

COURSE TITLE	FINITE ELEMENT METHODS
COURSE CODE	01ME2701
COURSE CREDITS	4

Objective:

- 1 The FEM subject will be helpful to teach numerical methods for solving governing equations of mechanical systems. The various mechanical problems of one and two-dimensional structural, thermal, and fluid analysis; beams and 3D structural problems will be analyzed.

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

- 1 Apply the fundamentals of finite element methods to model and solve basic mechanical engineering problems.
- 2 Apply FEM techniques for 1D stress, heat transfer, and fluid flow analysis.
- 3 Formulate and analyze truss, beam and dynamic problems using FEM.
- 4 Solve and evaluate two-dimensional FEM problems using triangular, quadrilateral, and higher-order elements.
- 5 Apply commercial FEM software to model, analyze, and interpret results for engineering problems.

Pre-requisite of course: Zeal to learn the Subject

Teaching and Examination Scheme

Theory Hours	Tutorial Hours	Practical Hours	ESE	IA	CSE	Viva	Term Work
3	0	2	50	30	20	25	25

Contents : Unit	Topics	Contact Hours
1	Understanding Mathematical models for structural problems Equilibrium of continuum. Formulation of mathematical equations, Energy Approach, Equilibrium of continuum. Formulation of mathematical equations, Energy Approach, Principle of Virtual work Variational formulation. Various methods for the solution of the mathematical models like: Rayleigh-Ritz method.	6

Contents : Unit	Topics	Contact Hours
2	Bars, Trusses and Beams Application of finite element analysis in design, Modelling and discretization, Types of elements and Degrees-of-Freedom, Shape functions, Strain – displacement relation, Local and Global equations, Applications of FEA, One dimensional Elements for Structural Problems: 1D – conduction problem, Linear and Quadratic elements, Elimination and Penalty Approach, Properties of global stiffness matrix, One dimensional thermal conduction and fluid flow problems. Formulation of Truss element, Plane truss, Formulation of Beam Element, various loading and boundary conditions.	18
3	Two Dimensional Elements: Gauss Quadrature formula, Gauss Quadrature in two dimensions, Plate stress and plane strain matrices., Constant strain Triangle and Linear strain Triangle Limitations of elements, Rectangular Elements, The Shape function	8
4	Dynamic Analysis Types of dynamic analysis, General dynamic equation of motion, point and distributed mass, lumped and Consistent mass, Mass matrices formulation of bar element, Mass matrices formulation of bar element, Undamped-free vibration- Eigenvalue problem, Evaluation of eigenvalues and eigenvectors (natural frequencies and mode shapes)	10
Total Hours		42

Suggested List of Experiments:

Contents : Unit	Topics	Contact Hours
1	Introduction to Finite Element Analysis software. Introduction to Finite Element Analysis software.	4
2	Solution of 1D – uniform bar subjected to Axial load using FEA software. Solution of 1D – uniform bar subjected to Axial load using FEA software.	2
3	Solution of 1D – tapered bar subjected to Axial load using FEA software Solution of 1D – tapered bar subjected to Axial load using FEA software	2
4	Solution of Beam problems with different boundary conditions using FEA software Solution of Beam problems with different boundary conditions using FEA software	2
5	Solution of Beam problems with different loading conditions using FEA software Solution of Beam problems with different loading conditions using FEA software	2

Suggested List of Experiments:

Contents : Unit	Topics	Contact Hours
6	Solution of truss problems, using FEA software. Solution of truss problems, using FEA software.	2
7	Solution of problems using different element types in FEA software. Also, analyze the effect of element formulation and the number of elements Solution of problems using different element types in FEA software. Also, analyze the effect of element formulation and the number of elements	2
8	Solve the problem of symmetry using FEA software Solve the problem of symmetry using FEA software	2
9	Solution of stress analysis of 3D component using FEA software Solution of stress analysis of 3D component using FEA software	2
10	Solution of Modal analysis of cantilever beam. Solution of Modal analysis of cantilever beam.	2
11	Solution of Harmonic analysis of cantilever beam. Solution of Harmonic analysis of cantilever beam.	2
12	Solution of 1D Thermal problems using FEA software Solution of 1D Thermal problems using FEA software	2
Total Hours		26

Textbook :

- 1 Introduction to Finite Elements in Engineering, T. R. Chandrupatla, PHI., 2011
- 2 Finite element Method in Engineering, Singiresu Rao, Elsevier. , 2017
- 3 Textbook of Finite Element Analysis, , P.Seshu, , PHI., 2015

References:

- 1 Finite Element Procedures, Finite Element Procedures, Bathe K. J, PHI, 2018
- 2 Concepts and Applications of Finite Element Analysis, Concepts and Applications of Finite Element Analysis, R D Cook, D S Malkus, M E Plesha, Wiley, 2014
- 3 The Finite Element Method - A Practical Course,, The Finite Element Method - A Practical Course,, G. R.Liu and S. S.Quek, , Butterworth, 2016
- 4 A First Course in the Finite Element Method , A First Course in the Finite Element Method , Logan, Thompson Publication, 2010

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
15.00	15.00	25.00	25.00	10.00	10.00

Instructional Method:

- 1 ppt, videos , animation, software

Supplementary Resources:

- 1 nptel.ac.in/courses/112104115/
- 2 nptel.ac.in/courses/112106135/