FINITE ELEMENT ANALYSIS

Subject Code: 13ME2202

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Pre requisites: Engineering mechanics and Mechanics of solids

Course Educational Objectives:

To make the student

1. understand the fundamental concepts and techniques of finite elements
2. learn Direct stiffness, Rayleigh-Ritz, Galerkin methods used in FEM
3. learn finite element formulation in solid mechanics and heat transfer problems
4. know the tools for analyzing engineering problems using FEM and typical commercial FEA package

Course Outcomes:

The student will be able to

1. apply concepts and methods of FEA
2. apply direct stiffness, Rayleigh-Ritz, Galerkin methods
3. formulate and analyze static, dynamic problems of solid mechanics and also heat transfer problems
4. use isoparametric, sub parametric and super parametric elements for modeling
5. analyze linear and nonlinear problems

UNIT-I

Introduction, comparison of FEM with other methods, Variational approach, Galerkin Methods. principle of minimum potential energy

Rayleigh- Ritz method, shape functions and characteristics, properties of stiffness matrix, treatment of boundary conditions, Convergence: requirements for convergence, h refinement and p-refinement, basic equations of elasticity, strain displacement relations.

UNIT –II

1-D structural problems – axial bar element – stiffness matrix, load vector, Trusses: Plane trusses, element stiffness matrix, assembly of global stiffness matrix, load vector, stress calculations

Two-dimensional problems using CST: FE modelling, isoparametric representation, PE approach, element stiffness, force terms, stress calculations, axisymmetric formulation, FE Modelling using CST- PE approach, body force terms, surface traction, stress calculations, cylinder subjected to internal pressure, infinite cylinder.

UNIT-III

Isoparametric formulation: 4-noded quadrilateral and its shape functions, element stiffness matrix, element force vectors, Numerical Integration-1D and 2D integrations, stiffness integration, stress calculations, nine -node quadrilateral, eight-node quadrilateral, six-node triangle, sub parametric, super parametric elements, serendipity elements.

UNIT-IV

Beams and frames: finite element formulation, load vector, boundary considerations, shear force and bending moment, and plane frames

Scalar field problems: steady state heat transfer-one-dimensional heat conduction, one-dimensional heat transfer in thin films.

UNIT-V

Dynamic analysis and nonlinear FEA: formulation-solid body with distributed mass, element mass matrices, evaluation of Eigen values and Eigen vectors for a stepped bar and a beam, introduction to non-linear problems, geometric nonlinearity, material non linearity non-linear dynamic problems, analytical problems

TEXT BOOKS:

1. S.S. Rao , “*The finite element method in Engineering*”,3e, Butterworth and Heinnemann, 2001.
2. Tirupathi K.Chandrupatla and Ashok D.Belegundu, “*Introduction to finite elements in engineering*”,3e, Pearson Education,2010.
3. O. P. Gupta, “*Finite and boundary element methods in Engineering*”, 2e, Taylor and Francis, 1999.

REFERENCES:

1. Robert Cook , “*Concepts and applications of finite element analysis*”,4e,John Wiley and sons,2009.
2. J. N. Reddy, “ *An Introduction to Finite Element Methods*”,2e, McGraw Hill,2009.
3. O.C. Zienkowitz, “*The Finite element method in engineering science*”,3e, McGraw Hill,2010.
4. K.J Bathe, “*Finite Element Procedures in Engineering analysis*”,1e,PHI,2009.
5. C.S.Krishnamoorthy , “*Finite Element Analysis - Theory and Programming*”,2e,Mc Graw Hill,2009.