bar element under axial loading, trusses, beam element with concentrated and distributed loads, matrices, Jacobian, Jacobian of 2D triangular element, quadrilateral, Consistent load vector, Numerical integration. [4 Lectures]

- **Heat transfer and Fluid mechanics problems**

  1D analysis for both heat transfer and fluid mechanics problem, heat conduction governing equation, boundary conditions, Galerkin approach, heat flux boundary condition, 1D heat transfer in thin fins. [4 Lectures]

- **Elasticity problems**

  Review of equations of elasticity, stress-strain and strain displacement relations, plane stress and plane strain problems. [4 Lectures]

- **Dynamic problems**

  Beam and Bar vibration; Natural frequency determination. [4 Lectures]

**Laboratory Component**

- Coding for the complete solution of any suitable problem, Such as Bar, Truss and Beam. [12 Hours]
- Introduction to ANSYS & ABAQUS. [4 Hours]
- Bar and truss problem and 2-D analysis (assuming plane stress and plane strain). [4 Hours]
- Introduction to OPEN SOURCE PROGRAMS (like OpenSees, FEAP, Elmer etc.) [2 Hours]
- Some complex analysis using ANSYS or ABAQUS (complex material modelling or geometrical modelling). [6 Hours]

**Text Books:**

1. Hutton, D.V., **Fundamentals of Finite Element Analysis**, TMH, 2005.
2. Logan, D. L., **A first course in the Finite Element Method**, 6th Edition, Cengage Learning, 2017.

**References:**

1. Rao, S.S., **The finite element method in engineering**, 4th Edition, Elsevier, 2005.
2. Reddy, J.N., **An introduction to the finite element method**, McGraw-Hill, 2005.
3. Huebner, K. H., Dewhirst, D. L., Smith, D. E. and Byrom, T. G., **The finite element method for engineers**, 4th Edition, John Wiley & Sons, 2001.

4. Chandrupatla, T.R., **Finite element analysis for engineering and technology**, University Press (India) Pvt Ltd, 2004.

5. Fish, J. and Belytschko, T., **A first course in Finite Elements**, Wiley 2007.

## 17.60 ME 514 : Fundamentals of Multiphase Flow

**Course Code: ME 514**

**Course Name : Fundamentals of Multiphase Flow**

L-T-P-C : 3-0-0-3
Intended for : M.Tech/MS/PhD/UG
Prerequisite : ME 210 and ME 303 or equivalent courses
Mutual Exclusion : None
Approval: 39th BoA

**Course Contents:**

- **Introduction and flow regimes**: Introduction to multiphase flows, equations of motion, flow regimes in horizontal and vertical pipes, flow regimes with phase change. [6 Lectures]

- **Modelling techniques for multiphase flow**: Homogeneous flow models, drift flux models, separated flow models, dispersed phase modelling, modelling of annular and stratified flow. [12 Lectures]

- **Computational techniques**: Introduction to computational modelling of multiphase flow, population balance modelling for dispersed phase, interface tracking methods for multiphase flow (Volume of Fluid and Level set), particle methods for multiphase flow (Lagrangian Point Particle and Smoothed Particle Hydrodynamics), molecular dynamics. [10 Lectures]

- **Experimental techniques**: Introduction to experimental techniques, importance of measurement and experimentation, calibration, uncertainty analysis, error propagation, pressure, velocity and temperature measurements, measurement of size distribution for dispersed phase, measurement of void-fraction and interface reconstruction, data acquisition and analysis techniques. [7 Lectures]

- **Special topics in multiphase flow**: Granular flows, slurry transport, lattice Boltzmann method, phase change heat transfer, micro-fluidics, multiphase flow in micro-channels. [7 Lectures]

**Textbooks:**

1. Christopher E. Brennen, **Fundamentals of Multiphase Flow**, Cambridge University Press, 2005.

2. S. Mostafa Ghiaasiaan, **Two-Phase Flow, Boiling, and Condensation**, 2nd Edition,Cambridge University Press, 2007.

**References:**

1. John G. Collier and John R. Thome, **Convective Boiling and Condensation**, Oxford University Press; 3rd Edition, 1994.

2. L. S. Tong and Y. S. Tang, **Boiling Heat Transfer and Two-Phase Flow**, 2nd Edition,CRC Press, 2010.

3. R. Clift, J. R. Grace and M. E. Weber, **Bubbles, Drops, and Particles**, Dover Publications, Inc., 2005.

4. Mamoru Ishii and Takashi Hibiki, **Thermo-Fluid Dynamics of Two-Phase Flow**, 2nd Edition, Springer, 2011.

5. J. P. Holman, **Experimental Methods for Engineers**, 7th Edition, Tata McGraw-Hill, 2001.

6. Andrea Prosperetti and Grwtar Tryggvason, **Computational Methods for Multiphase Flow**, Cambridge University Press, 2007.

7. Gretar Tryggvason, Ruben Scardovelli and Stephane Zaleski, **Direct Numerical Simulations of Gas-Liquid Multiphase Flows**, Cambridge University Press, 2011.

## 17.61 ME 515: Carbon Materials and Technology

**Course Code: ME 515**
**Course Name: Carbon Materials and Technology**

L-T-P-C: 3-0-0-3
Prerequisite: None (basic knowledge of material science expected)
Students intended for: M.Tech. / M.S./ Ph.D./ B.Tech. (4th year)/ M.Sc.
Elective or Core: Elective
Approval: 28th Senate

**Course contents**

- **Introduction to carbon**
  - Why should one study carbon materials and manufacturing?
  - Carbon economy
  - Atomic structure and hybridization
  - Carbon allotropes
  - Nomenclature and terminology [6 Lectures]
- **Microstructure of carbon materials**

  a Bulk industrial carbon
    - Graphite: natural and pyrolytic
    - Activated carbon

  - Glass-like carbon
  - Granular amorphous carbon

b Carbon fibers and composites

  - Activated carbon fiber
  - Carbon fiber reinforced plastics

c Carbon nanomaterials

  - Graphene
  - Carbon Nanotube
  - Fullerene
  - Graphite whiskers
  - Diamond-like carbon

d Characterization of carbon materials (discussed in a-c) by X-Ray Diffraction, Raman spectroscopy and electron microscopy[15 Lectures]

- **Raw materials**
  - Polymer precursors (Polyacrylonitrile, cellulose, resins, PVC etc.)
  - Needle coke (petroleum and pitch based)
  - Coal and its distillation
  - Gaseous hydrocarbons (for CVD)
  - Carbon yield and mechanism of carbonization (thermodynamic and kinetic aspects) [4 Lectures]
- **Properties of carbon materials**
  - Crystallinity and electrical conductivity
  - Electrochemistry and surface chemistry
  - Mechanical and thermal properties [4 Lectures]
- **Manufacturing techniques for carbon materials**
  - Pyrolysis (activated carbon, glassy carbon, pyrolytic graphite)
  - Electrospinning (carbon fibers)
  - Chemical vapor deposition (graphene and CNT)
  - Composite preparation (material/ binder interface)
  - Mechanical property testing methods [4 Lectures]
- **Applications**
  - Graphite electrodes
  - Carbon-fiber composites in automobile industry
  - Carbon-based micro and nano devices (sensors, microelectrodes etc.)
  - Filters and adsorbers [6 Lectures]

- **Special topics**
  - Health and environmental safety of carbon nanomaterials
  - Carbon-based flexible electronics
  - Future of carbon technology [3 Lectures]

**Text Books:**


1. Timothy D. Burchell, **Carbon Materials for Advanced Technologies**, Elsevier,1999.


**References:**


1. Jenkins, G. M. & Kawamura, K., **Polymeric carbons–carbon fibre, glass and char**, Cambridge University Press, 1976).
2. Marsh, H. & Rodríguez-Reinoso, F., **Activated carbon**, Elsevier, 2006.
3. Kong, L. B., **Carbon nanomaterials based on graphene nanosheets**, CRC Press, 2017.
4. Chung, D.D.L. **Carbon fiber composites**, Butterworth-Heinemann, 1994


## 17.62 ME 516 : Polymer Technology for Engineers

**Course Code: ME 516**

**Course Name : Polymer Technology for Engineers**

L-T-P-C : 3-0-0-3
Intended for : UG/PG
Prerequisite : Materials Science for Engineers (IC241) or equivalent material science course
Mutual Exclusion : None
Approval: 39th BoA

**Course Contents:**

**Introduction to Polymer**: Brief history of polymers; polymer classification; molar mass and molar mass distribution; polyethylene-polymerization process; chemical bonding-primary, secondary and tertiary structure; crystallinity. (3 Lectures)

**Thermal Transitions in Polymers**: Glass transition temperature; factor affecting glass transition temperature- molar mass dependence, plasticization, chain entanglement effect; crystalline melting point; differential scanning calorimetry. (4 Lectures)

**Mechanical Properties of Polymers**: Stress-strain measurements; dynamic modulus; methods of measurements of polymers- tensile testing, fracture, creep, relaxation time, compression; effect of structural and environmental factors on mechanical properties-molecular weight, cross-linking, crystallinity, strain rate, temperature. (6 Lectures)

**Viscoelastic Properties of Polymer**: Simple rheological responses- ideal elastic, pure viscous and rubberlike elastic; viscoelasticity; mechanical models for viscoelastic responses- Maxwell model, Kelvin-Voigt model, Four-parameter model; relaxation time; material response time-Deborah number. (6 Lectures)

**Polymer processing- Melt: Thermoplastics and Thermoset**: Processing thermoplastics-rotational moulding, injection moulding, compression moulding; melt spinning; processing thermosets- hand lay-up process, spray lay-up method, vacuum bagging, resin transfer moulding, resin infusion process; dry spinning, Spun bonding. (8 Lectures)

**Polymer processing- Solution: Thermoplastics:** Electrospinning; centrifugal spinning; wet spinning. (3 Lectures)

**Composites**: Importance of composites; classification- fiber and particle reinforced; factors affecting composite performance; failure. (3 Lectures)

**Case Studies**: Application of polymers in special cases-vibration damping; energy; adhesives; bio-medical- drug delivery, tissue engineering; water and air purification; electronics. (4 Lectures)

**Recycling of Plastics and Environmental Issues**: Need of recycling; degradation-thermal, chemical, hydrolysis, mechanical; incineration; bioplastics; issues with recycling. (3 Lectures)

**Text Books:**


1. Robert O. Ebewele, **Polymer Science and Technology**, CRC press, 2000.

2. Richard A. Pethrick, **Polymer Science and Technology for Scientists and Engineers**, Whittles Publishing, 2010.


## 17.63 ME 517: Advanced Analytical Techniques for Engineers

**Course Code: ME 517**
**Course Name: Advanced Analytical Techniques for Engineers**

L-T-P-C:3-1-0-4
Prerequisite: None
Students intended for: UG/MTech/MS/PhD in engineering streams core for M.Tech students in Fluid and Thermal Engineering
Elective or Core: Elective
Approval: 40th BoA

**Course contents**

- **Integral Transforms**

  Fourier transform for solution of ODEs and PDEs, Laplace transform for solution of ODEs and PDEs. [6 Lectures]

- **Partial Differential Equations**

  solution of linear PDEs including special cases of heat conduction equation and Navier–Stokes equation, solution of PDEs in cylindrical and spherical coordinate systems. [10 Lectures]

- **First-order integral equations**

Fredholm, Volterra and Wiener-Hopf equation, power series solution for integral equations, integral equations as a generalization of eigenvalue equations and connection to inverse problems. [6 Lectures]

- **Tensors**

  Einstein notation, tensor transformations, tensor fields and tensor calculus, integral theorems. [6 Lectures]

- **Complex analysis**

  functions of a complex variable, limits and continuity, analytic functions, complex exponents, contour integrals, Cauchy integral formula, complex series, Chauchy's residue theorem, singularity, zeros and poles, improper integrals in Fourier analysis, application to plane fluid flow and signal processing. [8 Lectures]

- **Linear Algebra**

  spaces and subspaces, positive definiteness and singular value decomposition (best basis), transformations and change of basis, pseudoinverse, eigenvalues and eigenvectors, introduction to multigrid, Krylov subspaces and conjugate gradients methods for solving large linear systems. [10 Lectures]

- **Statistical Methods**

  Probability, random variables, discrete and continuous probability distributions, autocorrelation and cross correlation, Monte-Carlo method for the solution of diffusion equation, radiative transfer equation and collimated beam radiation problem; linear regression and curve fitting. [10 Lectures]

**Text Books:**


1. B. Dasgupta, **Applied Mathematical Methods**, Pearson Education, 2006.
2. Sheldon M Ross, **Probability and Statistics for Engineers and Scientists**, 5th Edition, Academic Press, 2014.


**References:**


1. M D. Greenberg, **Advanced Engineering Mathematics**, 2nd Edition, Pearson India, 2007.
2. E. Kreyszig, **Advanced Engineering Mathematics**, International 10th Revised Edition, John Wiley and Sons, 2015.
3. G. Strang, **Linear Algebra and Its Applications**, Thomson, Brooks/Cole, 2006
4. P. V. O'Neil, **Advanced Engineering Mathematics**, CENGAGE Learning, 2011.
5. R. L. Thomas and G. B. Finney, **Calculus and Analytic Geometry**, 11/e Addition-Wisley Reading, 2010.
6. M. L. Boas, **Mathematical Methods in the Physical Sciences**, 3rd Ed, Wiley India, 2009.
7. A. D. Polyanin and A. V. Manzhirov, **Handbook of Integral Equations**, 2nd Edition, CRC Press, 2008.

## 17.64 ME 518: Conduction and Radiation

**Course Code: ME 518**
**Course Name: Conduction and Radiation**

L-T-P-C:3-0-0-3
Prerequisite: None
Students intended for: UG/MTech/MS/PhD in engineering streams
Core for M.Tech students in Fluid and Thermal Engineering
Elective or Core: Elective
Approval: 44th BoA

**Course contents**

- **Module I**

  Derivation of Heat Conduction Equation for Heterogeneous, Isotropic Materials in Cartesian Coordinates. Heat conduction equation for homogeneous, isotropic materials in Cartesian, Cylindrical and Spherical Coordinates. Heat transfer from a fin of uniform and variable cross-section. Two-dimensional Steady State Heat Conduction: Solution by Method of Separation of Variables, time constants, thermal boundary layer, Steady 2D Conduction in Cylindrical Coordinates - Fourier-Bessel Series Solution. [8 Lectures]

- **Module II**

  Treatment of variable conductivity by Kirchhoff transformation.Unsteady State Conduction: Applications. Biot Number and its Physical Significance. Lumped System Analysis: Time Constant and its Physical Significance. Semi-Infinite Solid: Definition. Solution by Laplace Transform and Similarity technique. Time-dependent Boundary Conditions-Duhamel's Superposition Principle. Derivation of the integral. Solidification and Melting: Introduction. Stefan problem, enthalpy method. [8 Lectures]

- **Module III**

  Inverse heat conduction and microscale transport: Determination of unknown boundary conditions from interior measurement; Stefan problem, enthalpy method, Experimental determination of thermal conductivity and heat capacity. Microscale heat transfer: hyperbolic heat conduction, speed of propagation of thermal waves, time lag, solution for a thin slab. [6 Lectures]

- **Module IV**

  Introduction To Radiation heat transfer. Physical Mechanism. Laws of Thermal Radiation: Planck's Law. Wien's Displacement Law. Stefan-Boltzmann Law. Intensity of Radiation. Diffuse and Specular Surfaces. Absorptivity, Reflectivity and Transmissivity. Monochromatic and Total Emissivity. Definition of an ideal gray body. Monochromatic and Total Absorptivity. Kirchhoff's Law. Restrictions of Kirchhoff's law. View Factor. Hottel's Crossed-strings Method:. Radiation Exchange in a Gray Enclosure. [5 Lectures]

- **Two-Surface Enclosure**

Network, Expression for the net radiation exchange. Radiation Shields. Radiation Effects in Temperature Measurement (Conduction effects negligible). Integral equation approach. Spectrally diffuse enclosure surfaces; band approximation. Treatment of specularly reflecting surfaces; specular and diffuse reflectivities, modified definition of radiosity, method of images. [5 Lectures]

- **Module VI**

  The equation of radiative heat transfer in participating media. Solution methods. Non-Gray Radiative properties of molecular gases. Introduction to HITEMP DATABASE. Approximate solution methods for one-dimensional media: The optically thin approximation. The optically thick approximation (Diffusion Approximation).[5 Lectures]

- **Gas Radiation**

  Introduction. Beer's law: Monochromatic transmissivity, absorptivity and emissivity of a gas. Mean Beam Length. Gas emissivity charts. Correction factor charts. Heat Exchange between gas volume and black enclosure: Calculation of gas absorptivity using charts. Heat exchange between two black parallel plates at different temperatures. Heat exchange between gas volume and gray enclosure: Hottel's Expression. [5 Lectures]

**Text Books:**


1. Hahn, D. W., and Ozisik, M. N., **Heat Conduction**, John Wiley and Sons, 2012.

2. Modest, M.F., **Radiative Heat Transfer**, 3rd Edition, Academic Press, 2013.


**References:**


1. Arpaci, V. S., **Conduction Heat Transfer**, Longman Higher Education 1967.

2. Siegel, R., and Howell, J., **Thermal Radiation Heat Transfer**, Taylor and Francis, 2015.

3. Schneider, P., **Conduction Heat Transfer**, Addison-Wesley Pub. Co, 1974.

4. Kakac et al., **Heat Conduction**, 5th Edition, CRC Press, 5th ed, 2018.

5. Myers, **Analytical Methods in Heat Conduction**, 2nd Edition, AMCH, 1998.


## 17.65 ME 518_Revised: Conduction and Radiation

**Course Code: ME 518_Revised**

**Course Name : Conduction and Radiation**

L-T-P-C : 3-0-0-3
Intended for : UG all branches
Prerequisite : None
Mutual Exclusion : None
Approval: 44th BoA; Check versions' approvals

**Course Contents:**

- **Derivation of Heat Conduction Equation for Heterogeneous, Isotropic Materials in Cartesian Coordinates**: Heat conduction equation for homogeneous, isotropic materials in Cartesian, Cylindrical and Spherical Coordinates. Heat transfer from a fin of uniform and variable cross-section. Two-dimensional Steady State Heat Conduction: Solution by Method of Separation of Variables, time constants, thermal boundary layer, Steady 2D Conduction in Cylindrical Coordinates - Fourier-Bessel Series Solution. [8Lectures]

- **Treatment of variable conductivity by Kirchhoff transformation**: Unsteady State Conduction: Applications. Biot Number and its Physical Significance. Lumped System Analysis: Time Constant and its Physical Significance. Semi-Infinite Solid: Definition. Solution by Laplace Transform and Similarity technique. Time-dependent Boundary Conditions-Duhamel's Superposition Principle. Derivation of the integral. Solidification and Melting: Introduction. Stefan problem, enthalpy method. [8Lectures]

- **Inverse heat conduction and microscale transport**: Determination of unknown boundary conditions from interior measurement; Stefan problem, enthalpy method, Experimental determination of thermal conductivity and heat capacity. Microscale heat transfer: hyperbolic heat conduction, speed of propagation of thermal waves, time lag, solution for a thin slab. [6Lectures]

- **Introduction To Radiation heat transfer**: Physical Mechanism. Laws of Thermal Radiation: Planck's Law. Wien's Displacement Law. Stefan-Boltzmann Law. Intensity of Radiation. Diffuse and Specular Surfaces. Absorptivity, Reflectivity and Transmissivity. Monochromatic and Total Emissivity. Definition of an ideal gray body. Monochromatic and Total Absorptivity. Kirchhoff's Law. Restrictions of Kirchhoff's law. View Factor. Hottel's Crossed-strings Method:. Radiation Exchange in a Gray Enclosure. [5Lectures]

- **Two-Surface Enclosure**: Network, Expression for the net radiation exchange. Radiation Shields. Radiation Effects in Temperature Measurement (Conduction effects negligible). Integral equation approach. Spectrally diffuse enclosure surfaces; band approximation. Treatment of specularly reflecting surfaces; specular and diffuse reflectivities, modified definition of radiosity, method of images. [5Lectures]

- **The equation of radiative heat transfer in participating media. Solution methods**: Non-Gray Radiative properties of molecular gases. Introduction to HITEMP DATABASE. Approximate solution methods for one-dimensional media: The optically thin approximation. The optically thick approximation (Diffusion Approximation). [5Lectures]

- **Gas Radiation**: Introduction. Beer's law: Monochromatic transmissivity, absorptivity and emissivity of a gas. Mean Beam Length. Gas emissivity charts. Correction factor charts. Heat Exchange between gas volume and black enclosure: Calculation of gas absorptivity using charts. Heat exchange between two black parallel plates at different temperatures. Heat exchange between gas volume and gray enclosure: Hottel's Expression. [5Lectures]

**Text Books**

1. Hahn, D. W., and Ozisik, M. N., **Heat Conduction**, John Wiley and Sons, 2012.
2. Modest, M.F., **Radiative Heat Transfer**, 3rd Edition, Academic Press, 2013.

**Reference Books**

1. Arpaci, V. S., **Conduction Heat Transfer**, Longman Higher Education 1967.
2. Siegel, R., and Howell, J., **Thermal Radiation Heat Transfer**, Taylor and Francis, 2015.
3. Schneider, P., **Conduction Heat Transfer**, Addison-Wesley Pub. Co, 1974.
4. Kakac et al., **Heat Conduction**, CRC Press, 5st ed, 2018.
5. Myers, **Analytical Methods in Heat Conduction**, AMCH, 2nd Ed 1998.

## 17.66 ME 519: Technical communication for Engineers

**Course Code: ME 519**

**Course Name : Technical communication for Engineers**

L-T-P-C : 0-2-0-2
Intended for : MTech / MS / PhD in Engineering
Prerequisite : None
Mutual Exclusion : None
Approval: 44th BoA

**Course Contents:**

- **Introduction**: What is technical writing and how it is different from non-technical writing. Standard writing models, building blocks and their description, and order of writing, case studies: establishing a clear distinction between "good" and "bad" writing (group activities are recommended), avoiding flowery language, word-processing tools (Latex). Writing assessment checklist. [4Lectures]
- **Writing introduction section:** Structure of the introduction section, literature review and referencing, grammar (active/passive, signalling language), sentence structures and paragraphing, model development, testing model on relevant papers/reports, vocabulary (establishing significance, verbs for previous work, identifying gap, the present work). [5Lectures]
- **Methodology**: Introduction, grammar and writing skills (tense pairs, 'a' vs 'the', countable and uncountable nouns, adverbs), model building, model testing exercise, vocabulary (general overview of the methods section, essential background information, providing precise details about materials and methods, justifying the choices made, taking appropriate care, comparison to other studies). [2Lectures]

- **Results**: Importance of reporting objectively, correct use of tenses, the importance of sequence, comparison with previous work, model development, model testing, vocabulary (existing research, general overview, invitation to view results, key results, sequence, frequency, quantity, causality, comparison with other results, problems with results, implications). [3Lectures]

- **Discussion and conclusion:** Structure, grammar and sentence structure (ability, possibility, probability, certainty, opinion, obligation), modals, model development, model testing, vocabulary (revisiting previous sections, summarising key results, refining implications, relationship to existing research, achievement/contribution, limitations, future work, applications. [4Lectures]

- **Abstract and title**: Abstract models, grammar and writing skills (choice of verb tense), length, language, model development, model testing, vocabulary (background, aim, problem, paper description, methods, results, achievements, implication, limitation), title and keywords. [2Lectures]

- **Technical presentations:** Data analysis and interpretation, specification of uncertainty, choice of scales, data density, difference between graphs for a manuscript and graph for a ppt, structure, tools, graphics, practice presentations. [8Lectures]

**Text Book:**

1. Glasman-Deal, H., **Science Research Writing for Non-native Speakers of English**, World Scientific, 2010.

**Reference Books:**

1. McCaskill, M. K., **Grammar, Punctuation and Capitalization**, NASA, Scientific and Technical Information Division, Washington DC, 1990.

2. Vidoli, C. A., **Technical Report Writing**, NASA Technical Memorandum 105419.

3. Paradis, J. G. and Zimmerman M.L., **The MIT Guide to Science and Engineering Communication**, Cambridge, Mass.: MIT Press, 1997.

## 17.67 ME 520 : Microwave based Manufacturing Processes

**Course Code: ME 520**

**Course Name : Microwave based Manufacturing Processes**

L-T-P-C : 3-0-0-3
Intended for : UG/PG
Prerequisite : None
Mutual Exclusion : None
Approval: 44th BoA

**Course Contents:**

- **Introduction and Fundamentals:** Perspective, Material Interactions, Microwave generators, wave propagation, waveguide modes, microwave applicators, Safety aspects in Microwave Material Processing (6 hours)
- **Science and Modelling of microwave material interaction:** Power absorption model and Maxwell's equations, dielectric properties, microwave penetration and power absorbed, material behavior during microwave interaction, heating mechanisms in microwave processing of materials: non-magnetic materials (conduction loss), magnetic materials (hysteresis loss, eddy current loss and residual loss), microwave absorption in characteristically different materials: insulators, metallic powers and bulk metals, composite materials. (10 hours)
- **Manufacturing Processes for Polymers:** Polymers, Polymer composites, microwave assisted compression moulding (MACM), vacuum assisted resin infusion microwave curing (VARIMC), mechanism of processing, roles of process parameters, case studies, lab demonstration. (10 hours)
- **Manufacturing Processes for Metals and their composites:** Surface Engineering, Physics of Microwave Glazing and Cladding. Concept of skin depth, Role of process parameters, advantages and limitations, case studies, lab demonstration. (8 hours)
- **Manufacturing Processes for Ceramics:** Microwave sintering of ceramics, process parameters in sintering, microwave drilling of ceramics, process parameters in microwave drilling, case studies, lab demonstration. (8 hours)

**Textbooks:**

1. Metaxas, AC and, and Roger J. Meredith, **Industrial microwave heating**, No. 4. IET, 1983.
2. Pozar, D.M., **Microwave engineering**, John Wiley & Sons, 2011.

**References:**

1. Dieter, G.E. and David J.B., **Mechanical metallurgy**, Vol. 3. New York: McGraw-hill, 1986.
2. DeGarmo, E.P., J. Temple Black, Ronald A. Kohser, and Barney E. Klamecki, **Materials and process in manufacturing**, Prentice Hall, 1997.
3. Chawla, K.K., **Composite materials: science and engineering**, Springer Science & Business Media, 2012.

## 17.68 ME 521 : Vehicle Design and Dynamics

**Course Code: ME 521**

**Course Name : Vehicle Design and Dynamics**

L-T-P-C : 3-0-0-3

Intended for : M.Tech, MS, PhD, B.Tech 3rd/4th year students or consent of faculty
Prerequisite : Basic Engineering Mathematics and Mechanics
Mutual Exclusion : None
Approval: 44th BoA

**Course Contents:**

- Basic Vehicle Mechanics: Kinematics, Dynamics - Equation of motion, acceleration, effect of grade, drag. Air flow around the vehicle, tire models, rolling resistance. Load and energy calculations in electric vehicle over drive cycle. (6 hours)
- Vehicle Design: Roll cage design, camber and caster angle, Stability analysis. (6 hours)
- Transmission: Manual gear box, gear ratio, automatic gear box. Torque speed characteristics. Torque convertors, clutch, brakes. (8 hours)
- Road handling: Differentials system, Torque vectoring, Suspension. Double wishbone suspension system. (8 hours)
- Steering: Rack and Pinion steering system, Ackermann Steering, power steering. (6 hours)
- Vehicle Dynamics: Lumped mass modelling, Basics of vibration, Quarter car model, Longitudinal and Lateral dynamics. (10 hours)

**Textbooks:**


1. Gillespie, Thomas D., **Fundamentals of vehicle dynamics**, Vol. 400, Society of automotive engineers, 1992.
2. Rill, Georg, and Abel Arrieta Castro, **Road Vehicle Dynamics: Fundamentals and Modeling with MATLAB**, CRC Press, 2020.


**References:**


1. Husain, Iqbal., **Electric and hybrid vehicles: design fundamentals**, CRC press, 2021.
2. Heisler, Heinz., **Advanced vehicle technology**, Elsevier, 2002.


## 17.69 ME 522 : High-Performance Scientific Computing

**Course Code: ME 522**

**Course Name : High-Performance Scientific Computing**

L-T-P-C : 2-0-1-3
Intended for : : BTech / MTech / MS / MSc / PhD
Prerequisite : Engineering Mathematics, Introduction to Programming or an equivalent course
Mutual Exclusion : CS 508 (Introduction to Heterogeneous Computing)
Approval: 46th BoA

**Course Contents:**

- **Introduction to the course:** Definition of HPC, history and latest developments, Moore's law, introduction to scientific computing, challenges with setting up HPC/data centres (storage, power supply and thermal management), topology of processors, demonstration of the use of HPC to solve a heat conduction problem, sparse matrices, binary storage, fixed-point and floating-point real numbers, IEEE standards, virtual machines, Unix shell and commands. (2 Hours)

- **Introduction to programming languages, version control and makefiles:** Introduction to compiled programming languages (precision, compiler optimisation, timing codes, LAPACK and BLAS), Git (Git commands, Github, graphical Git tools, Git demo), build systems and dependency checking. (6 Hours)

- **Python:** Introduction, interpreted versus compiled languages, object-oriented language, syntax, conditionals, loops, functions, modules, data structures (lists and arrays), mutable and immutable objects, NumPy, linear algebra in Python, Pylab, SciPy, IPython, IPython notebook (Jupyter), unit test, nosetests, graphics and visualisation (matplotlib, Mayavi, Visualisation Tool Kit, ParaView), debugging, just-in-time compilers for Python (such as PyPy, Numba, LLVM), ASCII and binary output, HDF and NetCDF binary formats, demonstrations. (4 Hours)

- **Parallel computing:** Introduction to parallelization, computer architecture (memory hierarchy, CPU, registers, cache), latency and throughput, cache lines, spatial locality, array ordering, cache collisions, padding, parallelizing algorithms (strip mining and loop reordering), shared-memory and distributed-memory parallelism, threads, parallelization issues (contention, dependencies, synchronization, and cache coherence), scaling (Amdahl's law, speedup, strong and weak scaling), SPMD (single program, multiple data) and SIMD (single instruction, multiple data), fine grain and coarse grain parallelism.

  - **OpenMP:** introduction, fork and join, synchronizations, race conditions, compiler directives, heap and stack memory, barriers, overheads, reductions, data dependencies, thread-safe functions, pseudo-random number generators in parallel, example codes, and demonstrations.
  - **MPI:** introduction, message passing, domain decomposition, MPI communicators, MPI modules and functions (broadcast, reduce, allreduce, MPI send and receive), master–worker paradigm, example codes, and demonstrations. Comparison of OpenMP and MPI – numerical integration using adaptive quadratures Use of HPC clusters for computing (10 Hours)

- **Scientific computing:** Solution to the steady-state diffusion problem using the finite difference method, Jacobi method with OpenMP and MPI, numerical integrals using Monte Carlo (MC) method, solution to Poisson problem using MC method (3 Hours) Cloud computing: Cloud computing demonstration using machine images (1 Hour)

**Laboratory/practical/tutorial Modules:**

One hour lab following each lecture Details of labs:

- Hours 1 – 2: Introductory heat conduction problem and linear algebra, and Unix shell
- Hours 3 – 8: Roots of a polynomial using numerical methods, version control, makefiles
- Hours 9 – 12: Python lists and modules using numerical integration, Jupyter notebook, Numpy arrays and timing codes
- Hours 13 – 22: Vector normalisation, Approximation of pi, adaptive quadratures, norms of matrices, LU factorisation, iterative methds to solve linear systems, Finite difference method for solving diffusion equation. All problems using OpenMP and MPI.
- Hours 23 – 25: Monte Carlo methods to solve a steady-state diffusion problem
- Hour 26: Cloud computing exercise

**Textbooks:**

No text book for this course

**References:**


1. L. R. Scott, T. Clark, B. Bagheri, **Scientific Parallel Computing**, Princeton University Press, 2005.
2. C. Lin and L. Snyder, **Principles of Parallel Programming**, Pearson, 2008.
3. R. Chandra, L. Dagum, et. al., **Parallel Programming in OpenMP**, Academic Press, 2001.
4. M. Quinn, **Parallel Programming in C with MPI and OpenMP**, McGraw-Hill Education, 2003.
5. G. Karniadakis, R. Kirby II, **Parallel Scientific Computing in C++ and MPI**, Cambridge University Press, 2003.
6. W. Gropp, E. Lusk, A. Skjellum, **Using MPI**, The MIT Press, 2014.
7. LD Fosdick, ER Jessup, CJC Schauble, G Domik, **An Introduction to High-performance Scientific Computing**, MIT Pres, 1996.


## 17.70 ME 523: Product Design

Course number : ME 523
Course Name : Product Design
Credit Distribution : 3-0-0-3, Elective
Intended for : B.Tech./M.Tech/Ph.D.
Prerequisite : None
Mutual Exclusion: None
Approval: 50th BoA

**Course Contents:**

- **Introduction, generic development process, opportunity identification**: Characteristics of Successful Product Development, Generic Product Development Process, Concept development, Generic product development process, Opportunity structure and the associate process. [10 Hours]

- **Product planning, customer needs and product specification**: Product planning process (Identification, Evaluation, Allocation), Importance of latent needs, Customer needs identification, Target specifications, Final product specifications [09 Hours]

- **Concept generation, selection and testing**: Activity of concept generation, Five step method, Choosing a concept, Concept screening and scoring, Concept tests, Survey population and format, response measurement and reflecting on the results [09 Hours]

- **Product architecture, Industrial design, Design for environment and economics**: Product Architecture, Modularity, Implications of the Architecture, Establishing the Architecture, Assessing the Need for Industrial Design, Impact of Industrial Design, Quality assessment, Design for environment and associated process, Elements of Economic Analysis, Economic analysis process, Patents and IPR, Case studies across all the disciplines [14 Hours]

**Text books:**

1. K T Ulrich and S D Eppinger, **Product Design and Development**, McGraw Hill, 2000.

2. K Otto and K Wood, **Product Design**, Pearson Education, Inc. 2001

3. K G Cooper, **Rapid Prototyping Technology**, Marcel Dekker, Inc. 2001

4. D T Pham and S SDimov, **Rapid Manufacturing**, Springer-Verlag, 2001

## 17.71 ME 524: Additive Manufacturing

Course number : ME 524
Course Name : Additive Manufacturing
Credit Distribution : 3-0-0-3, Elective
Intended for : B.Tech./M.Tech/Ph.D
Prerequisite : None
Mutual Exclusion: None
Approval: 50th BoA

**Course Contents:**

- **Introduction to Additive Manufacturing, Data formats and Preprocessing**: History, Comparison, Evolution, Methodology, Process chain, Classification, AM file formats, Part orientation, Support structure generation, slicing, Contour and tool path generation and build file preparation. [05 Hours]

- **Additive Manufacturing Methods**: AM equipment and Materials including Bio-active materials, Vat photo polymerization, Material jetting, Binder jetting, Material extrusion, Sheet lamination, Powder Bed fusion, Direct energy deposition, Thermal spray direct writing, Liquid phase dire deposition, PCB printing, Bioprinting, Concrete 3D printing, 4D printing and Hands on experience on the available AM machines. [22 Hours]
- **Design for AM**: DFMA, Part replacement, Adapt for AM, Design guidelines (part, support structure, Hole size, layer and wall thickness, residual stresses, optimization), Case studies. [05 Hours]
- **AM equipment and materials**: Laser, Electron beam, Arc, Beam, In situ monitoring, Polymer, Metal, Ceramics, Recent advances, Powder production and characterization. [05 Hours]
- **Post processing, Safety considerations, applications and Industry 4.0**: Quality evaluation, Surface finish and geometry improvement, Potential hazards, Powder and chemical hazards, Applications – Aerospace, Defence, Automobile, Biomedical, Rapid tooling, Reverse engineering, Industry 4.0 and future scope of AM. [05 Hours]

**Text books:**


1. Andreas Gebhardt, Jan-Steffen Hötter, **Additive Manufacturing: 3D Printing for Prototyping and Manufacturing**, Hanser Publications, 2016.
2. Chua Chee Kai, Leong Kah Fai, **3D Printing and Additive Manufacturing: Principles and Applications**, World Scientific, 2014.
3. Hod Lipson, Melba Kurman, **Fabricated: The New World of 3-D Printing**, Wiley 2013.
4. Patri K. Venuvinod, Weiyin Ma, **Rapid Prototyping - Laser-based and Other Technologies**, Kluwer Academic Publishers, 2003.


## 17.72 ME 526 : Programming Paradigm for Open-Source Software

**Course Code : ME 526**

**Course Name : Programming Paradigm for Open-source Software**

L-T-P-C : 0-0-2-1
Intended for : UG
Prerequisite : ME 303 - Heat Transfer & ME - 213 Engineering Thermodynamics, ME - 210 Fluid Mechanics
Mutual Exclusion:
Approval: 54th BoA

**Course Contents**

- **Language**
  - Module 1: Object oriented fundamentals, C++ Basics, C++ Functions (6 Hours)
  - Module 2: Encapsulation, Constructors and Destructors, Function and Programming Overloading. (7 Hours)
  - Module 3: Inheritance, Virtual functions, Dynamic binding (5 Hours)
  - Module 4: Containment and Private Inheritance, Designing with C++: Template and exceptions. (5 Hours)
- **Debugger**
  - Module 5: Navigating Through Codes, Stopping and Running the Program, Examining data (3 Hours)
- **Introduction to Open-Source Software**
  - Module 6: File and folder systems, make and makefile, including a file to open-source software, correction of a bug (2 Hours)

**Textbooks:**

1. Bjarne Stroustrup, **The C++ Programming Language**, 4th Edition, Addison Wisley Professional, 2013.
2. Andreas Zeller et al., **Debugging with DOD**, User's Guide and Reference Manual 2000.

**References:**

1. Stanley B. Lippman, Josee Lajoie, and Barbara E Moo, **C++ Primer**, 5th Edition, Addison-Wisley Professional, 2012.
2. Steve Oualline, **Practical C++ Programming**, 2nd Edition, O'Reilly Media, 2002
3. Bjarne Stroustrup, **Programming: Principles and Practice Using C++**, Addison-Wisley Professional 2008.
4. OpenFOAM: User Guide V21 12

## 17.73 ME 527 : Biofluid Dynamics

**Course Code : ME 527**

**Course Name : Biofluid Dynamics**

L-P-T-C: 3-0-0-3
Intended for: UG final year, and PG students
Prerequisites: ME210 or Equivalent Fluid Mechanics Course
Mutual Exclusion: None
Approval : 57th BoA

**Course Contents**

- **Review of Basic Fluid Mechanics**: Fluid Properties; Pressure and Buoyancy; Flow Phenomena (Laminar flow and turbulent flow; Equation for mass, momentum, and energy conservation in incompressible, frictionless fluids); Viscosity and Resistance (Poiseuille's law for laminar flow resistance in tubes) (6 Hours)
- **Biorheology**: Newtonian and non-Newtonian fluids. Understanding how these macromolecules respond to mechanical forces. Investigating the flow properties of large biological molecules. (6 Hours)
- **Hemodynamics**: Circulation in the heart, blood and lymphatic vessels. Blood properties. Steady flow in tubes. Pulsatile flow in a rigid tube. Pulsatile flow in an elastic tube. Blood flow dynamics in arteries and veins. Microcirculation. Flow in specific vessels and arteries. Heart-valve hemodynamics. Diseases related to obstruction of blood flow. (10 Hours)
- **Respiratory Biofluid Dynamics**: Flow in the upper and lower airways. Alveolar ventilation. Airflow in the lungs. Mechanics of breathing. Gas exchange and transport. (6 Hours)
- **Cardiovascular Implants & Drug Delivery Systems**: Function of artificial heart valves and devices (pressure distribution and fluid flow). Evaluation of cardiovascular and peripheral stents. Inhalation delivery systems such as propellant-metered dose inhalers, and dry powder inhalers (drug dispersion and flow behavior). (10 Hours)
- **Blood Flow and Pressure Measurement Technique**: Mechanics of Sphygmomanometer and Stethoscope. Heart sound and cardiac auscultation. (4 Hours)

**Text books:**

1. Wilmer W. Nichols and Michael F. O'Rourke, **McDonald's Blood Flow in Arteries: Theoretical, Experimental and Clinical Principles**, Hodder Arnold Publication
2. Lee Waite, **Biofluid Mechanics in Cardiovascular Systems**, McGraw-Hill
3. Goyal , Megh R, **Biofluid Dynamics of Human body systems**, CRC Press, 2013.
4. C. Kleinstreuer, **Biofluid Dynamics: Principles and Applications**, CRC Press, 2006
5. Ali Ostadfar, **Biofluid Mechanics: Principles and Applications**, Elsevier, 2016

**References:**

1. Biofluid Mechanics 535.661, Johns Hopkins University, School of Engineering
2. Biofluid Dynamics MEC433, UBC College of Engineering

3. Bio Fluid Mechanics (MTR003), Imperial College London
4. BEE 3310 Bio-Fluid Mechanics, Cornell SCE BMED/ME 4757
5. Biofluid Mechanics, Georgia Institute of Technology

## 17.74 ME 600 : Research Methodology

**Course Code : ME 600**

**Course Name : Research Methodology**

L-P-T-C: 1-0-0-1
Intended for: MTech(R), PhD
Prerequisites: None
Mutual Exclusion: Research Methodology courses running in various schools
Approval : 57th BoA

**Course Contents**

- **Overview of Research**: Purpose of research, selection of a research problem, literature review and research gap, various research methodologies, overview of logical reasonings, the scientific method, hypothesis forming (3 Hours)
- **Theoretical Research**: Importance of theory in research, introduction to physical and mathematical modeling, methods of theoretical research (1 Hour)
- **Experiments in Research**: Introduction to experimental research, design of experiments, measurement techniques and instrumentation, uncertainty analysis, best practices in experiments, and ethical considerations in experimental research (2 Hours)
- **Numerical Simulations in Research**: Importance of computational research, advances and applications of computational techniques in various fields, common numerical methods and tools (2 Hours)
- **Scientific Communication**: Elements of scientific communication, introduction to LaTeX, best practices in writing reports, theses and journal articles (6 Hours)

**Laboratory/practical/tutorial Modules:**

A technical report writing with LaTeX will be part of the course in which the student needs to submit a report based on one's own research work.

**Text books:**

1. Soumitro Banerjee, **Research Methodology for Natural Sciences**, IISc Press, 2022
2. Wayne Booth, Gregory Colomb, Joseph Williams, Joseph Bizup, William Fitzgerald, **The Craft of Research**, 4th Edition, The University of Chicago Press, 2016

**References:**

1. Kate L Turabian, **A Manual for Writers of Research Papers, Theses and Dissertations**, 9th Edition, The University of Chicago Press, 2018

2. John W. Creswell, J, David Creswell, **Research Design: Qualitative, Quantitative, and Mixed Methods Approaches**, 6th Edition, SAGE Publications, 2022

## 17.75 ME 601: Advanced Finite Element Methods

**Course Code: ME 601**
**Course Name: Advanced Finite Element Methods**

L-T-P-C: 3-0-0-3
Prerequisites:
Students intended for: MS/PhD
Elective or Core:
Approval: 2nd Senate

**Course contents**

- **Basic concepts**

  The standard discrete system, Finite elements of an elastic continuum- displacement approach, Generalization of finite element concepts- weighted residual and variational approaches. [ Lectures]

- **Element types**

  triangular, rectangular, quadrilateral, sector, curved, isoparametric elements and numerical integration. Automatic mesh generation schemes. [ Lectures]

- **Application to structural mechanics problems**

  Plane stress and plane strains. Axisymmetric stress analysis, introduction to three dimensional stress analysis. [ Lectures]

- **Module IV**

  Introduction to use of FEM in steady state field problems- heat conduction fluid flow and non linear material problems, plasticity, creep etc. [ Lectures]

- **Module V**

  Computer procedure for Finite element analysis. [ Lectures]

**Text and Reference Books:**

1. J N Reddy, **An introduction to the Finite Element Method**, McGraw – Hill, New York, 1993.

2. R D Cook, D S Malkus and M E Plesha, **Concepts and Applications of Finite Element Analysis**, 3rd Edition, John Wiley, New York, 1989.

3. K J Bathe, **Finite Element Procedures in Engineering Analysis**, Prentice-Hall, Englewood Cliffs, NJ, 1982.
4. T J R Hughes, **The Finite Element Method**, Prentice-Hall, Englewood Cliffs, NJ, 1986.
5. O C Zienkiewicz and R L Taylor, **The Finite Element Method**, 3rd Edition, McGraw-Hill, 1989.

**References:**

1. Arpaci, V. S., **Conduction Heat Transfer**, Longman Higher Education 1967.
2. Siegel, R., and Howell, J., **Thermal Radiation Heat Transfer**, Taylor and Francis, 2015.
3. Schneider, P., **Conduction Heat Transfer**, Addison-Wesley Pub. Co, 1974.
4. Kakac et al., **Heat Conduction**, 5th Edition, CRC Press, 5th ed, 2018.
5. Myers, **Analytical Methods in Heat Conduction**, 2nd Edition, AMCH, 1998.

