VALLIAMMAI ENGINEERING COLLEGE
DEPARTMENT OF MECHANICAL ENGINEERING
QUESTION BANK

SUBJECT CODE & NAME: ME6603 FINITE ELEMENT ANALYSIS
YEAR:3rd YEAR

UNIT I INTRODUCTION

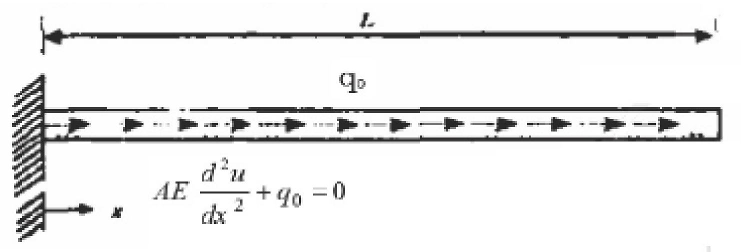
PART-A

1. Distinguish between Error and Residual.	BT2
2. Discuss the finite element method work.	BT2
3. List any four advantages of finite element method.	BT1
4. List out the types of nodes.	BT1
5. List any four advantages of weak formulation?	BT1
6. Compare the Ritz technique with the nodal approximation method.	BT4
7. How to develop the equilibrium equation for a finite element?	BT6
8. Classify boundary conditions	BT3
9. List the various method of solving boundary value problems.	BT1
10. Formulate the boundary conditions of a cantilever beam AB of span L fixed at A and free at B subjected to a uniformly distributed load of P throughout the span.	BT6
11. Name the weighted residual methods.	BT1
12. How will you identify types of Eigen Value Problems?	BT1
13. Explain weak formulation of FEA	BT4
14. Why are polynomial types of interpolation function recommended over trigonometric function?	BT5
15. What should be considered during piecewise trial function?	BT5
16. How will you develop total potential energy of a structural system?	BT6
17. Explain the principle of minimum potential energy.	BT4
18. Differentiate between initial value problem and boundary value problem?	BT2
19. List out the advantages of finite element method over other numerical analysis method.	BT1
20. Define node or joint.	BT1

PART-B

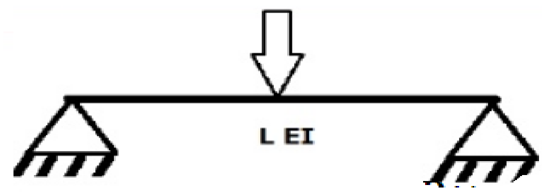
1. Explain the step by step procedure of FEA. (BT 4)
2. Explain the process of discretization of a structure in finite element method in detail, with suitable illustration for each aspect being and discussed. (BT 3)

3. A uniform rod subjected to a uniform axial load is illustrated in figure, the deformation of the bar is governed by the differential equation given below. Determine the displacement by applying Weighted Residual Method (WRM) (BT3)



with the boundary conditions $u(0) = 0, \left.\frac{du}{dx}\right|_{x=L} = 0$

4. Find the approximate deflection of a simply supported beam under a uniformly distributed load 'P' throughout its span. By applying Galerking and Least Square Residual Method (BT3)
5. Solve the differential equation for a physical problem expressed as $d^2y/dx^2 + 100 = 0$, $0 \leq x \leq 10$ with boundary conditions as y(0)=0 and y(10)=0 using (i) Point collocation method (ii) Sub domain collocation method (iii) Least square method and (iv) Galerkin method (BT3)
6. Develop the characteristic equations for the one dimensional bar element by using piece-wise defined interpolations and weak form of the weighted residual method? (BT6)
7. A simple supported beam subjected to uniformly distributed load over entire span and it is subjected to a point load at the centre of the span. Calculate the deflection using Rayleigh-Ritz method and compare with exact solutions. (BT3)
8. Calculate the value of central deflection in the figure below by assuming $Y = a \sin \pi x/L$ the beam is uniform throughout and carries and central point load P.(BT3)



