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P.E.S. College of Engineering, Mandya - 571 401

(An Autonomous Institution affiliated to VTU, Belgaum)

First Semester, Mechanical Engineering (MMDN)

Make-up Examination; Feb - 2017

Finite Element Methods

Time: 3 hrs *Max. Marks: 100*

***Note**: i) Answer any **FIVE** full questions, selecting at least **ONE** from each unit.*
ii) Missing data if any maybe suitably assume

UNIT-I

1 a. Differentiate between essential and non-essential boundary conditions. 6

b. Explain convergence criteria of a displacement model and mention how they are satisfied by the selected displacement function. 6

c. Derive an expression for potential energy functional for a 3D elastic body subjected to body force, surface force and point load components in its x,y and z directions. 8

2.a Derive shape functions for a 3-noded bar element in natural coordinates and plot their variations along the element 6

b. For the stepped bar shown in Fig Q 2(b), determine nodal displacements, element stresses and support reaction. Take E=200GPa. 14

UNIT-II

3.a Derive strain displacement matrix, B for a CST element. 6

b. With necessary sketches, explain the concept of Iso, Sub and Super parametric elements. 6

c. The nodal coordinates of a triangular element at node 1, 2 and 3 are (1,1), (4,1) and(1,5) respectively. The nodal displacement are given by 8

$u_1 = 0.005mm; \quad u_2 = 0.0mm; \quad u_3 = 0.005mm$

$v_1 = 0.002mm; \quad v_2 = 0.0mm; \quad v_3 = o.omm$

Determine the strain-displacement matrix, B and hence calculate element strains $\varepsilon_x, \varepsilon_y, \gamma_{xy}$

4 a. Obtain the Jacobian matrix for the quadrilateral element 10

b Derive shape functions for 4-noded Tetrahedral element. 10

UNIT-III

5 a. Derive the shape functions for an axi-symmetric triangular element. 8

b. The element of an axi symmetric body is rotating with a constant speed of 200 rpm and subjected to an external pressure of 2 MPa as shown in Fig Q 5(b). If the mass density of the material ρ = $7.6x10^{-6}$ kg/mm^2, evaluate the equivalent force at nodes. The nodal coordinates shown in figure in mm. 12

Contd…..2

6. For the truss structure shown in Fig Q 6, determine the nodal displacements, stress in horizontal member and reaction at top support. 20

UNIT-IV

7.a Write Harmite shape functions of a 2-noded beam element and draw their variations along the element. 6

b. For the beam shown in Fig Q 7(b), determine the nodal deflections, slops and the vertical deflections at the mid-point of distributed load. Use two element approximation and take $E = 70$ GPa, $I = 3\text{x}10^{-4}$ m^4. 14

8.a Write consistent mass matrix of plane truss element. 2

b. A one-dimensional bar of length L, modulus of elasticity E, mass density ρ and cross-sectional area A is fixed at one end and free at other end. Determine its first two natural frequencies using two elements of equal length. 18

UNIT-V

9 a. Using Galerkin's approach, derive the element conduction matrix for 1D element used for steady state heat transfer problems. 8

b. Consider a brick wall (Fig Q 9(b)) of thickness L = 0.3 m, K = 0.7 W/m°C. The inner surface is at 28°C and the outer surface is exposed to cold air at -15°C. The heat transfer coefficient associated with the outside surface is h = 40 W/m^2°C. Determine the steady-state temperature distribution within the wall and also the heat flux through the wall. Use two-element model. 12

10 . Fig Q 10 shows a uniform aluminium fin of diameter 20 mm. The root (left end) of the fin is maintained at a temperature of T_0 = 100°C while convention takes place from the lateral (circular) surface and the right (flat) edge of the fin. Assuming K = 200 W/m°C, h = 1000 W/m^2°C and T_∞ = 20°C, determine the temperature distribution in the fin using a two-element idealization. 20

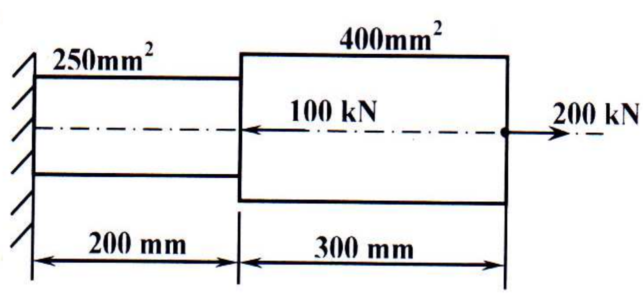

Fig. Q 2(b)

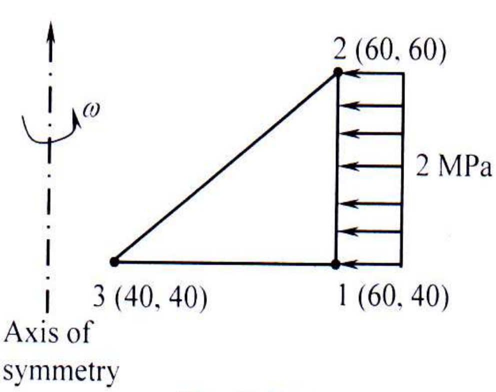

Fig. Q 5(b)

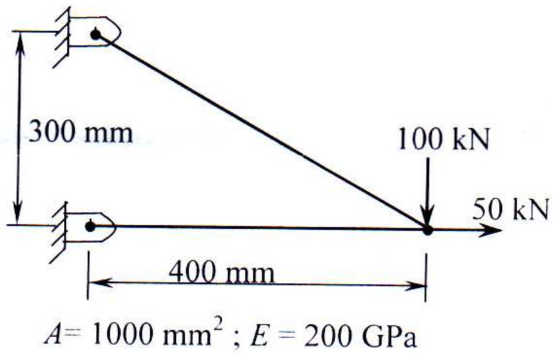

Fig. Q 6

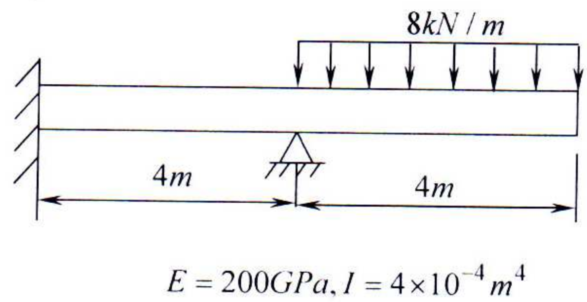

Fig. Q 7(b)

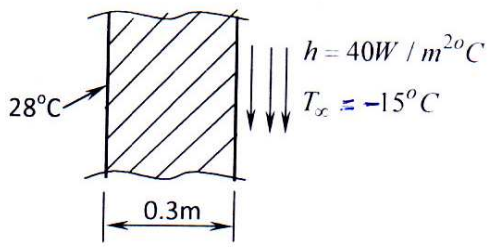

Fig. Q 9(b)

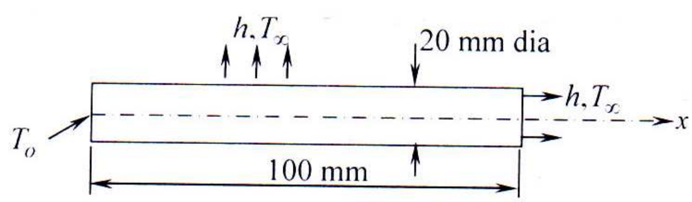

Fig. Q 10

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