CBCS SCHEME

USN | | | | | | | | | | 18ME61

Sixth Semester B.E. Degree Examination, June/July 2025
Finite Element Methods

Time: 3 hrs. Max. Marks: 100

Note: *Answer any FIVE full questions, choosing ONE full question from each module.*

Module-1

1 a. Define FEM. Explain the basic steps involved in FEM. **(10 Marks)**

b. Solve by principle of minimum potential energy method for the spring system shown in Fig Q1(b).

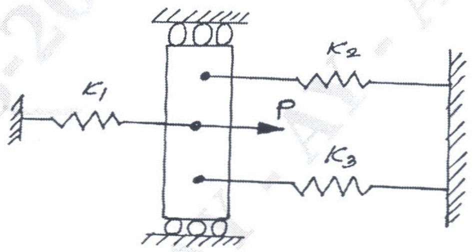

Fig Q1(b) **(10 Marks)**

OR

2 a. Explain plane stress and plane strain problems with suitable examples. **(08 Marks)**

b. A bar of length 'L' fixed at one end subjected to point load, determine the deformation at the free end using Galerkin's method, use second order polynomial.

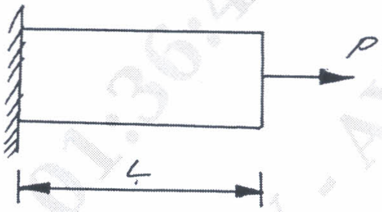

Fig Q2(b) **(12 Marks)**

Module-2

3 a. Derive the shape function for cubic bar element in natural coordinate system. **(10 Marks)**

b. A stepped bar as shown in Fig Q3(b), using penalty method find
i) Nodal displacement ii) Stresses in each element iii) Reactions at the supports.
Take E = 120 GPa.

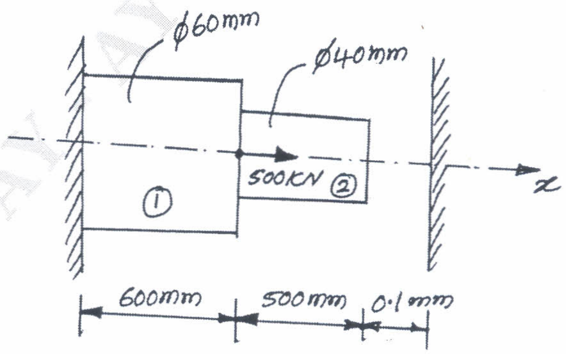

Fig Q3(b) **(10 Marks)**

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.

OR

4 a. Derive the elemental stiffness matrix for 2-noded bar element by direct method. **(08 Marks)**

b. Solve for displacement at each node and stresses in each element as shown in Fig Q4(b). Take $A = 200\ mm^2$ and $E = 2 \times 10^5\ N/mm^2$.

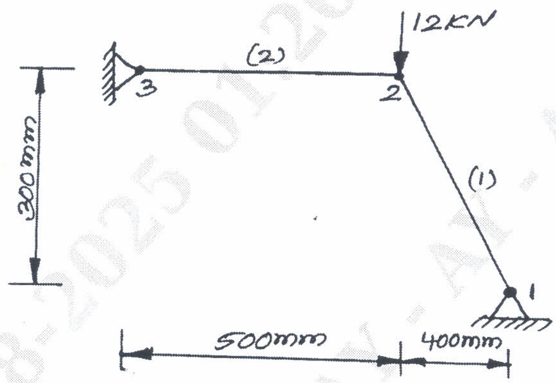

Fig Q4(b) **(12 Marks)**

Module-3

5 a. Derive the Hermite shape function for a beam element. **(08 Marks)**

b. A beam of span 6m and uniform flexural rigidity EI = 40000 kN-m^2 subjected to clockwise couple of 300 kN-m at a distance of 4m from left end as shown in Fig Q5(b). Find the deflection at the point of application of couple and internal loads.

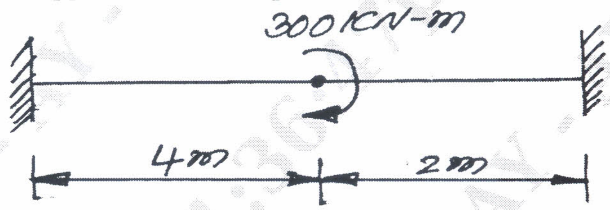

Fig Q5(b) **(12 Marks)**

OR

6 a. Derive the potential energy functional for a beam element. **06 Marks)**

b. A composite step shaft as shown in Fig Q6(b), consists of an aluminium section 50mm in diameter and a steel section 25mm in diameter. The ends of the shaft are fixed. Determine the maximum stress in aluminum and steel shafts. Take G_{Steel} = 84 GPa and $G_{A\ell}$ = 28 GPa.

