GUJARAT TECHNOLOGICAL UNIVERSITY

MECHANICAL (CAD/CAM) (08)/ MECHANICAL (MACHINE DESIGN) (09)
FINITE ELEMENT METHODS
SUBJECT CODE: 2720801
SEMESTER: II

Type of course: Post Graduate

Prerequisite: Zeal to learn the Subject

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			Credits	Examination Marks						Total Marks
L	T	P	C	Theory Marks		Practical Marks				
				ESE (E)	PA (M)	ESE (V)		PA (I)		
						ESE	OEP	PA	RP	
3	0	4#	5	70	30	20	10	10	10	150

Content:

Sr. No.	Topics	Teaching Hrs.	Module 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	15%
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	25%
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	20%
4	Plate and Shell Elements: Introduction, thin and thick plates: Kirchoff theory, Mindlin plate element,	6	15%

	conforming and nonconforming elements, degenerated shell elements, reduced and selective integration, shear locking and hour glass phenomenon.		
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	20%
6	Non-Linearity: Introduction and types of non-linearity, Formulation for geometrical and material non-linearity.	2	5%

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:

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, modal analysis, heat transfer analysis and 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.

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.

Design based Problems (DP)/Open Ended Problem:

1. Write a generic program for solving 1D and 2D structural problems.
2. Determine SIF using FEA

Major Equipment:

1. Computational facility and FEA solver.

List of Open Source Software/learning website:

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

Review Presentation (RP): The concerned faculty member shall provide the list of peer reviewed Journals and Tier-I and Tier-II Conferences relating to the subject (or relating to the area of thesis for seminar) to the students in the beginning of the semester. The same list will be uploaded on GTU website during the first two weeks of the start of the semester. Every student or a group of students shall critically study 2 papers, integrate the details and make presentation in the last two weeks of the semester. The GTU marks entry portal will allow entry of marks only after uploading of the best 3 presentations. A unique id number will be generated only after uploading the presentations. Thereafter the entry of marks will be allowed. The best 3 presentations of each college will be uploaded on GTU website