SREENIVASA INSTITUTE OF TECHNOLOGY AND MANAGEMENT STUDIES
(Autonomous)
DEPARTMENT of MECHANICAL ENGINEERING

QUESTION BANK **Finite Element Analysis**

III B.Tech II Semester		**L T P C**
		3 1 0 3
16MEC322	**Finite Element Analysis**	

Course Educational Objectives:

- **CEO1**: To understand the fundamental concepts of finite element analysis
- **CEO2**: To analyze one dimensional element and truss element problems
- **CEO3**: To evaluate the Constant Strain Triangle Element in two dimensional scalar problems
- **CEO4**: To develop the modern of vector variable problems and isoparametric elements
- **CEO5**: To demonstrate the numerical integration and applications in heat transfer

UNIT – 1: FUNDAMENTAL CONCEPT

Methods of engineering analysis – Historical background – General steps of finite element analysis – Galerkin method – Potential energy approach: Rayleigh Ritz method – Boundary, initial and eigen value problems – Gaussian elimination problems – Application of FEA.

UNIT – 2: ONE DIMENSIONAL PROBLEM

One Dimensional Elements: Finite element modeling – Co-ordinates and shape function – Analysis of stiffness matrix, element stiffness equation, displacements, load vector, treatment of boundary condition, Element stress calculation and support reactions for one dimensional bar, spring and tapered elements – Analysis of temperature effects with one dimensional bar element. **Truss Element:** Analysis of length calculation, element stiffness matrix, assembly of element equation, load vector, treatment of boundary condition and element stresses calculation in one dimensional truss element.

UNIT – 3: TWO DIMENSIONAL SCALAR PROBLEMS

Constant Strain Triangle Element (CST): Plane stress and plane strain – Finite element modeling – Shape function – Analysis of strain displacement matrix, stress-strain relationship, stiffness matrix, element stresses, element strains for CST element – Analysis of temperature effects with CST element.

UNIT – 4: VECTOR VARIABLE PROBLEMS AND ISOPARAMETRIC ELEMENTS

Axisymmetric Element: Finite element modeling – Shape function – Analysis of strain displacement matrix, stress-strain relationship, stiffness matrix, element stresses, element strains for CST element – Analysis of temperature effects with axisymmetric element. **Isoparametric Element:** Co-ordinates – Shape function for four noded rectangular elements – Shape function for four noded isoparametric quadrilateral element – Evaluation of Jacobian matrix, Strain-displacement matrix and element stresses.

UNIT – 5: NUMERICAL INTEGRATION AND APPLICATIONS IN HEAT TRANSFER

Numerical Integration: Gaussian quadrature and application to plane stress problems – Introduction to analysis software. **Heat Transfer Applications:** Temperature and shape function for one dimensional heat conduction element – Stiffness matrix finite element equations for one dimensional heat conduction element – One dimensional in heat transfer – Heat conduction in fin element.

Course Outcomes:

On successful completion of the course, students will be able to:

Course Outcomes		POs related to COs
CO1	Understand the concepts behind variation methods and weighted residual methods in FEM	**PO1,PO2,PO5,PO10,PO12**
CO2	Formulate and solve problems in one dimensional structures including trusses, beams and frames.	**PO1,PO2,PO3,PO4,PO5**
CO3	Implement the formulation techniques to solve two-dimensional problems using triangle and quadrilateral elements.	**PO1,PO2,PO3,PO4,PO5**
CO4	Formulate FE characteristic equations for one dimensional elements and analyze plain stress, plain	**PO1,PO2,PO5**
CO5	Able to identify how the finite element method expands beyond the structural domain, for problems involving dynamics, heat transfer, and fluid flow	**PO1,PO2,PO5**

Text Books:

1. Introduction to Finite Elements in Engineering, R.Chandraputla and Ashok D.Belegundu, 4/e, 2011, Prentice Hall of India Pvt. Ltd., New Delhi.
2. Text Book of Finite Element Analysis, Seshu,P, 2007, Prentice-Hall of India Pvt. Ltd., New Delhi.