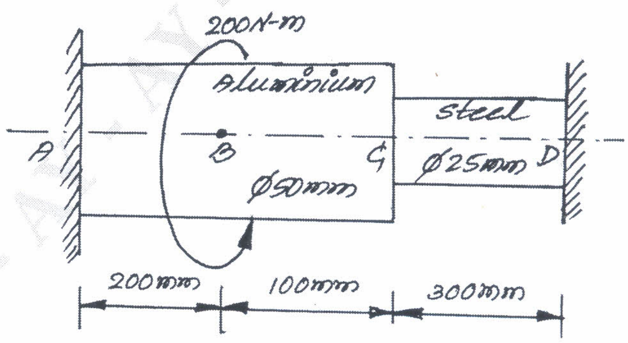

Fig Q6(b) **(14 Marks)**

Module-4

7 a. Explain the types of boundary conditions in heat transfer problems. **(06 Marks)**

b. Derive the element conductivity matrix for one dimensional heat flow element. **(06 Marks)**

c. Determine the temperature distribution of a rectangular fin as shown in Fig Q7(c). Assume steady state heat transfer and only conduction process. Take heat generated inside the fin as 500 W/m^3.

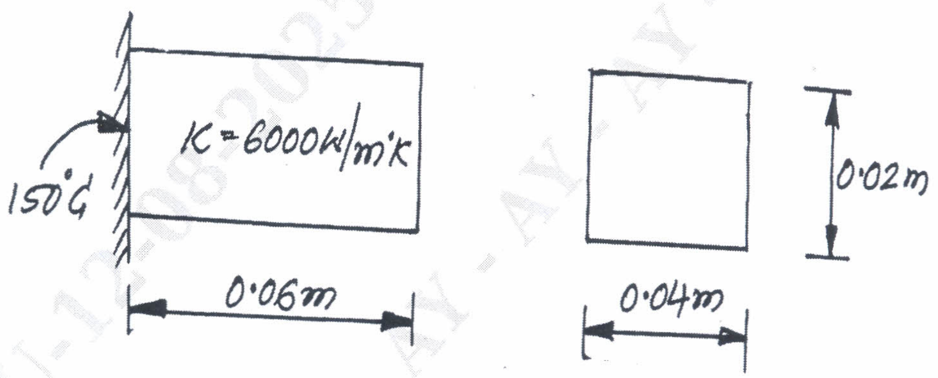

Fig Q7(c) **(08 Marks)**

OR

8 a. Derive the stiffness matrix for one dimensional fluid element. **(08 Marks)**

b. For the smooth pipe of variable cross section shown in Fig Q8(b), determine the potential at the junctions, the velocities in each section of pipe and the volumetric flow rate. The potential at the left end is $P_1 = 10\text{m}^2/\text{s}$ that at the right end is $P_4 = 1\text{m}^2/\text{sec}$. For the fluid flow through a smooth pipe, $K_x = 1$.

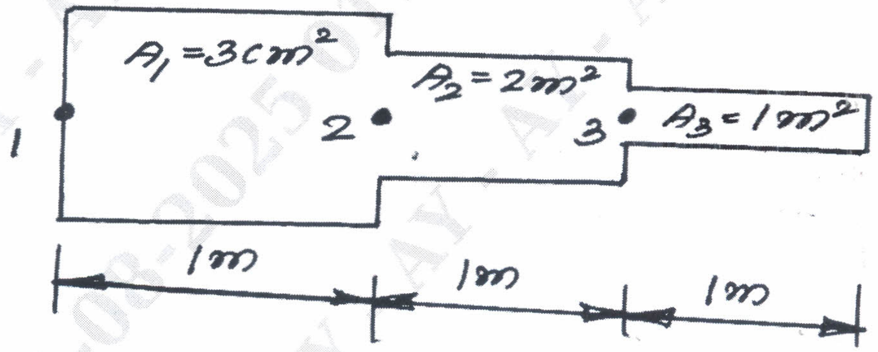

Fig Q8(b) **(12 Marks)**

Module-5

9 a. What is an axisymmetric element? Derive Jacobin matrix for axisymmetric triangular element. **(10 Marks)**

b. For a long cylinder of inside diameter 8 cm and outside diameter 12 cm snugly fits in a hole over its full length as shown in Fig Q9(b). The cylinder is subjected to an internal pressure of 5 MPa. Using two element model over a length of 1 cm, evaluate nodal displacement and element stresses. Take = 20×10^6 N/cm^2 and $\mu = 0.3$.

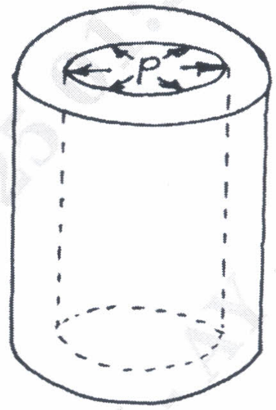

Fig Q9(b) **(10 Marks)**

OR

10 a. Derive the consistent mass matrix for bar element. **(05 Marks)**

b. Differentiate between consistent mass matrix and lumped mass matrix. **(05 Marks)**

c. Determine the natural frequency of vibration of the cantilever beam shown in Fig Q10(c). Take E = 200 GPa, $\rho = 7840$ Kg/m^3, I = 2000 mm^4, A = 240 mm^2.

Fig Q10(c) **(10 Marks)**

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