COURSE DESCRIPTION

Approval: 24th Senate Meeting

Course Number: ME 513
Course Name: Finite Element Methods in Engineering
Credits: 3-0-2-4
Prerequisites: Linear Algebra (IC 111); Mechanics of Rigid Body (IC 240); Mechanics of Solids (ME 206)/Strength of Material (CE 301).
Intended for: BTech 3rd and 4th Year; M.Tech/MS/Ph.D.
Distribution: Discipline Core for M.Tech-Structural Engineering; Elective for BTech 3rd and 4th Year; MTech/MS/Ph.D.
Semester: Odd/Even
Comments: The 24th Senate meeting of IIT Mandi held on 13th February, 2020 approves the discontinuation of the previous two course codes ME 352 and CE 607

---

1. Preamble: To provide the basic concepts of finite element method and its applications to wide range of engineering problems. This course deals with various modelling techniques and uses different numerical methods for solving a system of governing equations over the domain of a continuous physical system (such as structural problem, thermal problem, fluid mechanics problem), which is discredited into simple geometric shapes called finite element.

2. Course Modules with Quantitative lecture hours:

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 Hours]**

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, Pre-processing, post processing, One Dimensional Problems. **[6 Hours]**

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 Hours]**

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 Hours]**

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 Hours]**

COURSE DESCRIPTION

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 Hours]**

Elasticity problems: Review of equations of elasticity, stress-strain and strain displacement relations, plane stress and plane strain problems. **[4 Hours]**

Dynamic problems: Beam and Bar vibration; Natural frequency determination. **[4 Hours]**

Laboratory Component: [28 Hours]

- 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]**

3. Text book:

- Hutton, D.V., "Fundamentals of Finite Element Analysis", TMH, 2005.
- Logan, D. L., "A first course in the Finite Element Method", 6th edition, Cengage Learning, 2017.

4. References:

- Rao, S.S. "The finite element method in engineering", 4th edition, Elsevier, 2005.
- Reddy, J.N., "An introduction to the finite element method", McGraw-Hill, 2005.
- 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.
- Chandrupatla, T.R., "Finite element analysis for engineering and technology", University Press (India) Pvt Ltd, 2004.
- Fish, J. and Belytschko, T., "A first course in Finite Elements", Wiley 2007.

5. Similarity Content Declaration with Existing Courses:

S.N	**Course Code**	**Similarity Content**	**Approx. % of Content**
1	ME 206	Plane stress and plane strain	2%

6. Justification for new course proposal if cumulative similarity content is > 30%: NA