## 17.76 ME 602: Mechanical Vibration

**Course Code: ME 602**
**Course Name: Mechanical Vibration**

L-T-P-C: 3-0-0-3
Prerequisites: Consent of the faculty member
Students intended for: MS/PhD
Elective or Core: Elective
Approval: 2nd Senate

**Course contents**

- **Introduction**

  Free and forced vibrations with and without damping. [ Lectures]

- **Module II**

  Vibration isolation and transmissibility; Un-damped vibration absorbers. [ Lectures]

- **Module III**

  Generalized coordinates and coordinate coupling; Orthogonality of modes. [ Lectures]

- **MDOF systems**

  Free and forced vibration of multi-degree of freedom systems with and without viscous damping; Lagrange's equation; Holzer's method; Solution of Eigen value problem, transfer matrix and modal analysis. [ Lectures]

- **Self excited vibrations**

  Criterion of stability; Effect of friction on stability. [ Lectures]

- **Continuous Systems**

  Vibrations of strings; Free and forced longitudinal vibrations of prismatic bars; Ritz and Galerkin methods. [ Lectures]

- **Diagnosis**

  Introduction to diagnostic maintenance and signature analysis. [ Lectures]

- **Nonlinear Vibration**

  Introduction to Nonlinear Vibration. [ Lectures]

- **Random Vibration**

  Introduction to Random Vibration. [ Lectures]

- **Numerical Integration methods in Vibration Analysis**

  Finite difference method, Runga-Kutta method, and Newmark method. [ Lectures]

- **Finite Element Method**

  Equation of motion of an element, Mass matrix, stiffness matrix and Force vector for Bar element, Torsion element and Beam element. Consistent and Lumped mass matrices. [ Lectures]

**Text and Reference Books:**

1. S. S. Rao, **Mechanical Vibrations**, Pearson Education Inc. (4th Ed.)2007

2. Leonard Meirovitch, **Fundamental of Vibrations** Mc-Graw Hill Inc.2001

3. D. J. Inman, **Vibration and Control**, John Willey & Sons Inc2002

4. S. Tamadonni & Graham S. KellyM, **Mechanical Vibrations**, Schaum's Out line Series, Mc-Graw Hill Inc 1998

## 17.77 ME 603: Advanced Fluid Mechanics

**Course Code: ME 603**
**Course Name: Advanced Fluid Mechanics**

L-T-P-C: 3-0-0-3
Prerequisites: Fluid Mechanics
Students intended for: MS/PhD
Elective or Core: Elective
Approval: 2nd Senate

**Course contents**

- **Introduction**

  Eulerian and Lagrangian description of flow; Motion of fluid elementtranslation, rotation and deformation; vorticity and strain-rate tensors; Continuity equation, Cauchy's equations of motion, Derivation of Navier-Stokes equations for compressible flow. [ Lectures]

- **Exact solutions of Navier-Stokes equations**

  Plane Poiseuille flow and Couette flow, Hagen-Poiseuille flow, flow between two concentric rotating cylinders, Stokes first and second problems, flow near a rotating disk, flow in convergent-divergent channels. [ Lectures]

- **Slow viscous flow**

  Stokes and Oseen's approximation, theory of hydrodynamic lubrication. [ Lectures]

- **Boundary layer Analysis**

  Derivation of boundary layer equations; Exact solutions; Approximate methods; Momentum integral method. [ Lectures]

- **Stability**

  Introduction to hydrodynamic stability, Orr-Sommerfeld equation. [ Lectures]

- **Introduction to Turbulence**

  Description of turbulent flow, averaging, RANS, Introduction to turbulent models, Empirical laws. [ Lectures]

**Text and Reference Books:**

1. White F M, **Viscous Fluid Flow**, 3rd Edition, Tata McGrawhill, 2011.
2. Cebeci T and Bradshaw P, **Momentum Transfer in Boundary Layers**, McGrawHill, 1977.
3. Schlichting H and Gersten K, **Boundary Layer theory**, 8th Edition, Springer, 2000.
4. Kundu P K and Cohen I M, **Fluid Machanics**, 4th Edition, Elsevier, 2005.

## 17.78 ME 604: Experimental Methods in Thermal Engineering

**Course Code: ME 604**
**Course Name: Experimental Methods in Thermal Engineering**

L-T-P-C: 3-0-0-3
Prerequisites:
Students intended for: MS/PhD
Elective or Core: Elective
Approval: 2nd Senate

**Course contents**

- **Fundamentals**

  Importance of measurement and experimentation, calibration, uncertainty analysis, error propagation, Gaussian or Normal distribution, confidence level, regression analysis, correlation coefficient, Chi-Square test, zeroth-,first- and second-order systems. [ Lectures]

- **Pressure Measurement**

  Manometers, bourdon tube pressure gage, diaphragm gage, bellow gage, McLeod gage, Pirani gage and ionization gage. [ Lectures]

- **Flow measurement**

  Positive displacement flow meters, venture, orifice, impact tube, flow nozzle, sonic nozzle, rotameter, pitot static tube, hot-wire anemometer, laser Doppler anemometer, flow visualization techniques – shadowgraph, Schlieren and interferometer. [ Lectures]

- **Temperature measurement**

  Hg-in-glass thermometer, RTD, thermistor, thermocouple, thermopile, liquid-crystal thermography, optical pyrometer. [ Lectures]

- **Thermal conductivity measurement**

  Guarded hot plate apparatus, heat flux meter. [ Lectures]

- **Data acquisition and processing**

  Signal conditioning, data transmission, storage, A to D and D to A conversion. [ Lectures]

- **Designing experiments**

**Text and Reference Books:**


1. J. P. Holman, **Experimental Methods for Engineers**, 7th edition, Tata McGraw-Hill 2001.

2. T.G. Beckwith, J.H. Lienhard V, R. D. Marngoni, **Mechanical Measurements**, 5th Edition, Pearson Education, 2010.

3. E.O. Doebelin, **Measurement systems, Application and Design**, 5th Edition, Tata McGraw-Hill, 2008


## 17.79 ME 605: Air Conditioning and Ventilation

**Course Code: ME 605**
**Course Name: Air Conditioning and Ventilation**

L-T-P-C: 3-0-0-3
Prerequisites: Thermodynamics, heat transfer
Students intended for: MS/PhD

Elective or Core: Elective
Approval: 2nd Senate

**Course contents**

- **Fundamentals**

  Importance of measurement and experimentation, calibration, uncertainty analysis, error propagation, Gaussian or Normal distribution, confidence level, regression analysis, correlation coefficient, Chi-Square test, zeroth-,first- and second-order systems. [ Lectures]

- **Pressure Measurement**

  Air properties, psychrometry, basic processes, and summer and winter air-conditioning. [ Lectures]

- **Comfort**

  Concept of human comfort and thermal response, comfort factors and environmental indices, Indoor Air Quality. [ Lectures]

- **Equipment analysis and selection**

  Filter, fan, air-washer, cooling tower and cooling and dehumidifying coil. [ Lectures]

- **Load estimation**

  Heat and mass transfer in wall, insulation, vapour barrier, and cooling and heating load calculations. [ Lectures]

- **Air distribution**

  Air flow in duct, duct sizing and space air diffusion. [ Lectures]

- **Ventilation**

  Methods, applications in industries, exhaust systems and design.

**Text and Reference Books:**


1. A SHRAE Handbook

2. C.P. Arora, **Refrigeration and Airconditioning**, 3rd Edition, Tata McGraw-Hill 2009

3. R.C. Arora, **Refrigeration and Airconditioning**, 1st Edition, Prentice Hall India, 2010.

4. W. P. Jones, **Air conditioning engineering**, 5th Edition, Elseiver, 2001.

## 17.80 ME 606: Advanced Solid Mechanics

**Course Code: ME 606**
**Course Name: Advanced Solid Mechanics**

L-T-P-C: 3-0-0-3
Prerequisites:
Students intended for: MS/PhD
Elective or Core: Elective
Approval: 2nd Senate

**Course contents**

Shear centre and unsymmetrical bending. Beam columns: beams on electric foundations, curved beams, Rotating discs and thick cylinders, Virtual work; minimum potential energy; Hamilton's principle. Plate theory: formulation by Hamilton's principle: bending and buckling of homogeneous and sandwich plates. Shell theory: introduction to theory of surface; formulation by Hamilton's principle; membrane, bending and buckling analysis of shells of revolution.

**Text and Reference Books:**

1. Srinath L.S., **Advanced Mechanics of Solids**, Tata McGraw-Hill, 1980
2. Boresi, A.P. and Sidebottom, O.M., **Advanced Mechanics of Materials**, John Wiley, 1993.
3. Timoshenko, S.P. and Goodier, J.B., **Theory of Elasticity**, McGraw-Hill Kogakusha Ltd., 1970.
4. Reddy, J.N., **Theory and Analysis of Elastic Plates and Shells**, 2nd Edition

## 17.81 ME 607: Materials Science For Failure Analysis

**Course Code: ME 607**
**Course Name: Materials Science For Failure Analysis**

L-T-P-C: 3-0-0-3
Prerequisites:
Students intended for: MS/PhD
Elective or Core: Elective
Approval: 2nd Senate

**Course contents**

- Introduction remarks on Materials Science in the context of Engg.:
- Structure of perfect and imperfect solids; Elastic deformation and stress distribution, stress-strain relations under uniaxial loading.
- Introduction, theoretical strength of crystals and the motion of dislocation, energy of a dislocation and stable Burgers vectors.

- Slip planes and slip systems, relation between dislocation movement and plastic flow, dislocation generation, other modes of Deformation in crystalline solids.
- Some strengthening mechanisms.
- The phenomenon of yield point and strain hardening.Theories of yielding and strain hardening.
- Recovery, mechanisms of deformation at elevated temperatures, creep.
- Mechanism of fracture. Ductile - Brittle transition, fracture Design criteria for materials, environmental effects.
- Mechanical behavior of engineering materials under fatigue.
- Selection of materials and Processes, case studies.

**Text and Reference Books:**

1. George E. Dieter, **Mechanical Metallurgy**, McGraw Hill Book Company.
2. R. W. K. Honeycombe, **Plastic Deformation of Metals**, EWP
3. William D. Callister Jr., **Materials Science and Engineering**, Willey India (P) Ltd.
4. Knott, **Fundamentals of Fracture Mechanics**.
5. A. H. Cottrell, **Mechanical Properties of Matter**, Willey
6. K. J. Brown, **Introduction to Mechanical Behaviour of Materials**, Willey.

## 17.82 ME 608 (3) Thin Films And Devices

Approval: 8th Senate; OTA

**Course Outline:**

Thin film science and technology have gone through a thorough development which results in numerous new devices (e.g, Light Emitting Diodes (LED), fuel cell and solar cell) and new materials with fundamentally new properties. Thin film research shares the knowledge fiom multi-disciplines (e.g., materials science, chemistry, solid state physics, mechanics and etc.) This undergraduate course is designed as an introductory class for those students whoare interested in thin film fundamentals and processing for various industrial applications. A newly developed model called "The Art of Laying Apples" will be used throughout the course for explaining thin film concepts. Topics include, but are not limited to, fundamentals on crystal structures and defects in thin films, the .basic nucleation and growth mechanisms of thin films (growth models, lattice matching epitaxy and domain matching epitaxy), thin film processing techniques (CVD, MOCVD', MBE, PLD, Laser-MBE, sputtering, and evaporation etc.), thin film growth instrumentation aspect (energy source, chamber configurations, vacuum systems and growth controllers), and several advanced topics related to electrical and optical devices. Lab or tour session(s) will be provided to promote teaching and learning. The following table provides a tentative guideline for course subjects

## 17.83 ME 609: Functional Materials

**Course Code: ME 609**
**Course Name: Functional Materials**

L-T-P-C: 3-0-0-3
Prerequisites:
Students intended for: B. Tech
Elective or Core: Elective
Approval: 2nd Senate

**Course contents**

- **Introduction**

  Definition of functional materials, Different kind of functional materials; Use of functionalities of materials in fabricating devices, Causes for observed functionality in a material; Functionality arising due to (i) electronic, (ii) spin, and (iii) ionic degrees of freedom; Exploitation of combined effects in designing new functional materials. [3 Lectures]

- **Functionality driven by electronic degrees of freedom**

  Atoms and crystalline solids; electronic states of atoms and crystalline solids; Formation of bands in crystalline solids; Band dispersions; Density of states; Metals, semiconductors and insulators; Direct and indirect band gap semiconductors; Formation of impurity bands in the $p$-type and $n$-type semiconductors; Electrons effective mass in a semiconductor; Transport and optical properties of a semiconductor; Opto-electronic materials. [12 Lectures]

- **Functionality driven by spin degrees of freedom**

  Formation of magnetic moment in an atom; Spin and orbital part of magnetic moment in a solid; Magnetization of a solid; Diamagnetic, paramagnetic, ferromagnetic and antiferromagnetic materials; Different kind of antiferromagnetic structures; Exchange interaction; Determination of magnetic transition temperature using mean-field theory; Formation of domain wall in ferromagnetic material; Soft and hard ferromagnets; CMR/GMR materials. [10 Lectures]

- **Functionality driven by ionic degrees of freedom**

  Covalent, ionic and metallic solids; Formation of dipole moment; Polarization of a material; Paraelectric, ferroelectric, antiferroelectric, piezoelectric, and pyroelectric materials; formation of domain wall in ferroelectric material; Multiferroic materials. [5 Lectures]

- **Project**

  Brief overview of density functional theory; Different kinds of exchange-correlation functional; Use of full-potential LMTO and LAPW methods in designing functional materials. [12 Lectures]

**Text and Reference Books:**


1. N.W.Ashcroft and N.D. Mermin, **Solid State Physics**, Harcourt College Publishers

2. Marius Grundmann, **The Physics of Semiconductors: An Introduction Including Devices and Nanophysics**, Springer Berlin Heidelberg New York

3. R.M.Martin, **Electronic Structure: Basic Theory and Practical Methods**, Cambridge University Press

4. K.F. Wang, J. M. Liu, and Z.F.Ren, **Multiferroicity: the coupling between magnetic and polarization orders**, *Advances in Physics*, 58, 321 (2009)


## 17.84 ME 610: Advanced Thermodynamics

**Course Code: ME 610**
**Course Name: Advanced Thermodynamics**

L-T-P-C: 3-1-0-4
Prerequisites: Thermodynamics
Students intended for: MS/PhD
Elective or Core: Elective
Approval: 2nd Senate

**Course contents**

- **Laws of Thermodynamics**

  The first law for open and closed system; steady & transient processes; work and heat transfer; second Law of Thermodynamics for open and closed systems; Local Thermodynamic Equilibrium (LTE) Model, entropy maximum and energy minimum principles. [ Lectures]

- **Entropy**

  Concept of reversibility; change in entropy in various thermodynamic processes, entropy balance for closed and open systems, mechanism of entropy generation. [ Lectures]

- **Single and Multiphase systems**

  Maxwell relations; Clausius-Clapeyron equation; Gibbs-Duhem Relation, phase diagrams, corresponding states; phase transition; types of equilibrium and stability; multi- component and multi-phase systems, equations of state. [ Lectures]

- **Chemically Reacting System**

  Chemical reactions, irreversible reactions, combustion, chemical energy of fuels. [ Lectures]

- **Power Generation**

  Irreversibilities in a power plant; advanced steam-turbine power plants; advanced gas-turbine power plants, combined steam turbine and gas turbine plants. [ Lectures]

- **Refrigeration**

  Joule-Thomson expansion, Liquefaction, refrigerator models with heat transfer irreversibilities. [ Lectures]

- **Entropy Generation Minimization**

  heat transfer, trade-off between competing irreversibilites, principle of thermodynamic isolation, structure of heat exchanger irreversibility, energy storage systems, sensible and latent heat storage. [ Lectures]

- **Kinetic theory of gases**

  Introduction, basic assumption, molecular flux, equation of state for an ideal gas, collisions with a moving wall, principle of equipartition of energy, classical theory of specific heat capacity. Transport phenomena-intermolecular forces, The Vander Weals equation of state, collision cross section, mean free path. [ Lectures]

**Text Books:**


1. Adrian Bejan, **Advance Engineering Thermodynamics**, Wiley, 2006.

2. M.J.Moran and H.N.Shapiro, **Fundamentals Of Engineering Thermodynamics**, John Wiley and Sons.


**Reference Books:**


1. F.W. Sears and G.L.Salinger, **Thermodynamics, Kinetic Theory and Statistical Thermodynamics**, 3rd Edition, Narosa Publishing House, New Delhi, 1998.


## 17.85 ME 611: Design and Optimization of Thermal Systems

**Course Code: ME 611**
**Course Name: Design and Optimization of Thermal Systems**

L-T-P-C: 3-0-0-3
Prerequisites: Thermodynamics, Fluid Mechanics, Heat Transfer
Students intended for: MS/PhD
Elective or Core: Elective
Approval: 2nd Senate

**Course contents**

- Introduction to system design – Regression analysis and curve fitting – modeling of thermal equipment – system simulation (successive substitution – Newton – Raphson method) – examples – economic analysis – optimization – Lagrange multipliers, search methods, linear programming, geometric programming – New generation optimization techniques – simulated annealing, Genetic Algorithms, Bayesian statistics.

- Examples applied to heat transfer problems and energy systems such as gas and steam power plants, refrigeration systems, heat pumps and so on.

### Text and Reference Books:

1. Y.Jaluria, **Design and optimization of thermal systems**, McGraw Hill, 1998.
2. Adrian Bejan, George Tsatsaronis, Michael Moran, **Thermal Design and Optimization**, John Wiley and Sons, 1995.
3. L.C. Burmeister, **Elements of thermal fluid system design**, Prentice Hall, 1998.
4. W.F.Stoecker, **Design of thermal systems**, McGraw Hill, 1989.

## 17.86 ME 612 Introduction to Bio-materials

Course Number : ME 612
Course Name: Introduction to Bio-materials
Credits : 3-0-0-3
Prerequisites :
Intended for : B.'Tech., M. Tech.,M.S.,and Ph. D.
Distribution:
Approval: 8th Senate; OTA

### Objective:

Developing materials for use in medicine is a challenging interdisciplinary process and requires an understanding of material bulk and surface properties, the various biological responses to the materials, the clinical context of their use, manufacturing processes, cost, sterilization, packaging and regulatory issues. This course is designed to introduce students to the various classes of biomaterials'In use and their application In selected subspecialties of medicine.

Upon successfuI completion of this course, the student will be able to:

1. Differentiate the various classes of biomaterials on the basis of structure and function;
2. Differentiate various analytical methods based on their use to characterize bulk and surface properties of biomaterials
3. Differentiate the molecular and cellular events that follow exposure of materials to bodily fluids and to contact with various tissues of the human body;
4. Differentiate various biomedical devices based upon function, biomaterial composition patientrisk and clinicalapplication; and to
5. Describe various practical aspects of biomedical device design, fabrication and testing.

### Course contents

Introduction to basic concepts of Materials Science; Salient properties of important material classes; Property requirement of biomaterials; Concept of biocompatibility; Structure and properties of biological cells & tissues; cell-material interactions and foreign body response; Assessment of biocompatibility of biomaterials, in vitro biochemical assays (cellular adhesion, cellular viability using MTT osteogenic differentiation using ALP assay; Biomnuneralisation using Osteocalcin assay);

In vivo testingand histocompatibility assessment; genotoxicity assessment (Physical damage to DNA by biomaterial eluates); important biometallic alloys: Ti-based, stainless steels, Co-Cr—Moalloys; Bioinert, Bioactive and bioresorbable ceramics; Processing and properties of different bioceramic materials with emphasize on hydroxyapatite; synthesis of biocompatible coatingson structural implant materials; plasma spraying of carbon nanotljbe reinforced hydroxyapatite on Ti-6Al-4V substrate;Microstructureand properties of glass-ceramics;biodegradablepolymers; Design concept of developing new materials for bio-implant applications.

**References and text books:**


1. Ratner, Hoffman, Schoet and Lemons, (Editors), **Biomaterials Science: An introduction to Materials in Medicine**, 2nd Edition, Elsevier Academic Press, 2004.

2. Mithe Ritchie and Karihalo,**Comprehensive structural interity**,Vol.:9 Bioengineering, Elsevier, Academic Press, 2003.

3. Fredrick H. Silver and David L. Christiansen, **Biomaterials Science and Biocompatability**, Springer, New Jersey.

4. Janathan Black, **Biological Performance of Materials: Fundamentals of Biocompatibility**, Marcel Dekker, 1981.

5. J.M. Davis (Editor), **Basic Cell Culture: A Practical Approach**, IRL Press, Oxford University Press, 1994.


## 17.87 ME 613_Old: Thermal Radiation

**Course Code: ME 613_Old**

**Course Name: Thermal Radiation**

L-T-P-C: 3-0-0-3
Prerequisites: Fundamentals of heat transfer
Students intended for: MS/PhD
Elective or Core: Elective
Approval: 9th Senate

**Course Objective:**

This course will provide comprehensive knowledge of thermal radiation. The course covers the radiation properties of materials, radiation in participative and non-participative medium. The extensive emphasis will be given on the radiation in participative media and non-gray behaviors of gases and surfaces. The course also covers radiation phenomena in semitransparent medium and collimated beam radiation. Along with the finite volume method of the radiative transfer equation, the students will also be introduced with statistical monte carlo method for collimated ' beam radiation. This course is theoretical in nature and to make understand of radiation physics practice on some open source code wil! be encouraged.

**Course contents**

- **Fundamentals of Thermal Radiative Heat Transfer**

  Introduction, The nature of thermal radiation, Basic laws of thermal radiation Introduction to radiation characteristics of opaque surfaces, gases, solid, liquid and particles. [3 Lectures]

- **Radiation properties of real surfaces**

  Definitions of radiation phenomena at surfaces, Radiative properties of metals, non-conductors, semi-transparent sheets [2 Lectures]

- **Radiation Exchange between surfaces**

  Introduction to view factors and methods to calculate the view factors. Radiative exchange between Grey, Diffuse Surfaces, Partially-Specular Grey Surfaces. [10 Lectures]

- **Gas Radiation**

  The equation of radiative transfer in participative media, Boundary conditions for the equation of transfer, divergence of radiative heat flux, overall energy conservation, radiative properties of molecular gases, line radiation, spectral models for radiative transfer calculations, Narrow band models, Wide band models. radiative properties of particulate media Rayleigh scattering. P1, Zonal and Finite volume method for radiative transfer equation. [23 Lectures]

- **Radiation properties of semi-transparent media and Collimated beam radiation**

  Radiation phenomena in semi-transparent solids and liquids. Monte carlo method for the collimated beam radiation. [4 Lectures]

**Text and Reference Books:**

1. M. F. Modest, **Radiative Heat Transfer**, 3rd Edition, Academic Press,2013.

2. J. R. Howell, R. Siegel, M.P. Menguc, **Thermal Radiation Heat Transfer** 5th Edition, CRC Press, 2011.

## 17.88 ME 613: Thermal Radiation

**Course Code: ME 613**
**Course Name: Thermal Radiation**

L-T-P-C: 3-0-0-3
Prerequisites: Fundamentals of heat transfer
Students intended for: MS/PhD
Elective or Core: Elective
Approval: 9th Senate

**Course contents**

- **Fundamentals of Thermal Radiative Heat Transfer**

  Introduction, The nature of thermal radiation, Basic laws of thermal radiation Introduction to radiation characteristics of opaque surfaces, gases, solid, liquid and particles. [3 Lectures]

- **Radiation properties of real surfaces**

  Definitions of radiation phenomena at surfaces, Radiative properties of metals, non-conductors, semi-transparent sheets [2 Lectures]

- **Radiation Exchange between surfaces**

  Introduction to view factors and methods to calculate the view factors. Radiative exchange between Grey, Diffuse Surfaces, Partially-Specular Grey Surfaces. [10 Lectures]

- **Gas Radiation**

  The equation of radiative transfer in participative media, Boundary conditions for the equation of transfer, divergence of radiative heat flux, overall energy conservation, radiative properties of molecular gases, line radiation, spectral models for radiative transfer calculations, Narrow band models, Wide band models. radiative properties of particulate media Rayleigh scattering. P1, Zonal and Finite volume method for radiative transfer equation. [20 Lectures]

- **Radiation properties of semi-transparent media and Collimated beam radiation**

  Radiation phenomena in semi-transparent solids and liquids. Monte carlo method for the collimated beam radiation. [4 Lectures]

- **Design and Performance study of solar conversion devices by using open source or standard softwares** [3 Lectures]

**Text and Reference Books:**


1. M. F. Modest, **Radiative Heat Transfer**, 3rd Edition, Academic Press,2013.

2. J. R. Howell, R. Siegel, M.P. Menguc, **Thermal Radiation Heat Transfer** 5th Edition, CRC Press, 2011.


## 17.89 ME 614: Compressible Flow and Gas Dynamics

**Course Code: ME 614**
**Course Name: Compressible Flow and Gas Dynamics**

L-T-P-C: 3-0-0-3
Prerequisites: Fluid Mechanics, Thermodynamics, Conservation Laws
Students intended for: MS/PhD
Elective or Core: Elective
Approval: 3rd Senate

**Course contents**

- **Introduction**

  Gas dynamics, review of basic mass, momentum and energy conservation lass for compressible flows, speed of sound, wave equation, regimes of mach number, shocks , wave propagation, sound speed, Mach number, isentropic flow, static and stagnation properties. [6 Lectures]

- **One Dimensional Flow**

  Converging-diverging nozzles, shock waves, moving and reflected waves, blast waves, wind tunnels, supersonic engines [8 Lectures]

- **Two Dimensional Flow**

  Oblique shock wave theory, conical oblique shock waves, Prandtl-Mayer expansion Fans, supersonic inlets and diffusers. [8 Lectures]

- **Compressible Pipe Flow**

  Fanno-Line flow, Rayleigh pipe flow, natural gas flow in pipelines. [3 Lectures]

- **Compressible Potential Flow**

  Method of characteristics, supersonics nozzle design. [6 Lectures]

**Text and Reference Books:**


1. J.D. Anderson, **Modern Compressible Flow (With Historical Perspective)**, 2nd Edition, McGraw-Hill, 1990

2. S M Yahya , **Fundamentals of Compressible Flow**, 4th Edition, New Age International, 2010.

3. Shapiro, Ascher H., **Dynamics and thermodynamics of compressible fluid flow**, Vol 1 and Vol 2, John Wiley, 1953.


## 17.90 ME 615: Applied Computational Fluid Dynamics

**Course Code: ME 615**
**Course Name: Applied Computational Fluid Dynamics**

L-T-P-C: 2.5-0.5-0-3
Prerequisites:
Students intended for: BTech 4th Year/MS/PhD
Elective or Core: Elective
Approval: 2nd Senate

**Course contents**

- **Introduction**

  Basics of heat transfer, fluid flow; Mathematical description of fluid flow and heat 5 transfer: conservation equations for mass, momentum, energy and chemical species, classification of partial differential equations, coordinate systems. [ Lectures]

- **Discretization techniques**

  Discretisation techniques using finite difference methods: Taylor-Series and control volume formulations; Finite element discretization techniques. [ Lectures]

- **Modelling of diffusion problems using finite volume method**

  One dimensional steady state diffusion problems; discretization technique; Solution methodology for linear and non-linear problems: Point-by-point iteration, TDMA; Two and three dimensional discretization; Discretization of unsteady diffusion problems: Explicit, Implicit and Crank-Nicolson's algorithm; stability of solutions. [ Lectures]

- **Modelling of Convection- Diffusion Problems**

  One dimensional convection-diffusion problem: Central difference scheme; Discretization based on analytical approach (exponential scheme); Hybrid and power law discretization techniques; Higher order schemes (QUICK algorithm). [ Lectures]

- **Flow modeling**

  Discretization of incompressible flow equations; Pressure based algorithm: SIMPLE, SIMPLER etc; Unstructured grids; Introduction to FVM with unstructured grids; Introduction to turbulence modeling; Large Eddy Simulation (LES); Direct Numerical Simulation (DNS). [ Lectures]

- **Projects / Exercises/ Publications**

  Solving simplified problems: formulation, discretization with coarse grids, applying appropriate boundary and initial conditions and solving by hand calculations; Solving practical problems through software: writing user sub-routines; postprocessing and interpretation of results. [ Lectures]

**Text and Reference Books:**

1. S. V. Patankar, **Numerical Heat Transfer and Fluid Flow**, Hemi sphere Publishing Corporation, 1980.

2. D. A. Anderson, J. C. Tannehill , and R. H. Pletcher, **Computational Fluid mechanics and Heat Transfer**, Hemi sphere Publishing Corporation, 1984.

3. J. H. Ferziger and M. Peric, **Computanional Methods for Fluid Dynamics**, 2nd Edition, Springer, Berlin, 1999.

4. H. K. Versteeg and W. Malalasekera, **An Introduction to Computational Fluid Dynamics: The Finite Volume Method**, Pearson.

## 17.91 ME 616_Old: Dielectrics and Related Materials

**Course Code: ME 616_Old**

**Course Name: Dielectrics and Related Materials**

L-T-P-C: 3-0-0-3
Pre-requisites: Nil
Approval: 5th Senate

**Course contents:**

Students will be introduced to dielectric theory. Various dielectric related concepts such as relaxation phenomena will be discussed. Non-linear dielectrics, ferroelectrics, and antiferroelectrics will also be described. Soft mode theory will be used to link dynamic vibrational modes to static dielectric permittivity. Temperature coefficient of capacitance will be discussed for a wide group of materials using Clausius-Mossotti theory. Capacitor and microwave material design is described for a variety of applications: X7R, Y5V, and NPO capacitors, and microwave resonators and filters. Importance of crystal structures, defect chemistry will be emphasized in relation to the final performance of the devices. Performance will be considered in terms of temperature dependence, dielectric loss, defect chemistry, dielectric breakdown, and degradation. Piezoelectric materials will be considered in terms of properties, domain switching, and compositional design. Important piezoelectric applications are reviewed in terms of properties. Conduction mechanisms of dielectric materials will be discussed in terms of Mott insulators, semiconductors, and superconductors. Solid-state electronic theory will be discussed in relation to structure-property relationship to give the students an understanding of processes that control these unique properties.

## 17.92 ME 616: Convective Heat and Mass Transfer

**Course Code: ME 616**
**Course Name: Convective Heat and Mass Transfer**

L-T-P-C: 3-0-0-3
Prerequisites: ME-210: Fluid Mechanics, ME-303: Heat Transfer, IC110: Engineering Mathematics
Students intended for: UG/PG
Elective or Core: Elective
Approval: 9th Senate

**Course contents**

- **Governing Equations**

  Continuity, Momentum and Energy Equations, reduction of equations for various fluid flow systems, boundary layer approximations to momentum and energy, scale analysis, Introduction to nano-heat transfer. [6 Lectures]

- **Laminar external flow and heat transfer**

  Scale analysis, similarity solutions for flat plate (Blasius solution), scale analysis of thick and thin thermal boundary layer, Integral method solutions for flow over an isothermal flat plate, flat plate with constant heat flux and with varying surface temperature, flows with pressure gradient. [6 Lectures]

- **Laminar internal flow and heat transfer**

  (a) Exact solutions to N-S equations for flow through channels and circular pipe, Fully developed forced convection in pipes with different wall boundary conditions, Forced convection in the thermal entrance region of ducts and channels (Graetz solution), heat transfer in the combined entrance region, (b) Integral method for internal flows with different wall boundary conditions. [8 Lectures]

- **Natural convection heat transfer**

  Governing equations for natural convection, Boussinesq approximation, Scale analysis: thermal and hydrodynamic boundary layers, Scale analysis in flow in vertical plate, Walls different boundary conditions: constant temperature and heat flux, Similarity and integral solutions, effects of inclination, Natural convection in enclosures, mixed convection heat transfer past vertical plate and in enclosures. [10 Lectures]

- **Turbulent convection**

  Governing equations for averaged turbulent flow field (RANS), Analogies between heat and Mass transfer (Reynolds, Prandtl-Taylor and von Karman Analogies), Turbulence Models (Zero, one and two equation models), Turbulent flow and heat transfer across flat plate and circular tube, Turbulent natural convection heat transfer, Empirical correlations for different configurations. [6 Lectures]

- **Convective mass transfer**

  Mass conservation, mass diffusivities, laminar forced convection, internal forced convection, natural convection: mass and heat transfer driven flows, turbulent flows: time averaged concentration equation, effect of chemical reaction, concept of boiling and condensation phenomena. [6 Lectures]

**Text Books:**

1. Adrian Bejan, **Convective Heat Transfer**, 4th Edition, John Wiley & Sons, 2013.

2. Kays W M and Crawford M E, **Convective Heat and Mass Transfer**, 3rd Edition, McGraw Hill Int Edition, 1993.

3. Spalding D B, **Introduction to Convective Mass Transfer**, McGraw Hill, 1963.

**Reference Books:**

1. Louis C. Burmeister, **Convective Heat Transfer**, 2nd Edition, Wiley-Interscience, 1993

2. Arpaci & Larcen, **Convective Heat Transfer**, Prentice Hall, 1984.

3. Sadik Kakac, Yaman Yener, Anchasa Pramuanjaroenkij, **Convective Heat Transfer**, 3rd Edition, CRC Press, 2013.

4. Bird R. B., Stewart W. E. and Lightfoot E. N., **Transport Phenomena**, 1st Edition, John Wiley and sons, Inc., 1960.

5. Schlichting H., **Boundary Layer Theory**, 6th Edition, McGraw Hill , 1968.

## 17.93 ME 617_Old: Mechanics of Composite Materials

**Course Code: ME 617_Old**
**Course Name: Mechanics of Composite Materials**

L-T-P-C: 3-0-0-3
Prerequisites: ME-210: Fluid Mechanics, ME-303: Heat Transfer, IC110: Engineering Mathematics
Students intended for: UG/PG
Elective or Core: Elective
**One Time Approval in 2nd convocation meeting**

### Course contents

Introduction, Classification of Composite Materials, Linear Anisotropic Materials: Generalized Hooke's Law, Fundamental Equations and Variational Solution Procedures. Effective Material Moduli for Composites: Elementary Mixture Rules for Fiber-Reinforced Laminae, Improved Formulas for Effective Moduli of Composites. Classical and Improved Theories: Classical Laminate Theory, Shear Deformation Theory for Laminates and Sandwiches, Layer wise Theories. Modeling and Analysis of Beams, Modeling and Analysis of Plates, Modeling and Analysis of Circular Cylindrical.

## 17.94 ME 617: Mechanics of Composite Materials

**Course Code: ME 617**
**Course Name: Mechanics of Composite Materials**

L-T-P-C: 3-0-0-3
Prerequisites: Mechanics of Solids
Students intended for: MS/PhD
Elective or Core: Elective
Approval: 12th Senate

### Course contents

- **Module I**

  Introduction, Classification of Composite Materials, advantage of composite materials and applications [4 Lectures]

- **Module II**

  Macro-mechanical behaviour of a lamina; Stress strain relationships for anisotropic materials, stiffness's and compliances, restrictions of engineering constants, invariant properties of lamina, Strength of lamina [10 Lectures]

- **Module III**

  Micromechanical behaviour of lamina: Mechanics of materials approach for stiffness, elasticity approach, imperial approaches, strength estimations [12 Lectures]

- **Module IV**

  Micromechanical behaviour of Laminates: Classical laminate theory, special cases of laminates, strength of laminates, Interlaminar stresses [12 Lectures]

- **Module V**

  Experimental characterization of composites: Uniaxial, biaxial tension and compression tests, interfacial and inter laminate shear stress characterizations. [4 Lectures]

**Text and Reference Books:**


1. Laszolo P Kollar and George S. Springer, **Mechanics of Composite Structures**, Cambridge university Press, 2003.

2. J. N. Reddy, **Mechanics of Laminated Composite Plates and Shells Theory and Analysis**


## 17.95 ME 618: Stealth Technology: Infrared Signatures

**Course Code: ME 618**
**Course Name: Stealth Technology: Infrared Signatures**

L-T-P-C: 2-1-0-3
Prerequisites: Heat Transfer (for those who Credit this course / no Pre-requisite for those who Audit this course)
Students intended for: UG (ME final year) /MS (ME) /PhD (ME) can Credit this course [all other student categories can Audit this course (must at least pass in course to qualify as Audit)]
Elective or Core: Elective
Approval: 5th Senate

**Course contents**

- **Module I**

  Principles of Stealth Technology – camouflage, conceal, deceive, active vs. passive detection. [2 Lectures]

- **Module II**

  Introduction to Signatures – radar (RCS & its reduction), infrared, visual, aural. [3 Lectures]

- **Module III**

  Principles of Thermal / Infrared Radiation – basic laws (Planck's, Wien's Displacement, Kirchhoff's), grey body spectrum. [6 Lectures]

- **Module IV**

  Estimation of Infrared Signature (IR) from Internal Sources – engine heated casing, engine exhaust plume, aerodynamic heating of airframe. [6 Lectures]

- **Module V**

  Estimation of Infrared Signature from External Sources – reflection of earthshine, sunshine, & skyshine. [6 Lectures]

- **Module VI**

  Role of Atmosphere – attenuation of IR-signature by intervening atmosphere & atmospheric background radiance. [3 Lectures]

- **Module VII**

  Relation between IR-Signature and Target Susceptibility – lock-on envelope & lethal envelop for air-to-air combat in horizontal plane. [6 Lectures]

- **Module VIII**

  IR-Signature Suppression (& its Penalties) – optical blocking, cooling, emissivity optimization IR Countermeasures – decoys / flares [2 Lectures]

**Text Books:**


1. Hudson Jr., R.D., **Infrared System Engineering**, Wiley Series in Pure and Applied Optics, 2006.
2. Hackforth, H.L., **Infrared Radiation**, McGraw Hill, 1960.
3. Jones, J., **Stealth Technology: The Art of Black Magic (ed. Thurber, M.)**, McGraw-Hill Co. 1989.


**Reference Books:**


1. Mahulikar, S.P., Sonawane, H.R., & Rao, G.A., 2007, **Infrared signature studies of aerospace vehicles**, *Progress in Aerospace Sciences*, Vol. 43, Nos. 7-8, pp. 218-245.
2. Rao, G.A., & Mahulikar, S.P., 2002 (Dec), **Integrated review of stealth technology and its role in airpower**, *Aeronautical Journal*, Vol. 106, No. 1066, pp. 629-641.
3. Howe D., **Introduction to the basic technology of stealth aircraft: Part 1 - basic considerations and aircraft self emitted signals (passive considerations)**, *ASME Journal of Engineering for Gas Turbines & Power*, 1991, Vol. 113, No. 75, pp. 75-79.


## 17.96 ME 619: Experiments in Materials Science

**Course Code: ME 619**
**Course Name: Experiments in Materials Science**

L-T-P-C: ..-..-..-3
Prerequisites:
Students intended for: B.Tech/MS/PhD
Elective or Core: Elective
Approval: 2nd Senate

**Course contents**

- **Module I**

  Principles of Stealth Technology – camouflage, conceal, deceive, active vs. passive detection. [2 Lectures]

- **Module II**

  Introduction to Signatures – radar (RCS & its reduction), infrared, visual, aural. [3 Lectures]

- **Module III**Fabrication of various materials (metals, alloys, ceramics and composites) in various forms such as single crystals, thin films, and bulk materials using physical/chemical methods. Their structural and physical properties characterization using structural characterization (Diffraction, optical and electron microscopy), Thermal characterization (DTA/DSC/TGA) and miscellaneous materials characterization tools.Scanning probe microscopy, Scanning electron microscopy, Transmission electron microscopy and X-ray diffraction etc. Physical properties measurements such as VSM, Magnetoresistance, SQUID, impedance analysis, PES, IPES, X-ray absorption spectroscopy, AFM, STEM, P-E loop, piezoelectric measurements, thermoelectric measurements etc.

**Text and Reference Books:**


1. Kingery W. D., Bowen, H. K., Uhlhmen D. R., **Introduction to Ceramics**, 2nd Edition, John Wiley, 1976.

2. J. Reed, **Principles of Ceramic Processing**, 2nd Edition, John Wiley and sons,

3. C. R. Brundle, C.A. Evans and S.Wilson,**Encyclopedia of Materials Characterization**, Butterworth-Heinemann, 1992.

4. A.R West, **Solid State Chemistry**, Wiley

5. B.D. Cullity, **Elements of X-Ray Diffraction**, Prentice Hall, 2001.


**Reference Books:**


1. Mahulikar, S.P., Sonawane, H.R., & Rao, G.A., 2007, **Infrared signature studies of aerospace vehicles**, *Progress in Aerospace Sciences*, Vol. 43, Nos. 7-8, pp. 218-245.

2. Rao, G.A., & Mahulikar, S.P., 2002 (Dec), **Integrated review of stealth technology and its role in airpower**, *Aeronautical Journal*, Vol. 106, No. 1066, pp. 629-641.

3. Howe D., **Introduction to the basic technology of stealth aircraft: Part 1 - basic considerations and aircraft self emitted signals (passive considerations)**, *ASME Journal of Engineering for Gas Turbines & Power*, 1991, Vol. 113, No. 75, pp. 75-79.

## 17.97 ME 620: Modeling and Simulation

**Course Code: ME 620**
**Course Name: Modeling and Simulation**

L-T-P-C: 2-0-2-3
Prerequisites: Engineering Mathematics (IC110), Linear Algebra (IC111)
Students intended for: UG/MS/PhD
Elective or Core: Elective
Approval: 6th Senate

**Course contents**

- **Introduction**

  System, environment, input and output variables, State variables; Static and Dynamic systems; Hierarchy of knowledge about a system and Modeling Strategy. [2 Lectures]

- **Physical Modeling**

  Dimensions analysis, Dimensionless grouping of input and output variables of find empirical relations, similarity criteria and their application to physical models. [2 Lectures]

- **Modeling of System with Known Structure**

  Review of conservation laws and the governing equation for heat, mass and momentum transfer, Deterministic model-(a) distributed parameter models in terms of partial identification and their solutions and (b) lumped parameter models in terms of differential and difference equations, state space model, transfer functions block diagram and sub systems, stability of transfer functions, modeling for control. [7 Lectures]

- **Optimizations and Design of Systems**

  Summary of gradient based techniques : Nontraditional Optimizations techniques (1) genetic Algorithm (GA)- coding, GA operations elitism, Application using MATLAB:(ii) Simulated Annealing. [4 Lectures]

- **Neural Network Modeling of Systems only with Input-output Database**

  Neurons, architecture of neural networks, knowledge representation, learning algorithm. Multilayer feed forward network and its back propagation learning algorithm, Application to complex engineering systems and strategy for optimum output. [4 Lectures]

- **Modeling Based on Expert Knowledge**

  Fuzzy sets, Membership functions, Fuzzy Inference systems, Expert Knowledge and Fuzzy Models, Design of Fuzzy Controllers. [4 Lectures]

- **Simulation of Engineering Systems**

  Monte-Carlo simulation, Simulation of continuous and discrete processes with suitable examples from engineering problems. [5 Lectures]

**List of practicals**

- Exp. 1 & 2 Introductions to programming with MATLAB
- Exp. 3 & 4 Find the response of a lumped variable model expressed in terms of transfer function using MATLAB for input of (i) unit step function (ii) unit impact function and (iii) unit ramp function
- Exp. 5, 6 & 7 Use of Simulink in MATLAB for engineering problems
- Exp. 8, 9 & 10 Use of Neural Network in MATLAB for engineering problems
- Exp. 10, 11 &12 Use of FIS and ANFIS in MATLAB for engineering problems
- Exp. 13 & 14 Monte Carlo simulation

**Text Books:**


1. Zeigler B.P., Praehofer. H. and Kim I.G. **Theory of modeling and simulation**, 2nd Edition, Academic press, 2000
2. Ogata K, **Modern control Engineering**, 3rd Edition, Prentice hall of India, 2001
3. Jang J.S.R., sun C.T. and Mizutani E,, **Neuro-Fuzzy and soft Computing**, 3 rd Edition, Prentice hall of India, 2002.
4. Shannon, R. E., **System Simulation: the Art and Science**, Prentice Hall Inc., 1990.
5. Pratap R., **Getting started with MATLAB**, Oxford university Press 2009


## 17.98 ME 621: Aircraft Propulsion

**Course Code: ME 621**
**Course Name: Aircraft Propulsion**

L-T-P-C: 2-1-0-3
Prerequisites: Thermodynamics
Students intended for: UG/MS/PhD
Elective or Core: Elective
Approval: 6th Senate

**Course contents**

- **Module I**

  Aircraft propulsive devices / engines (basic principle of operation). [3 Lectures]

- **Module II**

  Brief information on - piston-prop, turbo-prop, turbojet, turbofan, turbo-shaft, ramjet, scramjet, vectored thrust (incl. lifting engines)

  Aircraft gas turbine engine vs. Industrial gas turbine engine (contrast). [1 Lectures]

- **Module III**

  Thermodynamic, aerodynamic, & mechanical design considerations in aircraft gas turbine engine. [3 Lectures]

- **Module IV**

  Aircraft propulsion mechanics, concepts, & performance measures. [2 Lectures]

  Thrust (T), Specific Thrust (F sp), Propulsive Efficiency, Overall efficiency, Thrust specific fuel consumption.

- **Gas turbine cycle (Joule) for Aircraft / Helicopter propulsion**

  Open cycle single shaft and twin shaft arrangements, multispool arrangements. [2 Lectures]

- **Thermodynamic analysis of ideal shaft power cycles**

  T-S diagram, cycle efficiency, specific work output (derivations). [3 Lectures]

- **Thermodynamic analysis of ideal reheat cycle**

  T-S diagram, optimum point of reheat, cycle efficiency & specific work output (derivations)

  Thrust augmentation using after burner and water injection in compressor inlet.

- **Methods for accounting for component losses (with illustrations on T-S diagram)**

  Compressor and Turbine efficiencies [isentropic and polytropic (including incides for compression and expansion)], intake & propelling nozzle efficiencies, mechanical losses

  Fuel air ratio, combustion efficiency (& relation with thermal efficiency) [4 Lectures]

- **Simple Turbo-Jet Engine (TJE) cycle**

  Calculation of $F$, $F_{sp}$, $\eta_{pr}$, sfc;

  Variation of of $F$, $F_{sp}$, $\eta_{pr}$, sfc with flight conditions for given TJE

- **Analysis of flow through - compressor, turbine, combustion chamber, afterburner, nozzle** [2 Lectures]

- **Variable area nozzle, thrust spoiler & reverser, engine noise suppressor** [2 Lectures]

- **Bypass engines**

  Turbo-fan Engine (TFE) configurations, thermodynamic design point performance prediction of TFE, turbo-prop engine & its propeller efficiency

  Optimization of TFE cycle for minizing sfc and maximizing $F_{sp}$ based on bypass ratio and fan pressure ratio. [6 Lectures]

- **Off-design performance prediction of aircraft gas turbine engines based on component characteristics**

  Relations based on work, flow, rpm compatibilities between components

  Single shaft engine delivering shaft power, free turbine engine (incl- matching of two turbines in series, study of variation of power output & sfc with rpm of free turbine)

  Jet engine (incl - matching of gas-generator turbine with nozzle, study of variation of $F$ with engine rpm, forward speed, altitude)

**Text Books:**

1. H.I.H. Saravanamuttoo, G.F.C. Rogers, H. Cohen, P. Straznicky, **Gas Turbine Theory**, 6th Edition, Prentice Hall / Pearson Education, Singapore, 2009.
2. P.G. Hill, C.R. Peterson, **Mechanics and Thermodynamics of Propulsion**, 2nd Edition, Addison-Wesley Co. Reading MA USA, 1992.
3. R.D. Flack, **Fundamentals of Jet Propulsion with Applications**, Cambridge University Press, Cambridge, 2005.

