FINITE ELEMENT ANALYSIS

Course Code: 15ME2102

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Course Outcomes: At the end of the course, a student will be able to

CO1: apply direct stiffness, Rayleigh-Ritz, Galerkin method to solve engineering problems and outline the requirements for convergence

CO2: analyze linear 1D problems like bars and trusses; 2D structural problems using CST element and analyse the axi-symmetric problems with triangular elements

CO3: write shape functions for 4 and 8 node quadrilateral, 6 node triangle elements and apply numerical integration to solve; 1D and 2D; stiffness integrations

CO4: solve linear 2D structural beams and frames problems; 1Dheat conduction and convection heat transfer problems

CO5: evaluate the Eigen values and Eigenvectors for stepped bar and beam, explain nonlinear geometric and material non linearity

UNIT-I (10-Lectures)

Introduction, comparison of FEM with other methods, Galerkin Methods. 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.

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

UNIT –II (10-Lectures)

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 (10-Lectures)

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 (10-Lectures)

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 (10-Lectures)

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