GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering

Subject Code: 3171920

SUBJECT NAME: Finite Element Methods

B.E 7th SEMESTER

Type of Course: - Professional Elective

Pre-requisite:-

Rationale: The course aims to impart basic skills of formulation and application of finite element methods for the analysis of mechanical systems.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
				Theory Marks		Practical Marks		
L	T	P	C	ES (E)	PA (M)	ESE (V)	PA (I)	
3	0	2	4	70	30	30	20	150

CONTENT:-

Sr. No.	Course Content	Total Hours
1	**Fundamental Concepts** Introduction, Stresses and Equilibrium, Boundary Conditions, Strain—Displacement Relations, Stress—Strain Relations, Temperature Effects, Potential Energy and Equilibrium: The Rayleigh—Ritz Method, Potential Energy, Rayleigh—Ritz Method, Galerkin's Method, Saint Venant's Principle, Von Mises Stress , Principle of Superposition, Matrix Algebra and Gaussian Elimination, Conjugate Gradient Method for Equation Solving, Conjugate Gradient Algorithm	**05**
2	**One-Dimensional Problems** Introduction ,Finite Element Modeling ,Element Division, Numbering Scheme, Shape Functions and Local Coordinates , The Potential-Energy Approach, Element Stiffness Matrix, Force Terms, The Galerkin Approach, Element Stiffness, Force Terms, Assembly of the Global Stiffness Matrix and Load Vector , Properties of **K** , The Finite Element Equations: Treatment of Boundary Conditions, Types of Boundary Conditions, Elimination Approach, Penalty Approach, Multipoint Constraints, Quadratic Shape Functions Temperature Effects, Problem Modeling and Boundary Conditions, Problem in Equilibrium, Symmetry, Two Elements with Same End Displacements, Problem with a Closing Gap	**09**
3	**Trusses** Introduction ,Plane Trusses, Local and Global Coordinate Systems, Formulas for Calculating I and m, Element Stiffness Matrix, Stress Calculations, Temperature Effects, Three-Dimensional Trusses, Assembly of Global Stiffness Matrix for the Banded and Skyline Solutions, Assembly for Banded Solution, Skyline Assembly, Problem Modeling and Boundary Conditions, Inclined Support in Two Dimensions, Inclined Support in Three Dimensions–Line Constraint, Inclined Support in Three Dimensions–Plane Constraint, Symmetry and Antisymmetry	**09**
4	**Beams and Frames** Introduction, Potential-Energy Approach, Galerkin Approach, Finite Element Formulation, Element Stiffness–Direct Approach, Load Vector, Boundary Considerations, Shear Force and Bending Moment, Beams on Elastic Supports, Plane Frames, Three-Dimensional Frames, Problem Modeling and Boundary Conditions	**06**
5	**Two-Dimensional Problems using Constant Strain Triangles** Introduction , Finite Element Modeling, Constant Strain Triangle (CST), Isoparametric Representation, Potential-Energy Approach, Element Stiffness, Force Terms, Integration	**08**

	Formula on a Triangle, Galerkin Approach, Stress Calculations, Temperature Effects, Problem Modeling and Boundary Conditions, Some General Comments on Dividing into Elements, Patch Test and Convergence, Patch Test, Orthotropic Materials, Temperature Effects.	
6	**Axisymmetric Solids Subjected to Axisymmetric Loading** Introduction, Axisymmetric Formulation, Finite Element Modeling: Triangular Element, Potential-Energy Approach, Body Force Term, Rotating Flywheel, Surface Traction, Galerkin Approach, Stress Calculations, Temperature Effects, Problem Modeling and Boundary Conditions, Cylinder Subjected to Internal Pressure, Infinite Cylinder, Belleville Spring, Thermal Stress Problem	**07**
	Total	**45**

Reference Books:

1. Introduction to Finite Elements in Engineering, Chandrupatla T. R. and Belegunda A. D., PHI.
2. A First Course in Finite Elements, Jacob Fish, Ted Belytschko, John Wiley & Sons Ltd
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.

Distribution of marks weightage for cognitive level

Bloom's Taxonomy for Cognitive Domain	Marks % weightage
Recall	10
Comprehension	10
Application	30
Analysis	40
Evaluate	10
Create	--

Course Outcome:

After learning the course the students will be able to:

Sr. No.	CO statement	Marks % weightage
CO-1	Demonstrate the concepts of finite element methods and its application in the field of mechanical engineering.	20
CO-2	Analyse one dimensional and two dimensional systems using finite element methods.	40
CO-3	Make use of finite element methods for analysis of trusses, beams, frames and axisymmetric solids.	30
CO-4	Estimate thermal stresses of machine elements.	10

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.

Major Equipment:

1. Computational facility and FAE solvers.

List of Open Source Software/learning website:

1. http://nptel.ac.in