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Question Paper Code : 30929

B.E./B.Tech. DEGREE EXAMINATIONS, NOVEMBER/DECEMBER 2024.

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. What are boundary and initial value problems? Give examples.
2. Write the advantages of adopting finite element method.
3. Differentiate between spar element and a beam element.
4. State the properties of stiffness matrix.
5. State any four typical applications where transient thermal analysis is required.
6. Mention any one shape function of CST element and provide its graphical representation.
7. Differentiate plate and shelf elements.
8. Distinguish between plane stress and plane strain problems.
9. What is meant by an isoparametric element? Give an examples.
10. State the required conditions for solving dynamic problems as specified by characteristics polynomial method.

PART B — (5 × 13 = 65 marks)

11. (a) Using Rayleigh-Ritz method, determine the displacement and stress in a vertical cantilever bar of uniform cross section due to self-weight only. Use an approximating polynomial with three terms.

Or

- (b) Explain the basic steps involved in the analysis of continuum structure using FEM.
12. (a) For the beam loaded as shown in Fig. 1, Determine the slopes at nodes 2 and 3 and the vertical deflection at the mid-point of the distributed load. Take $E = 200 \text{ GPa}$, $I = 4 \times 10^{-6} \text{ m}^4$.

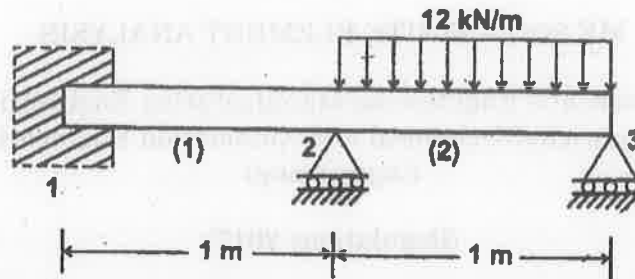
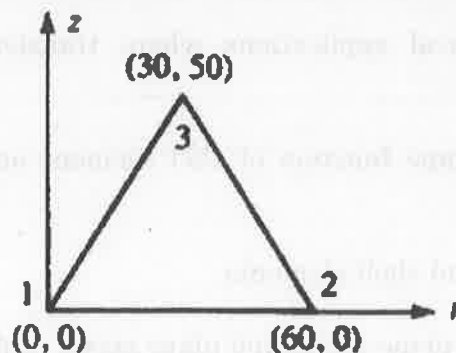


Fig. 1

Or

- (b) Establish the shape functions and derive the strain displacement matrix for a quadratic spar element.
13. (a) For the axisymmetric elements shown in Fig.2, determine the element stresses. Let $E = 210 \text{ GPa}$ and Poisson's ratio is 0.25. The coordinates (in millimeters) are shown in the figure, and the nodal displacement of an element are, $u_1 = 0.05 \text{ mm}$, $w_1 = 0.03 \text{ mm}$, $u_2 = 0.02 \text{ mm}$, $w_2 = 0.02 \text{ mm}$, $u_3 = 0.0 \text{ mm}$ and $w_3 = 0.0 \text{ mm}$.



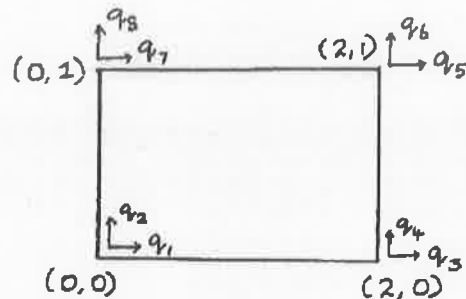
Or

- (b) Consider an iron rod of length 400 mm, diameter 12 mm and thermal conductivity $55 \text{ W/m}^\circ\text{C}$ attached to a heat source of 450°C . The rod is dissipating heat by convection into ambient air at 28°C with a heat transfer coefficient of $25 \text{ W/m}^2\text{C}$. Determine the temperature distribution in the rod using two elements.

14. (a) Derive the force vectors for the following two cases:
- Uniformly distributed load acting on one of the edges constant strain triangle (CST) element (7)
 - Body force acting on CST element (6)

Or

- (b) Evaluate Jacobin matrix and strain displacement matrix for a four noded rectangular element at $\zeta = 0, \eta = 0$ as shown in Fig. 3 Let $E = 30 \times 10^6 \text{ N/m}^2, \nu = 0.3, q = [0, 0, 0.002, 0.003, 0.006, 0.0032, 0, 0]^T \text{ m}$.



15. (a) (i) Brief on Serendipity elements and specify the advantages and limitations. (7)
- (ii) Solve the integral by numerical integration technique using 3 points. (6)

$$\int_1^4 \sqrt{x} + 3x dx$$

Or

- (b) A iso-parametric quadrilateral element has the co-ordinates as follows, A(1,5), B(5,10), C(6,15) and D(0,20). Determine the Jacobian matrix at the point Q (2,2).

PART C — (1 × 15 = 15 marks)

16. (a) A vertical plate of length 350 mm is rectangular in cross section with thickness 15 mm and width of 120 mm is fixed at the top end. Take Young's modulus as 200 GPa and density as 7800 kg/m^3 . Determine the natural frequencies of longitudinal vibration, Considering two elements.

Or

- (b) A bar assemblage consists of two outer steel bars and an inner brass bar as shown in Fig. 4. The three-bar assemblage is then heated to raise the temperature by an amount $T=40^{\circ}\text{C}$. Let all cross-sectional areas be $A=13\text{ cm}^2$ and $L=150\text{ cm}$, $E_{\text{steel}}=210\text{ GPa}$, $E_{\text{brass}}=105\text{ GPa}$, $\alpha_{\text{steel}}=12\times 10^{-6}/^{\circ}\text{C}$, and $\alpha_{\text{brass}}=10\times 10^{-6}/^{\circ}\text{C}$. Determine (i) the displacement of node 2 and (ii) the stresses in bars.

