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Sixth Semester B.E. Degree Examination, Feb./Mar. 2022

Finite Element Analysis

Time: 3 hrs.

Max. Marks: 80

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

Module-1

- 1 a. Explain the basic steps involved in FEM. (05 Marks)
- b. Explain briefly Node location system and node numbering scheme in FEM. (04 Marks)
- c. Derive an expression for total potential energy of elastic body subjected to body force, traction force and a point force. (07 Marks)

OR

- 2 a. Using Rayleigh-Ritz method, determine the displacement at mid-point and stress variation in one dimensional bar as shown in Fig.Q2(a).

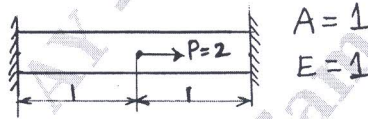


Fig.Q2(a)

(07 Marks)

- b. Write an equilibrium equation of a 3-D elastic body subjected to a body force. (03 Marks)
- c. Write an Interpolation polynomial function for linear, quadratic and cubic elements (Line and Triangular). (06 Marks)

Module-2

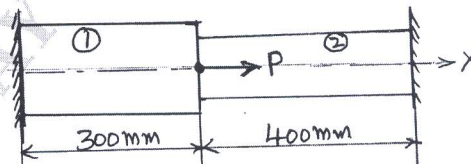
- 3 a. Derive the shape function for 1-D Quadratic element in natural coordinates. (06 Marks)
- b. Find the shape function for a 3-noded Constant Strain Triangular (CST) elements. (06 Marks)
- c. Evaluate the following integral using two point Gauss-Integration method.

$$I = \int_{-1}^{+1} \left[3e^{\xi} + \xi^2 + \frac{1}{(\xi+2)} \right] d\xi$$

(04 Marks)

OR

- 4 a. Consider the bar shown in Fig.Q4(a). An axial load $P = 200 \times 10^3$ N is applied as shown. Using penalty approach for handling boundary conditions do the following :
 - (i) Determine the Nodal displacement.
 - (ii) Determine the Stress in each element.
 - (iii) Determine the reaction forces.



Aluminium Steel
 $A_1 = 2400 \text{ mm}^2$ $A_2 = 600 \text{ mm}^2$
 $E_1 = 70 \text{ GPa}$ $E_2 = 200 \text{ GPa}$

Fig.Q4(a)

(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.

- b. Consider the truss shown in Fig.Q4(b), X-Y coordinates of the two nodes are indicated in the figure. If $q = [1.5, 1.0, 2.1, 4.3]^T \times 10^{-2}$ mm. Take $E = 300$ GPa, $A = 100$ mm². Determine the following :
- (i) Local coordinates (q') (ii) Stress in the element (iii) Stiffness matrix of the element.

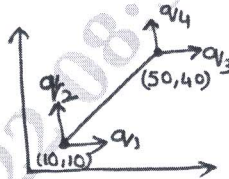


Fig.Q4(b)

(06 Marks)

Module-3

- 5 a. Derive Hermit shape function for a beam element. (06 Marks)
- b. For the beam and loading shown in Fig.Q5(b), determine the slopes at 2 and 3 and the vertical deflection at the midpoint of the distributed load. Take $E = 200$ GPa, $I = 4 \times 10^6$ mm⁴.

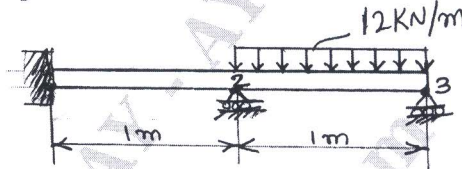


Fig.Q5(b)

(10 Marks)

OR

- 6 a. Derive the stiffness matrix for a circular shaft subjected to pure torsion. (06 Marks)
- b. A hollow circular shaft 2m long is firmly supported at each end and has an outside diameter 80mm and inside diameter 63.8mm. The shaft is subjected to a torque of 12 kN-m applied at a point 1.5m from one end. Calculate the maximum shear stress and angle of twist in the shaft. The shear modulus $G = 8 \times 10^4$ N/mm². (10 Marks)

Module-4

- 7 a. Derive the element stiffness matrix for one dimensional heat conduction. (06 Marks)
- b. A wall of 0.6m thickness having thermal conductivity of 12 W/mK. The wall is to be insulated with a material thickness of 0.06m having an average thermal conductivity of 0.3 W/mK. The inner surface temperature is 1000°C and the outside of the insulation is exposed to an atmospheric air at 30°C with heat transfer coefficient 35 W/m²K. Calculate the nodal temperatures. (10 Marks)

OR

- 8 a. Briefly explain one dimensional heat transfer in thin films. (04 Marks)
- b. Deduce the Governing differential equation for one dimensional fluid flow through a process medium. (06 Marks)
- c. Derive the stiffness matrix for one dimensional fluid element. (06 Marks)

Module-5

- 9 a. Derive the stiffness matrix of axisymmetric bodies with triangular elements. (08 Marks)

- b. Evaluate the Nodal forces used to replace the linearly varying surface traction shown in Fig.Q9(b).

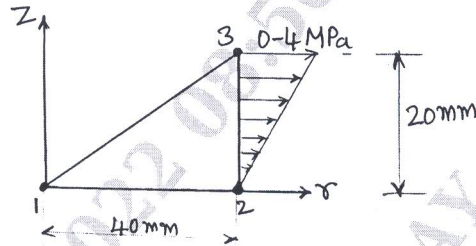


Fig.Q9(b)

(08 Marks)

OR

- 10 a. Derive the consistent mass matrix for truss element. (06 Marks)
 b. For the stepped bar shown in Fig.Q10(b), determine the eigen values and eigen vector. Take $A_1 = 400 \text{ mm}^2$, $\rho = 7850 \text{ kg/m}^3$, $E = 200 \text{ GPa}$, $A_2 = 200 \text{ mm}^2$. (10 Marks)

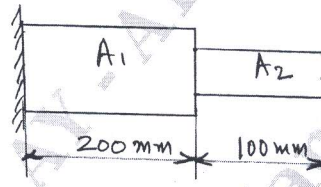


Fig.Q10(b)
