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Question Paper Code : 70907

B.E./B.Tech. DEGREE EXAMINATIONS, NOVEMBER/DECEMBER 2023.

Sixth/Seventh Semester

Mechanical Engineering

ME 8692 – FINITE ELEMENT ANALYSIS

(Common to : Automobile Engineering/Manufacturing Engineering/Mechanical Engineering (Sandwich)/Mechanical and Automation Engineering/Production Engineering)

(Regulations – 2017)

Time : Three hours

Maximum : 100 marks

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. Polynomial type of interpolation functions is mostly used in FEM. Why?
2. What is stiffness and mention why do you need it in FEA?
3. Give the difference between global and natural coordinates.
4. Distinguish between consistent and lumped mass matrices.
5. Compare scalar and vector variable problems.
6. Write the finite element equation for torsional bar element.
7. State the difference between CST and LST elements.
8. What are ways in which a 3D problem can be reduced to a 2D approach?
9. Illustrate your understanding about isoparametric elements.
10. What exactly do you mean by “serendipity elements”?

PART B — (5 × 13 = 65 marks)

11. (a) Solve the differential equation for a physical problem expressed as

$$d^2y/dx^2 + 50 = 0, 0 \leq x \leq 10$$

With boundary conditions as $y(0)=0$ and $y(10)=0$ using (i) Point collocation, (ii) Sub-domain collocation, (iii) Least squares and (iv) Galerkin's methods. Take trial function as $y = a_1x(10 - x)$.

Or

- (b) A simply supported beam subjected to uniformly distributed load over entire span is shown in Figure 1. Determine the deflection at midspan by using Rayleigh-Ritz method. Use one term trigonometric series for deflection 'y'.

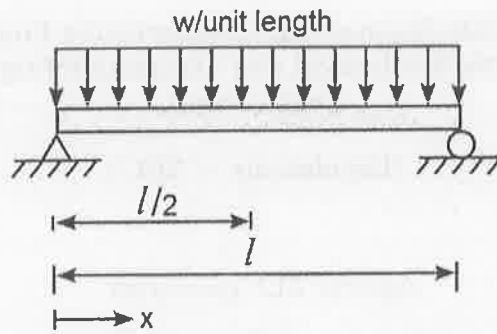


Figure. 1

12. (a) Consider a bar with fixed ends shown in Figure 2. An axial load $P=200 \times 10^3$ N is applied as shown. Using elimination method of boundary condition, determine: (i) Nodal displacements, (ii) Stress in each element, and (iii) Reaction forces. Take $A_1 = 2000 \text{ mm}^2$, $E_1 = 70 \text{ GPa}$, $L_1 = 500 \text{ mm}$, $A_2 = 500 \text{ mm}^2$, $E_2 = 200 \text{ GPa}$ and $L_2 = 400 \text{ mm}$.

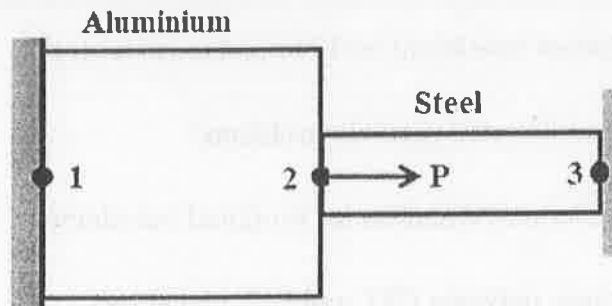


Figure. 2

Or

- (b) Figure 3 shows a two-member plane truss supported by a linearly elastic spring. The truss members are of a solid circular cross-section having $d = 20 \text{ mm}$ and $E = 83 \text{ GPa}$. The linear spring has stiffness constant 50 N/mm . Assemble the system global stiffness matrix and calculate the global displacements of the unconstrained node.

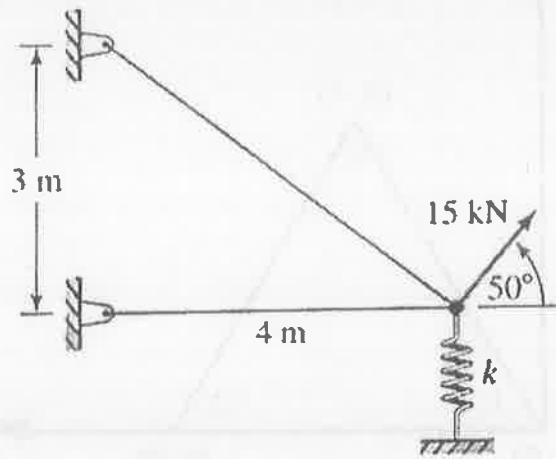


Figure. 3

13. (a) For a four noded rectangular element show in Figure 4, determine the temperature at the point $(7, 4)$. The nodal values of the temperature are $T_1 = 63^\circ\text{C}$, $T_2 = 81^\circ\text{C}$, $T_3 = 84^\circ\text{C}$ and $T_4 = 69^\circ\text{C}$.

