Subject Code: 01ME0701
Subject Name: Finite Element Methods
B. Tech. Year - IIII (Semester - 7)

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 one and two dimensional structural, thermal and fluid analysis; beams and 3D structural problems will be analyzed.

Course Outcome :

This course will help students 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 analysis, beams analysis and Dynamic analysis
4. Solve two dimensional FE formulations involving triangular, quadrilateral elements and higher order elements.
5. Prepare algorithms and write Finite Element code for solving simple design problems and understand the use of commercial packages for complex problems.

Teaching and Examination Scheme :

Teaching Scheme			Credits	Examination Marks					Total Marks
				Theory Marks			Practical Marks		
Theory	Tutorial	Practical	C	ESE (E)	IA	CSE	Viva (V)	Term Work (TW)	
4	0	2	5	50	30	20	25	25	150

Content :

Sr. No.	Topics	Total Hrs.
1	**Understanding Mathematical models for structural problems:** Equilibrium of continuum. Formulation of mathematical equations, Energy Approach- Integral formulation, Methods of Weighted Residuals (Galerkin, Least- squares). Principle of Virtual work Variational formulation. Various methods for the solution of the mathematical models like: Rayleigh-Ritz method.	**06**

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: 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 and three dimensions. Plate stress and plane strain matrices. Constant strain Triangle and Linear strain Triangle, Limitations of elements. Rectangular Elements, The Shape function, The Jacobian matrix, strain and displacement matrix, stress to strain relationship matrix, force vector	**12**
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. Undamped-free vibration- Eigenvalue problem, Evaluation of eigenvalues and eigenvectors (natural frequencies and mode shapes)	**10**

Distribution of Theory Marks

R Level	**U** Level	**A** Level	**N** Level	**E`** Level	**C** Level
10	**20**	**25**	**25**	**10**	**10**

Legends: R: Remember**; U:** Understand**; A:** Apply**; N:** Analyze**; E:** Evaluate**; C**: Create

List of Experiments :

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 analyze effect of element formulation and number of elements
6. Solution of 3D problems using FEA software.
7. Dynamic analysis – Buckling/ Eigenvalue analysis
8. Case study of stress analysis for one Machine component

List of Assignment :

1. Mathematical Modelling
2. Bar, Truss
3. 2-D elements
4. Dynamic analysis

Major Equipment :

1. Computational facility and FEA software.

Design based Problems (DP)/Open Ended Problem :

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

Reference books :

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

List of Open Base Software/learning website :

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