Reference Books:

1. Finite Element Method in Engineering, Singiresu S Rao, 5/e, 2012, Elsevier India Pvt.ltd Publishers. New Delhi.
2. An Introduction to Finite Element Method, JN Reddy, 3/e, 2013, Tata McGraw-Hill Education Pvt. Ltd., Noida.
3. A First Course in Finite Element Method, Daryl L Logan, 4/e, 2007, Cengage Learning, UK.
4. Fundamentals of Finite Element Analysis, David V Hutton, 1/e, 2012, Tata McGraw-Hill Education Pvt. Ltd., Noida.
5. Finite Element Analysis, Dhanaraj. R and Prabhakaran Nair. K, 2015, Oxford Publications.

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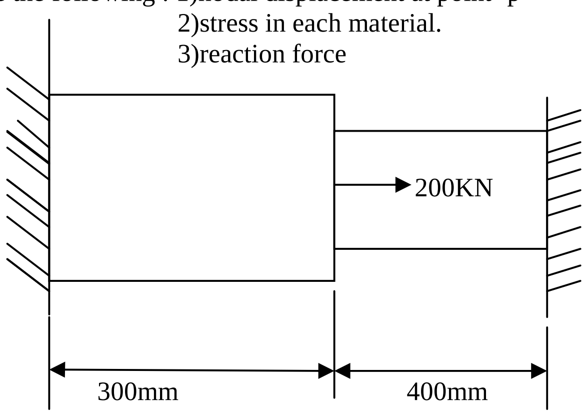
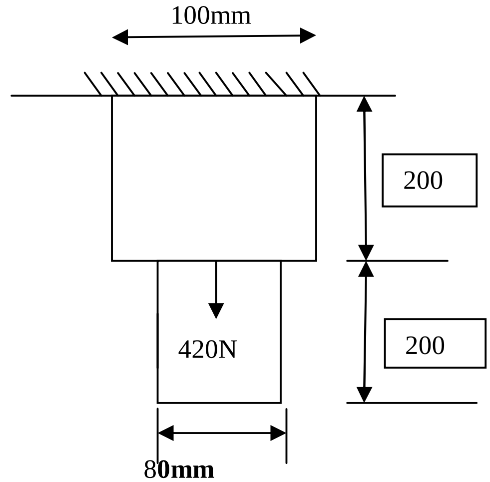
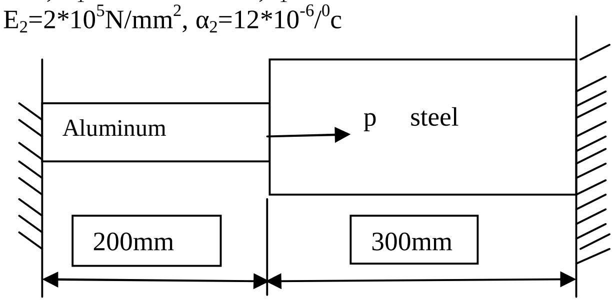
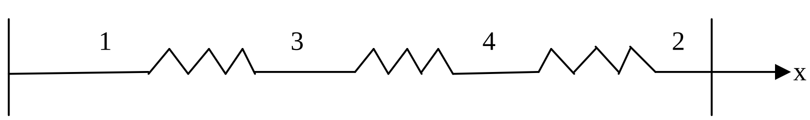
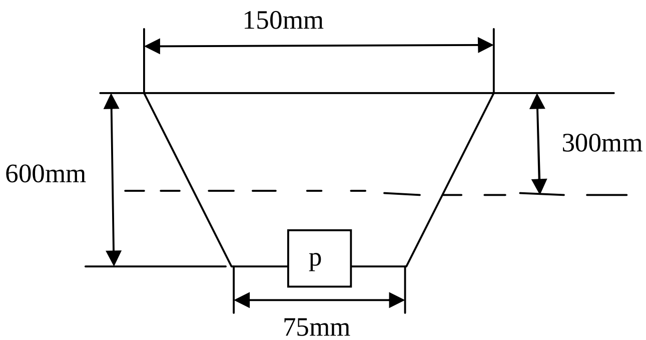
QUESTION BANK **Finite Element Analysis**

