Approval : 10th Senate Meeting

S12. Course Number: ME 641

Course Name: Finite Element Method

Credits: 3-0-0-3

Prerequisites: Instructor's consent

Intended for: UG/ M. Tech. /MS/PhD

Distribution: Specialized stream elective course for M. Tech. in Mechanical Engineering with specialization in Energy Systems, and elective course for other students

Semester: Odd/Even

Preamble: The objective of this course is to provide the basic concepts of finite element method and its applications to wide range of engineering problems.

Course Outline: Basics concepts and procedure of FEM, interpolation models, higher order and isoparametric elements and application of FEM in different disciplines of engineering i.e. Solid mechanics, Fluid mechanics Heat transfer, electromagnetics

Course Modules:

Module – 1: **(11L)**

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 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 Problem.

Module – 2: **(12L)**

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 (4-Noded quadrilateral element), Shape function of beam element. Hermite shape function of beam element

Module – 3: **(11L)**

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

Module -4 **(8L)**

Finite Element Analysis of piping systems, turbine blade, rotors, boilers, compressor, nozzle, blower, generator, solar concentrating collectors and associated drives.

Text book:

1. Finite Elements in engineering, Chandrupatla T.R., 3rd Pearson Edition.
2.The Finite Element Method in Engineering, S.S. Rao, 4th Edition, Elsevier, 2006

Reference Books

1. The FEM its basics and fundamentals: O.C.Zienkiewicz, Elsevier, 6e. 2.Finite Element Method, J.N.Reddy, McGraw –Hill International Edition.
3. Finite Element Methods, by Daryl. L. Logon, Thomson Learning 3rd edition, 2001. 4.Finite Element Analysis, C.S.Krishnamurthy,–Tata McGraw Hill Publishing Co. Ltd, New Delhi, 1995.

Other Faculty interested in teaching this course: Dr. Rajesh Ghosh, Dr. M. Talha