KINGS
COLLEGE OF ENGINEERING

ME 1401 INTRODUCTION OF FINITE ELEMENT ANALYSIS – QUESTION BANK

PART-A

UNIT I Introduction

1. What is meant by finite element analysis?
2. Name any four applications of FEA.
3. What is the concept of matrix algebra and in what way it is used in FEA?
4. Briefly explain Gaussion elimination method.
5. Why polynomial type interpolation functions are preferred over trigonometric functions?
6. What is meant by ‘descretization’?
7. List out the various weighted-residual methods.
8. Define the concept of potential energy
9. List out any four advantages of using FEA.
10. What is the need for FEA?
11. List out FEM software packages
12. Name the different modules of FEM and their function

UNIT II One dimensional problems

13. List out the properties of stiffness matrix
14. What are the different coordinate systems used in FEM?
15. Define a simplex, complex and multiplex element
16. What are shape functions and what are their properties?
17. Define ‘Natural coordinate system’
18. What are the advantages of natural coordinate system?
19. What are 1-Dimensional scalar and vector variable problems?
20. What types of problems are treated as one-dimensional problems?
21. Write down the expressions for shape functions of 1-D bar element.
22. Define aspect ratio. State its significance.
23. Write down the expressions for the element stiffness matrix of a beam element
24. What is a higher order element? Give an example

UNIT III Two dimensional continuum

25. Write down the shape functions for a ‘Rectangular element.
26. State a two dimensional scalar variable problem with an example.
27. What is meant by a CST element? State its properties.
28. In what way a bilinear element is different from simplex and complex element?
29. Define ‘Plane stress’ and ‘Plane strain’ with suitable example
30. Differentiate between a CST and LST element
31. What are the differences between use of linear triangular element and bilinear rectangular element?
32. What is meant by a two dimensional vector variable problem?
33. Write down the expression for the stress-strain relationship matrix for a 2-D system.
34. State the expression for stiffness matrix for a bar element subjected to torsion
35. Write down the finite element equation for one-dimensional heat conduction
36. Specify the various elasticity equations.

UNIT IV Axisymmetric continuum

37. What are the ways by which a 3-dimensional problem can be reduced to a 2-D problem?
38. What is meant by axisymmetric solid?
39. Write down the expression for shape functions for a axisymmetric triangular element
40. State the conditions to be satisfied in order to use axisymmetric elements
41. State the expression used for ‘gradient matrix’ for axisymmetric triangular element
42. State the constitutive law for axisymmetric problems.
43. Sketch ring shaped axisymmetric solid formed by a triangular and quadrilateral element
44. Write down the expression for stiffness matrix for an axisymmetric triangular element
45. Distinguish between plane stress, plane strain and axisymmetric analysis in solid mechanics
46. Sketch an one-dimensional axisymmetric (shell) element and two-dimensional axisymmetric element.

UNIT V Isoparametric elements for two dimensional continuum

47. What is an ‘Iso-parametric element’?
48. Differentiate between Isoparametric, super parametric and sub parametric elements.
49. Write down the shape functions for 4-noded linear quadrilateral element using natural coordinate system.
50. What is a ‘Jacobian transformation’?
51. What are the advantages of ‘Gaussian quadrature’ numerical integration for isoparametric elements??
52. How do you calculate the number of Gaussian points in Gaussian quadrature method?
53. Find out the number Gaussian points to be considered for $\int (x^4+3x^3-x)\,dx$
54. What is the Jacobian transformation fro a two nodded isoparametric element?
55. What is meant by isoparametric formulation?
56. Sketch an general quadrilateral element and an isoparametric quadrilateral element.
57. How do you convert Cartesian coordinates into natural coordinates?
58. Write down the expression for strain-displacement for a four-noded quadrilateral element using natural coordinates.

PART – B

UNIT I

1. A simply supported beam is subjected to uniformly distributed load over entire span. Determine the bending moment and deflection at the mid span using Rayleigh-Ritz method and compare with exact solution. Use a two term trial function $y = a_1\sin(\pi x/l) + a_2\sin(3\pi x/l)$

2. A beam AB of span 'l' simply supported at the ends and carrying a concentrated load 'W' at the centre 'C' as shown in figure 1.2. Determine the deflection at the mid span by using Rayleigh-Ritz method and compare with exact solution. Use a suitable one term trigonometric trial function.

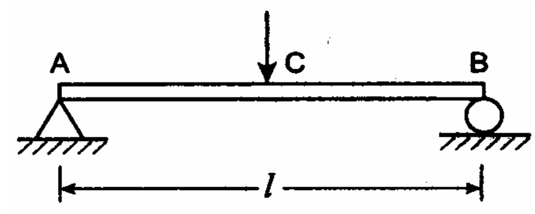

figure 1.2

3. A simply supported beam is subjected to uniformly distributed load over entire span and it is subjected to a point load at the centre of the span. Calculate the bending moment and deflection at the mid span using Rayleigh-Ritz method and compare with exact solution.

