SRM VALLIAMMAI ENGINEERING COLLEGE

(An Autonomous Institution)
SRM Nagar, Kattankulathur– 603203

DEPARTMENTOF MECHANICAL ENGINEERING

QUESTION BANK

VI SEMESTER

1909603 Finite Element Analysis

Academic Year 2024 – 25

Prepared by

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SRM VALLIAMMAI ENGINEERING COLLEGE

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UNIT I : INTRODUCTION

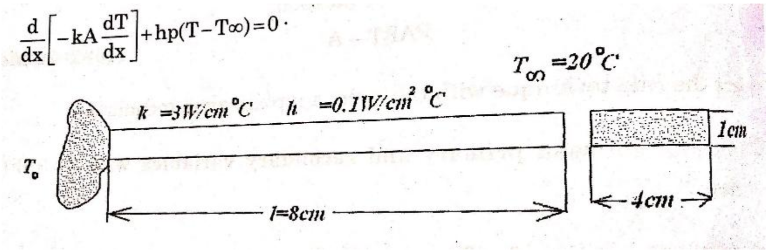
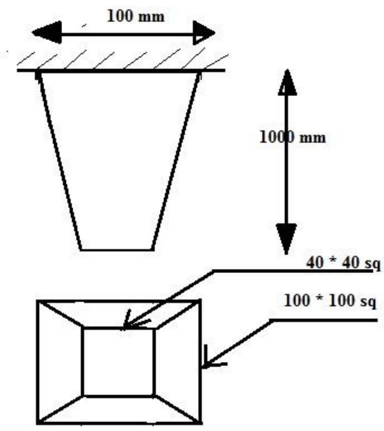
Historical Background – Mathematical Modeling of field problems in Engineering – Governing Equations – Discrete and continuous models – Boundary, Initial and Eigen Value problems– Weighted Residual Methods – Variational Formulation of Boundary Value Problems – Ritz Technique – Basic concepts of the Finite Element Method.

PART A (2 Marks)

1	Distinguish one dimensional bar element and beam element.	BT1	Remembering
2.	What do you mean by boundary value problem?	BT1	Remembering
3	What do you mean by weak formulation? State its advantages.	BT2	Understanding
4	Why are polynomial types of interpolation functions preferred over trianonometric functions?	BT2	Understanding
5	What do you mean by elements and nodes?	BT1	Remembering
6	What is Ritz method?	BT4	Analyzing
7	Distinguish Natural and Essential boundary condition.	BT6	Creating
8	Compare Ritz method with nodal approximation method.	BT2	Understanding
9	State the discretization error. How it can be reduced?	BT1	Remembering
10	What are the various considerations to be taken in discretization process?	BT1	Remembering
11	State the principle of minimum potential energy.	BT2	Understanding
12	Distinguish between classical methods and FEM.	BT1	Remembering
13	Distinguish between FDM and FEM.	BT4	Analyzing
14	What is meant by node or joint?	BT2	Understanding
15	What are the two types of nodes?	BT1	Remembering
16	State the methods of engineering analysis.	BT4	Analyzing
17	Name the variation methods.	BT2	Understanding
18	Name the weighted residual method.	BT4	Analyzing
19	State the principle of minimum potential or Principle of total stationary potential.	BT1	Remembering

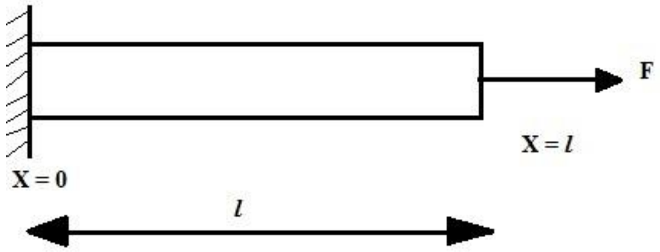
20	Name any four FEA software.	BT2	Understanding
21	Differentiate boundary value problem and initial value problem.	BT2	Understanding
22	Define strain energy.	BT4	Analyzing
23	Define potential energy.	BT2	Understanding
24	What do you mean by Numerical methods?	BT2	Understanding
25	Define FEA.	BT4	Analyzing

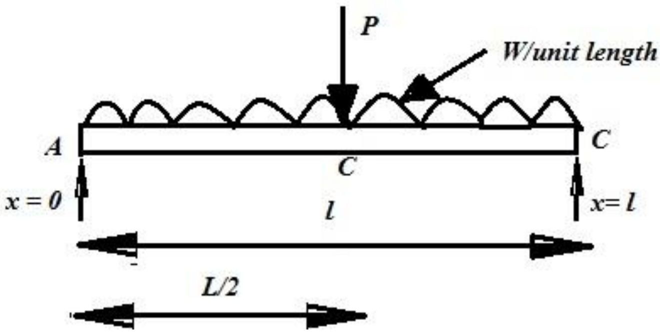
PART B (13 MARKS)			
1	i. Explain the various methods of engineering analysis with suitable illustrations. **(8)**	BT1	Remembering
	ii. Describe the principle of stationary total potential energy. **(5)**	BT1	Remembering
2	Using collocation method, find the solution of given governing equation $\frac{d^2\Phi}{dX^2} + \Phi + X = 0, 0 \leq X \leq 1$ subject to the boundary conditions $\Phi(0) = \Phi(1) = 0$. Use X=$1/4$ and $1/2$ as the collocation points.	BT5	Evaluating
3	Explain the step by step procedure of FEA.	BT1	Remembering
4	Find the Eigen value and Eigen function of $y'' - 4\lambda y' + 4\lambda^2 y = 0$; with the boundary conditions are $y(0) = 0,\ y(1) + \ y'(1) = 0$.	BT5	Evaluating
5	The following differential equation is available for a physical phenomenon AE$\frac{d^2y}{dx^2} + q_o = 0$ with boundary conditions $\frac{dy}{dx}\Big\vert \begin{matrix} y(0) = 0 \\ x(l) = 0 \end{matrix}$. Find the value of f(x) using the weighted residual method.	BT5	Evaluating
6	Explain the discretization process.	BT1	Remembering
7	The differential equation of a physical phenomenon is given by $\frac{d^2y}{dx^2} + 500x^2 = 0, 0 \leq x \leq 1$. By using the trial function $y = a_1(x - x^3) + a_2(x - x^5)$. Calculate the value of the parameters a_1 and a_2 by the following methods: (i) point collocation method (ii) Sub domain method (iii) Least square method (iv) Galerkin's method. The boundary conditions are y(0) = 0 and y(1) = 0.	BT5	Evaluating

8	Solve the following equation using a two parameter trial solution by: (i)Point collocation method (ii)Galerkin's method $$\frac{dy}{dx} + y = 0, \qquad 0 \le x \le 1, y(0) = 1$$		
9	A simply supported beam (span L and flexural rigidity EI) carries two equal concentrated loads at each of the quarter span points. Using Rayleigh-Ritz method determine the deflections under the two loads and the two end slopes.	BT3	Applying
10	The Governing Equation for one dimensional heat transfer through a fin of length *l* attached to a hot source as shown in fig is given by  If the free end of the fin is insulated, give the boundary conditions and determine using the Collocation technique the temperature distribution in the fin. Report the temperature at the free end.	BT3	Applying
11	For the tapered bar shown in figure subjected to its own self weight, determine the deflection at the free end using Ritz technique. Assume E=200 GPa and ρ=77 kN/m^3.  	BT3	Applying
12	For the differential equation $-\frac{d}{dx}\left[(1+x)\frac{dy}{dx}\right] = 0$ for 0<x<1 with the boundary conditions y (0)=0 and y (1) = 1, obtain an approximation solution using Rayleigh-Ritz method.	BT5	Evaluating

13	(i) Find the solution of the initial value problem. $y' + y = 0\,; y(3) = 2.$ **(5)**	BT4	Analyzing
	(ii) Find a solution of the initial value problem $\frac{d^2y}{dx^2} + \frac{dy}{dx} - 2y = 0$, boundary conditions y(0) = 2, $y'(0)$ =5. **(8)**	BT4	Analyzing
14	The governing differential equation for the long cylinder of radius R with heat generation q_o is given by $\frac{d^2T}{dr^2} + \frac{1}{r}\frac{dT}{dr} + \frac{q_o}{k} = 0$. The boundary conditions are $T(R) = T_w$, $q_o \pi R^2 L = (-k)\,(2\,\pi\,R\,L)\frac{dT}{dr}\vert r = R$. Find the temperature distribution T as a function of radial location r.	BT5	Evaluating
15	Solve the ordinary differential equation $d^2y/dx^2 + 10\,x^2 = 0$, $0 \le x \le 1$ with boundary conditions as y (0) = 0 and y (1) = 0 using the Galerkin's method with the trial function No(x) = 0; N1(x) = x $(1-x^2)$.	BT3	Applying
16	Solve the differential equation for a physical problem which is expressed as $d^2y/dx^2 + 50 = 0$, $0 \le x \le 10$ with the boundary conditions as y (0) = 0 and y (10) = 0 using the trial function y = a_1x (10-x) find the value of the parameters a_1 by the following methods listed below (i) Point collocation method (ii) Sub domain collocation method (iii) Least squares method and (iv) Galerkin method.	BT3	Applying
17	Find the solution of the boundary value problem $y'' + 4y = 0$ with $y\left(\frac{\pi}{8}\right)=0$, $y\left(\frac{\pi}{6}\right)=1$.	BT4	Analyzing
18	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	BT4	Analyzing

PART C (15 Marks)			
1	Find the Eigen value and Eigen function of $y'' - 4\lambda y' + 4\lambda^2 y = 0$; with the boundary conditions are $y'(1) = 0,\ y(2) + 2y'(2) = 0$.	BT5	Evaluating
2	A bar of uniform cross-section is fixed at one end and left free at the other end and it is subjected to a uniform axial load F as shown in the figure. Calculate the displacement and stress using Rayleigh-Ritz procedure with two term polynomial function. Also compare the solution with the exact values.	BT4	Analyzing

<table>
<tr><td></td><td>
</td><td></td><td></td></tr>
<tr><td>3</td><td>Determine the deflection and bending moment at the mid span for a beam of uniformly distributed load over entire span along with a central point load as shown in the figure. Use Rayleigh-Ritz method with two Ritz-parameters.


