Proposal

For

B.Tech-M.Tech Integrated Dual Degree

In

Bioengineering

School of Basic Sciences,

School of Computing and Electrical Engineering,

School of Engineering,

Indian Institute of Technology Mandi

Integrated Dual degree (IDD) B.Tech and M.Tech in Bioengineering

Preamble to the programme:

Bioengineering integrates physical, chemical, mathematical, computational and life sciences with core engineering principles driving the technologies towards advances and applications in health, environment, agriculture, energy etc thereby improving the quality of life. It creates knowledge from the molecular to organ systems levels, develops materials, devices, systems, information approaches, technology management, and methods for assessment and evaluation of technology, for the biological applications. The discipline of bioengineering has evolved drastically over the past 50 years, seemingly encompassing all fields that include bioelectric phenomena, bioinformatics, biomaterials, biomechanics, bioinstrumentation, biosensors, biosignal processing, biotechnology, computational biology, medical imaging, etc. The B.Tech and M.Tech dual degree programme on Bioengineering strives to train the students in the field of physical, chemical, mathematical and biological sciences together with engineering principles for inculcating knowledge enabling them in developing and deploying Bioengineering technologies in various fields.

MTech allows the Bioengineers to specialise in four advanced focused areas:

a) Biomedical Engineering aimed at gaining expertise in the areas of diagnostics, therapeutic and assistive support for healthcare applications.

b) Agricultural Automation Technology aimed at providing automation and assistive support to agricultural practices.

c) Environmental Science and Engineering aimed at training bioengineers to develop environment friendly processing technologies involving bio-organisms.

d) Computational Bioengineering aimed at both developing algorithms and models to understand biological systems and processes.

The curriculum will impart training to budding students that will cater to the requirements of Bio-based industries. At IIT Mandi, a student needs to complete 160 credits for B.Tech in 4 years and 70 credits for M.Tech in two years. The integrated dual degree programme in Bioengineering allows the students to go through a rigorous framework of core courses at Bachelors and Masters level and a comprehensive and detailed project and dissertation work which allows a student to graduate in 5 years with a B.Tech-M.Tech integrated dual degree earning 206 credits.

M.Tech Specializations:

1. Biomedical Engineering
2. Agro-Technology
3. Environmental Science and Engineering
4. Computational Bioengineering

A student can choose to take courses across specializations. In such a case, he/she will be awarded M.Tech in Bioengineering without any specialization.

Selection: Students will be selected through Joint Entrance (Advanced) Examination.

Provision of Scholarship in 5th year: Students are eligible for HTRA in the 5th year as per existing IIT Mandi norms for integrated M.Tech programmes.

Duration: 10 semesters. The degrees B.Tech in Bioengineering and M.Tech in specialised areas (Biomedical Engineering/Agro-Technology/Environmental Science and Engineering/Computational Bioengineering) will be awarded on completion of M.Tech. A student can choose to take courses across specializations. In such a case, he/she will be awarded M.Tech in Bioengineering without any specialization.

Objectives of the programme:

1. Assimilate knowledge of physical, mathematical and biological sciences together with engineering principles for the development of diagnostic, therapeutic and assistive technologies as well as developing algorithms and models to understand biological systems and processes.
2. Train manpower for industries dedicated to technologies applied to biological systems.
3. Develop manpower to apply engineering concepts and techniques to the investigation and exploration of biological processes.
4. Train manpower capable of solving problems related to preventive medical approaches, automation based agricultural practices, environmental friendly bioprocesses and computational techniques for understanding biological systems.

How is this programme different?

1. Strong engineering emphasis.
2. Freedom to choose between multiple specializations.
3. Industrial involvement in teaching courses.
4. Wide market opportunities.

Branch change policy: The existing branch change policy at IIT Mandi will be applicable to students enrolled in the IDD (Bioengineering) programme.

Exit option: There is no exit option available after 4th year for a single B.Tech degree in Bioengineering. This is in compliance with the existing practises of IIT s towards Integrated Dual Degree programmes.

Graduation requirements:

1. A student can complete B.Tech (Bioengineering) and M.Tech in X (X=Biomedical Engineering/Agro Technology/Environmental Science and Engineering/Computational Bioengineering) if he/she has earned 206 credits comprising of:

a. 76 credits of institute core,
b. 33 credits of discipline core,
c. 22 credits of free electives,

d. 5 credits of humanities electives,
e. 9 credits of M.Tech core and
f. 21 credits of M.Tech discipline electives,
g. 1 credit of Technical Communication,
h. 1 credit of Bioethics and Regulatory Affairs,
i. 4 credits of Mini project, Term Paper and Seminar, and
j. 34 credits of M.Tech dissertation.