4. The following differential equation is available for a physical phenomenon.
   $d^2y/dx^2 + 50 = 0, \; 0<x<10$
   The trial function is, $y=ax(10-x)$
   The boundary conditions are $y(0)=0$ and $y(10)=0$
   Find the value of the parameter 'a' by (i) Point collocation method (ii) Sub-domain collocation method (iii) Least squares method (iv) Galerkin's method

5. Write short notes on (i) Gaussian elimination (ii) Galerkin's method

6. Explain the process of discretization in detail.

7. A cantilever beam of length 'L' is loaded with a point load at the free end. Find the maximum deflection and maximum bending moment using Rayleigh-Ritz method using the function $y=a\{1-\cos(\pi x/2L)\}$.Given EI is constant.

UNIT II

1. i) Derive the shape functions for a 2-D beam element
   ii) Derive the stiffness matrix of a 2-D truss element

2. Derive the shape functions for a 2 noded beam element and a 3 noded bar element

3. Derive the stiffness matrix of a 3 noded bar element using the principle of potential energy

4. Calculate the nodal displacements and forces for the bar loaded as shown in figure 2.4

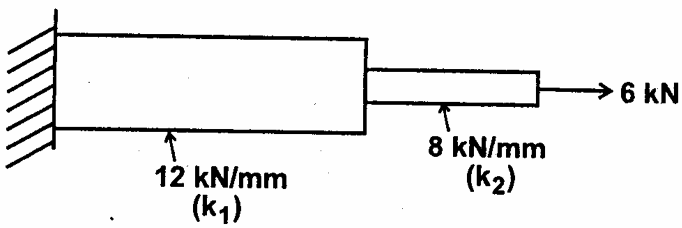

figure 2.4

5. A stepped bar is subjected to an axial load of 200 KN at the place of change of cross section and material as shown in figure 2.5. Find (a) The nodal displacements (b) the reaction forces (c) the induced stresses in each material

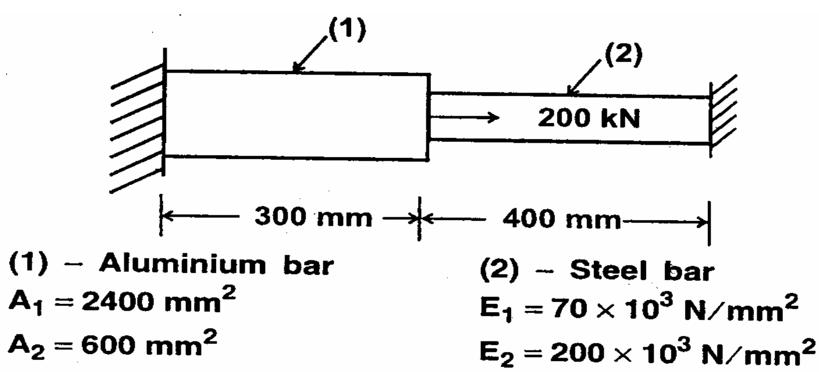

figure 2.5

6. For a tapered bar of uniform thickness t=10mm as shown in figure 2.6. find the displacements at the nodes by forming into two element model. The bar has a mass density ρ = 7800 Kg/M³, the young's modulus E = 2x10⁵ MN/m² . In addition to self weight, the bar is subjected to a point load P= 1 KN at its centre. Also determine the reaction forces at the support.

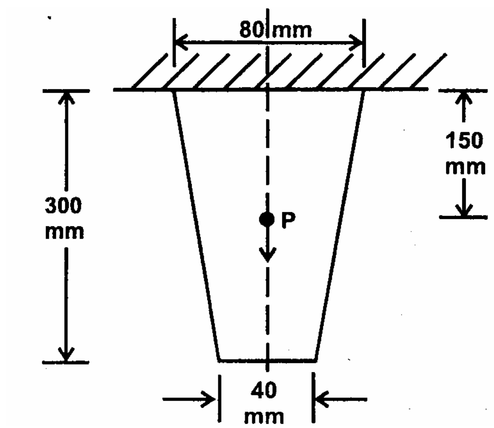

figure 2.6

7. Consider a 4-bar truss as shown in figure 2.7. It is given that E = 200 GPa and A= 500 mm² for all the elements. Determine (a) Nodal displacements (b) Support reactions (c) Element stresses.