</td><td>BT6</td><td>Creating</td></tr>
<tr><td>4</td><td>A physical phenomenon is governed by the differential equation for $\frac{d^2w}{dx^2} - 10x^2 = 5$, for $0 \le x \le 1$. The boundary conditions are given by $w(0)=w(1)=0$. Use two term trial solution as $w(x)=C_1f_1(x) + C_2f_2(x)$ with $f_1(x)=x(x-1)$ and $f_2(x)=x^2(x-1)$, find the solution of the problem using the Galerkin's method.</td><td>BT5</td><td>Evaluating</td></tr>
<tr><td>5</td><td>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.</td><td>BT5</td><td>Evaluating</td></tr>
</table>

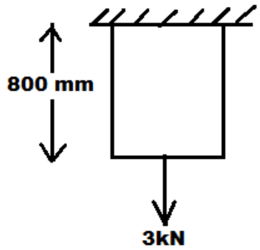
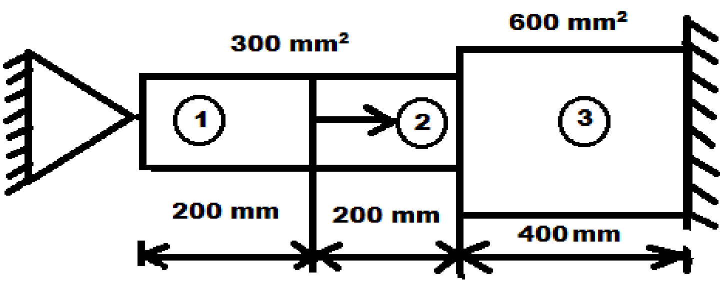
UNIT II : ONE-DIMENSIONAL PROBLEMS

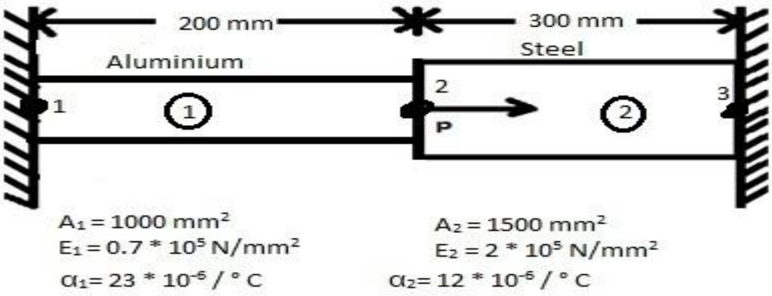
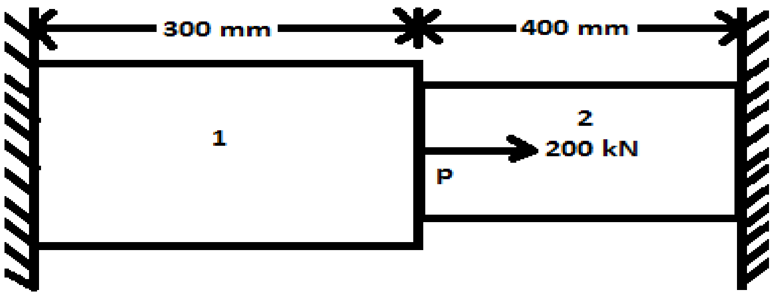
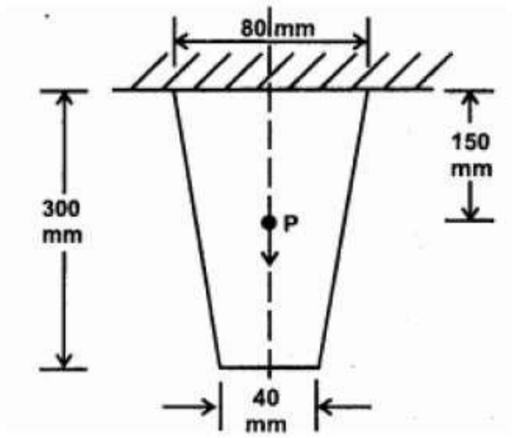
One Dimensional Second Order Equations – Discretization – Element types- Linear and Higher order Elements – Derivation of Shape functions and Stiffness matrices and force vectors- Assembly of Matrices - Solution of problems from solid mechanics and heat transfer. Longitudinal vibration frequencies and mode shapes. Fourth Order Beam Equation –Transverse deflections and Natural frequencies of beams

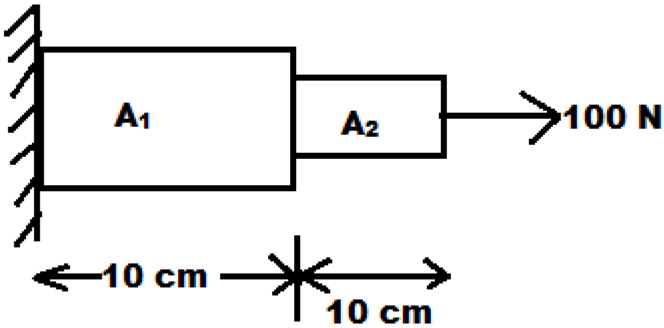
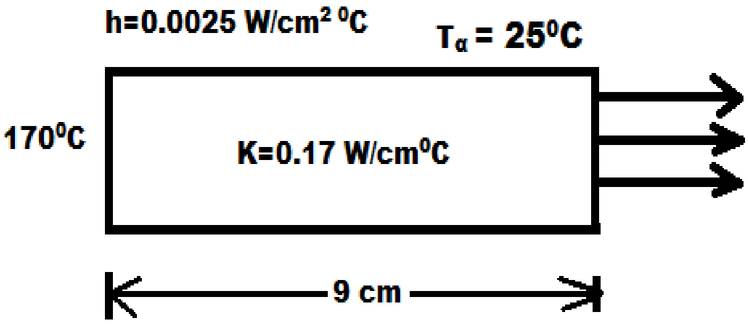
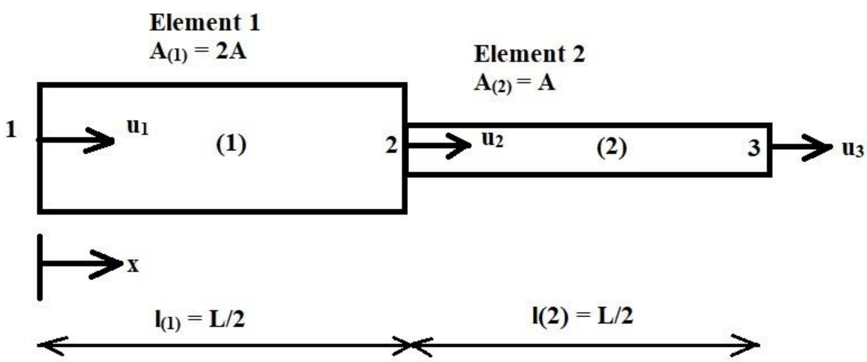
PART A (2 Marks)

