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Seventh Semester B.E. Degree Examination, Dec.2023/Jan.2024 Finite Element Modeling and Analysis

Time: 3 hrs.

Max. Marks: 100

Note: Answer any FIVE full questions, choosing ONE full question from each module.

Module-1

- 1 a. Express the plane stress and plane strain relation with assumptions. (10 Marks)
 b. Solve the following system of simultaneous equation by Gaussian elimination method :

$$x_1 - 2x_2 + 6x_3 = 0$$

$$2x_1 + 2x_2 + 3x_3 = 3$$

$$-x_1 + 3x_2 = 2$$

(10 Marks)

OR

- 2 a. For the spring shown in Fig. Q2 (a). Determine the nodal displacement using principle of minimum potential energy.

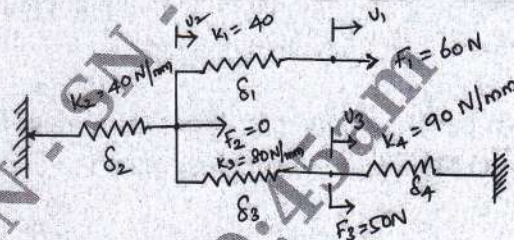


Fig. Q2 (a)

(10 Marks)

- b. Using Rayleigh-Ritz method determine the maximum deflection of the beam fixed at both ends subjected to a uniformly distributed load P_0 over the entire length as shown in Fig. Q2 (b)

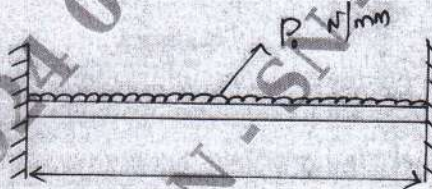


Fig. Q2 (b)

(10 Marks)

Module-2

- 3 a. Explain the steps involved in FEM and list the application of FEM. (10 Marks)
 b. Use Galerkin's method to obtain an approximate solution of differential equation,

$$\frac{d^2y}{dx^2} - 10x^2 = 5 \quad 0 \leq x \leq 1$$

 with boundary condition $y(0) = y(1) = 0$

(10 Marks)

OR

- 4 a. Derive the shape function for 1D bar element in natural co-ordinate system. (10 Marks)
 b. Explain the different types of Interpolation models in which brief about the polynomial form for 1D, 2D and 3D element. (10 Marks)

Module-3

- 5 a. Consider the bar shown in Fig.Q5 (a), using Penalty method of handling boundary condition. Determine the nodal displacement stress in each element. Due to applied force $P = 100 \text{ kN}$. Take steel $E = 200 \text{ GPa}$ copper $E_{CV} = 100 \text{ GPa}$.

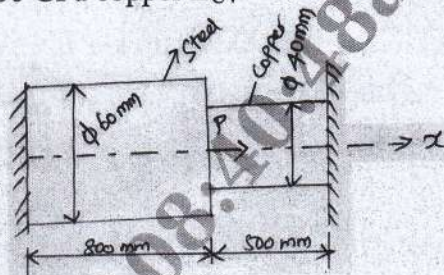


Fig. Q5 (a) (10 Marks)

- b. Determine the nodal displacement, stress in each element at the fixed support for the thin plate of uniform thickness of 1 mm shown in Fig. Q5 (b). Take Young's modulus $E = 200 \text{ GPa}$ weight density of the plate $P = 76.6 \times 10^{-6} \text{ N/mm}^3$. In addition to this weight, it is subjected to a point load of 100 N at its point, model using the two bar element.

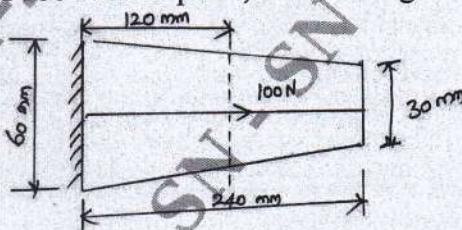


Fig. Q5 (b) (10 Marks)

OR

- 6 a. For the two bar truss shown in Fig. Q6 (a) determine the nodal displacement, stress in each element and reaction at the support. Take $E = 2 \times 10^5 \text{ N/mm}^2$. $A_C = 200 \text{ mm}^2$. (10 Marks)

