CBCS SCHEME

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18ME61

Sixth Semester B.E. Degree Examination, Dec.2025/Jan.2026
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. **(08 Marks)**

b. Explain briefly about the node location system and numbering scheme in FEM. **(06 Marks)**

c. Derive an expression for total potential energy of an elastic body subjected to body force, traction force and a point load. **(06 Marks)**

OR

2 a. Using Rayleigh – Ritz method, determine the displacement at midpoint and stress variation in a one dimensional rod as shown in fig. Q.2 (a). **(08Marks)**

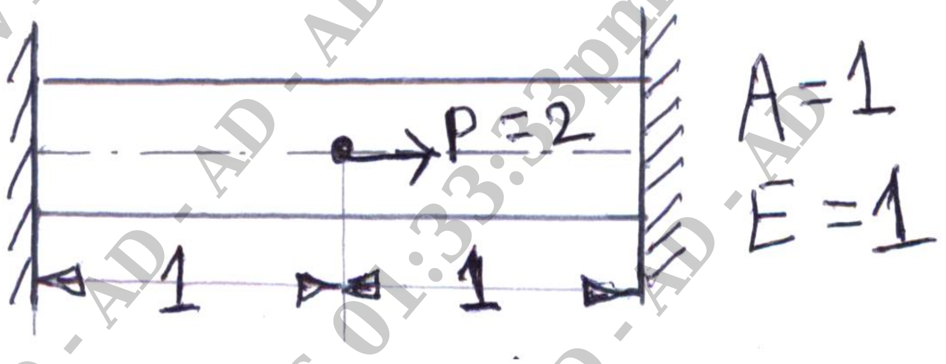

Fig. Q. 2 (a)

b. Explain plain stress and plain strain conditions with examples. **(06 Marks)**

c. Explain simplex, complex and multiplex elements. **(06 Marks)**

Module-2

3 a. What are higher order element? Derive shape function for 1D quadratic element in natural co-ordinates. **(08 Marks)**

b. Derive the shape function for Triangular Element (CST element) in natural co-ordinate system. **(08 Marks)**

c. Evaluate $\int_{-1}^{+1} (x^2 + \sin\frac{\pi x}{2})dx$ Using suitable Gauss points numerical Integration. **(04 Marks)**

OR

4 a. Consider the bar shown in Fig. Q.4 (a. Assume load P = 200 KN applied as shown in figure. Use penalty approach method for handling boundary conditions. Find the following:

i) Determine the Nodal displacement
ii) Determine the stress in each element
iii) Determine the reaction forces

$A_1 = 2400\ mm^2$; $A_2 = 600\ mm^2$
$E_1 = 70$ GPa ; $E_2 = 200$ GPa
P = 200 KN

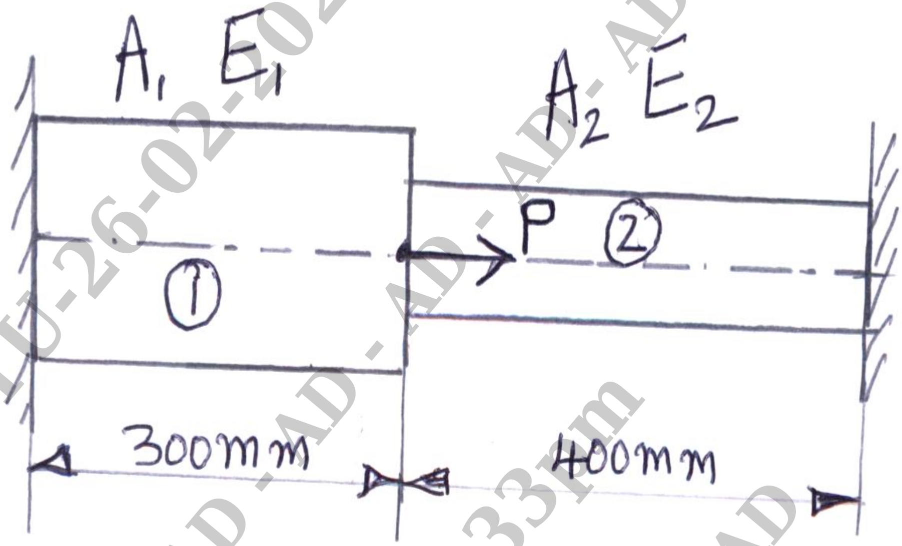

Fig. Q. 4 (a)

