

(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]

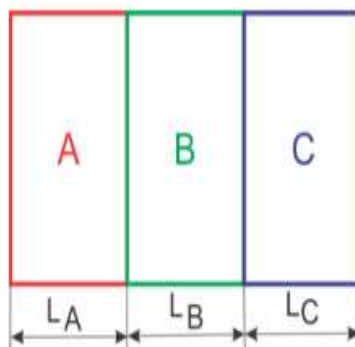
c) What is Boundary Condition? Explain its type in brief.

[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

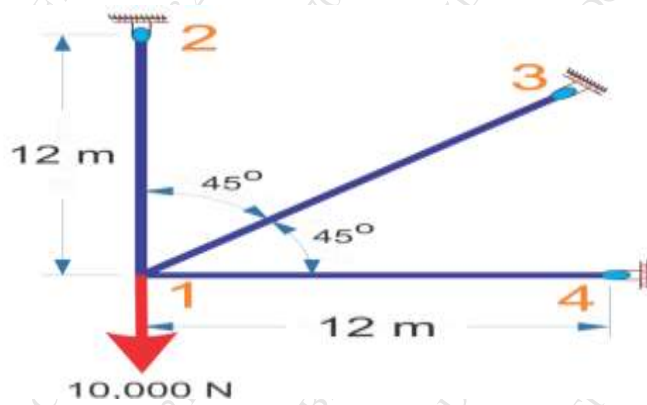
b) Develop the finite element equation for the most general element using Rayleigh Ritz Method for vertical bar with axial loading. The governing differential equation is given below [10]

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

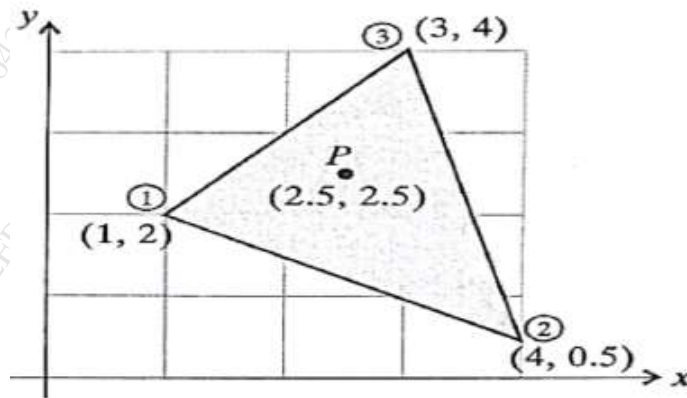
Where f is the weight of the bar. Consider one end of the bar to be fixed and other end free.

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

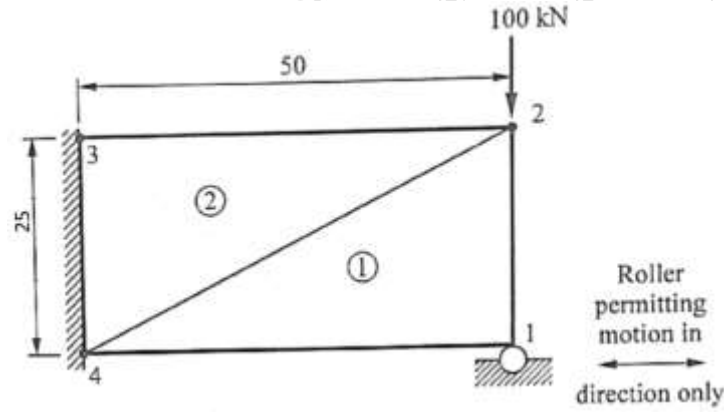
- (i) Determine the displacement at nodes
- (ii) Determine the stresses in each bar.



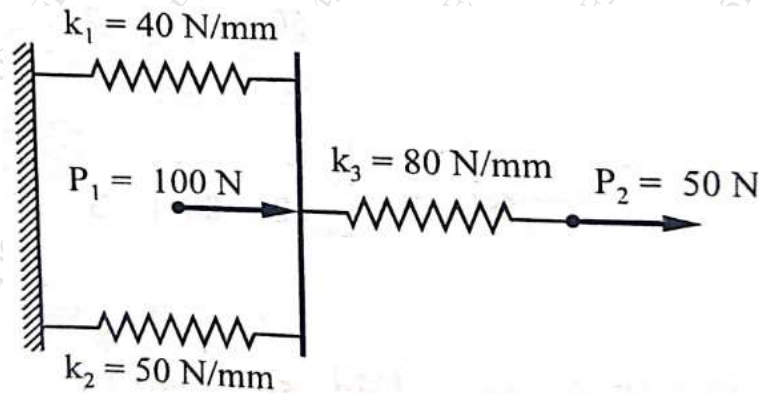
b) The triangular element used for ground water flow simulation is shown in below figure. The nodal coordinates are  $(x_1 = 1, y_1 = 2)$ ,  $(x_2 = 4, y_2 = 0.5)$ ,  $(x_3 = 3, y_3 = 4)$ . The nodal values of hydraulic heads  $\{\Phi\}$  at these nodes are  $[3.5, 2.2, 4.4]$  respectively. Find the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



Q5 a) For 2D loaded plate 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]

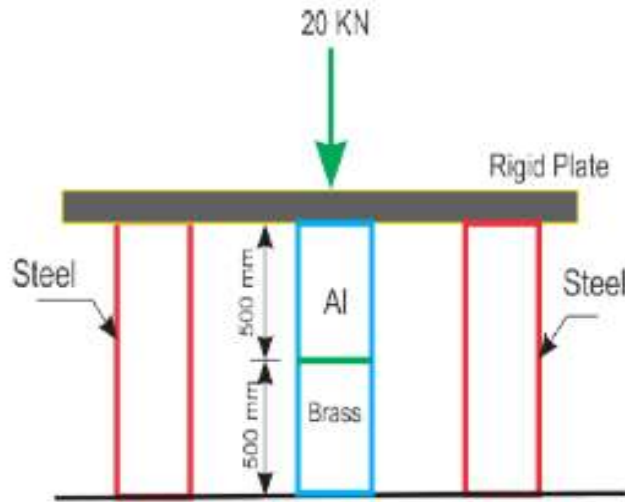


b) A three spring system with stiffness ( $k$ ) and loads ( $p$ ) are shown in figure. Calculate the displacement at nodal points. [08]



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 ( $\text{mm}^2$ )	200	370	
$E$ ( $\text{N/mm}^2$ )	$2 \times 10^5$	$7 \times 10^4$	$8.8 \times 10^4$