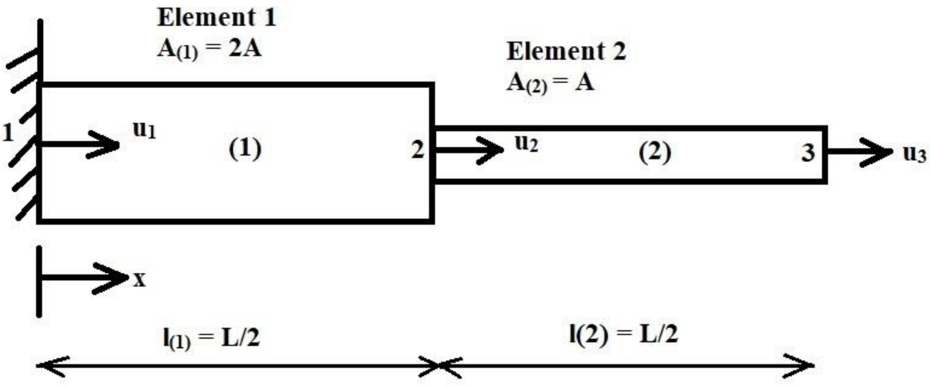
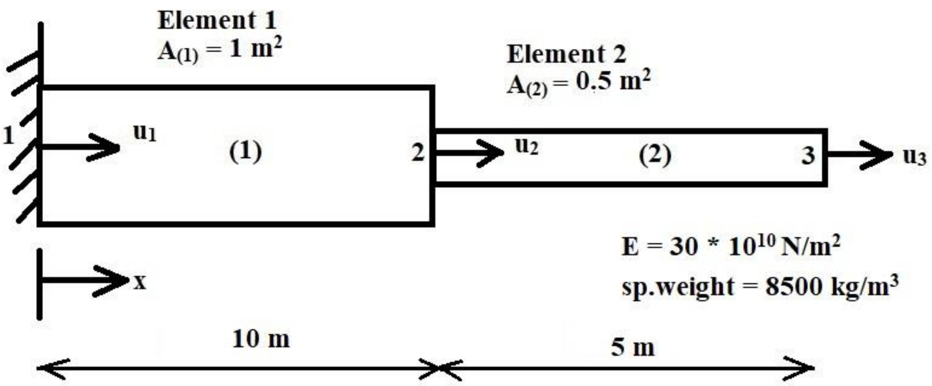
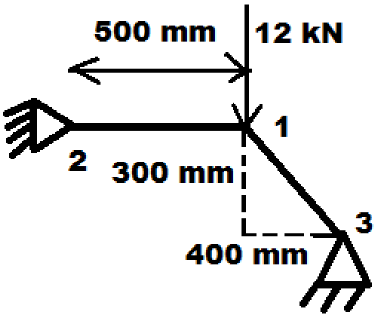
1	Deduce the stiffness matrix for a 1D two noded linear element.	BT1	Remembering
2	Define shape function.	BT1	Remembering
3	List out the stiffness matrix properties.	BT2	Understanding
4	Write the expression for shape function of a two node line element.	BT1	Remembering
5	Mention the characteristics of shape functions.	BT2	Understanding
6	Reframe a bar of varying cross section into a stepped bar for idealization in finite element method.	BT5	Evaluating
7	Distinguish between global and local coordinate.	BT4	Analyzing
8	Define natural coordinate system.	BT1	Remembering
9	Compare primary nodes and secondary nodes.	BT4	Analyzing
10	Define Lumped mass matrix.	BT1	Remembering
11	What are the types of problems consider as one dimensional problem?	BT4	Analyzing
12	Express the element stiffness matrix of a truss element.	BT2	Understanding
13	How do you calculate the size of the global stiffness matrix?	BT3	Applying
14	Interpret the types of loads acting on a body.	BT2	Understanding
15	Give the shape function equation for a 1D quadratic bar element.	BT1	Remembering
16	Summarize the types of dynamic analysis problems.	BT2	Understanding
17	Define mode superposition technique.	BT1	Remembering
18	Calculate the mass matrix for a 1D linear bar element whose density is 7800 kg/m^3, cross sectional area of 1 m^2 and element length of 10 m.	BT5	Evaluating
19	Write the expression of governing equation for free axial vibration of rod and transverse vibration of beam.	BT1	Remembering
20	Write the expression of governing equation for transverse vibration of beam.	BT1	Remembering
21	State the assumptions used in the solving the truss problems.	BT2	Understanding
22	Define the transverse vibration.	BT1	Remembering

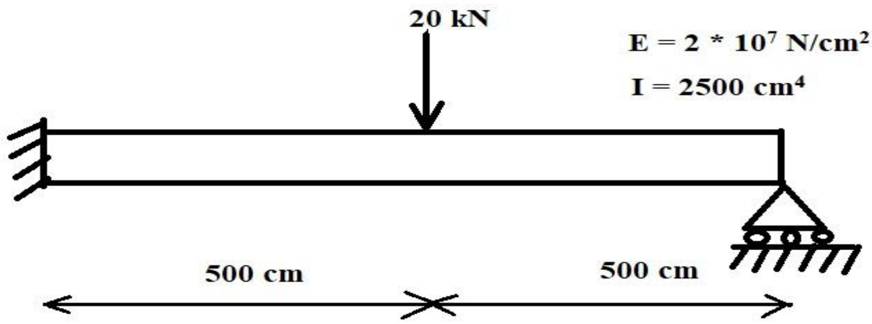
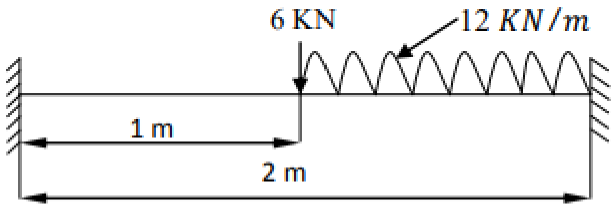
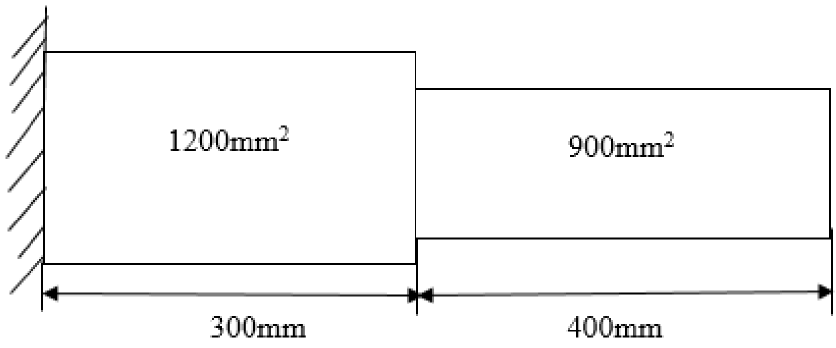
23	List two applications of transverse vibration.	BT3	Applying
24	Define the longitudinal vibration.	BT1	Remembering
25	Interpret the methods for solving transient vibration problems.	BT2	Understanding

PART B (13 MARKS)			
1	Formulate the shape function for One-Dimensional Quadratic bar element.	BT6	Creating
2	A steel bar of length 800 mm is subjected to an axial load of 3 kN as shown in fig. Estimate the nodal displacement of the bar and load vectors. Take A=400 mm^2 and E= 2 x 10^5 N/mm^2.Discretize into 2 elements. 	BT4	Analyzing
3	Formulate the stiffness matrix for One-Dimensional Quadratic bar element.	BT6	Creating
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.	BT4	Analyzing
5	For the bar element as shown in the figure. Calculate the nodal displacements and elemental stresses. Take E= 2.1 x 10^5N/mm^2 and load @ node 2 = 400 kN. 	BT3	Applying
6	An axial load of 4 x 10^5 N is applied at 30° C to the rod as shown in the figure. The temperature is then raised to 60° C, Calculate the following:	BT5	Evaluating

	(i) Assemble the K and F matrices (ii) Nodal displacements. (iii) Stresses in each material (iv) Reactions at each nodal point. 		
7	Consider a bar as shown in figure. An axial load of 200 kN applied at a point P. Take the values of area A_1=2400 mm^2, A_2=600 mm^2, Young's modulus E_1=70x10^9 N/mm^2 and E_2 = 200 x10^9 N/mm^2. Calculate the following (i) the nodal displacement at point,P (ii) Stress in each element (iii) Reaction force. 	BT4	Analyzing
8	For a tapered bar of uniform thickness t=10mm as shown in figure. Predict the displacements at the nodes by forming into two element model. The bar has a mass density ρ = 7800 kg/m^3, the young's modulus E = 2x10^5 MN/m^2. 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. 	BT4	Analyzing

<table>
<tr><td>9</td><td>Consider a bar as shown in fig. Young's Modulus E=2 x 10^5 N/mm^2, A1= 2 cm^2, A_2 = 1cm^2 and force of 100N. Calculate the nodal displacement.

</td><td>BT3</td><td>Applying</td></tr>
<tr><td>10</td><td>A metallic fin 20 mm wide and 4 mm thick is attached to a furnace whose wall temperature is 180 °C. The length of the fin is 120 mm. if the thermal conductivity of the material of the fin is 350 W/m °C and convection coefficient is 9 W/m^2 °C, determine the temperature distribution assuming that the tip of the fin is open to the atmosphere and that the ambient temperature is 25 °C.</td><td>BT5</td><td>Evaluating</td></tr>
<tr><td>11</td><td>Calculate the temperature distribution in the stainless steel fin shown in the figure. The region can be discretized in three elements of equal sizes.

</td><td>BT5</td><td>Evaluating</td></tr>
<tr><td>12</td><td>Find the natural frequencies of longitudinal vibration of the unconstrained stepped bar as shown in the figure.

