

COURSE TITLE	FINITE ELEMENT METHOD
COURSE CODE	01CA1202
COURSE CREDITS	3

Objective:

- 1 The subject aims to introduce numerical methods for solving governing equations of mechanical systems. The class of problems include 1D and 2D structural, thermal and fluid problems; beams and frames and 3D structural problems. Introduction to non-linear and dynamic problems is also included.

Course Outcomes: After completion of this course, student will be able to:

- 1 Apply concepts of the finite element method to develop algorithms for analysis of mechanical systems.
- 2 Apply FEM techniques to perform 1D stress analysis, modal analysis, heat transfer analysis, and flow analysis.
- 3 Analyze and solve engineering problems involving trusses, beams, and frames using appropriate FEM formulations.
- 4 Analyze and develop 2D finite element formulations using triangular, quadrilateral, and higher-order elements.
- 5 Apply commercial FEM software tools to analyze simple and complex engineering problems and interpret the results.
- 6 ..

Pre-requisite of course: Mechanics of solid, Machine Design

Teaching and Examination Scheme

Theory Hours	Tutorial Hours	Practical Hours	ESE	IA	CSE	Viva	Term Work
3	0	0	50	30	20	0	0

Contents : Unit	Topics	Contact Hours
1	Mathematical modeling for structure problems Equilibrium of continuum-Differential formulation, Energy Approach-Integral formulation,, Principle of Virtual work - Vibrational formulation., Overview of approximate methods for the solution of the mathematical models, Rayleigh-Ritz methods,, Methods of Weighted Residuals (Galarkin, Least-squares).	5

Contents : Unit	Topics	Contact Hours
2	Bar, Trusses, and Beams Relevance of finite element analysis in design, Modelling and discretization, Shape functions, elements and Degrees-of-Freedom, Strain – displacement relation, Local and Global equations, , Applications of FEA. Iso-Sub-Super parametric formulations, Linear and Quadratic elements, Elimination and Penalty Approach, Properties of global stiffness matrix, 1D thermal conduction and fluid flow problems. , Formulation of Truss element, , Plane truss, Beam: Element formulation, , plane frames, various loading and boundary conditions	15
3	2D and 3D Elements Gauss Quadrature formula, , Gauss Quadrature in two and three dimensions., Plane stress and plane strain matrices. , Triangular (CST, LST) , Rectangular (Q4, Q8) Elements:, Shape function Jacob Matrix, , strain displacement matrix, strain – stress relationship matrix, Force vector,, types of 3-D elements and their comparisons	7
4	Plate and Shell Elements Introduction, thin and thick plates: Kirchhoff theory,, Mindlin plate element, conforming and nonconforming elements,, degenerated shell elements, reduced and selective integration,, shear locking and hour glass phenomenon	6
5	Dynamic Problems Formulation of dynamic problems,, consistent and lumped mass matrices , Solution of eigenvalue problems:, Transformation methods Jacobi method, Vector Iteration methods,, subspace iteration method	7
6	Non-linearity Introduction and types of non-linearity,, Formulation for geometrical and material non- linearity	2
Total Hours		42

Textbook :

- 1 Text book of Finite Element Analysis, P. Seshu, PHI learning Private Limited, 2012
- 2 Introduction to Finite Elements in Engineering, TIRUPATHI R. CHANDRUPATLA, Prentice Hall,, 2002

References:

- 1 The Finite Element Method in Engineering, The Finite Element Method in Engineering, Singiresu Rao, Butterworth Heinemann, elsevier, 2018
- 2 Finite Element Procedures, Finite Element Procedures, K. J. Bathe, Prentice hall, 1996
- 3 A First Course in the Finite Element Method, A First Course in the Finite Element Method, Daryl L. Logan, Thomson, 2007
- 4 Concepts & Applications of Finite Element Analysis, Concepts & Applications of Finite Element Analysis, RD Cook, John Wiley & Sons Inc, 2001

References:

- 5 The Finite Element Method: A Practical Course, The Finite Element Method: A Practical Course, .R. Liu, S. S. Quek , Butterworth-Heinemann Ltd, 2013

Suggested Theory Distribution:

The suggested theory distribution as per Bloom's taxonomy is as follows. This distribution serves as guidelines for teachers and students to achieve effective teaching-learning process

Distribution of Theory for course delivery and evaluation					
Remember / Knowledge	Understand	Apply	Analyze	Evaluate	Higher order Thinking / Creative
10.00	20.00	20.00	20.00	20.00	10.00

Instructional Method:

- 1 ppt, video, animation,

Supplementary Resources:

- 1 <https://nptel.ac.in/courses/112104193>