2. In case a student chooses courses belonging to different baskets of M.Tech core and discipline electives, he/she can earn an M.Tech degree in Bioengineering only.
3. A student intending to do B.Tech (Hons.) in Bioengineering instead of B.Tech in Bioengineering is permitted to do so as per IIT Mandi norms.

Core faculty members:

1. Dr. Tulika Yadav (Spl: Bioinformatics, next generation sequencing technologies)
2. Dr. Shyam Kumar Masakapalli (Spl: Metabolic Systems Biology – Metabolomics and Fluxomics, NMR and GC-MS)
3. Dr. Amit Prasad (Spl: Immunology and microbiology)
4. Dr. Prosenjit Mondal (Spl: Molecular endocrinology and metabolism)
5. Dr. Amit Jaiswal (Spl: Nanobiotechnology)
6. Dr. Rajanish Giri (Spl: Biophysics and protein folding, T Cell Engineering, Protein Engineering)
7. Dr. Sarita Azad (Spl: Epidemics and Bio-surveillance)
8. Dr. Syed Abbas (Spl: Ecological modelling)
9. Dr. Rajesh Ghosh (Spl: Biomechanics)
10. Dr. Mohammed Talha (Spl: Biomechanics)
11. Dr. Sunny Zafar (Spl: Biomechanics)
12. Dr. Gaurav Bhutani (Spl: Biomechanics)
13. Dr. Anil Kr. Sao (Spl: Medical Image Analysis)
14. Dr. Arnav Bhavsar (Spl: Medical Image Analysis)
15. Dr. Aditya Nigam (Spl: Medical Image Analysis)
16. Dr. Renu Rameshan (Spl: Medical Image Analysis)
17. Dr. Srikant Srinivasan (Spl: IoT, Plant phenotyping)
18. Prof. Ajit Annachhatre (Spl: Environmental Science and Engineering)
19. Dr. Shubhajit Roy Chowdhury (Spl: Biomedical Systems)

Curriculum:

Semester I

Course Code	L-T-P-C	Course Name
IC110	2.5-0.5-0-3	Engineering Mathematics
IC152	3-0-3-4	Data Science I
IC160	3-0-0-3	Electrical Systems Around Us
IC160P	0-0-3-2	Electrical Systems Around Us Lab
IC140	2-0-3-4	Graphics for Design
IC101P	0-0-3-2	Reverse Engineering
HS106	3-0-0-3	English I
HS10X	1-0-0-1	Creative Understanding
Total	**22 credits**	

Semester II

Course Code	L-T-P-C	Course Name
IC111	2.5-0.5-0-3	Linear Algebra
IC141	2-0-0-2	Product Realization Technology
IC141P	0-0-3-2	Product Realization Technology Lab
IC161	3-0-0-3	Applied Electronics
IC161P	0-0-3-2	Applied Electronics Lab
IC252	3-0-2-4	Data Science II
HSXX1	3-0-0-3	HSS Language competence basket course
IC142	3-0-0-3	Engineering Thermodynamics
Total	**22 credits**	

Semester III

Course Code	L-T-P-C	Course Name
IC260	2.5-0.5-0-3	Signals and systems (Engg. Science basket)
IC136	3-0-0-3	Understanding Biotechnology and its applications (Science II basket)
IC2XX	2-0-2-3	Data Science III
IC240	2.5-0.5-0-3	Mechanics of Rigid Bodies
BEXX1	3-0-2-4	Biology-I
BEXX2	2-0-2-3	Biology-II
HSXX2	3-0-0-3	HSS Communication Skills basket course
Total	**22 credits**	

Semester IV

Course Code	L-T-P-C	Course Name
IC201P	0-0-6-4	Design Practicum

BEXX3	2-0-2-3	Biology-III
BEXX4	3-0-2-4	Physics and modeling of biological systems
BEXX5	2-0-2-3	Computational Biology
BEXX6	3-0-2-4	Biostatistics
BEXX7	3-0-2-4	Biomechanics
Total	**22 credits**	

Semester V

Course Code	**L-T-P-C**	**Course Name**
IC221	3-0-0-3	Foundations of Electrodynamics
IC241	3-0-0-3	Material Science for Engineers (Science I basket course)
BEXX8	1-0-0-1	Bioethics and Regulatory affairs
BEXX9	3-0-2-4	Biomaterials
BEXX10	3-0-2-4	Biosensing and Bioinstrumentation
HSXX3	3-0-0-3	HSS basket course
BEMC1	3-0-0-3	M.Tech Core-I
Total	**21 credits**	