## 17.99 ME 622: Biomechanics of Musculoskeletal System

**Course Code: ME 622**
**Course Name: Biomechanics of Musculoskeletal System**

L-T-P-C: 3-0-0-3
Prerequisites: ME206 Mechanics of solids, IC240 Mechanics of Rigid Bodies , IC242 Continuum Mechanics , ME352 Finite Element Methods i n Engineering
Students intended for: UG/PG
Elective or Core: Elective
Approval: 9th Senate

**Course contents**

- **Module I**

  Introduction to Biomechanics, Basic terminology and concept of hu man musculoskeletal system, anatomy and overall function. [4 Lectures]

- **Module II**

  Biomechanics of Tissues and Structures of musculoskeletal system composition and structure. [3 Lectures]

- **Module III**

  Biomechanical behaviour bone, articular cartilage, muscle, tendon and ligament. [8 Lectures]

- **Module IV**

Biom echanics of joints structure, range of motions, musculoskeletal model of forces: (i) hip; (ii)knee; (iii) shoulder; (iv) elbow; (v) spine, lubrication of joints. [8 Lectures]

- **Module V**

  Motion and gait analysis method, gait cycle, segmental kinetics, engineering approa ches to posture analysis. [6 Lectures]

- **Module VI**

  Joint replacement and fracture fixation stress analysis and basic design approach, failure mechanisms, wear in joint arthroplasty, bone remodelling. [8 Lectures]

- **Module VII**

  Biomaterials properties and application. [2 Lectures]

- **Module VIII**

  Image Processing T echniques: Quantitative CT scan / MRI reconstruction and generation of solid (CAD) models. [3 Lectures]

**Text Books:**


1. M. Nordin and V.H. Frankel, **Basic Biomechanics of the Musculoskeletal System**, 3rd edition, LWW.

2. Y. C. Fung, **Biomechanics**, 2nd Edition, Springer

3. J.D. Humphery and S.L. Delange, **An Introduction to Biomechanics**, Springer


**Reference Books:**


1. Dominique G. Poitout, **Biomechanics and Biomaterials in Orthopedics**, by Publisher: Springer

2. Kelvin L. Ong, Scott Lovald, Jonathan Black, **Orthopaedic Biomaterials in Research and Practice**, 2nd Edition, CRC Press.


## 17.100 ME 625: Introduction to Turbulence and its Modeling

**Course Code: ME 625**
**Course Name: Introduction to Turbulence and its Modeling**

L-T-P-C: 3-0-0-3
Prerequisites: ME 210 Fluid Mechanics, IC 110 Engineering Mathematics/ ME 504 Numerical Methods for Engineering Computation
Students intended for: UG/PG
Elective or Core: Elective
Approval: 9th Senate

**Course contents**

- **Introduction to Turbulence**

  Nature of turbulence, origin of turbulence, laminar and turbulent boundary layers, diffusion of turbulence, concept of eddy viscosity. [4 Lectures]

- **Statistics of Turbulence**

  Statistical aspects of turbulence, scales in turbulence, spectrum of turbulence, energy cascade in isotropic turbulence, Kolmogorov hypotheses. [6 Lectures]

- **Mathematical Theory of Turbulence**

  The Reynolds equation, Reynolds decomposition, equations for the mean flow, Reynolds stress, mixing length model, turbulent heat transfer, limitations of mixing length theory. [6 Lectures]

- **Dynamics of Turbulence**

  Dynamics of turbulence, Taylor microscale, Reynolds stress and vorticity, the vorticity equation. [4 Lectures]

- **Boundary-free and Wall-bounded Turbulence**

  Turbulent wakes, turbulent jets and mixing layers, turbulent flows in pipes and channels, experimental techniques for turbulence characteristics. [8 Lectures]

- **Introduction to Turbulence Modelling**

  Turbulence modelling and closure problem, algebraic models, modern variants of the mixing length model, one equation models, $k-\epsilon$ and $k-\omega$ models, Spalart–Allmaras turbulence model. [8 Lectures]

- **Numerical Techniques for Turbulence**

  Direct numerical simulations (DNS), large eddy simulations (LES) and Reynolds averaged Navier-Stokes (RANS) modelling techniques, spectral methods and particle based methods for turbulence. [8 Lectures]

**Text Books:**

1. Tennekes H. and Lumley J., **A first course in turbulence**, M.I.T. Press.

2. Tritton D.J., **Physical Fluid Dynamics**, Oxford University Press.

3. Davidson P.A., **Turbulence: An Introduction for Scientists and Engineers**, Oxford University Press.

**Reference Books:**

1. Pope S.B., **Turbulent flows**, Cambridge University Press, 2000

2. Townsend A.A., **The structure of turbulent shear flow**, Cambridge University Press, 1980.

3. Wilcox D.C., **Turbulence modeling for CFD**, DCW Industries, Incorporated, 1994.

### 17.101 ME 626: Acoustics

**Course Code: ME 626**
**Course Name: Acoustics**

L-T-P-C: 2-1-0-3
Prerequisites: Basic Engineering Mathematics. ME 602 Mechanical Vibration is desirable
Students intended for: MS and PhD students – SE, SCEE, B-Tech final and pre-final year students.
Elective or Core: Elective
Approval: 9th Senate

**Course contents**

- **Basics of Acoustics and Vibration**

  Introduction, frequency, Fourier series, FFT, loudness, decibel scale, octave, music scale. Vibration of one degree of freedom system. Brief introduction to multi degree of freedom systm. [5 Lectures]

- **Vibration of string, bars, membranes and plates**

  One dimensional wave equation, general solution of wave equation, plucked string. Longitudinal vibration of bars, transverse vibration of beam. Wave equation for stretched membrane, normal modes of membrane. Vibration of plates. [5 Lectures]

- **Acoustic wave equation and its solution**

  Equation of state, continuity, Euler's equation. Linear wave equation, speed of sound in fluids. Acoustic intensity, specific acoustic impedance, spherical waves, cylindrical waves. Waveguides, transmission line equations. and resonators. [8 Lectures]

- **Reflection and transmission**

  Changes in media, transmission from one fluid to another – normal and oblique incidence. Normal specific acoustic impedance, reflection from solid. Transmission through thin partition – mass law. Perfectly matched layer. [4 Lectures]

- **Radiation and reception of acoustic waves**

  Radiation from pulsating sphere, acoustic reciprocity, continuous line source, radiation from circular piston, radiation impedance. Models of electromechanical acoustic systems, Solution for a loudspeaker model, Microphones. [8 Lectures]

- **Hearing and Speech**

  The ear, fundamental properties of hearing – threshold, equal loudness level contours, critical bandwidth, masking, beats. Loudness level and loudness, pitch and frequency, voice. [4 Lectures]

- **Environmental and Architectural acoustics**

  Sound in enclosure, reverberation time, sound absorption materials, acoustics factors in architectural design. Speech interference, noise rating curves, highway noise, design of partitions. [8 Lectures]

- **Special topics**

  Underwater acoustics, shock waves and explosion. (can be in the form of seminars/presentation) [2 Lectures]

**Text Books:**

1. Lawrence E. Kinsler, Austin R. Frey, **Fundamentals of Acoustics**, 4th Edition, Wiley Publishers, 2000.
2. Munjal M. L., **Noise and Vibration Control**, World Scientific Publishers in Collaboration with IISc Press, Singapore, 2013

**Reference Books:**

1. Beranek Leo L., **Acoustics**, Acoustical Society of America, 1996.

## 17.102 ME 627: Mesh Independent Computational Techniques

**Course Code: ME 627**
**Course Name: Mesh Independent Computational Techniques**

L-T-P-C: 3-0-0-3
Prerequisites: FEM in Engineering (ME 513)/Advanced FEM (ME 601)
Students intended for:UG/M. Tech/MS/PhD
Elective or Core: Elective
Approval: 39th BoA

**Course contents**

- **Scope and Need of Mesh Independent methods**

  Equations for two-dimensional and three-dimensional solids, strong-forms and weak-forms, Weighted residual method, need of mesh free methods, solution procedure of Mesh Free methods, classification according to the formulation procedures, classification according to the function approximation schemes [9 Lectures]

- **Shape function construction**

  Meshfree shape function construction, point interpolation metnods, moving least square shape function, interpolation error using Meshfree shape function. [6 Lectures]

- **Methods based on global weak-forms**

  Meshfree radial point interpolation method and formulation, integration issues in RPI method, Imposition of essential BC in RPI method, Element Free Galerki method formulation, and shape function, Implementation issues and application examples in EFGM, Integration techniques and enforecement of BC in EFGM. [8 Lectures]

- **Methods based on local weak-forms**

  Meshless local Petrov-Galerkin method, Implementation issues and application examples. [4 Lectures]

- **eXtended Finite Element Method**

  Difference between FEM and XFEM, Partition of Unity and Level set function, Intrinsic enrichment and Extrensic enrichment, Numerical integration, Implementation and case studies [4 Lectures]

- **Computer Implementation and Case Studies**

  FEM Implementation with computer programming platform

  Implementation of meshfree EFGM using computer programming for analysis of (i) solid mechanics problem (ii) heat transfer problem. Enforcement of essential boundsary condition will be implemented using Lagrange multiplied method.

  Implementation of XFEM with extrinsic enrichment techniques for material discontinuity and crack discontinuity. [9 Lectures]

**Text Books:**


1. G. R. Liu and Y. T. Gu, **An Introduction to meshfee Methods and their Programming**, Sprinter Dorderecht, Berlin, 2005.

2. Timon Rabczuk, Jeong-Hoon Song, Xiaoying Zhuang, Cosming Anitescu, **Extended Finite Element and Meshfree Methods**, Academic Press, 2019.


**Reference Books:**


1. G. R. Liu, **Meshfree Methods: Moving Beyond the Finite Element Method**, CRC Press, 2018

2. **Meshfree Methods for Partial Differential Equations**, Lecture notes in Computational Science and Engineering book series, Springer, 2017.

3. Youping Chen, James Lee, Azin Eksandarin, **Meshless methods in Solid Mechanics**, Springer, 2006.

4. Hua Li, Santanu S. Mulay, **Meshless Methods and Their Numerical Propertis**, CRC Press, 2013.

5. Soheil Mohammadi, **Extened finite element method for fracture analysis of Structures**, Blackwell Publishing Inc., 2008.

6. Amir R. Khoei, **Extended Finite Element Method: Theory and Applications**, John Wiley & Sons, 2014.


## 17.103 ME 628: Impact Mechanics

**Course Code: ME 628**
**Course Name: Impact Mechanics**

L-T-P-C: 3-0-0-3
Prerequisites: Mechanics of Solids (ME206) & FEM in Engineering (ME513) or Advanced FEM (ME601)
Students intended for: UG/M. Tech/MS/PhD

Elective or Core: Elective
Approval: 39th BoA

**Course contents**

- **Introduction**

  Impact Mechanics - Appreciating Impact Problems in Engineering, Historical Background, Low velocity impact, Principle of dynamics, Percussion, Concussion, Collision and Explosion. [4 Lectures]

- **Rigid Body Impact Mechanics**

  Impulse - Momentum Equations, Measurement of Coefficient of Restitution, Kinetic Coefficient of Restitution, Energy Coefficient of Restitution, Oblique Impact- Role of Friction. [5 Lectures]

- **Impact Mechanics of Deformable Bodies**

  One-Dimensional Impact Mechanics of Deformable Bodies: Single Degree of Freedom Idealization ofImpact Process, 1-D Wave Propagation in Solids Induced by Impact, Governing Equation for Flexural Waves in Rods, D'Alembert's Solution for Wave Equation.

  Multi-Dimensional Impact Mechanics of Deformable Bodies: Analysis of Stress and Strain, Linearised Stress-Strain Relations. [8 Lectures]

- **Experimental Impact Mechanics**

  Quasi-Static Material Tests, Pendulum Impact Tests, High Strain Rate Testing of elastoplastic and visco-elastic materials, Split Hopkinson's Pressure Bar Test, Taylor Cylinder Impact Test, Drop Impact Test. [10 Lectures]

- **Impact Modeling**

  Modeling Deformation and Failure Under Impact: Equation of State, Gruneisen Parameter and Murnaghan Equation of State, Constitutive Models for Material Deformation and Plasticity, Johnson-Cook Material Model, Determination of Parameters in Johnson-Cook Model, Implementation of Damage, Implementation of penetration and bulging. [4 Lectures]

- **Computational Impact Mechanics**

  Lagrangean Formulation, Eulerian Formulation, Computational Aspects in Numerical Simulation, Shockwaves. [3 Lectures]

- **Case Studies**

  Low-velocity impact properties of composite materials, Simulation of Ballistic Impact of a Steel Bullet, Mechanics of Vehicle Collision, Case studies of vehicle crash impact test, Case studies of explosive impact test. [7 Lectures]

**Text Books:**

1. C. Lakshmana Rao, V. Narayanamurthy, K. R. Y. Simha, **Applied Impact Mechanics**, John Wiley & Sons Ltd., 2016.
2. W. J. Stronge, **Impact Mechanics**, Cambridge University Press, 2018.

**Reference Books:**


1. Laursen, Tod A, **Computational Contact and Impact Mechanics**, Springer. 2003.

2. Ian G. Crouch, **The Science of Armour Materials**, Elsevier, 2016.

3. Karl F. Graff, **Wave Motion in Elastic Solids**, Dover Publications, 2003.

4. Zvi Rosenberg and Erez Dekel, **Terminal Ballistics**, Spinger, 2012.

5. Jonas A Zukas, **High Velocity Impact Dynamics**, John Wiley & Sons. 1990.


## 17.104 ME 630 : Machine Learning for Engineers

**Course Code : ME 630**

**Course Name : Machine Learning for Engineers**

L-P-T-C: 2-0-2-3
Intended for: B.Tech/MTech/ MTech(R)/MS(R)/PhD
Prerequisites: None
Mutual Exclusion: None
Approval : 57th BoA

**Course Contents**

- Introduction: Various learning paradigms, definitions, examples. [1hr]

- Data handling: Data cleaning, Visualization and Pre-processing, Data Normalization, Linear Regression, Polynomial Regression [3hr]

- Optimization: gradient-based techniques, metaheuristic techniques, numerical implementation [4hrs]

- Statistics and probability: Probability distributions, hypotheses testing, Bayes' theorem, Maximum likelihood parameter estimation, Bayesian parameter estimation [3hrs]

- Supervised learning: Linear/nonlinear regression, overfitting, regularization, logistic regression, naive Bayes, k-NN, decision tree, random forest, maximum likelihood, support vector machine, applications in engineering [7hrs]

- Unsupervised learning: Singular value decomposition, principal component analysis, clustering, applications in engineering [5hrs]

- Artificial neural network: Single- and multi-layer networks, activation, backpropagation, stochastic gradient descent, physics-informed neural network, applications in engineering [5hrs]

List of Lab Experimentation:

It is suggested that the student should get hands-on experience by solving data analysis problems available on Machine Learning competition platforms. Some of the suggestive list of lab experiments is given below.

- Introduction to Python/MATLAB
- Extract the data from database
- Implement Support Vector Machine for a dataset and compare the accuracy by applying the following kernel functions: i. Linear ii. Polynomial iii. RBF
- Implement k-nearest neighbours classification
- Implement linear regression using
- Implement K-Means_Clustering using
- Implement Naive Bayes Theorem to Classify the English Text
- Implement an algorithm to demonstrate Back Propagation Algorithm
- Implement an algorithm to demonstrate the significance of Genetic Algorithm in python
- Implement an algorithm to demonstrate Back Propagation Algorithm
- Implement and demonstrate the FIND-S algorithm for finding the most specific hypothesis based on a given set of training data samples
- Project work

**Text books:**

1. R. G. McClarren, **Machine Learning for Engineers**, Springer
2. S. Rogera, M. Girolami, **A First Course in Machine Learning**, CRC Press

**References:**

1. Z-H. Zhou, **Machine Learning**, Springer
2. G. James et al., **An Introduction to Statistical Learning**, Springer
3. S. L. Brunton, J. L. Kutz, **Data-Driven Science and Engineering**, Cambridge Uni. press
4. J-A. Goulet, **Probabilistic Machine Learning for Civil Engineers**, MIT Press
5. J. Watt et al., **Machine Learning Refined**, 2nd Edition, Cambridge University press
6. A. Lindholm et al., **Machine Learning**, Cambridge University press

## 17.105 ME 631: Heat Transfer and Fluid Flow in Energy Systems

**Course Code: ME 631**
**Course Name: Heat Transfer and Fluid Flow in Energy Systems**

L-T-P-C: 3-0-0-3
Prerequisites: Instructor's consent
Students intended for: M. Tech / UG/MS/PhD
Elective or Core: Core for M. Tech, elective for / UG/MS/PhD
Approval: 10th Senate

**Course contents**

- **Module I**

  Overview of transport phenomena, Vectors and tensors, types/uses of control volume, notion of conservation principles and constitutive relations [4 Lectures]

- **Module II**

  Analysis of flow through pipes, Major and Minor losses, Hydraulic gradient and total energy line – pipe in series and parallel, hydraulic transmission of power, Turbulent flow in pipes, Smooth and rough boundaries, water hammer phenomena, Flow through fluidized and packed bed combustor, flow through nozzle and diffusers, cascade theory, flow through reciprocating, centrifugal and axial pumps, compressors and turbines, Cavitation phenomena. [28 Lectures]

- **Module III**

  Heat transfer phenomena in pipes, combustion chambers, fluidized and packed bed combustors, Analysis of heat exchangers, heat and fluid phenomena in boilers. [10 Lectures]

**Text and Reference Books:**


1. William S. Janna, **Design of Fluid and Thermal Systems**, 4th Edition
2. Steven G. Penoncello, **Thermal Energy Systems: Design and Analysis**, CRC Press.
3. R. Byron Bird, Warren E. Stewart, Edwin N. Lightfoot, **Transport phenomena**, 2nd Edition, Wiley, 2001.
4. J.C. Slattery, **Advanced transport phenomena**, Cambridge University Press, New York, 1999.
5. Welty J.R, Wicks J.E, Wilson R.E, Rorrer G, **Fundamentals of momentum, heat and mass transport**, 4th Edition, Wiley, 2001.

## 17.106 ME 632: Mechanics for Energy Systems

**Course Code: ME 632**
**Course Name: Mechanics for Energy Systems**

L-T-P-C: 3-0-0-3
Prerequisites: Mechanics of Solid
Students intended for: B. Tech./ M. Tech. /MS
Elective or Core: Compulsory for M. Tech in Mechanical Engineering with specialization in Energy Systems, and Elective for others
Approval: 10th Senate

**Course contents**

- **Brief overview of linear elasticity**

  Material constitutive relations, generalized Hooke's law, problems of linear elasticity, principle of Virtual work; minimum Potential energy; Hamilton's equation [4 Lectures]

- **Stress Analysis**

  Analysis of various components used in energy systems/ subsystems under different types of stresses - axial, bending and torsion; piping systems, turbine blade, rotors, boilers, compressor, nozzle, blower, generator, solar concentrating collectors and associated drives. [22 Lectures]

- **Dynamic Analysis**

  Free and forced vibrations; analysis of rotor systems, geared systems; natural frequencies and natural modes, steady state response

  Different kinds of bearing used in various types of turbine-rotor; stiffness and damping coefficients of journal bearings, half frequency whirl and resonance whip [10 Lectures]

- **Balancing**

  Balancing of rigid and flexible turbine rotors, influence coefficient and modal balancing techniques for flexible rotors. [4 Lectures]

**Text and Reference Books:**


1. Boresi, A.P. and Sidebottom, O.M., **Advanced Mechanics of Materials**, John Wiley, 1993.

2. Timoshenko, S.P. and Goodier, J.B., **Theory of Elasticity**, McGraw-Hill Kogakusha Ltd., 1970

3. J. S. Rao, **Rotor Dynamics**, New Age International Publishers, New Delhi.

4. Timoshenko, D H. Young and W. Weaver, **Vibration Problems in Engineering**, John Wiley.

## 17.107 ME 633: Design of Energy Systems

**Course Code: ME 633**
**Course Name: Design of Energy Systems**

L-T-P-C: 3-0-0-3
Prerequisites: Instructor Consent
Students intended for: B. Tech. /M. Tech./ MS/ PhD
Elective or Core: Compulsory for M. Tech in Mechanical Engineering with specialization in Energy Systems, and Elective for others
Approval: 10th Senate

**Course contents**

- **Module I**

  Introduction to energy systems, Introduction to critical components for design in energy system, thermal stresses, material selections. [4 Lectures]

- **Module II**

  Turbine blade design, overview of design criteria and certification guidelines, aerodynamic design, structural design, design and choice of sub-systems and components, design of blades for gas turbines, consideration of blade cooling in design of gas turbine blades, blades for hydro and wind turbines. [12 Lectures]

- **Module III**

  Design of critical, supercritical and ultra-supercritical boilers, Stresses in pressure storage sections, Autofrettage, Thermal stresses, Design of various boiler components such as shell, heads, nozzles, flanges as per ASME & IS codes, Buckling. [8 Lectures]

- **Module IV**

  Design of high pressure power plant piping systems, flow characteristics, material selection, thermal analysis of pipe and joints, thermal insulations. [4 Lectures]

- **Module V**

  Design of heat transfer equipments, Boilers: classification, selection, Heat exchangers: classification, selection, flow friction and pressure drop analysis, basic thermal design, e-NTU, p-NTU, MTD methods. Shell and tube heat exchanger, construction and thermal features, thermal design procedure, Kern method, Bell Delaware method. [8 Lectures]

- **Module VI**

  Thermal design of regenerators, classifications, design parameters. Design of compact heat exchangers, plate and fin, fin-tube and plate and frame heat exchangers, fouling and corrosion in heat exchangers. [6 Lectures]

**Text and Reference Books:**


1. J. F. Harvey, **Theory and Design of Pressure Vessels**, CBS Publishers and Distributors, 1987.

2. S. Walas, **Chemical Process Equipment, Selection and Design**, Buterworths Sr. in Chemical Engineering.

3. L. Brownell, E. Young, **Process Equipment Design**, John Wiley and Sons.

4. D. Kern, **Process Heat Transfer**, Tata McGraw-Hill, 2000.

5. Fraas, **Heat Exchanger Design**, 2nd Edition, John Wiley & Sons, 1989.

6. J. Manwell, J. McGowan, A. Rogers, **Wind Energy Explained, Theory, Design and Application**, Wiley, 2012.

7. R. Kulwiec, **Materials Handling Handbook**, ASME, John Wiley and Sons.

8. W. Stoecker, **Design of thermal systems**, Tata McGraw-Hill Education, 3rd Edition.


## 17.108 ME 634: Thermodynamics for Energy Systems

**Course Code: ME 634**
**Course Name: Thermodynamics for Energy Systems**

L-T-P-C: 3-0-0-3
Prerequisites: Instructor Consent
Students intended for: UG/M. Tech/MS/PhD
Elective or Core: Core for M. Tech Energy Engineering (Mechanical), elective for UG/MS/PhD
Approval: 10th Senate

**Course contents**

- **Laws of Thermodynamics**

  The first law for open and closed system; steady and transient processes, work and heat transfer; second law of thermodynamics for open and closed systems; Local temperature equilibrium (LTE) Model, entropy maximum an energy minimum principles [10 Lectures]

- **Module II**

  Entropy; Concept of reversibility and irreversibility; change in entropy in various thermodynamic processes, entropy balance for closed and open systems, mechanism of entropy generation, entropy generation minimization [7 Lectures]

- **Single and multiphase systems**

  Maxwell relatios; Clasius-Clapeyron equation; Gibbs-Duham relation, phase diagrams; phase transition; types of equilibrium and stability; multi-component and multi-phase systems, equations of state. [9 Lectures]

- **Combustion and Thermochemistry**

  Stoichiometry of reactions, enthalpy of formation and reaction, adiabatic flame temperature, second law availability analysis of chemical reactions. [6 Lectures]

- **Advanced Thermodynamic Cycles**

  Advanced vapour power cycles; advanced gas power cycles, combined cycle power cycles, cogeneration. [6 Lectures]

- **Module VI**

  Exergy Analysis of energy systems and case studies. [5 Lectures]

**Text and Reference Books:**


1. A. Bejan, **Advanced Engineering Thermodynamics**, Wiley, 2006.
2. M. J. Moran and H. N. Shapiro, **Fundamentals of Engineering Thermodynamics**, John Wiley and Sons
3. C. Borgnakke, G. Van Wylen and R. E. Sonntag, **Fundamentals of Thermodynamics**, Wiley India


## 17.109 ME 635: Manufacturing for Energy Systems

**Course Code: ME 635**
**Course Name: Manufacturing for Energy Systems**

L-T-P-C: 3-0-0-3
Prerequisites: Instructor Consent
Students intended for: UG/M. Tech/MS
Elective or Core: Compulsory elective for M. Tech (Mechanical Engineering) specializing in Energy system, and Elective for others
Approval: 10th Senate

**Course contents**

- **Casting and forging of super alloys**

  Principles related to the practice of melting and casting of non-ferrous alloys. Typical problems encountered during melting and casting. Fettling and heat-treatment of castings; Casting defects: inclusions, hot-tearing, blow holes and pin holes, shrinkage, misrun, coldshut and coldlap, metal penetration and sand burn-on, scabs and rat tails, lustrous carbon defect, mismatch, sand drop and mold break.

  Basic principles and development of additive manufacturing, generalized process chain, Vat photo polymerization, powder bed fusion, extrusion-based processes, material jetting, sheet lamination and directed energy deposition processes, direct write technologies, rapid tooling. [10 Lectures]

- **Advanced machining**

  Non-Traditional Machining: Abrasive Jet Machining, Ultrasonic Machining, Water Jet Machining, Electrical Discharge Machining, Laser Beam Machining, Electron Beam Machining CNC Machining: Milling center, turning center. [10 Lectures]

- **Joining similar & non-similar materials**

  Solid state welding- friction stir processing, and friction stir surfacing, process characteristics and applications, friction stir processing of particle reinforced composite materials, electron beam welding-weldability of aluminum and its alloys, Mg and its alloys and steels, flux cored arc welding, laser beam welding, cracks in welds, operations, advantages and limitations, applications, liquid penetration test, eddy current test, ultrasonic test, magnetic particle test, Xray radiography test. Non-destructive Testing: Liquid penetrant test, Ultrasonic testing, Thermography, Radiography. [10 Lectures]

- **Case studies**

  Manufacturing process of rotor, turbine blade, impeller, pipe, shaft, solar cell, solar panel and fabrication of microelectronic devices. [12 Lectures]

**Text and Reference Books:**


1. Kalpakijian, **Manufacturing Engineering and Technology**, Adisson Wesley, 1995.
2. Ian Gibson, David Rosen, Brent Stucker, **Additive Manufacturing Technologies**, Springer Publ. 2015.
3. R. A. Lindburg, **Process and Materials of Manufacturing**, 4th Edition, PHI 1990.
4. Chang Liu, **Foundation of MEMS**, Pearson, 2012.
5. V.K.Jain, **Advanced Machining Processes**, Allied Publications.
6. John Campbell, **Castings: The new metallurgy of cast metals**, 2nd edition, Elsevier Publications, 2004.
7. **Nondestructive Testing Handbook**, American Society for Nondestructive Testing


## 17.110 ME 636: Combustion Technology

**Course Code: ME 636**
**Course Name: Combustion Technology**

L-T-P-C: 3-0-0-3
Prerequisites: Instructor Consent
Students intended for: UG/M. Tech. /MS/PhD
Elective or Core: Elective
Approval: 10th Senate

**Course contents**

- **Module I**

  Introduction to combustion processes; combustion thermodynamics, reaction kinetics and combustion transport. Chain reactions, ignition, quenching and flammability limits, detonations, deflagrations and flame stability; Introduction to turbulent premixed combustion; Applications in IC engines, furnaces, gas turbines, and rocket engines. [4 Lectures]

- **Module II**

  Fuels - Characteristics and Properties; Combustion Thermodynamics and Thermochemistry, Heat of Reaction, Calorific Value, Adiabatic Flame Temperature etc

  Combustion Kinetics – Reaction Mechanism / Pathways, Rate Constants, Activation Energy; Flame –Diffusion Flame, Mixed Flame, Flame Velocity; Formation of Pollutants – CO, Soot, NOX and SOX; Combustion Modeling – Solid Combustion, Gas Combustion and Liquid. [12 Lectures]

- **Module III**

  Combustion - Combustion Equipment: Combustion in Boilers (including Fluidized Bed Combustion), Liquid Combustion – Atomizer, Spray Combustion etc.; Gas Combustion – Gas Burners

  Interchangeability of Fuels, Special Equipment; Engines, Combustion Phenomenon in Engines, Performance of Engine and Emissions; Stoves; Catalysis – Catalytic Combustion and Control of Emissions. [14 Lectures]

- **Module IV**

  Advanced treatment of fundamental combustion processes; Conservation equations for reacting gas mixtures; The structure of one-dimensional diffusion and premixed flames; introduction to activation energy asymptotics. Two-dimensional Burke-Schumann flames and boundary layer combustion; Flame instabilities and flame stretch; turbulent combustion. [12 Lectures]

**Text Books:**

1. Stephen Turns, **An Introduction to Combustion: Concepts and Applications**, 3rd Edition, McGraw Hill Education India Private Limited, 2012.

2. Mishra D P., **Fundamentals of Combustion**, PHI Learning Private Limited-New Delhi, 2010.

## 17.111 ME 637: Wind Power Plant

**Course Code: ME 637**
**Course Name: Wind Power Plant**

L-T-P-C: 3-0-0-3
Prerequisites: Instructor Consent
Students intended for: UG/M. Tech. /MS/PhD

Elective or Core: Specialized stream elective for M. Tech in Mechanical Engineering with specialization in Energy Engineering, elective for other students

Approval: 10th Senate

**Course contents**

- **Module I**

  Introduction, General theories of wind machines, Basic laws and concepts of aerodynamics [8 Lectures]

- **Module II**

  Micro-siting, Description and performance of the horizontal-axis wind machines, Blade design, Description and performance of the vertical-axis wind machines [12 Lectures]

- **Module III**

  The generation of electricity by wind machines, case studies, overview of micro, mini and small hydro, site selection and civil works, penstocks and turbines, speed and voltage regulation. [14 Lectures]

- **Module IV**

  Investment issues, load management and tariff collection, distribution and marketing issues, case studies. [8 Lectures]

**Text Books:**


1. Gasch Jochen Twele, **Wind Power Plants Fundamentals, Design, Construction and Operation**, Springer-Verlag Berlin, 2012

2. Mathew Sathyajit, **Wind Power Plants: Fundamentals, Resource Analysis and Economics**, Springer-Verlag Berlin, 2006.


## 17.112 ME 638: Solar Thermal Power Plant

**Course Code: ME 638**
**Course Name: Solar Thermal Power Plant**

L-T-P-C: 3-0-0-3

Prerequisites: Instructor Consent

Students intended for: UG/M. Tech. /MS/PhD

Elective or Core: Specialized stream elective course for M. Tech. in Mechanical Engineering with specialization in Energy Systems, and elective course for other students

Approval: 10th Senate

**Course contents**

- **Module I**

  Physical processes that determine the output of a solar thermal collector, and mathematical models that can be used to calculate this output, relation between factors and models, materials and surface treatments for use in a solar collector, optical parameters of absorbers, reflectors and transparent materials and comparison of their characteristics. [6 Lectures]

- **Module II**

  Evaluate of different thermal loads and its mathematical modeling, design of different solar thermal systems and comparing their suitability for different boundary conditions [8 Lectures]

- **Module III**

  Calculation of storage capacity for different heat storage techniques and determine their suitability for given boundary conditions. [7 Lectures]

- **Module IV**

  Function of the important components necessary in a solar thermal system and the testing standards used for their evaluation. [7 Lectures]

- **Module V**

  Need and challenges involved in using solar energy for cooking, cooling, distillation and drying applications as well as identify niche areas for these applications, functioning of different designs and system dimensions of solar cookers, stoves, cooling systems and dryers [14 Lectures]

**Text Books:**

1. Peter Gevorkian, **Large-Scale Solar Power System Design: An Engineering Guide for Grid Connected Solar Power Generation**, McGraw-Hill, 2011.

## 17.113 ME 639: Thermal Power Plant Engineering

**Course Code: ME 639**
**Course Name: Thermal Power Plant Engineering**

L-T-P-C: 3-0-0-3
Prerequisites: Instructor Consent
Students intended for: UG/M. Tech. /MS/PhD
Elective or Core: Specialized stream elective course for M. Tech. in Mechanical Engineering with specialization in Energy Systems, and elective course for other students
Approval: 10th Senate

**Course contents**

- **Module I**

  Types of thermal power stations, steam power stations based on fossil fuels, Economy and thermal scheme of the steam power stations. [4 Lectures]

- **Module II**

  Thermal power plant equipment – boilers, superheaters, super critical steam generator economizers, feedwater heaters, condensers. [20 Lectures]

- **Module III**

  Combustion chamber and gas loop, turbines, cooling towers, etc. Gas turbine power statiooons, combined cycle power plants. [12 Lectures]

- **Module IV**

  Internal combustion engine plant for peak load, standby and start-up. [6 Lectures]

**Text Books:**

1. Amiya Ranjan Mallick, **Practical Boiler Operation Engineering and Power Plant**, 4th Edition, PHI, 2015.
2. R. Yadav, **Steam and Gas Turbines and Power Plant Engineering**, 7th Edition, Central Publishing House, 2000.

## 17.114 ME 640: Solar Power Utilization

**Course Code: ME 640**
**Course Name: Solar Power Utilization**

L-T-P-C: 3-0-0-3
Prerequisites: Instructor Consent
Students intended for: UG/M. Tech. /MS/PhD
Elective or Core: Specialized stream elective course for M. Tech. in Mechanical Engineering with specialization in Energy Systems, and elective course for other students
Approval: 10th Senate

**Course contents**

- **Module I**

  Solar radiation and modelling, solar collectors and types: flat plate, concentrating solar collectors, advanced collectors and solar concentratrs, Sensitive coating. [14 Lectures]

- **Module II**

  Solar water heating, solar cooking, solar drying, solar distillation and solar refrigeration, Active and passive heating and cooling of buildings. [14 Lectures]

- **Module III**

  Solar thermal power generation, solar cells, Home lighting systems, Solar lanterns, Solar PV pumps, Solar energy storage options, Industrial heat systems, Solar thermal power generation and sterling engine, Solar economics. [14 Lectures]

**Text Books:**

1. Robert Foster, Majid Ghassemi, Alma Cota, **Solar Energy: Renewable Energy and the Environment**, CRC Press, 2009..

## 17.115 ME 641: Finite Element Method

**Course Code: ME 641**
**Course Name: Finite Element Method**

L-T-P-C: 3-0-0-3
Prerequisites: Instructor's Consent
Students intended for: UG/M. Tech. /MS/PhD
Elective or Core: Specialized stream elective course for M. Tech. in Mechanical Engineering with specialization in Energy Systems, and elective course for other students
Approval: 10th Senate

**Course contents**

- **BASIC CONCEPT**

  Introduction to FEM : Need for use of FEM, Advantages and Disadvantages of FEM, Engineering applications of finite element method,. Rayleigh- Ritz method, Weighted residual methods: Galerkin s method, Principal of a minimum potential energy, Principle of virtual work, Boundary value problem, initial value and Eigenvalue problem, Guass elimination method.

  BASIC PROCEDURE: General description of Finite Element Method, Discretization process; types of elements lD, 2D and 3D elements, size of the elements, location of nodes, node numbering scheme, half Bandwidth, Stiffuess matrix of bar element by direct method, Properties of stiffuess matrix, Preprocessing, post processing. One Dimensional Problem.[11 Lectures]

- **Module II**

  INTERPOLATION MODELS: Polynomial form of interpolation functions- linear, quadratic and cubic, Simplex, Complex, Multiplex elements, Selection of the order of the interpolation polynomial; Convergence requirements, 2D Pascal triangle, Linear interpolation polynomials in terms of global coordinates of bar, triangular (2D simplex) elements, Linear interpolation polynomials in terms of local coordinates of bar, triangular (2D simplex) elements, CST clement.

  HIGHER ORDER AND ISOPARAMETR!C ELEMENTS: Lagrangian interpolation, Higher order one dimensional elements- quadratic, Cubic element and their shape functions, properties of shape functions, Truss element, Shape functions of 2D quadratic triangular element in natural coordinates, 2D quadrilateral element shape functions - linear, quadratic, Biquadric rectangular element (4-Noded quadrilateral element), Shape function of beam element. Hermite shape function of beam element. [12 Lectures]

- **Module III**

  FEM for Solid Mechanics Problems: Derivation of element stiffness matrices and load vectors for bar element under axial loading, trusses, beam element with concentrated and distributed loads. Solution of bars, plane trusses and beam for displacements, reactions and stresses by using elimination approach, penalty approach.

  FEM for Heat Transfer Problems: Steady state heat transfer, One-dimensional heat conduction governing equation, boundary conditions, One dimensional element, Galerkin approach for heat conduction, heat flux boundary condition, heat transfer one-dimensional problems with conduction and convection.

FEM for Fluid Mechanics Problems: One-dimensional fluid flow governing equation, Onedimensional finite element formulation, boundary conditions.

FEM for Electromagnetics Problems: One-dimensional Electrostatics & Magnetostatic problems.

FEM for Elasticity Problem: Numerical integration, Plane stress and plane strain problems, dynamic problems on vibrations. [11 Lectures]

- **Module IV**

  Finite Element Analysis of piping systems, turbine blade, rotors, boilers, compressor, nozzle, blower, generator, solar concentrating collectors and associated drives. [8 Lectures]

**Text Books:**

1. Chandrupatla T.R., **Finite Elements in engineering**, 3rd Edition, Pearson
2. S.S. Rao, **The Finite Element Method in Engineering**, 4th Edition, Elsevier, 2006

**Reference Books:**

1. O.C.Zienkiewicz, **The FEM its basics and fundamentals**, 6th Edition, Elsevier.
2. J.N.Reddy, **Finite Element Method**, McGraw -Hill International Edition.
3. Daryl. L. Logon, **Finite Element Methods**, 3rd Edition, Thomson Learning, 2001.
4. C.S.Krishnamurthy, **Finite Element Analysis**, Tata McGraw Hill Publishing Co. Ltd, 1995.

## 17.116 ME 695P : Post Graduate Project-I

**Course Code: ME 695P**

**Course Name : Post Graduate Project-I**

L-T-P-C : 0-0-4-2
Intended for : MTech. in Materials and Energy Engineering
Prerequisite : None
Mutual Exclusion : None
Approval: 44th BoA

**Course Contents:**

- The students are expected to conduct their literature survey in the winter term based on the research topic the students and their advisors decide upon. Their level of satisfactory progress will be judged at the beginning of the 2nd semester based on the problem identification and their requisite literature survey. Their involvement on the project will be a key factor of their judgement and will contain various aspects like- discussion with the advisor, completion of literature survey, report writing and presentation

**Text books:**

1. As suggested by advisor.

**References:**

1. As suggested by supervisor or the material student finds necessary while working on project

## 17.117 MI 101 Thermodynamics

Course Code: MI-101
Course Name: Thermodynamics
L-T-P-C: 2-1-0-3
Pre-requisite: NIL Sem. Both
Approval: 5th Senate; OTA

**Course Contents:**

- **Introduction**: Introduction to thermodynamic system, surrounding, state, process, properties, equilibrium, heat and work, Zeroth Law of Thermodynamics;
- **Properties of Pure Simple Compressible Substance**: PvT Surface, Pv, Tv, TP diagrams. Equation of state for ideal and real gases. Virial equation of state, Van-der waal, Redlich- Kwong,Peng Robinson equation of state etc. use of steam tables and Mollier diagram;
- **First Law of Thermodynamics**: First law application to non-flow processes such as isochoric, isobaric, isothermal, adiabatic and polytropic processes. Steady flow energy equation, flow work. Application to various practical systems viz nozzles, diffuser, turbines, heat exchangers etc. Application of energy equation to transient flow problems;
- **Second Law of Thermodynamics**: Second law, reversible and irreversible processes, Clausius and Kelvin Planck statements, Carnot cycle, corollaries of second law: thermodynamic temperature scale, Clausius inequality, entropy as a property, principle of increase of entropy. Calculation of entropy change;
- **Thermodynamic Cycles**: Otto, Diesel, Rankine cycles and their applications. Vapour compression refrigeration cycle.

**References:**

1. Van Wylen and Sonntag, **Fundamentals of Thermodynamics**, John Wiley.
2. Roger G. F. C. and Mayhew, **Engineering Thermodynamics Work and Heat Transfer**, Longman.
3. Smith J. M., Van Ness H. C. and Abbott M. M, **Introduction to Chemical Engineering Thermodynamics**, Tata McGraw Hill.
4. Version S. I., Moran M. J. and Shapiro H. M., **Fundamentals of Engineering Thermodynamics**, John Wiley.

## 17.118 MI 102 Manufacturing Techniques

Course Code: MI-102
Course Name: Manufacturing Techniques
L-T-P-C: 2-0-2-3
Pre-requisite: NIL Sem. Both
Approval: 5th Senate; OTA

**Course Contents:**

- **Introduction** : Engineering materials, their manufacturability and applications;
- **Casting** : Pattern materials, pattern types, allowances, molding sand, composition and properties, cores, casting defects and their remedies, plastic parts molding;
- **Machining**: Lathe, drilling, milling and grinding machines and their operations, cutting tools used;
- **Joining** : Welding fundamentals, types of welded joints, types of welding processes, gas welding process, manual metal arc welding, welding defects and remedies, Soldering and brazing, their applications in electronics industry;
- **Forming**: Forging, rolling, extrusion, wire drawing and tube drawing, sheet metal operations, forging defects and remedies;
- **Advance Manufacturing Process**: Introduction to advanced manufacturing technique and their application.

**References:**

1. De Garmo P. E., Black J.T., Kohser R. A., **Materials and Processes in Manufacturing**, Prentice Hall of India Pvt. Limited.
2. Kalpakjian S., Schmid S. R., **Manufacturing Engineering and Technology**, Pearson Education.
3. Groover M. P., **Fundamentals of Modern Manufacturing**, John Wiley and Sons Inc.
4. Lindberg R. A., **Processes and Materials of Manufacture**, Prentice Hall India Limited.

# 18 Materials Science and Engineering Courses

## 18.1 MT 201 : Physics of Solids

**Course Code : MT 201**

**Course Name : Physics of Solids**

L-P-T-C: : 3-0-0-3
Intended for: B.Tech. (MSE)
Prerequisites: None
Mutual Exclusion: None
Approval : 57th BoA

**Course Contents**

- **Crystal Structures**: Elementary cell (Translation vectors, Primitive translation vectors, Bravais lattice, Basis, Crystal systems, Unit cell, and Bravais lattice types), Symmetry transformations (Axis of symmetry, Mirror planes, Point and Space symmetry groups), (Reciprocal space, Reciprocal lattice. Bragg planes, Brillouin zone, Ewald sphere Surface and Interface Physics (surface crystallography), Bragg conditions (Methods of structural studies: Laue method, rotating crystal method, powder method), Ewald construction, Lattice defects, Burger's vector. [12 Hours]

- **Transport Properties**: Free Electron Theory, Fermi-Dirac distribution function, and Density of states (DoS). Energy bands in solids, electronic band structure of solids Bloch theorem and energy band, Effective mass theory, Boltzmann transport equation, Thermal and electrical conductivity (for metals, dielectrics, semiconductors), Lattice dynamics, Electron and phonon scattering, Thermal properties, the specific heat of solids, 2D electron gas, Quantum wells & semiconductor superlattices. [10 Hours]

- **Optical Properties**: Drude theory-free carrier contribution to the optical properties, Absorption of light in solids, Optical properties of solids over a wide frequency range, Impurities and excitons, Luminescence and photoconductivity, Optical study of lattice vibrations, Nonlinear optics, and Electron spectroscopy and surface science. [6 Hours]

- **Magnetic Properties**: Hund's law, Spin-orbit interactions, Heisenberg exchange interaction, Diamagnetism and paramagnetism, Ferromagnetism and antiferromagnetism, Curie & Neel point, Landau Diamagnetism, Magneto-resistance, Nuclear magnetic resonance (NMR), and Kondo effect. [5 Hours]

- **Superconducting Properties of Solids**: Review of superconducting properties of solids, superconductivity, Meissner effect, London equation, Type I and Type II superconductors, High temperature superconducting materials, Electron orbitals, Macroscopic quantum description of the supercurrent. [8 Hours]

**Text books and References:**


1. H. Ibach and H. Luth, **Solid-State Physics, An Introduction to Principles of Materials Science**, 4th Edition, Springer, 2009.

