GUJARAT TECHNOLOGICAL UNIVERSITY

MECHANICAL ENGINEERING (19)
FINITE ELEMENTS METHOD
SUBJECT CODE: 2181911
B.E. 8TH SEMESTER

Type of course: Undergraduate

Prerequisite: Zeal to learn the Subject

Rationale: Methods for formulations of mathematical models of analysis of mechanical systems are introduced. The class of problems include 1D and 2D structural, thermal and fluid problems; trusses and beams structural problems.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks						Total Marks
				Theory Marks			Practical Marks			
L	T	P	C	ESE (E)	PA (M)		PA (V)		PA (I)	
					PA	ALA	ESE	OEP		
3	0	2	5	70	20	10	20	10	20	150

Content:

Sr. No.	Content	Total Hrs	% Weightage
1	**Fundamentals of Continuum Mechanics:** Equilibrium of continuum-Differential formulation, Energy Approach-Integral formulation. Overview of approximate methods for the solution of the mathematical models: Rayleigh-Ritz methods, Methods of Weighted Residuals (Galerkin, Least-squares & Collocation methods).	**6**	**15%**
2	**Numerical Integration:** Central Difference Method, Newmark's Methods, Wilson's method, Gauss quadrature.	**4**	**5%**
3	**Line Elements and Applications:** Concepts of Modelling and discretization, Shape functions, elements and Degrees-of-Freedom, Strain – displacement relation, Local and Global equations; Iso-Sub-Super parametric formulation.	**4**	**5%**
	Structural Problems: Linear and Quadratic elements, Elimination and Penalty Approach, Properties of global stiffness matrix; Structural and Thermal strains; Treatment for various boundary conditions. Formulation of Truss element, Plane truss: Stiffness and Force matrix. Beam: Euler – Bernoulli Element formulation, plane frames, various loading and boundary conditions.	**10**	**25%**
	Thermal and Fluid Problems: Steady state heat transfer: Element formulations, treatment to boundary conditions with application to 1-D heat conduction, heat transfer through thin fins; Potential flow problems.	**5**	**15%**
4	**2D Elements:** Triangular (CST, LST): Shape function, Jacobian matrix, strain-displacement matrix, stress-strain relationship matrix, force vector. Quadrilateral Elements (Q4, Q8): Shape function, Jacobian matrix, strain-displacement matrix, stress-strain relationship matrix, force vector.	**8**	**20%**

	Axisymmetric problems and applications.		
5	**Dynamic Problems:** Formulation of dynamic problems, consistent and lumped mass matrices for 1-D and 2-D element, Solution of eigenvalue 1-D problems: Transformation methods, Jacobi method, Vector Iteration methods, subspace iteration method.	**7**	**15%**

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R Level	**U Level**	**A Level**	**N Level**	**E Level**	**C Level**
10	**15**	**15**	**10**	**10**	**10**

Legends: R: Remembrance ; U = Understanding; A = Application and above Levels (Revised Bloom's Taxonomy)

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table

Reference Books:

1. Introduction to Finite Elements in Engineering, Chandrupatla T. R. and Belegunda A. D., PHI.
2. A First Course in the Finite Element Method, D Logan, Thompson Learning
3. An Introduction to Finite Element Method, J N Reddy, McGraw - Hill.
4. Concepts and Applications of Finite Element Analysis, R D Cook, Wiley India.

Course Outcome:

After learning the course the students should be able to:

1. Understand the concept of finite element method for solving Mechanical Engineering problems.
2. Apply the knowledge of FEM for 1D stress analysis, heat transfer analysis and flow analysis.
3. Formulate and solve problems of trusses, beams, planar loading and axisymmetric.
4. Formulate and solve preliminary problems for dynamic analysis.

List of Experiments:

1. Introduction to Finite Element Analysis software.
2. Solve 1D – Structural, thermal and fluid problems using FEA software and manually.
3. Solve Plane truss problems, using FEA software and manually. Include problems with symmetry.
4. Solve Beam problems with different boundary and loading conditions using FEA software and manually.
5. Solve planar problems.
6. Solve axisymmetric problems.
7. Solve Dynamic problems.

Design based Problems (DP)/Open Ended Problem:

1. Write a generic program for solving 1D and 2D structural problems.
2. Analyse effect of node numbering, element types and meshing on solutions.

Major Equipment:

1. Computational facility and FEA solver.

ACTIVE LEARNING ASSIGNMENTS: Preparation of power-point slides, which include videos, animations, pictures, graphics for better understanding theory and practical work – The faculty will allocate chapters/ parts of chapters to groups of students so that the entire syllabus to be covered. The power-point slides should be put up on the web-site of the College/ Institute, along with the names of the students of the group, the name of the faculty, Department and College on the first slide. The best three works should submit to GTU.