9. Determine the expression for deflection and bending moment in a simply supported beam subjected to uniformly distributed load over entire span. Find the deflection and moment at mid span and compare with exact solution Rayleigh-Ritz method. Use

$$y = a_1 \sin\left(\frac{\pi x}{l}\right) + a_2 \sin\left(\frac{3\pi x}{l}\right)$$

(BT5)

10. A simply supported beam carries uniformly distributed load over the entire span. Calculate the bending moment and deflection. Assume EI is constant and compare the results with other solution. (BT5)

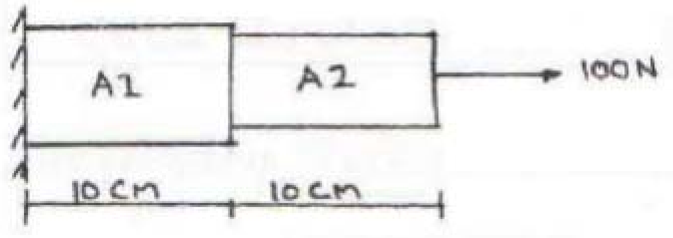
UNIT II ONE-DIMENSIONAL PROBLEMS

PART-A

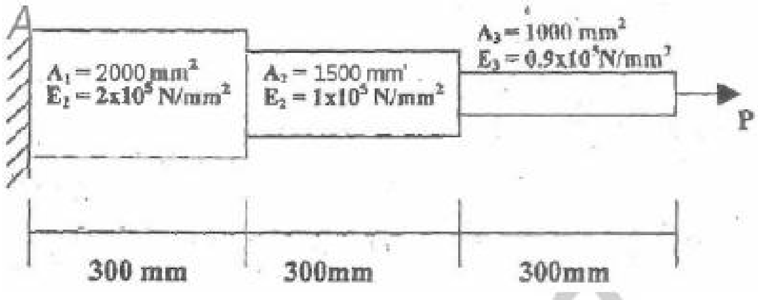
1. What are the types of problems consider as one dimensional problem?	BT5
2. Define shape function.	BT1
3. illustrate shape function of a two node line element	BT3
4. List out the stiffness matrix properties.	BT1
5. Describe the characteristics of shape functions	BT2
6. Differential global and local coordinate.	BT2
7. Express the element stiffness matrix of a truss element	BT2
8. illustrate a typical truss element shown local global transformation	BT3
9. Define natural coordinate system	BT1
10. List the types of dynamic analysis problems	BT1
11. Define Lumped mass matrix?	BT1
12. Define mode superposition technique?	BT1
13. Formulate the lumped mass matrix for the truss element.	BT6
14. Assess the accuracy of the values of natural frequencies obtained by using lumped mass matrices and consistent mass matrices.	BT5
15. Determine the element mass matrix for one-dimensional dynamic structural analysis problems. Assume the two-node, linear element.	BT4
16. Write down the Governing equation and for 1D longitudinal vibration of a bar fixed at one end and create the boundary conditions	BT6
17. Explain the transverse vibration?	BT4
18. Compare primary nodes and secondary nodes?	BT4
19. Show that the global stiffness matrix is differed from element stiffness matrix?	BT3
20. Classify some of the structural problems.	BT3

PART-B

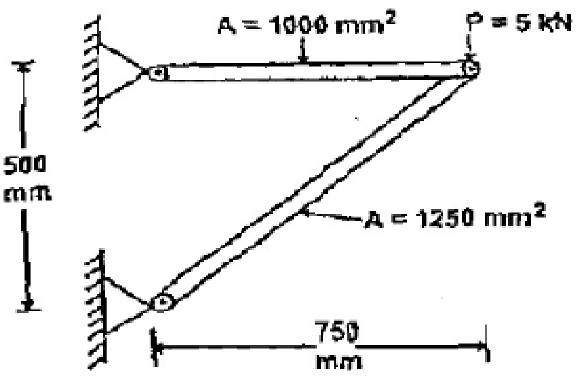
1. Develop the Shape function, Stiffness matrix and force vector for one dimensional linear element. (BT6)
2. Consider a bar as shown in fig. Young's Modulus E= 2 x 10^5 N/mm^2. A_1 = 2cm^2, A_2 = 1cm^2 and force of 100N. Calculate the nodal displacement (BT3)