2. C. Kittel, **Introduction to Solid State Physics**, 8th Edition, John Wiley & Sons, 2005.

3. N. W. Ashcroft and N. D. Mermin, **Solid State Physics**, Brooks Cole, 1976.

4. David W. Snoke, **Solid State Physics: Essential Concepts**.

## 18.2 MT 202 : Applied Quantum Mechanics

**Course Code : MT 202**

**Course Name : Applied Quantum Mechanics**

L-P-T-C: : 3-0-0-3
Intended for: B.Tech. (MSE)
Prerequisites: None
Mutual Exclusion: None
Approval : 57th BoA

**Course Contents**

- **Module 1**: Review of classical mechanics and its failure in understanding the behaviour of microscopic particles, Waves and particles (double-slit experiments), Introduction to the basic ideas of quantum mechanics, The postulates of quantum mechanics, Eigen-states and eigen-values of position and momentum operators, Uncertainty principle. Observables and their operators. [10 hours]

- **Module 2**: Time independent and time dependent Schrodinger's equations, The fundamental properties of Schrodinger's equations, One-dimensional square well potential, The electron gas in a 3-dimensional box, Tunneling, The one-dimensional Harmonic oscillator, Vibration of the nuclei of a diatomic molecule, Vibration of the nuclei in a crystal. [10 hours]

- **Module 3**: General properties of angular momentum, Commutation relations characteristic of angular momentum, General theory of angular momentum, Electron spin, Particle in a central potential, The hydrogen atom, The hydrogen atom placed in a uniform magnetic field, Paramagnetism and diamagnetism, The Zeeman effect. [10 hours]

- **Module 4**: Stationary Perturbation theory: non degenerate and degenerate cases, A one-dimensional harmonic oscillator subjected to a perturbing potential in x, x2, and x3, The variational method, Energy bands of electrons in solids: a simple model. [6 hours]

- **Module 5**: Quantum confinement in nanostructures, and important example problems like optical absorption in semiconductors, Experimental realization of quantum mechanics; STM, LIGO Interferometer, SQUID, nano-optomechanics, optical cavities, quantum sensor; atomic/ion trap, atomic clock etc. Brief introduction about the qubit, logic gate, Bell's inequality, entanglement, quantum interference. [6 hours]

**Text books and References:**

1. Claude Cohen-Tannoudji, Bernard Diu, and Franck Laloe, Quantum Mechanics: Vol. 1 & 2, 2nd Edition, Wiley-Vch, 2020.

2. R. Shankar, Principles of Quantum Mechanics, 2nd Edition, Plenum Press, 1994.

## 18.3 MT 203 : Materials Synthesis & Characterization

**Course Code : MT 203**

**Course Name : Materials Synthesis & Characterization**

L-P-T-C: 3-0-2-4
Intended for: B.Tech. (MSE)
Prerequisites: None
Mutual Exclusion: EN 512 - Structure-Property correlation in materials for Energy Applications.
Approval : 57th BoA

**Course Contents**

- **Module-I**: Introduction to the importance of materials synthesis. Describe the different synthesis methods. Describe the process of single crystal growth methods in solution. [4 Hours]

- **Module-II**: Importance of materials characterization. Basic Crystallography; lattice, reciprocal lattice, crystal planes, and directions; Symmetry operations, point and space groups, Structure of Materials – Crystal structure, microstructure, and macrostructure; Determination of crystal structure by diffraction, X-ray diffraction, and electron and neutron diffraction; Vibrational spectroscopy (IR and Raman spectroscopy) for structural characterization of materials. [14 Hours]

- **Module-III**: Microstructure determination by light, and electron microscopy (SEM and TEM); contrast mechanisms in imaging, binary alloys and distribution of phases in microstructure. [6 Hours]

- **Module-IV**: Thermal analysis by TGA-DSC; Determination of enthalpy, melting, decomposition, and phase transition temperatures. [3 Hours]

- **Module-V**: Optical properties of materials, Absorption (UV-Vis), emission (Photoluminescence), Ellipsometry for refractive index. [5 Hours]

**Experiments (Teaching Laboratory: 24 Hours )**

1. **Synthesis of materials** (Module-I):

   (a) Synthesis of materials using hydrothermal, co-precipitation, and sol-gel methods. Types of materials; a. porous ceramic materials; b. composites, c. metal oxides, and d. semiconducting materials

   (b) 2. Demonstration of single crystal growth in the solution phase.

2. **Structural Characterization** (Module-II):
   (a) The structural characterization of developed materials using XRD. Determination of crystal structure by X-ray diffraction in a diffractometer, Crystallite size.
   (b) The determination of functional groups and phase identification of mentioned materials using FT-IR, and Raman spectroscopy.
3. **Microstructural Characterization** (Module-III):
   (a) The processing of specimen and observation of microstructure under optical microscope, scanning electron microscope.
   (b) The processing of specimen and observation of microstructure and electron diffraction using a transmission electron microscope.
4. **Optical Characterization** (Module-IV):
   (a) The processing of specimen for Absorption (UV-Vis), and emission (Photoluminescence/fluorescence) spectroscopy. Thermal Analysis (Module-V):
   (b) Thermal characterization for the determination of melting, decomposition, phase transition temperatures and enthalpy.

**Text books:**

1. L.E. Smart and E.A., **Solid State Chemistry: An Introduction**, Taylor & Francis.
2. B. D. Cullity, **Elements of X-Ray Diffraction**.
3. William D. Callister (Jr.), **Materials Science and Engineering**.
4. Anthony West, **Solid State Chemistry and Its Applications**, John Wiley & Sons.

**References:**

1. Marc J.Madou, **Fundamentals of Microfabrication and Nanotechnology**.
2. A. J. Moulson and J. M. Herbert, **Electroceramics: Materials, Properties and Applications**, 2nd edition, Wiley, 2003.
3. V. R. Remya, **Nanostructured Smart Materials Synthesis, Characterization, and Potential Applications**, CRC Press, 2022.
4. M. A. Serio, D. M. Gruen, R. Malhotra, **Synthesis and Characterization of Advanced Materials**, American Chemical Society, 1997.

## 18.4 MT 204 : Thermodynamics and Kinetics of Materials

**Course Code : MT 204**

**Course Name : Thermodynamics and Kinetics of Materials**

L-P-T-C: 3-0-0-3
Intended for: B.Tech.
Prerequisites: None
Mutual Exclusion: None
Approval : 57th BoA

**Course Contents**

- **Introduction**: Introduction to thermodynamics: enthalpy, entropy, heat capacity, specific heat, and an atomic view, Systems, states, and material properties; Processes and the First Law of Thermodynamics, Irreversible processes, the Second Law of Thermodynamics, and equilibrium, The combined statement and differential forms, equilibrium conditions, thermodynamic potentials, Helmholtz free energy, Gibbs free energy, chemical potential, thermodynamic relations, and Maxwell's relations and their applications. (10 Hours)

- **Free Energy Functions and their significance**: Clausius-Clapeyron Equation: Derivation of Clausius-Clapeyron Equation and its Integration; Ramsay-Young, Trouton's and Duhring's rules; Fugacity, Activity and Equilibrium Constant, Numerical calculations involving equilibrium constant; Variation of equilibrium constant with temperature, integration of free-energy equation, Sigma function, Concept of Chemical Potential, and Gibbs Phase Rule. (8 Hours)

- **Thermodynamic solutions and Phase diagram**: Thermodynamic stability of materials. Ellingham diagram and its importance, application of electrochemical series. Behavior of solutions: ideal solution, Gibb's-Duhem equation, Raoults and Henry's law, activity of a component, regular solutions, free energy-composition diagrams for ideal and regular solutions. Phase equilibria & phase diagram: Gibbs phase rule, isobaric phase rule and application to unary, binary, and ternary systems, eutectic and eutectoid, peritectic and peritectoid diagrams, lever rule and its application. Sievert's law: residual gases in steel-properties and functions of slags, slag compositions, structure of molten slags, molecular theory, concept of basicity index, ionic theory; thermodynamics of slag-metal reactions. (12 Hours)

- **Kinetics**: Basic kinetic laws, order of reactions, rate constant, elementary and complex reactions, rate limiting steps and Arrhenius equations, theories of reaction rates-simple collision theory, activated complex theory Heterogeneous reaction; Gas-solid, solid-liquid, liquid-liquid and solid-solid systems. Empirical and Semi-empirical Kinetics, Concept of Johnson-Mehl equation, Thermal analysis. (12 Hours)

**Text books:**


1. C. H. P. Lupis, **Chemical Thermodynamics of Materials**, Elsevier Science, 1982

2. Gaskell, D.R., **Introduction to Metallurgical Thermodynamics**, 3rd Edition, McGraw-Hill, 1995.

3. Ghosh A., **Textbook of Materials and Metallurgical Thermodynamics**, Prentice Hall of India, 2003.

4. Balluffi R.W., Allen S.M. and Carter W.C., **Kinetics of Materials**, John Wiley & Sons, 2005

5. Upadhyaya G.S. and Dube R.K., **Problems in Metallurgical Thermodynamics and Kinetics**, Pergamon Press, 1985.

**References:**

1. Ahindra Ghosh, **Text Book of Materials and Metallurgical Thermodynamics**, Prentice Hall of India Pvt. Ltd., 2003.

2. Tupkary R.H., **Introduction to Metallurgical Thermodynamics**, TU Publishers, 1995.

## 18.5 MT 205 : Functional Properties of Materials

**Course Code : MT 205**

**Course Name : Functional Properties of Materials**

L-P-T-C: 3-0-2-4
Intended for: B.Tech. (MSE)
Prerequisites: None
Mutual Exclusion: EN509: Functional Materials for Energy Engineering
Approval : 57th BoA

**Course Contents**

- **Introduction**: Overview of functional materials, including inorganic, organic, and metal-organic frameworks, as well as hybrid organic-inorganic perovskites. Discussion on the use of material functionalities in device fabrication. Exploration of functionalities driven by electronic, spin, and ionic properties, along with the integration of these effects for designing novel materials. [4 Hours]

- **Functionality Driven by Electronic Properties**: Examination of amorphous and crystalline solids, electronic states, band formation, and band dispersions in crystalline materials. Coverage of metals, semiconductors, and insulators, including direct and indirect bandgap semiconductors, impurity bands in doped semiconductors, charge carrier transport, and optical properties, with a focus on optoelectronic materials. [12 Hours]

- **Functionality Driven by Spin Properties**: Exploration of magnetic moments in atoms, spin and orbital contributions in solids, magnetization, and various types of magnetic materials and their applications. Detailed discussion on exchange interactions, magnetic transition temperatures (mean-field theory), domain wall formation, and materials like Magnetoresistance, CMR/GMR. [10 Hours]

- **Functionality Driven by Ionic Properties**: Investigation of covalent, ionic, and metallic solids, dipole formation, and polarization. Overview of paraelectric, ferroelectric, antiferroelectric, piezoelectric, and pyroelectric materials, including domain wall formation in ferroelectrics and multiferroic materials. [6 Hours]

- **Functional Devices Driven by Functionality**: Study of functional devices such as light-emitting diodes, solar cells, quantum devices, FETs, Memristors, MOS Capacitors, photodetectors, thermoelectric, and photovoltaic devices, showcasing the practical application of functional materials. [10 Hours]

**Experiments:**

1. Crystal structures (Utilizing 3D models to understand crystal structures and understand lattice, packing fraction, mass, density, concept of Avogadro Number, etc.).

2. Optical properties characterization using absorption/photoluminescence spectroscopy.

3. Evaluate the electrical conductivity of materials through experiments such as four-point probe measurements.

4. Magnetic /Piezoelectric materials; measurement of M-H and P-E hysteresis loops.

5. Thermal Analysis: Perform experiments to measure thermal properties like thermal conductivity, TGA-DSC, specific heat, and thermal expansion of different materials.

6. Superconductivity and its phenomena. Demonstrating the Meissner effect and examining persistent currents.

7. Design and development of power packs with supercapacitors.

8. Characterizations of optoelectronic devices such as solar cells, photodetectors, and phototransistors. Analyse the effects of varying light intensity on power output of solar cells, current-voltage characteristics/ detectivity & sensitivity of the photodetector.

**Text books:**

1. W. Ashcroft and N.D. Mermin, **Solid State Physics**, Harcourt College Publishers, 1976.

2. Marius Grundmann, **The Physics of Semiconductors: An Introduction Including Devices and Nanophysics**, Springer , 2010.

3. W.F. Smith, **Principles of Materials Science and Engineering**, McGraw-Hill.

4. R.A. Flinn and P.K. Trojan, **Engineering Materials and Their Applications**, Haughton.

5. Neil W. Ashcroft and N. David Mermin, **Solid State Physics**, Saunders College Publishing, 1976

**References:**


1. R. M. Martin, **Electronic Structure: Basic Theory and Practical Methods**, Cambridge University Press, 2004.

2. K.F. Wang, J. – M. Liu, and Z. F. Ren, **Multiferroicity: The coupling between magnetic and polarization orders**, Advances in Physics 58, 321, 2009.

3. S. O. Kasap, **Principles of Electronic Materials and Devices**.


## 18.6 MT 206 : Extraction and Materials Processing

**Course Code : MT 206**

**Course Name : Extraction and Materials Processing**

L-P-T-C: 3-0-2-4
Intended for: B.Tech. (MSE)
Prerequisites: None
Mutual Exclusion: EN509: Functional Materials for Energy Engineering
Approval : 57th BoA

**Course Contents**

- **Introduction to extraction and materials processing**: Define extraction and material processing, processing methods for different types of materials (Meals, Ceramics, Glass, Polymers, and Composites), the significance of these processes in various industries, including urban mining (waste material management), the importance of sustainable sourcing and responsible extraction practices. Discuss standard processing techniques such as crushing, grinding, smelting, refining, and sorting. Environmental and social impacts of extraction methods. [5 hours]

- **Heat treatment**: Annealing, normalizing, hardenability, hardening, tempering, mechanism of heat removal during quenching, quenching media, residual stresses and quench cracks, martempering and austempering, alloying, effect of alloying on Fe-Fe3C phase diagram, sintering, and spark plasma sintering. [5 hours]

- **Electrolysis**: Electroplating, electrorefining, extraction, purification, and standard electrode potential (SEP) of metals and metal ions. [2 hours]

- **Grinding/Polishing**: Abrasion, classification of abrasive, principles, factors determining grinding/polishing, grinding (ball milling, mechanical alloying, mechanochemical processing). Wet and dry grinding, chemical comminution-leaching, dissolution, screening, crushing and sizing of comminuted particles, concentration techniques: gravity concentration, magnetic and electrostatic separation, froth floatation factors affecting rate of screening. [5 hours]

- **Thin film deposition**: Definition and significance of thin films, thin film growth techniques (CVD, thermal evaporation, sputtering, and solution process), applications of thin films (semiconductor device fabrication, optoelectronic devices, e.g., solar cells, LEDs, OLEDs, and coatings for corrosion protection & wear resistance.), and lithography. [8 hours]

- **Laser Processing**: Introduction to laser processing, basics of laser technology, significance and applications in industry, direct patterning, laser cutting, laser welding, emerging trends in laser processing (e.g., Ultrafast laser processing, laser-assisted material synthesis laser micropatterning and nanostructuring). [5 hours]

**Laboratory:**

1. Heat treatment: To study the material at extremely high temperatures using the muffle furnace and tube furnace. [3 hours]
2. To study the advanced processing methods (Spark plasma sintering and glass processing), [3 hours]
3. To study the fine finishes or light cuts on metals and other materials (grinding). [3 hours]
4. To study the extraction and purification of metals from raw materials. [3 hours ]
5. To study electroplating, electro-refining, and the standard electrode potential (SEP) of metals/metal ions. [3 hours ]
6. To study the process of creating a smooth and shiny surface by rubbing it or applying a chemical treatment (Polishing). [3 hours]
7. Thin film deposition:
   (a) Thin film coating using a solution process (e.g., spin coater) [3 hours]
   (b) Thin film coating using a vacuum process (e.g., sputtering) [3 hours]
8. Laser lithography: To study the modification of the shape or appearance of a material. Micro-scale pattern development. [3 hours]

**Text books and References:**


1. T.V. Rajan, C.P. Sharma, Ashok Rajan, **Heat Treatment: Principles and Techniques**, PHI Learning.
2. William D. Callister, Jr., David G. Rethwisch, **Fundamentals of Materials Science and Engineering**, John Wiley & Sons
3. Colin Bodsworth & Brian Ralph, **The Extraction and Refining of Metals (Materials Science & Technology)**.
4. William F. Smith, **Materials Science and Engineering**, Tata McGraw-Hill Education.
5. Free M., Moats M., Houlachi G., Asselin E., Allanore A., Yurko J., Wang S, **Electrometallurgy**, John Wiley & Sons, Inc., 2012.


**References:**

1. **NA**.

## 18.7 MT 301: Phase Transformations

**Course Code : MT 301**

**Course Name : Phase Transformations**

L-P-T-C: 3-0-0-3
Intended for: B.Tech. (MSE)
Prerequisites: None
Mutual Exclusion: None
Approval : 57th BoA

**Course Contents**

- **Module-1**: Overview of phase transformations, phase equilibria, thermodynamics of phase changes, free energy, order of transformation, thermodynamic driving force; nucleation and growth theories, homogeneous and heterogeneous nucleation, growth kinetics, precipitation and phase separation - spinodal microstructures, crystal interfaces and microstructure. (6 Hours)
- **Module-2**: Eutectic and peritectic transformation, heat-treatment of ferrous and nonferrous metals, eutectoid, phase diagrams and equilibria in relation to free energy-composition diagrams. interpretation of phase diagrams, determination and calculations, solid-liquid miscibility gap; invariant reaction. Principles of ternary phase diagram, examples of a few metallic and ceramic phase diagrams. (12 Hours)
- **Module-3**: Principles of Solidification in metals and alloys: thermodynamics involved, eutectic and peritectic Solidification, Homogeneous and heterogeneous nucleation, Mechanisms of growth. Rapid Solidification Processing. Austenite, transformation of austenite, TTT diagram, eutectoid transformation, pearlite and bainite transformation, order-disorder transformation, precipitation hardening, spinodal decomposition and massive transformation, solidification. (8 Hours)
- **Module-4**: Martensite transformation: characteristics and nature, morphology, crystallography, theory of nucleation and growth, and pre-martensite phenomena, martensitic transformation in steel. Martensite in non-Ferrous systems-thermoelastic martensite and shape memory effect (8 Hours)
- **Applications**: Smart materials and actuators, shape memory effect, metal-insulator transition. (4 Hours)

**Laboratory:**

1. NA

**Text books:**


1. D.A. Potter and K.E. Easterling, **Phase transformations in metals and alloys**, CRC Press,1992.
2. P.G. Shewmon, **Transformations in Metals**, Mc-Graw Hill, 1969.
3. S. N. Avner, **Introduction to Physical Metallurgy**, Tata McGraw Hill, 1997.

4. Peter Haasen, **Physical Metallurgy**, Cambridge University Press, 1996.

**References:**

1. A. G. Guy, **Physical Metallurgy for Engineers**, Addison-Wesley Pub. Co., 1962.
2. R. E. Smallman, **Modern Physical Metallurgy**, Butterworths, 1963.

## 18.8 MT 302 : Transport Phenomena

**Course Code : MT 302**

**Course Name : Transport Phenomena**

L-P-T-C: 3-0-0-3
Intended for: B.Tech. (MSE)
Prerequisites: None
Mutual Exclusion: None
Approval : 57th BoA

**Course Contents**

- **Introduction**: Transport phenomena are vital for understanding the electrical conductivity of metals, semiconductors, and various other fields. Focus on the transport of heat, energy, and mass on a macroscopic scale. Ellipsoidal carrier pockets. Electrons and holes in intrinsic semiconductors. Donor and acceptor doping of semiconductors. characterization of semiconductors. (2 Hours)
- **Thermal Transport**: Thermal conductivity for metals, semiconductors, and insulators. Thermoelectric phenomena in metals. Thermopower for semiconductors. Effect of Thermoelectricity on the thermal conductivity. Thermoelectric measurements. Seebeck Effect (Thermopower). Peltier effect. Thomson effect. The kelvin relations. Phonon drag effect. Electron and Phonon Scattering, Scattering processes in semiconductors. Electron-phonon scattering. ionized impurity scattering. Temperature dependence of the electrical and thermal conductivity. Liouville's equation, Boltzmann equation, carrier scattering, Classical Laws and conservation equations, phonon hydrodynamic equation. (12 Hours)
- **Energy Transport**: Fourier's law and thermal conductivity of materials, gases, solids, liquids and bulk materials. Heat transfer with forced convention in a tube, flat plate, natural convention and the energy equation. Conduction heat transfer: Conduction of heat in solids, the energy equation for conduction, Steady-state one-dimensional systems, Transient systems, finite dimensions, Transient conditions, infinite and semi-infinite solids, Simple multidimensional, Moving sources. Radiation heat transfer: Concept of black body and emissivity, radiation view factors. The energy distribution and the emissive power. Gray bodies and absorptivity, Exchange between infinite parallel plates. Radiation combined with convection. Radiation from gases, transparent solids. Transient conduction with radiation at the surface. Transient heating with thermal stresses. (12 Hours)

- **Mass Transport**: Interphase mass transfer, Definition of fluxes-Fick's first law, Diffusion in solids, Diffusion in ceramic materials, Diffusion in elemental semiconductors, Diffusion in liquids, Diffusion in gases, Diffusion through porous media. Diffusion in solids, Steady-state diffusion experiments. Transient diffusion experiments. Finite system solutions. Microelectronic diffusion processing. Homogenization of alloys. Formation of surface layers. Mass transfer in fluid systems Diffusion through a stagnant gas film. Diffusion in a moving gas stream. Diffusion into a falling liquid film. The mass transfer coefficient. General equation of diffusion with convection. Mass transfer with forced convection over a flat plate. (10Hours)
- **Coupled Fluids with Heat and Mass Transfer**: Coupled fluids, heat and mass transfer, heat and mass transfer coefficients, natural convection (4 Hours)
- **Applications of transport phenomena**: Cooling devices, microfluidics devices, thermoelectric materials, semiconductor/solid-state devices, electrochemical devices, food industry, biomedical. (2 Hours)

**Laboratory:**

1. NA

**Text books:**


1. Gaskell, David R., **An Introduction to Transport Phenomenon in Materials Engineering**, 2nd Edition, Momentum Press.
2. Bird, R. Byron, W. E. Stewart, and E. N. Lightfoot, **Transport Phenomena**, 4th Edition, Wiley, 2006.
3. Thomson, William J., **Introduction to transport phenomena**, 2000.
4. Robert S., and Harry C. Hershey, **Transport phenomena: a unified approach**, Brodkey Publishing, 2003.


**References:**


1. C. J. Geankoplis, **Transport Processes and Separation Process Principles**, 4th Edition, Prentice-Hall Inc., 2003.
2. C. O. Bennett, J. O. Myers, **Momentum, Heat, and Mass Transfer**, 2nd International Student Edition, McGraw Hill, 1983.


## 18.9 MT 303 : Computational Materials Science

**Course Code : MT 303**

**Course Name : Computational Materials Science**

L-P-T-C: 3-0-2-4
Intended for: B.Tech. (MSE)
Prerequisites: None
Mutual Exclusion: None
Approval : 57th BoA

**Course Contents**

- **Introduction**: Definition and scope of Computational Materials Science; Overview of computational methods: Quantum Mechanics, Molecular Dynamics, Monte Carlo simulations; Role of computational tools in materials discovery and design; Hands-on session introducing materials modeling codes [4 Hours]
- **Quantum Mechanical Methods for Materials Simulation**: Basics of quantum mechanics applied to materials science; Density Functional Theory (DFT) and its practical applications; Quantum Monte Carlo methods and their role in materials simulations; Practical exercises using materials modeling codes for electronic structure calculations [10 Hours]
- **Classical Methods for Materials Simulation**: Molecular Dynamics simulations: principles and applications; Monte Carlo simulations in materials science: theory and practice; Introduction to classical force fields; Application of classical methods in predicting material behavior [8 Hours]
- **Electronic Structure Calculations**: Band structure calculations and their interpretation; Electronic density of states and its significance; Tight-binding and empirical methods for electronic structure predictions; Hands-on application of computational tools for electronic structure analysis [12 Hours]
- **Materials Design and Optimization**: Rational design of materials using computational methods; Optimization algorithms and their role in materials science; High-throughput screening for material discovery; Case studies on computationally designed materials [6 Hours]
- **Advanced Topics in Computational Materials Science**: Quantum transport simulations for materials applications; Computational studies of surfaces and interfaces; Machine learning applications in materials science; Future directions and challenges in the field [10 Hours]

**Laboratory:**

1. Introduction to computational software for materials science simulations.
2. Quantum mechanical simulations using DFT software.
3. Molecular Dynamics simulations for understanding material behavior.
4. Electronic structure calculations and visualization.
5. Materials design and optimization using computational tools.
6. Hands-on session on machine learning applications in materials science.

**Text books:**

1. Richard LeSar, **Introduction to Computational Materials Science**.
2. June Gunn Le, **Computational Materials Science: An Introduction**.

3. Koenraad George Frans Janssens, **Computational Materials Engineering: An Introduction to Microstructure Evolution.**

4. Richard M. Martin, **Electronic Structure: Basic Theory and Practical Methods**.

5. Peter Comba, **Molecular Modeling of Inorganic Compounds**.

6. David Sholl and Janice A. Steckel, **Density Functional Theory: A Practical Introduction**.

7. Keith T. Butler, Felipe Oviedo, **Pieremanuele Canepa Machine Learning in Materials Science**.

**References:**

1. NA

## 18.10 MT 304 : Mechanical Behavior of Materials

**Course Code : MT 304**

**Course Name : Mechanical Behavior of Materials**

L-P-T-C: 3-0-2-4
Intended for: B.Tech. (MSE)
Prerequisites: None
Mutual Exclusion: None
Approval : 57th BoA

**Course Contents**

- **Module 1**: Static loading and Deformation behavior Distinctive load – elongation behavior of different types of materials under uni-axial loading, definition of stress and strain, stress-strain diagram, elastic behavior, yielding and plastic behavior of ductile materials; necking instability, Important design criteria based on stress and strain at ambient temperature; strain rate and its influence of stress-strain diagram at elevated temperature. [4 Hours]

- **Module 2**: Durability under static loading Defects in materials; linear defects or dislocations – types, burgers vector, slip, slip planes and slip directions, cross slip and climb, movement of dislocations leading to plastic deformation, stacking fault and partial dislocations, strain hardening, grain boundaries, strengthening mechanisms; recovery, recrystallization and grain growth during heating of deformed materials. [4 Hours]

- **Module 3**: Durability under Creep Deformation, Deformation under static loading at elevated temperature - creep curve, mechanisms of creep, the temperature dependence of creep, deformation mechanism maps, cavitations, stress rupture versus creep, extrapolation schemes; Development of materials for ultra-supercritical boilers for application in furnace panels, super-heaters, thick section components, and steam lines. [4 Hours]

- **Module 4**: Durability under Cyclic Loading, Deformation under cyclic loading, high cycle fatigue – S-N curve, effect of mean stress, Miner rule, cyclic stress-strain curve, low cycle fatigue, strain life equation, effect of stress concentration and size of component, Design for fatigue, effect of temperature on fatigue; creep-fatigue interaction, development of turbine materials. [4 Hours]

**Laboratory:**

1. Tensile test on ferrous materials: Determine mechanical properties (yield stress, ultimate stress, breaking stress, percentage of reduction in area, percentage of elongation, and Young's modulus) for ferrous materials.
2. Tensile test on non-ferrous materials: Compare the stress-strain diagrams of non-ferrous materials with those of ferrous materials.
3. Compression test on brittle vs. ductile metallic materials: Analyze the mechanical properties of both brittle and ductile materials under compression.
4. Compression test on ceramic materials: Determine the mechanical properties of ceramic materials through compression testing.
5. Microstructure examination: Study and compare the grain structures in various metallic and non-metallic materials using optical or electron microscopy.
6. Creep test: Conduct a creep test to observe the time-dependent deformation behavior of a selected material under constant stress.
7. Stress corrosion cracking study: Investigate the effects of stress corrosion cracking in specific materials by applying tensile stress in a corrosive environment.
8. Hydrogen embrittlement study: Analyze the effects of hydrogen embrittlement on selected metallic specimens by subjecting them to hydrogen exposure.
9. Micro-hardness/nanoindentation test: Perform hardness tests on various materials using micro-hardness or nanoindentation techniques to assess material properties at small scales.
10. Fatigue test: Conduct fatigue tests on selected materials to evaluate their resistance to cyclic loading and determine fatigue life.
11. Impact resistance and hardness measurement: Measure the hardness and impact resistance of various samples to assess their toughness and durability.
12. Friction and wear study: Investigate the frictional behavior of different material combinations under varying loads, sliding speeds, temperatures, and lubrication conditions to predict the coefficient of friction and wear rates.

**Text books:**

1. George E. Dieter, **Mechanical Metallurgy**, McGraw Hill Book Company 1986

**References:**

1. Meyers, M.A. and Chawla, K.K., **Mechanical Behavior of Materials**, 2nd edition, Prentice Hall, 2008.

## 18.11 MT 501 : Energy Conversion & Storage Technology

**Course Code : MT 501**

**Course Name : Energy Conversion & Storage Technology**

L-P-T-C: 3-0-0-3
Intended for: B.Tech./M.Tech./M.Sc./Ph.D
Prerequisites: None
Mutual Exclusion: EN 503
Approval : 57th BoA

**Course Contents**

- **Energy conversion & storage systems overview**: Scope of energy storage & conversion, needs and opportunities in energy storage, Overview of key technologies and interdisciplinary aspects, with a focus on comparing the time scales of various storage methods and their application, Energy storage in the power and transportation sectors. Importance of energy conversion systems in the development and performance of electric vehicles. (5 Hours)

- **Energy Conversion Systems**: Energy conversion systems transform various forms of energy—such as mechanical, thermal, chemical, or solar—into electrical energy. (6 Hours)

- **Chemical Energy Storage Systems**: Chemical storage system- hydrogen, methane, etc., concept of chemical storage, advantages and limitations, challenges, and future prospects of chemical storage systems. (5 Hours)

- **Thermal Storage Systems**: thermal storage systems such as heat pumps, hot water storage tanks, and solar thermal collectors. Examine the application of phase change materials (organic and inorganic) for heat storage, along with system efficiencies and economic assessments. (6 Hours)

- **Electromagnetic Energy Storage Systems**: Electromagnetic storage systems, including double-layer capacitors for electrostatic charge storage and superconducting magnetic energy storage (SMES). Analyze the concepts, advantages, limitations, and future prospects of these systems. (5 Hours)

- **Electrochemical storage and conversion systems**:

  - Batteries-Working principle of battery, primary and secondary (flow) batteries, battery performance evaluation methods, major battery chemistries and their voltages- Li-ion battery & Metal hydride battery vs lead-acid battery, metal-air battery. (6 Hours)

  - Supercapacitors- Working principle of supercapacitor, types of supercapacitors, cycling and performance characteristics, difference between battery and supercapacitors, Introduction to Hybrid electrochemical supercapacitors (6 Hours)
  - Fuel cell: Operational principle of a fuel cell, types of fuel cells, hybrid fuel cell-battery systems, hybrid fuel cell-supercapacitor systems. (3 Hours)
  - Water electrolysis for hydrogen generation: Cell technologies, Gibbs Free energy of the water splitting reaction and cell voltage, Current-Voltage relationships, Degradation mechanisms. (3 Hours)

- **Battery design for transportation**: Mechanical design and packaging of battery packs for electric vehicles, advanced quick charging methods, thermal management, state of charge and state of health estimation, and the recycling of batteries used in electric vehicles. (4 Hours)

**Laboratory:**

1. NA

**Text books:**

1. Frank S. Barnes and Jonah G. Levine, **Large Energy Storage Systems Handbook**, CRC press, 2011.
2. Ralph Zito, **Energy storage: A new approach**, Wiley, 2010.

**References:**

1. Pistoia, Gianfranco, and Boryann Liaw, **Behaviour of Lithium-Ion Batteries in Electric Vehicles: Battery Health, Performance, Safety, and Cost**, Springer International Publishing AG, 2018.
2. Robert A. Huggins, **Energy storage**, Springer Science & Business Media, 2010.

## 18.12 MT 502 : Recycling and Circular Economy

**Course Code : MT 502**

**Course Name : Recycling and Circular Economy**

L-P-T-C: 3-0-0-3
Intended for: B.Tech/PG/Ph.D.
Prerequisites: None
Mutual Exclusion: None
Approval : 57th BoA

**Course Contents**

- **Introduction to unit operations**: Introduction to materials recycling and waste management, Categories of metallurgical and electronic waste, Key unit operations involved in pre-treatment of metallurgical and electronic waste, Application of pyrometallurgy, hydrometallurgy and electrometallurgy and refining for Material separation and enrichment of raw materials. [6 Hours]

- **Materials Cycle**: Materials and their cycle, Introduction to recycling sustainability, energy accounting minerals, Energy consumption in primary production, Management of wastes from primary production, Present and future availability and demand of minerals and metals, Techniques of sustainable extraction from secondary materials. [12 Hours]

- **Metallurgical Waste Recycling**: Aluminium industrial waste: dross, scrap, red mud, spent pot lining, salt slag. Copper industrial waste: smelter slags, raffinates, spent electrolytes, Zinc industrial waste: zinc ash, zinc dross, flue dust, and scraps, Iron and Steelmaking waste, scraps, ironmaking slag, steelmaking slag and wastewater. Recycling and reuse of blast furnace ironmaking slags, steel-making dust, and sludges. [8 Hours]

- **Electronic Waste Recycling**: Waste Printed Circuit Board, delamination and metal recovery, end-of-life batteries and recovery of valuable materials from waste electrodes, rare earth elements comprising electronic waste (LEDs, magnets, etc.), and environmental impacts of materials recycling. [6 Hours]

- **Introduction to Circular Economy**: From linear to circular economy, Cradle to Cradle concept, Eliminate waste and pollution, Circulate products and materials (at their highest value), Regenerate nature, Eliminate waste and pollution, Design changes, Focus on design to eliminate the concept of waste, Designers eliminating waste for a circular economy, Walter Stahel's The Performance Economy, William McDonough and Michael Braungart's Cradle to Cradle, Janine Benyus' Biomimicry, Industrial ecology, Regenerative design, Gunter Pauli's The Blue Economy, Systems thinking, Sustainable Development Goals (SDG) and linkages with Circular Economy model. [8 hours]

**Laboratory:**

1. NA

**Text books:**

1. P.C. Hayes, **Process principles in minerals and materials production-with a focus on metal production and recycling**, 2021.

2. L. Peter, **Materials for a Sustainable Future**, Royal Society of Chemistry Publishing, 2012.

3. J.A.S. Green, **Aluminum Recycling and Processing for Energy Conservation and Sustainability**, ASM International, 2007.

4. Ken Webster, **The Circular Economy: A Wealth of Flows**, 2nd Edition, 2017.

5. William McDonough, **Cradle to Cradle: Remaking the Way We Make Things**.

6. Andy Schmitz, **Sustainability, Innovation, and Entrepreneurship**. 1.0 Saylor Academy under a Creative Commons Attribution, Saylor Academy, 2012.

7. Amory Lovins, **A New Dynamic: Effective Business in a Circular Economy**.

**References:**

1. S. Ramachandra Rao (Editor), **Resource Recovery and Recycling from Metallurgical Wastes**, Waste Management Series, 7, Elsevier.

2. Hugo Marcelo Veit and Andrea Moura Bernardes, **Electronic Waste Recycling Techniques**, Topics in Mining, Metallurgy and Materials Engineering, Springer International Publishing.

3. R. E. Heister and R. M. Harrison, **Electronic Waste Management**, Issues in Environmental Science and Technology, 27, RSC Publishing, Cambridge.

## 18.13 MT 503 : Semiconductor Materials and Devices

**Course Code : MT 503**

**Course Name : Semiconductor Materials and Devices**

L-P-T-C: 3-0-0-3
Intended for: B.Tech. (Elective) /M.Tech./Ph.D.
Prerequisites: None
Mutual Exclusion: None
Approval : 57th BoA

**Course Contents**

- **Introduction**: History of semiconductors, semiconductor industry & market. Comprehensive understanding of semiconductor materials and their fundamental properties. Crystal properties,Intrinsic and extrinsic semiconductors, n-type and p-type semiconductors. Carrier dynamics, doping, and semiconductor junctions. Introduction to heavily doped semiconductors and their applications in modern electronics and devices. [8 hours]

- **Semiconductor Crystals and Band Structure**: Semiconductor crystal properties (amorphous, crystalline, and polycrystalline), atoms, electrons, holes, and Schrodinger equation. Energy band formation, density of states, and fermi distributions in semiconductors, direct and indirect band gap semiconductors. Energy band diagram of semiconductor junctions, p-n junction, built-in voltage, electric field and potential distributions in p-n junctions and heterojunctions. Concept of holes, and carrier concentration. [6 hours]

- **Carrier in Semiconductors**: Effective mass: heavy and light mass carriers, carrier concentration, excess carriers, charge neutrality, carrier transport (diffusion &

drift) in semiconductors. Basics of conductivity, mobility, and resistivity in semiconductors, doping in semiconductors, and heavily doped semiconductors. Description of mobility and generation-recombination effects. Introduction to Excitons and optical properties, Phonons: formation and properties, lattice structure and vibrations, optical and acoustic phonons, thermal conductivity in semiconductors. [10 hours]

- **Semiconductor Contacts and Devices**: Metal-semiconductor contacts, Schottky barriers, and ohmic contacts, field effect transistors (FET) metal-oxide-semiconductor (MOS) capacitor, metal-oxide-semiconductor field effect transistors (MOSFETs), MOSFET I-V equation, mobility calculation, short/long channel MOSFET. DRAM & RRAM, PN diodes: principles and operation, thin film transistors (TFT), active matrix organic LED (AMOLED). Electrical characterization in various semiconductor devices. Optoelectronic Devices; solar cell, photodetectors, light emitting diodes (LED) and semiconductor lasers. [10 hours]

- **Advanced Micro/Nano Fabrication Technology**: Basic micro/nanofabrication processes. Crystal growth and wafer preparation, Methods for p-n junction formation, Thin-film deposition processes. Doping techniques. Heavily doped semiconductors, impact of doping on electronic properties, application of semiconductors in modern electronics. Photolithography and etching. Advanced micro/nanofabrication technologies such as EUV, thin film transistors (TFT), complementary metal oxide semiconductors (CMOS), and 2D material integration. Basic principles of low-dimensional nanodevices. [8 hours]

**Laboratory:**

1. NA

**Text books:**

1. S. M. Sze, **Physics of Semiconductor Devices**, 4th Edition, John Wiley & Sons, Inc, 2021
2. C. Kittel, **Introduction to Solid State Physics**, 8th Edition, John Wiley & Sons, 2005.
3. N. W. Ashcroft and N. D. Mermin, **Solid State Physics**, Brooks Cole, 1976.
4. Thin Film Materials: Stress, **Defect Formation and Surface Evolution**.
5. Dieter K. Schroder, **Semiconductor Material and Device Characterization**, 3rd Edition, Wiley, 2015

**Any other Study Material:**

1. Students will be supplied with published journal articles as reference materials to support their studies.

## 18.14 MT 504 : Powder Metallurgical Processing of Materials

**Course Code : MT 504**

**Course Name : Powder Metallurgical Processing of Materials**

L-P-T-C: 3-0-0-3
Intended for: B.Tech/PG/Ph.D.
Prerequisites: None
Mutual Exclusion: None
Approval : 57th BoA

### Course Contents

- **Introduction**: Historical background, important steps in the powder metallurgy (P/M) process, advantages and limitations of the powder metallurgy process, and applications. [6 Lectures]
- **Powder Production**: Production methods like physical, chemical, and mechanical methods; Single fluid atomization like rotating electrode atomization, roller atomization, and rotating disc atomization; Two fluid atomizations like gas atomization, water atomization, oil atomization, etc. Reduction methods, carbonyl process, hydride-dehydride process, electrolytic method. Mechanical milling, fluid energy grinding, machining. Production of ceramic powders. [8 Lectures]
- **Powder Characteristics**: Sampling-chemical composition, particle shape and size analysis, Surface area, packing and low characteristics, Porosity and density, compressibility, and strength properties. Blending and mixing of metal powders. [8 Lectures]
- **Powder Compaction and Sintering**: Compaction of powders, pressure less and pressure compaction techniques-single action and double action compaction, cold compaction, powder rolling, continuous compaction, explosive compaction, hot temperature compaction, uniaxial hot pressing, hot extrusion, spark sintering, hot isostatic pressing, injection moulding, sintering types, theory of sintering, process variables, effects of sintering, sintering atmospheres, and metallographic technique for sintered products. [8 Lectures]
- **Post-sintering operations**: sizing, coining, repressing, and resintering; impregnation; infiltration; Heat treatment, steam treatment, machining, joining, plating; and other coatings. [6 Lectures].
- **Application of powder Metallurgy & products**: Self-lubricating bearings, magnetic materials, tungsten carbide tool bits, bearing materials, dispersion-strengthening materials for high temperature applications, and manufacture of diamond-based cutting tools. [6 Lectures]

### Laboratory:

1. NA

**Text books:**

1. Masuda H., **Powder Technology Handbook**, Taylor & Francis, 2006.

2. Angelo, P.C., and R. Subramanian, **Powder metallurgy science, technology, and applications**, Prentice Hall Publishers, 2008.

**References:**

1. German R.M., **A to Z of Powder Metallurgy**, Elsevier 2005.

2. Sands R.L. and Shakespeare C.R., **Powder Metallurgy Practice and Applications**, Newness Publication 1970.

3. **Powder Metal Technologies and Applications**, Metals Handbook, Vol. 7, 9th1989 edition, ASM

4. Hirschhorn J.S., **Introduction to Powder Metallurgy**, APMI 1975

5. Upadhyaya G.S., **Powder Metallurgy Technology**, Cambridge Press 1996

## 18.15 MT 505 : Thin Film Technology

**Course Code : MT 505**

**Course Name : Thin Film Technology**

L-P-T-C: 3-0-0-3
Intended for: B.Tech. (Elective) /M.Tech./Ph.D.
Prerequisites: None
Mutual Exclusion: None
Approval : 57th BoA

**Course Contents**

- **Introduction**: This course provides a comprehensive understanding of the science and technology behind the growth of inorganic solid thin films and coatings. It introduces key characterization techniques for real-time and post-growth analysis. The second part emphasizes project-based learning, exploring thin film applications tailored to student interests. Key concepts in vacuum technology, components, and plasma will also be introduced, as these are essential for understanding thin film deposition processes. [6 hours]

- **Thin film growth**: Introduction of thin film deposition techniques: Physical Vapor Deposition (PVD) methods like sputtering and ion-beam, and Chemical Vapor Deposition (CVD) processes such as APCVD, MOCVD, and PECVD. Solution-based methods include ink-jet printing, spin coating, and spray pyrolysis. Other advanced techniques include Atomic Layer Deposition (ALD), Pulsed Laser Deposition (PLD), and Molecular Beam Epitaxy (MBE). Along with these techniques, it is essential to understand the basic mechanisms of thin film growth from the vapour phase for a complete understanding of the process. [12 hours]

- **Thin film characteristics**: Introduction of optical, physio-chemical, mechanical, and electrical properties of thin films. Optical properties: optical microscope, and UV-Vis Spectroscopy for absorption, transparency, and refractive index. Physio-chemical properties: thickness, film density, chemical composition, structure, and surface morphology, analyzed through Ellipsometry, XRR, XPS, XRD, SEM, TEM, and AFM. Electrical properties involve conduction phenomena and Hall measurements. Mechanical properties address thin film stress and wafer curvature using Stoney's equation, bulge tests, and other methods to understand residual stresses in thin films. [12 hours]

- **Thin film applications**: Thin films are widely used in batteries, resistors, solar cells, and photovoltaics. They also play a key role in Microelectromechanical (MEMS) and Nanoelectromechanical (NEMS) systems, sensors, actuators, memristors, diodes, thin film transistors, and display technologies, contributing to advancements in electronics, energy, and display industries. [8 hours]

**Laboratory:**

1. NA

**Text books and References:**

1. **Thin Film Materials: Stress, Defect Formation and Surface Evolution**

2. Fredrick Madaraka Mwema, Tien-Chien Jen, Lin Zhu, **Thin Film Coatings: Properties, Deposition, and Applications**, (Emerging Materials and Technologies), CRC Press, 2022.

3. Krishna Seshan, Dominic Schepis, **Handbook of Thin Film Deposition**, William Andrew, 2018.

4. K. S. Sree Harsha, **Principles of Vapor Deposition of Thin Films**, Elsevier, 2006.

5. K. Seshan, **Handbook of Thin-Film Deposition Processes and Techniques**, William Andrew Publishing, 2002.

6. John E. Mohan, **Physical Vapor Deposition of Thin Film**, John Wiley & Sons, 2000

**Any other Study Material:**

1. Students will be supplied with published journal articles as reference materials to support their studies.

## 18.16 MT 506 : Biomaterials

**Course Code : MT 506**

**Course Name : Biomaterials**

L-P-T-C: 3-0-0-3

Intended for: B.Tech./PG./Ph.D.
Prerequisites: None
Mutual Exclusion: None
Approval : 57th BoA

**Course Contents**

- **Introduction and importance of biomaterials**: Overview of biomaterials and their critical role in modern medicine. Understanding the interdisciplinary nature of biomaterials, integrating biology, chemistry, engineering, and materials science. The impact of biomaterials in medical devices, implants, and tissue engineering (6 Hours)

- **Types of biomaterials**: Metallic Biomaterials: Stainless Steels, CoCr Alloys, Ti Alloys, Dental Metals, Other Metals, Corrosion of Metallic Implants, Manufacturing of Implants Ceramic Biomaterials: Nonabsorbable or Relatively Bio inert Bio ceramics, Biodegradable or Resorbable Ceramics, Bioactive or Surface-Reactive Ceramics, Deterioration of Ceramics, Bio ceramic Manufacturing Techniques Polymeric Biomaterials: Polymerization and Basic Structure, Polymers Used as Biomaterials, Sterilization, Surface Modifications for Improving Biocompatibility, Chemo gradient Surfaces for Cell and Protein Interaction Composite Biomaterials: Structure, Bounds on Properties, Anisotropy of Composites, Particulate Composites, Fibrous Composites, Porous Materials, Biocompatibility. (10 Hours)

- **Classification according to physiological response of biomaterials**: Bio inert, bioactive and bioresorbable biomaterials, Surface modifications, Surface analysis, Surface-protein interactions (4 Hours)

- **Biodegradable Polymeric Biomaterials**: Glycolide/Lactide Based Biodegradable Linear Aliphatic Polyesters, Non-Glycolide/Lactide Based Linear Aliphatic Polyesters. Non-Aliphatic Polyesters Type Biodegradable Polymers, Biodegradation Properties of Synthetic Biodegradable Polymers. Hydrolytic Degradation. Enzymatic Degradation, Surface vs. Bulk Erosion: (10 Hours)

- **Cell interactions with biomaterials**: General introduction to cellular structure and functions, Techniques and assays to determine the cell material interactions (Cytotoxicity Assays, Direct Contact Assay, Agar Diffusion Assay, Elution Assay, Adhesion/Spreading Assays, Migration Assays) (4 Hours)

- **Biomaterials implants and implementation problems**: Orthopaedic implants, artificial organs, dental materials, etc.; Implementation problems - inflammation, rejection, corrosion, structural failure. ((8 Hours)

- **Applications of biomaterials in various medical conditions**: Wound Healing and the Presence of Biomaterials, Biomaterials and Thrombosis. (4 Hours)

**Laboratory:**

1. NA

**Text books:**

1. NA

**References:**

1. Johnna S. Temenoff, Antonios G. Mikos, **Biomaterials the Intersection of Biology and Materials Science**, Pearson, 2008. by Johnna S. Temenoff, Antonios G.

