ME352 Finite Element Methods in Engineering

Credit: 2.5-0.5-0-3 Approval: Approved in 3rd Senate

Students intended for: B.Tech

Elective or Core: Core Semester: Odd/Even

Prerequisite: Continuum Mechanics, Mechanics of Rigid Bodies, Mechanics of Solid Mechanics (Desirable), Programming language (C, MATLAB)

Course objective To provide the basic concepts of finite element method and its applications to wide range of engineering problems

Course content

1. **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
2. **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
3. **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
4. **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
5. **DERIVATION OF ELEMENT STIFFNESS MATRICES AND LOADVECTORS**: 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
6. **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
7. **FLUID MECHANICS PROBLEMS**
8. **ELASTICITY PROBLEMS**: Review of equations of elasticity, stress-strain and strain-displacement relations, plane stress and plane strain problems
9. **DYNAMIC PROBLEMS**: on vibrations

Suggested Books:

Huebner K. H., Dewhirst D. L., Smith D. E., and Byrom T. G., The Finite Element Method for Engineers, 4th Ed, John Wiley and Sons, 2001.

Rao S. S., The Finite Element Methos in Engineering, 4th Ed., Elsevier Science, 2005.

Reddy J. N., An introduction to Finite Element Methods, 3rd Ed., Tata McGraw-Hill, 2005.

Fish J., and Belytschko T., A Sirst course in Finite elements, 1st Ed., John Wiley and Sons, 2007.

Chaskalovic J., Finite Element Methods for Engineering Sciences, 1st Ed., Springer, 2008.