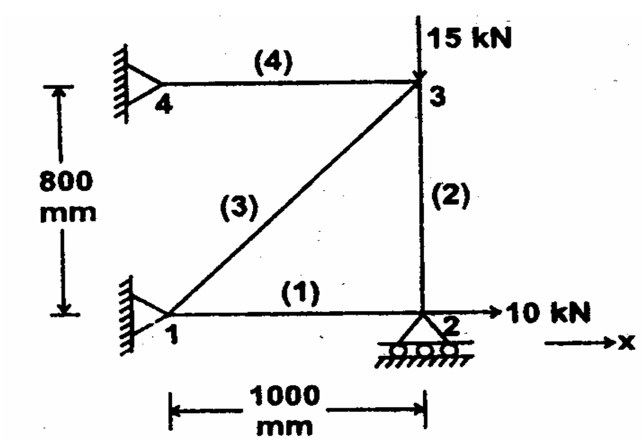

figure 2.7

UNIT III

1. Find the temperature at a point P(1,1.5) inside a triangular element shown with nodal temperatures given as T_i= 40°C, T_j= 34°C and T_k= 46°C. Also determine the location of the 42°C contour line for the triangular element shown in figure 3.1.

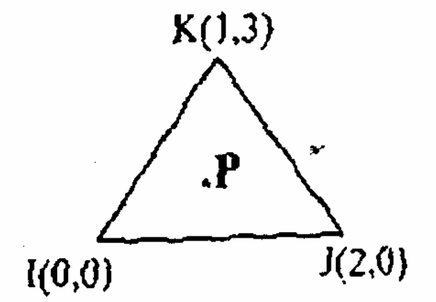

figure 3.1

2. Calculate the element stiffness matrix and thermal force vector for the plane stress element shown in figure 3.2. The element experiences a rise of 10°C.

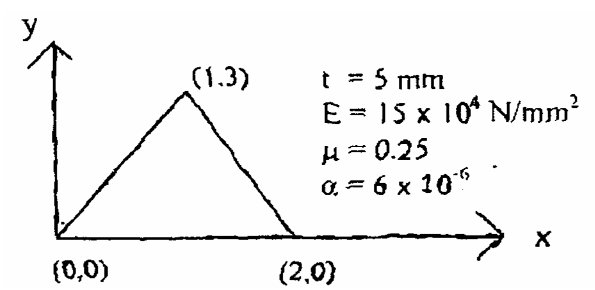

figure 3.2

3. Derive the stiffness matrix and equations for a CST element.

4. Derive the stiffness matrix and equations for a LST element

5. Derive the shape functions for a bilinear rectangular element .

6. For a 4-noded rectangular element shown in figure 3.6. Determine the temperature at the point (7,4). The nodal values of the temperatures are T_1= 42°C, T_2= 54°C and T_3= 56°C and T_4= 46°C. Also determine the three points on the 50°C contour line.

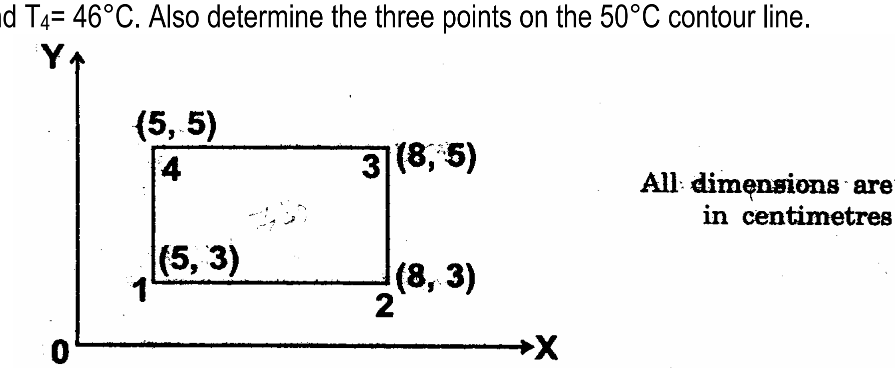

figure 3.6

7. For the plane stress element shown in figure 3.7. Evaluate the stiffness matrix. Assume E = 210 X 10^3 N/mm^2 , poisson's ratio μ=0.25 and element thickness t=10mm. The coordinates are given in millimeters.

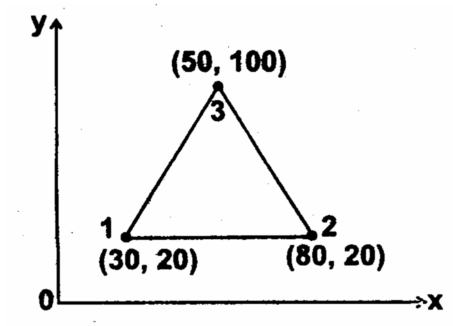

figure 3.7

UNIT IV

1. Derive the shape functions for an axisymmetric triangular element

2. Derive an expression for the strain-displacement matrix for an axisymmetric triangular element

3. For the axisymmetric element shown in figure 4.3, determine the stiffness matrix. Let E = 2.1X10^5 MN/m^2 and μ=0.25. The coordinates are in mm.

