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18ME61

Sixth Semester B.E. Degree Examination, Feb./Mar. 2022
Finite Element Method

Time: 3 hrs.

Max. Marks: 100

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

Module-1

- 1 a. Explain the basic steps involved in FEM. (10 Marks)
- b. State the principle of minimum potential energy. (02 Marks)
- c. Explain with sketches, plane strain and plane stress. (08 Marks)

OR

- 2 a. Explain simplex, complex and multiplex elements. (06 Marks)
- b. Use Rayleigh-Ritz method to find the stress and displacement at loading point of a bar shown in Fig.Q2(b). Take $E = 70 \text{ GPa}$, $A = 100 \text{ mm}^2$.

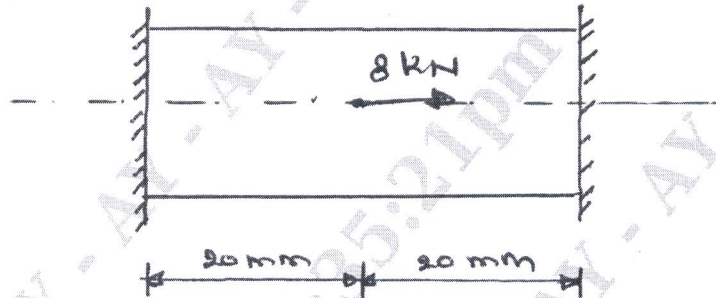


Fig.Q2(b)

(12 Marks)

- c. List the advantages of the finite element method. (02 Marks)

Module-2

- 3 a. Derive shape function for a two noded bar element. (08 Marks)
- b. Derive the strain-displacement matrix [B] for a CST element. (12 Marks)

OR

- 4 a. Determine the nodal displacements and the stresses in each element in the bar shown in Fig.Q4(a). Take $E_{Al} = 70 \text{ GPa}$, $E_{Steel} = 210 \text{ GPa}$, $P = 12 \text{ kN}$.

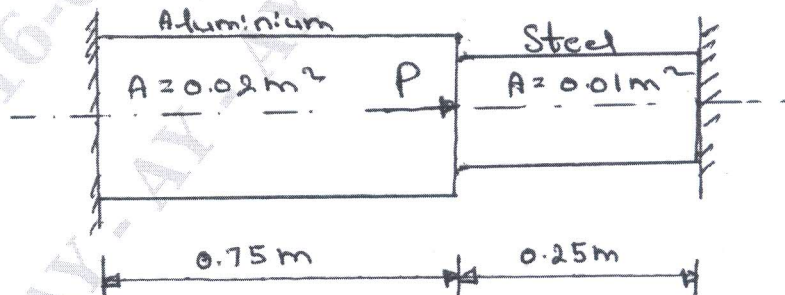


Fig.Q4(a)

(10 Marks)

Important Note : 1. On completing your answers, compulsorily draw diagonal cross lines on the remaining blank pages.
2. Any revealing of identification, appeal to evaluator and /or equations written eg, 42+8 = 50, will be treated as malpractice.

- b. For the two bar truss shown in Fig.Q4(b). Determine the nodal displacement, stress in each element. Take $A = 200 \text{ mm}^2$, $E = 2 \times 10^5 \text{ N/mm}^2$.

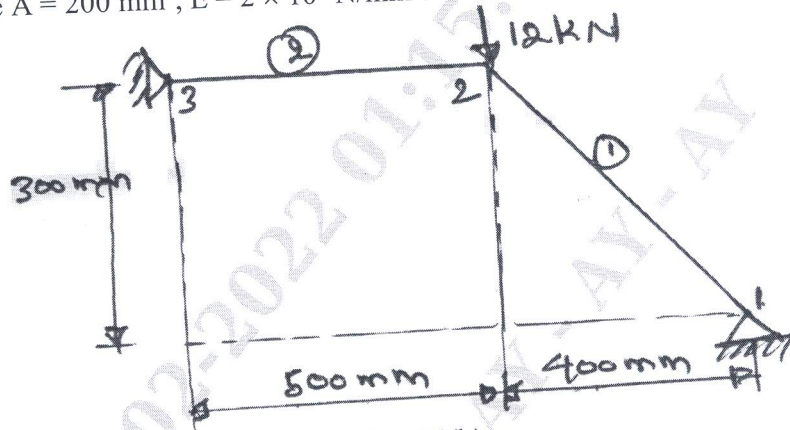


Fig.Q4(b)

(10 Marks)

Module-3

- 5 a. Derive Hermite shape function of a beam element and show the variation of the shape function over the element. (10 Marks)
- b. For the beam and loading shown in Fig.Q5(b), determine the slopes at 2 and 3, and the vertical deflection at the midpoint of the distributed load. Take $E = 200 \text{ GPa}$, $I = 4 \times 10^6 \text{ mm}^4$.

