

(3 Hours)

Total marks: 80

N.B.: 1) Question No. 1 is compulsory.

2) Attempt any three questions out of remaining five questions.

3) Assume suitable data if required.

Q1 Solve any 4

[Each 5 Marks]

- i) Why Finite Element Method is an approximate solution? Explain in brief how the accuracy of FEM results improve.
- ii) Explain the Principle of minimum total potential with suitable example.
- iii) Derive the shape function for One Dimensional Linear Element in Natural Coordinates.
- iv) What is Convergence in FEA? Explain its types in brief.
- v) What is the significance of Jacobian Matrix in FEA? Explain in brief.
- vi) What do you mean by Consistent and Lumped mass matrix? Explain in brief with their importance.

Q2 a) Solve the following differential equation using Galerkin Method.

[12]

$$-\frac{d}{dx} \left[(x-1) \frac{du}{dx} \right] = x^2; \quad 3 \leq x \leq 5$$

Boundary Conditions are; $u(5) = 10$ and $u'(3) = 5$

Also compute the value of primary (u) variable at $x = 3.5, 4.5$

b) What are the sources of Errors in FEA?

[04]

c) What is Boundary Condition? Explain its type in brief.

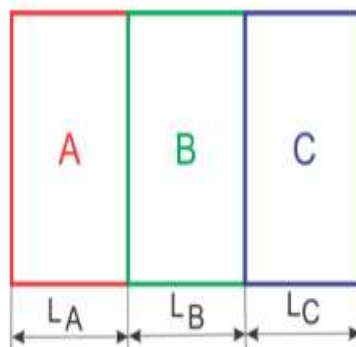
[04]

Q3 a) Find the temperature at interfaces and heat transfer per unit area through the wall.

[10]

$$T_L = 100^\circ\text{C},$$

$$h_L = 150 \text{ w/m}^2\text{C},$$



$$T_R = 30^\circ\text{C},$$

$$h_R = 20 \text{ w/m}^2\text{C},$$

$$L_A = 50 \text{ mm}$$

$$L_B = 50 \text{ mm},$$

$$L_C = 50 \text{ mm}$$

$$K_A = K_B = K_C = 40 \text{ W/m}^2\text{C}$$

Where K- denotes thermal conductivity, h- denotes heat transfer coefficient and T-temperature

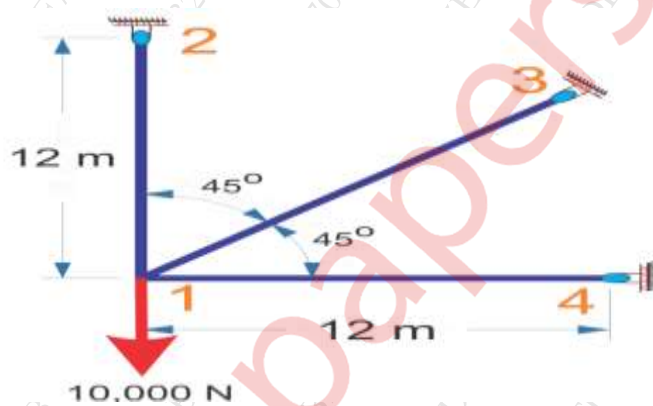
b) Develop the finite element equation for the most general element using Rayleigh Ritz Method for vertical bar with axial loading. The governing differential equation is given below [10]

$$\frac{d}{dx} \left(EA \frac{du}{dx} \right) + f = 0 \quad ; 0 \leq x \leq L$$

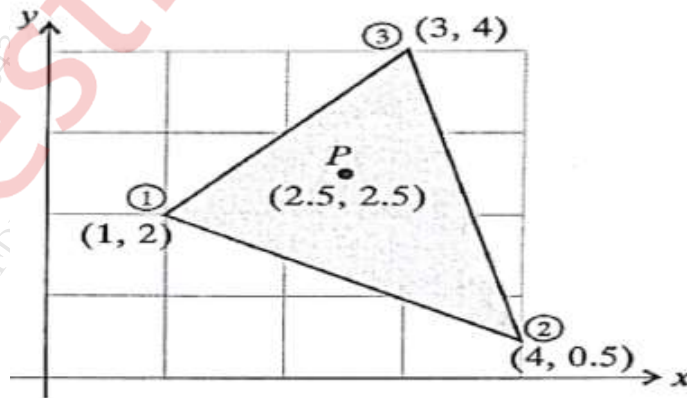
Where f is the weight of the bar. Consider one end of the bar to be fixed and other end free.

