18ME61

USN

Sixth Semester B.E. Degree Examination, June/July 2023
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. List the advantages and disadvantages of FEM.　**(10 Marks)**
　　b.　List and explain steps in FEM.　**(10 Marks)**

OR

2　a.　Explain simplex, complex and multiplex elements.　**(06 Marks)**
　　b.　A cantilever beam of span 'L' is subjected to a point load at its free end as shown in Fig.Q2(b). Derive an equation for the deflection at free end by using RR method. Assume polynomial displacement function.
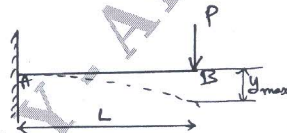

Fig.Q2(b)　**(14 Marks)**

Module-2

3　a.　Derive the element stiffness matrix of 1D bar element.　**(08 Marks)**
　　b.　Using penalty method of handling boundary condition, determine the nodal displacement, stress in each element and support reaction in the bar shown due to applied load in Fig.Q3(b). P = 100 kN.
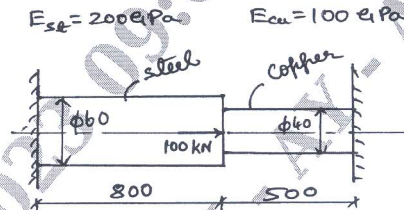

Fig.Q3(b)　**(12 Marks)**

OR

4　a.　List the assumptions made in Truss.　**(04 Marks)**
　　b.　A 4 bar truss element is shown in Fig.Q4(b). Determine the following:
　　　i) Nodal displacement　　ii) Stress in each element　　iii) Reaction at supports.
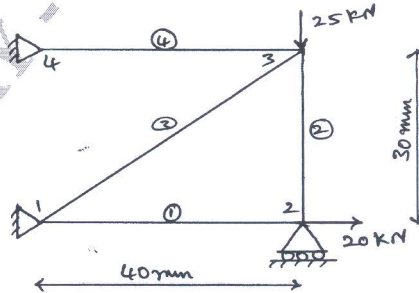　　Area of each truss element = 100 mm^2 ;　E = 2×10^5 N/mm^2.

Fig.Q4(b)　**(16 Marks)**

Module-3

5 a. Derive the Hermite shape function of a Beam element. (08 Marks)
   b. For the beam shown in Fig.Q5(b), determine the displacement at node 2 and internal loads. Take E = 210 GPa, b = 0.2 m ; h = 0.4 m.
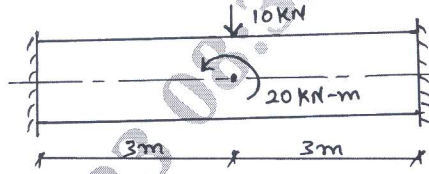

Fig.Q5(b) (12 Marks)

OR

6 a. Derive the stiffness matrix for the torsion of shafts. (08 Marks)
   b. A solid stepped bar of circular cross section shown in Fig.Q6(b) is subjected to a torque of 1 kN-m at its free end and a torque of 3 kN-m at its change in c/s. Determine the angle of twist and shear stresses in the bar. Take $E = 2\times10^5$ N/mm^2 and $G = 7\times10^4$ N/mm^2.
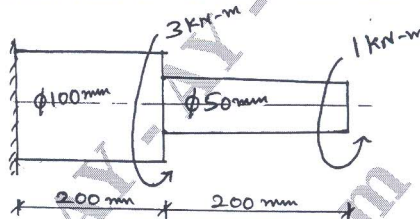

Fig.Q6(b) (12 Marks)

Module-4

7 a. Derive the governing differential equation for 1-D heat conduction. (06 Marks)
   b. Determine the temperature distribution in the composite wall using 1D heat elements, use penalty approach of handling BC's. Refer Fig.Q7(b).

   Given :
   $k_1 = 20$ W/m °C
   $k_2 = 30$ W/m °C
   $k_3 = 55$ W/m °C
   $h = 30$ W/m^2 C
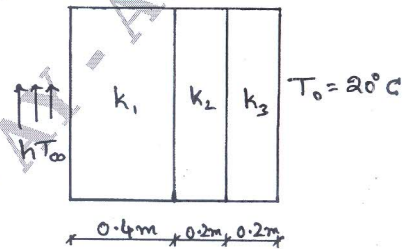 $T_\infty = 900$°C
   A = Unit area

Fig.Q7(b) (14 Marks)

OR

8 a. Derive the element stiffness matrix of 1-D fluid flow element. (06 Marks)
   b. For the smooth pipe of variable cross-section shown in Fig.Q8(b), determine the potential at the junction, the velocities in each section of pipe and the volumetric flow rate. The potential at left end is $P_1 = 10$ m^2/s and at right end is $P_4 = 1$ m^2/s. For the fluid flow through a smooth pipe $k_x = 1$.
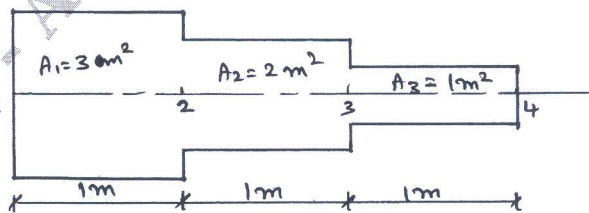

Fig.Q8(b) (14 Marks)

Module-5

9 a. Derive the element stiffness matrix of a triangular axisymmetric element using potential energy approach. **(06 Marks)**

b. For the element of an axisymmetric body rotating with constant angular velocity $w = 1000$ rev/min as shown in Fig.Q9(b). Determine the body force vector. Include the weight of the material, where specific density is 7850 kg/m^3.
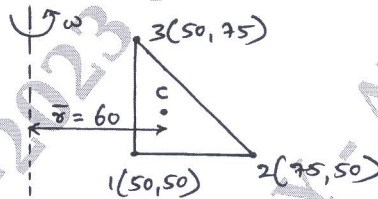

Fig.Q9(b) **(14 Marks)**

OR

10 a. Derive an expression of element mass matrices of
(i) 1-D bar element
(ii) Truss element **(10 Marks)**

b. Evaluate eigen value and eigen vector of longitudinal vibration of the constrained uniform circular bar shown in Fig.Q10(b). Take minimum two elements. Take E = 210 GPa and $\rho = 7860$ kg/m^3.

Fig.Q10(b) **(10 Marks)**

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