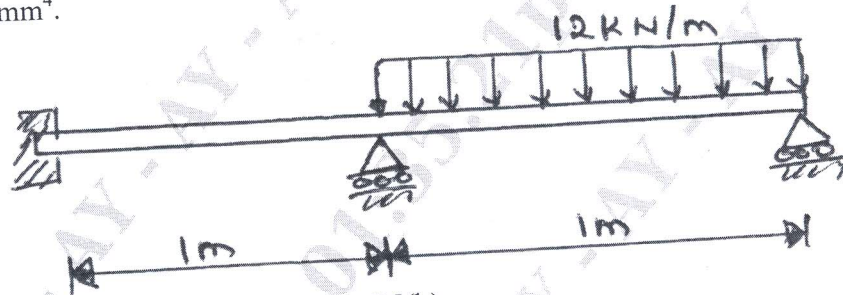


Fig.Q5(b)

(10 Marks)

OR

- 6 a. Derive the stiffness matrix for beam elements. (10 Marks)
- b. A solid stepped bar of circular cross section shown in Fig.Q6(b) is subjected to a torque of 1 kN-m at its free end and torque of 3 kN-m at its change in cross section. Determine the angle of twist and shear stresses in the bar. Take $E = 2 \times 10^5 \text{ N/mm}^2$ and $G = 7 \times 10^4 \text{ N/mm}^2$.

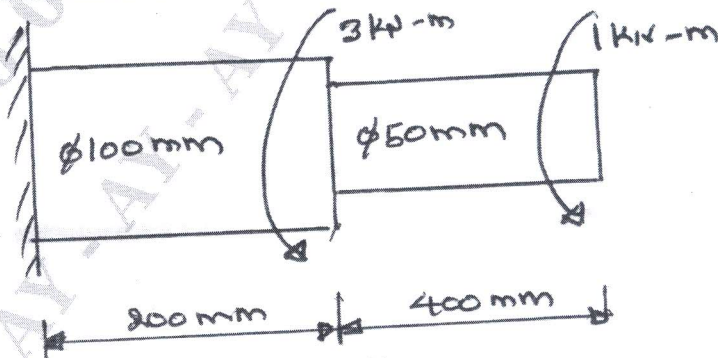


Fig.Q6(b)

(10 Marks)

Module-4

- 7 a. Discuss the derivation of one dimensional heat transfer in thin fin. (08 Marks)
- b. A composite wall consists of three materials as shown in Fig.Q7(b). The outer temperature is $T_0 = 20^\circ\text{C}$. Convection heat transfer takes place on the inner surface of the wall with $T_\infty = 800^\circ\text{C}$ and $h = 25 \text{ W/m}^2\text{C}$. Determine the temperature distribution in the wall. Take $K_1 = 20 \text{ W/m}^\circ\text{C}$, $K_2 = 30 \text{ W/m}^\circ\text{C}$, $K_3 = 50 \text{ W/m}^\circ\text{C}$.

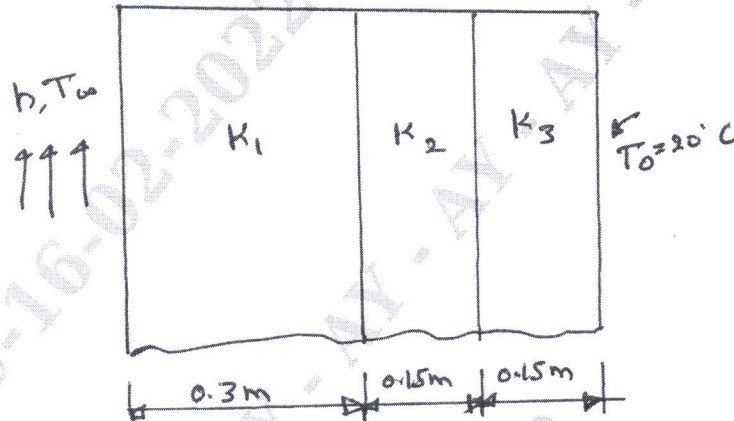


Fig.Q7(b)

(12 Marks)

OR

- 8 a. Calculate the temperature distribution in a one dimensional fin with the physical properties given in Fig.Q8(a). There is a uniform generation of heat inside the wall of $\bar{Q} = 400 \text{ W/m}^3$. Take $K = 300 \text{ W/m}^\circ\text{C}$.