2. B. Rolando (Ed.), **Integrated Biomaterials Science**, Springer. 2002.

3. J.B. Park and J.D. Bronzino, **Biomaterials: Principles and Application**s, CRC Press. 2002.

## 18.17 MT 507 : Modeling and Simulation in Materials Science

**Course Code : MT 507**

**Course Name : Modeling and Simulation in Materials Science**

L-P-T-C: 3-0-0-3
Intended for: B.Tech.
Prerequisites: None
Mutual Exclusion: None
Approval : 57th BoA

**Course Contents**

- **Motivation - Introduction to Modeling and Simulation**
  - The need for modeling and simulation techniques in material science
  - Experimental measurements and computational calculation of materials properties
  - The role of modeling in predicting material performance and design.
- **Molecular Dynamics (MD) Simulations**
  - Thermodynamics and statistical mechanics principles and Ensembles
  - Basic principles and algorithms (Verlet, leapfrog)
  - Force fields and potentials for material systems
  - Integration schemes and time step considerations
- **Monte Carlo (MC) Simulations**
  - portance sampling and the Metropolis algorithm
  - Canonical ensemble MC
  - Applications in materials (e.g., phase transitions)
- **Interatomic Potentials**

- Lennard-Jones potential, Coulombic interactions
- Embedded Atom Model (EAM) for metals
- Force field development and selection for different materials

- **Modeling Phase Transitions**
  - Modeling solid-solid and solid-liquid transitions
  - Nucleation and growth processes

- **Simulation of Specific Material Types**
  - Crystalline materials: Simulation of defects, dislocations, and fracture in metals
  - Nanomaterials: Deformation of nanowires and analysis of grain boundaries

- **Other examples for modelling**
  - Grain Boundary Generation of Al -Dislocation Nucleation in Single Crystal Al
  - Grain Boundary Generation of Cu and Mg

**Laboratory:**

1. NA

**Text books:**

1. Daan Frenkel, **Understanding molecular simulation**.

**References:**

1. Richard LeSar, **Introduction to Computational Materials Science**.
2. Kurt Binder and Dieter W. Heermann, **Monte Carlo Methods in Statistical Physics**.
3. June Gunn Lee, **Computational Materials Science: An Introduction**.

## 18.18 MT 508 : Iron and Steel Making

**Course Code : MT 508**

**Course Name : Iron and Steel Making**

L-P-T-C: 3-0-0-3
Intended for: B.Tech./PG/Ph.D.
Prerequisites: None
Mutual Exclusion: None
Approval : 57th BoA

**Course Contents**

- **Introduction to Iron Making**: Introduction: Various routes of modern steel making (BF-BOF, DRI-EAF, SR). Blast furnace Ironmaking: Shape of the furnace, Various reactions, and zones in the blast Furnace Thermodynamics of Iron making, Direct & indirect reduction Blast furnace as an efficient counter-current gas-solid reactor with maximum carbon efficiency. [6 Hours]

- **Heat and Mass Transfer in the blast furnace**: Overall heat and material balance in the blast furnace. Rist diagram based on oxygen balance. Rist diagram based on heat & material balance. Blast furnace as a two-stage reactor. A predictive model for coke rate in the blast furnace. [8 Hours]

- **Transport processes in a blast furnace**: Aerodynamics in Blast Furnace (pressure drop, fluidization, channeling, flooding). Burden preparation (sintering, pelletization, coke making). Testing of raw materials. Burden distribution in blast furnace. Auxiliary injection, fuel efficiency, and productivity in blast furnaces. [6 Hours]

- **Steelmaking Fundamentals**: Thermodynamics of steelmaking. Introduction to LD steel making (process, emulsion, decarburization, catch carbon technique, impurity & slag evolution). Hybrid steel making. Modern EAF/IF steel making. Secondary Steelmaking: Thermodynamics & kinetics of deoxidation. Secondary steel making: Vacuum treatment of steel and processes, gas stirring. [8 hours]

- **Secondary Steelmaking and Alternative Ironmaking Routes**: Secondary Steelmaking: Ladle desulphurization, inclusion modification by calcium treatment. Inclusion control by optimizing upstream operating parameters. Heat transfer and segregation during casting. Ingot casting, continuous casting, defects in steel. Environmental issues related to ironmaking; Alternative routes of iron & steel making (rotary kiln, Corex, Midrex). [10 Hours]

**Laboratory:**

1. NA

**Text books:**


1. H.S. Ray and A. Ghosh, **Principles of extractive metallurgy**, Wiley Eastern Ltd., 1991.

2. Dr. R. H. Tupkary, **Modern ironmaking**.

3. R.W. Backforth, **Manufacture of Iron & Steel**,Vol. I.

4. G. Word, **Physical Chemistry of Iron & Steel**.

5. A.K. Biswas, **Principals of Blast Furnace Ironmaking**.

6. Dr. R.H. Tupkary, **Modern Steelmaking**.

7. E.T. Tukdogan, **Fundamentals of steel making**.

**References:**


1. Turkdogan, E.T., and Fruehan, R.J., **Fundamentals of iron and steelmaking**.

2. RJ Fruehan, ed., **The Making, Shaping and Treating of Steel**, Steelmaking and Refining Volume 11, 11th Edition, AISE Steel Foundation, pp. 125-126, 1998.

3. A. Ghosh, **Secondary processing and casting of liquid steels**.


## 18.19 MT 509 : Hydrogen Energy

**Course Code : MT 509**

**Course Name : Hydrogen Energy**

L-P-T-C: 3-0-0-3
Intended for: B.Tech./PG/Ph.D.
Prerequisites: None
Mutual Exclusion: : Some similarly with CY552: Hydrogen Generation and Storage
Approval : 57th BoA

**Course Contents**

- **Introduction to Hydrogen Energy and Production**: Properties of hydrogen, global status of supply and demand, and key hydrogen production methods (steam reforming, partial oxidation, autothermal reforming). Comparison of conventional and advanced methods, and production from hydrocarbons and biomass. (6 Hours)

- **Hydrogen Production from Renewable Sources**: Thermochemical cycles for hydrogen production, electrolysis of water (fundamentals, electrolytic cell design, stack configuration), photoelectrochemical hydrogen production, and a comparative technical and economic analysis of various production methods. (6 Hours)

- **Hydrogen Storage**: Introduction to hydrogen storage methods, fundamentals of hydrogen compression, liquefaction, and underground storage. Hydrogen storage in tanks and adsorption-based materials, metal hydrides, and design of hydrogen storage systems. (6 Hours)

- **Transportation and Distribution of Hydrogen**: Long-distance hydrogen transport via pipelines, ships, and as liquid organic hydrogen carriers (LOHC). Road transportation of hydrogen and refueling stations. Economic analysis of transport methods. (4 Hours)

- **Utilization of Hydrogen**: Hydrogen use in internal combustion engines, fuel cells, and other energy conversion devices. Applications of hydrogen in different sectors, with a focus on decarbonization. (6 Hours)

- **Hydrogen Safety and Regulations**: Properties of hydrogen associated with hazards, safety concerns in storage and transport, classification of hazards, safety regulations, codes, and standards. Case studies of hydrogen incidents and mitigation strategies. (6 Hours)

**Laboratory:**

1. NA

**Text books:**

1. Gupta, Ram B., **Hydrogen Fuel: Production, Transport and Storage**, CRC Press, 2008.

**References:**


1. Tzimas, E., Filiou, C., Peteves, S.D., &Veyret, J.B., **Hydrogen storage: state-of-the-art and future perspective**, European Communities, 2003.

2. Agata Godula-Jopek, **Hydrogen Production by Electrolysis**, Wiley-VCH, 2015

3. Global Hydrogen Review 2021, IEA (2021), Paris, https://www.iea.org/reports/global-hydrogen-review-2021

4. Michael Hirscher, **Handbook of Hydrogen Storage**, Wiley-VCH, 2010.

5. Yuda Yurum (Editor), **Hydrogen energy system: production and utilization of hydrogen and future aspects**, Springer Science & Business Media; NATO ASI Series, Series E: Applied Sciences – Vol. 295, 2012.


## 18.20 MT 510 : Colloids and Interfaces

**Course Code : MT 510**

**Course Name : Colloids and Interfaces**

L-P-T-C: 3-0-0-3
Intended for: B.Tech./PG/Ph.D.
Prerequisites: None
Mutual Exclusion: : Some similarly with CY552: Hydrogen Generation and Storage
Approval : 57th BoA

**Course Contents**

- **Introduction to colloid and interface**: colloids, classification of colloids based on affinity to carrier fluids, concept of stability of colloidal systems (DLVO and DLVO like theories and kinetics of coagulation and general principles of diffusion in a potential field/Brownian movement, physical characteristics of colloids, interfaces, Natures of interfaces, Thermodynamics of Interfaces, Adsorption and deposition at surfaces and interfaces (10 Hours)

- **Surface Tension, Adhesion and Capillarity**: Effect of confinement and finite size, concepts of surface and interfacial energies and tensions, Surface Tension, Contact Angle, Thermodynamics of Surfaces: Surface Tension as Surface Free Energy, Surface Tension: Implications for Curved Interfaces and Capillarity, Effects of Curved Interfaces on Phase Equilibria and Nucleation: The Kelvin Equation, Surface Tension and Contact Angle: Their Relation to Wetting and Spreading

Phenomena, Contact Angles: Some Complications, Contact of Liquids with Porous Solids and Powders, Molecular Interpretation of Surface Tension, Apolar (Van Der Waals) and polar(acid-base) components of interfacial tensions. Young-Laplace equation of capillarity, examples of equilibrium surfaces, multiplicity. Free energies of adhesion, kinetics of capillary and confined flows (10 Hours)

- **The Rheology of Dispersions**: Introduction, Newton's Law of Viscosity, Concentric-Cylinder and Cone-and-Plate Viscometers, The Poiseuille Equation and Capillary Viscometers, The Equation of Motion: The Navier-Stokes Equation, Einstein's Theory of Viscosity of Dispersions, Deviations from the Einstein Model, Non-Newtonian Behavior, Viscosity of Polymer Solutions (10 Hours)
- **Van der Waals Forces**: Introduction and importance of Van der Waals Forces, Molecular Interactions and Power Laws, Molecular Origins and the Macroscopic Implications of van der Waals Forces, van der waals forces between large particles and over large Distances, calculating van der waals forces between macroscopic bodies, Theories of van der Waals Forces based on Bulk Properties, Effect of the medium on the van der Waals Attractions. (8 Hours)
- **Electric Double layer**: Background of surface charges and electrical, capacitor model of the double layer, diffuse double layer, Debye- Huckel Approximation, electrical double layer, Gouy-Chapman Theory, overlapping Double layer and interparticle repulsion, stern adsorption (8 Hours)

**Laboratory:**

1. NA

**Text books:**


1. P.C. Hiemenz and R. Rajagopalan (Editors), **Principles of Colloid and Surface Chemistry**, 3rd Edition, Academic Press, New York, 1997.
2. T. Cosgrove, **Colloid Science: Principles, Methods and Applications**, Wiley-Blackwell, 2005


**References:**

1. NA

## 18.21 MT 511 : Sensor Materials and Technologies

**Course Code : MT 511**

**Course Name : Sensor Materials and Technologies**

L-P-T-C: 3-0-0-3
Intended for: B.Tech./M.Tech./M.Sc./Ph.D.
Prerequisites: None
Mutual Exclusion: None
Approval : 57th BoA

**Course Contents**

- **Introduction and Fundamental Concepts**: Overview of sensors, materials used for sensors, multidisciplinary aspects of sensor technology, key sensor parameters such as sensitivity, range, accuracy, and resolution. (5 hours)
- **Sensor Materials**: Examination of sensor materials including silicon, plastics, metals, ceramics, structural glasses, optical glasses, and nanomaterials. (4 hours)
- **Physical Principles of Sensing**: Study of sensing principles for various physical phenomena, including force, temperature, vibration, pressure, flow, and optical properties. This section also explores a range of sensors such as piezoelectric, electrical, acoustic, pneumatic, magnetic, optical, and pH sensors. (7 hours)
- **Sensor Fabrication and Characterizatio**n: Overview of fabrication processes such as surface processing (spin casting, vacuum deposition, sputtering, chemical vapor deposition, electroplating). Introduction to Microelectromechanical Systems (MEMS) technologies, including lithography, silicon micromachining, micromachining of bridges and cantilevers, lift-off, wafer bonding, and LIGA technologies. Fundamentals of etching techniques (both wet and dry), and microscopy techniques (optical and electron microscopy, among others). (12 hours)
- **Signal Conditioning, Processing, and Display Systems**: Covers signal conditioning methods like deflection bridges, amplifiers, A.C. carrier systems, current transmitters, oscillators, and resonators. Signal processing techniques such as analog-to-digital conversion, computer and microcontroller systems, and related software. Discusses data display methods, including pointer-scale indicators, LED displays, cathode ray tubes (CRT), liquid crystal displays (LCDs), and electroluminescence (EL) displays. (12 hours)
- **Sensor Applications in Various Fields**: Exploration of sensor applications, covering occupancy and motion detectors, position and displacement sensors, velocity, and acceleration sensors, as well as force, strain, tactile, pressure, and temperature sensors. Specific applications include sensors utilized in CNC machine tools (linear and angular position, velocity sensors) and acoustic emission, accompanied by an introduction to concepts in pattern recognition. (4 hours)

**Laboratory:**

1. NA

**Text books:**


1. John P. Bentley, **Principles of Measurement Systems**, 4th Edition, Pearson Education, 2005.
2. S.M. Sze, **Semiconductor sensors**, 3rd Edition, John Wiley & Sons Inc., 2006.
3. J. Fraden, **Handbook of Modern Sensors: Physical, Designs, and Applications**, AIP Press, Springer.
4. Neil W. Ashcroft and N. David Mermin, **Solid State Physics**, Saunders College Publishing, 1976.

**References:**


1. NA

# 19 Physics Courses

# Engineering Physics Courses

## 19.1 EP 301: Engineering Mathematics-2

**Course Code: EP 301**
**Course Name: Engineering Mathematics-2**

L-T-P-C: 3-1-0-4
Prerequisite: IC 110, IC 111 and/or faculty consent; Out of PH511 and EP301, a student is allowed to take only one course.
Students intended for: B.Tech.
Elective or Core: Core
Approval: 28th Senate

**Course content**

- **Module I**

  Linear vector spaces, Gram-Schmidt orthogonalization, Self-adjoint, Unitary, Hermitian, Non-Hemitian Operators, transformation of operators, eigenvalue equation, Hermitian matrix diagonalization; with focus on application to physical problems. [8 Lectures]

- **Module II**

  Second order Linear ODE, Series Solution- Frobenius Method, Inhomogeneous linear ODE. Sturm Liouville equation Hermition operators-eigenvalue problem; with focus on application to physical problems. [7 Lectures]

- **Special functions**

  Bessel, Neumann, Henkel, Hermite, Legendre, Spherical Harmonics, Laguerre, Gamma, Beta, Delta functions, with focus on application of these functions to physical problems. [10 Lectures]

- **Module IV**

  Complex analysis, Cauchy- Riemann conditions, Cauchy's Integral theorem, Laurent expansion, Singularities, Calculus of residues, evaluation of definite integrals, Method of steepest descent, saddle point. [11 Lectures]

- **Module V**

  Partial differential equations and introduction to Green's functions. [6 Lectures]

**Text Books**

1. Arfken and Weber, **Mathematical methods for physicists**, 6th Edition, Elsevier Academic Press, 2015.

2. Mary L Boas, **Mathematical Methods in Physical Sciences**, 3rd Edition, Willey 2011

**Reference Books:**

1. K. F. Riley and M. P. Hobson, **Mathematical Methods for Physics and Engineering: A Comprehensive Guide**, Cambridge India South Asian Edition, 2009.

2. J. Mathews and R. L. Walker, **Mathematical Methods for Physicists**, New edition, Imprint, 1973.

3. F. W. Byron and R. W. Fuller, **Mathematics of Classical and Quantum Physics**, New edition, Dover Publication, 1992.

4. P. M. Morse and H. Freshbach, **Methods of theoretical Physics Vol. I and II**, McGraw-Hill, 1953.

5. E. Kreyszing, **Advanced Engineering Mathematics**, 10th edition, Wiley India Private Limited, 2003.

6. Philippe Dennery and Andre Krzywicki, **Mathematics for Physicists**, Dover Publications Inc. 1996.

## 19.2 EP 302: Computational Methods for Engineering

**Course Code: EP 302**
**Course Name: Computational Methods for Engineering**

L-T-P-C: 2-0-2-3
Prerequisite: IC 110 Engineering Mathematics
Students intended for: UG
Elective or Core: Core
Approval: 4th BoA

**Course content**

- **Module I**

  Numerical techniques: Linear and non-linear equations; Solving linear systems: Gauss Elimination, Gauss Jordan, LU Decomposition; Solving linear equations with iterative methods: Jacobi method, Gauss-Seidal method, Successive Over Relaxation (SOR); Finding roots of polynomial and transcendental equations: Bisection method and Newton-Raphson Method; Numerical Integration: Trapezoidal rule, Simpson's rule, Gaussian Quadrature; Case study from multi-physics systems. [14 Lectures]

- **Module II**

  FEM Concept: Introduction, Engineering applications of finite element method,Weak formulation, Interpolation scheme, FEM formulation for 1D and 2D problems, Computer implementation issues, Convergence and Error analysis. [6 Lectures]

- **Module III**

  FEM for Multi-Physics Systems: Case study of thermo-mechanical systems, electromechanical systems, thermo-electro-mechanical systems. [5 Lectures]

- **Module IV**

  Simulation of Engineering Systems: Monte-Carlo simulation, Simulation of continuous and discrete processes with suitable examples from engineering problems. [3 Lectures]

**Laboratory sessions**

:

- Exp. 1 & 2 Use of numerical techniques to solve system of equations using computer programming platform.
- Exp. 3 &4 Introductions to computational software (FEM based packages).
- Exp. 5,6 & 7 Find the simulation response of a physical system under (i) Mechanical load (ii) Thermal load (iii) Electrical load environment.
- Exp. 8 & 9 Use of computational (FEM based) package to simulate multi-physics systems case e.g. Electric motor under electro-mechanical and thermal environment.
- Exp. 10 & 11 Monte Carlo simulation.

**Text Books**

1. JN Reddy, **Introduction to Finite Element Methods**, 3rd Edition, McGraw Hill, 2005.
2. Steven C. Chapra and Raymond P. Canale, **Numerical methods for Engineers**, 4th Edition, Wiley 2015.

**Reference Books:**

1. Conte and de Boor, **Elementary Numerical Analysis: Algorithmetic Approach**, 3rd Edition, McGraw Hill, 1980.
2. Rubinstein, **Simulation and the Monte Carlo method**, 2nd Edition, Wiley 2007.
3. Smith, Griffiths and Margetts, **Programming the Finite Element Method**, 5th Edition, Wiley, 2013.
4. Anju Khandelwal, **Numerical Methods and Computer Programming**, 4th Edition, Alpha Science International ltd. 2015.

## 19.3 EP 401P: Engineering of Instrumentation

**Course Code: EP 401P**
**Course Name: Engineering of Instrumentation**

L-T-P-C: 1-0-5-4
Prerequisite: PH301 or PH513 and PH501 or PH523
Students intended for: B.Tech.
Elective or Core: Core
Approval: 37th BoA

**Course content**

- **Module I**

  Introduction to data Acquisition systems, Labview/open source (such as Python) programming (Interfacing and programming), Signal processing and Error analysis. [ Lectures]

- **Module II**

  Automatic control (PID control, Feed forward control, Time delay and inverse response systems, Sequence control). [ Lectures]

- **Module III**

  Cryogenics Instrumentation (Low temperature, Liquefaction of gases, Close Cycle Refrigerator, Temperature sensor). Vacuum pumps (Rotary, Dry scroll, Root pumps) with focus on role of valves, gauges etc. [ Lectures]

- **Module IV**

  Introduction to design and working of instruments (Electron microscope, Scanning Tunneling Microscopy, Atomic force microscope and Superconducting magnets) [ Lectures]

**Text Books**


1. C. Barry Carter and David B. Williams, **Transmission Electron Microscopy**, Springer, New York (2016).

2. Robert C. Richardson and N. Smith, **Experimental Techniques in Condensed Matter Physics at Low Temperatures**, CRC Press (2018).


## 19.4 EP 402P: Engineering Physics Practicum

**Course Code: EP 402P**
**Course Name: Engineering Physics Practicum**

L-T-P-C: 1-0-5-4
Prerequisite: PH301 or PH513 and PH501 or PH523
Students intended for: B.Tech.
Elective or Core: Core
Approval: 37th BoA

**Course content**

**Part-A**

- **Hall Effect in Semiconductor**

  Measure the resistivity and Hall voltage of a semiconductor sample as a function of temperature and magnetic field. The band gap, the specific conductivity, the type of charge carrier and the mobility of the charge carriers can be determined from the measurements. [ Lectures]

- **Diffraction of ultrasonic waves**

  Fraunhofer and Fresnel diffraction and determine the wavelength of the ultrasound wave. Students may also develop their own sound wave generator and receiver and perform this experiment. [ Lectures]

- **Geiger-Muller-Counter**

  To study random events. Determination of the half-life and radioactive equilibrium. Verification ofthe inverse-square law for beta and gamma radiation. [ Lectures]

- **Dispersion and resolving power of a grating**

  Determination of the grating constant of a Rowland grating based on the diffraction angle (up to the third order) of the high intensity spectral lines. Determination of the angular dispersion and resolving power of a grating. Students may also design). their own gratings and study that using this experimental technique. [ Lectures]

**Devices Fabrication Technologies**

- **Basic clean room training and introduction to instruments**

  Draw a comprehensive wafer clean process flow/cleaning of wafer and validate the hydrophobic and hydrophilic nature through contact angle measurements.

- **Metal-Semiconductor contact fabrications and characterizations**

  Design and fabricate basic metal semiconductor junction and do the characterization. Basic characterization may also be extended to thin films grown via spin coater or any other technique.

**Text Books**


1. R. A. Dunlop, **Experimental Physics**, Oxford University Press (2012).
2. S. K. Ghandhi, **VLSI Fabrication Principles: Silicon and Gallium Arsenide**, 2nd Edition. (2014)


**Reference Books:**


1. A. C. Melissinos, **Experiments in Modem Physics**, Academic Press (1996).
2. E. Hecht, **Optics**, 4 edition, Addison-Wesley. (2011)
3. J. Varma, **Nuclear Physics Experiments**, New Age Publishers (2010)
4. B. L. Worsnop and H. T. Flint, **Advanced Practical Physics for Students**, Methusen & Go. (1950).
5. E. V. Smith, **Manual for Experiments in Applied Physics**, Butterworths (1970).
6. D. Malacara (ed), **Methods of Experimental Physics**, Series of Volumes, Academic Press Inc. (1988).
7. D. K. Schroder, **Semiconductor Material and Device Characterization**, 3rd Edition.

## 19.5 EP 403: Physics of atoms and molecules

**Course Code: EP 403**
**Course Name: Physics of atoms and molecules**

L-T-P-C: 3-0-0-3
Prerequisite:PH301and/or faculty consent; Out of EP403 and PH524, a student is allowed to take only one course.
Students intended for: UG
Elective or Core: Core
Approval: 40th BoA

### Course content

- **Module I**

  Time-independent perturbation theoryfor first and second-order correction and its application; Identical particles, eigen functions for identical two particle systems. [6 Lectures]

- **Module II**

  Time-dependent perturbation theory for two level systems and it generalization to higher level systems, its application to Fermi-Golden rule. [6 Lectures]

- **Module III**

  Interaction of electromagnetic radiation with single electron atoms,Sinusoidal perturbationand Rabi flopping, Dipole approximation and dipole selection rules, Transition rates, Line broadening mechanisms,Incoherent perturbations, spontaneous and stimulated emissions andEinstein coefficients, selection rules for transitions [12 Lectures]

- **Module IV**

  Review of atomic structure of H, Atomic structure of two electron system-variational method, central field approximation, Slater determinant, L-S coupling, J-J coupling. [7 Lectures]

- **Module V**

  General nature of molecular structure, molecular binding, LCAO, Born-OppenheimerApproximatio
  [5 Lectures]

- **Module VI**

  Introduction to infra-red and Raman spectroscopy, Introduction to group theory andsymmetry and Spectroscopy. [6 Lectures]

### Text Books


1. C. J. Foot, **Atomic Physics**, Oxford, First edition 2005.

2. C. Banwell and E. Maccash, **Fundamentals of molecular spectroscopy**, Mc Graw Hill, 2013.

## 19.6 EP 502: Informatics for Materials Design

**Course number : EP 502**

**Course Name : Informatics for Materials Design**

Credit Distribution : 2-0-2-3
Intended for : BTech 4th Year, M.Sc. Physics, PhD Scholars, M.Tech
Prerequisite : None
Mutual Exclusion : None
Approval: 50th BoA

**Course Contents:**

- **Computational material science**: Crystal Structure and symmetry, Material properties, Property based classification of materials (mechanical, electrical, thermal, magnetic, optical), Performance of materials, Meta materials, Need for new materials. (4 Hours)
- **State of art techniques at different length scales:** Concept of multiscale modeling, First principles approach, Density Functional Theory (electronic level), Brief introduction to Schrodinger's equation, Overview of most commonly used approximations (Born Oppenheimer, Local Density Approximations), Kohn-Sham equations, Pseudopotentials, Description of the self-consistent field iterations, Total energy minimization, Overview of major algorithms in DFT calculations. (9 Hours)
- **Databases and Python Scripting:** DBMS fundamentals, Design, Workflows, Query writing, python libraries: Numpy, Panda, Pymatgen, Materials database repositories, Materials open database integration APIs. (6 Hours)
- **Introduction to Machine learning for material design:** Philosophy behind machine learning, Basic vocabulary terms, Algorithms based on learning: supervised and unsupervised, Regression vs. classification, Regression algorithms, Clustering algorithms, Decision tree algorithms, Interpretability analysis using Lyme/Shap. Model independent Descriptors for material data analytics. (9 Hours)

**Laboratory/practical/tutorial Modules:**

1. Lab work (1 Credit)
2. Hands on with Quantum Espresso (QE)- 3 Labs
3. Hands on with MySQL- 1 Lab
4. Working with python scripts, use of APIs etc – 2 Labs
5. Creating databases using APIs to fetch material data – 1 Lab
6. Machine learning with Scikit/Weka – 2 Labs

**Research project (1 Credit):**

Based on use of machine learning/Quantum Espresso for understanding material design and its properties for particular applications like magnetic storage, photovoltaic response, electrical conductivity, magnetism and spintronic application.

**Text books:(Relevant and Latest, Only 2)**

1. June Gunn Lee, **Computational Materials science**, CRC press, 2012.

2. Aurélien Géron, **Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow**, 2nd Edition, O'Reilly Media, Inc. 2019

**References:**

1. Online resources for learning SQL, python

2. Research papers

# Physics Courses

## 19.7 PH 001 Preparatory Physics - 1

**Course Code:** PH 001
**Course Name:** Preparatory Physics - 1
L-T-P-C: 3-1-0-4
**Students Intended for:** Preparatory Students
**Core or Elective:** Core
Approval: 50th BoA

**Course Contents:**

- **Units, Dimensions:** Basic dimensional analysis and a consolidated information of units of various physical observables. [3 Lectures]

- **Vector Analysis:** Vector multiplication and vector algebra, Vector analysis: gradient, divergence, and curl. Cartesian, cylindrical, plane polar and spherical polar coordinate system. [9 Lectures]

- **Concepts of Classical mechanics:** Velocity, linear momentum, acceleration, forced, Newton's law of motion, work and energy, conversion laws for energy and momentum, centre of mass, collision, moment of a force, angular momentum, conservation of angular momentum, moment of inertia. [12 Lectures]

- **Laws of Gravity:** Acceleration due to gravity, escape velocity, Kepler's laws of planetary motion. [6 Lectures]

- **Heat and Thermodynamics:** Thermal equilibrium, concept of temperature, tehermometers and the Kelvin scale, heat, work, and internal energy. First law of thermodynamics. Second law of thermodynamics. [6 Lectures]

- **Waves and Acoustics:** Waves, propagating and stationary waves, interferenfe of waves, sound wave. [6 Lectures]

**Text Books:**

1. D. Halliday, R. Resnick, and J. Walker, **Fundamentals of Physics**, John Wiley.
2. Sears and Zemansky's **University Physics with Modern Physics**, 13th Edition, Pearson.

## 19.8 PH 002 Preparatory Physics - 2

**Course Code:** PH 002
**Course Name:** Preparatory Physics - 2
L-T-P-C: 3-1-0-4
**Students Intended for:** Preparatory Students
**Core or Elective:** Core
Approval: 50th BoA

**Course Contents:**

- **Electrostatics:** Electric Charge, Coulomb's law, electric field and electric potential, electric field lines, electric dipole, Gauss' law, capacitors and capacitance, current, resistivity, Ohm's law, resistance in series and parallel, Kirchhoff's law. [9 Lectures]
- **Magnetism:** Magnetism, magnetic field, Bio Savart's law, Ampere's law, Faraday's laws of induction, self and mutual inductance, LCR Circuit. [9 Lectures]
- **Optics:** Reflection of light, spherical mirrors, mirror formula. Refraction of light, total internal reflection and its applications, lenses, thin lens formula, maginification power of a lenses, wave nature of light, Huygen's principle, interference, diffraction, Young's double slit experiment. [9 Lectures]
- **Modern Physics:** Structure of the atom, Bohr's model, alpha, beta and gamm radiations, law of radioactive decay, half-life and mean life, blackbody radiation, Wien's law, Stefan's law, photoelectric effect, X-rays, Moseley's law, de Broglie wavelength of matter waves, ideas of quantum physics. [15 Lectures]

**Text Books:**

1. D. Halliday, R. Resnick, and J. Walker, **Fundamentals of Physics**, John Wiley.
2. Sears and Zemansky's **University Physics with Modern Physics**, 13th Edition, Pearson.

## 19.9 PH 101 Physics-I

Course Code: PH-101
Course Name: Physics-I
L-T-P-C: 3-1-2-5
Pre-requisite: NIL
Sem. Both
Approval:
Equivalent Course:

**Course Contents:**

- **Vector Fields**: Vector transformation, Vector calculus, Divergence and curl in curvilinear coordinates. Divergence and curl of electrostatic fields, Electric potential, Laplace's and Poisson's equation, Divergence and curl of magnetic field, Magnetic vector potential;
- **Electromagnetic Waves**: Maxwell's equations. Conservation of charge and energy, Electromagnetic waves in vacuum and in matter, Polarized and unpolarized electromagnetic waves. Absorption and dispersion;
- **Special Relativity**: Postulates of special relativity, Lorentz transformation, Introduction to four-vectors, Time dilation, Doppler effect, Length contraction, Twin paradox, Relativistic momentum, Mass and energy, energy and momentum, Relativity as bridge between electricity and magnetism, Magnetism as relative phenomenon (Qualitative discussion);
- **Wave Particle Duality an Quantizators**: Blackbody radiation, photoelectric effect, Compton effect, DeBrogtie waves, Electron Diffraction, Davission–Germer experiment, Uncertainty principle. Bohr atom model and Somerfield corrections. Franck-hertz experiment.

**Practicals:**

Measurement of magnetic susceptibility by Quinck's method; Deter- mination of Planck's constant by photoelectric effect; Franck-Hertz Experiment; Single-slit, double slits and multiple slits diffraction by Laser; Determination of Planck's constant by radiation method; Stefen's constant; Magnetic field of paired coils in Helmholtz arrangement; Davisson – Germer Experiment

**References:**

1. David J. G., **Introduction to Electrodynamics**, 3rd Edition, Prentice Hall of India
2. Arthur B., **Concepts of Modern Physics**, 6th Edition, Tata McGraw- Hill.
3. Mathew N. O. S., **Elements of Electromagnetic**, 3rd Edition, Oxford University Press
4. Feymman R. P., Leighton R.B. and Sands M., **The Feymman Lectures on Physics**, Volume 1 & II, Narosa Publishing House.

## 19.10 PH 211 The Physics Behind Computers

Course Code: PH 211

Course name: The Physics Behind Computers

Credits: 3

Approval: 8th Senate; OTA

The purpose of this course is to attract students into a physics course within a specific context— the fascination Of how computers work, explained from the very basic principles. This course will be really useful to students, because it provides real working examples of the physics they are learning in a relevant, unified context. Students will realize that much of what physicists know about the world goes into the physics of making/understanding of computers.

**Course Contents:**

- **Introduction:**
  - The Physics Behind Computers
  - Physics, Silicon, and the "Magic" Behind the 'computer' Age.
  - A Zoomed-In Look Inside a Computer.
  - Timeline of Great Discoveries and Inventions in Physics and Computer.
- **Mathematics:**
  - The Language of Science and Technology
  - The Utility of Mathematics in Science and Technology.
  - Precision and Significant Digits -Real-World Example, Precision of Display Pixels Large and Small Numbers and Scientific Notation.
  - Units for Physical Quantities
  - Metric-System Units, Binary Numbers. Converting from Decimal to Binary. Converting from Binary to Decimal. Real-World Example -Analog and Digital Variables
  - The Concept of Information
  - Bits, Bytes and Other Units,Exponential Growth
  - Social Impacts: The Exponential Change of Nearly Everything.
- **Mechanics:**
  - Energy Enables Information Technology
  - From Looms to Computers.
  - Speed, Acceleration, and Force.
  - Description of Motion- Distance Travelled, Seek Time of a Hard Drive Head.
  - Force Vectors Net Force Vectors. Electron Acceleration In Cathode Ray Tubes.
  - Principles of Mechanics, Force on a Hard-Drive Head, Gravity, Physics of Energy

- Friction and Heat Energy, The Constancy of Energy. Motion Sensors in Laptops.

- **Electricity and Magnetism: The Workhorses of Information Technology**
  - Electricity and Magnetism are the Basis of Computers.
  - Electric Charge Electric Forces: Coulomb's Law, Electric Fields— Field Lines.
  - Electric Current and Conductors Electrical Energy and Voltage.
  - Voltage Sources - Batteries, Energy Stored in a Battery.
  - Energy Storage in a Capacitor, Capacitor Computer Memory.
  - Resistors Conductors, and Ohm's Law, Electrical Power.
  - Magnetism,Electromagnetism, Electric Current Creates Magnetic Field.
  - The Telegraph, Precursor to the Internet.
  - Changing Electric Field Creates Magnetic Field.
  - Changing Magnetic Field Creates Magnetic Field.
  - Magnetic Materials and Data Storage.

- **Digital Electronics and Computer Logic:**
  - The Reasoning" Abilities of Computers.
  - Concepts of Logic, Electronic Logic Circuits Logic Operations and Diagrams
  - Three-input Logic Operations Building Logic Operations Using the NOR Operation.
  - Using Logic to Perform Arithmetic.
  - Implementing Logic -Electromagnetic Switches. Boolean Search of Databases.

- **Quantum Physics of Atoms and Materials:**
  - Atoms, Crystals and Computers.
  - The Quantum Nature of Electrons and Atoms, Electron Scattering from Crystals.
  - The Spinning of Electrons, Fluorescent Lamps.
  - Electrical Properties of Materials, Conductors, Insulators, Semiconductors.
  - Origin of the Energy Gap in Silicon Crystals.
  - Atomic Nature of Magnetic Domains.

- **Semiconductor Physics:**
  - Transistors and Circuits Silicon, Transistors and Computers
  - Controlling the Conductivity of Silicon p-n Junctions and Diodes.
  - Rectifying an alternating signal, A Simple Crystal AM Radio Receiver
  - Transistors,CMOS Computer Logic,"Water-Effect Transistors.
  - Miniaturization, Integrated Circuits, and Photolithography.

- Silicon Crystal Preparation Lithography for Fabricating a p-n Junction.
- Bipolar Transistors.

- **Digital Memory and Computers:**
  - Physics, Memory and Computers.
  - Sequential Logic for Computer Memory.
  - The Set-Reset Latch, Enabled Data Latch or D-Latch.
  - Static Random-Access Memory.
  - SRAM with Six Transistors.
  - Dynamic Random-Access Memory, Nonvolatile Memory. Quantum Tunneling.
  - Magnetic Tape and Hard Disk Memory, Optical Compact Disk Memory.
  - Error Immunity of Digital Data, The Structure of a Computer.
  - Hierarchy of Computer Memory, Heat-Imposed Limits of Computers
  - Representing Information in Computers using Codes, ASCII de.
  - Coding Images, Data Compression.

**Textbook:**

1. Michael G. Raymer, **Silicon Web-Physics for Internet Age**.

**References:**

1. Paul Hewitt, **Conceptual Physics**.
2. Louis Bloomfield, **How Things Work: The Physics of Everyday Life**.
3. Art Hobson, **Physics: Concepts and Connections**.

## 19.11 PH 301: Quantum mechanics and applications

**Course Code: PH 301**

**Course Name: Quantum mechanics and applications**

L-T-P-C: 2.5-0.5-0-3
Approval: 2nd Senate

**Course Contents**

- **Module I**
- Review of postulates in quantum mechanics, observables and operators, theory of measurement in quantum mechanics, state of the system and expecation values, transition from quantum mechanics to classical mechanics-Ehrenfast theorem. [5 Lectures]
- **Module II**

- Application of Schrodinger equation in 1-D: rectangular barrier, tunneling, square potential well, delta- function potential [5 Lectures]

- **Module III**

- Basic mathematical formalism of quantum mechanics, Dirac notation, linear vector operators, matrix representation of states and operators, commutator relations in quantum mechanics, commutator and uncertainity relations, complete set of commuting observables [6 Lectures]

- **Module IV**

- Quantum computation and information: Qubits and logic gates 14 Lectures]

- **Module V**

- Theory of angular momentum in quantum mechanics, commutator relations in angular momentum, eigenvalues and eigen states of angular momentum [5 Lectures]

- **Module VI**

- Application of Schrodinger equation in 3-D models, central potentials, Schrodinger equation in spherical co-ordinates, solution to hydrogen atom problem [5 Lectures]

- **Module VII**

- Time independent non-degenerate and degenerate perturbation theory, fine-structure of hydrogen, Zeeman effect and hyperfine splitting. [5 Lectures]

- **Module VIII**

- Time dependent perturbation theory, two level systems, emission and absorption of radiation [5 Lectures]

**References:**


1. D J Griffith, **Introduction to quantum mechanics**
2. R Liboff, **Introductory Quantum Mechanics**
3. R Eisberg & R Resnick, **Quantum physics of atoms and molecules**
4. D A B Miller, **Quantum Mechanics for Scientists and Engineers**
5. Levi, **Applied quantuum mechanics**
6. B. H. Bransden & C. J. Joachain, **Quantum Mechanics**
7. J J Saku'rai, **Modern Quantum Mechanics**
8. R Shankar, **Principles of Quantum Mechanics**
9. Cohen-Tannoudji, B Diu, F Laloe, **Quantum Mechanics -Vol.1**

## 19.12 PH 302: Introduction to Statistical Mechanics

**Course Code: PH 302**

**Course Name: Introduction to Statistical Mechanics**

L-T-P-C: 2.5-0.5-0-3
Approval: 2nd Senate

**Course Contents**

- **Module I**
- Statistical concepts and examples- random walk problem in one dimension- mean values- probability distribution for large N. Probability distribution many variables. [ 6 Lectures]
- **Module II**
- Statistical description of a system of particles - Statistical ensemble- Microstate and macrostate - Density of states. Connection between statistics and thermodynamics - Relation between number of macrostates and entropy-classical ideal gas, Gibb's paradox. [ 6 Lectures]
- **Module III**
- Liouvellie's theorem- Phase space and connection between mechanics and statistical mechanics Microcanonical ensemble - Computational methods to calculate phase space trajectory- Molecular dynamics and Monte Carlo methods. [6 Lectures]
- **Module IV**
- Canonical ensemble- partition function. Thermodynamics from the partition function-Helmholtz free energy. Classical 1deal gas- equipartition and virial theorem. System of harmonic oscillators and spin systems. Grand canonical ensemble- density and energy fluctuations- Gibbs free energy. [6 Lectures]
- **Module V**
- Formulation of quantum statistical mechanics- density matrix- micro-canonical, canonical and grand canonical ensembles- Systems composed of indistinguishable particles, Slater determinant. [ 6 Lectures]
- **Module VI**
- Maxwell-Boltzmann , Fermi-Dirac, and Bose-Einstein statistics - Ideal gas in classical and quantum. ensembles -Ideal Bose systems Black body radiation-lattice vibrations in solids- Ideal Fermi systems -magnetic systems- Pauli paramagnetism-Landau diamagnetism- electron gas in metals. [6 Lectures]
- **Module VII**
- Brownian motion - Langevin equation - Fluctuation-dissipation theorem-correlation functions and friction coefficient. [4 Lectures]

**References**


1. F. Reif, **Fundamentals of statistical and thermal physics**
2. K. Huang, **Introduction to statistical physics**
3. F Mandl, **Statistical physics**
4. R K Pathria, **Statistical Mechanics**
5. K Huang, **Statistical Physics**


## 19.13 PH 421: Electromagnetic Theory

**Course Code: PH 421**

**Course Name : Electromagnetic Theory**

L-T-P-C: 4-0-0-4
Prerequisites : Basic undergraduate physics courses and faculty consent
Intended for : I-Ph.D, M.Sc., B.Tech 3rd and 4th Year
Distribution : Core for I-Ph.D. and elective for others
Semester: Even
Approval: 11th Senate; OTA

**Course Contents**

- **Electrostatics**
- Differential equation for electric field, Poisson and Laplace equations, Formal solution for potential with Green's functions, Boundary value problems, Solutions of Laplace equation in cylindrical and spherical coordinates by orthogonal functions, Dielectrics, Polarization of a medium, Electrostatic energy. [9 Lectures]
- **Magnetostatics**
- Biot-Savart law, Differential equation for static magnetic field, Vector potential, Magnetic field from localized current distributions, Examples of magnetostatic problems, Faraday's law of induction, Magnetic energy of steady current distributions. [7 Lectures]
- Maxwell's Equations
- Displacement current, Maxwell's equations, Vector and Scalar potentials, Gauge symmetry, Coulomb and Lorentz gauges, Electromagnetic energy and momentum, Conservation laws. [5 Lectures]
- **Electromagnetic Waves**
- Plane waves in a dielectric medium, Reflection and Refraction at dielectric interfaces, Frequency dispersion in dielectrics and metals, Dielectric constant and anomalous dispersion, Wave propagation in one dimension, Group velocity, Metallic wave guides, Boundary conditions at metallic surfaces, Propagation modes in wave guides, Resonant modes in cavities. [8 Lectures]

- **Electromagnetic Radiation**
- Radiation, Electric dipole radiation, Magnetic dipole radiation, Radiation from a localized charge, The Lienard-Wiechert potentials, Radiation from an accelerated point charge. Abraham-Lorentz formula. [8 Lectures]
- **Relativistic Electrodynamics**
- The special theory of relativity, Radius four-vector in contravariant and covariant form, Four-vector fields, Minkowski space, Covariant classical electrodynamics. [5 Lectures]

**Textbooks:**

1. J.D. Jackson, **Classical Electrodynamics**, John Wiley & Sons Inc., 1999.
2. D.J. Griffiths, **Introduction to Electrodynamics**, Prentice Hall, 1999.
3. W. Greiner, **Classical Electrodynamics**, Spinger, 1998.
4. J.R. Reitz, F.J. Milford and R.W. Christy, **Foundations of Electromagnetic Theory**, Addition-Wesley, 2008.

**References:**

1. L.D. Landau, E.M. Lifshitz and L.P. Pitaevskii, **Electrodynamics of Continuous Medi**a, Elsevier, 2010.
2. Feynman, Leighton, Sands, **The Feynman Lectures on Physics**, CALTECH, 2013.

## 19.14 PH 422: Statistical Mechanics

**Course Code: PH 422**

**Course Name : Statistical Mechanics**

L-T-P-C : 4-0-0-4

Prerequisites : Undergraduate Physics Courses and First course Quantum mechanics and faculty consent.