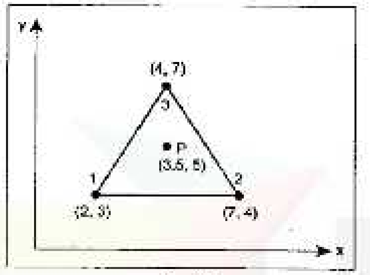
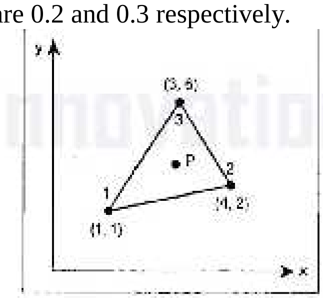
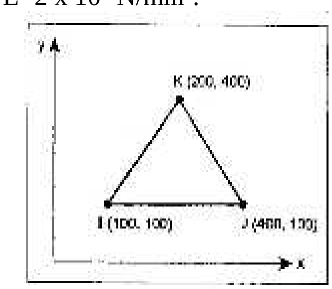
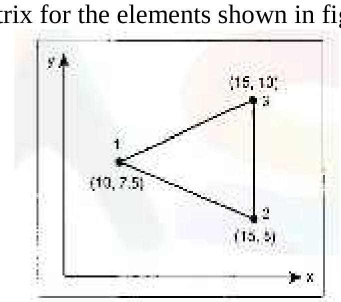
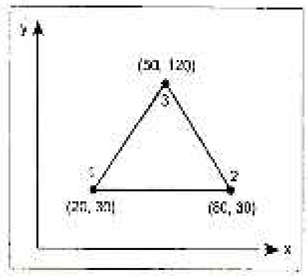
Question No.	Questions	PO Attainment
	UNIT 1 – FUNDAMENTAL CONCEPT	
	PART-A (Two Marks Questions)	
1	What is the finite element method?	**PO1**
2	What are the main steps involved in FEA?	**PO1**
3	What are the methods of engineering analysis?	**PO1**
4	List any four advantages of finite element method.	**PO1**
5	What are the applications of FEA?	**PO1**
6	What is the limitation of using a finite difference method?	**PO1**
7	Define finite difference method	**PO1**
8	What is the limitation of using a finite difference method?	**PO1**
9	What is discretization?	**PO1**
10	Mention the basic steps of Rayleigh-Ritzmethod	**PO1**
11	What is meant by node or joint?	**PO1**
12	What are the different types of boundary conditions?	**PO1**
13	Name the weighted residual methods	**PO1**
14	What is meant by post processing?	**PO1**
15	What is difference between static and dynamic analysis?	**PO1**
	PART-B (Ten Marks Questions)	
1	Find the solution of initial value problem $\frac{d^2y}{dx^2}+\frac{dy}{dx}-2y=0$ boundary condition y(0)=2 , y'(0)=5	**PO1, PO2**
2	Find the solution of a boundary value problem y" + y =0 with y(0)=0 and $y(\frac{\pi}{6})=4$	**PO1, PO2**
3	Find the solution of a boundary value problem y" +4y =0 with $y(\frac{\pi}{6})=1$ and $y(\frac{\pi}{8})=0$	**PO1, PO2**
4	Find eigen value and eigen function of $y''-4\lambda y'+4\lambda^2 y=0$ Boundary condition Y'(1)=0 and y(2)+2y'(2)=0	**PO1, PO2**
5	The differential equation is available for the physical phenomenon $\frac{d^2y}{dx^2}+50=0$ $0 \le x \le 10$. Trial function is $y=a_1x(x-x^4)$, boundary condition y(0)=0 , y(10)=0. Find the value of parameter a_1 by using Galerkin method	**PO1, PO2**
6	3x+y-z = 3 2x-8y+z = -5 x-2y+9 = 8 solve the above equation by using Gaussian elimination method	**PO1, PO2**
7	x-2y+6x = 0 2x+2y+3x=3 -x+3y =2 Solve above equation by using Gaussian elimination method	**PO1, PO2**
8	2x+4y+2z = 15 , 2x+y+z = -5 , 4x+y -2z = 0 Solve above equation by using Gaussian elimination method	**PO1, PO2**
9	The differential equation of a physical phenomenon is given by $\frac{d^2y}{dx^2}+500x^2=0$; $0 \le x \le 1$ Trial function $y=a_1(x-x^3)+a_2(x-x^5)$ Calculate the value of parameter a_1 and a_2 by using galerkin method boundary condition y(0)=0 , y(1) = 0	**PO1, PO2**
10	Explain Discretization and its type with neat sketch.	**PO1**