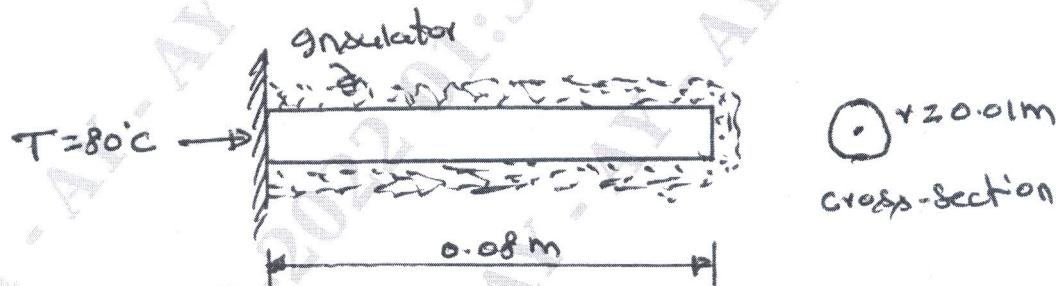


Fig.Q8(a)

(10 Marks)

- b. For the smooth pipe shown in Fig.Q8(b), with uniform cross-section of 1 m^2 , determine the flow velocities at the center and right end, knowing the velocity at the left is $V_x = 2 \text{ m/sec}$.

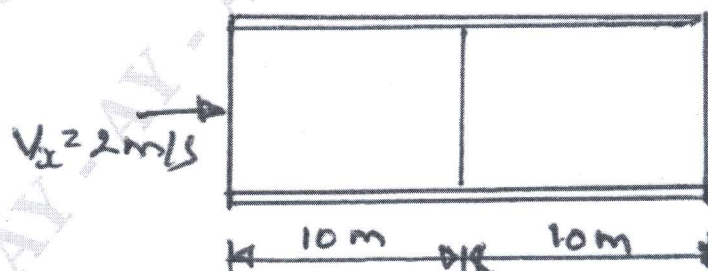


Fig.Q8(b)

(10 Marks)

Module-5

- 9 a. Derive the stiffness matrix of axisymmetric bodies with triangular elements. (12 Marks)
 b. For the element of an axisymmetric body rotating with a constant angular velocity $w = 1000$ rev/min as shown in Fig.Q9(b), determine the body force vector. Include the weight of the material, where the specific density is 7850 kg/m^3 .

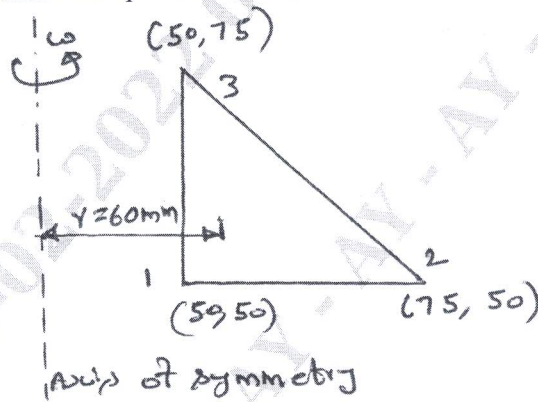


Fig.Q9(b)

(08 Marks)

OR

- 10 a. Derive the consistent mass matrix of one dimensional bar element. (06 Marks)
 b. Evaluate eigen vectors and eigen values for the stepped bar shown in Fig.Q10(b). Take $E = 200 \text{ GPa}$ and specific weight 7850 kg/m^3 . Draw mode shapes. Take $A_1 = 400 \text{ mm}^2$ and $A_2 = 200 \text{ mm}^2$.

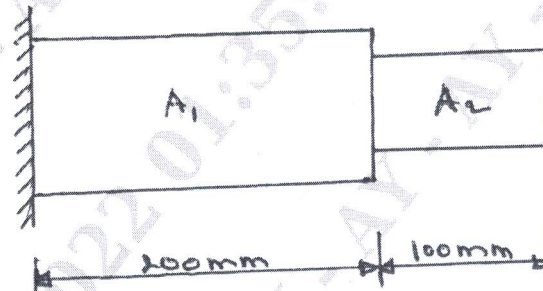


Fig.Q10(b)

(14 Marks)
