June 11, 2024 02:30 pm - 05:30 pm 1T01435 - T.E.(Mechanical) Engineering)(SEM-V)
(Choice Base Credit Grading System) ((R- 19) (C Scheme) / 32624 - Finite Element Analysis
QP CODE: 10056096

(3 hours)   **Total marks: 80**

- *Question No.1 is compulsory.*
- *Solve ANY THREE questions from the remaining five questions.*
- *The 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**

   i)   Explain general FEM procedure.

   ii)   Define shape function and enlist the properties of shape functions.

   iii)   Explain h-method and p-method of FEM.

   iv)   Describe the significance of Jacobian Matrix in co-ordinate transformation.

   v)   Explain the principle of minimum total potential.

   vi)   Explain iso-parametric, sub-parametric and super-parametric elements.

Q. 2 a)   Solve following differential equation using galerkin method   **10**

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

Boundary Conditions: y(0) = 1, y(1) = 2, find y(0.6)

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/m² °C and the material B is in contact with a cold fluid at 30°C and heat transfer coefficient α_b = 23.6 W/m² °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**
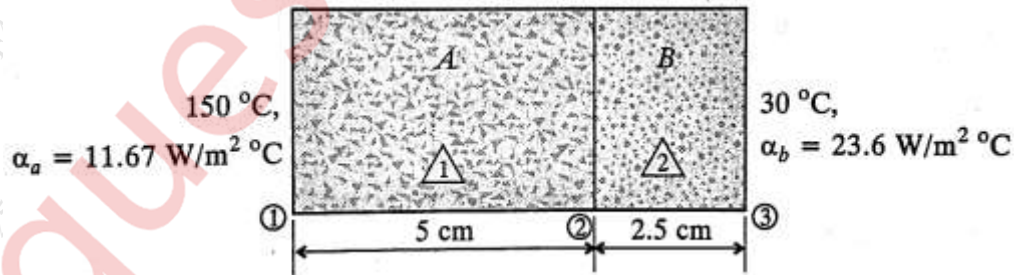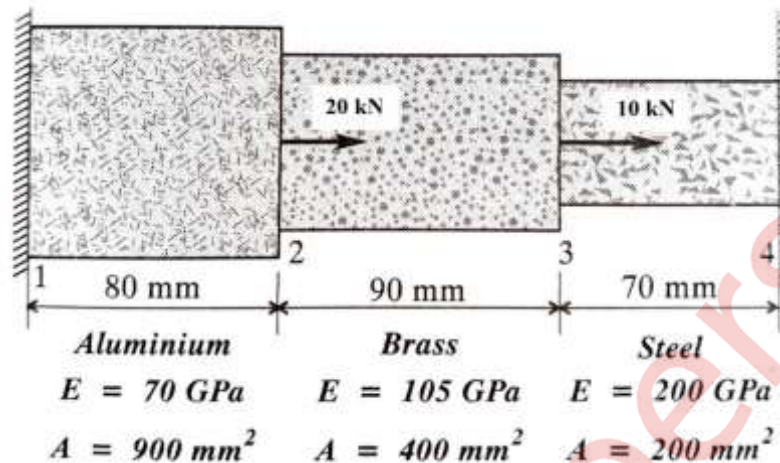

Q. 3 a)   Solve the following differential equation by Rayleigh Ritz method.   **10**

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

Given boundary conditions are: $y(0) = y(1) = 0$

b)   Find the natural frequency of axial vibrations of a bar of uniform cross section of 50 mm² and length of 1 meter using consistent mass matrix. Take E = 200 GPa and density = 8000 kg/m³. Take two linear elements.   **10**

Q. 4 a) Determine the unknown reactions, displacement and element stresses for the stepped bar shown in the figure below.   **10**

| 80 mm	90 mm	70 mm
Aluminium	Brass	Steel
E = 70 GPa	E = 105 GPa	E = 200 GPa
A = 900 mm²	A = 400 mm²	A = 200 mm²

b) Determine the two natural frequencies of transverse vibration of a beam fixed at both ends as shown in figure. Use consistent mass matrix and comment on the results. Divide the whole domain into two elements of equal lengths. [Take EI $= 10^6$ units, $\rho A = 10^6$ units]   **10**

1 unit
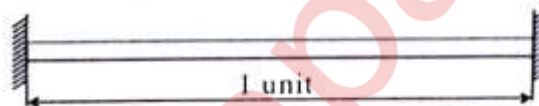
Q. 5 a) Using the concept of serendipity, derive the shape functions for eight node rectangular element in natural co-ordinate system (ξ and η).   **10**

b) The nodal displacements for the CST element shown in the figure are given as:
$u_1 = 1$ mm, $u_2 = 0.5$ mm, $u_3 = 2$ mm
$v_1 = 1$ mm, $v_2 = 0.5$ mm, $v_3 = 2$ mm
Evaluate the stress for the element. Take Young's Modulus (E) = 200 GPa, Poisson's Ratio (ν) = 0.3 and thickness (t) = 1 cm.   **10**
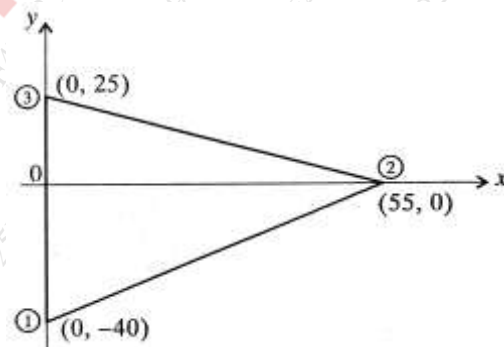
Q. 6 a) A CST element ABC having vertices A(10, 10), B(10, 50), C(40, 10), and nodal temperatures 50 ^{0}C, 60 ^{0}C, and 80 ^{0}C respectively. Determine shape functions and nodal temperature at (20, 20).   **10**

b) The following differential equation arises in connection with heat transfer in an insulated rod.   **10**

$$\frac{d}{dx}\left(-K\frac{dT}{dx}\right) = q; \qquad 0 \le x \le L$$

$$BCS; T(0) = T_0 \text{ and } \left[K\frac{dT}{dx} + \beta(T - T_\infty)\right]_{x=L} = 0$$

Where T is temperature, K is thermal conductivity and q is the heat generation. Take the following data;
L= 0.1m, K=0.1 W/m^{0}C, β= 25 W/m$^{2\,0}$C, q = $\bar{q}$ = 0, T_0=50^{0}C and T_∞=5^{0}C.
Solve the problem using two linear finite elements for temperature values at x=L/2 and x=L. Derive the element matrix equation for the same.