</td><td>BT4</td><td>Analyzing</td></tr>
<tr><td>13</td><td>Find the natural frequencies of longitudinal vibration of the constrained stepped bar as shown in the figure. Also find the mode shapes.</td><td>BT3</td><td>Applying</td></tr>
</table>

			
14	Determine the eigen values and frequencies for the stepped bar as shown in the figure. 	BT3	Applying
15	For the two bar truss shown in the fig, Estimate the displacements of node 1 and the stress in element 1-3.Take E=70GPa and A=200 mm^2. 	BT4	Analyzing
16	A beam, fixed at one end and supported by a roller at the other ends, has a 20 kN concentrated load applied at the centre of the span, as shown in the figure. Calculate the deflection under the load and construct the shear force and bending moment diagrams for the beam.	BT5	Evaluating

<table>
<tr><td></td><td>
</td><td></td><td></td></tr>
<tr><td>17</td><td>For the beam and loading shown in fig. calculate the nodal displacements. Take [E] =210 Gpa =210×10^{9} N/m^2 , [I] = 6×10^{-6} m^4

</td><td>BT4</td><td>Analyzing</td></tr>
<tr><td>18</td><td>Determine the axial vibration of a steel bar shown in fig. Take [E] =2.1×10^{5} N/mm^2 , [ρ] = 7800 Kg/m^3

</td><td>BT3</td><td>Applying</td></tr>
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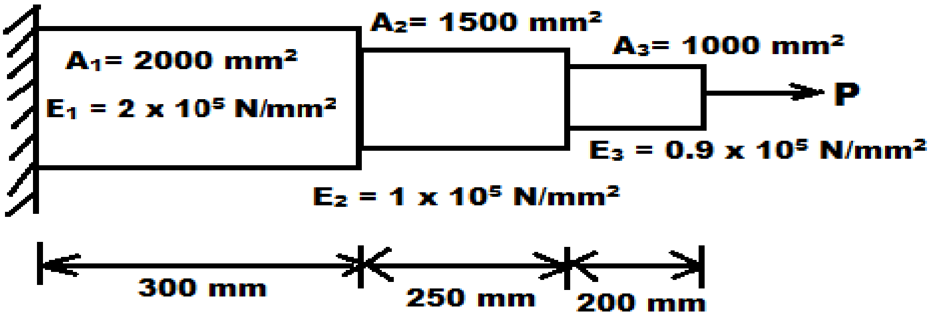
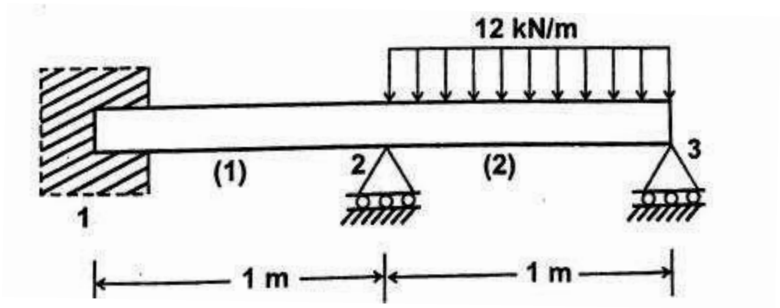
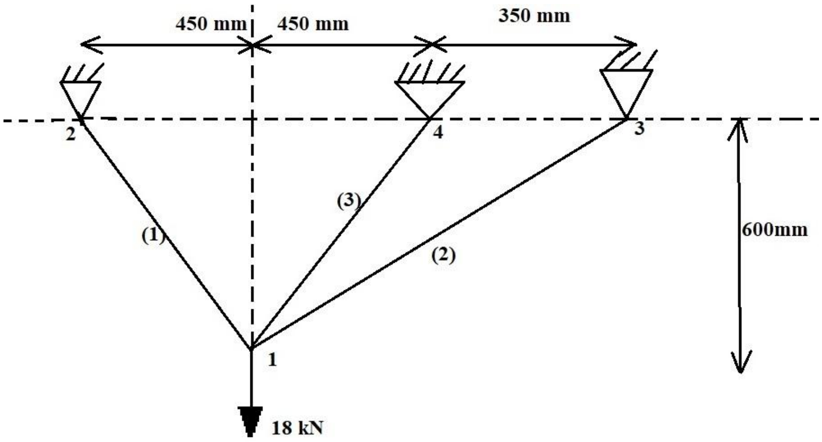
PART C (15 MARKS)			
1	Develop the Shape function, Stiffness matrix and force vector for one dimensional linear element.	BT6	Creating
2	Consider the bar shown in figure axial force P = 30kN is applied as shown. Determine the nodal displacement, stresses in each element and reaction forces.	BT5	Evaluating

			
3	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=4×10^{-6} m^4. 	BT5	Evaluating
4	For the plane truss shown in the figure, determine the horizontal and vertical displacements of the nodes and the stresses in each element. All the elements have E = 200 GPa and A = 250 mm^2. 	BT5	Evaluating
5	A metallic fin, with thermal conductivity *k* = 360 W/m °C, 0.1 cm thick and 10 cm long, extends from a plane wall whose temperature is 235°C. Determine the temperature distribution and amount of heat transferred from the fin to the air at 20°C with h = 9 W/m °C. Take width of the fin to be 1 m.	BT5	Evaluating

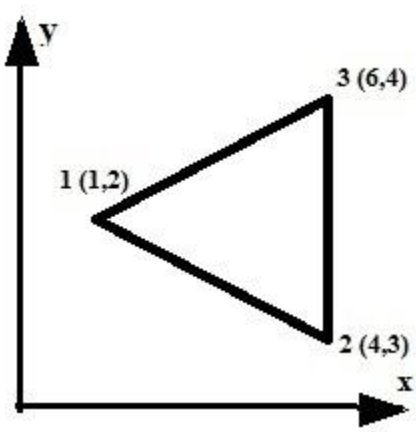
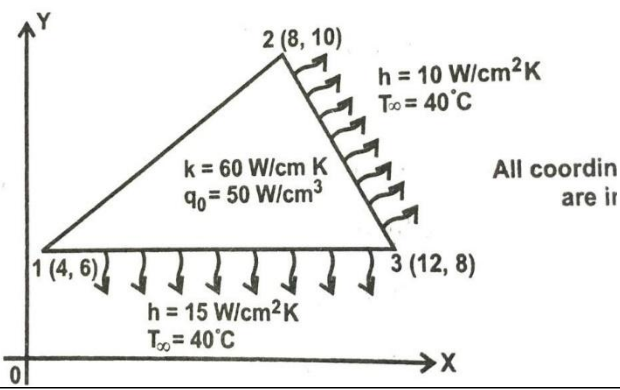
UNIT III : TWO DIMENSIONAL SCALAR VARIABLE PROBLEMS

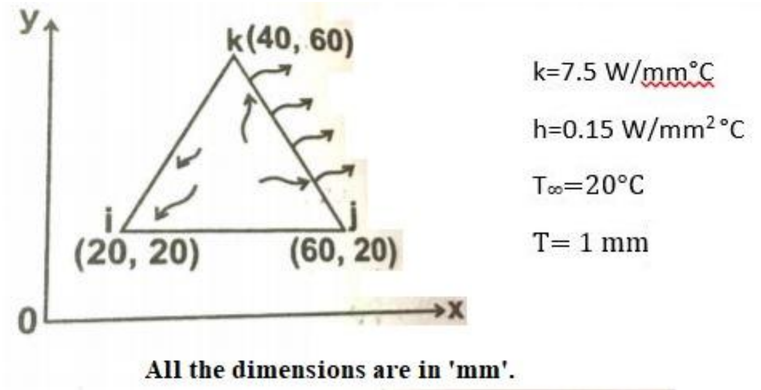
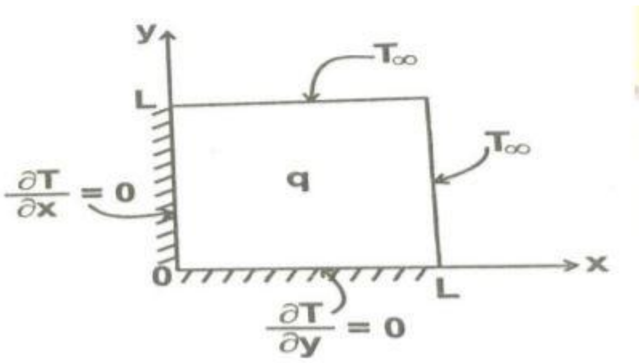
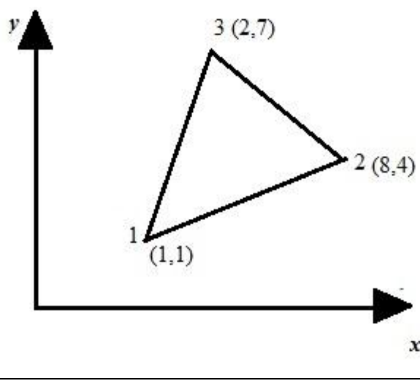
Second Order 2D Equations involving Scalar Variable Functions – Variational formulation –Finite Element formulation – Triangular elements – Shape functions and element matrices and vectors. Application to Field Problems - Thermal problems – Torsion of Non circular shafts –Quadrilateral elements – Higher Order Element.

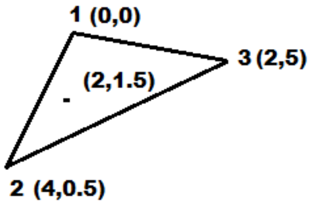
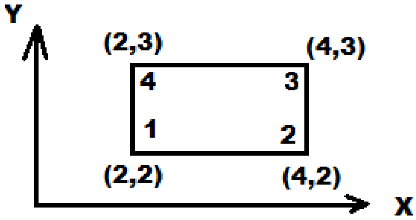
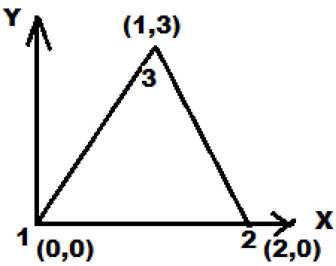
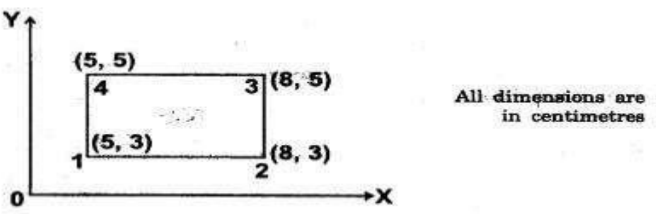
PART A (2 Marks)

