

Subject Code	Courses	L	T	P	Hrs.	Credits
ME5CD01	Finite Element Methods	4	0	0	4	4

Unit 1

Introduction to FEM, Mathematical Models and Approximations: History of FEM and applicability to mechanical engineering design problems: Review of elasticity. Mathematical models for structural problems: Equilibrium of continuum-Differential formulation, Energy Approach Integral formulation, Principle of Virtual work Variational formulation. Overview of approximate methods for the solution of the mathematical models, Residual methods and weighted residual methods, Ritz, Rayleigh-Ritz and Galerkin's methods. Philosophy of solving continuum problems using Finite Element method.

Unit 2

Finite Element Formulation: Generalised FE formulation based on weighted residual method and through minimisation of potential, displacement based formulation, Concept of discretisation, Interpolation, Formulation of Finite element characteristic matrices and vectors, Compatibility conditions, Assembly and boundary considerations, Concept of Shape Functions.

Unit 3

FE Analysis for One Dimensional Structural problems: Structural problems with one dimensional geometry. Bar element: formulation of stiffness matrix, consistent and lumped load vectors. Boundary conditions and their incorporation: Elimination method, Penalty Method, Introduction to higher order elements and their advantages and disadvantages. Formulation for Truss elements, Case studies involving hand calculations with an emphasis on Assembly, boundary conditions, contact conditions and multipoint constraints. **Beams and Frames:** Review of bending of beams, interpolation for beam elements and formulation of FE characteristics, Plane and space frames and examples problems involving hand calculations. Algorithmic approach for developing computer codes involving 1-D elements.

Unit 4

FE analysis of Two dimensional Problems: Interpolation in two dimensions, natural coordinates, Isoparametric representation, Concept of Jacobian. Finite element formulation for plane stress plane strain and axi-symmetric, Fluid Flow problems; Triangular and Quadrilateral elements, higher order elements, subparametric, Isoparametric and superparametric elements. Formulation of plate bending elements using linear and higher order bending theories, Shell elements, General considerations in finite element analysis of design problems, Choosing an appropriate element and the solution strategies. Introduction to pre and post processing of the results and analysis.

Three Dimensional Problems: Finite element formulation for 3-D problems, mesh preparation, tetrahedral and hexahedral elements, case studies.

Unit 5

FEM in Heat Transfer and Fluid Mechanics problems: Finite element solution for one dimensional heat conduction with convective boundaries. Formulation of element characteristics and simple numerical problems. Formulation for 2-D and 3-D heat conduction problems with convective boundaries. Introduction to thermo-elastic contact

problems. Finite element applications in potential flows; Formulation based on Potential function and stream function. Design case studies.

Unit 6

Dynamic Analysis: FE formulation in dynamic problems in structures using Lagrangian Method, Consistent and lumped mass models, Formulation of dynamic equations of motion, Modelling of structural damping and formulation of damping matrices, Model analysis, Mode superposition methods and reduction techniques.

Text / Reference Books:

1. Seshu P, Textbook of Finite Element Analysis, PHI. 2004
2. Reddy, J.N., Finite Element Method in Engineering, Tata McGraw Hill, 2007.
3. Singiresu S.Rao, Finite element Method in Engineering, 5ed, Elsevier, 2012
4. Zeinowicz, The Finite Element Method 4 Vol set, 4th Edition, Elsevier 2007.
5. Alavala C.R., Finite Element Methods, PHI, 2009.
6. Moaveni S. PHI, 2009