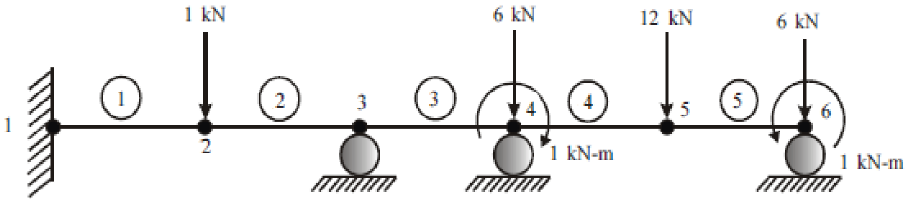
3. Consider the bar shown in figure axial force P = 30KN is applied as shown. Determine the nodal displacement, stresses in each element and reaction forces.(BT5)



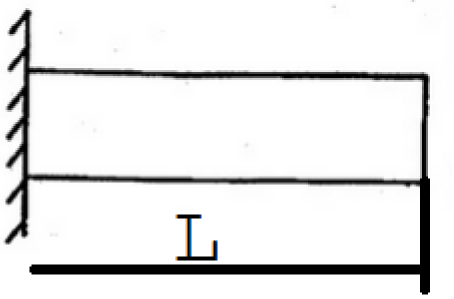
4. Axial load of 500N is applied to a stepped shaft, at the interface of two bars. The ends are fixed. Calculate the nodal displacement and stress when the element is subjected to all in temperature of 100˚C. Take E_1 = 30 x10^3 N/mm^2&E_2 = 200 x 10^3 N/mm^2, A_1=900 mm^2 & A_2 = 1200mm^2, α_1 = 23x10-6 /˚C & α_2 = 11.7x10-6/˚C, L_1=200mm & L_2 =300mm. (BT3)
5. The loading and other parameters for a two bar truss element is shown in figure. Calculate (i) The element stiffness matrix for each element (ii) Global stiffness matrix (iii) Nodal displacements (iv) Reaction force (v) The stresses induced in the elements. Assume E=200GPa. (BT3)



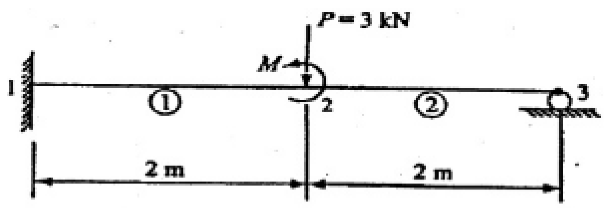
6. Figure shown a typical continuous beam. We wish to obtain the deflection of the beam using the beam element just described. For simplicity we assume EI=1 (BT1)



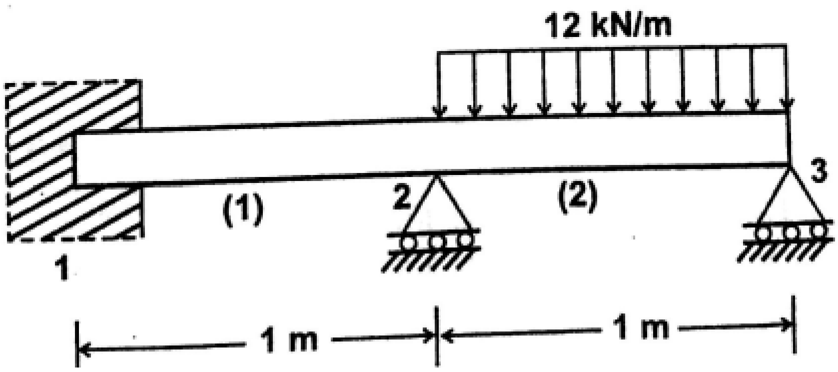
7. Find the natural frequencies of transverse vibrations of the cantilever beam shown in figure by applying one 1D beam element (BT3)