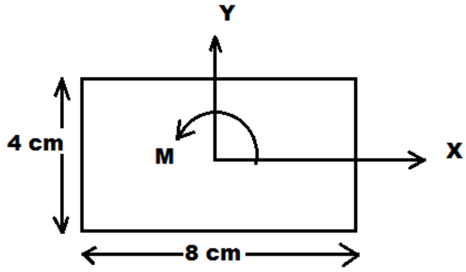
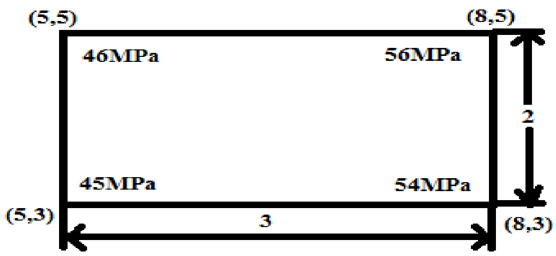
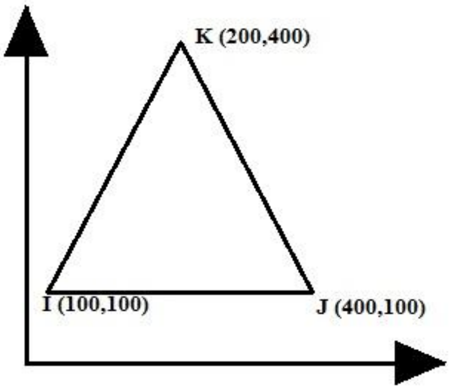
1	Write the displacement function equation for CST element.	BT1	Remembering
2	How will you modify a three-dimensional problem to a Two-dimensional problem?	BT2	Understanding
3	List any two properties of shape functions for 2 D triangular element.	BT2	Understanding
4	Define steady state heat transfer.	BT1	Remembering
5	Define two-dimensional scalar variable problem.	BT1	Remembering
6	State the assumptions in the theory of pure torsion.	BT2	Understanding
7	Define torsion.	BT1	Remembering
8	Distinguish between stream line and path line.	BT4	Analyzing
9	Formulate the (B) matrix for CST element.	BT1	Remembering
10	Express the interpolation function of a field variable for three-node triangular element.	BT1	Remembering
11	Define path line.	BT1	Remembering
12	Illustrate the shape function of a CST element.	BT1	Remembering
13	Distinguish between scalar and vector variable problems in 2D.	BT4	Analyzing
14	List two examples of plane stress analysis probelms.	BT2	Understanding
15	Write down the shape functions for a 4 noded quadrilateral element.	BT1	Remembering
16	Estimate the area of a CST element whose coordinates are A(0,0) , B(50,0) and C(25,50).	BT5	Evaluating
17	Mention two examples of plane stress analysis problems.	BT2	Understanding
18	Write the expression for element force vector equation for four noded quadrilateral element.	BT1	Remembering
19	Define geometric Isotropy.	BT1	Remembering
20	Mention two examples of plane strain analysis problems.	BT2	Understanding
21	Define Isoperimetric elements with suitable examples.	BT1	Remembering
22	Write the strain displacement relation for CST element.	BT1	Remembering

23	Why higher order elements are preferred?	BT4	Analyzing
24	List out the two theories for calculating the shear stress in a solid non circular shaft subjected to torsion.	BT2	Understanding
25	Write down the shape functions associated with three noded linear triangular element and plot the variation of the same.	BT1	Remembering

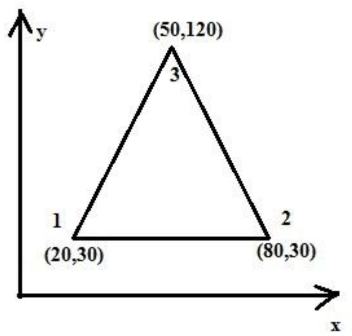
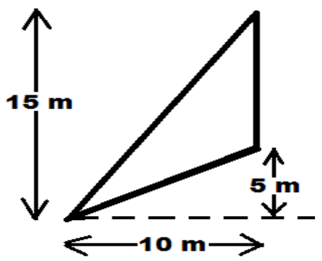
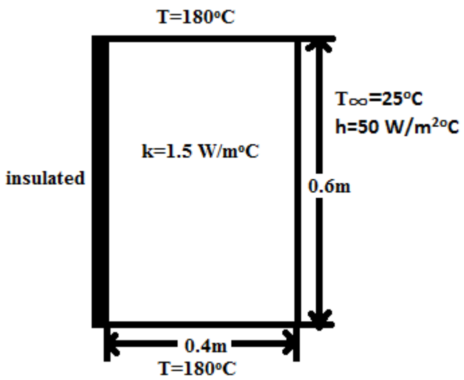
PART B (13 MARKS)			
1	The nodal coordinates of the triangular element are shown in the figure. At the interior point P, the x coordinate is 3.5 and N_1= 0.4, calculate N_2, N_3 and the y coordinate at the point P. Also Estimate [B] matrix. 	BT5	Evaluating
2	Determine the shape functions for a constant strain triangular (CST) element.	BT6	Creating
3	Determine the strain – displacement matrix [B] for a constant strain triangular (CST) element.	BT6	Creating
4	Determine the stiffness matrix for a constant strain triangular (CST) element.	BT6	Creating
5	Compute the element matrices and vectors for the element shown in the Figure when the edges 2-3 and 1-3 experience convection heat loss. 	BT5	Evaluating

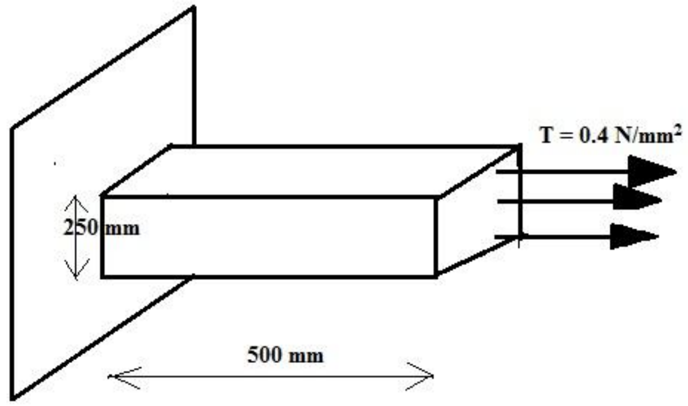
6	Calculate the element equations for the element shown in the figure which experiences convection on the side jk and its upper face. 	BT4	Analyzing
7	Estimate the temperature distribution in a square region with the uniform energy generation as shown in figure. Assume that there is no temperature variation in the Z-direction. Take k=300W/cm°C, L=10cm, $T\infty$ =50°C and q=100 W/cm^3. 	BT5	Evaluating
8	For the triangular element shown in the figure. Obtain the strain displacement relation matrix [B] and determine the strains e_x, e_y and γ_{xy}. 	BT5	Evaluating
9	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.	BT5	Evaluating

	 		
10	For a 4-noded rectangular element shown in fig. Infer the temperature at the point (2.5, 2.5). The nodal values of the temperatures are T_1= 100°C, T_2= 60°C and T_3=50°C and T_4= 90°C. Also determine the 80°C isotherm.  	BT4	Analyzing
11	Calculate the element stiffness matrix and the temperature force vector for the plane stress element shown in figure. The element experiences a 20°C increase in temperature. Assume the value of α = $6 x 10^{-6}$ C. Take E=$2x10^5$ N/mm^2, v= 0.25, t= 5mm.  	BT5	Evaluating
12	For a 4-noded rectangular element shown in the figure. Estimate the temperature point (7,4). The nodal values of the temperatures are given as T_1 = 42˚C, T_2 = 54˚C and T_3 = 56˚Cand T_4 = 46˚C. Also determine 3 point on the 50˚C contour line.  	BT5	Evaluating
13	The figure below shows a shaft having rectangular cross section with 8 cm x 4 cm sides. The material has shear modulus 80 x 10^5 N/mm^2. Shaft length is 100 cm. the shaft is fixed at one end and subjected to torque T at the other end. Determine the total angle of twist if the applied torque is 10 x 10^3 N-cm.	BT5	Evaluating

			
14	Determine the pressure at the location (7, 4) in a rectangular plate with the data shown in Figure and also draw 50 MPa contour line. 	BT4	Analyzing
15	For the constant strain triangular element shown in figure, Assemble strain displacement matrix. Take t = 20 mm, E = 2 * 10^5 N/mm^2 and calculate [D] matrix assuming plane strain condition. 	BT5	Evaluating
16	Estimate the stiffness matrix for the triangular element with the (x,y) coordinates of the nodes are (0,-4), (8,0) and (0,4) at nodes i, j, k. Assume plane stress condition E= 200 GPa, Poisson's ratio = 0.35.	BT5	Evaluating
17	Develop the Shape function derivation for the Eight Noded Rectangular Element (higher order).	BT6	Creating
18	Develop the Shape function derivation for the Six Noded Triangular Element (higher order).	BT6	Creating

PART C (15 MARKS)			
1	For the plane stress element shown in the figure, the nodal displacements are u_1=2 mm, v_1=1 mm, u_2=0.5 mm, v_2=0 mm, u_3=3 mm and v_3=1 mm.	BT5	Evaluating