Intended for : I-Ph.D, M.Sc., B.Tech 3rd and 4th Year

Distribution : Elective B.Tech/ Core I-Ph.D

Approval: 11th Senate; OTA

**Course Contents**

- **Module I**
- Probability concepts and examples - random walk problem in one dimension mean values probability distribution for large N. Probability distribution of many variables. [6 Lectures]
- **Module II**

- Liouvellie equation- Boltzmann transport equation, Gibbsian ensemble, BBGKY hierarchy, Boltsmann's H-theorem, Maxwell-Boltzmann distribution, Poincare cycle. Phase space and connection between mechanics and statistical mechanics - Microcanonical ensemble. Classical ideal gas. Gibb's paradox. [12 Lectures]

- **Module III**

- Canonical ensemble partition function. Helmholtz free energy, Thermodynamics from the partition function. Classical ideal gas- equipartition and virial theorem. Examples Grand canonical ensemble- density and energy fluctuations- Gibbs free energy. [12 Lectures]

- **Module IV**

- Formulation of quantum statistical mechanics density matrix- micro-canonical, canonical and grand canonical ensembles- Maxwell-Boltzmann , Fermi-Dirac, and Bose-Einstein statistics - comparison Ideal gas in classical and quantum ensembles Ideal Bose systems Examples of quantum ideal gases, Landau diamagnetism, Pauli paramagnetism, quantum Hall effect, phonons in solids, Bose-Einstein condensation, super fluids. [14 Lectures]

- **Module V**

- Interacting systems: One dimensional and two dimensional Ising models, lattice gas and binary alloy, Bragg-Willam's approximations. [10 Lectures]

**Text Books:**

1. R K Pathria, **Statistical Mechanics**, 3rd Revised Edition, Academic Press Inc., 2011.

2. K Huang, **Statistical Physics**, 2nd Edition Wiley, 2008.

**Reference Books:**

1. F. Reif, **Fundamentals of statistical and thermal physics**, Waveland Press, 2010.

2. L D Landau and E M Lifshitz, **Statistical Physics Part I**, 3rd Edition, Butterworth-Heinemann, 2013.

3. Mehran Kardar, **Statistical physics of particles**, Cambridge University Press, 2007.

4. R. C Tolman, **The principles of Statistical Mechanics**, New Edition, Dover Publications Inc., 1980.

## 19.15 PH 424: Atomic and Molecular Spectroscopy

### Course Code: PH 424

### Course Name : Atomic and Molecular Spectroscopy

L-T-P-C : 4-0-0-4

Prerequisites : Basic undergraduate physics courses, first course on Quantum Mechanics and faculty consent

Intended for : I-Ph.D, M.Sc., B.Tech 3rd and 4th Year

Distribution : Core for I-Ph.D. and elective for others Semester : Even

Approval: 11th Senate; OTA

### Course Contents

- **Module I**
- Review of atomic structure of H, Review of time-independent and time-dependent perturbation theory. Interaction of electromagnetic radiation with single electron atoms, Rabi flopping, Transition rates, Line broadening mechanisms, spontaneous and stimulated emissions and Einstein coefficients, Masers and Lasers [8 Lectures]
- **Module II**
- Atomic structure of two electron system, alkali system, Hartree-Fock method, L-S coupling, J-J coupling [8 Lectures]
- **Module III**
- General nature of molecular structure, molecular binding, LCAO, Born-Oppenheimer approximation. [6 Lectures]
- **Module IV**
- Microwave spectroscopy, rotation of molecules, rotational spectra, spectra of molecule and poly- atomic molecular spectra, oscillator strengths, selection and transition rules, line broadening mechanisms, Doppler, natural, and collisional broadening [8 Lectures]
- **Module V**
- Vibrational spectroscopy, vibrating diatomic molecules, vibration and rotation spectrum of Raman effect, modern experimental tools of spectroscopy [8 Lectures]
- **Module VI**
- Raman spectroscopy, pure rotational and vibrational spectra, spin resonance spectroscopy, NMR and ESR, electronic spectra of molecules [8 Lectures]
- **Module VII**
- Introduction to group theory, molecular symmetry and symmetry groups, representation of groups [8 Lectures]

**Text Books:**

1. Bransden and Joachain, **Physics of atoms and molecules**, 2nd Edition, Pearson, 2011.
2. C. Banwell and E. Maccash, **Fundamentals of molecular spectroscopy**, McGraw Hill, 2013.
3. F Albert Cotton, **Chemical applications of group theory**, 3rd Edition, Willey, 2015.
4. M. Tinkham, **Group theory and Quantum Mechanics**, Dover Publications, 2003.

**References:**

1. Wolfgang Demtroder, Atoms, **Molecules and Photons**, 2nd Edition, Springer, 2006.
2. C. J. Foot, **Atomic Physics**, Oxford, 2005.

## 19.16 PH 501: Solid State Physics

**Course Code: Solid State Physics**

**Course Name: PH 501**

L-T-P-C: 3-0-0-3
Approval: 2nd Senate

**Course Contents**

- **Module I**
- Crystal structure, Brillouin zone [2 Lectures]
- **Module II**
- Quantum mechanics of electrons in a solid: Electronic degrees of freedom: from a single atom to N atoms, "Free" electron description- why should it ever work?, "Independent" electron description existence of a Fermi surface, Electron' bands: metal, semiconductor and insulator, Quantum well, dot, wire, nanotube. [6 Lectures]
- **Electron Transport**
- Electrons in a field, Boltzmann transport, Quantum of conductance, Meaning of Ohm's law, coherent transport, From atoms to quantum devices. [6 Lectures]
- **Phonons**
- Vibrations of crystals with monoatomic basis, Two atoms per primitive basis Quantisation of elastic waves, Phonon Momentum [3 Lectures]

- **Magnetism**
- A macroscopic quantum phenomenon, Magnetic coupling of electrons: Para, Ferro and Diamagnets, Curie's Law, Pauli Paramagnetism, Curie-Weiss theory, No classical analogue: Bohr van Leueen theorem, Magnetic interactions: long range order, magnetic excitations, Spintronics applications: using itinerant electron spin for transport a new paradigm, new electronic materials, GMR and CMR [10 Lectures]
- **Superconductivity**
- Basic phenomena, Meissner effect, London equation, Towards a paiting mechanism: Cooper problem, BCS theory, experimental verification, Type II superconductors [10 Lectures] .
- **Module VII**
- Two dimensional electron gas in a FET, IQHE: MOSFET configuration: 20 electron confinement, Electrons in a magnetic field: Landau levels, Hall effect: the quantized version. [5 Lectures]

Note: Experimental techniques associated with each chapter will also be covered

**Text Books:**

1. Ashcroft & Mermin, **Solid State Physics**, Cengage learning.
2. G. D. Mahan, **Condensed Matter Physics in a Nutshell**, Princeton University Press.
3. Charles Kittel, **Quantum Theory of Solids**, Wiley.

**Reference Books:**

1. A. H. MacDonald, **Quantum Hall effect**, Kluwer Academic.
2. B. Martin Janssen, Janos Hajdu, **Introduction to the theory of the integer quantum Hall Effect**, VCH.
3. S.M. Szeand kwok K.Nag, **Physics of Semiconductor Devices**.

## 19.17 PH 502: Optics/Photonics

### Course Code: PH 502 Course Name: Optics/Photonics

L-T-P-C: 3-0-0-3
Prerequisites: Foundations of Electrodynamics & Quantum mechanics
Students intended for: B.Tech
Elective or Core: elective
Approval: 2nd Senate

**Course contents**

- **Electromagnetic Optics**
- Electromagnetic theory of light, electromagnetic waves in vacuum & dielectric media, absorption and dispersion, pulse propagation in dispersive media, Metamaterials [6 lectures]
- **Polarization Optics**
- Polarization of light, reflection and refraction, optics of anisotropic media, Optics of liquid crystals, polarization devices. [5 lectures]
- **Guided wave Optics**
- Electromagnetic waves in dielectric layered media, photonic crystals, waveguides, resonators, plasmonics. [5 lectures]
- **Fiber Optics**
- Electromagnetic waves in fiber, Attenuation and dispersion, photonic crystal fibers. [5 lectures]
- **Semiconductor Optics**
- Quantization of electromagnetic field, quantum states of light, photon statistics, interaction of photons with charge carriers, light emitting diodes, laser diodes, microcavity lasers. [6 lectures]
- **Detection of light**
- Theory of photo detection, photodetectors, photodiodes, avalanche photodiodes, noise in photodetectors. [5 lectures]
- **Acousto and Electro Optics**
- Interaction of light and sound, acousto-optic devices, Principles of electro optics, electro optics of anisotropic media, electro optics of liquid crystals. [5 lectures]
- **Optical fiber communication**
- Fiber Optic components, optical fiber communication syatem, modulation and multiplexing, fiber optic networks. [5 lectures]

**Text Books:**

1. A.K. Ghatak, K. Thyagarajan, **Optical Electronics**, Cambridge University Press

**References:**

1. Max Born, Emil Wolf, **Principles of Optics**, Cambridge University Press.
2. Saleh & Teich, **Fundamentals of Photonics,** Wiley-Inter science.

## 19.18 PH 503: Laser and Applications

### Course Code: PH 503

### Course Name: Laser and Applications

L-T-P-C: 3-0-0-3
Prerequisites: Mechanics of Particles and Waves & Electrodynamics
Students intended for: B.Tech
Elective or Core: elective
Approval: 2nd Senate

### Course contents

- **Radiation**
- Energy density and pressure of radiation, cavity radiation, modes of oscillation. [1 Lectures]
- **Interaction of radiation with matter**
- Absorption, spontaneous and stimulated emission, Einstein coefficients, photoexcitation cross-section, amplification of radiation, laser pumping systems: optical pumping, electrical pumping other methods of pumping, spectral lines shapes, different types of broadening mechanism, gain calculation, threshold condition. [7 Lectures]
- **Cavity resonator**
- Time constant and quality factor of optical cavity, stability of resonators, g parameters, various types of resonators. [6 Lectures]
- Various Lasers: [8 Lectures]
  - Solid state lasers: Ruby Laser and Nd: YAG laser
  - Gas lasers: He-Ne laser, CO2 laser and Nitrogen laser
  - Liquid lasers: Dye lasers
  - Semiconductor lasers
  - Free electron lasers
- **Laser pulse generation**
- Q-switching theory and various methods; mode locking: methods of mode locking, efficiency of mode locking, ultrashort (nanosecond, picosecond and femtosecond) laser pulse generation. [6 Lectures]
- **Applications in time-resolved spectroscopy**
- Fluorescence lifetime, various measurement techniques- oscilloscope method, time-correlated Application in optical communication Optical fibre, fibre laser. [2 Lectures]
- **Higher harmonic generation**

- White light continuum generation, optical parametric amplifier, pump-probe spectroscopy. [3 Lectures]
- **Holography**
- Theory, classification and application. [3 Lectures]

**Text Books:**


1. O. Svelto, Principles of lasers.
2. W. Koechner, Solid State Laser Engineering


**References**


1. W. T. Silfvast, **Laser and Fundamentals**
2. A. E. Seigman, **Lasers**.
3. A. Yariv, **Quantum Electronics**.
4. D.R.Hall and P.E.Jackson (eds.,), **The Physics and Technology of Laser Resonators**.
5. M.Young, **Optics and Lasers**.
6. D. Meschede, **Optics, Lights and Lasers**.
7. B.A.Lengyel, **Lasers**.


## 19.19 PH 504: Organic Optoelectronics

**Course Code: PH 504**

**Course Name: Organic Optoelectronics**

L-T-P-C: 3-0-0-3

Approval: 2nd Senate

**Course Contents**

**PART I**

- **Organic Molecules**
- Electronic structure of atoms, Atomic and Molecular Orbitals, LCAO, Bonding and antibondig orbitals, Covalent Bond, Sigma and Pi Bonds, Energy Levels, Spectroscopic properties. [4 Lectures]
- **Photophysics of Molecules and Aggregates**
- Excited states: Absorption and emission, Singlet and triplet states, Radiative and non-radiative transitions, Aggregates, Vander Waals Bonding, Hydrogen Bonding, Dimer, Eximers. [2 Lectures]

- **Excitons**
- Wannier Exciton, Charge-transfer Exciton Frenkel Exciton, Exciton Diffusion, Excitonic Energy Transfer. [2 Lectures]
- **Conduction in Organic Solids**
- Conductivity: carrier concentration versus mobility, Carrier generation, Hopping transport, Mobility measurements, Traps. [2 Lectures]
- **Photovoltaics and Photodetectors**
- Photovoltaic Devices: Organic Heterojunction Photovoltaic Cells, Organic/Nanorod hybrid Photovoltaics, Gratzel Cells (Dye sensitized solar cells), Photodetector Devices. [5 Lectures]
- **Organic Light Emitting Devices**
- Basic OLED Properties, Charged Carrier Transport, Organic LEDs, Quantum Dot LEDs. [8 Lectures]
- **Lasing Action in Organic Semiconductors**
- Lasing Process, Optically Pumped Organic Lasers, Electrical Pumping of Organic Lasers. [2 Lectures]
- **Organic Thin Film Transistors**
- OFETs: Materials, Contacts, Applications, Nanotube Transistors. [2 Lectures]
- **Device Fabrication Technology**
- Growth Techniques: Evaporation, Langmuir-Biodget, Chemical Vapor Phase Deposition, Ink-Jet Printing, Self Assembly. [3 Lectures]

**PART II**

**Project**

- Literature review on a certain relevant topic. [10 Lectures]

**Text Books:**

No textbook required. Lecture notes and handouts will be provided.

**General Refernces:**

1. Gilbert & Baggott, **Essentials of Molecular Photochemistry**, CRC Press,1991.
2. K. K. Rohatgi, Mukherjee, **Fundamentals of Photochemistry**, New Age International,1978.
3. Pope & Swenberg, **Electronic Processes of Organic Crystals and Polymers**, 2nd Edition, Oxford University press, 1999.

4. H. Meier, **Organic Semiconductors**, Verlag Chemie GmbH,1974.

5. Wolfgang Briltting, **Physics of Organic Semiconductors**, John Wiley, 2005.

## 19.20 PH 505: Electronic Structure

**Course Code: PH 505**

**Course Name: Electronic Structure**

L-T-P-C: 3-0-0-3
Approval: 2nd Senate

**Course Contents**

- **Overview**
- Quantum theory and origin of electronic structure, electronic ground state, basic equations for interacting electron and nuclei, periodic solids and bands, uniform electron gas and simple metals. [7-8 Lectures]
- **Density functional theory**
- DFT foundations, Thomas Fermi Dirac approximations, Hohenberg-Kohn Theorems, intricacies of DFT, Kahn Sham variational equations, Time dependent DFT, local spin density approximation, GGA, LDA, saving Kahn-Sham equations [7-8 Lectures]
- **Important preliminaries on atoms**
- One electron Schrodinger equation, relativistic Dirac equation, atomic sphere approximations, pseudopotentials, orthogonalized plane waves, ultrasoft potentials, projected augmented waves. [7-8 Lectures]
- **Determination of Electronic structure**
- Bloch Theorem, Nearly free electron model, ab initio pseudopotential method, crystal structure, supercelss, clusters and molecules, tight binding methods, augmented functions: APw, MTO, linear methods, LAPW. [7-8 Lectures]
- **Module V**
- Predicting properties of matter from electronic structure - recent developments and computational resources in use. [7-8 Lectures]

**Text Books:**

1. R.M. Martin, Electronic Structure: **Basic theory and practical methods**, Cambridge University Press, 2004.

**References:**


1. R.M. Martin, Electronic Structure: **Basic theory and practical methods**, Cambridge University Press, 2004.

2. Ashcroft and Mermin, **Solid State Physics**, Holt, Rinehart and Winston,1976.

3. Kittel, **Introduction to Solid State Physics**, Wiley,1986.

4. Omar, **Elementary Solid State Physics**, Addison-Wesley,1975.

5. Ziman, **Principles of the Theory of Solids**, Cambridge,1972.

6. W. Hergert A. Ernst M. D " ane (Eds.), **Computational Mterials Science: From Basic Principles to Material Properties**

7. JMD Coey, **Magnetic Materials**


## 19.21 PH 507_Old (3) X-rays as a probe to study materials properties

**Course Outline:**

This coursewill deal with the experimental flavour of the quantum mechanicsand solid state physicsusingthe state of the art techniques. The techniques which we study here are currently used in understanding the emergent phenomena which forms the basis for making magnetoelectric, spintronic, superconducting, ferroelectric, dielectric, magnetic, thermoelectric, fuel cell and battery applications etc. Focus will be made to understand the basic theory, experimental and the extraction of information from the experimentally collected data.

## 19.22 PH 507: X-rays as a probe to study material properties

**Course Code: PH 507**

**Course Name: X-rays as a probe to study material properties**

L-T-P-C: 3-0-0-3
Prerequisites: IC 121 Mechanics of Particles and waves
Intended for: UG /PG
Distribution: Elective
Approval: 8th Senate

**Course Contents**

- **The discovery of x-rays** [1 Lecture]
- **Interaction of radiation with matter** [5 Lectures]
  - Time independent perturbation theory
  - Time dependent perturbation theory
  - Fermi Golden rule

- **State-of-the art Techniques**
  - (a) **X-ray sources**
    - Conventional laboratory sources
    - Synchrotron radiation sources
  - (b) **X-ray Diffraction** [10 Lectures + lab visit]
    - **Theory**
      - Scattering by electrons
      - Scattering by atoms
      - Scattering by unit cell
      - Crystal axes and Reciprocal lattice
      - Structure factors
      - Diffraction Intensity calculations
    - **Diffractometer measurements**
      - Various diffraction geometries
      - This includes geometries used for (a) ambient conditions (b) extreme (high pressure using diamond anvil cell) conditions.
      - Basic idea behind the generation of high pressure conditions in the laboratory.
    - **Detection systems**
    - **Applications**- understanding the order-disorder transformation
  - (c) **X-ray absorption Spectroscopy** [7 Lectures]
    - Basic theory
    - Experimental Importance of local structural measurements
    - Local structural link with the physical properties of different materials
    - X-ray magnetic circular dichroism
  - (d) **Photoemission spectroscopy** [12 Lectures]
    - Electron Spectroscopy- Basic Concepts
    - Electron spectrometer Design
    - Electron spectrum- Qualitative and Quantitative
    - Different Photoemission spectroscopic techniques
      - Angle integrated photoemission spectroscopy
      - Angle resolved photoemission spectroscopy
      - Spin resolved photoemission spectroscopy
      - Inverse photoemission spectroscopy
  - Application of spectroscopy in Material Science

**Text books:**

1. Arthur Holly Compton, **X-rays in Theory and Experiment**, Samuel King Allison, 1935.

2. B.D. Cullity, **Elements of x-ray diffraction**, 3rd Edition, Prentice Hall, 2001.

3. D.C. Konningsberger and R.Prins, (Eds.), **X-ray absorption: Principles, Applications, Techniques of EXAFS, SEXAFS and XANES**, 1988.

4. Stephan Hufner, **Photoelectron Spectroscopy**, Springer, 2003.

## 19.23 PH 508: Magnetism and Magnetic Materials

**Course Code: PH 508**

**Course Name: Magnetism and Magnetic Materials**

L-T-P-C: 3-0-0-3
Prerequisites: PH 301 Quantum Mechanics
Intended for: UG/PG Distribution: Elective
Approval: 8th Senate

**Course Contents**

- **Introduction**
- History of magnetism, Magnetic units, Classical and quantum mechanical model of magnetic moment of electrons, magnetic properties of free atoms. [3 Lectures]
- **Types of magnetism**
- Classification of magnetic materials, Theories of Diamagnetism, Paramagnetism, Theories of ordered magnetism, Quantum theory of magnetism: electron-electron interactions, localized electron theory, itinerant electron theory. [8 lectures]
- **Magnetic interactions**
- Origin of crystal field, Jahn Teller effect, Magnetic dipolar interaction, Origin of exchange interaction, Direct exchange interactions, Indirect exchange interactions in ionic solid and metals, double and anisotropic exchange interaction. [5 lectures]
- **Magnetic domains**
- Development of domain theory, Block and Neel Wall, Domain wall pinning, Magnons, Bloch's law, Magnetic anisotropy, magnetorestriction. [5 Lectures]
- **Competing interactions and low dimensionality**
- Frustration, Spin glass, superparamagnetism, one and two dimensional magnets, Thin film and multilayers, Heisenberg and Ising models. [4 lectures]
- **Novel magnetic materials**
- Colossal and giant magnetoresistive materials, magnetic refrigerant materials, Shape memory alloys, multiferroics, spintronics devices and their application in magnetic storage. [7 lectures]
- **Measurements techniques**
- Production and measurement of field, magnetic shielding, Faraday balance, AC susceptometer, Vibration sample magnetometer, torque magnetometer, SQUID magnetometer, Experimental method in low temperature. [8 lectures]

**Text books:**

1. B. D. Cullity and C. D. Graham, **Introduction to magnetic materials**, John Wily & Sons, 2011.

2. D. Jiles, **Introduction to magnetism and magnetic materials**, Taylor and Francis, CRC Press, 1998.

**Reference Books:**

1. K. H. J. Buschow and F. R. de Boer, **Physics of Magnetism and Magnetic Materials**, Kluwer Academic Publishers, 2003.

2. Stephen Blundell, **Magnetism in Condensed Matter**, Oxford University Press, 2001.

3. Mathias Getzlaff, **Fundamentals of Magnetism**, Springer, 2008.

## 19.24 PH 511: Mathematical Physics

**Course Code: PH 511**

**Course Name : Mathematical Physics**

L-T-P-C : 4-0-0-4
Prerequisites : Undergraduate physics courses and faculty consent.
Intended for : I-Ph.D, M.Sc., B.Tech 3rd and 4th Year.
Distribution : Core course for I-PhD and elective for others
Approval: 10th Senate

**Course Contents**

- **Module-I**

- Coordinate system, Vector calculus in Cartesian and Curvilinear coordinates, Introduction to Tensor analysis. [9 lectures]

- **Module-II**

- Linear vector spaces, Gram-Schmidt orthogonalization, Self -adjoint, Unitary, Hermitian Operators, transformation of operators , eigenvalue equation, Hermitian matrix diagonalization. [8 lectures]

- **Module-III**

- Ordinary differential equation (ODE) with constant coefficients, Second order Linear ODE, Series Solution- Frobenius Method, Inhomogeneous linear ODE. Sturm Liouville equation Hermition operators - eigenvalue problem. [9 Lectures]

- **Module-IV**

- Special functions: Bessel, Neumann, Henkel, Hermite, Legendre, Spherical Harmonics, Laguerre, Gamma, Beta, Delta functions. [10 lectures]

- **Module-V**
- Complex analysis, Cauchy- Riemann conditions, Cauchy's Integral theorem, Laurent expansion, Singularities, Calculus of residues, evaluation of definite integrals, Method of steepest descent, saddle point. [12 lectures]
- **Module-VI**
- Fourier Series general properties and application, Integral transform, Properties of Fourier transform, Discrete Fourier transform, Laplace transform, Convolution theorem [6 lectures]

**Text Books:**

1. Arfken and Weber, **Mathematical methods for physicists**, 6th Edition, Elsevier Academic Press, 2005.
2. Mary L Boas, **Mathematical Methods in Physical Sciences**, 3rd Edition, Wiley, 2005.

**References**

1. K. F. Riley, M. P. Hobson, **Mathematical Methods for Physics and Engineering: A Comprehensive Guide**, Cambridge India South Asian Edition, 2009.
2. Mathews, J., and Walker, R.L., **Mathematical Methods for Physicists**.
3. F W Byron and R W Fuller, **Mathematics of Classical and Quantum Physics**, Dover Publication, 1992.
4. P M Morse , H. Freshbach, **Methods of theoretical Physics,** Vol. I and II, Mc-Graw Hill, 1953.
5. E Kreyszing, **Advanced Engineering Mathematics**, 10th Edition, Wiley India, 2003.
6. Philippe Dennery and Andre Krzywicki, **Mathematics for Physicists**, Dover Publications, 1996.

## 19.25 PH 512: Classical Mechanics

### Course Code: PH 512

### Course Name : Classical Mechanics

L-T-P-C : 4-0-0-4
Prerequisites : Undergraduate physics courses and faculty consent.
Intended for : UG/PG
Distribution : Core I-Ph.D/Elective for others
Approval: 10th Senate

**Course Contents**

- **Introduction**
- Mechanics of a system of particles, constraints, DAlemberts Principle and Lagranges Equations, Simple Applications of the Lagrangian Formulation, Hamiltons principle, some techniques of the calculus of variations, derivation of Lagranges equations from Hamiltons principle, conservation theorems and symmetry properties. [12 lectures]
- **The Central Force Problem**
- The Equivalent one-dimensional problem, and classification of orbits, the virial theorem, the Kepler problem. [6 lectures]
- **The Kinematics of Rigid Body motion**
- Orthogonal transformations, Eulers theorem on the motion of a rigid body, finite rotations, infinitesimal rotations, rate of change of a vector, Angular momentum and kinetic energy of motion, the inertia tensor and the moment of inertia. Euler equation of motion of rigid body. [8 lectures]
- **Oscillations**
- Formulation of the problem, the eigenvalue equation and the principal axis transformation, small oscillations, frequencies of free vibration, and normal coordinates. [4 lectures]
- **The Hamilton Equations of Motion**
- Legendre Transformations and the Hamilton Equations of Motion, Cyclic Coordinates and Conservation Theorems, The Principle of Least action. [8 lectures]
- **Canonical Transformations**
- The examples of canonical transformation Poissons Bracket and canonical invarients, Liouvilles theorem.[8 lectures]
- **Hamilton-Jacobi theory and Action-Angle Variables**
- The Hamilton-Jacobi equation for Hamiltons characteristic function, Separation of variables in the Hamilton-Jacobi Equation, Ignorable coordinates and the Kepler problem, Action-Angle Variables in systems of one degree of freedom. [8 lectures]

**Text Books:**

1. H. Goldstein, **Classical Mechanics**, 3rd Edition, Pearson Education, 2011.
2. Cornelius Lanczos, **The Variational Principles of Mechanics**, Dover Publications, 1986.
3. N.C. Rana and P.S. Joag, **Classical Mechanics**, McGraw Hill Education, 2001.

**References:**


1. J.V.Jose and E.J. Saletan, **Classical Dynamics: A contemporary Approach**, Cambridge University Press, 2002.

2. L.D. Landau and E.M. Lifshitz, **Mechanics**, 3rd Revised Edition, Butterworth Heinemann Ltd., 1982.

3. D T Greenwood, **Classical Dynamics**, Dover Publications, 1997.

4. I.C. Percival and D. Richards, **Introduction to Dynamics**, Cambridge University Press, 1982.

5. E.T. Whittaker, **A treatise on the analytical dynamics of particles and rigid bodies**, Forgotten Books, 2015.

6. John R Taylor, **Classical mechanics**, University Science Books, 2004.

7. Thorton and Marion, **Classical Dynamics of particles and systems**, Cengage, 2012.


## 19.26 PH 513 : Quantum Mechanics I

**Course Code: PH 513**

**Course Name : Quantum Mechanics I**

L-T-P-C : 4-0-0-4
Prerequisites : Basic undergraduate physics courses and faculty consent
Distribution : : Core for 1-Ph.D./Elective for others
Intended for: UG/PG
Approval: 9th Senate

**Course Contents:**

- **Module I**: Origins of quantum theory, Postulates of quantum mechanics, observables and operators, theory of measurement in quantum mechanics, state of the system and expectation values, time-evolution of the state, wave-packets, uncertainty principle, probability current, transition from quantum mechanics to classical mechanics-Ehrenfast theorem. [6 Lectures]

- **Application of Schrodinger equation in 1-D**: scattering, tunneling, bound states , harmonic oscillator, comparison of classical and quantum results [6 Lectures]

- **Module III**: Basic mathematical formalism of quantum mechanics, Dirac notation, linear vector operators, matrix representation of states and operators, commutator relations in quantum mechanics, commutator and uncertainity relations, complete set of commuting observables [8 Lectures]

- **Module IV**:Theory of angular momentum in quantum mechanics, commutator relations in angular momentum, eigen values and eigen states of angular momentum, spin-angular momentum [8 Lectures]

- **Module V**:Application of Schrodinger equation in 3-D models, symmetry and degeneracy , central potentials, Schrodinger equation in spherical co-ordinates, solution to hydrogen atom problem [8 Lectures]
- **Module VI**:Time independent non-degenerate and degenerate perturbation theory, fine-structure of hydrogen, Zeeman effect and hyperfine splitting [8 Lectures]
- **Module VII**:WKB approximation, variational method, Time-dependent perturbation theory, simple examples with two level systems, Fermi Golden rule, Transition induced by periodic external field, Dipole. [10 Lectures]

**Textbooks:**


1. Claude Cohen-Tannoudji, B Diu, F Laloe, **Quantum Mechanics -Vol.l**, Wiley, 1991.
2. D J Griffith, **Introduction to quantum mechanics**, 2nd Edition, Pearson, 2004.
3. B. H. Bransden and C. J. Joachain, **Quantum Mechanics**, 2nd Edition, Pearson, 2000.


**References:**


1. R Liboff, **Introductory Quantum Mechanics**, 4th edition, Pearson, 2002.
2. R Eisberg and R Resnick, **Quantum physics of atoms and molecules**, 2nd Edition, Wiley, 1985.
3. J J Sakurai, **Modem Quantum Mechanics**, Addison Wisley, 1993.
4. R Shankar, **Principles of Quantum Mechanics**, 2nd Edition, Plenum Press, 2011.
5. R.P. Feynman, R.B. Leighton, and M. Sands, **The Feynmam Lectures in Physics**, Vol. 3, Narosa Publishing House, 1992.


## 19.27 PH 513: Quantum Mechanics

**Course Code: PH 513**

**Course Name : Quantum Mechanics**

L-T-P-C : 3-0-0-3
Prerequisites : Basic undergraduate physics courses and faculty consent
Intended for : I-Ph.D., M.Sc., B.Tech 3rd and 4th Year.
Distribution : Core for I-Ph.D./Elective for others
Approval: 10th Senate

**Course Contents**

- **Module I**
- Origins of quantum theory, Postulates of quantum mechanics, observables and operators, theory of measurement in quantum mechanics, state of the system and expectation values, time- evolution of the state, wave-packets, uncertainty principle, probability current, transition from quantum mechanics to classical mechanics-Ehrenfest theorem. [6 lectures]
- **Module II**
- Application of Schrodinger equation: scattering, tunneling, bound states , harmonic oscillator, electrons in a magnetic field in 2D, comparison of classical and quantum results [8 lectures]
- **Module III**
- Basic mathematical formalism of quantum mechanics, Dirac notation, linear vector operators, matrix representation of states and operators, commutator relations in quantum mechanics, commutator and uncertainity relations, complete set of commuting observables [7 lectures]
- **Module IV**
- Theory of angular momentum in quantum mechanics, commutator relations in angular momentum, eigen values and eigen states of angular momentum, spin-angular momentum [6 lectures]
- **Module V**
- Application of Schrodinger equation in 3-D models, symmetry and degeneracy, central potentials, Schrodinger equation in spherical co-ordinates, solution to hydrogen atom problem [6 lectures]
- **Module VI**
- Time independent non-degenerate and degenerate perturbation theory, fine-structure of hydrogen, Zeeman effect and hyperfine splitting [7 lectures]

**Text books:**


1. D J Griffith, **Introduction to quantum mechanics**, 2nd Edition, Pearson, 2004.
2. Claude Cohen-Tannoudji, B Diu, F Laloe, **Quantum Mechanics,** Vol. 1, Wiley.
3. J J Sakurai, **Modern Quantum Mechanics**, Addison Wesley, 1993.

**References:**

1. R Liboff, **Introductory Quantum Mechanics**, 4th Edition, Pearson, 2002.
2. R Eisberg and R Resnick, **Quantum physics of atoms and molecules**, 2nd Edition, Wiley, 1985.
3. B. H. Bransden and C. J. Joachain, **Quantum Mechanics**, 2nd Edition, Pearson, 2000.
4. R Shankar, **Principles of Quantum Mechanics**, 2nd Edition, Plenum Press, 2011.
5. R.P. Feynman, R.B. Leighton, and M. Sands, **The Feynmam Lectures in Physics**, Vol. 3, Narosa Publishing House, 1992.
6. Siegefried Flugge, **Practical Quantum Mechanics**, Springer 1994.

## 19.28 PH 514: Electronics

**Course Number : PH 514**

**Course Name : Electronics**

L-T-P-C : 4-0-0-4
Prerequisites : Undergraduate physics courses and faculty consent
Intended for : PG
Distribution : Core for I-Ph.D. and elective for others
Approval: 9th Senate; Changed to 3 credits in 10th Senate

**Course Contents**

- **Amplifiers**
- BJT, Classification of Amplifiers, Cascading of amplifiers, Types of power amplifiers, Amplifier characteristics, Feedback in amplifiers, Feedback amplifier topologies, Effects of negative feedback [11 lectures]
- **Oscillators and Multivibrators**
- Classification and basic principle of oscillator, Feedback oscillators concepts, Types of oscillator, Classes of multibrators [4 lectures]
- **Field effect transistors**
- JFET, Static characteristics of JFET, FET parameters, FET oscillators, MOSFET, Static characteristics of MOSFET [3 lectures]
- **Operational amplifiers**
- OPAMPs, OPAMP applications [3 lectures]
- **Boolean Algebra and Digital circuit**

- Binary numbers, Interconversion between decimal, binary, hexadecimal number system, Boolean algebra, De Morgan's theorem, Logic Gates, Karnaugh Maps. [7 lectures]
- **Combinational circuits**
- Adder, Multiplexer, Demultiplexer, Encoder, Decoder [5 lectures]
- **Clock and timing circuit**
- Clock waveform, Schmitt Trigger, 555 Timer-Astable, Monostable [3 lectures]
- **Sequential circuits**
- Filp-Flops, Registers, Counters, Memories, D/A and A/D conversions [11 lectures]
- **Digital integrated circuits**
- Switching circuit, TTL, CMOS [3 lectures]
- **Microprocessor Basics**
- Introduction, Outline of 8085 processor, Data analysis [4 lectures]

**Text Books:**


1. Millman and Halkias, **Integrated electronics**, McGraw-Hill, 2001.
2. A. P. Malvino and D. P. Bates, **Electronic Principles**, 7th Edition, McGraw-Hill, 2006.
3. D. P. Leach, A. P. Malvino and G. Saha, **Digital Principles and Applications**, 6th Edition, Tata McGraw Hill, 2007.
4. A. K. Maini, **Digital Electronics-Principles, Devices and Applications**, John Wiley & Sons, 2007.
5. R. S. Gaonkar, **Microprocessor Architecture: Programming and Applications with the 8085**, Penram India, 1999.


## 19.29 PH 515P: Physics Laboratory

**Course Code : PH 515P**

**Course Name : Physics Laboratory**

L-T-P-C : 0-0-5-3
Prerequisites : Faculty consent
Intended for :I-Ph.D.
Distribution : Core
Approval: 10th Senate

**Experiments :**

1. **Hall Effect in Semiconductor**
2. Objective: To measure the resistivity and Hall voltage of a semiconductor sample as a function of temperature and magnetic field. The band gap, the specific conductivity, the type of charge carrier and the mobility of the charge carriers can be determined from the measurements.
3. **Michelson Interferometer**
4. Objective: To determine the wavelength of the light source by producing interference pattern.
5. **Fabry-Perot Interferometer**
6. Objective: To investigate the multibeam interference of a laser light. Also, the determination of the wavelength of light source and thickness of a transparent foil.
7. **Zeeman Effect**
8. Objective: To observe the splitting up of the spectral lines of atoms within a magnetic field (normal and anormalous Zeeman effect) and find the value of Bohr's magneton.
9. **Diffraction of ultrasonic waves**
10. Objective: To observe Fraunhofer and Fresnel diffraction and determine the wavelength of the ultrasound wave.
11. **Frank-Hertz Experiment**
12. Objective: To demonstrate the quantization of atomic energy states and determine the first excitation energy of neon.
13. **Fourier optics**
14. Objective: To observe Fourier transformation of the electric field distribution of light in a specific plan.
15. **Dispersion and resolving power of a grating**
16. Objective: Determination of the grating constant of a Rowland grating based on the diffraction angle (up to the third order) of the high intensity spectral lines. Determination of the angular dispersion and resolving power of a grating.
17. **Geiger-Muller-Counter**
18. Objective: To study random events. Determination of the half-life and radioactive equilibrium. Verification of the inverse-square law for beta and gamma radiation.
19. **Scintillation counter**
20. Objective: Energy dependence of the gamma absorption coefficient / Gamma spectroscopy.

**Reference Books:**

1. R. A. Dunlop, **Experimental Physics**, Oxford University Press, 1988.
2. A. C. Melissinos, **Experiments in Modern Physics**, Academic Press, 1996.
3. E. Hecht, Optics, **Addison-Wesley**, 4 edition, 2001.
4. J Varma, **Nuclear Physics Experiments**, New Age Publishers, 2001.
5. E. Hecht, **Optics**, Addison-Wesley, 4th Edition, 2001.
6. Worsnop and Flint, **Advanced Practical Physics for Students**, Methusen & Go., 1950.
7. E.V. Smith, **Manual for Experiments in Applied Physics**, Butterworths, 1970.
8. D. Malacara (ed), **Methods of Experimental Physics**, Series of Volumes, Academic Press Inc., 1988.

## 19.30 PH 516: Research project I

**Course Code : PH516**

**Course Name : Research project I**

L-T-P-C: 0-0-4-2
Prerequisites : Faculty consent
Intended for : I-Ph.D.
Distribution : Core for I-Ph.D.
Approval: 10th Senate

**Modules:**

Faculty members of physics and related areas can offer this project course. Towards the end of vacation they have to submit their report and must give a seminar based on their work. Evaluation will be based on students performance during the period and their report and talk. The evaluation will be carried out by the faculty members involved in the program.

**Textbooks:**

As advised by the faculty member

**References:**

As advised by the faculty member

### 19.31 PH 517: Research project II

**Course Code : PH517**

**Course Name : Research project I**

L-T-P-C : 0-0-8-4
Prerequisites : Faculty consent
Intended for : I-Ph.D.
Distribution : Core for I-Ph.D.
Approval: 19th Senate; Previously ran as 0-0-6-3 (10th Senate)

**Modules:**

Faculty members of physics and related areas can offer this project course. Towards the end of vacation they have to submit their report and must give a seminar based on their work. Evaluation will be based on students performance during the period and their report and talk. The evaluation will be carried out by the faculty members involved in the program.

**Textbooks:**

As advised by the faculty member

**References:**

As advised by the faculty member

### 19.32 PH 518P: Post-Graduate Project - I

**Course Code : PH 518P**

**Course Name : Post graduate project I**

L-T-P-C : 0-0-6-3
Prerequisites : Faculty consent
Intended for : M. Sc. Physics
Distribution : Core for M. Sc. Physics
Approval: 19th Senate

**Modules:**

Faculty members of physics and related areas can offer this project course. Towards the end of vacation they have to submit their report and must give a seminar based on their work. Evaluation will be based on students performance during the period and their report and talk. The evaluation will be carried out by the faculty members involved in the program.

**Textbooks:**

As advised by the faculty member

**References:**

As advised by the faculty member

## 19.33 PH 519P: Post-Graduate Project - II

**Course Code : PH 519P**

**Course Name : Post graduate project II**

L-T-P-C : 0-0-16-8
Prerequisites : Faculty consent
Intended for : M. Sc. Physics
Distribution : Core for M. Sc. Physics
Approval: 19th Senate

**Modules:**

Faculty members of physics and related areas can offer this project course. Towards the end of vacation they have to submit their report and must give a seminar based on their work. Evaluation will be based on students performance during the period and their report and talk. The evaluation will be carried out by the faculty members involved in the program.

**Textbooks:**

As advised by the faculty member

**References:**

As advised by the faculty member

## 19.34 PH 521: Electromagnetic Theory

**Course Code : PH521**

**Course Name : Electromagnetic Theory**

L-T-P-C : 4-0-0-4
Prerequisites : Basic undergraduate physics courses and faculty consent
Intended for : I-Ph.D, M.Sc., B.Tech 3rd and 4th Year
Distribution : Core for I-Ph.D. and elective for others
Approval: 10th Senate

**Course Contents**

- **Module I**
- Overview of Electrostatics & Magnetostatics:
- **Module II**

- Differential equation for electric field, Poisson and Laplace equations, Boundary value problems, Dielectrics, Polarization of a medium, Electrostatic energy, Differential equation for magnetic field, Vector potential, Magnetic field from localized current distributions [10 Lectures]
- **Maxwell's Equations**
- Maxwell's equations, Gauge symmetry, Coulomb and Lorentz gauges, Electromagnetic energy and momentum, Conservation laws. [8 Lectures]
- **Electromagnetic Waves**
- Plane waves in a dielectric medium, Reflection and Refraction at dielectric interfaces, Frequency dispersion in dielectrics and metals, Dielectric constant and anomalous dispersion, Wave propagation in one dimension, Group velocity, and Metallic wave guides. [12 Lectures]
- **Electromagnetic Radiation**
- Electric dipole radiation, Magnetic dipole radiation, Radiation from a localized charge, The Lienard-Wiechert potentials [10 Lectures]
- **Relativistic Electrodynamics**
- Michelson–Morley experiment, Special theory of relativity, Relativistic kinematics, Lorentz transformation and its consequences, Covariance of Maxwell equations, Radius four-vector in contravariant and covariant form, Four-vector fields, Minkowski space, Covariant classical electrodynamics. [14 Lectures]

**Text Books:**

1. J.D. Jackson, **Classical Electrodynamics**, John Wiley & Sons, 1999.
2. D.J. Griffiths, **Introduction to Electrodynamics**, Prentice Hall, 1999.

**References:**

1. L.D. Landau, E.M. Lifshitz and L.P. Pitaevskii, **Classical theory of fields**, Elsevier, 2010.
2. Feynman, Leighton, Sands, **The Feynman Lectures on Physics**, CALTECH, 2013.
3. W. Greiner, **Classical Electrodynamics**, Spinger, 1998.
4. J.R. Reitz, F.J. Milford and R.W. Christy, **Foundations of Electromagnetic Theory**, Addition-Wesley, 2008.

## 19.35 PH 522 : Statistical Mechanics

### Course Code: PH 522

### Course Name : Statistical Mechanics

L-T-P-C : 4-0-0-4

Prerequisites : Undergraduate Physics Courses and First course Quantum mechanics and faculty consent.

Intended for : I-Ph.D, MSc, B.Tech 3rd and 4th Year.

Distribution : Core for I-Ph.D and elective for others

Approval: 10th Senate

### Course Contents:

- **Review of Thermdynamics:** Laws of Thermodynamics, Specific heat, Maxwell Thermodynamic potentials, Ideal gas, Equation of state, van der Waal's equations relations, (4 Lectures)
- **Module II**: Probability concepts and examples - random walk problem in one dimension mean values probability distribution for large N. Probability distribution of many variables. (8 Lectures)
- **Module III**: Liouvellie equation-Boltzman ergodic hypothesis, Gibbsian ensemble. Phase space and connection between mechanics and statistical mechanics- Microcanonical ensemble. Classical ideal gas. Gibb's paradox. (10 Lectures)
- **Module VI**: Canonical ensemble partition function. Helmholtz free energy, Thermodynamics from the partition function. Classical ideal gas- equipartition and virial theorem. Examples: harmonic oscillator and spin systems, Grand canonical ensemble- density and energy fluctuations- Gibbs free energy. (12 Lectures)
- **Module V**: Fmmulation of quantum statistical mechanics density matrix- microcanonical, canonical and grand canonical ensembles- Maxwell-Boltzmann , Fermi-Dirac, and Bose-Einstein statistics - comparison (6 Lectures)
- **Module VI**: Ideal gas in classical and quantum ensembles Ideal Bose and fermi systems Examples of quantum ideal gases, Landau diamagnetism, Pauli paramagnetism, Phonons in solids, Bose-Einstein condensation in Harmonic Trap, White dwarf Star, Phase transformation. (14 Lectures)

### Text Books:


1. R K Pathria, **Statistical Mechanics**, 3rd Revised Edition, Academic Press, 2011.
2. K Huang, **Statistical Physics**, 2nd Edition, Wiley, 2008.
3. Stephen Blundell, Concepts in Thermal Physics, 2nd Edition, OUP, 2009.

**References:**


1. F. Reif, **Fundamentals of statistical and thermal physics**, Waveland Press, 2010.

2. L D Landau and E M Lifshitz, **Statistical Physics,** Part I, 3rd Edition, Butterworth-Heinemann, 2013.

3. Mehran Kardar, **Statistical physics of particles**, Cambridge University Press, 2007.

4. R. C Tolman, **The principles of Statistical Mechanics**, Dover Publications, 1980.


**Course Number : PH 523**

**Course Name : Condensed Matter Physics**

L-T-P-C : 4-0-0-4
Prerequisites : Quantum Mechanics-I and faculty consent.
Intended for : I-Ph.D., M.Sc., B.Tech 3rd and 4th Year
Distribution : Core for I-PhD (Physics) and Elective for others

**Course Contents**

- **Introduction:** Crystal Structures, Reciprocal Lattice, Brillioun Zones, Experimental methods for crystal structure determination, symmetry operations. [7 Lectures]

- **Lattice Vibrations and Phonons:** Monoatomic and Diatomic basis, Quantization of elastic waves, Phonon momentum and Phonon density of states, Einstein and Debye model of heat capacity, Thermal conductivity and thermoelectric power. [8 Lectures]

- **Electrons in Solids:** Drude and Somerfield theories, Fermi momentum and energy, Fermi surface, Density of states, Bloch Theorem and crystal momentum, Band theory, Metals, Insulators and Semiconductors. [8 Lectures]

- **Electron Transport in solids**: Electrical conductivity, Olun 's law, thermoelectric power, Hall Effect and magneto-transport, Boltzmann transport equation. [7 Lectures]

- **Semiconductors:** Intrinsic and extrinsic semiconductors, Effective mass, Acceptor and donor level, Bound State and optical transitions in semiconductors. [7 Lectures]

- **Magnetism**: Introduction, Origin of magnetism, Types of magnetism: Diamagnetism, Paramagnetism, Ferro and Anti-ferro magnetism, Ferrimagnetism, Magnetic materials, Spintronics and Nano magnetism. [8 Lectures]

- **Superconductivity:** Basic phenomena, Meissner effect, Types of superconductors, London equation, Thermodynamics of superconducting transition, cooper pairs and BCS theory, Flux quantization in a superconducting ring, Josephson's tunneling, High Tc superconductors and new types of superconductors. [9 Lectures]

**Text Books:**

1. C. Kittel, **Introduction to Solid State Physics**, 8th Edition, John Wiley & Sons, 2005.

2. N. W. Ashcroft and N. D. Mermin, **Solid State Physics**.

3. M. P. Marder, **Condensed Matter Physics**, John Wiley & Sons, 2010.

**References:**

1. Phillips, **Advanced Solid State Physics**, Cambridge University Press, 2012.

2. Hook and Hall, **Solid State Physics**, Wiley Science.

3. S. M. Sze, **Physics of Semiconductor Devices**.

## 19.36 PH 523: Condensed Matter Physics

**Course Code : PH 523**

**Course Name : Condensed Matter Physics**

L-T-P-C : 3-0-0-3
Prerequisites : Quantum Mechanics-I and faculty consent.
Intended for : I-Ph.D., M.Sc., B.Tech 3rd and 4th Year
Distribution : Core for I-PhD (Physics) and Elective for others
Approval: 10th Senate; approved as 4 credit course in 9th Senate

**Course Contents**

- **Introduction**

- Crystal Structures, Reciprocal Lattice, Brillioun Zones, X-ray diffraction and Structure factor, Defects in Crystal structures [5 Lectures]

- **Lattice Vibrations and Phonons**

- Monoatomic and Diatomic basis, Quantization of elastic waves, Phonon momentum and Phonon density of states, Einstein and Debye model of heat capacity, Thermal properties of solids. [6 Lectures]

- **Electrons in Solids**

- Drude and Somerfield theories, Fermi momentum and energy, Fermi surface, Density of states, Electrical conductivity, Ohm's law, Motion in a magnetic field, Hall Effect, Bloch Theorem and crystal momentum, Electron motion in Solids, Kroning-Pening Model, Formation of band, Effective mass [8 Lectures]

- **Semiconductors**

- Intrinsic and extrinsic semiconductors, Acceptor and donor level, Bound State and optical transitions in semiconductors. Degenerate and non-degenerate semiconductor, Optical properties of solids. [6 Lectures]

- **Magnetism**
- Introduction, Origin of magnetism, Bohr-Van Leeuwen theorem, Types of magnetism: Diamagnetism, Paramagnetism, Ferro and Anti-ferro magnetism [7 Lectures
- **Superconductivity**
- Basic phenomena, Meissner effect, Types of superconductors, London equation, Idea of Cooper pair, Flux quantization, Josephson's tunneling [8]

**Text Books:**


1. C. Kittel, **Introduction to Solid State Physics**, 8th Edition, John Wiley & Sons, 2005.
2. N. W. Ashcroft and N. D. Mermin, **Solid State Physics**.
3. M. P. Marder, **Condensed Matter Physics**, John Wiley & Sons, 2010.


