Ref. No.: Ex/PG/MEC/PE/T/124B/2025

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

ADVANCED FINITE ELEMENT ANALYSIS

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. Evaluate the strain-displacement matrix for a triangular element with three nodes (**Fig. 1**) considering isoparametric formulation. (20)

2. Determine the stiffness matrix for a flexure element (**Fig. 2**) of Length L considering two nodes and each of the two nodes having two degrees of freedom, one being rotation and other translation. (20)

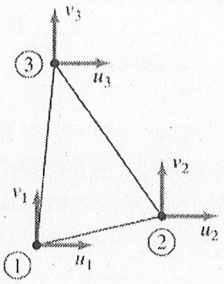

Fig. 1

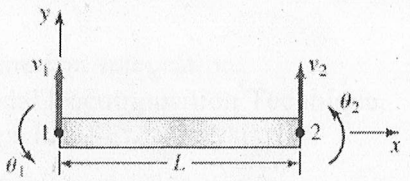

Fig. 2

3. (a) Explain the difference between consistent and lumped mass matrix.
(b) Using two equal-length finite elements, determine the natural circular frequencies of the solid circular shaft fixed at one end shown in **Fig. 3**. (20)

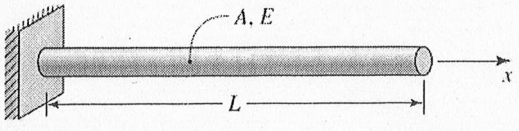

Fig. 3

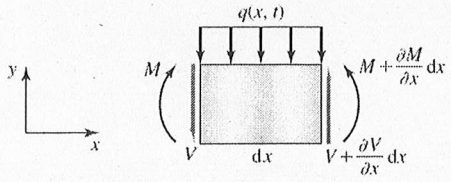

Fig. 4

4. Derive an expression for the mass matrix for a beam element considering a differential element of the beam subjected to time-dependent loading as shown in **Fig. 4.** (20)

5. Explain the principle of 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 occurring for lower and higher modes with suitable diagram. (20)

6. Using the orthogonality principle, explain the principle of normalization of the mass and stiffness matrices to arrive at the modal mass 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 5,** determine the stiffness matrix assuming E=210GPa and ν=0.30. The nodal coordinates are specified. (20)

8. Derive an expression for the conductance matrix considering one-dimensional heat conduction with convection as shown in **Fig. 6.** (20)

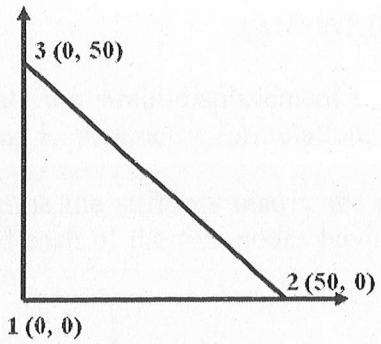

Fig. 5

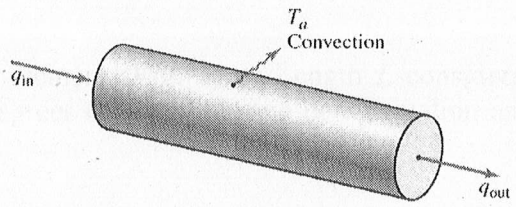

Fig. 6

9. Write Short notes on (**Any Four**) (5X4=20)

(a) Isoparametric formulation.
(b) Numerical Integration.
(c) Axisymmetric element.
(d) Modal Decomposition Technique.
(e) h-refinement and p-refinement.
(g) Steps in a FEM analysis.