	Determine the element stresses σ_x, σ_y, τ_{xy}, σ_1, σ_2 and the principal angle Θ_p. Let E=210 Gpa, μ=0.25 and t=10 mm. All coordinates are in mm. 		
2	For the triangular element shown in the figure determine the strain-displacement matrix [B] and constitutive matrix [D]. Assume plane stress conditions. Take μ=0.3 , E=30 x 10^6 N/m^2 and thickness t= 0.1 m. And also calculate the element stiffness matrix for the triangular element. 	BT4	Analyzing
3	Determine the temperature distribution in the rectangular fin shown in figure. The upper half can be meshed taking into account symmetry using triangular elements. 	BT4	Analyzing
4	A thin plate is subjected to surface traction as shown in the figure. Calculate the global stiffness matrix.	BT3	Applying

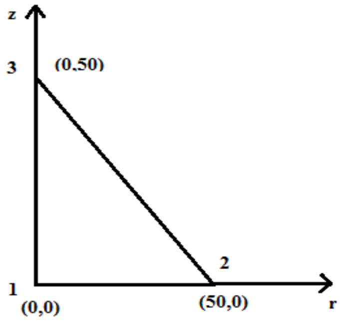
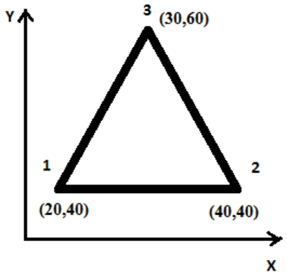
			
5	Determine the stiffness matrix for two dimensional torsional triangular (CST) element.	BT6	Creating

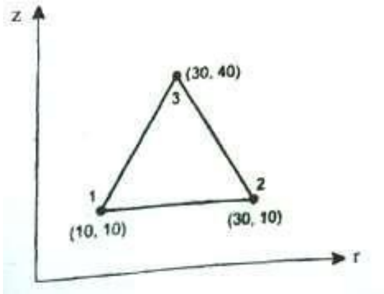
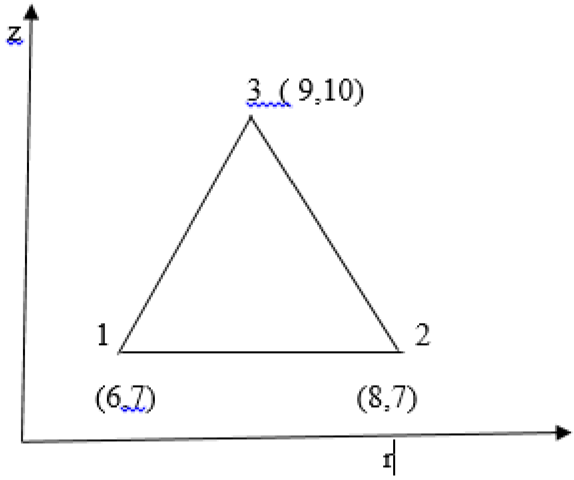
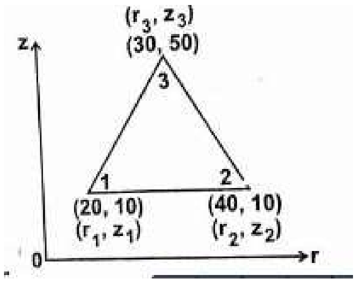
UNIT IV : TWO DIMENSIONAL VECTOR VARIABLE PROBLEMS

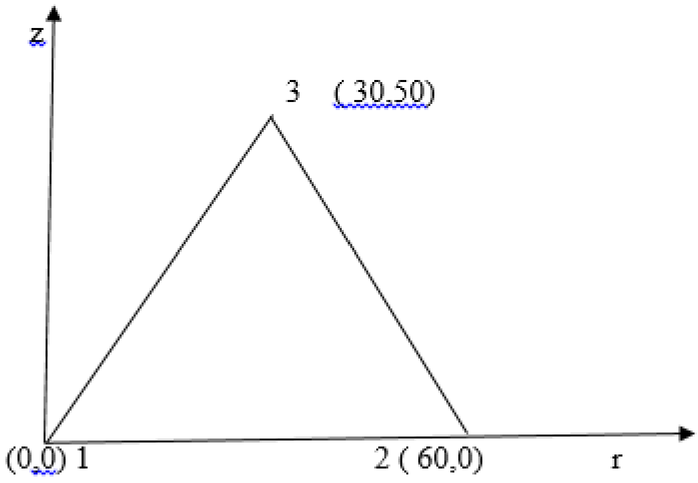
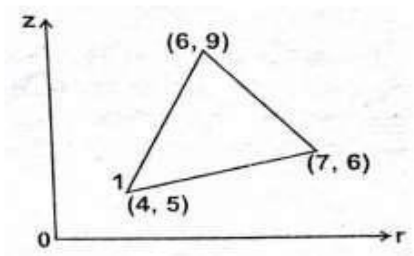
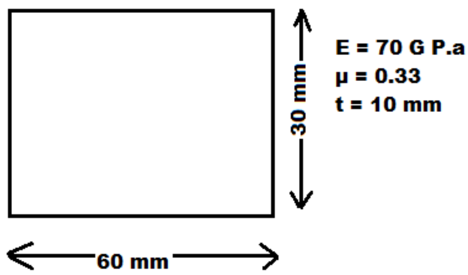
Equations of elasticity – Plane stress, plane strain and axisymmetric problems – Body forces and temperature effects – Stress calculations - Plate and shell elements

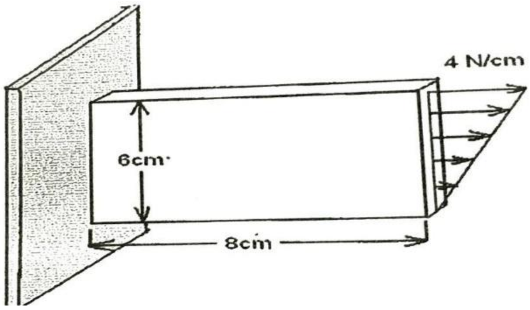
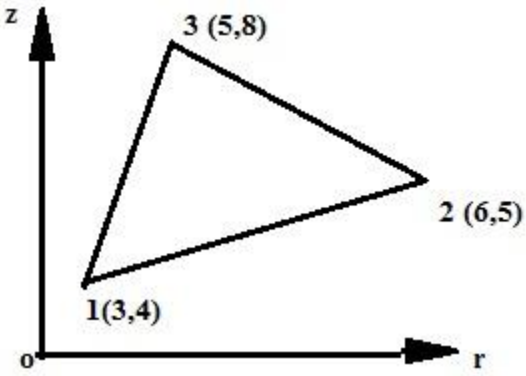
PART A (2 Marks)

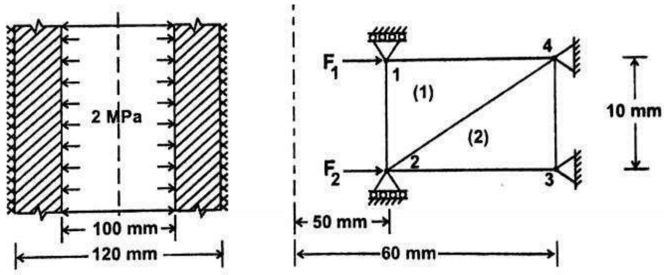
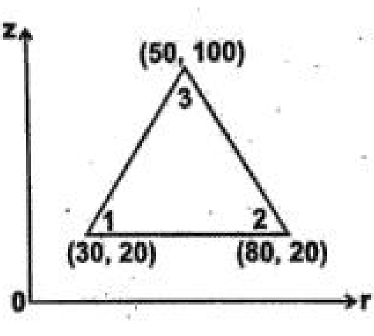
1	Write the stress-strain relationship matrix for an axisymmetric triangular element.	BT1	Remembering
2	Classify the types of shell element.	BT2	Understanding
3	Define 2D vector variable problems.	BT1	Remembering
4	List any two elasticity equations.	BT2	Understanding
5	Define shell element.	BT1	Remembering
6	Define axisymmetric formulation.	BT1	Remembering
7	Mention the difference between the use of linear triangular elements and bilinear rectangular elements for a 2D domain.	BT2	Understanding
8	Write the strain displacement matrix for a 3 noded triangular element.	BT1	Remembering
9	State the assumptions used in thick plate element.	BT2	Understanding
10	Distinguish between plate and shell elements.	BT4	Analyzing
11	Define plate element.	BT1	Remembering
12	Write the expression for shape functions for axisymmetric triangular elements.	BT1	Remembering
13	Specify the machine components related with axisymmetric elements.	BT2	Understanding
14	Write the expression for strain-displacement matrix for axisymmetric element.	BT1	Remembering
15	Write the Stress-Strain displacement matrix for axisymmetric solid.	BT1	Remembering
16	Deduce the Stiffness matrix for axisymmetric solid.	BT1	Remembering
17	State the conditions to be satisfied in order to use axisymmetric elements.	BT2	Understanding
18	State the assumptions used in thin plate element.	BT2	Understanding
19	Define a plane strain.	BT1	Remembering
20	Define a plane stress problem.	BT1	Remembering
21	Define super parametric element	BT1	Remembering
22	Define sub parametric element	BT1	Remembering
23	What are the forces acting on shell elements? Give its applications	BT4	Analyzing
24	Write the governing equation for 2D bending of plates.	BT1	Remembering
25	Differentiate material non linearity and geometric non linearity.	BT4	Analyzing