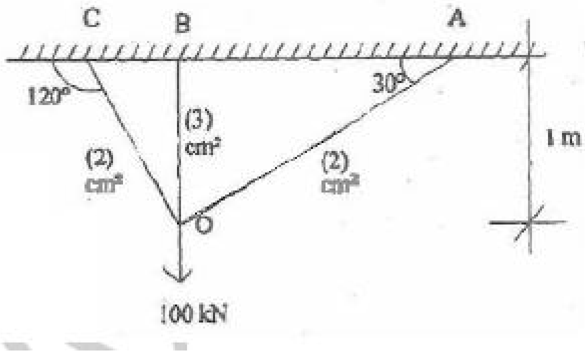
8. Calculate the displacements and slopes at the nodes for the beam shown in figure. Find the moment at the midpoint of element 1 (BT3)



9. For the beam and loading as shown in figure. Calculate the slopes at nodes 2 and 3 and the vertical deflection at the mid-point of the distributed load. Take E=200 GPa and $I=4\times10^{-6}$ m^4 (BT3)



10. Calculate the force in the members of the truss as shown in fig. Take E=200 GPa. (BT3)


C
B
A
120°
30°
(3)
cm²
(2)
cm²
(2)
cm²
1 m
O
100 kN

UNIT III TWO DIMENSIONAL SCALAR VARIABLE PROBLEMS

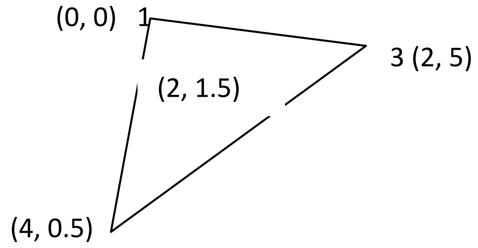
PART-A

1. Define two-dimensional scalar variable problem. BT1
2. How will you modify a three-dimensional problem to a Tow-dimensional problem? BT6
3. List out the application of two-dimensional problems. BT1
4. Express the shape functions associated with the tree noded linear triangular element and plot the variation of the same. BT2
5. Why a CST element so called? BT4
6. How do you define two dimensional elements? BT1
7. Explain QST (Quadratic strain Triangle) element? BT4
8. With suitable examples and the governing equation distinguish between vector and scalar variable problems. BT2
9. Formulate the (B) matrix for CST element. BT6
10. Express the interpolation function of a field variable for three-node triangular element BT2
11. List out the CST and LST elements. BT1
12. illustrate the shape function of a CST element. BT3
13. Define LST element. BT1
14. Express the nodal displacement equation for a two dimensional triangular elasticity element BT2
15. Show the transformation for mapping x-coordinate system into a natural coordinate system for a linear spar element and for a quadratic spar element. BT3
16. What do you understand by area coordinates? BT2
17. Define Isoperimetric elements with suitable examples BT1
18. Explain shape function of four node quadrilateral elements. BT4
19. Explain geometric Isotropy. BT5
20. Write the Lagrange shape functions for a 1D, 2noded elements. BT5

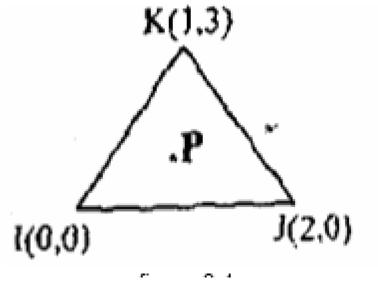
PART-B

1. Develop the element strain displacement matrix and element stiffness matrix of a CST element (BT6)
2. Determine the shape functions for a constant strain triangular (CST) element. (BT3)
3. The (x, y) coordinate of nodes i, j, and k of triangular elements are given by (0, 0), (3, 0) and (1.5, 4) mm respectively. Evaluate the shape functions N_1, N_2 and N_3 at an interior point P (2, 2.5) mm for the element. For the same triangular element, obtain the strain-displacement relation matrix B. (BT5)
4. Calculate the value of pressure at the point A which is inside the 3 noded triangular element as shown in fig. The nodal values are Φ_1 = 40 MPa, Φ_2 = 34 MPa and

