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APR-MAY 2022

B. E. (Eighth Semester) Examination, ~~2020~~

(New Scheme)

(Mech. Engg. Branch)

FINITE ELEMENT METHODS

Time Allowed : Three hours

Maximum Marks : 80

Minimum Pass Marks : 28

***Note** : Solve all questions as per choices given. Assume suitable data and notations if required.*

1. (a) Expain the method of weighted residuals. 2

(b) Describe the basic steps involved in the finite element analysis of a problem. 4

(c) Solve the following boundary value problem by Rayleigh-Ritz method :

$$\frac{d^2u}{dx^2}+u=1,\ 0\le x\le 1,\quad \text{with}\quad u(0)=0\quad \text{and}$$

$$\frac{du}{dx}=0 \text{ at } x=1. \qquad 10$$

Or

Solve the differential equation

$$-\frac{d^2u}{dx^2}-u+x^2=0,\ 0<x<1$$

subject to the boundary conditions

$$u(0)=0,\ \left.\frac{du}{dx}\right|_{x=1}=0$$

Use Galerkin method. Assume an appropriate trial function. 10

2. (a) Define shape functions. Explain the properties of shape functions. 2

(b) Differentiate between linear and quadratic bar finite elements. Write the expressions for nodal shape functions and stiffness matrix for a quadratic bar element. 4

(c) A composite wall consists of three materials as shown in fig.1 The inside wall temperature is 200°C and the outside air temperature is 50°C. With a convection coefficient (h) = 10 W/m²K. Determine the temperature at the junctions along the composite wall.

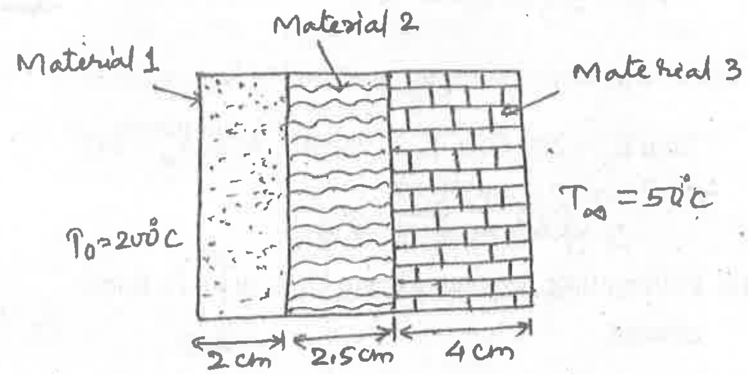

Fig. 1

$k_1 = 70$ W/mK

$k_2 = 40$ W/mK

$k_3 = 20$ W/mK

Surface area A = 1 m² 10

Or

A composite bar consisting of a steel bar fastened to an aluminium rod of uniform cross-section is subjected to loads as shown in fig.2 Determine the displacements at the junction of steel bar and aluminium rod and at the end of composite bar. 10

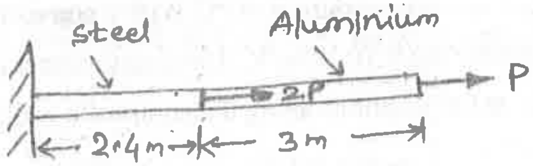

Fig. 2

Take E_S = 200 GPa, E_{al} = 70 GPa, $A_s = A_{al}$ = 645 mm^2, and P = 44·5 kN.

3. (a) Differentiate between a beam element and a frame element. 2

(b) A simply supported beam is subjected to uniform transverse load as shown in fig. 3. Using two equal length elements, obtain a finite element solution for the deflection at midspan and slopes at the end supports. 14

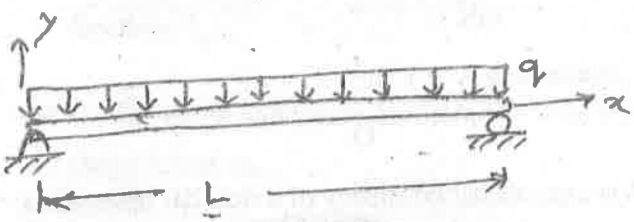

Fig. 3

Or

A frame shown in fig. 4 is composed of identical beams having 25 mm square cross-section and a modulus elasticity (E) = 70 GPa. The supports at O and C are to be considered completely fixed. The horizontal beam is subjected to a uniform load of intensity 2 kN/m. Determine the displacements and rotation at B. 14

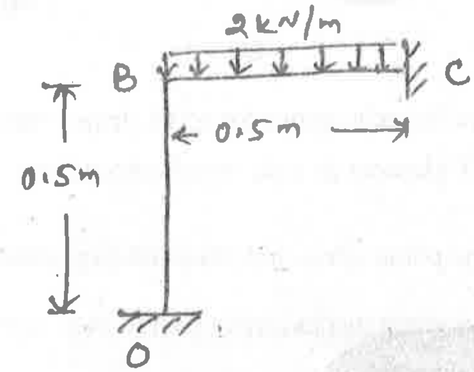

Fig. 4

4. (a) Name and draw the two-dimensional elements used in finite element analysis. 2

(b) Evaluate the integral :

$$I = \int_{-1}^{1} \frac{r^2 - 1}{(r+3)^2}\, dr$$

using Gaussian integration with one, two and three integration points. 4

(c) Derive the expressions for nodal shape functions for a 4-noded rectangular element in (i) global co-ordinate system. (ii) Natural coordinate system. 10

Or

Derive the expressions for nodal shape functions for a CST element in area coordinate system. 10

5. (a) Define plane stress and plane strain problems. 2

(b) Derive strain displacement matrix relationship for a CST element. 14

Or

Derive stress strain relationship for plane stress condition. 14