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Question Paper Code : 10931

B.E./B.Tech. DEGREE EXAMINATIONS, APRIL/MAY 2025.

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 — ($10 \times 2 = 20$ marks)

1. State your understanding about degrees of freedom.
2. Mention the basic steps of Galerkin's method.
3. List any four properties of the stiffness matrix.
4. Name the types of problems treated as one dimensional problem?
5. What is called as higher order elements?
6. State any two assumptions made in theory of pure torsion.
7. Mention how a plane stress problem differ from that of a plane strain problem?
8. Write any four applications of axisymmetric element.
9. Compare Isoparametric, super parametric and sub-parametric elements.
10. What are 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 method (3)
- (ii) Sub-domain collocation method (3)
- (iii) Least squares method and (3)
- (iv) Galerkin's method. Take trial function is $y = a_1x(10 - x)$. (4)

Or

- (b) Find the deflection at the centre of a simply supported beam of span length 'L' subjected to a concentrated load P at its mid-point as shown in figure 1. Use Rayleigh-Ritz method.

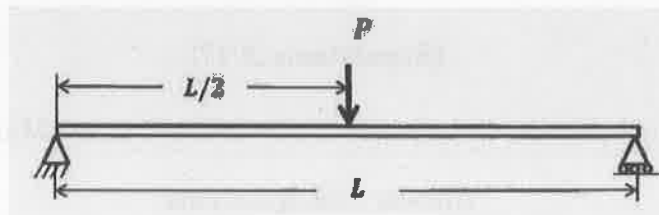


Figure 1

12. (a) A bar subjected to a load of $p = 750$ kN is shown in figure 2. Determine the following:

- (i) Nodal displacements. (4)
- (ii) Element stresses (4)
- (iii) Support reactions. (5)

Take $E = 2 \times 10^5 \text{ N/mm}^2$.

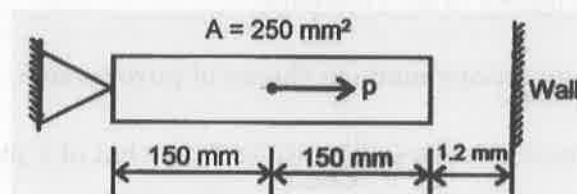


Figure 2

Or

- (b) A wall of 0.5 m thickness having thermal conductivity of 6 W/mK. The wall is to be insulated with a material of thickness 0.1 m having an average thermal conductivity of 0.3 W/mK. The inner surface temperature is 1200°C and the outside of the insulation is exposed to atmospheric air at 30°C with heat transfer coefficient of 40 W/m²K. Calculate the nodal temperatures.

13. (a) For a four noded rectangular element shown in figure 3, determine the temperature at the point (14, 8). The nodal values of temperature are $T_1 = 46^\circ\text{C}$, $T_2 = 58^\circ\text{C}$, $T_3 = 61^\circ\text{C}$ and $T_4 = 49^\circ\text{C}$.

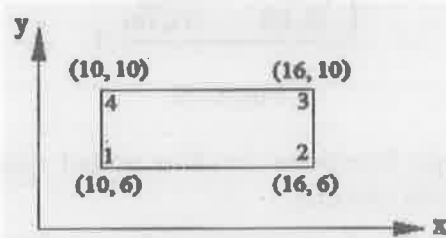


Figure 3

Or

- (b) Evaluate the element stiffness matrix for the triangular element shown in figure 4, under plane stress conditions. Take $E = 2 \times 10^5 \text{ N/mm}^2$, $\nu = 0.3$, $t = 10 \text{ mm}$.

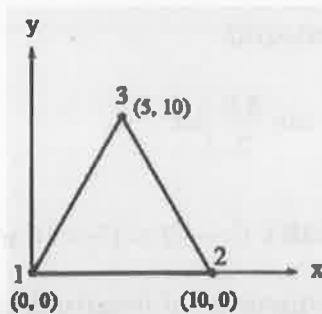


Figure 4

14. (a) For an axisymmetric triangular element as shown in figure 5. Evaluate the stiffness matrix. Take modulus of elasticity $E = 210 \text{ GPa}$. Poisson's ratio = 0.25. The coordinates are given in millimeters.

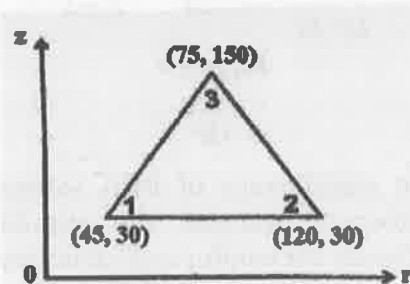


Figure 5

Or

- (b) Calculate the element stiffness matrix and the thermal force vector for the axisymmetric triangular element shown in figure 6. The element experiences a 20°C increase in temperature. The coordinates are in mm. Take $\alpha = 15 \times 10^{-6}/^\circ\text{C}$; $E = 2 \times 10^5 \text{ N/mm}^2$ $\mu = 0.3$.

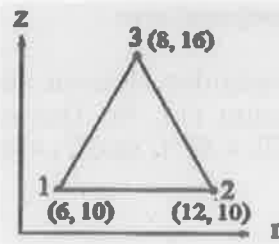


Figure 6

15. (a) Derive the shape functions for four-noded quadrilateral element using natural coordinate system.

Or

- (b) (i) Evaluate the following integral and compare with exact solution. (6)

$$\int_{-1}^{+1} \left[3e^x + x^2 + \frac{1}{(x+2)} \right] dx$$

- (ii) Evaluate the integral. (7)

$$I = \int_{-1}^{+1} \left(\cos \frac{\pi x}{2} + \sin \frac{\pi x}{2} \right) dx.$$

PART C — (1 × 15 = 15 marks)

16. (a) Find the natural frequencies of longitudinal vibration of the constrained stepped bar shown in figure 7. Also find the mode shapes.

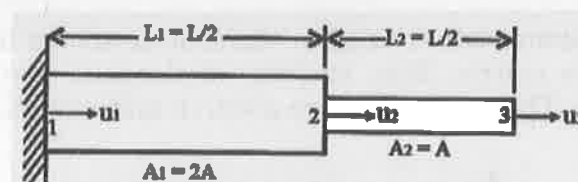


Figure 7

Or

- (b) Elaborate on the significance of FEA software in addressing complex engineering problems. Describe the standard workflow followed in utilizing FEA software for conducting structural analysis.