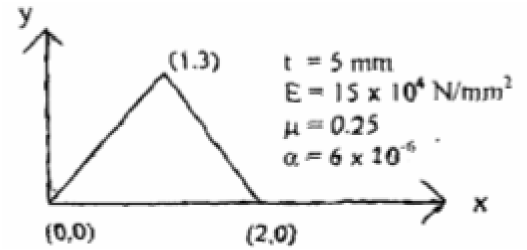
Φ_3 = 46 MPa. point A is located at (2, 1.5). Assume the pressure is linearly varying in the element. Also determine the location of 42 MPa contour line. (BT3)



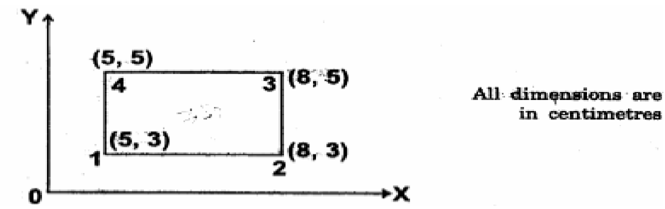
5. Find the temperature at point (1, 1.5) inside a triangular element shown with nodal temperature given as T_i = 40˚C, T_j = 34˚C and T_k = 46˚C. Also Calculate the location of the 42˚C contour line for triangular element shown in fig. (BT3)



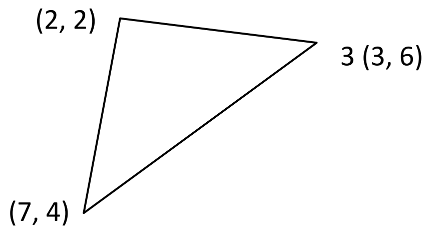
6. Calculate the element stiffness matrix and thermal force vector for the plane stress element shown in fig. The element experiences a rise of 10˚C (BT3)



7. For a 4-noded rectangular element shown in fig. Calculate the temperature point (7, 4). The nodal values of the temperatures are T_1 = 42˚C, T_2 = 54˚C and T_3 = 56˚C and T4 = 46˚C. Also determine 3 point on the 50˚C contour line. (BT3)



8. A 3 noded triangular element as shown in fig Calculate the temperature at the point P (4, 3), given that the temperatures at nodes 1, 2 and 3 are 75˚C, 90˚C and 60˚C respectively. (BT3)



9. Develop the shape function derivation for a two-dimensional quadratic element. (BT6)
10. Evaluate the partial derivatives of the shape function at $\zeta = 1/2$, $\eta = ½$ of a quadrilateral element, assuming that the temperature is approximated by bilinear. (BT5)

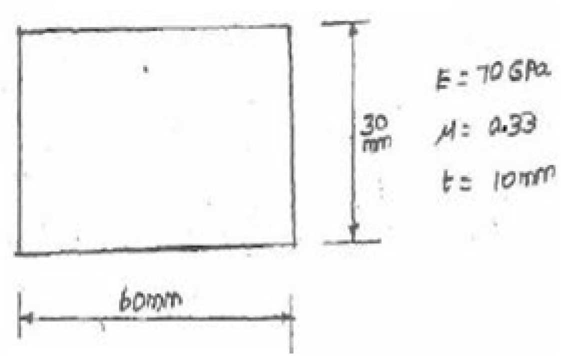
UNIT IV TWO DIMENSIONAL VECTOR VARIABLE PROBLEMS