(10 Marks)

b. A truss shown in Fig. Q. 4(b) is made of 2 bars. Determine :

i) Nodal displacement
ii) Stress in each element

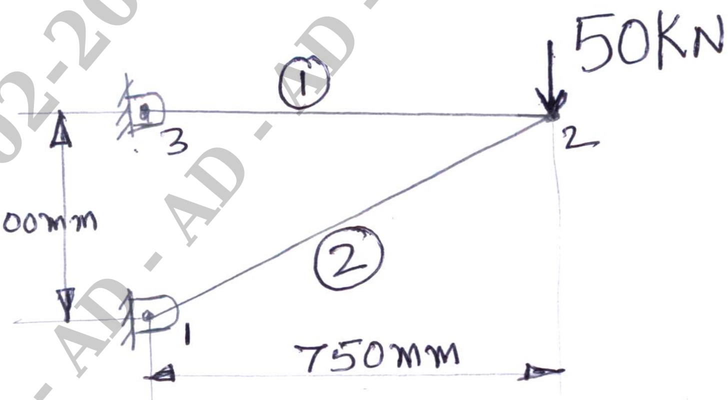

Fig. Q. 4 (b)

$A_1 = 1000\ mm^2$
$A_2 = 1200\ mm^2$
$E_1 = E_2 = 200$ GPa

(10 Marks)

Module-3

5 a. Derive the Hermite shape function for Beam Element. **(08 Marks)**

b. For the beam and loading shown in fig. Q. 5(a) , determine the slopes at 2 and 3 and the vertical deflection at the midpoints of the distributed load.
Take E = 200GPa
$I = 4 \times 10^6 \text{ mm}^4$

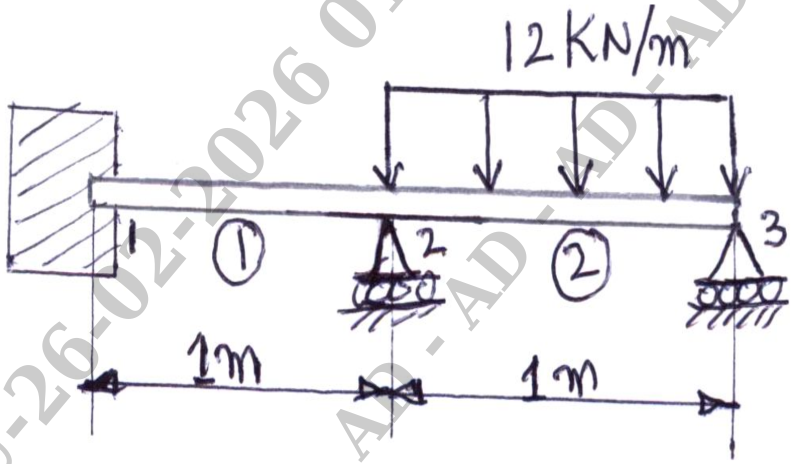

Fig. Q. 5 (b) **(12 Marks)**

OR

6 a. Derive the stiffness matrix for a circular shaft subjected to pure torsion. **(08 Marks)**

b. For the circular stepped shaft shown in fig. Q. 6(b). Determine stresses and angle of twist.