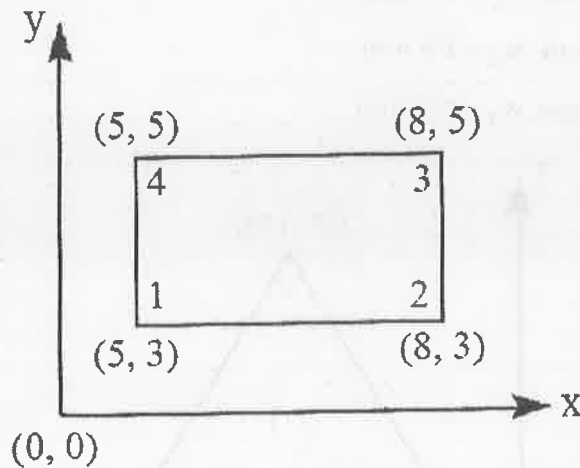


Figure. 4

Or

- (b) What do you mean by higher order elements? Derive the shape function for the eight noded rectangular element.

14. (a) Evaluate the element stiffness matrix for the triangular element shown in Figure 5, under plane stress conditions. Take $E = 200 \text{ GPa}$; $\nu = 0.25$; $t = 1 \text{ mm}$.

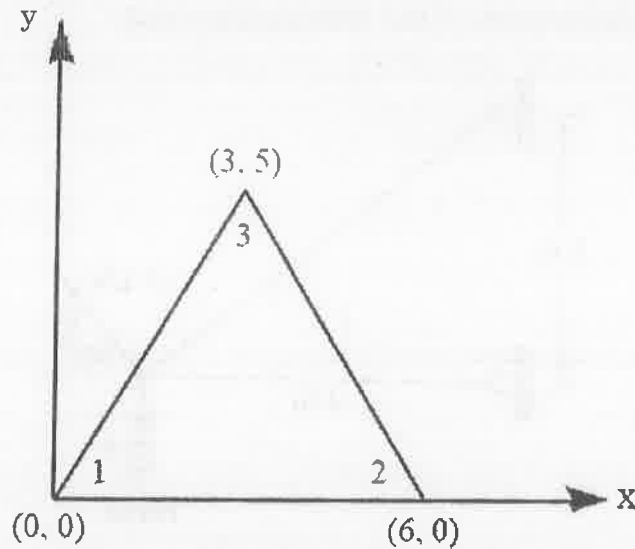


Figure. 5

Or

- (b) For the axisymmetric element shown in Figure 6, the nodal displacements are-
- $u_1 = 2.0 \text{ mm}$; $w_1 = 1.0 \text{ mm}$
 - $u_2 = 1.0 \text{ mm}$; $w_2 = 1.5 \text{ mm}$
 - $u_3 = 2.5 \text{ mm}$; $w_3 = 0.5 \text{ mm}$

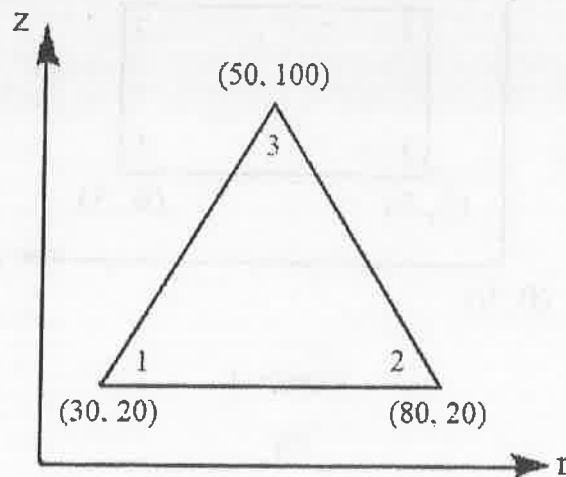


Figure. 6

Determine the element stresses. Assume $E = 210 \text{ GPa}$, and $\nu = 0.25$. All coordinates are in millimeters.