PART-A

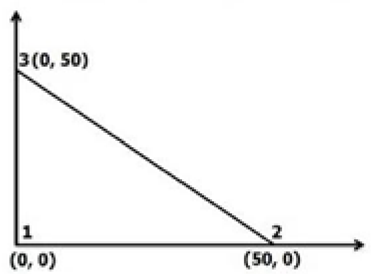
1. Define 2D vector variable problems?	BT1
2. What problems are considered as 2D vector variable problems?	BT5
3. List out the various elasticity equations.	BT1
4. Define plane stress and plane strain.	BT1
5. Discuss 'Principal stresses".	BT2
6. Discuss the difference between the use of linear triangular elements and bilinear rectangular elements for a 2D domain.	BT2
7. Define axisymmetric solid?	BT1
8. Distinguish between plane stress, plane strain and axisymmetric analysis in solid mechanics.	BT2
9. Specify the machine component related with axisymmetric concept.	BT3
10. Discuss axisymmetric formulation.	BT2
11. Develop the Shape functions for axisymmetric triangular elements	BT6
12. Explain about finite element modeling for axisymmetric solid.	BT4
13. Develop the Strain-Displacement matrix for axisymmetric solid	BT6
14. Write down Stress-Strain displacement matrix for axisymmetric solid	BT3
15. Write down Stiffness matrix for axisymmetric solid	BT3
16. Explain plane stress conditions.	BT5
17. Explain constitutive relationship for the plane stress problems.	BT4
18. State whether plane stress or plane strain elements can be used to model the following structures. Explain your answer. a. A wall subjected to wind load b. A wrench subjected to a force in the plane of the wrench.	BT4
19. Define a plane strain with suitable example.	BT1
20. Define a plane stress problem with a suitable example.	BT1

PART-B

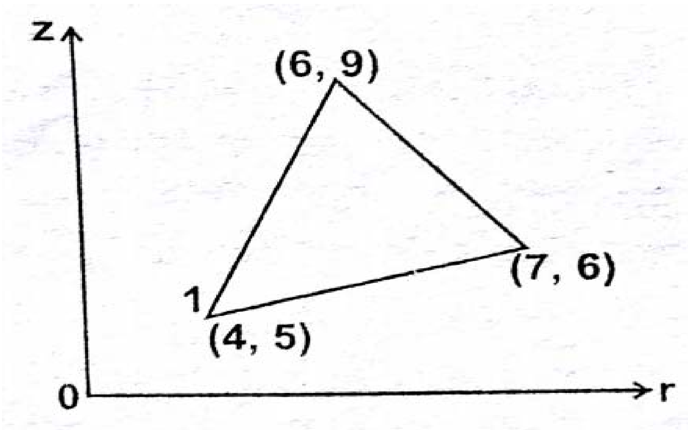
1. Develop elasticity equation for 2D element (BT6)
2. Develop shape function for axisymmetric triangular elements (BT6)
3. Develop Stress-Strain relationship matrix for axisymmetric triangular element (BT6)
4. Develop Strain-Displacement matrix for axisymmetric triangular element (BT6)
5. Calculate the global stiffness matrix for the plate shown in fig. Taking two triangular elements. Assume plane stress conditions (BT3)



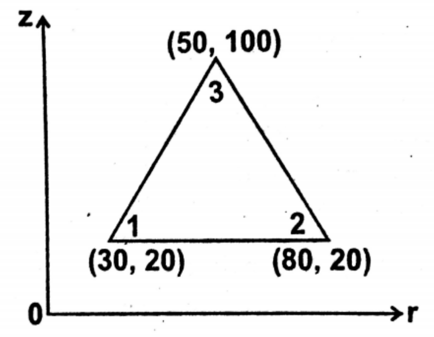
6. Calculate the stiffness matrix for the axisymmetric element shown in fig E= 2.1 x 10^6 N/mm^2 and Poisson's ratio as 0.3 (BT3)



