

GUJARAT TECHNOLOGICAL UNIVERSITY

FINITE ELEMENT ANALYSIS OF MECHATRONICS SYSTEMS SUBJECT CODE: 2172008 B.E. 7TH SEMESTER

Type of course: Engineering Science (Departmental Elective – II)

Prerequisite: NA

Rationale: This subject deals with fundamentals of Finite Element Methods and its applications, which are useful for Mechatronics engineers.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks						Total Marks
L	T	P		C	Theory Marks		Tutorial /Practical Marks			
				ESE(E)	PA(M)	ESE (V)		PA (I)		
						ESE	OEP	PA	RP	
3	0	2	5	70	30	20	10	10	10	150

L- Lectures; T- Tutorial/Teacher Guided Student Activity; P- Practical; C- Credit;

ESE- End Semester Examination; PA- Progressive Assessment

Sr. No	Contents	Teaching Hrs	Weightage (%)
1	Finite Element Method: Basics, history, Comparison with other methods, General steps of FEM, Applications and Advantages.	3	7
2	Introduction to the Stiffness (Displacement) Method Definition of the Stiffness Matrix, Derivation of the Stiffness Matrix for a Spring Element, Assembling the Total Stiffness Matrix by Superposition (Direct Stiffness Method), Boundary Conditions, Potential Energy Approach to Derive Spring Element Equations, Examples of a Spring Assemblages	7	17
3	Development of Truss Equations – Introduction, Derivation of the Stiffness Matrix for a Bar Element in Local Coordinates, Selecting Approximation Functions for Displacements, Transformation of Vectors in Two Dimensions, Global Stiffness Matrix formulation, Computation of Stress for a Bar in the x-y Plane, Solution of a Plane Truss, Transformation Matrix and Stiffness Matrix for a Bar in Three-Dimensional Space, Use of Symmetry in Structure, Inclined, or Skewed, Supports, Potential Energy Approach to Derive Bar Element Equations, Comparison of Finite Element Solution to Exact Solution for Bar	7	17
4	Development of Beam Equations –Introduction, Beam Stiffness, Example of Assemblage of Beam Stiffness Matrices, Examples of Beam Analysis Using the Direct Stiffness Method, Distributed Loading, Comparison of the Finite Element Solution to the Exact Solution for a Beam, Beam Element with Nodal Hinge, Potential Energy Approach to Derive Beam Element Equations.	10	24
5	Development of the Plane Stress and Plane Strain Stiffness Equations - Basic Concepts of Plane Stress and Plane Strain, Derivation of the Constant-Strain Triangular Element Stiffness	10	24

	Matrix and Equations, Treatment of Body and Surface Forces, Explicit Expression for the Constant-Strain Triangle Stiffness Matrix, Finite Element Solution of a Plane Stress Problem Development of the Linear-Strain Triangle Equations – Introduction, Derivation of the Linear-Strain Triangular Element Stiffness Matrix and Equations, Example LST Stiffness Determination, Comparison of Elements.		
6	Element Types: Axisymmetric element, Isoparametric formulation, three dimensional stress analysis. Dynamic Analysis - Dynamic considerations, Dynamic equations – consistent mass matrix – Eigen Values, Eigen Vector, natural frequencies – mode shapes – modal analysis.	5	11
	TOTAL	42	100

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks				
Remembrance R Level	Understanding U Level	Application A Level	Analyze N Level	Evaluate E Level
40	30	10	15	05

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.

Text Book:

1. A First course in Finite Element Methods by Daryl Logan, Thomson Publishers.

Reference Books:

1. Introduction to finite elements in Engineering by Tirupathi K. Chandrupatla and Ashok D.Belegundu, PHI Learning.
2. Finite Element Procedures in Engineering analysis by K.J Bathe.
3. An Introduction to Finite Element Methods – J. N. Reddy – McGraw Hill.
4. A Textbook of Finite Element Analysis by P. Seshu
5. The Finite Element Method in Engineering science – O.C. Zienkowicz, McGraw Hill.
6. Concepts and applications of finite element analysis – Robert Cook

Course Outcomes:

After learning the course the students should be able to

1. Learn the mathematical formulation of the finite element method and how to apply it to basic (linear) ordinary and partial differential equations.
2. Learn how to implement the finite element method efficiently in order to solve a particular equation for simple problems.
3. Solve simple and complicated 3D structural problems for stress analysis under impact loads from general engineering aspects.
4. Appreciate the importance of ethical issues pertaining to the effective utilization of FEA in mechatronics engineering.

List of Practicals

1. Introduction to ANSYS – Modelling and analysis
2. Solve Problems on 1-D Spring elements
3. Solve Problems on beam elements
4. Solve Problems on Truss element
5. Solve Problems on 2-D element
6. Solve problem on Bars with Constant and variable Cross-section Area, Stepped bars etc.
7. Solve problems on Bars of Tapered Cross section Area
8. Part modeling of an assembly.
9. Assembly modeling of an assembly.
10. Analysis of different components of an assembly.

Tutorials:

NA

Design based/open ended problem

Student may be given a task to exhibit the knowledge of the course studied during the academic year.

Major Equipments / softwares:

ANSYS -14.5 - Software

Active learning Assignments (AL) : 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.