15. (a) For the element shown in Figure 7, assemble Jacobian matrix and strain displacement matrix for the Gaussian point (0.57735, 0.57735).

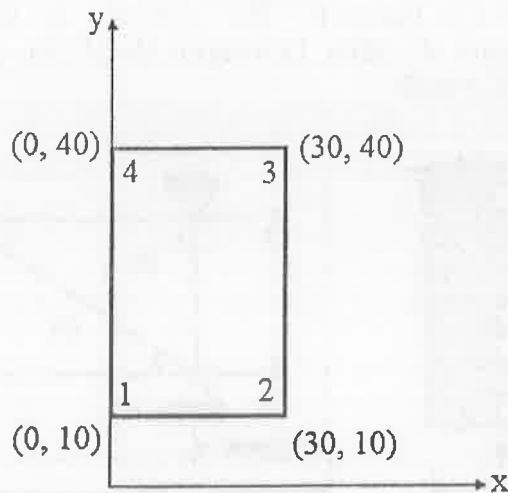


Figure. 7

Or

- (b) (i) Evaluate the following integral and compare with exact solution. (8)

$$\int_{-1}^1 \int_{-1}^1 (\xi^2 + 2\xi\eta + \eta^2) d\xi d\eta$$

- (ii) Enlist the types of FEA software packages and discuss the type of problems that can be analyzed using commercial software packages. (5)

PART C — (1 × 15 = 15 marks)

16. (a) Determine the temperature distribution along the length of the rod (at $L/4$, $L/2$, $3L/4$ and L) as shown in Figure 8. The rod with radius of 25 mm is insulated at the perimeter. The left end has a constant temperature of 40°C and a free stream temperature T_∞ is -10°C . Let $k=35 \text{ W/m}^\circ\text{C}$ and $h=55 \text{ W/m}^2 \text{ }^\circ\text{C}$.

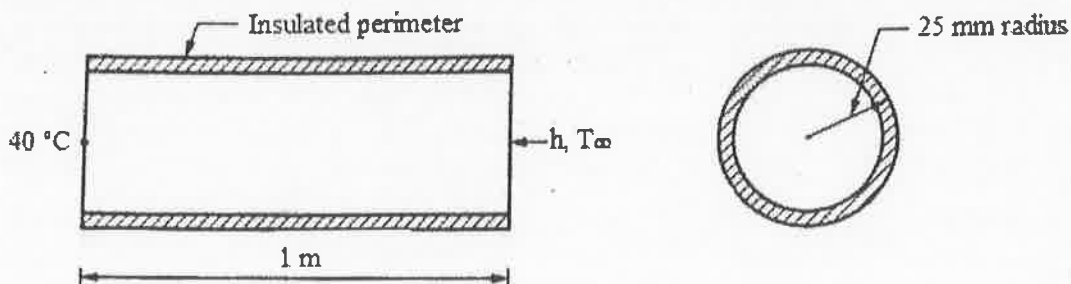


Figure. 8

Or

- (b) A long hollow cylinder of inside diameter 100 mm and outside diameter 120 mm is firmly fitted in a hole of another rigid cylinder over its full length as shown in Figure 9. The cylinder is then subjected to an internal pressure of 2 MPa. Determine the [K] for element 2 by assuming $E = 210 \text{ GPa}$ $\nu = 0.25$.

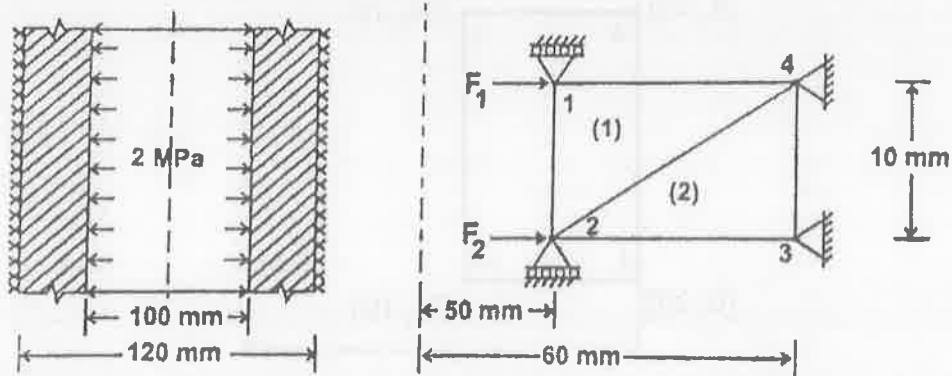


Figure. 9