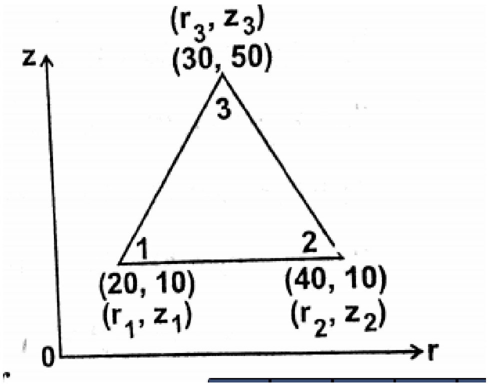
7. Calculate the element strains for an axisymmetric triangular element shown in fig the nodal displacement are. u_1= 0.001, u_2 = 0.002, u_3 = -0.003, w_1 = 0.002, w_2 = 0.001 and w_3 = 0.004 all dimensions are in mm. (BT3)



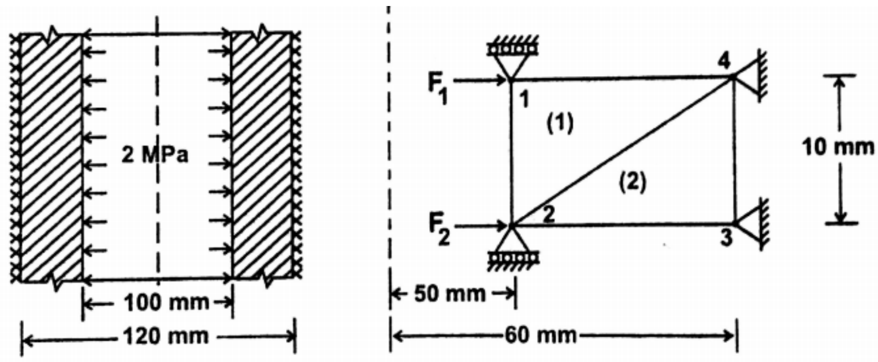
8. For an axisymmetric triangular elements as shown in fig. Evaluate the stiffness matrix. Take modulus of elasticity E = 210 GPa. Poisson's ratio = 0.25. the coordinates are given in millimetres. (BT5)



9. The nodal coordinates for an axisymmetric triangular element shown in fig are given below. Calculate the strain-displacement matrix for that element (BT3)



10. A long hollow cylinder of inside diameter 100mm and outside diameter 120mm is firmly fitted in a hole of another rigid cylinder over its full length as shown in fig. The cylinder is then subjected to an internal pressure of 2 MPa. By using two element on the 10mm length shown calculate the displacements at the inner radius tame E = 210 GPa. μ = 0.3 (BT3)



UNIT V ISOPARAMETRIC FORMULATION

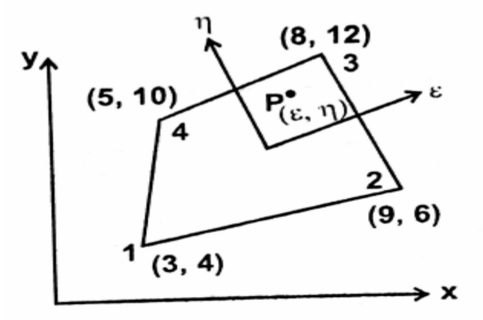
PART-A

1. Define Isoparametric element?	BT1
2. Differentiate between Isoparametric, super parametric and sub-parametric elements.	BT4
3. Define Isoparametric formulation?	BT1
4. Explain the Jacobian transformation?	BT5
5. Give the shape functions for a four-noded linear quadrilateral element in natural coordinates.	BT2
6. Describe the Jacobian of transformation for two-noded Isoparametric element.	BT2
7. List out the advantages of Gauss quadrature numerical integration for Isoparametric element?	BT1
8. Discuss about higher order element.	BT2
9. Discuss about Numerical integration	BT2
10. Discuss about Gauss-quadrature method.	BT2
11. Differentiate between implicitly and explicitly methods of numerical integration	BT4
12. Differentiate between geometric and material non-linearity.	BT4
13. List out the significance of Jacobian transformation?	BT1
14. Define Isoparametric element with suitable examples.	BT1
15. Develop Stress- displacement matrix for Four noded quadrilateral element using natural coordinates.	BT6
16 Develop Stiffness matrix for Isoparametric quadrilateral element	BT6
17. Define Newton cotes quadrature method	BT1
18. Distinguish between trapezoidal rule and Simpson's rule	BT2
19. Distinguish between trapezoidal rule and Gauss quadrature.	BT2
20.Explain the transformation for mapping x-coordinate system into a natural coordinate system for a linear spar element and for a quadratic spar element.	BT5

