USN **06ME63**

Sixth Semester B.E. Degree Examination, June 2012

Modelling and Finite Element Analysis

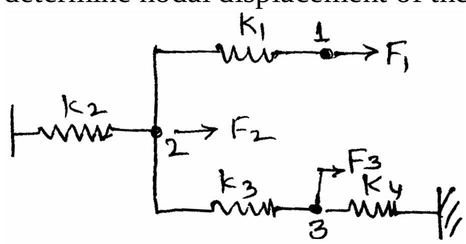
Time: 3 hrs. Max. Marks:100

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

PART – A

1 a. Differentiate between plane stress and plane strain problems. Also state the stress-strain relations for both. **(05 Marks)**

b. State the principle of minimum (stationary) potential energy and apply the same to determine nodal displacement of the spring system shown in Fig.Q1(b). **(10 Marks)**



$k_1 = 50$ N/mm
$k_2 = k_3 = 60$ N/mm
$k_4 = 80$ N/mm
$F_1 = 100$ N, $F_2 = 150$ N, $F_3 = 200$ N,

Fig.Q1(b)

c. Evaluate the following integral using two point Gauss quadrature formula.

$$I = \int_1^3 \left(\frac{1}{x}\right) dx$$ **(05 Marks)**

2 a. What is FEM? What are the advantages and limitations of the method? **(08 Marks)**

b. Derive the element stiffness matrix of linear bar element and list the properties of stiffness matrix. **(12 Marks)**

3 a. What do you understand by C° and C^1 shape functions? State the properties of C° shape functions. Derive shape functions of a 3-noded bar element in natural coordinates. Show the variation of each shape function over the element. **(12 Marks)**

b. Discuss the various convergence criteria and geometric isotropy as regards to finite element models. **(08 Marks)**

4 a. What do you understand by Hermitian shape functions? Derive Hermite shape functions of a beam element and show the variation of the shape functions over the element. **(10 Marks)**

b. Explain the sub-super and isoparametric finite elements. **(05 Marks)**

c. Write a note on higher order elements used in FEM. **(05 Marks)**

PART – B

5 a. Derive a stiffness matrix for 2D truss element. **(10 Marks)**

b. Derive strain-displacement [B] matrix for a 3-noded CST element. **(10 Marks)**

6 a. Write a note on application of FEM in solving scalar field problems. **(04 Marks)**

b. Write the governing differential equations for one dimensional heat transfer and discuss the various types of boundary conditions used in solving heat transfer problems. **(06 Marks)**

c. Derive element conductivity matrix for one dimensional heat flow element. **(10 Marks)**

7 a. Determine the nodal displacement at node 2, the stresses in the elements at support reactions for the stepped bar shown in Fig.Q7(a). **(10 Marks)**

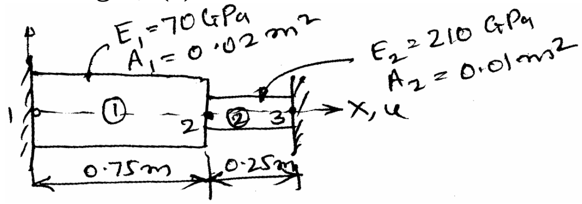


Fig.Q7(a)

b. For the truss element shown in Fig.Q7(b), (x, y) co-ordinates of the element are indicated near nodes 1, 2. The element displacement dof vector is given by $\{u\} = \lfloor 1.5 \;\; 1.0 \;\; 2.1 \;\; 4.3 \rfloor^T \times 10^{-2}$ mm. Take E = 300×10^3 N/mm^2, A = 100 mm^2, determine the following:

i) Element displacement dof in local coordinates (u_1^1 & u_2^1)
ii) Stress in the element
iii) Stiffness-matrix of the element. **(10 Marks)**

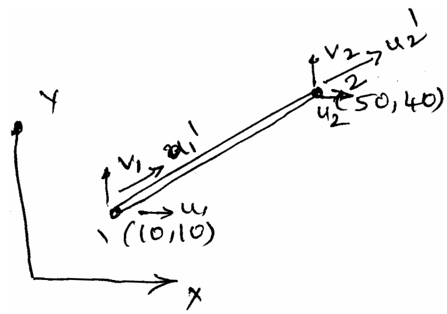


Fig.Q7(b)

E = 300×10^3 N/mm^2
A = 100 mm^2

$$\begin{Bmatrix} u_1 \\ v_1 \\ u_2 \\ v_2 \end{Bmatrix} = \begin{Bmatrix} 1.5 \\ 1.0 \\ 2.1 \\ 4.3 \end{Bmatrix} \times 10^{-2}\,\text{mm}$$

8 a. For the brick wall shown in Fig.Q8(a), the inner surface temperature is 28°C and outer surface is exposed to cold air at –15°C. Determine the temperature distribution in steady state, within the wall, by considering 2 elements, one dimensional heat flow elements. What is heat flux through the wall? **(10 Marks)**

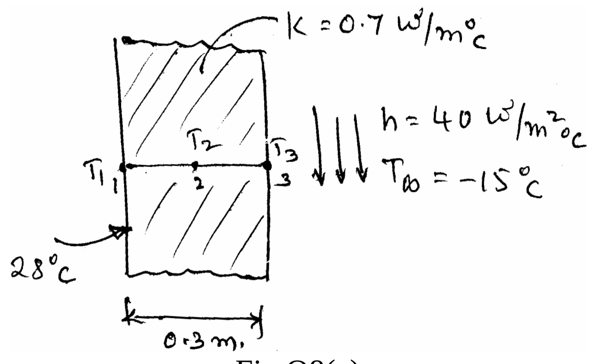


Fig.Q8(a)

b. For the beam fixed at both ends and loaded as shown in Fig.Q8(b), determine the displacement and slopes at node 2, and reaction force at node 1 only. **(10 Marks)**

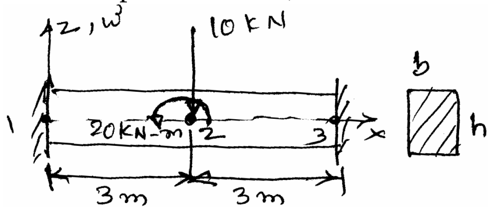


Fig.Q8(b)

E = 210 GPa
b = 0.2 m
h = 0.4 m

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