

Subject Code: 01ME0701
Subject Name: Finite Element Methods
B.Tech. IV Year – (Sem-7) Mechanical Engineering
Type of course: Under Graduate

Prerequisite: Zeal to learn the Subject

Rationale: The FEM subject will be helpful to teach numerical methods for solving governing equations of mechanical systems. The various mechanical problems of 1D and 2D structural, thermal and fluid analysis; beams and frames and 3D structural problems will be analyzed.

Teaching and Examination Scheme:

Teaching Scheme (Hours)			Credits	Evaluation Scheme					Total Marks
Theory	Tutorial	Practical		Theory Marks			Practical Marks		
				ESE (E)	IA	CSE	Viva (V)	Term Work (TW)	
4	---	2	5	50	30	20	25	25	150

Course Outcome:

After learning the course the students should be able to:

1. Understand the basics of finite element method for solving Mechanical Engineering problems.
2. Apply the knowledge of FEM for 1D stress analysis, heat transfer analysis and fluid flow analysis.
3. Formulate and solve problems of trusses, beams and frames.
4. Develop 2-D FE formulations involving triangular, quadrilateral elements and higher order elements.
5. Develop algorithms and write FE code for solving simple design problems and understand the use of commercial packages for complex problems.

Content:

Sr. No.	Topics	Teaching Hrs.	Module Weightage
1	Understanding Mathematical models for structural problems: Equilibrium of continuum. Formulation of mathematical, Energy Approach- Integral formulation, Methods of Weighted Residuals (Galerkin, Least-squares). Principle of Virtual work Variational formulation. Approximate methods for the solution of the mathematical models: Rayleigh-Ritz methods,	6	15%
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. 1D Elements Structural Problems: Linear and Quadratic elements, Elimination and Penalty Approach, Properties of global stiffness matrix. One dimensional thermal conduction and fluid flow	18	40%

	problems. Formulation of Truss element, Plane truss. Formulation of Beam Element , plane frames, various loading and boundary conditions.		
3	2D Elements: Gauss Quadrature formula, Gauss Quadrature in two and three dimensions. Plate stress and plane strain matrices. Triangular (CST, LST) and Rectangular (Q4, Q8) Elements: Shape function, Jacobian matrix, strain-displacement matrix, stress-strain relationship matrix, force vector, Limitations of elements.	12	25%
4	Plate and Shell Elements: Conforming and nonconforming elements, degenerated shell elements, reduced and selective integration, shear locking in shell element and hour glass phenomenon.	10	20%

Distribution of Theory Marks

R Level	U Level	A Level	N Level	E Level	C Level
10	10	20	15	25	20

Legends: R: Remembrance; **U:** Understanding; **A:** Application, **N:** Analyze, **and E:** Evaluate

Reference Books:

1. A First Course in the Finite Element Method, D Logan, Thompson Learning
2. Concepts and Applications of Finite Element Analysis, R D Cook, D S Malkus, M E Plesha, and R J Witt, Wiley.
3. Text book of Finite Element Analysis, Seshu P., PHI.
4. Finite Element Procedures, Bathe K. J., PHI.
5. Introduction to Finite Elements in Engineering, Chandrupatla T. R. and Belegunda A. D., PHI.
6. The Finite Element Method – A Practical Course, Liu G. R. and Quek S. S., Butterworth-Heinemann.
7. Finite element Method in Engineering, S S Rao, Elsevier.

List of Experiments:

During practical sessions, various problems should from syllabus topics should be solved using FEA software. Wherever feasible, problems should also be solved with manual calculations.

1. Introduction to Finite Element Analysis software.
2. Solution of 1D – Structural, thermal and fluid problems using FEA software.
3. Solution of Plane truss problems, using FEA software. Include problems with symmetry.
4. Solution of Beam problems with different boundary and loading conditions using FEA software.
5. Solution of problems using different element types in a FEA software. Also analyse effect of element formulation and number of elements.

6. Solution of 3D problems using FEA software.
7. Solution of plate and shell problems using FEA software.
8. Case study of stress analysis for one Machine component

Design based Problems (DP)/Open Ended Problem:

1. Write a generic program for solving 1D and 2D structural problems.

Major Equipment:

1. Computational facility and FEA software.

List of Open Source Software/learning website:

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