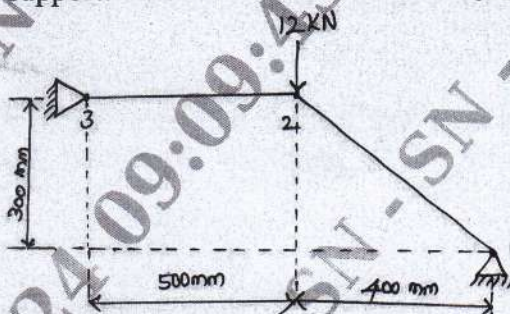


Fig. Q6 (a) (10 Marks)

- b. Derive element stiffness matrix for truss method. (10 Marks)

Module-4

- 7 a. For the triangular element shown in Fig. Q7 (a). Obtain the strain-displacement matrix 'B' and determine the strains ϵ_x , ϵ_y and γ_{xy} Nodal displacement

$$\{q\} = \{2 \ 1 \ 1 \ -4 \ -3 \ 7\} \times 10^{-7} \text{ mm}$$

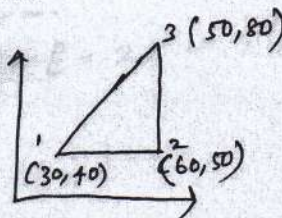


Fig. Q7 (a) (10 Marks)

- b. Derive shape function for 2-D elements Quadrilateral / rectangular element. (10 Marks)

OR

- 8 a. Explain the properties of shape function. (04 Marks)
 b. Explain the following with neat diagram,
 (i) Iso-parametric element.
 (ii) Sub-parametric element.
 (iii) Super-parametric element. (06 Marks)
 c. Derive the Hermite shape function for beam element. (10 Marks)
 Note : (Find the shape function 'H₁' and 'H₂' alone.)

Module-5

- 9 a. For the beam element shown in Fig. Q9 (a) determine deflection under the given load. Take $E = 2 \times 10^8 \text{ KN/m}^2$ and $I = 4 \times 10^{-6} \text{ m}^4$.

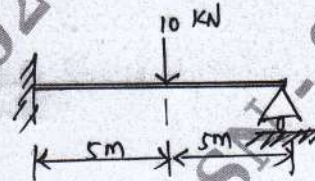


Fig. Q9 (a)

- b. Derive element stiffness matrix using Hermite Shape function. (10 Marks)

OR

- 10 a. Find the heat distribution in the '1D' Fin as shown in Fig. Q10 (a). Take two elements for FE idealization.

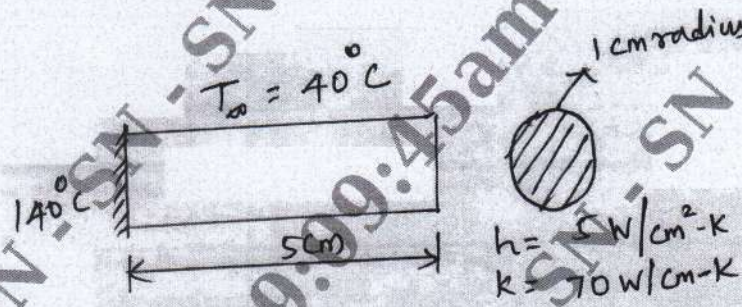


Fig. Q10 (a)

- b. Find the heat distribution in the fin shown in Fig. Q10 (b). Take two elements for FE idealization. The heat transfer co-efficient around the fin is $10 \text{ W/m}^2\text{K}$ and ambient temperature is 28°C . The base fin is at 108°C . Take $K = 50 \text{ W/mK}$.

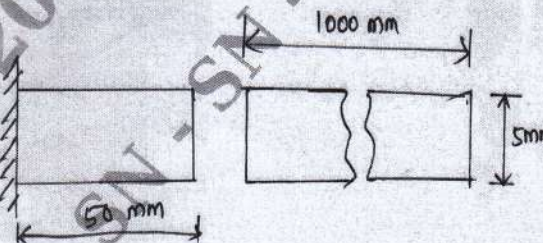


Fig. Q10 (b)