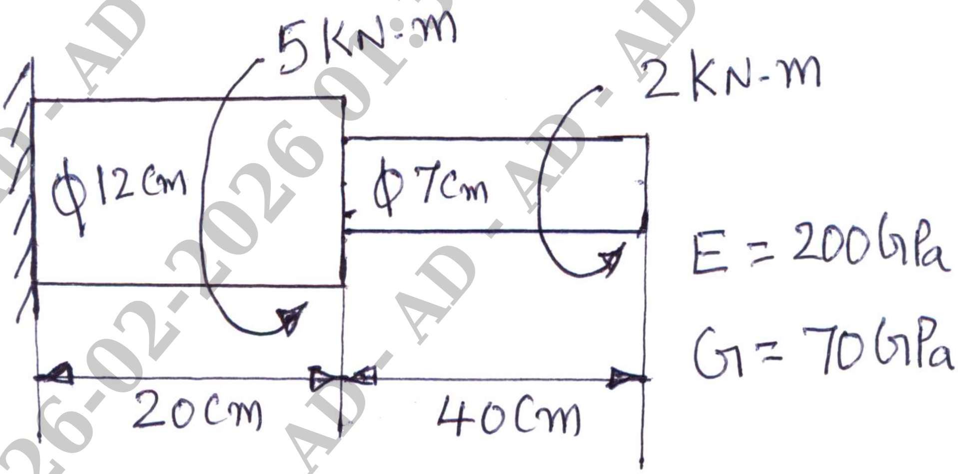

Fig. Q. 6 (b) **(12 Marks)**

Module-4

7 a. Derive element conductivity matrix for one- dimensional heat flow element. **(08 Marks)**

b. A composite slab consists of three materials with thermal conductivities of 20 W/m°C, 30 W/m°C 50 W/m°C and thickness 0.3 m, 0.15. m and 0.15 m respectively as shown in fig. Q. 7 (b). The outer surface is at 20°C and the inner surface is exposed to the convective heat transfer co-efficient of 25 W/m^2 °C and medium at 800°C. Determine the temperature distribution within the wall.

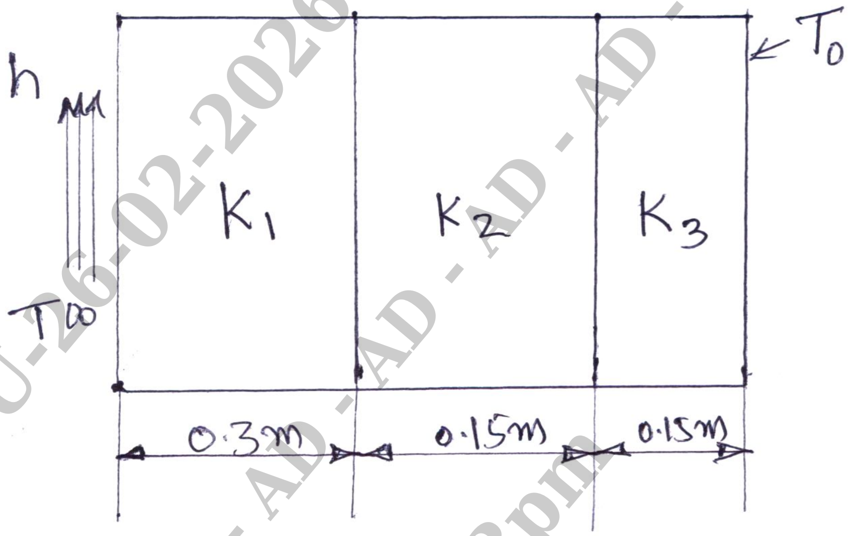

Fig. Q. 7 (b) **(12 Marks)**

OR

8 a. Derive the stiffness matrix for 1 – D element with two – nodes having nodal fluid heads. **(08 Marks)**

b. For the smooth pipe of variable c/s shown in fig. Q. 8 (b) . Determine the potential at the junction the velocities in each section of pipe and volumetric flow rate. The potential at the left end is $P_1 = 12\ m^2/s$ and that at right end is $P_4 = 3m^2/s$.
Take $K_x = 1$

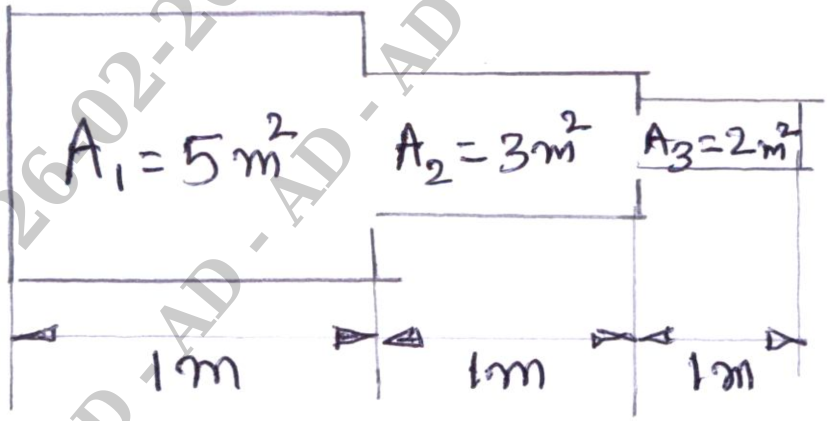

Fig. Q.8 (b) **(12 Marks)**

Module-5

9 a. What is axisymmetric element? Derive Jacobian matrix for axisymmetric triangular element. **(08 Marks)**