**References:**


1. Phillips, **Advanced Solid State Physics**, Cambridge University Press, 2012.
2. Hook and Hall, **Solid State Physics**, Wiley Science.
3. S. M. Sze, **Physics of Semiconductor Devices**.


## 19.37 PH 524: Atomic and Molecular Spectroscopy

**Course Code : PH 524**

**Course Name : Atomic and Molecular Physics**

L-T-P-C : 4-0-0-4

Prerequisites : Basic undergraduate physics courses, first course on Quantum Mechanics and faculty consent

Intended for : I-Ph.D, M.Sc., B.Tech 3rd and 4th Year

Distribution : Core for I-Ph.D. and elective for others

Approval: 9th Senate; Changed in 10th Senate

**Course Contents**

- **Module I:** Review of atomic structure of H, Review of time-independent and time-dependent perturbation theory. Interaction of electromagnetic radiation with single electron atoms, Rabi flopping, Transition rates, Line broadening mechanisms, spontaneous and stimulated emissions and Einstein coefficients, Masers and Lasers [8 Lectures]
- **Module II:** Atomic structure of two electron system, alkali system, Hartree-Fock method, L-S coupling, J-J coupling [8 Lectures]

- **Module III**: General nature of molecular structure, molecular binding, LCAO, Born-Oppenheimer approximation. [6 Lectures]
- **Module IV:** Microwave spectroscopy, rotation of molecules, rotational spectra, spectra of molecule and polyatomic molecular spectra, oscillator strengths, selection and transition rules, line broadening mechanisms, Doppler, natural, and collisional broadening [8 Lectures]
- **Module V**: Vibrational spectroscopy, vibrating diatomic molecules, vibration and rotation spectrum of Raman effect, modem experimental tools of spectroscopy [8 Lectures]
- **Module VI:** Raman spectroscopy, pure rotational and vibrational spectra, spin resonance spectroscopy, NMR and ESR, electronic spectra of molecules. [8 Lectures]
- **Module VII:** Introduction to group theory, molecular symmetry and symmetry groups, representation of groups. [8 Lectures]

**Text Books:**


1. Bransden and Joachain, **Physics of atoms and molecules**, 2nd Edition, Pearson, 2011.
2. C. Banwell and E. Maccash, **Fundamentals of molecular spectroscopy**, Mc Graw Hill, 2013.
3. F Albert Cotton, **Chemical applications of group theory**, 3rd Edition, Willey, 2015.
4. M. Tinkham, **Group theory and Quantum Mechanics**, Dover Publications, 2003.


**References:**


1. Wolfgang Demtroder, **Atoms, Molecules and Photons**, 2nd Edition, Springer, 2006.
2. C. J. Foot, **Atomic Physics**, Oxford, 2005.
3. M. Tinkham, **Group theory and Quantum Mechanics**, Dover Publications, 2003.
4. F Albert Cotton, **Chemical applications of group theory**, 3rd Edition, Willey, 2015.


## 19.38 PH 524: Atomic and Molecular Physics

**Course Code : PH 524**

**Course Name : Atomic and Molecular Physics**

L-T-P-C : 3-0-0-3
Prerequisites : Basic undergraduate physics courses, first course on Quantum Mechanics

and faculty consent
Intended for : I-Ph.D, M.Sc., B.Tech 3rd and 4th Year
Distribution : Core for I-Ph.D. and elective for others
Approval: 10th Senate; with 4 credit course in 9th Senate

**Course Contents**

- **Module I**
- Time-independent perturbation theory, Time-dependent perturbation theory and application Fermi-Golden rule. Interaction of electromagnetic radiation with single electron atoms, Rabi flopping, Dipole approximation and dipole selection rules, Transition rates, Line broadening mechanisms, spontaneous and stimulated emissions and Einstein coefficients [12 Lectures]
- **Module II**
- Review of atomic structure of H, Atomic structure of two electron system-variational method, alkali system, central field approximation, Slater determinant, Introduction to self-consistent field method, L-S coupling, J-J coupling. [8 Lectures]
- **Module III**
- General nature of molecular structure, molecular binding, LCAO, Born-Oppenheimer approximation [6 Lectures]
- **Module IV**
- Introduction to microwave, infra-red and Raman spectroscopy, NMR and ESR, Symmetry and Spectroscopy [14 Lectures]

**Text Books:**

1. Leonard Schiff, **Quantum Mechnics**, 3rd Edition, Mc Graw Hill Education, 2010.
2. Bransden and Joachain, **Physics of atoms and molecules**, 2nd Edition, Pearson, 2011.
3. C. Banwell and E. Maccash, **Fundamentals of molecular spectroscopy**, Mc Graw Hill, 2013.
4. R.L. Liboff, **Introductory Quantum Mechanics**, Addison-Wesley, 2002.

**References:**

1. Wolfgang Demtroder, **Atoms, Molecules and Photons**, 2nd Edition, Springer, 2006.
2. C. J. Foot, **Atomic Physics**, Oxford, 2005.
3. M. Tinkham, **Group theory and Quantum Mechanics**, Dover Publications, 2003.
4. F Albert Cotton, **Chemical applications of group theory**, 3rd Edition, Willey, 2015.

## 19.39 PH 525P: Electronics Laboratory Practicum

**Course Code : PH 525P**

**Course Name : Electronics Laboratory Practicum**

L-T-P-C : 0-0-5-3
Prerequisites : Electronics
Intended for : i-PhD
Distribution : Core for i-PhD (Physics)
Approval: 10th Senate

**List of Experiments**

1. To design and use bipolar junction transistor (BJT) as an amplifier and switch, based on common emitter (CE), common collector (CC) and common base (CB) configurations.
2. Design of Integrator, Differentiator, low pass and high pass filter using operational amplifier (OpAmp) IC 741.
3. Design of Wein Bridge and Colpitts oscillator.
4. Verify mathematical expression of De-morgans theorem using electronic circuits.
5. Design of 4-bit Multiplexer and Demultiplexer using flip flops.
6. Design of 4-bit Shift registers and Counters using flip flops.
7. Design and verify A/D and D/A converters using OpAmp.
8. Design of Astable and Mono stable Multivibrator using IC 555.
9. Study of 8085 Microprocessor.

**References:**

1. B.L. Thareja, **Basic Electronics**
2. V.K. Mehta and Rohit Mehta, **Principles of Electronics**.

## 19.40 PH 526: Seminar

**Course Code : PH 526**

**Course Name : Seminar**

L-T-P-C:
Credits: 1
Prerequisites : Faculty consent
Intended for : I-Ph.D.
Distribution : Core for I-Ph.D.
Semester : second semester of I-Ph.D.
Approval: 9th Senate

**Preamble:**

This course is aimed at developing students self-study and presentation skills which are very much important to build a successful research career.

**Course outline:**

Each student will choose a particular topic for their seminar. Student will be continually preparing in a self-study mode in consultation with faculty members working in physics related topics.

**Modules**

Student will be continually preparing during the semester in consultation with faculty members . At the end of the semester students have to give a seminar and faculty members who are involved in the program will evaluate the performance of students.

**Text Books:**

As advised by the faculty member

**References:**

As advised by the faculty member

## 19.41 PH 526: Research project III

**Course Code : PH 526**

**Course Name : Research project III**

L-T-P-C: 0-0-6-3
Prerequisites : Faculty consent
Intended for : I-Ph.D.
Distribution : Core for I-Ph.D.
Semester : second semester of I-Ph.D.
Approval: 10th Senate; with 1 credit course in 9th Senate

**Modules**

Faculty members of physics and related areas can offer this project course. Towards the end of vacation they have to submit their report and must give a seminar based on their work. Evaluation will be based on students performance during the period and their report and talk. The evaluation will be carried out by the faculty members involved in the program.

**Text Books:**

As advised by the faculty member

**References:**

As advised by the faculty member

## 19.42 PH 527: Vacation Project I

**Course Code : PH 527**

**Course Name : Seminar**

L-T-P-C:
Credits: 2
Prerequisites : Faculty consent
Intended for : PG
Distribution : Core for I-Ph.D.
Semester : second semester of I-Ph.D.
Approval: 9th Senate

**Preamble:**

This course is aimed at giving research exposure to students by giving small projects to them in physics related areas and will be offered

**Course outline:**

Each student will be given a project which they have to complete during their first year winter vacation.

**Modules**

Faculty members of physics and related areas can offer this project course. Towards the end of vacation they have submit their report and must give a seminar based on their work. Evaluation will be based on their report and their talk by the faculty members involved in the program.

**Text Books:**

As advised by the faculty member

**References:**

As advised by the faculty member

## 19.43 PH 527: Research project IV

**Course Code : PH 527**

**Course Name : Research project IV**

L-T-P-C: 0-0-6-3
Prerequisites : Faculty consent
Intended for : I-Ph.D.

Distribution : Core for I-Ph.D.
Semester : second semester of I-Ph.D.
Approval: 10th Senate

**Modules**

Faculty members of physics and related areas can offer this project course. Towards the end of vacation they have to submit their report and must give a seminar based on their work. Evaluation will be based on students performance during the period and their report and talk. The evaluation will be carried out by the faculty members involved in the program.

**Text Books:**

As advised by the faculty member

**References:**

As advised by the faculty member

## 19.44 PH 528 : Introduction to General Relativity

**Course Code: PH 528**

**Course Name : Introduction to General Relativity**

L-T-P-C : 3-0-0-3
Intended for : : I-Ph.D., M.Sc., B.Tech 3rd and 4th Year.
Prerequisite : Mathematical Physics (PH511), Classical Physics (PH 512), Electromagnetic Theory (PH 521).
Mutual Exclusion : None
Approval: 46th BoA

**Course Contents:**

- **Special Relativity:** Principles of special relativity – Lorentz transformations, Covariant and contravariant vectors, Relativistic Mechanics. (4 Hours)
- **Tensor Algebra and Tensor Calculus:** Manifolds and metric, Introduction to tensors – Transformation of coordinates, Lie derivatives – covariant differentiation – Christoffel symbols, The Riemann and Ricci tensors – The Bianchi identities, Geodesics, Isometries – The Killing equation and conserved quantities. (9 Hours)
- **General Relativity:** The equivalence principle – The principle of general covariance, The stress-energy tensor, Einstein equations, The equation of geodesic deviation, linearized gravity and idea of gravitational waves. (9 Hours)
- **Schwarzschild solution and Black holes:** The Schwarzschild solution, Motion of particles in the Schwarzschild metric – Precession of the perihelion – Bending of light, Black holes – event horizon and singularity, The Kruskal extension – Penrose diagrams. (10 hours)

- **Cosmology:** Homogeneity and isotropy – The FRW metric, Friedmann equations – Solutions with different types of matter, Cosmological redshift – standard candles, Dark matter and dark energy, Thermal history of the universe, Horizon problem and Inflation. (10 hours)

**Textbooks:**

1. J. B. Hartle, **Gravity: An Introduction to Einstein's General Relativity**, Pearson Education India, 2003
2. B. F. Schutz, **A First Course in General Relativity**, 2nd Edition, Cambridge University Press, 2009

**References:**

1. S. Carroll, **Spacetime and Geometry**, Addison Wesley, 2004.
2. Barbara Ryden, **Introduction to Cosmology**, 2nd Edition, Addison-Wesley, 2016.

## 19.45 PH 530 : Cosmology-I

**Course Code : PH 530**

**Course Name : Cosmology-I**

L-T-P-C : 3-0-0-3
Intended for : UG/PG/IPhD/PhD elective
Prerequisite :
Mutual Exclusion:
Approval: 54th BoA

**Course Contents**

- **Introduction:** What is Cosmology? A brief history of the Universe a Cosmological erasination, reheating, recombination,etc. Time and length scales involved in Cosmology What is our beloved universe made of? (1 Hour)
- **Homogeneous Universe:** The Cosmological Principle Geometry of theUniverse a The FLRWMetric Kinematics a The Hubble Law a Geodesics a Redshift Distances a Luminosity a Angular Diameter Dynamics a Energy Budget of the Universe a Friedmann Equations Some Exact solutions Our Universe. (14 hours)
- **Hot Big Bang:** Thermal Equilibrium a Some aspects of Statistical Mechanics a Primordial Plasma a Entropy and Expansion History a Cosmic Microwave Background a Cosmic Background Beyond Equilibrium a The Boltzmann Equation a Dark Matter Freeze Out a Big Bang Nucleosynthesis More on recombination. (15 hours)
- **Cosmological Inationary Theory:** Problems faced by the Big BangTheory a The Horizon Problem a The Flatness Problem a Superhorizon Correlations Before

the Hot Big Bang The Physics of Ination a How in ation solves these problems? a Slow Roll Ination. (12 hours)

**Textbooks:**

1. Daniel Baumann, **Cosmology**, Cambridge University Press, 2021
2. Scott Dodelson & Fabian Schmidt, **Modern Cosmology**, Academic Press, Elsevier, 2021.

**References:**

1. Steven Weinberg, **Cosmology**, Cambridge University Press, 2008
2. Valery Rubakov and Dmitry Gorbunov, **Introduction to the theory of Early Universe**, Volume1&2, World Scientic, 2011
3. Luca Amendola, **Cosmology Lecture Notes**, University of Heidelberg, 2023
4. Viatcheslav Mukhanov, **Physical Foundations of Cosmology**, Cambridge University Press, 2005.
5. Andrew Liddle, David Lyth, **Cosmological Ination and Large Scale Structure**, Cambridge University Press, 2000.

## 19.46 PH 550 : Introduction to Quantum Optics

**Course Code : PH 550**

**Course Name : Introduction to Quantum Optics**

L-P-T-C: 3-0-0-3
Intended for: UG/PG/IPhD/PhD
Prerequisites: Basics of Quantum Mechanics , Classical Electrodynamics ,Mathematical Methods for Physics
Mutual Exclusion: None
Approval: 57th BoA

**Course Contents**

- **Module 1: Two-Level Atom System** (8 lectures)
  - Oscillating dipoles and Bloch sphere representation
  - Density Operator and Density Matrix formalism
  - Optical Bloch Equations
  - Rabi Frequency and Spontaneous Decay
  - Lineshape in Fluorescence and Saturation Broadening
- **Module 2: Quantization of the Electromagnetic Field** (14 lectures)
  - uantized Modes and Operators

- Ladder Operators, Number Operator, and Quadrature Operators
- Quantization of the Electromagnetic Field
- Hamiltonian of Radiation Field and Vacuum State Energy
- Fock States, Coherent States, and Squeezed States
- Thermal States and Planck's Black Body Radiation Formula

- **Module 3: Photon Statistics and Measurement** (10 lectures)
  - Photon Statistics
    - Poissonian, Sub-Poissonian, and Super-Poissonian light
    - Intensity interferometer and Hanbury Brown–Twiss experiments
    - Second-order correlation function, g2(t)
    - Photon bunching and antibunching phenomena
    - Coherent, Bunched, and Antibunched light
  - Experimental Demonstrations
    - Photon antibunching experiments
    - Single-photon sources and their application in quantum technologies
- **Module 4: Atoms in Cavities** (10 lectures)
  - Optical and Microwave Cavities
    - Fundamentals of Optical Cavities
    - Microwave Cavities and Rydberg Atoms
  - Atom-Cavity Coupling
    - Weak coupling regime and the Purcell Effect
    - perimental observations of the Purcell Effect
    - Strong coupling regime and Cavity QED
    - Experimental observation of strong coupling in cavities

**Laboratory:**

1. NA

**Text books:**

1. Scully, M. O., & Zubairy, M. S., **Quantum optics**.
2. Christopher Gerry and Peter Knight, **Introductory Quantum Optics**.
3. Mark Fox, **Qantum Optics**.
4. Leonard Mandel and Emil Wolf, **Optical Coherence and Quantum Optics**.

**References:**

1. NA

## 19.47 PH 579 : Quantum Computation and Information

**Course Code : PH 579**

**Course Name : Quantum Computation and Information**

L-P-T-C: 3-0-0-3
Intended for: UG/PG/I-PhD/PhD
Prerequisites: PH 513, PH 301 or equivalent
Mutual Exclusion: NA
Approval: 57th BoA

**Course Contents**

- **Foundations of Quantum Computing**: Introduction to Quantum Computing, Review of linear vector spaces, Review of Quantum postulates, Qubits and Bloch Sphere, Basic Quantum Gates, Quantum Circuits, Quantum No-Cloning Theorem and Teleportation, Quantum Teleportation Protocol, Quantum Dense Coding, Density Matrix I. (Lectures 1–10)
- **Advanced Quantum Concepts**: Density Matrix II, Projective Measurement, Positive Operator-Valued Measure (POVM), EPR Paradox and Bell's Inequalities I, Bell's Inequalities II, Deutsch Algorithm, Deutsch-Jozsa Algorithm, Simon's Problem, Grover's Search Algorithm I, Grover's Search Algorithm II. (Lectures 11–20)
- **Quantum Algorithms and Applications**: Grover's Search Algorithm III, Grover's Search Algorithm IV, Quantum Fourier Transform I, Quantum Fourier Transform II, Period Finding Problem, Method of Continued Fractions, Shor's Factorization Algorithm I, Shor's Factorization Algorithm II, Quantum Error Correction Codes I, Quantum Error Correction Codes II. (Lectures 21–30)
- **Quantum Information Theory and Cryptography**: Classical Information Theory, Shannon Entropy I, Shannon Entropy II, Von Neumann Entropy I, Von Neumann Entropy II, Classical Cryptography, RSA Algorithm, Quantum Cryptography: BB84 Protocol, Quantum Cryptography: B92 and Eckert Protocol. (Lectures 31–39)
- **Advanced Topics in Quantum Computing**: Practical Realization of Quantum Computers, Future of Quantum Computing, Introduction to Quantum Simulators (QISKIT, etc.). (Lectures 40–42)

**Laboratory:**

1. NA

**Text books:**


1. Michael A. Nielsen and Issac L. Chuang, **Quantum Computation and Information**, Cambridge, 2002)
2. Mikio Nakahara and Tetsuo Ohmi, **Quantum Computing**, CRC Press, 2008.

3. N. David Mermin, **Quantum Computer Science**, Cambridge, 2007.

**References:**

1. NA

## 19.48 PH 600 : Research Methodology

**Course Code : PH 600**

**Course Name : Research Methodology**

L-T-P-C : 1-0-0-1
Intended for : MS/Ph.D.
Prerequisite :
Mutual Exclusion: RM-600 in other schools
Approval: 54th BoA

**Course Contents**

- **Module I**: Formal communication of email and verbal, Teacher-student relationship, Technical and scientific presentation Skills (3 Hours)
- **Module II**: Ethics in research, Copyright and plagiarism, Interdisciplinary research work, Project management (3 Hours)
- **Module III**: Safety and precautions, best practices in experimental as well as simulation research (2 Hours)
- **Module IV**: Literature Survey, Designing of the experimental and theoretical research, Data analysis and presentation (3 Hours)
- **Module V**: Drafting the reports, Reading and Writing research paper (3 Hours)

**Laboratory/practical/tutorial Modules:**

1. A technical presentation on the specific topic and write a report on the same topic in journal format.
2. Task on data analysis of scientific data sets.
3. Group discussions on a specific topic.

Assessment will be based on a combination of individual and group assignments, presentations, and a final research report.

**Textbooks:**

1. Michael P. Marder, **Research Methods for Science**, Cambridge University Press, 2012.
2. Caroline Van Den Brul, Crackle And Fizz, **Essential Communication And Pitching Skills For Scientists**, Imperial College Press , 2014.

**References:**


1. E.M. Phillips and D.S. Pugh, **How to get a Ph.D.?**, UBSPD, 1993.

2. Wyne C. Booth, Colomb, William, **The Craft of Research**, University of Chicago Press, eBook.

3. Ranjit Kumar, **Research Methodology: A Step-by-Step Guide for Beginners**, Sage South Asia, 2011.

4. R Panneerselvam, **Research Methodology**, PHI Learning, 2009.

5. C. R. Kothari, **Research Methodology: Methods and Techniques**, New Age International, 2004.


## 19.49 PH 601: Mesoscopic Physics and Quantum Transport

**Course Code: PH 601**

**Course Name: Mesoscopic Physics and Quantum Transport**

L-T-P-C: 3-0-0-3
Prerequisites: PH 501 Introductory Solid State Physics or teachers consent
Intended for: UG/PG Distribution: Elective
Approval: 8th Senate

**Course Contents**

- **Introduction** [5 Lectures]

- Drude and Somerfield modelfor electrons in solids, Quantum mechanics of particle in a box, Bloch states,Density of states and Dimensionality.

- **Mesoscopic physics** [5 Lectures]

- Mesoscopic phenomena and length scaling in physics,Quantum structures, Tunneling through the potential barrier, Coulomb blockade.

- **Quantum transport and Localization** [7 Lectures]

- Influence of reduced dimensionality on electron transport: Ballistic and Diffusive Transport, Single channel Landauer formula, Landauer-Buttiker formalism, Localization, Thermal activated conduction, Thouless picture,General and special cases of localization, Weak localization regime.

- **Quantum Hall effect** [8 Lectures]

- Origin of zero resistance, Two Dimensional Electron Gas, Transport in Graphene and two dimensional systems, Localizations in weak and strong magnetic fields, Quantum Hall effect,Spin Hall Effect.

- **Quantum interference effects in electronic transport** [6 Lectures]

- Conductance in mesoscopic systems, Shubnikov de Haas-Van and Aharonov-Bohm Oscillations, Conductance fluctuations.
- **Mesoscopic Physics withSuperconductivity** [5 Lectures]
- Superconducting ring and thin wires, weakly coupled superconductors, Josephson effects, Andreev Reflections, Superconductor-Normal and Superconductor-Normal-Superconductor junctions.
- **Application of mesoscopic physics** [4 Lectures]
- Optoelectronics, Spintronics and Nanoelectronic Devices.

**Text Books:**


1. Y. Imri, **Introduction to Mesoscopic Physics**, Oxford University Press, 2008.
2. S. Datta, **Electronic Transport in Mesoscopic Systems**, Cambridge University Press, 1997


**Reference Books:**


1. S. Datta, **Quantum Transport: Atom to transistor**, Cambridge University Press, 2005.
2. B.L. Altshuler, P.A. Lee, R.A. Webb, (Editors), **Mesoscopic Phenomena in Solids** (Modern Problems in Condensed Matter Sciences), North Holland, 1991.
3. D. K. Ferry, S. M. Goodnick, **Transport in Nanostructures**, Cambridge University Press, 2009.
4. N. W. Ashcroft and N. D. Mermin, **Solid State Physics**, Cengage Learning, 1976.
5. P. Harrison, **Quantum Wells, Wires & Dots, Theoretical and Computational Physics of Semiconductor Nanostructures**, 2nd Edition, Wiley Science, 2009.


## 19.50 PH 603: Advanced Condensed Matter Physics

**Course Code : PH 603**

**Course Name : Advanced Condensed Matter Physics**

L-T-P-C : 3-0-0-3
Prerequisites : PH301 Quantum Mechanics-I , PH 501 Introductory Solid State Physics or faculty consent.
Intended for : PG and UG
Distribution : Elective
Approval: 8th Senate

**Course Contents**

- **Modules I**
- Second quantization for Fermions and Bosons, Review of Bloch's theorem, tight binding Model, Wannier orbitals, density of states. [6 Lectures]
- **Modules II**
- Born-Oppenheimer approximation, Effects of electron-electron interactions - Hartree-Fock approximation, exchange and correlation effects. Fermi liquid theory, elementary excitations, quasiparticles. [6 Lectures]
- **Modules III** [7 Lectures]
- Dielectric function of electron systems, screening, random phase approximation, plasma oscillations, optical properties of metals and insulators, excitons, polarons, fluctuation- dissipation theorem.
- **Modules IV** [7 Lectures]
- Review of harmonic theory of lattice vibrations, anharmonic effects, electron-phonon interaction -mass renormalization, effective interaction between electrons, polarons.
- **Modules V** [8 Lectures]
- Metal-Insulator transition, Mott insulators, Hubbard model, spin and charge density waves, electrons in a magnetic field, Landau levels, integer quantum Hall effect.
- **Superconductivity** [8 Lectures]
- Phenomenology, Cooper instability, BCS theory, Ginzburg-Landau theory.

**Text Books:**


1. N. W. Ashcroft and N. D. Mermin, **Solid State Physics**, Holt, Rinehart and Winston, 1976)
2. C. Kittel, **Quantum Theory of Solids**, Wiley, 1987.
3. M. P. Marder, **Condensed Matter Physics**, John Wiley & Sons, 2010.
4. H. Ibach and H. Luth, **Solid State Physics**, Springer Science & Business Media, 2009.


**References:**


1. W. Jones and N. H. March, **Theoretical Solid State Physics**, Courier Corporation, 1985).
2. Phillips, **Advanced Solid State Physics**, Cambridge University Press, 2012.
3. G. D. Mahan, **Many Particle Physics**, Springer Science & Business Media, 2000.

4. D. Pines, **Elementary Excitations in Solids**, Advanced Book Program, Perseus Books, 1999.

5. Patrik Fazekas, **Lecture Notes on Electron Correlation and Magnetism**, World Scientific, 1999.

6. Giuliani and Vignale, **Quantum Theory of the Electron Liquid**, Cambridge University Press, 2005.

## 19.51 PH 604: Optical Properties of Solids

**Course Code : PH 604**

**Course Name : Optical Properties of Solids**

L-T-P-C : 3-0-0-3
Prerequisites : Mathematical Physics (PH511) or Mathematics-2 (EP301), Quantum Mechanics (PH513) or Quantum Mechanics and Applications (PH301), Electromagnetic Theory (PH521) or Foundation of electrodynamics (IC221), Condensed Matter Physics (PH523) or Solid State Physics (PH501)
Intended for :
Distribution: Elective
Approval: 36th BoA

**Course Contents**

- **Introduction**
- Optical processes, the complex refractive index and dielectric constant, quantum theory of radiative transition. [3 Lectures]
- **Propagation of light in solid**
- Phenomenological models-Drude and Lorentz models. quantum mechanical description, linear response functions and Kramers–Kronig relations, dispersion, birefringence, optical anisotropy. [4 Lectures]
- **Absorption of light**
- Interband transitions, transition rate, absorption in direct and indirect semiconductor, spin-orbit coupling, indirect gaps, Urbach tails, Landau levels, Franz-Keldysh effect, and absorption spectra. [3 Lectures]
- **Excitons**
- Frenkel vs. Wannier excitons, optical selection rules, effect of Coulomb interaction on interband absorption, Franck-Condon approximation, Huang-Rhys model, Wannier exciton – LO phonon bound states. [3 Lectures]
- **Luminescence**
- Emission from solids, Interband luminescence, photo and electro luminescence, photoluminescence spectroscopy. [3 Lectures]

- **Quantum structures**
- Low dimensional materials and their electronic structures, absorption of quantum well, quantum confined Stark-effect, photoluminescence, optical properties of quantum dots, recent advancement in confined optical materials like zero and two-dimensional materials. [6 Lectures]
- **Plasmonic systems**
- Metals, doped semiconductors, free carrier absorption and plasmons, surface and slab plasmons, plasmons in metallic particles, negative refraction. [3 Lectures]
- **Light-phonon interactions**
- Infrared and Raman active phonons, Phonons absorption and reflectivit y, polaritons, polarons, inelastic light scattering (Raman and Brillouin scattering), Feynman diagrams for light scattering [4 Lectures]
- **Impurity centers in semiconductors**
- Electronic spectrum of shallow donors, multiple valleys, valley-orbit coupling and acceptors, pseudospin-orbit coupling, impurity bands and metal- insulator transition, localized vibrational modes, LO modes bound to neutral impurities, lattice dynamics of isoelectronic impurities and mixed crystals. [5 Lectures]
- **Nonlinear optics**
- Optical nonlinearities, second order nonlinearities, third-order nonlinearties, optical Kerr effect, stimulated Raman scattering, generation and detection of terahertz radiation and recent advancement in this field. [6 Lectures]

**Text Books:**

1. Mark Fox, **Optical Properties of Solids**, Oxford University Press, 2010.

**References:**

1. Yutaka Toyozawa, **Optical Processes of Solids**, Oxford University Press, 2010.
2. Frederick Wooten, **Optical Properties of Solids**, Academic Press, 2013.
3. M. S. Dresselhaus, **Solid State Physics Part II: Optical Properties of Solids**, 2001.

## 19.52 PH 605: Superconductivity

**Course Code: PH 605**

**Course Name: Superconductivity**

L-T-P-C: 3 0-0-3
Prerequisites: Quantum Mechanics-1(PH 513), Condensed Matter Physics (PH 523)
Intended for: PhD/PG/UG
Distribution: Elective
Approval: 19th Senate

**Course Contents**

- **Introduction**

- Historical perspective, Resistivity, Specific heat, Thermal conductivity, Magnetic Susceptibility and Hall Effect of normal metal; Zero resistance, persistent Current, Meissner effect, London-London equations, Penetration depth and critical field. [9 Lectures]

- **Phenomenon logical theory of Superconductivity**

- Free energy, First order and second order transition, specific heat, thermal conductivity, Superconducting order parameter, Ginzberg-Landau equations and its predictions, Coherence length, Type-I and Type-II superconductors, The vortex lattice. Phase coherence, Flux quantization. [9 Lectures]

- **Microscopic Theory of Superconductivity**

- Isotope effect and its significance, The Cooper problem, Formation of Cooper pairs, BCS wave function, Existence of energy gap, Finite temperature properties of BCS ground state [9 Lectures]

- **Tunneling and energy gap**

- Tunneling phenomenon, DC Josephson Effect AC Josephson, Effect, Inverse AC Josephson Effect and Shapiro jump , supercomputing quantum interference device (SQUID).[7 Lectures]

- **Unconventional Superconductors**

- Alternate pairing mechanisms (e.g, spin-triplet, d-wave etc.), Symmetry of the gap function, Experimental methods for probing Nodal structure, Parity, spin state, Lattice symmetry and internal structure, Heavy Fermion, High temperature superconductivity, Cuprates, and Fe based Superconductors. [8 Lectures]

**Text Books:**


1. J.B. Ketterson and S.N, Song, **Superconductivity**, Cambridge University Press, 1999.


**References:**


1. M. Tinkham, **Introduction to Superconductivity**, McGraw-Hill, 1996.
2. Grenel Goll, **Unconventional Superconductors**, Springer-Verlag, 2006.
3. Charles p. Poole Jr., H.A. Farach, R.J. Creswick, R. Prozorov, **Superconductivity**, Elsevier, 2007.
4. James F. Annett, **Superconductivity, Superfluids and Condensates**, Oxford University Press, 2004.

## 19.53 PH 606: Quantum Field Theory

### Course Code: PH 606

### Course name: Quantum Field Theory

L-T-P-C: 3-0-0-3
Prerequisites: Quantum mechanics (PH 513), Mathematical Physics (PH 511)
Intended for: M. Sc (Physics), Ph.D, iPhD, B. Tech 3rd and 4th year
Distribution: Elective for M. Sc (Physics), Ph.D, iPhD, B. Tech 3rd and 4th year
Approval: 37th BoA

### Course Contents

- **Module I**
- Mathematical Preliminaries, Lagrangian and Hamilton density, second quantization, functionals, path integrals, functional field integrals, coherent states for bosons and fermions. [7 Lectures]
- **Module II**
- Classical fields, Klein-Gordan field, massless scalar field theory, massive scalar fields, Phi-4 theory, complex scalar fields. [5 Lectures]
- **Module III**
- Schrodinger, Heisenberg, and interaction pictures, time-evolution operator, translations, and rotations in space-time, transformations of quantum fields, symmetries and conservation laws, Noether's theorem. [8 Lectures]
- **Module IV**
- Canonical quantization of fields with examples, normal ordering, internal symmetries, massive vector fields, polarizations, gauge fields and gauge theory. [7 Lectures]
- **Module V**
- Propagators and Green's function, Dyson equation, field and Feynmann propagator, Smatrix, perturbation expansion, Wick's theorem, Feynmann Diagrams. [7 Lectures]
- **Module VI (Some Application of Field theory in condensed matter physics)**
- Superfields and fields. Fermi liquid theory, field theory formulation of many body problem in metals and superconductors, Hartree-Fock energy, random phase approximation, fractional quantum Hall effect. [8 Lectures]
- or
- **Module VI (Some applications of field theory in particle physics)**
- Dirac and Weyl equation, spinors, transformation of spinors, quantizing the Dirac field, fermion propagator, quantum electrodynamics (QED) scattering cross sections [8 Lectures]

**Text Books:**

1. Lancaster and Blundell, **Quantum field theory for gifted amateur**, Oxford, 2014.
2. Mandl and Shaw, **Quantum field theory**, John Wiley and Sons, 2010.
3. Peskin and Schroeder, **An Introduction to Quantum field theory**, CRC Press, 2018.

**Reference Books:**

1. S. Weinberg, **Quantum Theory of Fields**, Vol. 1, Cambridge, 1995.
2. M. Srednicki, **Quantum field theory**, Cambridge, 2007.
3. M. H. Ryder, **Quantum field theory**, Cambridge, 1996.

**Online Resources:**

1. David Tong, **Lectures on QFT**: http://www.damtp.cam.ac.uk/user/tong/qft.html
2. Freeman Dyson, **Lectures on advanced quantum mechanics**, https://arxiv.org/pdf/quant-ph/0608140.pdf

## 19.54 PH 607 : Physics of Ultracold Quantum Gases

**Course Code: PH 607**

**Course Name : Physics of Ultracold Quantum Gases**

L-T-P-C : 3-0-0-3
Intended for : UG/PG/I-PhD/PhD elective
Prerequisite : PH301/PH513 (Quantum Mechanics), PH522 (Statistical Mechanics), PH524/EP403(Physics of Atoms and Molecules)
Mutual Exclusion : None
Approval: 46th BoA

**Course Contents:**

- **The ideal Bose gas**: The Bose Einstein condensation in ideal Bose gases, Off-diagonal long-range order, Transition temperature and condensate fraction, velocity distribution, Thermodynamic quantities. [6 Hours]
- **Manipulation of atomic internal and external degrees of freedom**: Level structure and atomic transitions of alkali-metal atoms, Atom-field interaction, Cooling, trapping and imaging ultracold gases. [6 Hours]
- **Atom-atom interaction**: Contact interaction, scattering length, Feshbach resonances, Dipolar long-range interactions. [4 Hours]

- **Bose-Einstein condensates (BEC)**: Condensation and Gross-Pitaevskii equation (GPE) for the macroscopic wave function, BEC dynamics in uniform and trapped configurations; Thomas-Fermi approximation, Hydrodynamic equations, Elementary excitations, BEC as simulator of quantum vacuum effects(Hawking radiation and Casimir effect), collapse and supersolidity with dipolar quantum gases. [12 Hours]

- **Atomic mixtures**: Coupled GPE, spin waves, phase diagram, Josephson effect and magnetism, Quantum droplets. [7 Hours]

- **Lower dimensional systems as solid-state quantum simulators**: Phase fluctuations, Mermin-Wagner-Hohenberg theorem, optical lattices, Bose-Hubbard model, Entanglement and correlations. [7 Hours]

**Text books:**

1. C.J. Foot, **Atomic Physics**, Oxford University Press, 2005.

2. C.J. Pethick and H. Smith, **Bose-Einstein condensation in dilute gases**, Cambridge University Press, 2008.

**References:**

1. M. Ueda, **Fundamentals and New Frontiers of Bose-Einstein Condensation**, World Scientific Publishing Company 2010.

2. Lev Pitaevskii and Sandro Stringari, **Bose-Einstein Condensation, and Superfluidity**, Oxford Science Publication, 2016

3. F. Dalfovo, S. Giorgini, Lev P. Pitaevskii, and S. Stringari, **Theory of Bose-Einstein condensation in trapped gases**, Rev. Mod. Phys. 71, 463 (1999)

## 19.55 PH 608 : Computer assisted quantum mechanics

Course number : PH 608

Course Name : Computer assisted quantum mechanics

Credit Distribution : 2-0-3-3

Intended for : UG/PG/I-PhD/PhD elective

Prerequisite : PH301 / PH513 (Quantum Mechanics), PH524 / EP403 (Physics of Atoms and Molecules), PH613 (Computational methods for physicists)/EP302 (Computational methods for engineering)

Mutual Exclusion : NA

Approval: 50th BoA

**Course Contents:**

- **The single-particle problem**: Time independent Schrodinger equation and its solution with Numerov's method, Bound state solutions for one-dimensional (1D) case such as Harmonic oscillator, Schrodinger equation for central potentials, solutions of hydrogen atom, scattering from different type of central potentials, Response of atoms to external fields (20 hours)

- **Variational method**: The variational principle, Numerical solutions to quantum mechanical problems using variational methods, Plane-wave basis set and Non-orthonormal basis set (15 hours)
- **Multi-electron systems**: Basics of Hartree-Fock (HF) methods and its numerical implementation to a few selected problems, going beyond HF methods, density functional theory and its implementation with some specific examples for simple atomic systems. (15 hours)
- **Time propagation**: Spectral methods, direct numerical integration, split operator and Crank-Nicolson methods. Implementation of these methods to a few quantum mechanical systems (20 hours)

**Text books:**

1. J. M. Thijssen, **Computational Physics**, Cambridge University Press, 2007.
2. J. Izaac and J. Wang, **Computational Quantum Mechanics**, Springer, 2018.

**References:**

1. Paolo Giannozzi, **Numerical methods in quantum mechanics**. (Online lecture notes, http://www.fisica.uniud.it/∼giannozz/Corsi/MQ/LectureNotes/mq.pdf)
2. R. H. Landau, M. J. Páez and C. C. Bordeianu, Computational physics, WILEY-VCH Verlag, 2015.

## 19.56 PH 609 : Theory of quantum collision and spectroscopy

Course number : PH 609
Course Name : Theory of quantum collision and spectroscopy
Credit Distribution : 3-0-0-3
Intended for : UG/PG/I-PhD/PhD elective
Prerequisite :PH301/PH513 (Quantum Mechanics), PH524/EP403(Physics of Atoms and Molecules), PH613: Special topics in Quantum Mechanics
Mutual Exclusion : None
Approval: 50th BoA

**Course Contents:**

- **Scattering theory-Quantum collisions**: Review of Method of Partial wave analysis, and Integral equation of potential scattering; Lippman-Schwinger equation, Born series and approximations, Applications of scattering: Coulomb scattering, Scattering by complex potential Scattering of identical particles, Pseudo-potential and Bethe–Peierls collision theory, Levinson's and Seaton's theorems. (12 hours)
- **Resonant Scattering**: Scattering of partial wave, Resonances in quantum collisions, Breit-Wigner formalism, Fano parameterization of Breit-Wigner formula, correlations induced resonances and shape resonances Broad Vs narrow resonances, Resonance life time, Eisenbud-Wigner-Smith formalism of time-delay in scattering, recent experiments (8 hours)

- **Many-body formalism**: Many-body theory, electron correlations, Second quantization, Many-particle Hamiltonian in occupation number representation, Density fluctuations of electron gas in the Hartree-Fock method, introduction to density functional theory, Bohm-Pines approach to random phase approximation, (12 hours)

- **Relativistic formulation**: Foldy-Woutheysen transformations and separation of radial and angular parts of the Dirac equation, introduction to relativistic many body theory (4 hours)

- **Feynman diagrammatic methods**: Schrodinger, Heisenberg and Dirac pictures, Dyson's chronological operator, Gell-Mann-Low Theorem, Rayleigh-Schrodinger perturbation methods and adiabatic switching, Feynman Diagrams, I Order Feynman Diagrams, II and higher order Feynman Diagrams, Linear response of electron correlations (4 hours)

**Text books:**


1. B. H. Bransden & C. J. Joachain, **Physics of Atoms and Molecules**, Pearson, 2003.

2. A.L.Fetter and J.D.Walecka, **Quantum Theory of Many Particle Systems**, Dover, 2003.


**References:**


1. P. G. Burke and C. J. Joachain, **Theory of electron-atom collisions**, Plenum Press, 1995.

2. Stanley Raimes, **Many Electron Theory**, Elsevier, 1972.


## 19.57 PH 611: Nuclear and Particle Physics

**Course Code : PH 611**

**Course Name : Nuclear and Particle Physics**

L-T-P-C : 4-0-0-4
Prerequisites : PH 514 Quantum Mechanics-I, PH 521 Electromagnetic Theory
Intended for : UG/PG
Distribution : Core for I-Ph.D.; Elective for the rest
Approval: 9th Senate

**Course Contents**

- **Properties of Nuclei**

- Nuclear size, Rutherford scattering, nuclear radius and charge distribution, nuclear form factor, mass and binding energy, semiempirical mass formula, angular momentum, parity and isospin, magnetic dipole moment electric quadrupole moment and nuclear shape, experimental determination. [4 Lectures]

- **Two-body problems**
- Deuteron ground state, excited states, spin dependence of nuclear forces, electromagnetic moment and magnetic dipole moment of deuteron and the necessity of tensor forces, two nucleon scattering, n-p scattering, partial wave analysis, phase-shift, scattering length, p-p scattering, charge symmetry and charge independence of nuclear forces, exchange nature of nuclear forces, Yukawa's theory. [6 Lectures]
- **Nuclear decay**
- Beta emission and electron capture, Fermi's theory of beta decay, selecti Liquid drop model, Fermi gas model, shell and collective model. [5 Lectures]
- **Nuclear models**
- Liquid drop model, Fermi gas model, shell and collective model. [5 Lectures]
- **Nuclear Reactions**
- Different types of reactions, conservation laws, energetics, isospin, reaction cross-section, resonance scattering and reactions, Breit-Wigner dispersion relation, Compound nucleus formation and break-up, Optical model, transfer reactions, nuclear fission, neutron physics, fusion reaction. [7 Lectures]
- **Particle accelerators and detectors**
- Electrostatic accelerators, cyclotron, Synchrotron and synchrosyclotron, linear accelerators, colliding beam accelerators, ionization chamber, scintillationdetectors, semiconductor detectors. [5 Lectures]
- **Elementary particles**
- Fundamental interactions, properties mesons and baryons, symmetries and conservation laws, charge-conjugation, parity and time reversal, CPT theorem, Gell-Mann-Nishijima formula, intrinsic parity of pions, resonances, symmetry classification of elementary particles, quark model, concept of colour charge, discrete symmetries, properties of quarks and leptons, gauge symmetry in electrodynamics, particle interactions and Feynman diagrams. [8 Lectures]

**Text Books:**

1. K. S. Krane, **Introductory Nuclear Physics**, John Wiley.

**References**

1. W. E. Burcham and M. Jobes, **Nuclear and particle Physics**, John Wiley & Sons.
2. D. J. Grifths, **Introduction to Elementary Particles**, John Wiley & Sons.
3. A. Das and T. Ferbel, **Introduction to nuclear and particle physics**, John Wiley.

4. M. A. Preston and R. K. Bhaduri, **Structure of the nucleus**, Addison-Wesley.

5. S. N. Ghoshal, **Atomic and Nuclear Physics**, Vol. 2.

6. Roy and B. P. Nigam, **Nuclear Physics: Theory and Experiment**, New Age.

7. D. Perkins, **Introduction to High Energy Physics**, 4th Edition, Cambridge University Press, 2000.

## 19.58 PH 611P_10: Experimental Research Techniques

**Course Code: PH 611P_10**

**Course Name: Experimental Research Techniques**

L-T-P-C: 0-0-7-4
Prerequisites:
Intended for: First year I-Ph.D.
Core/Elective: Core
Approval: 10th Senate

**Course Contents:**

- **Temperature dependence of Electrical resistivity of materials:** This experiment involves measuring temperature dependent resistivity of any material using four probe method and Vander Pauw methods. The skills that one will develop are to make fine contacts on the sample, learn the intricacies involved in making this set up.

- **Electronic properties of material using photoemission technique:** Photoemission experiments will be done on any material and its electronic properties will be studied. The skills that one will develop are the intricacies involved in conducting experiments in ultra high vacuum conditions.

- **Seebeck coefficient measurement:** Develop mini Seebeck coefficient experiment to distinguish n-type and p-type semiconductors from a mixture of it.

- **Structural properties of materials using powder x-ray diffraction (xrd) technique:** To understand structural phase transition of any given material. The skills that one will develop are to understand the intricacies involved in any diffraction experiment, temperature variation set up, analysis of any powder xrd pattern.

- **Optical pumping**: The technique is useful to measure the difference between the atomic energy levels with great precision. One can also measure the resonance frequencies, and thereby measure the Zeeman splitting, the nuclear spins and the strength of the Earth's magnetic field. Students will develop skills to handle laser, lock in amplifier and nonlinear curve fitting.

- **Two slit interference-one photon at a time**: This experiment will give hands on familiarity to confront wave-particle duality in a precise and definite way. It will develop the skill of single photon detection and theoretical modeling.

