10-06-2026 TE MECHANICAL SEM-V C SCHEME FEA QP CODE: 220015381

Time: 3 Hours **Total Marks: 80**

N.B.: 1) ***Question No.1 is compulsory.***
2) Solve ***ANY THREE*** *questions from the* ***remaining five questions.***
3) *Assume suitable data wherever required.*

Q. 1 Solve **ANY FOUR** questions from following. **20**

a) Explain consistent mass matrix and lumped mass matrix. Also compare their advantages. **05**

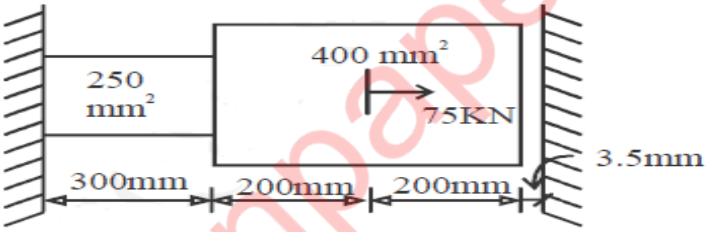
b) Distinguish between plane stress and plane strain conditions. **05**

c) Explain shape function and enlist the properties of shape functions. **05**

d) Describe the significance of principle of minimum potential energy. **05**

e) Explain iso-parametric, sub-parametric and super-parametric element. **05**

Q. 2 **a)** Determine the unknown reactions, displacement and element stresses for the stepped bar shown in the figure below (E = 200 GPa). **10**



b) Using the concept of serendipity, derive the shape functions for eight node rectangular element in natural co-ordinate system (ξ and η). **10**

Q. 3 **a)** A steel fin of diameter 2 cm, length 10 cm and thermal conductivity 80 W/m-K is exposed to ambient air at 40^0C with a heat transfer coefficient of 100 W/m^2-K. One end of the fin is at a temperature of 540^0C and the other end is insulated. Governing DE is: **15**

$$\frac{d^2\theta}{dx^2} - m^2\theta = 0 \qquad \theta = T - T_\infty$$

Where $m^2 = \frac{hp}{KA}$ and $\Omega = 0 \leq x \leq L$

P = Perimeter
A = C/s area
h = Heat transfer coefficient
K = Thermal conductivity
T_∞ = Ambient temperature

Take three liner elements of equal lengths and solve to get temperatures at these intermediate points.

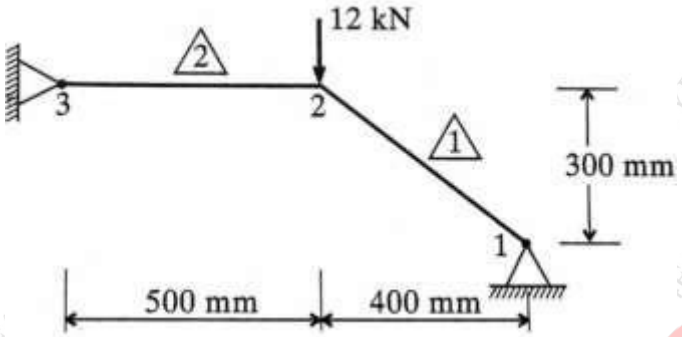
b) Explain different types of boundary conditions with suitable examples. **05**

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Q. 4 **a)** Calculate linear interpolation functions for linear triangular element whose vertices are A(2, 5), B(1, -1) and C(3, 4). **10**

b) Find nodal displacement, reaction forces and stresses in each element for a truss given below. Take E= $2x10^5$ N/mm^2 and A = 200 mm^2. **10**



Q. 5 **a)** Solve following differential equation using Galerkin method **10**

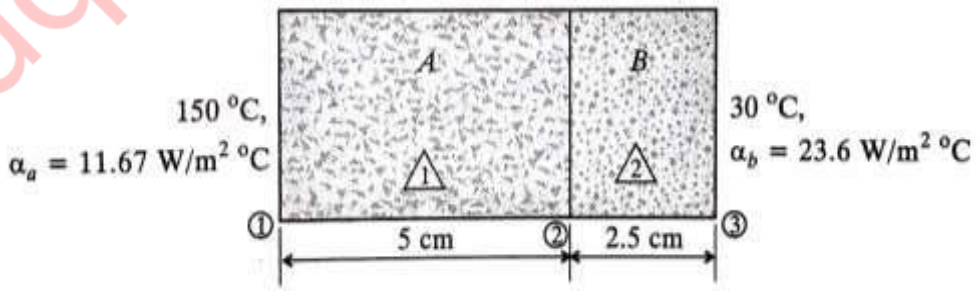
$$3\frac{d^2y}{dx^2} - \frac{dy}{dx} + 8 = 0 \; ; 0 \leq x \leq 1$$

Boundary Conditions: y(0) = 1, y(1) = 2, find y(0.3)

b) A CST element has nodal coordinates (10, 10), (70, 35) and (75, 25) for nodes 1, 2, and 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 deflection 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, v_3= -0.04 mm. **10**

Determine:
The Jacobian for (x-y) – (ξ-η) transformation
The Strain displacement relation matrix
The strains ξ_x, ξ_y and γ_{xy}

Q. 6 **a)** 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**



b) Find the natural frequency of axial vibrations of a bar of uniform cross section of 50 mm^2 and length of 1 meter using consistent mass matrix and compare with exact frequencies. Take E = 200 GPa and density = 7860 kg/m^3. Take two linear elements. **10**

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