GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Master of Engineering

Level: PG

Subject Code: ME02000411

Subject Name : Finite Element Methods

w. e. f. Academic Year:	2024-25
Semester:	2
Category of the Course:	PCC

Prerequisite:	Nil
Rationale:	To approximate solutions to complex engineering problems by dividing a continuous domain into smaller, manageable "elements" which can be analyzed individually, then assembling the results to represent the behavior of the entire system, allowing for accurate modeling of intricate geometries and diverse physical phenomena while maintaining computational efficiency;

Course Outcome:

After Completion of the Course, Student will able to:

No	Course Outcomes	RBT level
1	Students will be able to understand the concept of finite element method and develop algorithms for analysis of mechanical systems.	Understand
2	Students will be able to apply the knowledge of FEM for 1D stress analysis, modal analysis, heat transfer analysis and flow analysis.	Apply
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.	Evaluate
4	Students will be able to develop 2-D FE formulations involving triangular, quadrilateral elements and higher order elements.	Develop

Teaching and Examination Scheme:

Teaching Scheme (in Hours)			Total Credits L+T+ (PR/2)	Assessment Pattern and Marks				Total Marks
				Theory		Tutorial / Practical		
L	T	PR	C	ESE (E)	PA / CA (M)	PA/CA (I)	ESE (V)	
3	0	2	4	70	30	20	30	150

Course Content:

Unit No.	Content	No. of Hours	% of Weightage

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	12
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	30
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.	8	18
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	14
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.	8	18
6.	**Non-Linearity:** Introduction and types of non-linearity, Formulation for geometrical and material non-linearity.	3	8
	Total	**45**	**100**

Suggested Specification Table with Marks (Theory):

Distribution of Theory Marks					
R Level	**U Level**	**A Level**	**N Level**	**E Level**	**C Level**
-	**10**	**20**	**20**	**30**	**20**

Where R: Remember; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create (as per Revised Bloom's Taxonomy)

References/Suggested Learning Resources:

(a) 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.

(b) Open-source software and website:

1. NPTEL courses
2. Scilab Software

Suggested Course Practical List: 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.

Suggested Activities for Students: If any

Computational facility and FEA solver.

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