Q4 a) For the plane truss shown in figure. [12]

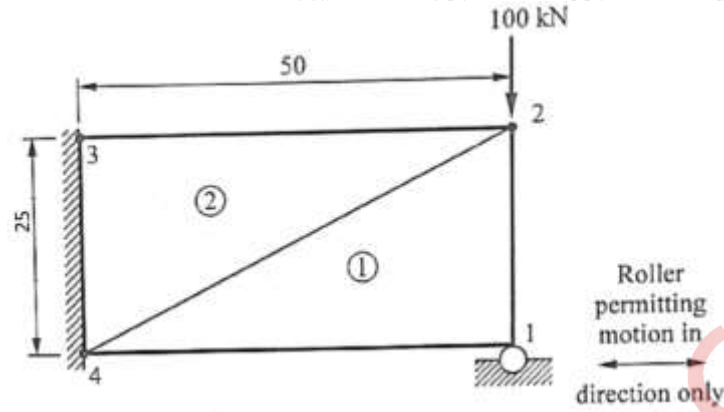
- (i) Determine the displacement at nodes
- (ii) Determine the stresses in each bar.



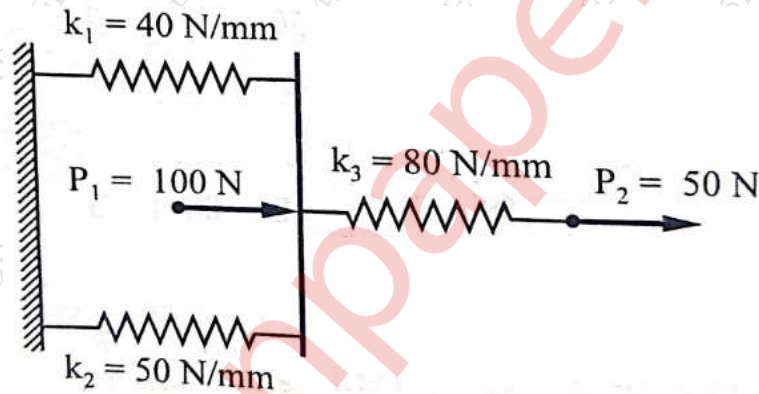
b) The triangular element used for ground water flow simulation is shown in below figure. The nodal coordinates are $(x_1 = 1, y_1 = 2)$, $(x_2 = 4, y_2 = 0.5)$, $(x_3 = 3, y_3 = 4)$. The nodal values of hydraulic heads $\{\Phi\}$ at these nodes are $[3.5, 2.2, 4.4]$ respectively. Find the values of hydraulic head Φ at point $(2.5, 2.5)$ [08]



Q5 a) For 2D loaded plat shown in below figure below. Determine the displacements of nodes 1 and 2 and the element stresses using the plane stress conditions. Assume thickness as 10 mm, $E = 225 \text{ GPa}$ and poisons ratio = 0.25, All Dim are in mm [12]

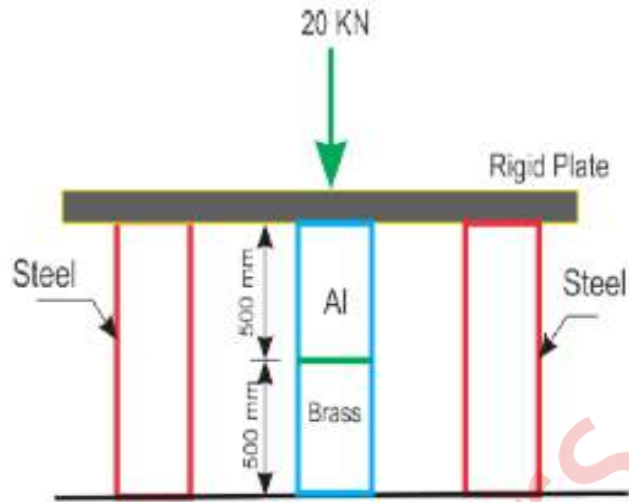


b) A three spring system with stiffness (k) and loads (p) are shown in figure. Calculate the displacement at nodal points. [08]



Q6 a) For a uniform cross-section bar shown in fig. below of length $L = 1\text{ m}$ made up of a material having $E = 2 \times 10^{11}\text{ N/m}^2$ and $\rho = 7800\text{ kg/m}^3$. Estimate the natural frequencies of axial vibration of the bar using both consistent mass matrices. Use a two element mesh. Given $A = 30 \times 10^{-6}\text{ m}^2$ [08]

b) For the given steel block supporting rigid plates shown in below fig, Determine displacement, Stress in the blocks. [12]



| Properties | Steel | Aluminium | Brass |
|----------------------------|-----------------|-----------------|-------------------|
| C/s Area (mm^2) | 200 | 370 | |
| E (N/mm^2) | 2×10^5 | 7×10^4 | 8.8×10^4 |