11/06/2025 TE MECHANICAL SEM-V C-SCHEME FEA QP CODE: 10082751

Time: 3 Hours **Marks: 80**

- **Question No.1 is compulsory.**
- Solve **ANY THREE** questions from the **remaining** five questions.
- Figure to the right indicates full marks.
- Assume suitable data wherever required, but justify the same.

Marks

Q. 1 Solve **ANY FOUR** questions from following. (Each question carries 5 marks) **20**

a) Differentiate between Essential and Natural boundary conditions with suitable examples. **5**

b) Summarize the properties of shape functions. **5**

c) Explain lumped mass matrix, consistent mass matrix and HRZ lumping scheme with suitable examples. **5**

d) Distinguish between h and p methods of mesh refinement with necessary illustrations. **5**

e) Describe the significance of principle of minimum potential energy. **5**

Q. 2 a) Solve the following differential equation by Galerkin method and Sub-domain method for y (0.5). **15**

$$\frac{d^2y}{dx^2} + y - 2 = 0; \quad 0 \le x \le 1$$

$$\text{BCS; } y(0) = y(1) = 0$$

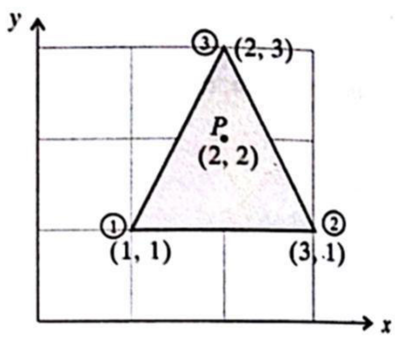
b) Derive shape functions for linear bar element in local coordinates and show the variations over element domain. **5**

Q. 3 a) For the triangular element shown in figure, the nodal values of displacement are : **10**

$u_1 = 2.0$, $u_2 = 3.0$, $u_3 = 5.0$

$v_1 = 1.0$, $v_2 = 2.0$, $v_3 = 3.0$

Determine the displacement (i.e. u, v) of point P (2, 2) within the element.



b) Solve the following differential equation by Rayleigh Ritz method. **10**

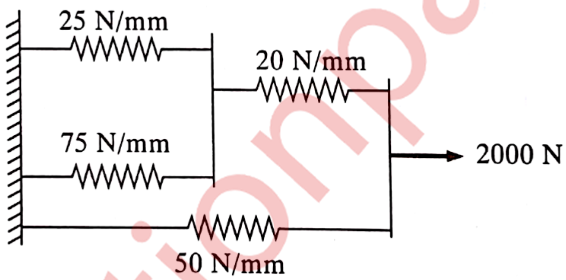
$$\frac{d^2y}{dx^2} - 10\,x^2 = 5 \quad ; \qquad 0 \le x \le 1$$

Given Boundary Conditions are: y(0) = y(1) = 0

Q. 4 **a)** For a uniform cross-section bar of length L = 1 m made up of a material having $E = 2 \times 10^{11}$ N/m^2 and $\rho = 7800$ kg/m^3, estimate the natural frequencies of axial vibrations of the bar using both consistent and lumped mass matrices. Use a two element mesh. If the exact solution is given by the relation. **10**

$\omega_i = \frac{i\pi}{2L}\sqrt{\frac{E}{\rho}}$; $i = 1, 3, 5, \ldots\ldots\ldots\infty$. Compare your answer and give your comments. $A = 30 \times 10^{-6}$ m^2.

b) Figure shows a cluster of four springs. Calculate deflections of each spring when a force of 2000 N is applied. Model the springs as 1-D element. **10**