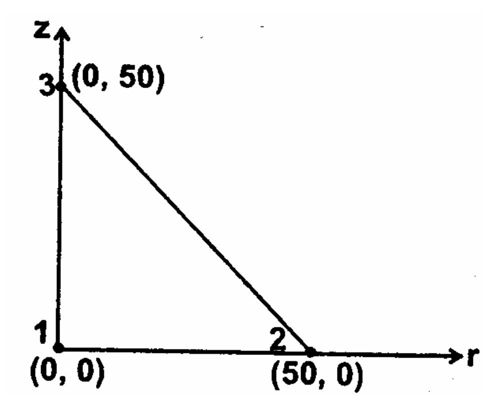

figure 4.3

4. Determine the element strains for an axisymmetric triangular element shown in figure 4.4. The nodal displacements are u_1= 0.001, u_2= 0.002, u_3= - 0.003, w_1= 0.002, w_2= 0.001, w_3= 0.004. All dimensions are in cm.

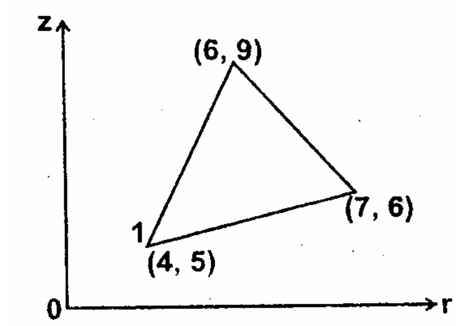

figure 4.4

5. The nodal coordinates for an axisymmetric triangular element at its three nodes are (r_1 , z_1) = (30,10), (r_2 , z_2) = (50,10), (r_3 , z_3) = (40,60). Determine the strain displacement matrix for that element.

6. A long hollow cylinder of inside dia 80 mm and outside dia 120 mm is subjected to an internal pressure of 40 bar as shown in figure 4.6. By using two elements pn the 20 mm length, calculate the displacements at the inner radius.

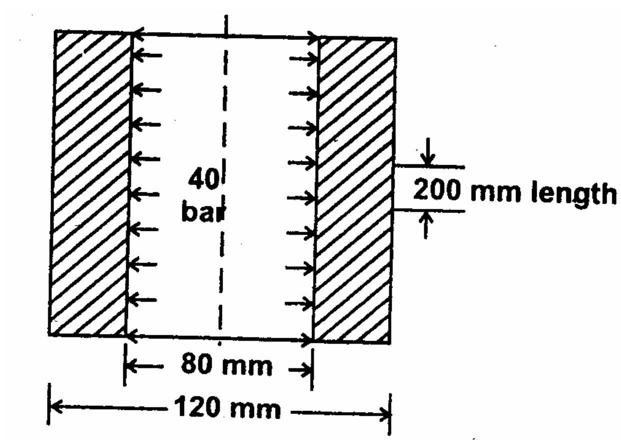

figure 4.6

7. Derive the expression for the stiffness matrix for an axisymmetric shell element

UNIT V

1. Integrate $f(x) = 10 + 20x – (3x^2/10) + (4x^3/100) – (-5x^4/1000) + (6x^5/10000)$ between 8 and 12. Use Gaussian quadrature rule.

2. Derive the stiffness matrix for a linear isoparametric element.

3. Establish the strain displacement matrix for the linear quadrilateral element as shown in figure 5.3. at Gauss point r= 0.57735 and s= -0.57735

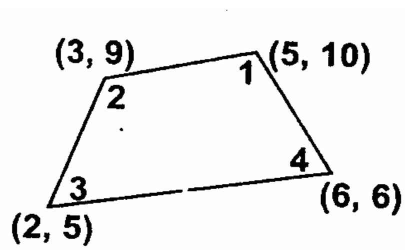

figure 5.3

4. Write short notes on (a) Uniqueness of mapping of isoparametric elements. (b) Jacobian matrix (c) Gaussian quadrature integration technique

5. (a) Use Gaussian quadrature rule (n=2) to numerically integrate $\int_{-1}^{1}\int_{-1}^{1} xy\, dx\, dy$

   (b) Using natural coordinates derive the shape function for a linear quadrilateral element

6. Evaluate the integral $I = \int_{-1}^{1} (3e^x + x^2 + 1/(x+2))\, dx$ using one point and two point Gauss-quadrature. Compare this with exact solution.