Syllabus for Master of Technology

Subject Code: 01CA0203

Subject Name: Finite Element Analysis

M.Tech. I Year – (Sem-2) CAD/CAM

Type of course: Core

Rationale: 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.

Teaching and Examination Scheme:

Teaching Scheme (Hours)			Credits	Evaluation Scheme					Total Marks
				Theory Marks			Practical Marks		
Theory	Tutorial	Practical		ESE (E)	IA	CSE	Viva (V)	Term Work (TW)	
3	---	2	4	50	30	20	25	25	150

Sr. No.	Topics	Teaching Hrs.
1	**Mathematical models for structural problems:** Equilibrium of continuum-Differential formulation, Energy Approach-Integral formulation, Principle of Virtual work - Variational formulation. Overview of approximate methods for the solution of the mathematical models: Rayleigh-Ritz methods, Methods of Weighted Residuals (Galerkin, Least-squares).	5
2	**Bars, 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. 1D Elements Structural Problems: 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. 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. Types of 3D elements and their comparison.	7
4	Plate and Shell Elements: Introduction, thin and thick plates: Kirchoff 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

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.

Course Outcome:

Sr. No.	Course Outcome	Percentage weightage
CO-1	Students will be able to understand the concept of finite element method and develop algorithms for analysis of mechanical systems.	10%
CO-2	Students will be able to apply the knowledge of FEM for 1D stress analysis, modal analysis, heat transfer analysis and flow analysis.	30%
CO-3	Students will be able to formulate and solve problems of trusses, beams and frames, students will also be able to use commercial packages for complex problems.	30%
CO-4	Students will be able to develop 2-D FE formulations involving triangular, quadrilateral elements and higher order elements.	30%

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. Solve 1D – Structural, thermal and fluid problems using FEA software.
3. Solve Plane truss problems, using FEA software. Include problems with symmetry.
4. Solve Beam problems with different boundary and loading conditions using FEA software.
5. Solve 2D problems using different element types in a FEA software. Also analyse effect of element formulation and number of elements.
6. Solve 3D problems using FEA software.
7. Solve plate and shell problems using FEA software.
8. Solve Dynamic problems using FEA software.

Major Equipment:

1. Computational facility and FEA solver.

List of Open Source Software/learning website:

1. NPTEL courses
2. Scilab Software