Semester VI

Course Code	**L-T-P-C**	**Course Name**
IC222P	0-0-3-2	Physics Practicum
BEMC2	3-0-0-3	M.Tech Core-II
BEMC3	3-0-0-3	M.Tech Core-III
BEXE1	3-0-0-3	Discipline Elective-I
BEXE2	3-0-0-3	Discipline Elective-II
BEXE3	3-0-0-3	Discipline Elective-III
FEXX1	3-0-0-3	Free Elective-I
Total	**20 credits**	

Semester VII

Course Code	**L-T-P-C**	**Course Name**
ITXX1	0-0-2-2	Industrial Internship
BEXE4	3-0-0-3	Discipline Elective-IV
BEXE5	3-0-0-3	Discipline Elective-V
BEXE6	3-0-0-3	Discipline Elective-VI
HSXE1	3-0-0-3	HSS Elective-I
FEXX2	3-0-0-3	Free Elective-II

FEXX3	3-0-0-3	Free Elective-III
HS541	1-0-0-1	Technical Communication
Total	**21 credits**	

Semester VIII

Course Code	L-T-P-C	Course Name
BEXE7	3-0-0-3	Discipline Elective-VII
FEXX4	3-0-0-3	Free Elective-IV
FEXX5	3-0-0-3	Free Elective-V
FEXX6	3-0-0-3	Free Elective-VI
FEXX7	4-0-0-4	Free Elective VII
BEXE8	0-0-8-4	Mini Project, Term Paper and Seminar
HSXX5	2-0-0-2	HSS Elective-II
Total	**22 credits**	

Semester IX

Course Code	L-T-P-C	Course Name
BEXE9	0-0-34-17	M.Tech Project-1
Total	**17 credits**	

Semester X

Course Code	L-T-P-C	Course Name
BEXE10	0-0-34-17	M.Tech Project-2
Total	**17 credits**	

Total: 206 Credits

Compulsory IC courses in Baskets:

Science I:

Material Science for Engineers

Science II:

Understanding Biotechnology and its applications

Engineering Science:

Signals and Systems

M.Tech Core courses and Electives leading to specializations:

A. Biomedical Engineering:

M.Tech Core:

1. Anatomy and Physiology
2. Biomedical Systems (existing)
3. Analytical biotechniques (existing)

Discipline Electives (any seven):

1. Medical Imaging Systems and Analysis
2. Medical Devices and Packaging
3. Biomedical Instrumentation
4. Embedded Systems (existing)
5. Neuroscience and Cognitive Science
6. Optical Microscopy
7. Next generation biomanufacturing
8. Tissue Engineering
9. Regenerative Medicine
10. Nanobiotechnology (existing)
11. Biomedical Image and Signal Analysis
12. Biosolid Mechanics
13. Biofluid mechanics

B. Agro-Technology:

M.Tech Core:

1. Precision Farming
2. IoT for agriculture
3. Agricultural Biotechnology

Discipline Electives (any seven):

1. Plant phenotyping
2. Machine learning for plant phenotyping
3. Plant genotyping
4. Embedded Systems

5. Bioprocess Technology
6. Post-harvest technology and managment
7. Design of farm machinery/Farm mechanisation
8. Agroresidue management
9. Green House Technology
10. Storage and enhancing shelf life
11. Food processing technologies and devices
12. Agro-cultivation technologies (Hydroponics, Aquaponics etc)
13. Technology for Agribusiness and marketing of produces
14. Irrigation technologies

C. Environmental Science and Engineering:

M.Tech Core:

1. Microbiology for environmental applications
2. Environment friendly bioprocesses
3. Environmental biotechnology practicum

Discipline Electives (any seven):

1. Solid waste management
2. Waste water management
3. Air pollution control techniques
4. Waste reuse and recycle
5. Toxic and hazardous waste management
6. Water quality management
7. Modeling of waste water treatment system
8. Environmental quality management

D. Computational Bioengineering:

M.Tech Core:

1. Bioinformatics
2. Analysis and Design of Algorithms
3. Biological modeling and simulation

Discipline Electives (any seven):

1. Next generation sequencing
2. Biomedical Image and Signal Analysis
3. Computational Neuroscience
4. Deep learning
5. Pattern Recognition

6. Neuroscience and Cognitive Science
7. Modeling of bioprocess parameters
8. Transcriptomics
9. Proteomics
10. Metabolomics
11. Fluxomics
12. Computational drug discovery
13. Finite Element Methods

E. M.Tech in Bioengineering (for candidates choosing courses across specializations)

M.Tech Core courses (Any three):

1. Biomedical Systems
2. Bioinformatics
3. Microbiology for environmental applications
4. Analytical biotechniques
5. Agricultural biotechnology

Discipline Electives: Any seven courses from discipline electives across all specializations

Course Name: Biology-I

Course Number:

Credits: 3-0-2-4

Prerequisites:

1. **Course Preamble:**

The objective of the course is to provide students with a comprehensive and concise overview of biological science with emphases on its relationship with bio-engineering.