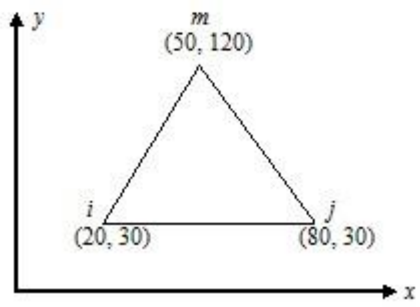
PART B (13 MARKS)			
1	Determine the stiffness matrix for the axisymmetric element shown in figure. Take E=2.1 x 10^5 N/mm^2,v=0.25 The coordinates are in mm. 	BT5	Evaluating
2	Develop shape function for axisymmetric triangular elements.	BT6	Creating
3	Triangular element are used for the stress analysis of plate subjected to inplane loads. The (x,y) coordinates of nodes i, j, and k of an element are given by (2,3), (4,1), and (4,5) mm respectively. The nodal displacement are given as u_1=2 mm, u_2=0.5 mm, u_3= 3 mm, v_1=1 mm, v_2= 0 mm, v_3= 0.5 mm Examine element stress. Let E=160GPa, poisson's ratio = 0.25 and thickness of the element t=10 mm.	BT5	Evaluating
4	The nodal coordinates for an axisymmetric triangular element are given in figure. Evaluate the strain-displacement matrix. 	BT5	Evaluating
5	The nodal coordinates for an axisymmetric triangular element shown in figure are given below. Examine the strain-displacement matrix for that element.	BT5	Evaluating

			
6	Calculate the element stiffness matrix for the axisymmetric triangular element shown in fig. The element experiences a 15ºC increase in temperature. The coordinate are in mm. Take the value of $\alpha=10x10^{-6}/^{o}C$, $E=2x10^5\ N/mm^2$ and v=0.25. 	BT3	Applying
7	The nodal coordinates for an axisymmetric triangular element shown in figure are given below. Evaluate the strain-displacement matrix for that element. 	BT4	Analyzing
8	For the axisymmetric element shown in fig .Determine the element stresses. Take E= 2.1 x $10^5\ N/mm^2$ ν = 0.25. The co-ordinates shown in fig are in mm. The nodal displacements are u1=0.05 mm, u2=0.02 mm, u3=0.0 mm, w1 = 0.03mm, w2 = 0.02mm, w3 = 0.0mm.	BT3	Applying

<table>
<tr><td></td><td>
</td><td></td><td></td></tr>
<tr><td>9</td><td>Calculate the element strains for an axisymmetric triangular element shown in fig the nodal displacement are. u_1= 0.001 mm, u_2 = 0.002 mm, u_3 = -0.003 mm, w_1 = 0.002 mm, w_2 = 0.001 mm and w_3 = 0.004 mm. All dimensions are in mm.

</td><td>BT3</td><td>Applying</td></tr>
<tr><td>10</td><td>Estimate the global stiffness matrix for the plate shown in figure. Taking two triangular elements. Assume plane stress conditions.

</td><td>BT5</td><td>Evaluating</td></tr>
<tr><td>11</td><td>The (x,y) coordinates of nodes i, j and k of an axisymmetric triangular element is given as (3,4), (6,5) and (5,8) cm respectively. The element displacement vector (in cm) of the axisymmetric triangular element is given as $q=[0.002, 0.001, 0.001, 0.004, -0.003, 0.007]^T$. Determine the element strains.</td><td>BT4</td><td>Analyzing</td></tr>
</table>

12	A tin plate of thickness 5mm is subjected to an axial loading as shown in the figure. It is divided into two triangular elements by dividing diagonally. Determine the Strain displacement matrix [B], load vector and the constitutive matrix. How will you derive the stiffness matrix? (Need not be determined). What will be the size of the assembled stiffness matrix? What are the boundary conditions? $E=2x10^7$ N/cm^2 μ=0.3. 	BT4	Analyzing
13	Compute the strain displacement matrix for the axisymmetric triangular element shown in the figure. Also determine the element strains. The nodal dsiplacements are found out as u_1=0.002, w_1=0.001, u_2=0.001, w_2=-0.004, u_3=-0.003 and w_3=0.007. All dimensions are in millimeters. 	BT5	Evaluating
14	Develop Strain-Displacement matrix for axisymmetric triangular element.	BT6	Creating
15	Derive the Finite element equation for triangular plate bending element with 9 degrees of freedom.	BT6	Creating
16	Develop Stress-Strain relationship matrix for axisymmetric triangular element	BT6	Creating
17	The nodel co-ordinates for an axisymmetric triangular element are given below: r_1=15mm, z_1=15mm, r_2=25mm, z_2=15mm, r_3=35mm, z_3=50mm. Determine [B] matrix for that element.	BT5	Evaluating
18	Define shell element and explain the types of shell element.	BT2	Understanding

PART C (15 MARKS)			
1	Develop the four basic sets of elasticity equation.	BT6	Creating
2	A long hollow cylinder of inside diameter 100 mm and outside diameter 120 mm is firmly fitted in a hole of another rigid cylinder over its full length as shown in the figure. The cylinder is then subjected to an internal pressure of 2 MPa. By using two element on the 10 mm length shown in the figure. Calculate the displacements at the inner radius. Take E = 210 GPa, μ = 0.3. 	BT5	Evaluating
3	Triangular element are used for the stress analysis of plate subjected to in plane loads. The (x,y) coordinates of nodes 1, 2, and 3 of an element are given by (5,5), (25,5), and (15,15) mm respectively. The nodal displacement are given as : u1=0.005 mm, u2=0.002 mm, u3= 0.0 mm, u4=0.0 mm, u5= 0.005 mm, u6= 0.0 mm. Evaluate element stress. Let E= 200 GPa, poisson's ratio = 0.3 and use unit thickness of the element.	BT5	Evaluating
4	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 millimeters. 	BT5	Evaluating
5	Evaluate the temperature force vector for the axisymmetric triangular element shown in fig. The element experiences a 1515ºC increase in temperature. The coordinate are in mm. Take the value of $\alpha=10\times10^{-6}/^{\circ}C$, $E=2\times10^{5}\ N/mm^{2}$ and v=0.25.	BT5	Evaluating

	y m (50, 120) i (20, 30) j (80, 30) x		

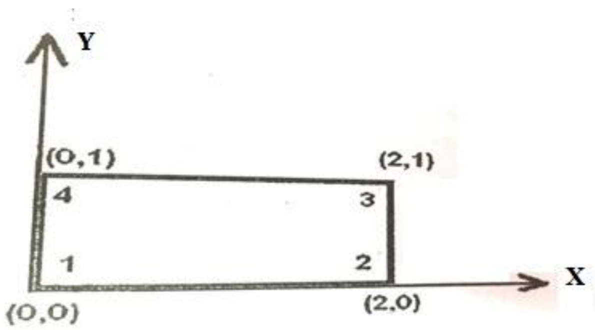
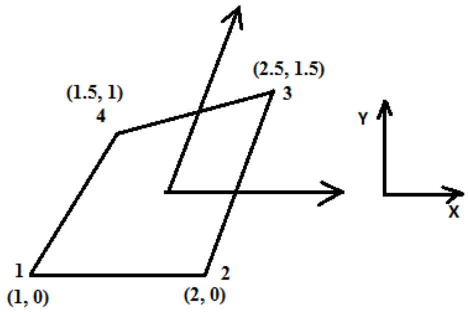
UNIT V : ISOPARAMETRIC FORMULATION

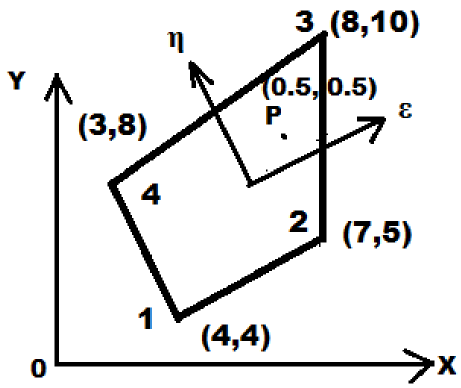
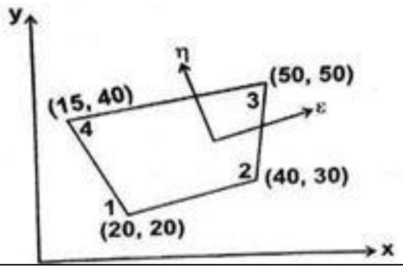
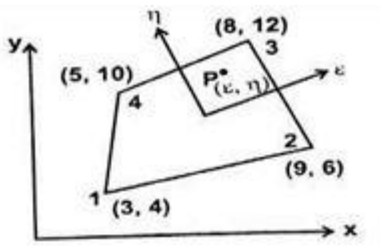
Natural co-ordinate systems – Isoparametric elements – Shape functions for isoparametric elements– One and two dimensions – Serendipity elements – Numerical integration and application to plane stress problems - Matrix solution techniques – Solutions Techniques to Dynamic problems – Introduction to Analysis Software.

