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Seventh Semester B.E. Degree Examination, June/July 2024

Finite Element Modeling and Analysis

Time: 3 hrs.

Max. Marks: 100

Note: Answer any FIVE full questions, choosing ONE full question from each module.

Module-1

- 1 a. Derive the equilibrium equations for 3-D elastic body subjected to body force, surface and point load. (10 Marks)
- b. Explain with a neat sketch, plane stress and plane strain conditions. (10 Marks)

OR

- 2 a. A rectangular bar of cross sectional area A, Elastic modulus E, when subjected to axial loading P. Prove that at a distance of 'x' from fixed end is $u = \left(\frac{P}{AE} \right) x$. (10 Marks)
- b. Explain the principle of minimum potential energy. (04 Marks)
- c. Solve the following system of equations by Gauss-elimination method. (06 Marks)

$$\begin{aligned} x + y + z &= 9 \\ x - 2y + 3z &= 8 \\ 2x + y - z &= 3 \end{aligned}$$

Module-2

- 3 a. Derive the stiffness matrix for the bar element subjected to axial load 'F' using direct method. (10 Marks)
- b. Explain the basic steps involved in FEM. (10 Marks)

OR

- 4 a. What is shape function? Derive the shape function for 1-D bar element in global co-ordinates. (10 Marks)
- b. Explain the convergence requirements. (04 Marks)
- c. List the applications and limitations of FEM. (06 Marks)

Module-3

- 5 a. Determine the nodal displacements and stress in each element for the stepped bar as shown in Fig. Q5 (a). (10 Marks)

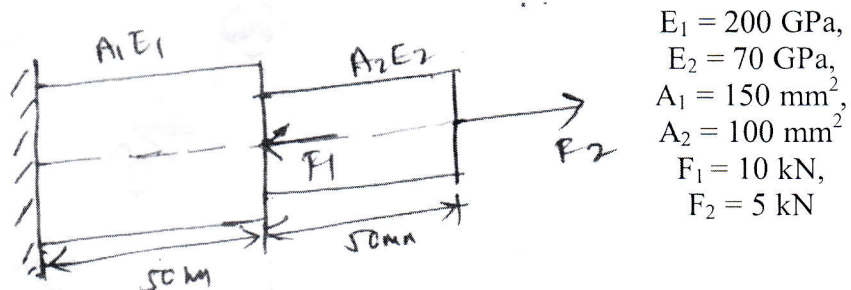
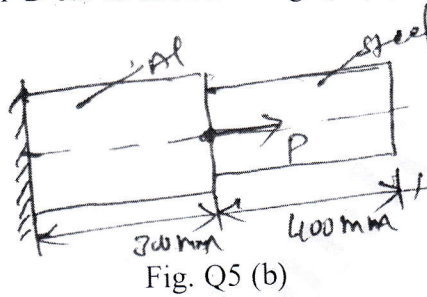


Fig. Q5 (a)

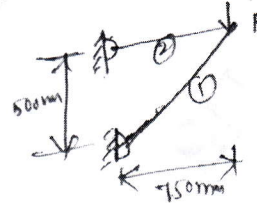
- b. Using penalty approach for handling boundary condition. Determine the nodal displacements for 1-D bar as shown in Fig. Q5 (b). (10 Marks)



$$\begin{aligned}
 P &= 200 \times 10^3 \text{ N}, \\
 A_1 &= 2400 \text{ mm}^2, \\
 E_1 &= 70 \times 10^9 \text{ N/m}^2, \\
 A_2 &= 600 \text{ mm}^2, \\
 E_2 &= 200 \times 10^9 \text{ N/m}^2, \\
 \ell_1 &= 300 \text{ mm}, \\
 \ell_2 &= 400 \text{ mm}
 \end{aligned}$$

OR

- 6 a. Derive the element stiffness matrix for truss element. (10 Marks)
 b. A plane truss shown in Fig. Q6 (b), determine nodal displacement. (10 Marks)



Module-4

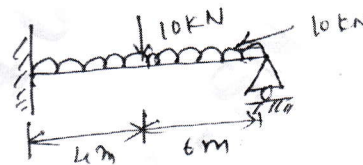
- 7 a. Derive the shape function for linear bar element using Lagrangian interpolation. (12 Marks)
 b. Brief about the properties of shape function. (08 Marks)

OR

- 8 a. Derive the hermite shape function for beam element. (16 Marks)
 b. Draw the variation of shape function for 1-D cubic bar element. (04 Marks)

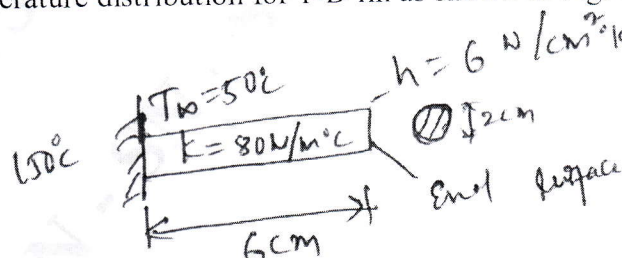
Module-5

- 9 a. Derive stiffness matrix for beam element. (10 Marks)
 b. For the beam shown in Fig. Q9 (b), determine the load vector due to the load acting on the beam. (10 Marks)



OR

- 10 a. Derive an expression for stiffness matrix for 3-D heat conduction. (10 Marks)
 b. Find the temperature distribution for 1-D fin as shown in Fig. Q10 (b). (10 Marks)



$$\begin{aligned}
 T_\infty &= 50^\circ \text{C} \\
 h &= 6 \text{ W/cm}^2 \cdot ^\circ \text{C} \\
 K &= 80 \text{ W/m} \cdot ^\circ \text{C}
 \end{aligned}$$