2. **Course Outline:**

Module I: cells: The fundamental units of life **[10 hours]**

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

Module 2: Cell Membranes and membrane transport **[10 hours]**
Membrane structure (lipid bilayer, and membrane protein) , principles of transmembrane transport, Transporter and their function

Module 3: cytoskeleton and cell motility **[10 hours]**
Intermediated filaments, microtubules, actin filaments, Extra Cellular Matrix

Module 4: The cell-division cycle **[12 hours]**
Overview of the cell cycle, The Eukaryotic Cell Cycle, prokaryotic cell division, Mendel and the law of inheritance

Lab: **[28 hours]**

Subcellular fractionation and isolation of organelles •Sub cellular localization of proteins •Techniques for the propagation of eukaryotic and prokaryotic cells Culture and Gram's staining of Gram positive and negative bacteria, • cell proliferation and apoptosis monitoring •Experiments to study active and passive transports across cell membranes

3. TEXT BOOKS

 Molecular Biology of the Cell - 5th Edition; 2015 - Bruce Alberts et al - Garland Science
 Molecular Cell Biology - 7th Edition; 2016 - Harvey Lodish, Arnold Berk & Chris A. Kaiser - W.H. Freeman
 Lewin's Cells – 3rd Edition – Cassimeris/Lingappa/Plopper – Johns & Bartlett Publishers4. REFERENCES

4.Reference

.Campbell Biology (11th Edition) byJane B. Reece,Lisa A. Urry,Michael L.Cain,Steven A. Wasserman,Peter V. Minorsky,Robert B. Jackson, Benjamin Cummings, 2015

Course Name: Biology-II

Course Number:

Credits:2-0-2-3

Prerequisites: Biology-I

1. **Course Preamble:**

The objective of the course is to provide students with a comprehensive and concise overview of biological science with emphases on its relationship with biomedical engineering.

2. **Course Outline:**

Module 1: Cells: Chemical components of cells **[7 hours]**
Chemical bonds, small molecules in cells, macro molecules in cells

Module 2: From DNA to protein: how cells read the genome **[6 hours]**
From DNA to RNA, from RNA to Protein, control of gene expression

Module 3: How cells obtain energy from food **[6 hours]**
Breakdown and utilization of sugars and fats, energy generation in mitochondria and chloroplasts, electron transport and proton pump, chloroplast and photosynthesis

Module 4: cell-cell communication and protein transport **[9 hours]**
General principles of cell signaling, G-protein couple receptor, enzymes-couple receptor, protein sorting, vesicular transport, endocytic pathways

Lab: **[28 hours]**

DNA/RNA isolation •cDNA synthesis, qRT PCR •ELISA to measure 2nd messenger • side directed mutagenesis assay •glucose output assay, Intracellular lipid staining

3. TEXT BOOKS

- Molecular Biology of the Cell - 5th Edition - Bruce Alberts et al - Garland Science

REFERENCES

- Molecular Cell Biology - 7th Edition - Harvey Lodish, Arnold Berk & Chris A. Kaiser - W.H. Freeman
- Lewin's Cells – 2nd Edition – Cassimeris/Lingappa/Plopper – Johns & Bartlett Publishers.

Course Name: Biology-III (Biochemical reactions and Bioprocessing)

Course Number:

Credit: 2-0-2-3

Prerequisites: IC136

Course Preamble:

This course introduces the fundamentals of biochemical reactions and the principles of bioprocessing. The first part of the course will give an appreciation of the key roles the enzyme driven biochemical reactions in different biological systems play in terms of bioenergetics, cellular metabolism and sustainable biosynthesis of biomolecules that serve wide applications. The second part introduces bioprocessing principles and related parameters that would influence cellular growth kinetics in typical bioreactor operation conditions. The laboratory component covering key areas from both the modules will provide basic hands-on understanding of the enzyme kinetics and bioprocessing.

Course Outline:

Module 1: Fundamentals of Biochemical reactions and Enzymology

Bioenergetics - exergonic and endergonic reactions, redox reactions, high energy compounds, cofactors – ATP, NAD, NADH, NADP, NADPH etc and their significance.

Enzyme kinetics, mechanism, Regulation, Multienzyme systems, Enzyme turnover, Enzyme inhibition.

Case studies of enzyme applications in Industry, Health, Food and Environment

Metabolism – Anabolism and catabolism; Overview of central and secondary metabolism.

Metabolic pathways and their analysis (qualitative and quantitative)

Module 2: Introduction to Bioprocessing and bioreactors

Bioprocessing – definition, controls and parameters such as Oxygen transfer, redox, pH etc.

