

B.E. DEGREE EXAMINATIONS: NOV/DEC 2010

Seventh Semester

MECHATRONICS ENGINEERING

U07MHE07: Introduction to Finite Element Analysis

Time: Three Hours

Maximum Marks: 100

Answer ALL Questions:-

PART A (10 x 1 = 10 Marks)

1. The spring constant of a spring is $(4 + 1000x)$ N/m, where the spring deflection x is in m. the expression for the strain energy (in N-m) of the spring is.
(a) $2x^2 + 10^3 x^3/3$ (b) $2 \times 10^{-6}x^2 + 10^{-9}x^3/3$
(c) $10^{-3}/2 (4+1000x) x$ (d) $10^{-6}/2 (4+1000x) x$
2. Choose the incorrect statement from the following;
a) The members of an ideal truss carry out only axial loads.
b) Frames never have pin joints.
c) Statically indeterminate frames can be analyzed by finite element method.
d) Stiffness matrix for a truss is never negative definite.
3. Which of the following is a correct statement regarding the units of shape functions N_1 and N_2 in SI system?
a) Both N_1 and N_2 have units as meters.
b) Both N_1 and N_2 are dimensionless.
c) N_1 is dimensionless; N_2 is expressed in m^{-1}
d) N_1 is dimensionless, N_2 is expressed in meters.
4. For a beam element, which of the following relations is true?
a) $N_1 + N_2 + N_3 + N_4 = 1$ b) $N_1 + N_3 = 1$ c) $N_1 + N_2 = 1$ d) $N_1 + N_4 = 1$
5. In plane stress FEM formulation, the vector containing the components of strain is related to the displacement vector by the relation $\{\epsilon\} = [B] \{u\}$ is constant for
a) a CST element b) any triangular element
c) any rectangular element d) a four-noded quadrilateral element
6. For two dimensional plane stress problems
a) $\sigma_z = \tau_{xz} = \tau_{yz} = 0$ b) $\sigma_z = \tau_{xz} = \tau_{yz} \neq 0$ c) $\tau_{xz} = \tau_{yz} = 0$ d) $\sigma_z = \tau_{xz} = 0$
7. Subparametric Element;

- a) Nodes used for geometry greater than the displacements nodes
 - b) Nodes used for geometry less than the displacements nodes
 - c) Nodes used for geometry equal to nodes used to displacements
 - d) Nodes not used to defining the geometry and displacements
8. In axisymmetric triangular element the no of co-ordinates is
 (a) 7 (b) 5 (c) 6 (d) 8
9. For exactly integrating a polynomial of degree 10, the number of Gauss points needed in Gauss quadrature is
 a) 3 b) 4 c) 5 d) 6
10. If the thickness of a thick plate is doubled, its flexural rigidity increases by a factor of
 a) 2 b) 3 c) 4 d) 8

PART B (10 x 2= 20 Marks)

- 11. What role did the computer play in the use of FEM?
- 12. Explain principle of minimum potential energy.
- 13. What is natural co-ordinates?
- 14. State the assumptions are made while finding the forces in a truss.
- 15. What are CST & LST elements?
- 16. Write a strain-displacement matrix for CST element.
- 17. What are Sub-parametric, Iso-parametric and Super-parametric elements?
- 18. What are the conditions for a problem to be axisymmetric?
- 19. Write Kirchhoff assumptions for plate bending problems
- 20. Write FEM equation for 1D element with conduction, convection and internal heat generation.

PART C (5 x14= 70 Marks)

- 21. a) Explain step by step procedure for General Algorithm in Gaussian Elimination Approach. (14)
- (OR)**
- b) (i) Determine the displacements of nodes of the spring system shown fig.1 (10)
- (ii) Enumerate the advantages of FEM. (4)
- 22. a) Derive the stiffness matrix[k] for 1D-Beam element (14)

(OR)

b) For the two-bar truss shown in fig 2, determine the nodal displacements, element stresses and support reactions. A force of $P = 1000 \text{ kN}$ is applied at node-1. Assume $E=210\text{GPa}$ and $A= 600\text{mm}^2$ for each element. (14)

23. a) Derive the shape function for constant strain triangular element (CST) (14)

(OR)

b) For the plane element shown in fig 3.the nodal displacements are:

$$u = 2.0\text{mm}; \quad v = 1.0 \text{ mm};$$

$$u=0.5 \text{ mm}; \quad v = 0.0 \text{ mm};$$

$$u= 3.0 \text{ mm}; \quad v = 1.0 \text{ mm};$$

Determine the element stresses $\sigma_x, \sigma_y, \tau_{xy}, \sigma_1$ and σ_2 and the principal angle θ_p . Let $E = 210 \text{ GPa}, \nu = 0.25$ and $t = 10 \text{ mm}$. All co-ordinates are in millimeters. (14)

24. a) (i) Derive the strain displacement matrix [B]for Axisymmetric Triangular Element (12)

(ii) Evaluate the integral by using Gaussian quadrature $\int_{-1}^1 x^2 dx$. (4)

(OR)

b) (i) Use gauss quadrature rule ($n = 2$) to numerically integrate $\int_{-1}^1 \int_{-1}^1 xy \, dx \, dy$. (7)

(ii) Evaluate [J] at $\xi = \eta = 1/2$ for the linear quadrilateral element shown in fig 4. (7)

25. a) Derive stiffness matrix and Equations of a Basic Rectangular Plate Bending Element

(OR)

b) A composite wall consists of three materials as shown in fig 5, the outer temperature is $T_o = 20^\circ\text{C}$. convection heat transfer takes place on the inner surface of the wall with $T_\infty = 800^\circ\text{C}$ and $h = 25 \text{ W / m}^2 \cdot ^\circ\text{C}$. Determine the temperature distribution in the wall.
