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Question Paper Code: U1102

M.E. DEGREE EXAMINATION, DEC 2025

First Semester

CAD / CAM

21PCD102 -ADVANCED FINITE ELEMENT ANALYSIS

(Regulations 2021)

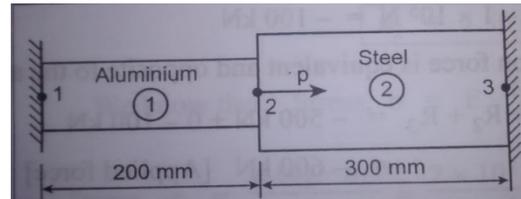
Duration: Three hours

Maximum: 100 Marks

Answer ALL Questions

PART - A (5 x 20 = 100 Marks)

1. (a) Derive the strain–displacement matrix (B-matrix) for a Mindlin plate element including transverse shear deformation. CO2-App (20)
Or
(b) Derive the bending moment–curvature relationship for a thin plate using Kirchhoff plate theory. Show how M_x , M_y , M_{xy} are expressed in terms of second derivatives of deflection w . CO2-App (20)
2. (a) An axial load of 4×10^5 N is applied at 30°C to the rod as shown in the figure. The temperature is then raised to 60°C . CO2-Ana (20)



For Aluminium

$$A1 = 1000 \text{ mm}^2$$

$$E1 = 0.7 \times 10^5 \text{ N/mm}^2$$

Thermal coefficient = 20×10^{-6} / deg Celcius

For Steel

$$A2 = 1500 \text{ mm}^2$$

$$E2 = 2 \times 10^5 \text{ N/mm}^2$$

12×10^{-6} / deg Celcius

Calculate and Analyze the following:

- (i) Assemble the K and F matrices
- (ii) Nodal Displacements
- (iii) Analyze the Stresses in each material
- (iv) Analyze the Reactions at each nodal point

Or

- (b) Consider a three bar truss as shown in figure. It is given that $E = 2 \times 10^5 \text{ N/mm}^2$ CO2-Ana (20)

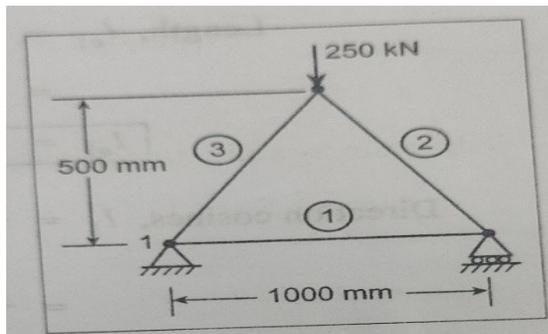
Take Area of Element (1) = 2000 mm^2

Area of Element (2) = 2500 mm^2

Area of Element (3) = 2500 mm^2

Calculate and Analyze the following:

- (i) Displacements in each elements.
- (ii) Analyze the Stresses in each elements
- (iii) Analyze the Reaction force at the support.

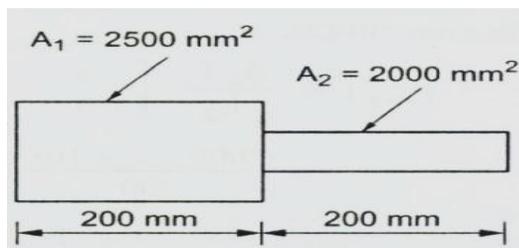


3. (a) Determine the Eigen values and frequencies for the stepped bar as shown in the figure. CO2-App (20)

Take,

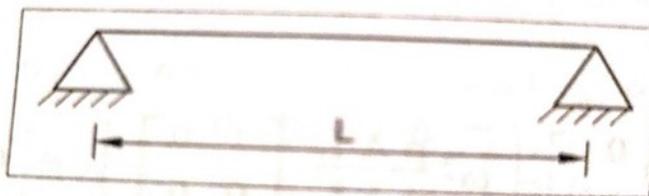
Young's modulus $E = 2 \times 10^5 \text{ N/mm}^2$,

Unit weight Density $\rho = 0.8 \times 10^{-4} \text{ N/mm}^3$



Or

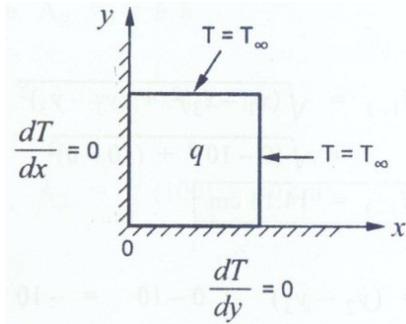
- (b) Consider the simply supported beam shown in figure. Let the length $L = 1 \text{ m}$, $E = 2 \times 10^{11} \text{ N/m}^2$, area of cross section, $A = 30 \text{ cm}^2$, Moment of inertia $I = 100 \text{ mm}^4$, density $\rho = 7800 \text{ kg/m}^3$. Compare the natural frequency using two types of mass matrix i.e., lumped mass matrix and consistent mass matrix. CO2-App (20)



4. (a) A furnace wall is made up of 3 layers, inside layer with thermal conductivity 8.5W/mK , the middle layer with conductivity 0.25W/mK , the outer layer with conductivity 0.08W/mK . The respective thickness of the inner, middle and outer layer are 25cm , 5cm and 3cm respectively. The inside temperature of the wall is 600°C and outside of the wall is exposed to atmospheric air at 30°C with heat transfer coefficient of $45\text{W/m}^2\text{K}$. Analysis the nodal temperatures. CO4-Ana (20)

Or

- (b) Analysis the temperature distribution in a square region with uniform energy generation as shown in figure . Assume that there is no temperature variation in the z -direction. Take $k=30\text{W/cm}^\circ\text{C}$, $l=10\text{cm}$, $T_\infty=50^\circ\text{C}$, $q=100\text{W/cm}^3$. CO4-Ana (20)



5. (a) Derive the residual-based a-posteriori error estimator for a 1D bar finite element problem. Using a two-element mesh, show step-by-step how to compute:
 (i) element residuals,
 (ii) edge (jump) residuals,
 (iii) element-wise error indicators. CO3-App (20)

Demonstrate how these indicators are used to mark elements for h-refinement.

Or

- (b) Use the diagonal decay test to evaluate mesh quality in the analysis of a 2D square plate under uniform pressure. Explain how to perform the test, interpret its results, and decide on adaptive refinement strategies based on the findings. CO3-App (20)