Stoichiometry and Kinetic Model of Cell Growth. Monod Model and its Derivatives.

Fermentation technology and Downstream processing

Bioreactor types and their Operating Modes

Labs:

Enzyme kinetics – Effect of substrate concentration, Effect of temperature, Effect of pH, Enzyme inhibitory assay, Demonstration of Bioreactor, Microbial cultivation in a batch and estimation of growth rates, Fermentation and downstream analysis/processing of end products

TEXT BOOKS

- Lehninger Principles of Biochemistry, David L. Nelson and Michael M. Cox, Seventh Edition **2017**; ISBN-10: 1-4641-2611-9; ISBN-13: 978-1-4641-2611-6
- Fundamentals of Modern Bioprocessing, Sarfaraz K. Niazi, Justin L. Brown 1st edition, CRC Press 2017; ISBN 9781138893290

Similarity Content Declaration with Existing Courses – 20%, BY513

Course Name: Physics and modeling of biological systems

Course Number:

Credits: 3-0-2-4

Prerequisites: IC160 Electrical systems around us, Biology I.

Preamble: The course aims at modeling biological systems in the light of circuit theory and control theory and uses those models for further analysis of signal extraction from biological systems. The course begins with a description of circuit theory and control theory and then applies those theories in the modeling and analyses of biological systems. Some discussion on signal extraction from biological systems and its initial conditioning will be provided at the end.

Course Objectives:

1. Understand the basic concepts of networks and control systems
2. Apply the concepts of networks and controls in biological systems
3. Understanding the signal acquisition from biological systems based on its dynamical behavior.

Course content:

1. **Transport in an infinite medium:** Flux, fluence and continuity, drift and diffusion, Fick's laws of diffusion, time dependent solutions for diffusion and solvent drag, steady state diffusion to a spherical cell, modeling of excretion of metabolites from a spherical cell. 7 hours

2. **Transport through neutral membranes:** Membranes, Osmotic pressure in gases and liquids, transport of solute and solvents from root to leaves, modeling of edema, solute transport through a membrane. Examples from cellular systems, ion transport mechanism in cells, application of

circuit theory to cell analysis – the cable model, electrotonus model, Hodgkin Huxley model for membrane current, voltage changes in cell over space and time, biological networks. 10 hours

3. **Exterior potential:** Potential outside a long cylindrical cell, exterior potential for an arbitrary pulse, electrical properties of organs and organ-systems. 7 hours

4. **Biomagnetism:** Magnetic field of a cell in an infinite homogeneous conducting medium, electromagnetic induction, detection of weak magnetic fields, magnetic materials and biological systems, detection of weak magnetic fields. 8 hours

5. **Feedback and control:** Basics of control engineering – notion of open loop and closed loop systems, homeostasis, stability of systems, criteria of stability, example study in practical systems. 6 hours

6. **Molecular dynamics:** Simulation of biological molecules, cellular modeling, metabolic modeling, flux. 6 hours

Text book:

1. Introduction to Biomedical Engineering, Enderle, Blanchard and Bronzino, Elsevier Press, 2015.

Reference books:

1. Biomedical Circuits and Systems, Culurciello, CRC Press, 2017.
2. Electronic Device for Non Invasive Monitoring of Blood Glucose Levels, Khandolkar, Lambert Academic Publishing, 2018.

Course Name: Computational Biology

Course Number:

Credit: 2-0-2-3

Prerequisites: IC136

Students intended for: B. Tech., M.Tech., M.S., and Ph.D.

Elective or Compulsory: Core

Semester:

Course Outline:

Objective: The course is aimed at providing a basic understanding to the students about bioinformatics methods and their in-depth applications for solving biological problems. The course will include practical sessions for the students to help them master some of the bioinformatics techniques from hands-on experience. The course may also involve a project/term-paper development towards important biological problems within the purview of the course.

Part I: Basic Bioinformatics

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

Introduction to Basic Programming: Introduction to basic scripting and programming routinely used for bioinformatics analysis.

Sequence and Molecular File formats: Introduction to different file formats used for biological data. Sequence and molecular file conversion tools.

Databases in Bioinformatics: Introduction to different biological databases, their classification schemes, and biological database retrieval systems.

Part II: Bio-algorithms and Tools

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.

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

Pathways and Systems Biology: Introduction to pathways and systems biology, Analysis of Pathways, Metabolic network properties, Metabolic control analysis, Simulation of cellular activities.

Protein Structure Analysis: Introduction to basic approaches for protein structure analysis and visualization.

