Ref. No.: Ex/PG/ME/T/129A/2025

M.E. MECHANICAL ENGINEERING FIRST YEAR SECOND SEMESTER - 2025

FINITE ELEMENT ANALYSIS IN ENGINEERING

Time: 3 Hrs **Full Marks: 100**

Any missing data may be assumed with suitable justification
Symbols/notations carry its usual meanings
All Questions Carry Equal Marks

(ANSWER ANY FIVE QUESTIONS)

1. Derive the strain-displacement matrix for a triangular element with three nodes having two degrees of freedom at each node. Highlight the significance and use of a constant strain triangle (CST) element. (20)

2. Derive the expression for the stiffness matrix for a flexure element (**Fig. 1**) with two nodes denoted by **1** and **2** and each of the two nodes having two degrees of freedom, one being rotation and other translation. (20)

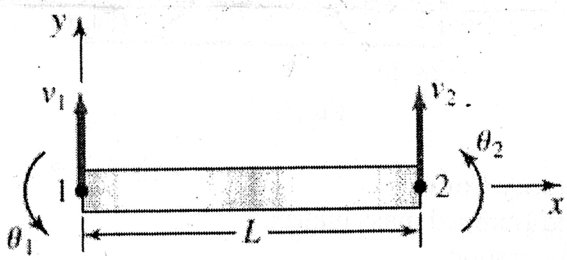

Fig. 1

3. Assuming isoparametric formulation, derive the strain-displacement for a four-noded quadrilateral element with two degrees of freedom at each node. (20)

4. Using two equal-length finite elements, determine the natural circular frequencies of the solid circular shaft fixed at one end shown in **Fig. 2**. (20)

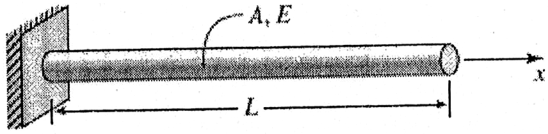

Fig. 2

[Turn over

5. Define Rayleigh's Damping? Using the normalization principle, evaluate an expression for the damping factor in case of structural damping. Explain the variations in the damping factor considering lower and higher modes. (20)

6. Using the orthogonality principle, explain the principle of normalization of the mass and stiffness matrices to arrive at the modal mass matrix and modal stiffness matrices such that

$$\{\emptyset\}^T[M]\{\emptyset\} = [I] \ \& \ \{\emptyset\}^T[K]\{\emptyset\} = [\omega^2]$$

(20)

7. For the axisymmetric element shown in **Fig 3,** determine the stiffness matrix assuming E=210GPa and ν=0.30. The nodal coordinates are specified. (20)

8. Derive an expression for the strain-displacement for an axisymmetric element with usual notations. (20)

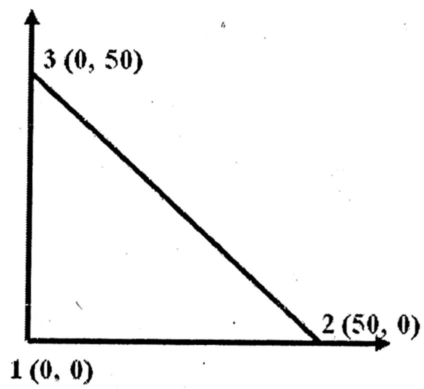

Fig. 3

9. Write Short notes on (**Any Four**) (5X4=20)
   (a) Consistent and Lumped mass matrix.
   (b) Numerical Integration.
   (c) 3D finite element formulation.
   (d) Modal Decomposition Technique.
   (e) h-refinement and p-refinement.
   (f) Steps in a FEM analysis.