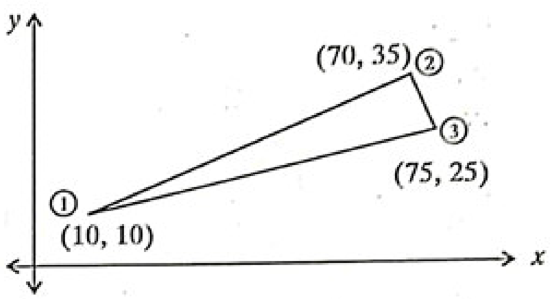


Q. 5 **a)** The CST element has nodal coordinates (10, 10), (70, 35) and (75, 25) for node 1, node 2 and node 3 respectively. The element is 2 mm thick and is of material with properties E = 70 GPa. Poisson's ratio is 0.3. Upon loading of model the nodal deflections were found to be $u_1 = 0.01$ mm, $v_1 = -0.04$ mm, $u_2 = 0.03$ mm, $v_2 = 0.02$ mm, $u_3 = -0.02$ mm and $v_3 = -0.04$ mm. **10**

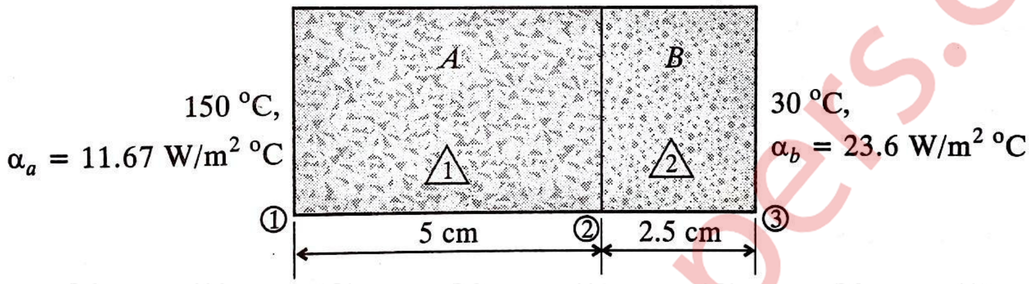
Determine: -

i) The Jacobian for (x-y) – (ξ – η) transformation.

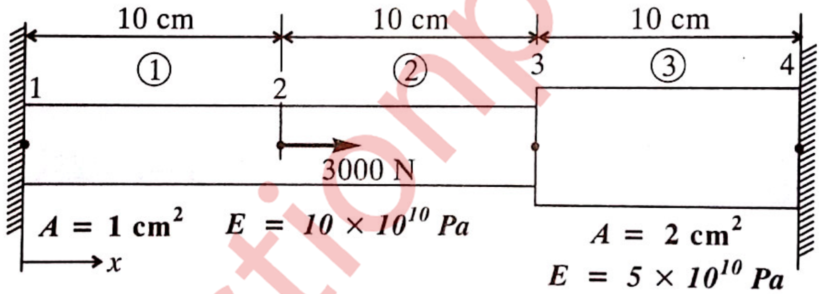
ii) The Strain displacement relation matrix.



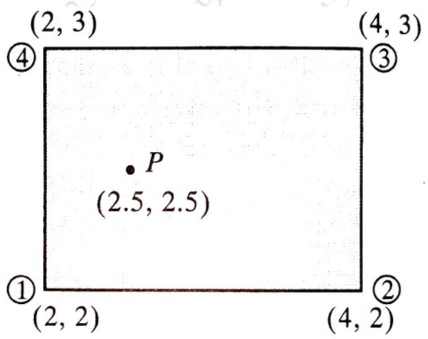
b) Consider a plain composite wall which is made of two materials of thermal conductivity k_a = 204 W/m °C and k_b = 46 W/m °C and thickness h_a = 5 cm and h_b = 2.5 cm. Material A adjoins a hot fluid at 150 °C for which heat transfer coefficient α_a = 11.67 W/m^2 °C and the material B is in contact with a cold fluid at 30 °C and heat transfer coefficient α_b = 23.6 W/m^2 °C. Calculate rate of heat transfer through the wall and the temperature at the interface. The wall is 2 m high and 2.5 m wide. **10**



Q. 6 a) Determine the unknown reactions and displacement for the arrangement of bars shown in figure. **10**



b) Coordinates of nodes of a quadrilateral element are as shown in the figure. Temperature distribution at each node is computed as T_1 = 100°C, T_2 = 60°C, T_3 = 50°C and T_4 = 90°C. Calculate temperature at point P (2.5, 2.5). Use local co-ordinate system. **10**



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