Lab Course content:

1. Perl programming
2. Databases for Bioinformatics and format conversion
3. Sequence similarity (Local alignment)
4. Sequence similarity (Global alignment)
5. Gene prediction Prokaryotic
6. Gene prediction Eukaryotic
7. Phylogenetic analysis
8. Functional analysis (patterns, profiles, clusters etc)
9. Pathway analysis
10. Protein structure visualization

Text Book:

1. Bioinformatics: Methods and Applications Genomics, Proteomics, and Drug Discovery S.C. Rastogi, N. Mendiratta, P. Rastogi (3rd Edition) PHI Learning Private Limited New Delhi (2011)

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

Other References:

1. Introduction to Bioinformatics. Arthur M. Lesk (3rd Edition) Oxford University Press.

Articles:

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

Course Name: Biostatistics

Course Number:

Credits: 3-0-2-4

Prerequisites: Data Science II

Preamble: This course is intended to cover fundamental concepts in biostatistics, data science in biology, and how to apply these concepts using the R statistical programming language. In general, this course will emphasize applied statistical theory on biological data analysis.

Course content:

1. Application of statistics in biological data analysis. Parametric, semi-parametric and non-parametric methods, survival analysis, longitudinal data analysis, linear mixed effect models. 10 hours
2. Multivariate Analysis: various types of classification, ANOVA, PCA,ICA. 10 hours
3. Epidemiological indicators of plant, animal and human health. 10 hours
4. Statistical issues with bio-experimental data and economic modeling for cost effectiveness evaluation, dynamic treatment regimes, assessment of diagnostic tests and instruments, analysis of sequential trials. 10 hours

Lab: Laboratory experiments on Plant, animal and human data analysis using R.

Text book:

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

Reference book:

1. Biostatistics and Epidemiology: A Primer for Health and Biomedical Professionals, Wassertheil-Smoler, Springer-Verlag 2014.
2. Design and Analysis of Clinical Trials: Concepts and Methodologies, Shein-Chung Chow, Jen-Pei Liu, 3rd edition, Wiley, 2016.

Course Name: Bioethics and regulatory affairs

Course No.:

Credits: 1-0-0-1

Preamble: This is a pass-fail course intended to serve as a broad introduction to the field of bioethics and regulatory affairs. The course will combine lectures with small-group case work that encourages students to explore ethical dilemmas in a faculty-supported, peer-educated environment. The course also provides a discussion on drug and pharmaceutical regulatory affairs.

1. **Introduction to Bioethics:** Ethics and ethical theory, justice and rights, liberty and morality. Principlism, Virtue ethics, Ethics of Care, Human Rights 2 hours
2. **Ethics of research with human subjects:** The Nuremberg code, Declaration of Helsinki, the Belmont report, ethics of investigator-participant relationship, problems of randomized clinical trial, purpose and function of institutional review board, informed consent, research with those with impaired capacity for consent and participant panel, research involving persons at risk for impaired decision making 4 hours
3. **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. 4 hours

Text Book:

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

Reference book:

1. Atul Gawande, *Being Mortal: Medicine and What Matters in the End, Henry Holt and Co.* , 2017.

Course Name: Biosensing and Bioinstrumentation

Credits: 3-0-2-4

Prerequisites: Physics and modeling of biological systems

Preamble: The course aims at studying techniques of measurement, obtaining signals from biological systems and processing those signals for estimating various biological parameters. The general principles of measurements , sensing and instrumentation will be applied in various bio-instruments. The students will also have a current background on the basic principles of key analytical biotechnologies, and how these technologies allow sensitive and accurate detection, purification, and characterization of biomolecules.

Course Objectives:

1. Understand the basic concepts of measurement, sensing and instrumentation
2. Apply the concepts of sensing and instrumentation in biological systems
3. Understanding the signal acquisition from biological systems based on its dynamical behavior.
4. Detect and characterize biomolecules

Course content:

1. **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. 4 hours

2. **Sensors:** 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, basics of magnetic sensing; Interferometer: applications in metrology; basics of optical sensing and LASER. 10 hours

3. **Biosignals:** Origin, nature, and types of Biosignals, Principles of sensing physiological parameters from plants and animals, types of transducers and their characteristics, Electrodes for bioelectric signals, Bioelectric signals and their characteristics. Chemical and electrochemical biosignals, optical signals. 6 hours

4. **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. 10 hours

5. **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. 12 hours

Lab: 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.

Text book:

1. A.G. Webb, Principles of Biomedical Instrumentation, Cambridge University Press, 2018.

Reference books:

1. R.S. Khandpur, Biomedical Instrumentation – Technology and Applications, TMH, 2017.
2. S.C. Mukhopadhyay, A.L. Ekuakille, Advances in Biomedical Sensing, Measurements, Instrumentation and Systems, Springer-Verlag, 2018.
3. Principles of Fluorescence Spectroscopy by Lakowicz, Joseph R. (3rd Edition), 2006.
4. Instrumental Methods of Analysis, Willard, CBS publishers, 2015.

