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10ME64

Sixth Semester B.E. Degree Examination, June/July 2023
Finite Element Method

Time: 3 hrs. Max. Marks:100

Note: ***Answer any FIVE full questions, selecting at least TWO full questions from each part.***

Important Note : 1. On completing your answers, compulsorily draw diagonal cross lines on the remaining blank pages.
2. Any revealing of identification, appeal to evaluator and /or equations written eg, 42+8 = 50, will be treated as malpractice.

PART – A

1 a. Derive an equilibrium equation of a 2D-elastic body subjected to a body force. **(08 Marks)**
b. List down the basic steps involved in FEM for stress analysis of elastic body. **(06 Marks)**
c. Discuss the types of elements based on geometry. **(06 Marks)**

2 a. Derive an expression for displacement of a cantilever bar subjected to uniform distributed axial load 'ρ_0', using Rayeligh – Ritz method, assuming the polynomial displacement function, uniform c/s 'A', Youngs modulus 'E' and length 'L'. **(10 Marks)**
b. State the principle of minimum potential energy and derive the element stiffness matrix for 1D bar element using minimum potential energy principle. **(10 Marks)**

3 a. Determine the Jacobian of the transformation 'J' for a triangular element shown in Fig.Q.3(a). **(06 Marks)**

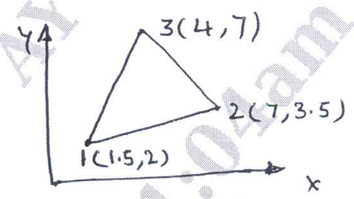

Fig.Q.3(a)

b. Derive the shape functions for 1D linear bar element in natural co-ordinate system. **(08 Marks)**
c. What is convergence requirements? Discuss the three conditions of convergence requirements. **(06 Marks)**

4 a. Obtain displacement at node '2', reactions, stresses and strains in the circular solid stepped bar as shown in Fig.Q.4(a). Take E_1 = 70Gpa, E_2 = 200Gpa for the element (i) and (ii) respectively. **(12 Marks)**

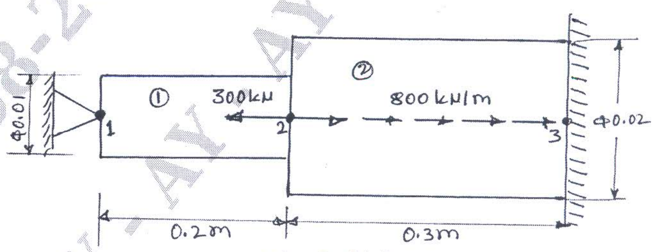

Fig.Q.4(a)

b. Solve the following system of equations by Gaussian elimination method:

$$x_1 - 2x_2 + 6x_3 = 0$$
$$2x_1 + 2x_2 + 3x_3 = 3$$
$$-x_1 + 3x_2 = 2$$

(08 Marks)

PART – B

5 a. Using Lagrange's method, derive the shape function of 1D quadratic elements. **(06 Marks)**

b. Evaluate $I = \int_{-1}^{+1} (1 + r + 2r^2 + 3r^3)dr$. **(06 Marks)**

c. Determine the Cartesian co-ordinates of the point P(ξ = 0.8, η = 0.9) given the Cartesian co-ordinates of nodes of quadrilateral elements as shown in Fig.Q.5(c). **(08 Marks)**

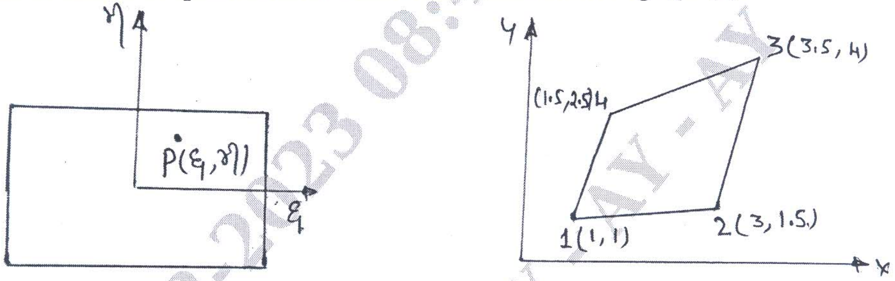

Fig.Q.5(c)

6 a. Obtain an expression for stiffness matrix of a truss element in the global co-ordinate system. **(08 Marks)**

b. For the two bar truss structure, as shown in Fig.Q.6(b). Determine the nodal displacement and stress in each element. Take $E = 210 \times 10^9$Pa, $A = 0.01m^2$. **(12 Marks)**

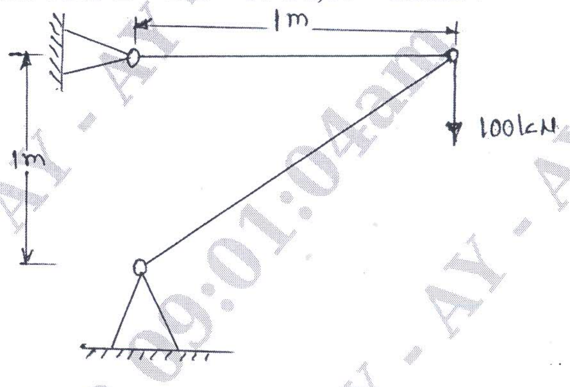

Fig.Q.6(b)

7 a. Derive the shape functions for the beam element. **(08 Marks)**

b. Determine the maximum deflection and internal loads in the uniform cross-section of the cantilever beam as shown in Fig.Q.7(b). If the beam is treated as a single element. Take $E = 70 \times 10^9 N/m^2$, $I = 4 \times 10^{-4} m^4$. **(12 Marks)**

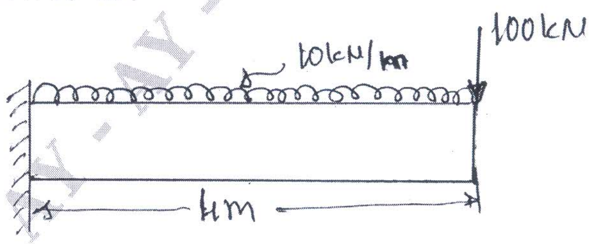

Fig.Q.7(b)

8 A composite wall as shown in Fig.Q.8(a) consists of three materials. The outer temp. $T_0 = 20°C$, Convective heat transfer takes place on the inner surface of the wall with $T\infty = 800°C$. The convective heat transfer coefficients $h_i = 25 W/m^2 °C$. Determine the temp distribution in the wall. Take $A = 1m^2$. Use penalty approach of boundary handling conditions. **(20 Marks)**

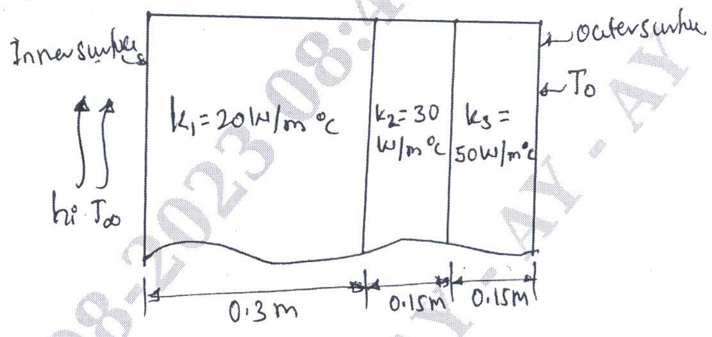

Fig.Q.8

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