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10ME64

Sixth Semester B.E. Degree Examination, Dec.2023/Jan.2024
Finite Element Methods

Time: 3 hrs. Max. Marks:100

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

PART – A

1 a. Derive equations of equilibrium for a 2-D elastic body. **(10 Marks)**

b. List the advantages, limitations and applications of finite element method. **(06 Marks)**

c. What is meant by "Band Width"? Why should it be minimized? **(04 Marks)**

2 a. State the principle of virtual work and principle of minimum potential energy. **(04 Marks)**

b. Derive elemental stiffness matrix for 1-D element under axial load using direct stiffness approach. **(06 Marks)**

c. A uniform Cantilever with flexural rigidity EI is subjected to a uniformly distributed load of intensity q_0 per unit length over the entire span. Determine deflection at the free end using Rayleigh-Ritz method. Use a trial function $y = \frac{C}{2L}\left(3Lx^2 - x^3\right)$. **(10 Marks)**

3 a. Define shape function. What are the properties that the shape function should satisfy? **(05 Marks)**

b. Discuss the convergence criteria with suitable examples and geometric isotropy as regards to finite element models. **(09 Marks)**

c. Evaluate the shape functions N_1, N_2 and N_3 at the interior point P for the triangular element shown in Fig.Q3 (c).

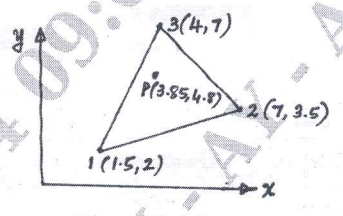


Fig. Q3 (c) **(06 Marks)**

4 a. Explain the elimination method of enforcing the boundary conditions. **(08 Marks)**

b. An axial load P = 250 KN is applied as shown in Fig. Q4 (b). Using the penalty approach for handling boundary conditions ; Determine

(i) Nodal displacements
(ii) Elemental stresses.
(iii) Reaction forces at the supports.

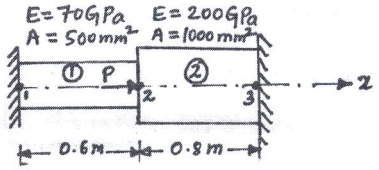


Fig. Q4 (b) **(12 Marks)**

PART – B

5 a. What is higher order element? Obtain the shape function for eight noded quadrilateral element in natural co-ordinate system. **(14 Marks)**

b. Evaluate the integral $I = \int_{-1}^{+1} \left(x^2 + \cos\left(\frac{x}{2}\right) \right) dx$ using three point Gaussian quadrature, compare the result with exact integration. **(06 Marks)**

6 a. Derive the stiffness matrix for a 2-D truss element. **(08 Marks)**

b. A two-dimensional truss structure is loaded as shown in Fig. Q6 (b). Determine

(i) Nodal displacement
(ii) Elemental stresses.
(iii) Reaction forces.

Assume E = 200 GPa, A = 1000 mm^2 for both elements.

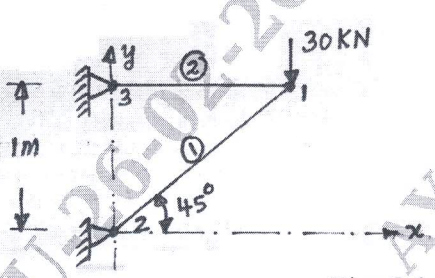
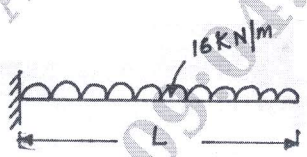


Fig. Q6 (b) **(12 Marks)**

7 a. Define Hermite shape functions. Derive the Hermite shape function for the beam element. **(12 Marks)**

b. Determine the maximum deflection for the Cantilever beam subjected uniformly distributed load for the entire span as shown in Fig. Q7 (b) by assuming the beam as a single element.



$E = 7.2 \times 10^9$ N/m^2,
$I = 4.3 \times 10^{-4}$ m^4,
L = 1 m

Fig. Q7 (b)

(08 Marks)

8 a. Discuss the Galerkin approach for 1-D heat conduction problem. **(10 Marks)**

b. The thermal conductivity of a stainless steel rod of 0.1 m length and area of cross-section of 1 cm^2 is 20 W/m °C. The rate of heat generation in the rod is 10^5 W/m^3. One end of the rod is kept at 0 °C and the others end at 100 °C. The rod is insulated except at the ends. Using one dimensional finite element with two elements, find the temperature at the mid point of the rod. **(10 Marks)**

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