Course Name: Biomechanics

Credits: 3-0-2-4

Preamble: The course provides an overview of musculoskeletal anatomy, plant mechanics, the mechanical properties and structural behavior of biological tissues, and bio-dynamics. Specific course topics will include structural and functional relationships in tissues and organs; application of stress and strain analysis to biological tissues; analysis of forces in human function and movement; energy and power in human activity; introduction to modeling viscoelasticity of tissues

Course Objectives:

1. Understand the basic concepts of musculoskeletal anatomy, the mechanical properties and structural behavior of biological tissues and plants
2. Apply stress and strain analysis to biological tissues
3. Analyze the dynamics of movement and locomotion.

Course content:

1. **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 hours

2. **Tissues:** Plant tissues and animal tissues. Plant tissues – vascular bundles – xylem and phloem. 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, Continuum Mechanics Concepts in Modeling of large deformation, Finite Element Modeling 14 hours

3. **Joints and Movements: Classification of** joints, forces and stresses, biomechanical analysis joints, Gait, Joint replacement and reasons, Finite Element Modeling. 6 hours

4. **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. 8 hours

Lab: Simulation and practical experiments based on the theory syllabus – root strength analysis, bones strength analysis - experimental and numerical analysis.

Text Books:

1. Basic Biomechanics of the Musculoskeletal System, by Nordin & Frankel
2. Biomechanics: Mechanical Properties of Living Tissues, by Fung
3. Plant Biomechanics: An engineering approach to plant form and function, by K. J. Niklas

Reference Book:

1. Berne & Levy Physiology, 6th Updated Edition, Elsevier, 2018.
2. Fundamentals of Biomechanics: Equilibrium, Motion, and Deformation, by Ozkaya and Nordin
3. Principles of Biomechanics by Robert L.Huston, CRC Press

Course Name: Biomaterials

Course Number:

Credit: 3-0-2-4

Prerequisites: IC 136 Understanding Biotechnology and its Applications and IC 241 Materials Science for Engineers

1. **Course Preamble:**

The objective of this course is to build a solid foundation of knowledge for biomaterial science and technology. The target is to teach the physical and biological principles that serve as the scientific basis for understanding the interactions of biological molecules and cells with biomaterials employed for different biomedical applications.

2. **Course Outline:**

Module 1: Introduction to Biomaterials (8 hours)

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

Module 2: Classes of Biomaterials (8 hours)

Polymeric materials and blends, Biopolymers and hydrogels, Metal based biomaterials, Ceramics and bioglasses; Adhesive and sealants, Elastomers

Module 3: Biomaterials Applications (20 hours)

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

Module 4: Device development, Standards and regulatory compliance (6 hours)

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

3. **Text Books**

1. Biomaterials Science (Third Edition), An Introduction to Materials in Medicine, ISBN 978-0-12-374626-9, Academic Press, Edited by: Buddy D. Ratner et al.

2. Advanced Biomaterials: Fundamentals, Processing and Applications; John Wiley & Sons, Inc., USA (ISBN: 978-0-470-19340-2), September, 2009.

3. Biomaterials Science and Biocompatability, Fredrick H. Silver and David L. Christiansen, Piscataway, Springer, New Jersey.

4. References:

1. Related journal articles

Lab Space and Resources needed: Three lab spaces are needed for:

i. Biology Labs-I,II,III
ii. Biomedical Engineering Lab (covering Biosensing and Bioinstrumentation, Biomedical Instrumentation, Biomechanics)
iii. Computational Bioengineering Lab (covering Computational Biology, Biostatistics, Bioinformatics, etc)

Reviewers’comments:

1. Dr. Atul Minhas, Macquarie University, Australia

Atul Minhas **atul.minhas@mq.edu.au** **via** **iitmandi.ac.in** Wed, Dec 5, 2018, 2:29 AM

to Shubhajit

Dear Dr Shubhajit,

Congratulations on thinking about Bioengineering at IIT Mandi. It is certainly a major in very high demand. I have some quick comments

(1) Introduce at least one course per semester related with biomedical engineering

- at the moment there is no biomedical engineering course in semester 1 and 2
- Like MBBS 1st year, physiology must be taught in 1st year (may be 1st semester and 2nd semester courses as **Physiology-I** and **Physiology-II,** respectively
- **Anatomy** as a separate course can come in semester III and **Systems Biology** in semester 4
- Semester V is very heavy, full of biomedical engineering courses, I do not know what will you cover in **Bomputational Biology,** however **Biostatistics** must be a separate course. So, you might want to move **Biomedical Measurements and Instrumentation** to second year (semester 4?)
- **Ethical Issues in Biomedical Engineering** must be taught in early stage (may be semester V), because this is the course which really inculcates the feeling of biomedical engineering to students. Otherwise, they would never understand the key difference between biomedical engineering and other engineering streams.

