IV B.Tech I Semester

15AME53-FINITE ELEMENT METHODS

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Course objective:

The subject should enable the students to learn the principles involved in discretization in finite element approach, form stiffness matrices and force vectors for simple elements, find the various approach followed in finite element approach, use the various elements for discretization and learn about shape functions. To learn the application of FEM to various structural problems incorporating temperature. and boundary conditions and heat transfer problems.

UNIT I

Introduction: Equilibrium equations in elasticity subjected to body force, traction forces and point loads, stress strain relations in 3D elasticity, plane stress and plane strain, Boundary conditions, Initial conditions. Governing equation for Steady state heat conduction with convective boundary conditions.

Approximate Methods For Solving The Differential Equations: Rayleigh-Ritz method, Weighted residual methods, Galerkin's method.

Integral formulation: Principle of a minimum potential energy, principle of virtual work, Generalized Finite element approach in solving these problems.Solution methods for solving simultaneous equations.

Learning Outcome & Suggested Student Activities:

After completion of this unit students are able to know introductory basic principles and approaches for solving FEM problems in different fields

UNIT II

Problems With One-Dimensional Geometry:

Bars: Formulation of stiffness matrix, Load vectors, Incorporation of boundary conditions: Elimination approach and penalty approach.

Trusses: Plane truss and space truss elements, Example problems involving plane truss elements. Examples involving multipoint constrains. Stress calculations.

Beams & Frames: Bending of beams, Interpolation functions, formulation of stiffness matrix and load vectors. Plane frames, space frames. Transformations of stiffness and load vectors.

Learning Outcome & Suggested Student Activities:

After completion of this unit students are able to formulate FEM model for simple problems.

UNIT III

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 for triangular (2D simplex) elements, Linear interpolation polynomials in terms of local coordinates for triangular (2D simplex) elements, quadrilateral element.

Higher Order And Isoparametric Elements: Lagrangian interpolation, Higher order one dimensional elements- quadratic, Cubic element and their shape functions, properties of shape functions, Shape functions of 2D quadratic triangular element in natural coordinates, 2D quadrilateral element shape functions - linear, quadratic, Biquadric rectangular element Tetrahedral and hexahedral elements.

Learning Outcome &Suggested Student Activities:
After completion of this unit students are able to write interpolation functions to higher order isoparametric elements.

UNIT IV
Finite Element Application In Solid Mechanics:
Problem modeling and Finite element analysis in 2D plane elasticity with triangular and quadrilateral elements, Isoparametric, subparametric and superparametric elements. Interpolation, Jacobian, matrices relating strain and nodal displacements, stiffness matrix formulation, Consistent and lumped load vectors, Numerical integration Gaussian quadrate.
Axi-symmetric triangular elements: formulation of stiffness and load vectors. Introduction to 3D stress analysis.
Learning Outcome &Suggested Student Activities:
After completion of this unit students are able to derive element matrices for applying the principles to find stresses in beams and trusses and temperature distribution in composite walls and fins.

UNIT V
Heat Transfer And Fluid Mechanics Problems:
Steady state heat conduction with convective and heat flux boundary conditions, Functional approach, Galerkin approach formulation of element characteristic matrices and vectors in 1D and 2D problems. Temperature distribution in composite walls one dimensional and two dimensional fins and extended surfaces.
Two Dimensional Potential Flow Problems: Potential function formulation and stream functionformulation.
Learning Outcome & Suggested Student Activities:
After completion of this unit students are able to solve bars, trusses, beams and heat transfer problems using FEM and also to apply boundary conditions in realistic problems.

TEXT BOOKS:

1. Introduction to Finite Element in Engineering, TirupatiChandrapatla and Bellagundu ,Pearson Education, New Delhi.
2. Finite Element Methods, S. S. Rao ,Pergamom Press, New York.

REFERENCE BOOKS:

1. Introduction to FEM, J. N. Reddy, TMH Publishers, New Delhi.
2. Finite Element Analysis, C.S. Krishna Moorthy, TMH Publishers, New Delhi.
3. Fundamentals of Finite Element Analysis, David V. Hutton , TMH Publishers, New Delhi.
4. Introduction to the Finite Element Methods, Desai and Abel , CBS Publishers, New Delhi.
5. Finite and Boundary Methods in Engineering, O.P.Gupta, Oxford and IBH Publishers.
6. Finite Element Modeling for Stress Analysis, R. D. Cook, John. Wiley & Sons, 1995.