- **Molecular absorption and emission spectrophotometer**: The objective is to study photophysical properties of molecules by measuring absorption and emission spectra. Preparation of molecular solution and data analysis skills will be developed.
- **Reverse engineering of any vacuum pump**: A rotary pump along with its manual will be provided to the students. They have to dismantle this pump and assemble it and learn about its internal parts. This process helps in the development of skills related with assembling (spatial skills).
- **Design and making of any components**: This involves training to make technical drawing, operate lathe for shaping and making any given components.
- **Skill development for carpentry**: Self explanatory

**Textbooks:**

Not Available

## 19.59 PH 612: Nuclear and Particle Physics

**Course Code: PH 612**

**Course Name: Nuclear and Particle Physics**

L-T-P-C: 3-0-0-3
Prerequisites: Quantum Mechanics, Electromagnetic Theory
Intended For: I-Ph.D., M.Sc., B.Tech 3rd and 4th Year
Core/Elective: Elective
Approval: 10th Senate

**Course Contents**

- **Properties of Nuclei**
- Nuclear size, nuclea radius and charge distribution, mass and binding energy, semiempirical mass formula, angular momentum, parity and isospin, magnetic dipole moment, electric quadrupole moment and nuclear shape. [5 Lectures]
- **Two-body problems**
- Deuteron ground state, excited states, spin dependence of nuclear forces, two nucleon scattering, charge symmetry and charge independence of nuclear forces, exchange nature of nuclear forces, Yukawa's theory. [4 Lectures]
- **Nuclear decay**
- Alpha, Beta and Gamma decay, Gamow theory, Fermi theory, direct evidence for the neutrino. [4 Lectures]
- **Nuclear models**
- Liquid drop model, shell model, magic numbers, ground state spin, and collective model. [4 Lectures]

- **Nuclear Reactions**
- Different types of reactions, Breit-Wigner dispersion relation, Compound nucleus formation and break-up, nuclear fission, neutron physics, fusion reaction, nuclear reactor. [5 Lectures]
- **Elementary particles**
- Fundamental interactions. Particle Zoo: Leptons, Hadrons. Organizing principle: Baryon and Lepton Numbers, Strangeness, Isospin, The eightfold way. Quarks: Color charge and strong interactions, confinement, Gell-Marm - Okubo mass. relation, magnetic moments of Hadrons. Field Bosons: charge carrier. The Standard Model: party non conservation of weak interaction, Wu's experiment, elementary idea about electroweak unification, Higgs boson and origin of mass, quark model, concept of colour charge, discrete symmetries, properties of quarks and leptons, gauge symmetry in electrodynamics, particle interactions and Feynman diagrams. [18 Lectures]

**Text Books:**

1. K. S. Krane, **Introductory Nuclear Physics**, John Wiley, 2008.
2. D. J. Grifths, **Introduction to Elementary Particles**, John Wiley & Sons, 2008.

**Reference Books:**

1. W. E. Burcham and M. Jobes, **Nuclear and particle Physics**, John Wiley & Sons, 1979.
2. W. L. Cottingham and D. A Greenwood, **An Introduction to Nuclear Physics**, Cambridge University Press, 2001.
3. A. Das and T. Ferbel, **Introduction to nuclear and particle physics**, John Wiley, 2003.
4. M. A. Preston and R. K. Bhaduri, **Structure of the nucleus**, Addison-Wesley, 2008.
5. S. N. Ghoshal, **Atomic and Nuclear Physics**, Vol. 2, S. Chand, 2010.
6. Roy and B. P. Nigam, **Nuclear Physics: Theory and Experiment**, New Age.
7. D. Perkins, **Introduction to High Energy Physics**, 4th Edition, Cambridge University Press, 2000.
8. L. Kane, **Modern Elementary Particle Physics**, Westview Press.
9. B. R. Martin, **Nuclear and Particle Physics: An Introduction**, Wiley, 2013.

## 19.60 PH 612: Numerical and Computational Methods

**Course Code: PH 612P**

**Course Name: Numerical and Computational Methods**

L-T-P-C: 4-0-0-4
Prerequisites: Quantum Mechanics, Electromagnetic Theory
Intended for: 1-Ph.D., M.Sc., B.Tech 3rd and 4th Year.
Core/Elective: Elective
Approval: 9th Senate

**Course Contents:**

- **Module I:** Introduction to C: Program Organization and Control Structures loops, arrays, and function, Error, Accuracy, and Stability. (12 lectures)
- **Module II:** Interpolation and Extrapolation - Curve Fitting: Polynomial Interpolation and Extrapol˜tj.on Gubic Spline Interpolation Fitting Data to a Straight Line. (7 lectures)
- **Module III:** Integration and differentiation:Numerical Derivatives Romberg Integration Gaussian Quadratures and Orthogonal Polynomials (?lectures)
- **Module IV:** Root Finding:Newton-Raphson Method Using Derivative- Roots of a Polynomial (6lectutes)
- **Module V:** Ordinary Differential Equations: Runge-Kutta Method, Adaptive Stepsize Control for Runge-Kutta (8 lectUres)
- **Module VI:** Matrices and algebraic equations: Gauss-Jordan Elimination Gaussian Elimination with Backsubstitution, LU Decomposition and Its Applications Reduction of a Symmetric Matrix to Tridiagonal Form: Eigenvalues and Eigenvectors of a Tridiagonal Matrix Hermitian Matrices. (14 lectures)

**Textbooks:**


1. B W Kernighan and D M Richie, **The C Programming Language**, PHI Learning Pvt. Ltd, 2011.
2. S D Conte and C de Boor, **Elementary numerical analysis : algorithmic approach**, McGrawHill International, 1980.


**References:**


1. V. Rajaraman, **Computer Programming in C**, PHI Learning Pvt. Ltd., 2011.
2. Germund Dalquist and Ake Bjork, **Numerical Methods**, Dover Publications, 1974.
3. William H. Press, Saul A. Teukolsky, William T. Vetterling, and Brian P. Flannery, **Numerical Recipes**, Cambridge University Press, 1992.

## 19.61 PH 613: Special Topics in Quantum Mechanics

### Course Code: PH 613

### Course Name: Special Topics in Quantum Mechanics

L-T-P-C: 3-0-0-3
Prerequisites: First course on Quantum Mechanics and faculty consent
Intended For: I-Ph.D., M.Sc., B.Tech 3rd and 4th Year
Core/Elective: Elective
Approval: 10th Senate

### Course Contents

- **Review of Basic Concepts**
- Review of basic concepts in quantum mechanics, measurements, observables and generalized uncertainty relations, change of basis, generator of translation [6 Lectures]
- **Angular Momentum**
- General theory of angular momentum, Angular momentum algebra, Addition of angular momenta, Clebsch-Gordon coefficients, Tensor operators, matrix elements of tensor operators, Wigner-Eckart theorem [9 Lectures]
- **Scattering Theory**
- Non-relativistic scattering theory. Scattering amplitude and cross- section. The integral equation for scattering. Born approximation. Partial wave analysis, optical theorem [8 Lectures]
- **Symmetries in Quantum Mechanics**
- Symmetry principles in quantum mechanics, conservation laws and degeneracies, discrete symmetries, parity and time reversal [5 Lectures]
- **Second Quantization**
- Systems of identical particles, Symmetric and antisymmetric wavefunctions. Bosons and Fermions. Pauli's exclusion principle, occupation number representation, commutation relations, applications of second quantization [5 Lectures]
- **Instructors may choose any one of the modules given below:**
- Elements of relativistic quantum mechanics. The Klein-Gordon equation. The Dirac equation. Dirac matrices, spinors. Positive and negative energy solutions, physical interpretation. Nonrelativistic limit of the Dirac equation [7 Lectures]
- Quantum Information theory, Entanglement, EPR paradox Quantum cryptography [7 Lectures]

**Text Books:**

1. J J Sakurai, **Modem Quantum Mechanics**, Addison Wisley, 1993.
2. J J Sakurai, **Advanced Quantum Mechanics**, Pearson, 2002.
3. Cohen-Tannoudji, B Diu, F Laloe, **Quantum Mechanics**, Vol. II, 2nd Edition, Wiley, 1977.

**References:**


1. Messiah, **Quantum Mechanics**, Vol. I and II, Dover Publications, 2014.
2. Siegefried Fliigge, **Practical Quantum Mechanics**, Springer, 1994.
3. S. Raimes, **Many electron theory**, North-Holland Pub. Co., 1972.
4. W. Greiner and D. A. Bromley, **Relativistic Quantum Mechanics**, 3rd Edition, Springer, 2000.
5. Fetter and Walecka, **Quantum theory of many particle systems**, Dover Publications, 2003.
6. Merzbacher, **Quantum Mechanics**, 3rd Edition, Wiley, 2011.
7. Landau and Lifshitz, **Quantum mechanics**, 3rd Revised Edition, Butterworth-Heinemann, 1981.


## 19.62 PH 613: Quantum Mechanics II

**Course Code: PH 613**

**Course Name: Quantum Mechanics II**

L-T-P-C: 4-0-0-4
Prerequisites: First course on Quantum Mechanics and faculty consent
Intended For: I-Ph.D., M.Sc., B.Tech 3rd and 4th Year
Core/Elective: Elective
Approval: 9th Senate

**Course Contents**

- Review of basic concepts in quantum mechanics, measurements, observables and generalized uncertainty relations, change of basis, generator of translation [ 10 lectures]
- General theory of angular momentum, Angular momentum algebra, Addition of angular momenta, Clebsch-Gordon coefficients, Tensor operators, matrix elements of tensor operators, Wigner-E˜kart theorem [10]
- Non-relativistic scattering theory. Scattering amplitude and cross- section. The integral equation for scattering. ˜om approximation. Partial wave analysis, optical theorem [10]

- Symmetry principles in quantum mechanics, conservation laws and degeneracies, discrete symmetries, parity and time reversal [6]
- Systems of identical particles. Symmetric and antisymmetric wavefunctions. Bosons and Femlions. Pauli's exclusion principle. Second quantization, occupation number representation [10]
- Elements of relativistic quantum mechanics. The Klein-Gordon equation. The Dirac equation. Dirac matrices, spinors. Positive and negative energy solutions, physical interpretation. Nonrelativistic limit of the Dirac equation [8]
- **Review of Basic Concepts**
- Review of basic concepts in quantum mechanics, measurements, observables and generalized uncertainty relations, change of basis, generator of translation [10 Lectures]
- **Angular Momentum**
- General theory of angular momentum, Angular momentum algebra, Addition of angular momenta, Clebsch-Gordon coefficients, Tensor operators, matrix elements of tensor operators, Wigner-Eckart theorem [10 Lectures]
- **Scattering Theory**
- Non-relativistic scattering theory. Scattering amplitude and cross- section. The integral equation for scattering. Born approximation. Partial wave analysis, optical theorem [10 Lectures]
- **Symmetries in Quantum Mechanics**
- Symmetry principles in quantum mechanics, conservation laws and degeneracies, discrete symmetries, parity and time reversal [6 Lectures]
- **Systems of identical particles** :Symmetric and antisymmetric wavefunctions. Bosons and Femlions. Pauli's exclusion principle. Second quantization, occupation number representation [10 Lectures]
- Elements of relativistic quantum mechanics. The Klein-Gordon equation. The Dirac equation. Dirac matrices, spinors. Positive and negative energy solutions, physical interpretation. Nonrelativistic limit of the Dirac equation [8 Lectures]

**Text Books:**


1. J J Sakurai, **Advanced Quantum Mechanics**, Pearson, 2002.
2. Cohen-Tannoudji, B Diu, F Laloe, **Quantum Mechanics**, Vol. II, 2nd Edition, Wiley, 1977.
3. Landau and Lifshitz, **Quantum mechanics**, 3rd Revised Edition, Butterworth-Heinemann, 1981.
4. Fetter and Walecka, **Quantum theory of many particle systems**, Dover Publications, 2003.

5. Bjorken and Drell, **Relativistic Quantum Mechanics**, McGraw Hill Education (India), 2013.

**References:**

1. Messiah, **Quantum Mechanics**, Vol. I and II, Dover Publications, 2014.
2. S. Raimes, **Many electron theory**, North-Holland Pub. Co., 1972.
3. W. Greiner and D. A. Bromley, **Relativistic Quantum Mechanics**, 3rd Edition, Springer, 2000.

## 19.63 PH 614: Seminar and Report

**Course Code : PH614**

**Course Name : Seminar and report**

L-T-P-C : 0-0-4-2
Prerequisites : Faculty consent
Intended for : I-Ph.D.
Distribution : Core for I-Ph.D.
Semester : Semester III (Odd)
Approval: 10th Senate

**Course Contents**

Student will be continually preparing during the semester in consultation with faculty members . At the end of the semester students have to give a seminar and a report. Faculty members who are involved in the program will evaluate based on performance of students during the period and their seminar and report.

**Textbooks:**

As advised by the faculty member

**References:**

As advised by the faculty member

## 19.64 PH 614P: Experimental Research Techniques

**Course Code: PH 614P**

**Course Name: Experimental Research Techniques**

L-T-P-C : 0-0-7-4
Prerequisites : First year I-Ph.D. courses
Intended for : PG
Distribution : Core
Approval: 9th Senate

**Course Contents**

- **Transport properties of materials using homemade set up.**
- This experiment involves measuring temperature dependent resistivity of any material using four probe method and Vander Pauw methods. The skills that one will develop are to make fine contacts on the sample, learn the intricacies involved in making this set up.
- **Electronic properties of material using photoemission technique.**
- Photoemission experiments will be done on any material and its electronic properties will be studied. The skills that one will develop are the intricacies involved in conducting experiments in ultra high vacuum conditions.
- **Seebeck coefficient measurement using homemade semi automated set up.**
- Develop mini Seebeck coefficient experiment to distinguish n-type and p-type semiconductors from a mixture of it.
- **Structural properties of materials using powder x-ray diffraction (xrd) technique.**
- To understand structural phase transition of any given material. The skills that one will develop are to understand the intricacies involved in any diffraction experiment, temperature variation set up, analysis of any powder xrd pattern.
- **Optical pumping**
- The technique is useful to measure the difference between the atomic energy levels with great precision. One can also measure the resonance frequencies, and thereby measure the Zeeman splitting, the nuclear spins and the strength of the Earth's magnetic field.
- Students will develop skills to handle laser, lock in amplifier and nonlinear curve fitting.
- **Two slit interference-one photon at a time**
- This experiment will give hands on familiarity to confront wave-particle duality in a precise and definite way. It will develop the skill of single photon detection and theoretical modeling.
- **Molecular absorption and emission spectrophotometer.**
- The objective is to study photophysical properties of molecules by measuring absorption and emission spectra. Preparation of molecular solution and data analysis skills will be developed.
- **Reverse engineering of any vacuum pump.**
- A rotary pump along with its manual will be provided to the students. They have to dismantle this pump and assemble it and learn about its internal parts. This process helps in the development of skills related with assembling (spatial skills).

- **Design and making of any components**
- This involves training to make technical drawing, operate lathe for shaping and making any given components.
- **Skill development for carpentry.**
- Self explanatory

## 19.65 PH 615: Mini-thesis I

**Course Code : PH 615**

**Course Name : Mini-thesis I**

L-T-P-C : 0-0-6-3
Prerequisites : Faculty consent
Intended for : I-Ph.D.
Distribution : Core I-Ph.D.
Semester : Semester III (odd)
Approval: 10th Senate

### Modules

At the end of semester they have to submit their report and must give a seminar based on their work. A committee shall be formed to evaluate the performance of the students during the period and their report and seminar.

### Textbooks:

As advised by the faculty member

### References:

As advised by the faculty member

## 19.66 PH 617: Vacation Project II

**Course Code: PH 617**

**Course Name: Vacation Project II**

Credits: 2
Prerequisites: Faculty Consent
Distribution: Core for iPhD
Semester: Summer vacation after their first year of I-Ph.D.
Approval: 9th Senate

**Modules**

Faculty members of physics and related areas can offer this project course. Towards the end of vacation they have submit their report and must give a seminar based on their work. Evaluation will be based on their report and their talk by the faculty members involved in the program.

**Textbooks:**

As advised by the faculty member

**References:**

As advised by the faculty member

## 19.67 PH 621: Computational Methods for Physicists

**Course Code : PH 621**

**Course Name : Computational Methods for Physicists**

L-T-P-C : 3-1-0-4
Prerequisites : Facutly consent
Intended for : I-Ph.D., M.Sc., B.Tech 3rd and 4th Year.
Distribution : Core for I-Ph.D. ; Elective for the rest
Approval: 10th Senate

**Course Contents**

- **Introduction**
- Basic introduction to operating system fundamentals [4 Lectures]
- **Introduction to C**
- Program Organization and Control Structures loops, arrays, and function, Error, Accuracy, and Stability. [8 Lectures]
- **Interpolation and Extrapolation - Curve Fitting**
- Polynomial Interpolation and Extrapolation Cubic Spline Interpolation Fitting Data to a Straight Line, examples from experimental data fitting [8 Lectures]
- **Integration and differentiation**
- Numerical Derivatives Romberg Integration Gaussian Quadratures and Orthogonal Polynomials [8 Lectures]
- **Root Finding**
- Newton-Raphson Method Using Derivative - Roots of a Polynomial [8 Lectures]
- **Ordinary Differential Equations**

- Runge-Kutta Method, Adaptive Stepsize Control for Runge-Kutta, Examples from electrodynamics and quantum mechanics [8 Lectures]
- **Matrices and algebraic equations**
- Gauss-Jordan Elimination Gaussian Elimination with Backsubstitution, LU Decomposition [8 Lectures]
- **Module VIII**
- Concept of simulation, random number generator [2 Lectures]

**Textbooks:**


1. B W Kernighan and D M Richie, **The C Programming Language**, PHI Learning, 2011.
2. S D Conte and C de Boor, **Elementary numerical analysis : algorithmic approach**, McGraw-Hill International, 1980.


**References:**


1. V. Rajaraman, **Computer Programming in C**, PHI Learning Pvt. Ltd, 2011.
2. Germund Dalquist and Ake Bjork, **Numerical Methods**, Dover Publications ,1974.
3. William H. Press, Saul A. Teukolsky, William T. Vetterling, and Brian P. Flannery, **Numerical Recipes**, Cambridge University Press, 1992.


## 19.68 PH 622: Mini-thesis II

**Course Code : PH 622**

**Course Name : Mini-thesis II**

L-T-P-C : 0-0-6-3
Prerequisites : Facutly consent
Intended for : I-Ph.D.
Distribution : Core for I-Ph.D.

Semester : IV
Approval: 10th Senate

### Course Contents

Modules: At the end of semester they have to submit their report and must give a seminar based on their work. A committee shall be formed to evaluate the students performance during the period and their report and seminar.

The work carried out in this program during semester III and semester IV will be considered as part of their M.Sc. Thesis work.

**Textbooks:**

As advised by the faculty member

**References:**

As advised by the faculty member

## 19.69 PH 625 : Data Analysis in Particle Physics

**Course Code : PH 625**

**Course Name : Data Analysis in Particle Physics**

L-T-P-C : 2-0-4-4
Intended for : UG/PG/I-PhD/PhD elective
Prerequisite : PH 621 (Computational Methods for Physicists), PH612 (Nuclear and Particle Physics)
Mutual Exclusion: None
Approval: 52nd BoA

**Course Contents**

- **Data in Experiments, Particle Physics** [4 Lectures]
  - Brief overview of experiments in High Energy Physics. RHIC & CERN experiments.
  - Data from Experiments: Pulse processing, Timing and energy resolution, Tracking, Particle Identification (PTD).
  - Analysis Methods: Acceptance, Efficiency, Error Calculations, Observable quantities.
  - Data Stmcture/Type/Fonnat and algorithms from experiments and handling.
- **Recalls** [10 Lectures]
  - Brief Overview of c++: Program Organization and Control Stmctures loops, arrays, and fimction, Error, Accuracy, and Stability. Transition from C to c++.
  - Brief Overview of numerical analysis in c++: Curve Fitting, ROOT finding, Integration and differentiation, Interpolation and Extrapolation
- **ROOT Framework and Familiarities [in root/pyroot/rootpy]** **[15 Lectures]**
  - Introduction to ROOT: Is an object-oriented programming framework based on c++ developed by CERN. Originally designed for particle physics, but it is used in other applications such as astronomy and data mining. ROOT has capability to work in any field and potential to scale globally.
  - ROOT installation: ROOT is available on Linux, Mac. and (as a beta release) on Windows. The latest stable ROOT re lease is updated.

- ROOT preliminaries:
- Mathematical foundation, input, output, functions
- Histograms handling: Writing and reading: Basic, Binning, Statistical analysis: lD, 20,30
- Tree handling: Writing and reading of the key feature of root
- Libraries and useful tools
- Fitting data: Formulas, Reading data, Writing data, TFI functions, Fittings.

- **Visualization in ROOT [in root/pyroot/rootpy]** (10 Lectures)
  - Histograms: 1D, 2D, 3D and asymmetric binning
  - Trees, TProfiles, TBrower
  - Graph Plotting, TCanvas, TGraph, TGraphError, Graphs with asymmetric error.
  - Markers and legends
  - Histograms fitting with functions

- **Statistical Analysis and Error Methods** (7 Lectures)
  - Statistical Analysis
  - Statistical Error: Gaussian Method, Delta Theorem, Bootstrap method
  - Systematic error Estimation

- **Data Gneration and Models** (5 Lectures)
  - Concept of Simulation
  - Random Generators
  - Monte Carlo Simulation and Data Generation

- **Data Analysis: Class Project** (5 Lectures)
  - Astro Physics data analysis High Energy Physics data Analysis

**Textbooks:**

1. Yashavant Kanetkar, Let Us C: Authentic guide to C programming.
2. Yashavant Kanetkar, Let Us C++.
3. https:/IROOT.cem/manual/
4. David J. Griffiths, Introduction to Elementary Particles
5. William R. Leo, Techniques for Nuclear and Particle Physics Experiments
6. Fred James, Statistical Methods in Experimental Physics

**References:**


1. Yashavant Kanetkar, Let Us C++ Solutions
2. ROOT.cern.ch
3. cern.ch
4. rhic.bnl.gov


## 19.70 PH 626 : Elementary Theoretical Particle Physics

**Course Code : PH 626**

**Course Name : Elementary Theoretical Particle Physics**

L-T-P-C : 3-0-0-3
Intended for : UG/PG/I-PhD/PhD
Prerequisite : PH612 (Nuclear and Particle Physics), PH301/PH513 (Quantum Mechanics)
Mutual Exclusion:
Approval: 52nd BoA

**Course Contents**

- **Feynman Calculus:** Decays, scattering and cross-sections, Mandelstem variables, Fermi Golden rule, Golden rule for two particle decays and scattering of particles, two-body scattering in the COM frame. Feynman rules and diagrams for a toy theory. (6 Lectures)
- **Quantum Electrodynamics:** Dirac equation, solutions to the Dirac equation, and bilinear covariants, photon, Feynman rules for QED and examples, Casimir's Trick, cross-sections and lifetimes, and renormalization, hadron production in e+e- collisions, elastic electron-proton scattering. (10 Lectures)
- **Quantum Chromodynamics:** Feynman rules for Chromodynamics, Color factors, quark and antiquark, Pair annihilation in QCD, asymptotic freedom. (8 Lectures)
- **Weak Interactions:** Charged leptonic weak Interactions, decay of muon, neutron, and pion, charged weak interactions of quarks, neutral weak interactions, Electroweak unification and chiral fermion states, Weak isospin and hypercharge, Electroweak mixing. (10 Lectures)
- **Gauge Theories:** Lagrangian formulation of classical particle mechanics and Lagrangians in relativistic field theory, Local gauge invariance and Yang-Mills Theory, Chromodynamics, Feynman rules and Mass term Spontaneous symmetry-breaking, Higgs Mechanism. (8 Lectures)

**Textbooks:**

1. David Griffiths, **Introduction to Elementary Particles**, 2nd edition, Wiley, 2008.
2. F. Halzen and A. D. Martin, **Quarks and Leptons**, John Wiley, 2016.

**References:**


1. M. Thomson, **Modern Particle Physics**, Cambridge University Press India, 2016.
2. M. E. Peskin, **An Introduction to Quantum Field Theory**, Westview Press, 1995.
3. D. H. Perkins, I**ntroduction to High Energy Physics**, 4th Edition, Cambridge, 2000.


## 19.71 PH 627 : Topological Quantum Matter

**Course Code : PH 627**

**Course Name : Topological Quantum Matter**

L-T-P-C : 3-0-0-3
Intended for : UG/PG/I-PhD/PhD
Prerequisite : PH513, PH523
Mutual Exclusion:
Approval: 52nd BoA

**Course Contents**

- The basics: Potentials in quantum mechanics, Aharanov-Bohm effect, Monopoles in physics, Berry phase. [4 Lectures]
- Symmetries: Time-reversal symmetry (TRS) in classical and quantum mechanics, TRS operator, Kramer's degeneracy, Symmetries in momentum space, Inversion symmetry, particle-hole symmetry, ten-fold classification. [6 Lectures]
- 1D Lattice models: Lattice models and band in momentum space, Peierl's instability, Su-Schrieffer-Heeger model, Berry phase effect on dynamics, topological index, charge fractionalization. [6 Lectures]
- Quantum Hall Effect: Kubo formula and TKNN invariant, quantization of Hall conductance, QHE in 2DEG, Landau levels, QHE in graphene. [6 Lectures]
- Topological insulators: Graphene, Dirac points, topological insulators, , Anomalous Hall Effect, BHZ model, edge states of BHZ model. Kane-Mele model, Z2 invariant, 3D topological insulators, strong and weak TI. [6 Lectures]
- Topological metals: Accidental degeneracies, Weyl and Dirac fermions, symmetry analysis, chiral anomaly, anomalous Hall effect, Fermi arcs, Weyl semimetals, Dirac semimetals. [5 Lectures]

- Majorana fermions: Topological superconductivity, Majorana fermions, Majorana modes in chiral p-wave superconductors, Majorana modes in Rashba spin-orbit coupled semiconductors, detection of Majorana fermions. [5 Lectures]

- Miscellaneous Topics: Quantum Spin Liquid, RVB, Kitaev model, spin fractionalization. Materials research, experimental realization of several topological phases in TIs and topological metals. Electronic structure theory aspect of topological phases. [4 Lectures]

**Textbooks:**

1. B. Andrei Bernevig, Taylor L. Hughes, Topological Insulators and Topological Superconductors, Princeton Universtiy Press, 2013

2. Shun-Qing Shen, Topological Insulators: Dirac Equation in Condensed Matter, Spinger, 2012

**References:**

1. R. Shankar, **Topological Insulators - A review**, https://arxiv.org/pdf/1804.06471.pdf

2. M. Z. Hasan, C. L. Kane, **Topological Insulators**, https://arxiv.org/pdf/1002.3895.pdf

3. Xiao-Liang Qi and Shou-Cheng Zhang, **Topological insulators and superconductors**, https://arxiv.org/pdf/1008.2026.pdf

4. N.P. Armitage, E. J. Mele, Ashvin Vishwanath, **Weyl and Dirac Semimetals in Three-Dimensional Solids**, https://arxiv.org/pdf/1705.01111.pdf

5. David Vanderbilt, **Berry Phases in Electronic Structure Theory**, Cambridge University Press, 2018

## 19.72 PH 701: Introduction to Molecular Simulations

**Course Code: PH 701**

**Course Name: Introduction to Molecular Simulations**

L-T-P-C: 2-2-0-4
Prerequisite: Master-level courses in Physics/Chemistry
Students intended for: Ph.D.
Elective or Core: Elective
Approval: 11th Senate; OTA

**Course contents**

- **Classical statistical mechanics**

- **Ensembles**

- microcanonical, canonical, grand canonical ensembles ideal gas- harmonic oscillator – Spin Systems. Introduction to Stochastic process, Brownian Motion, Langevin equation, Fokker- Planck equation, Introduction to liquid state theory- pair distribution functions- structure factor- coherent and in-coherent scattering- Ornstein-Zernike correlation function Diffusion in a liquid- mean square displacement- self and collective van Hove correlation function – Intermediate scattering function and dynamics structure factor.
- **Programing in C and Fortran 95**
- Essential for programming in this course
- **Introduction of Monte Carlo methods**
- Value of using MC method, Gaussian distribution from 1d random walk, Metrapolis algorithm for construction NVT ensemble, Implementation of ensemble using MC methods.
- **Project 1**
- Write a Monte Carlo simulation to simulate model liquid.
- **Introduction to Molecular dynamic simulations**
- Molecular dynamics simulations, Numerical integration of linear differential equations, Leap-Frog algorithm, Velocity Verlet algorithm, Periodic boundary condition one, two and three dimensions.
- **Project 2**
- Write a MD simulation code for simple liquids and for a polymer chain connected by harmonic spring.
- **Introduction to Brownian and Lengevin dynamics simulations**
- Simple Brownian dynamics algorithm without hydrodynamic interactions.Langevin dynamics simulations.
- **Project 3**
- Write a Brownian dynamics code to simulate colloids in a solution and motion of single polymer chain.
- **Analysis data from simulations**
- Computation of radial distribution function, Structure factor, Time series analysis, Mean square displacement.
- **Project 4**
- Using trajectories produced from the earlier simulation to compute: Radial distribution functions. Mean square displacement of center of mass and monomers for a polymer chain. Computation of stress, stress correlation function and viscosity.

**Text & Reference Books:**

1. R. K. Pathria, **Statistical Mechanics**
2. **Introduction stochastic process in physics and astronomy**, Rev. Mod. Phys., 1, 15, 1943.
3. J. A. Barker and D. Henderson, **What is liquid? Understanding the state of matter**, Rev. Mod. Phys. 587, 48, 1976.
4. J. P. Hansen and I. R. McDonald, **Theory of simple liquids**
5. D. A. McQuarrie, **Statistical Mechanics**.
6. M. P. Allen and D. J. Tildesey, **Computer simulation of liquids**
7. Daan Frenkel, **Understanding molecular simulation**.
8. D. C. Rappaport, **The art of molecular dynamics simulations**.
9. D. P. Landau and Kurt Binder, **A guide to Monte Carlo simulations in statistical Physics**.

## 19.73 PH 702 (3) Theoretical Atomic Physics

Approval: 8th Senate, 14th Senate; OTA

**Course Outline:**

- Quantum Mechanics and symmetry'of hydrogen atom; Rotational and dynamical symmetry of of the M potential, degeneracy of hydrogen atom (S04) (6 lectures)
- Angular momentum algebra in quantum mechanics, agnular momentum addition, Direct product, CGC ˜ recursion relations,irreducible tensor operators, wigner-eckart theorem (8 lectures)
- Relativistic quantum mechanics, Dirac equation, Relativistic hydrogen atom, Foldy-Wouthysen transformations, perturbative treatment of relativistic effects (8 lectures)
- Hartree-Fock formalism, self-consistent formalism, Koopmans' theorem (6 lectures)
- Probing the atom, atomic collision and boundary conditions, Time reversal symmetry, photoionization as half-scattering (4 lectures)
- Atomic photoinization cross section and angular distribution parameters, Cooper-late formula (4 lectures)
- Basic introduction to Laser cooling, BEC, atomic clock and attosecond metrology (4 lectures)

## 19.74 PH 702: Advanced Quantum Mechanics

**Course Code: PH 702**

**Course Name: Advanced Quantum Mechanics**

L-T-P-C: 3-0-0-3
Prerequisites: None
Intended For: PhD
Core or Elective: Elective
Approval: 2nd Senate

**Course Contents**

- **Module I**
- Review of basic concepts in quantum mechanics, measurements, observables and generalized uncertainty relations, change of basis, generator of translation [3 Lectures]
- **Module II**
- Rotations and angular momentum commutation relations, spin-1/2 systems and finite rotations of general theory of angular momentum, addition of angular momenta, Clebsch-Gordon Coefficient (CGC) and its properties, conventions of CGC, choice of phases and 3-j symbols, Schwinger's oscillator model of angular momentum [4 Lectures]
- **Module III**
- Tensor operators, Cartesian tensors, irreducible tensor operators, matrix elements of tensor operators, Wigner-Eckart theorem and its applications [4 Lectures]
- **Module IV**
- Symmetry principles in quantum mechanics, conservation laws and degeneracies, discrete symmetries, parity and time reversal, symmetry in collision and ionization process [4 Lectures]
- **Module V**
- Approximation methods in quantum mechanics, review of non-degenerate perturbation theory, degenerate perturbation theory, time dependent perturbation theory, periodic perturbation, Rabbi flopping frequency, Adiabatic approximation, Berry phase, sudden approximation [5 Lectures]
- **Module VI**
- Interaction of quantum systems with radiation, Dipole approximation and selection rules, length, velocity and acceleration forms of matrix transition matrix elements, Absorption process, spontaneous emission, stimulated absorption, Einstein coefficients, life times, line intensities, widths and shapes [5 Lectures]
- **Module VII**

- Many electron atoms, central field approximation, self-consistent field method, Hartree-Fock equations, Koopman's theorem [5 Lectures]
- **Module VIII**
- Relativistic quantum mechanics, Klein-Gordon equation, Dirac equation, probability densities and current densities, plane wave solutions of Dirac's equation, solutions of the Dirac equation for a central potential, non-relativistic limit of Dirac equation, negative energy states and hole theory [5 Lectures]
- **Module IX**
- Second quantization, creation and destruction operators, occupation numbers, commutation relations, matrix elements of H for N-electron systems, field operators [5 Lectures]

**Text & Reference Books:**


1. J.J. Sakurai, **Modern quantum mechanics**
2. Tannoudji, B Diu, F Laloe, **Quantum Mechanics** -Vol. I & II, Cohen.
3. Messiah, **Quantum Mechanics**, Vol. I and II
4. Bransden and Joachain, **Quantum mechanics**
5. Bransden and Joachain, **Physics of atoms and molecules**
6. R Shankar, **Principles of quantum mechanics**.
7. S. Raimes, **Many electron theory**.
8. Bethe, **Intermediate quantum mechanics**.
9. Landau & Lifshitz, **Quantum mechanics**.


## 19.75 PH 705: Foundations in Experimental Physics

**Course Code: PH 705**

**Course Name: Foundations in Experimental Physics**

L-T-P-C: 3-0-1-4
Intended for: Ph. D (Physics)
Core/Elective: Elective
Approval: 1st Senate

**Course contents**

- **PART-A** Lectures on experiments, which made an impact on physics and/or lectures on new/modem experiments of current importance to frontier research in Physics. (Lecture Hours: 24)
- A1: Great Experiments In Physics:
- Starting with Galileo's experiments with motion, this study of 25 crucial discoveries includes Newton's laws of motion, ChadwicK's study ofth neutron, Hertz on electromagnetic waves, and more.
- A2: Top I 10 beautiful experiments:
  1. Young's double-slit experiment applied to the interference of single electrons
  2. Galilee's experiment on falling bodies (1600s)
  3. Millikan's oil-drop experiment (191 Os)
  4. Newton's decomposition of sunlight with a prism (1665-1666)
  5. Young's light-interference experiment (1801)
  6. Cavendish's torsion-bar experiment (1798)
  7. Eratosthenes' measurement of the Earth's circumference (3rd century BC)
  8. Galileo's experiments with rolling balls down inclined planes (1600s)
  9. Rutherford's discovery ofthe nucleus (1911)
  10. Foucault's pendulum (1851)
- Others experiments:
  - Archimedes' experiment on hydrostatics
  - Roemer's observations of the speed of light
  - Joule's paddle-wheel heat experiments
  - Reynolds's pipe flow experiment
  - Mach & Salcher's acoustic shock wave
  - Michelson-Morley measurement of the null effect of the ether
  - Rontgen's detection of Maxwell's displacement current
  - Oersted's discovery of electromagnetism
  - The Braggs' X-ray diffraction of salt crystals
  - Eddington's measurement of the bending of starlight
  - Stem-Gerlach demonstration of space quantization
  - Schr1idinger's cat thought experiment
  - Trinity test of nuclear chain reaction
  - Wu et al.'s measurement of parity violation
  - Goldhaber's study of neutrino helicity
  - Feynman dipping an 0-ring in water

- A3: Experiments of current interest:
- A3.1 Proton lifetime measurement
- A3.2 Bose-Einstein Condensation.
- A3.3 Measurement ofthe Fine-Structure Constant.
- A3.4 Experimental tests of Bell's inequalities
- A3.5 Experiments on Quantum Computation
- A3.6 The High Temperature Superconductivity Space Experiment
- A3.7 Study of electrnoic structure of materials using photoemission spectroscopic experiments (angle integrated, angle resolved and spin resolved photoemission experiments)

- Part-B Actual Laboratory Experiments [14 Lecture Hours]. Experiments will be chosen from the list below:

1. Four probe method
2. Michelson Interferometer (white light)
3. Sand piles and rice piles, avalanche distribution
4. X-ray of an NaCl single crystal
5. Directed percolation – spreading of ink on paper
6. Viscous fingering - effect of viscosity
7. Hall effect
8. Measurement of Band Gap in a Semiconductor
9. Construction of a hologram
10. Zeeman Effect
11. Kerr Effect
12. Short Noice and Johnson noise – measurement of Boltzmann Constant
13. Absolute zero of temperature and charge of electron
14. Preparation (CVD) and characterization (AFM, STM) of thin films
15. Experiments on photon squeezing, Bose-Einstein condensation, parity-violation in weak interaction

- Part – C Demonstrations in the experimental laboratories in our Institute [Lecture Hours: 18]

**References:**


1. Morris H. Shamos, **Firsthand Accounts from Galileo to Einstein**
2. http://physicsweb.org/articles/world/15/9/2
3. Webb, Denis C., Nisenoff, M., **Microwave Journal**, 1991.
4. Nisenoff M., Gubser D.U., Wolf, S.A., Ritter J.C., Price G.Source, **High temperature superconductivity space experiment (HTSSE)**, Superconductor, Science and Technology, Volume 4, Number 9, 1991.
5. Stephan Hufner(ed.), **Very high resolution Photoelectron spectroscopy**, 2007.

## 19.76 PH 706: Introduction to Stochastic Problems in Physics

### Course Code: PH 706

### Course Name: Introduction to Stochastic Problems in Physics

L-T-P-C: 3-0-0-3
Prerequisites: Masters Level Courses in Mathematical Physics, introductory statistical mechanics course
Students intended for: Ph D
Elective or Compulsory: Elective
Approval: 2nd Senate

### Course Contents

- **Module I**
- Introduction random walk in lD, Mean values of random walk problem, Probability distribution for large N, Binomial and Gaussian distributions. Probability distribution of many variables, continuous probability distributions . General calculation of mean values for the random walk. Example of random walk problem, freely joined model for polymers, Gaussian chains.
- **Module II**
- Historical introduction to stochastic process. Einstein's formulation of the random walk. Comparison between ordinary and stochastic differential equation. Differential equation of probability - the diffusion equation from - random walk - kinetic argu01ents. Definition of the diffusion coefficient.
- **Module III**
- Langevin equation for a Brownian particle - average velocity and mean square displacement. Formal solution. Probabilistic approach to stochastic process. Birth and death process - master equation. Noise in the electronic system - short noise and Johnson noise. Poisson distribution - formulation of the differential equation. Limitation of ordinary calculus.
- **Module IV**
- Definition of a stochastic variable, probability distribution, probability density distribution. Transformation between stochastic variable. Characteristic function, moments and cumulants. Stochastic process of many variables. Conditional probability density, cross correlations. Multivariate Gaussian distribution.
- **Module V**
- Time depended random variables, stationary processes. Classification or stochastic process, purely random, Markov process, and non-Markovian process. Chapman Kolrnogorov equation-Weiner Khinchine theorem.
- **Module VI**

- Langevin equation revisited - velocity autocorrelation function- mean square displacement. Maxwell Boltzmann distribution from moments of velocity. Ornstein Uhlenbeck process, Green's function solution, correlation function, moments, solution by Fourier transformation. Non-linear Langevin equation- Kubo oscillator. Drift and diffusion coefficients - Kramer's Moyal expansion coefficients- Ito and Stratonovich's definitions o.f stochastic calculus.

- **Module VII**

- Fokker-Planck equation- Kramers Maya! Forward and backward expansion and equivalence. Fokker-Planck equation for one variable. Application of truncated Kramer's Moyal expansion. FP equation of many variables with examples. Methods of solution of FP equation of one variable.

- **Module VIII**

- Discussion of Kramers problem of escape over barrier. Master equations. Probabilistic approaches molecular systems. BBGKY higherary. Boltzmann equation. Quantum stochastic processes. Master equation approaches to density matrix. Linear response theory - fluctuation dissipation theory.

**Text & Reference Books:**

1. H Risken, **The Fokker-Planck Equation Methods of solution and applications**, Springer

2. C Gardiner, **Stochastic Methods: A Handbook for the Natural and social science**, Springer

3. Herm.an Haaken, **Synergetics : An introduction**, Springer.

4. D Middleton, **An introduction to statistical Communication theory**, Peninsula Publishing

5. Nelson Wax, **Collected papers in noise and stochastic process**, Dover

6. F Reif, **Fundaments of Statistical and thermal physics**, McGrew Hill

7. M Doi and S F Edwards, **Theory of polymer dynamics**, Oxford University Press.

8. W Feller, **An introduction to probability theory and and its applications**, Vol. I & II, John Wiley & Sons.

9. H S Wio, **An introduction to stochastic processes and non-equilibrium statistical physics**, World Scientific.

# 20 Centre for Quantum Computing Courses Courses

## 20.1 QS 501P : Experiments in Quantum Optics

**Course Code : QS 501P**

**Course Name : Experiments in Quantum Optics**

L-T-P-C : 0-0-5-3
Intended for : B.Tech, M.Tech, M.Sc, Ph.D.
Prerequisite : First course on Quantum Mechanics
Mutual Exclusion:
Approval: 54th BoA

**Course Contents**

- NA

**Laboratory/practical/tutorial Modules:**

1. Fourier Transform: To demonstrate the Fourier Transform of sample images
2. Optical Tweezers: Demonstrate microscale particle manipulation dynamics through laser induced forces using Portable Optical Tweezers.
3. Optical Vortices: Demonstrate the Optical Vortices corresponding to various topological charges.
4. Quantum Eraser: To demonstrate the sensitivity of path information on the measurement process
5. Polarized 3D Cinema: Create a 3D Projection using circularly polarized light based on Real 3D Cinema Technology
6. Bomb Tester: Experiment on Interaction-free Quantum measurements: Testing the Bombs in Michelson Interferometer
7. Quantum Cryptography: Demonstration of BB84 Quantum Cryptography Protocol and detection of eavesdropper on Encrypted data

**Textbooks:**

1. Christopher Garry, **Introductory Quantum Optics**, Cambridge University Press, 2012.
2. Mark Fox, **Quantum Optics: An Introduction, Oxford master series in Physics**, 2006.
3. Laboratory manual for experiments

**References:**

1. NA

# 21 Research Methodology Courses

## 21.1 RM 510 : Research Methodology

**Course Code: RM 510**

**Course Name : Research Methodology**

L-T-P-C : 1-0-0-1
**Intended for :** MS/PhD
**Prerequisite :** None
**Mutual Exclusion :** None
Approval: 9th Senate

**Course Contents:**

Each topic below represents one lecture.

- **Introduction:** What is research, how research has benefited human society
- **Literature survey:** What is it? Why is it needed? How to do a literature survey, how to read a research paper, use of tools like Google Scholar, CiteSeer etc.
- **Ph.D degree and thesis:** What are the objectives, and what are not. What is the role of the advisor and the scholar?
- **Things that may help a research scholar:** for example, maintain a daily routine, attend talks in other areas, go for others' Ph.D. seminars, maintain physical fitness, time management etc.
- **Research ethics:** plagiarism, academic dishonesty, a few case studies
- **Writing:** How to write good papers, and research proposals
- **Presentation:** How to make good presentations
- **School-specific lecture 1**
  - SHSS: Theory (broad topics, specific to the discipline ofthe student)
  - SBS: Important sources of literature -journals and conferences of RSC, ACS, AMS, lOP, APS, ScienceDirect, use of different reference tools
  - SCEE: Important sources of literature- journals and conferences of ACM, IEEE etc. • SE: Intellectual property rights
- **School-specific lecture 2**
  - SHSS: Practice (broad topics, specific to the discipline of the student)
  - SBS: Introduction to software like ChemDraw, SolidWorks- 1
  - SCEE: Using computing tools: HPC cluster, LaTeX, Matlab, producing figures and plots
  - SE: Good practices for numerical simulations

- **School-specific lecture 3**
  - SHSS: Writing (broad topics, specific to the discipline ofthe student)
  - SBS: Introduction to software like ChemDraw, SolidWorks-2
  - SCEE: Reproducible research in computer science and electrical engineering
  - SE: Good practices for experimental methods
- Writing a research proposal and making presentation. Each student will prepare a 3-page proposal and give a 10-minute presentation on it.
- Exercise 1
- Exercise 2
- Exercise 3
- Exercise 4

**Note on abbreviations:**

- SHSS: School of humanities and social sciences
- SBS: School of basic sciences
- SCEE: School of computing and electrical engineering
- SE: School of engineering

**TextBooks:**

**Reference Books:**


1. Richard Hamming, **You and your research**, Bell Communications Research Colloquium Seminar, 1986 (Transcription available online.)
2. Cone, J.D. & Foster, S.L., **Dissertations and theses from start to finish**, DC,APA, 2006.
3. Galvin, J.L., **Writing literature reviews: A guide for students of the social and behavioral sciences**, 4th Edition, Pyrczak, 2009.
4. Gilpin, A.A., **A guide to writing in the sciences**, U. Toronto Press, 2000.
5. Gustavii, B., **How to write and illustrate a scientific paper**, Cambridge University Press, 2003.
6. Babbie, E.R.,. **The practice of social research**, Wadsworth, 2010.

## 21.2 RM 600 Research Methodology

**Course Code: RM 600**

**Course Name: Research Methodology**

L-T-P-C: 1-0-0-1
Students intended for: MS/ Ph.D.
Prerequisites: MA 202 for undergraduate
Elective or Core: Compulsory
Grading Pattern : Satisfactory / Not Satisfactory
Approval: 5th Senate

**Course Contents:**

- Why research/Getting research ideas/Executing research
- Aspect teacher-students relationship/stress management
- Communication
- Oral presentation
- Introduction IIT Mandi library resources
- Introduction to Latex/Google docs
- Common errors in English
- Technical paper/proposal writing
- Best practices for numerical simulations
- Best practices for experimentation
- Safety precautions in experiments
- Result analysis/scrutinizing
- Copyright
- Plagiarism
- Ethics in research

**Reference Books:**

1. Wyne C. Booth, Colomb, William, **The Craft of Research**, University of Chicago Press.
2. Ranjit Kumar, **Research Methodology: A Step-By-Step Guide For Beginners**, Sage South Asia, 2011,
3. R Panneerselvam, **Research Methodology**, PHI Learning, 2009.
4. C. R Kothari, **Research Methodology: Methods and Techniques**, New Age International, 2004.