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Question Paper Code : D 2308

B.E./B.Tech. DEGREE EXAMINATION, APRIL/MAY 2010.

Seventh Semester

Mechanical Engineering

ME 1401 — INTRODUCTION OF FINITE ELEMENT ANALYSIS

(Common to Automobile Engineering and Mechatronics Engineering)

Time : Three hours   Maximum : 100 marks

Answer ALL questions.

PART A — ($10 \times 2 = 20$ marks)

1. What is the limitation of using a finite difference method?

2. List the various methods of solving boundary value problems.

3. Write down the interpolation function of a field variable for three-node triangular element.

4. Highlight at least two rules to guide the placement of the nodes when obtaining approximate solution to a differential equation.

5. List the properties of the global stiffness matrix.

6. List the characteristics of shape functions.

7. What do you mean by the terms : c^0, c^1 and c^n continuity?

8. Write down the nodal displacement equations for a two dimensional triangular elasticity element.

9. List the required conditions for a problem assumed to be axisymmetric.

10. Name a few boundary conditions involved in any heat transfer analysis.

PART B — (5 × 16 = 80 marks)

11. (a) Discuss the following methods to solve the given differential equation :

$$EI\frac{d^2y}{dx^2} - M(x) = 0$$

with the boundary conditions $y(0)=0$ and $y(H)=0$

(i) Variational method

(ii) Collocation method.

Or

(b) For the spring system shown in Figure 1, calculate the global stiffness matrix, displacements of nodes 2 and 3, the reaction forces at node 1 and 4. Also calculate the forces in the spring 2. Assume, $k_1 = k_3 = 100$ N/m, $k_2 = 200$ N/m, $u_1 = u_4 = 0$ and P = 500 N.

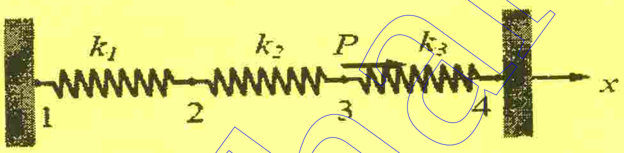

Figure 1 Spring System Assembly

12. (a) Determine the joint displacements, the joint reactions, element forces and element stresses of the given truss elements.

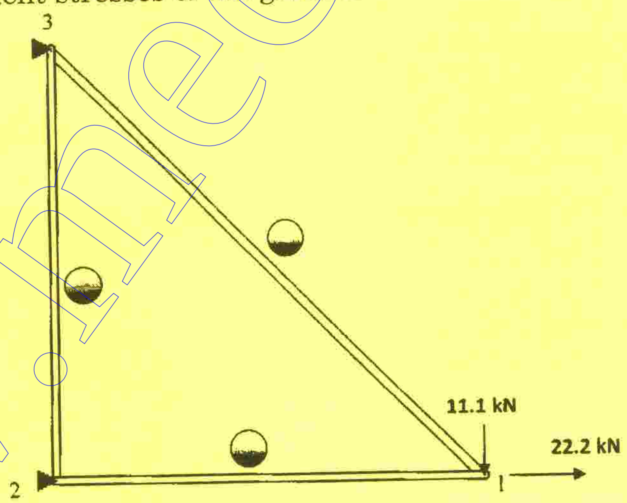

Figure 2 Truss with applied load

Table 1 : Element Property Data

Element	A cm²	E N/m²	L m	Global Node Connection	α Degree
1	32.2	6.9e10	2.54	2 to 3	90
2	38.7	20.7e10	2.54	2 to 1	0
3	25.8	20.7e10	3.59	1 to 3	135

Or

(b) Derive the interpolation function for the one dimensional linear element with a length 'L' and two nodes, one at each end, designated as 'i' and 'j'. Assume the origin of the coordinate system is to the left of node 'i'.

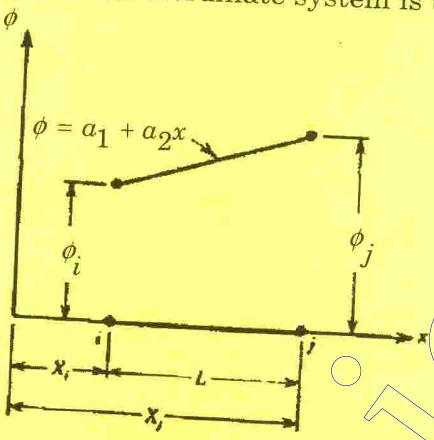

Figure 3 the one-dimensional linear element

13. (a) Determine three points on the 50°C contour line for the rectangular element shown in the Figure 4. The nodal values are $\Phi_i = 42^\circ C$, $\Phi_j = 54^\circ C$, $\Phi_k = 56^\circ C$ and $\Phi_m = 46^\circ C$.