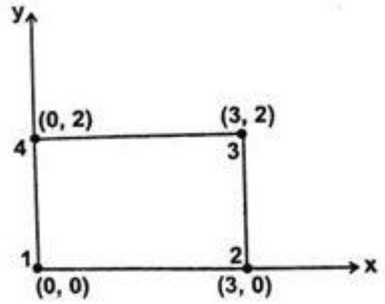
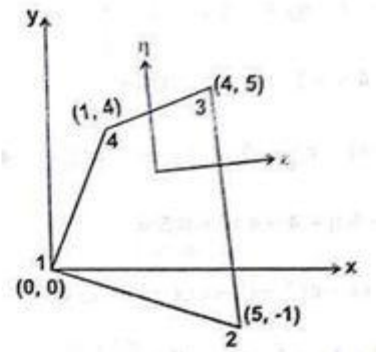
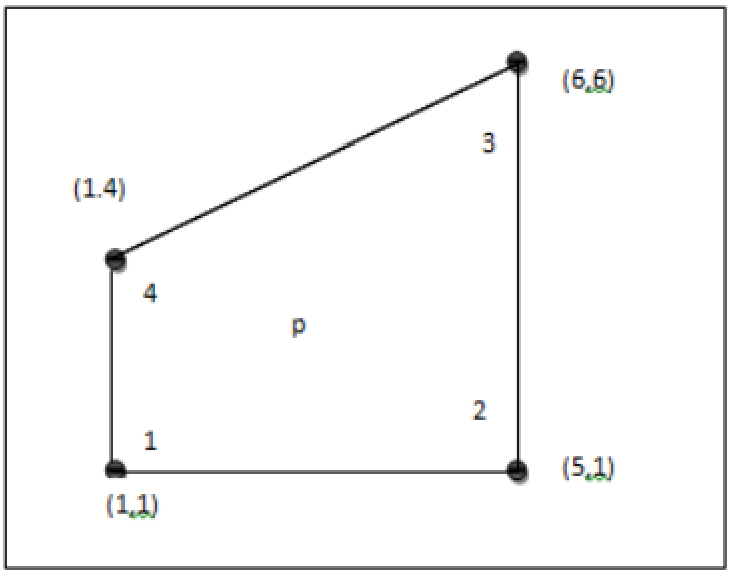
PART A (2 Marks)

1	Illustrate the purpose of isoparameteric element.	BT2	Understanding
2	List the types of non-linearity.	BT2	Understanding
3	Define isoparametric formulation.	BT1	Remembering
4	Give examples of non-essential boundary conditions.	BT2	Understanding
5	Give the shape functions for a four-noded linear quadrilateral element in natural coordinates.	BT2	Understanding
6	Determine the value of $\int_0^1 L_1^3 dx$.	BT5	Evaluating
7	Determine the value of $\int_0^1 L_1 L_2 dx$.	BT5	Evaluating
8	Give examples of essential boundary conditions.	BT2	Understanding
9	Name any 4 FEA software.	BT1	Remembering
10	Define Gauss-quadrature method.	BT1	Remembering
11	Differentiate between implicitly and explicitly methods of numerical integration.	BT4	Analyzing
12	Differentiate between geometric and material non-linearity.	BT4	Analyzing
13	Interpret the methods used for solving transient vibration problems.	BT2	Understanding
14	Define isoparametric element with suitable examples.	BT1	Remembering
15	Write the expression for Stress- displacement matrix for Four noded quadrilateral element using natural coordinates.	BT2	Understanding
16	Mention the difference between natural coordinate and simple natural coordinate.	BT4	Analyzing
17	Point out the significance of jacobian matrix.	BT2	Understanding
18	Define jacobian transformation.	BT1	Remembering
19	List the advantages of Gauss quadrature method.	BT2	Understanding
20	State any two differences between direct and iterative methods for solving system of equations.	BT4	Analyzing
21	Write down the element force vector equation for four noded quadrilateral element.	BT2	Understanding

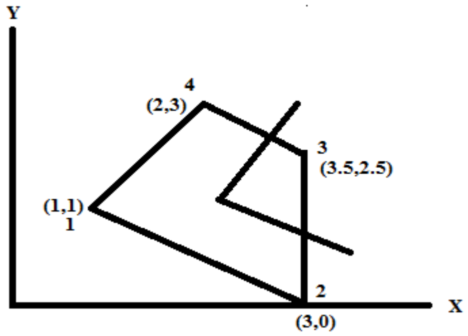
22	Write down the Jacobian matrix for four noded quadrilateral element.	BT2	Understanding
23	Define resonance.	BT1	Remembering
24	Define Dynamic Analysis.	BT1	Remembering
25	State the principle of superposition.	BT4	Analyzing

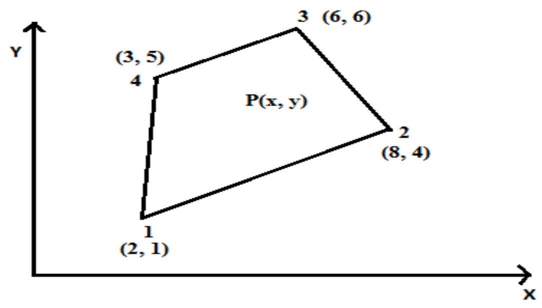
PART B (13 MARKS)			
1	For the four noded element shown in the figure. Determine the Jacobian matrix and evaluate its value at the point (0,0). 	BT5	Evaluating
2	Evaluate the Jacobian matrix for the isoparametric quadrilateral element shown in the figure. 	BT3	Applying
3	Develop the shape function for 4 noded isoparametric quadrilateral element.	BT6	Creating
4	Develop the strain displacement matrix, stress-strain matrix and stiffness matrix for an isoparametric quadrilateral element.	BT6	Creating
5	Evaluate the Jacobian matrix at the local coordinates $\varepsilon=\eta= 0.5$ for the linear quadrilateral element with its global coordinates as shown in figure. Also evaluate the strain-displacement matrix.	BT5	Evaluating

<table>
<tr><td></td><td>
</td><td></td><td></td></tr>
<tr><td>6</td><td>For the four noded quadrilateral element shown in fig analysis the Jacobian and evaluate its value at the point (1/2, 1/2).

</td><td>BT4</td><td>Analyzing</td></tr>
<tr><td>7</td><td>Calculate the Cartesian coordinates of the point P which has local coordinates ε = 0.8 and η = 0.6 as shown in figure.

</td><td>BT3</td><td>Applying</td></tr>
<tr><td>8</td><td>Evaluate $\int_{-1}^{1}(x^4 + x^2)dx$ by applying 3 point Gaussian quadrature.</td><td>BT5</td><td>Evaluating</td></tr>
<tr><td>9</td><td>Evaluate $\int_{-1}^{1} e^{-x}dx$ by applying 3 point Gaussian quadrature.</td><td>BT5</td><td>Evaluating</td></tr>
<tr><td>10</td><td>Evaluate the integral, I = $\int_{-1}^{1} Cos\frac{\pi x}{2}dx$ by applying 3 point Gaussian quadrature and compare with exact solution.</td><td>BT4</td><td>Analyzing</td></tr>
<tr><td>11</td><td>For a four noded rectangular element shown in fig. Estimate the following
a. Jacobian matrix b. Strain-Displacement matrix c. Element strain and d. Element stress.</td><td>BT5</td><td>Evaluating</td></tr>
</table>

<table>
<tr><td></td><td>
</td><td></td><td></td></tr>
<tr><td>12</td><td>For the element shown in the figure. Calculate the Jacobian matrix.

</td><td>BT3</td><td>Applying</td></tr>
<tr><td>13</td><td>Consider the isoparametric quadrilateral element with nodes 1 to 4 at (5,5), (11,7), (12,15), and (4,10) respectively. Estimate the jacobian matrix and its determinant at the element centroid.</td><td>BT5</td><td>Evaluating</td></tr>
<tr><td>14</td><td>Evaluate the integral I = $\int_{-1}^{1}\left[3e^{x}+x^{2}+\frac{1}{(x+2)}\right]dx$ using one point and two point Gauss-quadrature. Compare this with exact solution.</td><td>BT4</td><td>Analyzing</td></tr>
<tr><td>15</td><td>For the isoparametric four noded quadrilateral element shown in fig. Determine the Cartesian co-ordinates of point P which has local co-ordinatesε= 0.5 , η =0.5

</td><td>BT5</td><td>Evaluating</td></tr>
</table>

16	Evaluate the integral I = $\int_{-1}^{1}\left[e^x + x^2 + \frac{1}{(x+7)}\right]dx$ using Gaussian integration with one, ,two , three integration points and compare with exact solution	BT5	Evaluating
17	Explain the isoperimetric, super parametric and sub parametric elements.	BT2	Understanding
18	Explain the FEA software packages.	BT2	Understanding

PART C (15 MARKS)			
1	Evaluate the integral by two point Gaussian Quadrature, I= $\int_{-1}^{1}\int_{-1}^{1}(2x^2+3xy+4y^2)dxdy$ .Gauss points are +0.57735 and -0.57735 each of weight 1.0000.	BT5	Evaluating
2	i) Derive the shape function for all the corner nodes of a nine noded quadrilateral element. ii) Using Gauss quadrature, evaluate the following integral using 1,2 and 3 point integration. $\int_{-1}^{1}\frac{\mathbf{SinS}}{\mathbf{S\,(1-S^2)}}\mathbf{ds}$	BT5	Evaluating
3	For the four noded element shown in Figure, (i) Determine the Jacobian and evaluate its value at the point $(1/3, 1/3)$ (ii) Using energy approach derive the stiffness matrix for a 1D linear isoparametric element. 	BT5	Evaluating

4	For the isoparametric quadrilateral element shown in figure, the Cartesian coordinates of point ‘P’, are (6,4). The loads 10 kN and 12 kN are acting in x and y direction on that point P. Evaluate the nodal forces. 	BT5	Evaluating
5	Evaluate the integral I = $\int_{-1}^{1}\left[e^{x}+x^{3}+\frac{1}{(x+9)}\right]dx$ using Gaussian integration with one, ,two , three integration points and compare with exact solution	BT5	Evaluating