Seat No./Enrollment No.: _____

GUJARAT TECHNOLOGICAL UNIVERSITY
BACHELOR OF ENGINEERING – SEMESTER 7 – EXAMINATION – SUMMER 2026

Subject Code: 3172008 **Date: 29/05/2026**

Subject Name: Finite Element Analysis

Time: 02:30 PM TO 05:00 PM **Total Marks: 70**

Instructions:

1. **Attempt all questions.**
2. **Make suitable assumptions wherever necessary.**
3. **Figures to the right indicate full marks.**
4. **Simple and non-programmable scientific calculators are allowed.**

Q.1	**(a)**	Define the Finite Element Method and list its main advantages over other numerical methods.	**03**
	(b)	Explain how boundary conditions are applied in FEM.	**04**
	(c)	Derive the stiffness matrix for a 2-spring system connected in series using the potential energy method.	**07**
Q.2	**(a)**	A linear spring has stiffness 800 N/m and is subjected to a 50 N force. Find the displacement at the free end.	**03**
	(b)	Derive the stiffness matrix for a 1D bar using the potential energy approach.	**04**
	(c)	For a 2-element spring system with stiffnesses k_1 = 100 N/mm and k_2 = 200 N/mm connected in parallel under 30 N load, determine total stiffness and displacement.	**07**
		OR	
Q.2	**(c)**	Explain the concept of isoparametric elements, and derive 1D isoparametric formulation.	**07**
Q.3	**(a)**	Write down the global stiffness matrix for a bar element in plane coordinates.	**03**
	(b)	A bar of length 300 mm is made of aluminum (E = 70 GPa, A = 100 mm^2) and carries a 5 kN load at the free end. Find elongation and stress.	**04**
	(c)	Derive and explain transformation and stiffness matrices for a 3D truss member.	**07**
		OR	
Q.3	**(a)**	Explain the use of symmetry in structural analysis.	**03**
	(b)	Differentiate between lumped mass and consistent mass matrices.	**04**
	(c)	A single degree of freedom system has k = 4000 N/m, m = 50 kg, and damping c = 100 Ns/m. Find natural frequency, damping ratio, and damped frequency.	**07**
Q.4	**(a)**	Define natural frequency and mode shape.	**03**
	(b)	A system has stiffness k = 2000 N/m and mass m = 10 kg. Determine natural frequency in rad/s and Hz.	**04**
	(c)	Derive the equations of motion for a finite element dynamic system.	**07**
		OR	
Q.4	**(a)**	Two springs with stiffness k1 =50 N/mm and k2 =100N/mm are connected in series. Derive the global stiffness matrix for this assembly.	**03**
	(b)	Explain the concept of 'Shape Functions' and state the characteristics they must satisfy for a 1D bar element.	**04**

	(c)	A stepped bar is subjected to an axial load of 100 kN. Section 1: L = 300 mm, A = 500 mm2Section 2: L = 200 mm, A = 300 mm 2E = 200 GPa for both.One end is fixed. Calculate the nodal displacements, stresses in each section, and reaction forces.	**07**
Q.5	**(a)**	State the properties of a Global Stiffness Matrix.	**03**
	(b)	Compare Constant Strain Triangle (CST) and Linear Strain Triangle (LST) elements in terms of convergence and accuracy.	**04**
	(c)	Explain Isoparametric, Sub-parametric, and Super-parametric elements with neat sketches. Why is the Isoparametric formulation preferred in commercial FEM software like ANSYS?	**07**

OR

Q.5	**(a)**	Explain why the global stiffness matrix is always a symmetric and banded matrix.	**03**
	(b)	Describe the Penalty Method used for applying boundary conditions in FEM.	**04**
	(c)	A 2D truss element is oriented at 45◦ to the global x-axis. If the local stiffness is k =AE/L , find the global stiffness matrix for this single element.	**07**

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