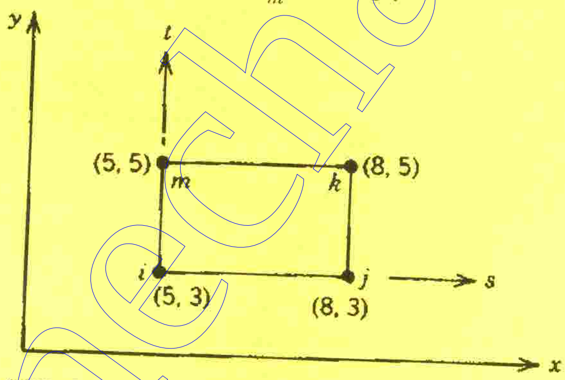

Figure 4 Nodal coordinates of the rectangular element

Or

(b) The simply supported beam shown in Figure 5 is subjected to a uniform transverse load, as shown. Using two equal-length elements and work-equivalent nodal loads obtain a finite element solution for the deflection at mid-span and compare it to the solution given by elementary beam theory.

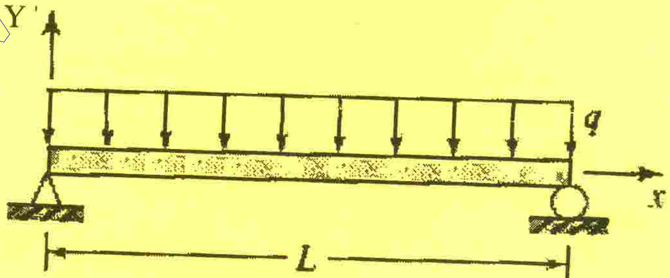

Figure 5 uniformly loaded beam

14. (a) For the plane strain element shown in the Figure 6, the nodal displacements are given as : $u_1 = 0.005$ mm, $u_2 = 0.002$ mm, $u_3 = 0.0$ mm, $u_4 = 0.0$ mm, $u_5 = 0.004$ mm, $u_6 = 0.0$ mm. Determine the element stresses. Take E = 200 Gpa and $\gamma = 0.3$. Use unit thickness for plane strain.

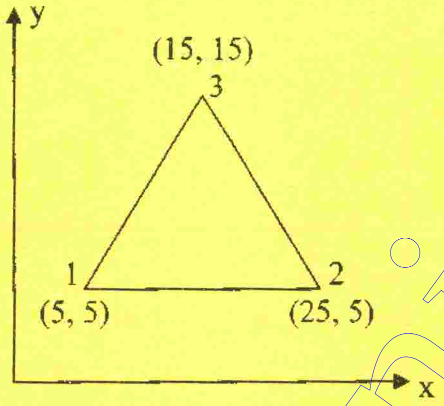

Figure 6 Triangular Element

Or

(b) Determine the element stiffness matrix and the thermal load vector for the plane stress element shown in Figure 7. The element experiences 20°C increase in temperature. Take E = 15e6 N/cm², $\gamma = 0.25$, t = 0.5 cm and a = 6e–6/°C.

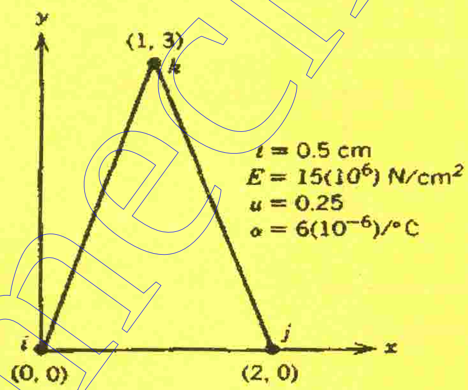

Figure 7 Triangular elastic elements

15. (a) Use Gaussian quadrature to obtain an exact value of the integral.

$$I = \int_{-1}^{1}\int_{-1}^{1} (r^3 - 1)(s - 1)^2 \, dr\, ds.$$

Or

(b) Define the following terms with suitable examples :

(i) Plane stress, Plane strain

(ii) Node, Element and Shape functions

(iii) Iso-parametric element

(iv) Axisymmetric analysis.

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