b. For the element of an axisymmetric body rotating with a constant angular velocity W = 1000 rev/min as shown in fig. Q. 9 (b). Determine the body force vector. Include the weight of the material. $\rho = 7850\ kg/m^3$.

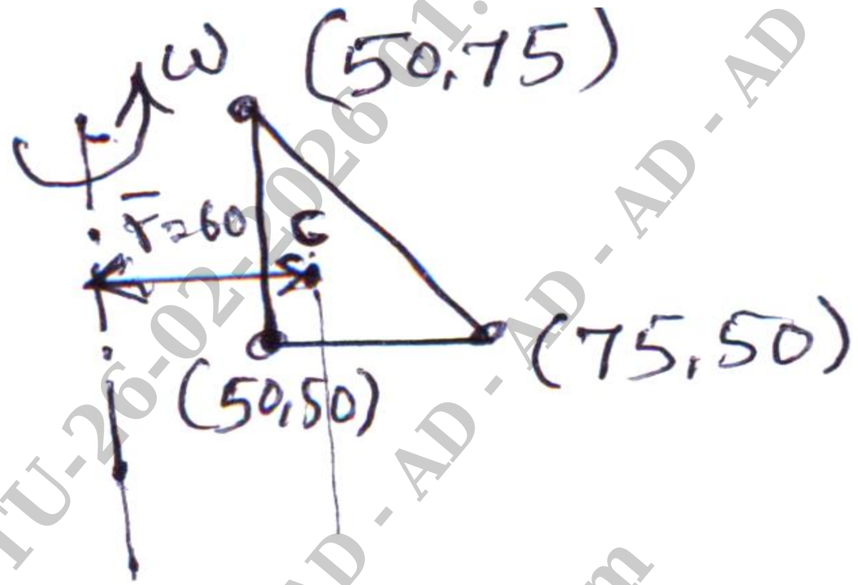

Fig. Q.9 (b) **(12 Marks)**

OR

10 a. Derive consistent mass matrix for truss element. **(10 Marks)**

b. For the stepped bar shown in fig. Q. 10 (b) determine the eigen values and eigen vector. Take $A_1 = 400\ mm^2$, $A_2 = 200\ mm^2$ $\rho = 7850\ kg/m^3$, $E = 200\ GPa$

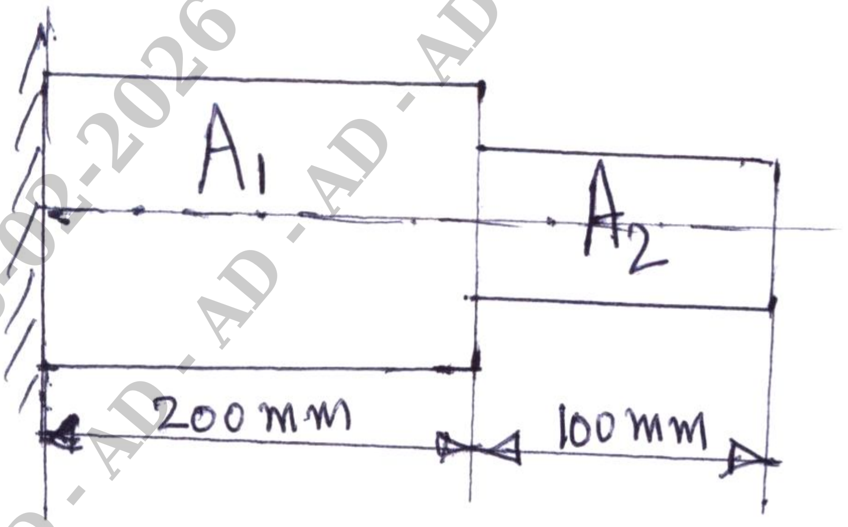

Fig. Q. 10 (b)

(10 Marks)