(2) **Biomedical Technology**

- What is the difference in the course contents between **Control Systems** and **Biomedical Systems? Control Systems** in biomedical engineering cannot be case as the typical course for electrical/electronics engineers. It must be **Biomedical Systems and Control (refer to IIT Madras's course for MTech students)**.
- What are you covering in **Medical Imaging?** I recommend you make it **Medical Imaging Systems (X-ray, CT, PET, SPECT, MRI, Ultrasound).** I am teaching this course at the monent in Macquarie.
- I do not see any explicit course in **Medical Image Processing (**which is expertise of Anil and others).

Other specializations in your MTech are not my area, so I cannot comment on them.

Hope my comments were helpful. Happy to help more if you are planning to work on these comments.

With warm regards,

Atul Singh Minhas
Senior Lecturer in Biomedical Engineering

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2. Prof. Prasun Kumar Roy, IIT BHU, Varanasi

Dr. P K Roy <pkroy.bme@iitbhu.ac.in>

Sat, Dec 8, 2018, 8:02 AM

to src

Dear Dr Roy Chowdhury,

Thank you for your mail about your new schema for the IDD Bio-Engg. program.

The proposal indeed looks attractive.

I think some points might be considered.

Recently, after the breakthroughs of the international initiatives as the Human Genome program and the Personalized Medicine Program, the discipline of Bio-Engineering has spawned such that there is equal importance to all the 3 components of the discipline: Biology, Medicine, Engineering.

It would be nice to give also give a good emphasis to both Biology as well as to Medicine (particularly diagnostic and therapeutics) aspects right from the initial year of your program. The program appears more loaded towards the "Engineering" fields. I think shifting some programs between the years may be needed, which I mention later.

Your effective teaching program is 4 years (the 5th year is for only MTech thesis).

In that teaching program's first 50% duration (i.e. the first 2 years), the course deals mainly with Engineering and allied fields, as Basic engineering/I.T./Computing/Physical sciences,. Basic Biology and Basic Medical areas may now be considered. From the bioscience perspective, in the first 2 years, you have only 2 biology subjects, buth they are more technology/mathematics oriented, as Bio-"technology", and Systems Biology (this field is mostly Bio-mathematics).

It may be preferable to have courses in core biology in the first 2 years from the beginning, and at least 1 biological subject every semester. Is it possible to have a foundational course on "Molecular Biology and Genetics" in your First year (Genetics, DNA, RNA and Ribosome machine is very exciting to younsters I find, if put from an "algorithm' and "machine" perspective). Also, is it possible to shift your "Cell biology and cellular processes" subject to the Second year (Medical students do similar courses in first year, after school).

We are having the Indian Academy of Neuroscience annual conference, in AIIMS Delhi, next November, 2019 (we organized this years conference here at BHU here last month). Your faculty and students are welcome to participate (http://neuroscienceacademy.org.in/joinacademy.php#)

Hope this may be useful to you.

It is a very good initiative that you are doing.

All the best,

Prasun

Prof. Prasun Kumar Roy, MBBS, MRCR, FRSM, PhD; J.N. Tata Innovation Fellow (DBT, GOI).
FNAE, FNASc, FNAMedSc.
Professor,
Neuroscience & Neuro-Imaging Laboratory,
School of Bio - Medical Engineering,
Indian Institute of Technology, I. I. T.;
Banaras Hindu University (B.H.U.).
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Council Member, CTSI, International Neuroinformatics Coordination Facility, Karolinska Institute, Stockholm.
Principal Investigator, National Consortium Program (Multimodal Brain Imaging), Ministry of I.T., Govt. of India.
Former Director, Incharge & Professor, National Brain Research Centre, NBRC-Deemed University, DBT, GOI; Gurgaon (Delhi).

3. Prof. M. Manivannan, IIT Madras

Manivannan M mani@iitm.ac.in via iitmandi.ac.in Wed, Dec 19, 2018, 8:49 PM

to Shubhajit

Nice Curriculum designed, congratulations.

Few minor suggestions:

V, VI semesters can have few specialization labs such as (a) Biomedical Instrumentation Lab, Biomechanics Lab, (b) Systems Biology Lab, Omics Lab, (c) Biosensors Lab, Nanotechnoligy lab.

Can you think of adding a biomaterials course.

Can you think of adding a ANalog and Digital Circuits course

Can you think of adding a modeling and simulation course

In summary, I am for master level programme alone, with various specialization as designed.

Hope this is useful.

-M Manivannan

Dr.M.Manivannan
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http://apm.iitm.ac.in/biomedical/mani

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