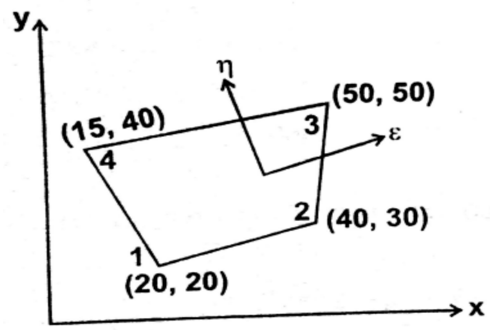
PART-B

1. Develop the shape functions for a four-noded Isoparametric quadrilateral element. (BT6)
2. Develop Strain-Displacement matrix, Stress-Strain relationship matrix and Stiffness matrix for Isoparametric quadrilateral element(BT6)

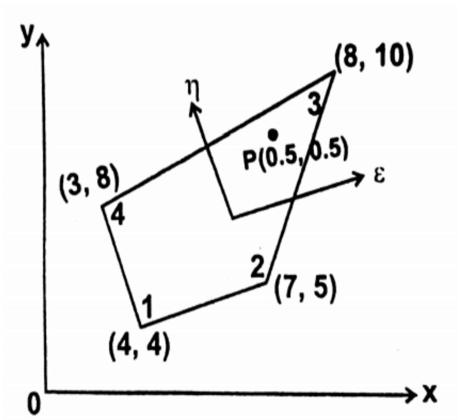
3. Calculate the Cartesian coordinates of the point P which has local coordinates ε = 0.8 and η = 0.6 as shown in figure (BT3)



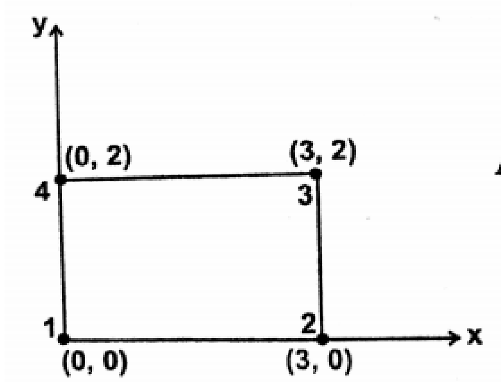
4. For the four noded quadrilateral element shown in fig determine the Jacobian and evaluate its value at the point (1/2, ½) (BT5)



5. Evaluate the Jacobian matrix at the local coordinates ε=η= 0.5 for the linear quadrilateral element with its global coordinates as shown in fig. Also evaluate the strain-displacement matrix. (BT5)



6. For a four noded rectangular element shown in fig Calculate the following
   a. Jacobian matrix b. Strain-Displacement matrix c. Element strain and d. Element stress. (BT3)



7. Find the integral I= $\int_{-1}^{1}(2x^3 + 5x^2 + 6)dx$ using Gaussian quadrature method with 2 point scheme. The Gauss points are ±0.5774 and the weight at the two points are equal to unity. (BT3)
8. Evaluate the integral $\int_{-1}^{1}(x^4 + 3x^3 - x)dx$ (BT5)
9. Evaluate the integral I= $\int_{-1}^{1}(a1 + a2x + a3x^{32} + a4^3)dx$ using three point Gauss integration. (BT5)
10. For the element shown in fig. Calculate the Jacobian matrix. (BT3)