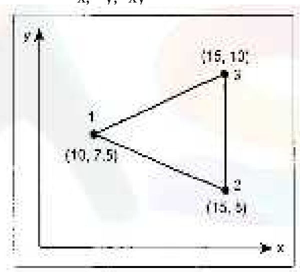
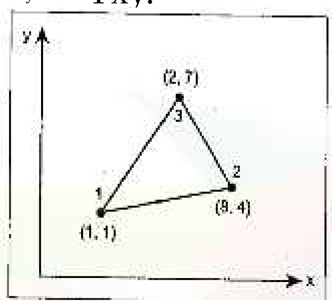
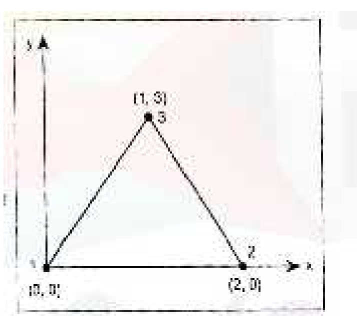
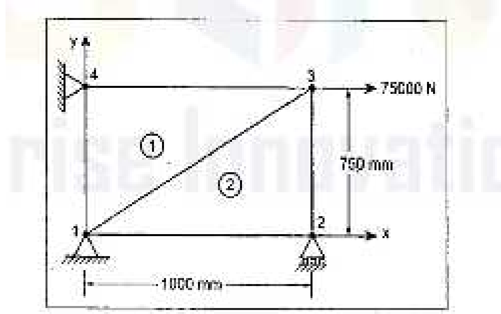
Question No.	Questions	PO Attainment
	UNIT 2 – ONE DIMENSIONAL PROBLEM	
	PART-A (Two Marks Questions)	
1	What are the types of problems treated as one dimensional problem?	**PO1**
2	What are types of loading acting on the structure?	**PO1**
3	Write down the general finite element equation.	**PO1**
4	What is a shape function?	**PO1**
5	Write down the finite element equation for one dimensional two noded bar element.	**PO1**
6	What are the characteristics of shape function?	**PO1**
7	State the assumption are made while finding the forces in truss?	**PO1**
8	State the properties of stiffness matrix.	**PO1**
9	Write down the stiffness matrix equation for one dimensional heat condition element.	**PO1**
10	Write down the expression of the shape function N and displacement u for one dimensional bar element.	**PO1**
11	What is truss?	**PO1**
12	How do you calculate the size of the Global stiffness matrix?	**PO1**
13	What are the classifications of coordinates?	**PO1**
14	What is Global co-ordinates?	**PO1**
15	What is natural co-ordinates?	**PO1**
	PART-B (Ten Marks Questions)	
1	Derivation of stiffness matrix one – dimensional linear bar element	**PO1**
2	Derivation for finite element equation for one – dimensional bar element	**PO1**
3	Consider a bar as shown in fig. An axial load of 200KN is applied at point ‘p’ . Take A_1 = 2400 mm^2 , $E_1=70*10^9$ N/m^2 and $A_2=600mm^2$, $E_2=200 X 10^9$ N/m^2 Calculate the following : 1)nodal displacement at point ‘p’ 2)stress in each material. 3)reaction force  	**PO1,PO2**
4	A thin plate of uniform thickness 25mm is subjected to a point load of 420 KN at mid depth as shown in fig. the plate is also subjected to a self-weight if young’s modulus $E=2*10^5 N/mm^2$	**PO1,PO2**

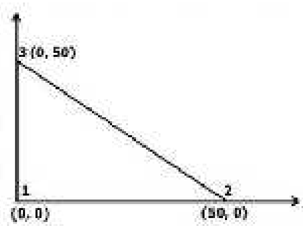
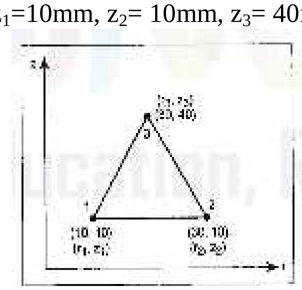
	and unit weight density ρ==$0.8*10^{-4}$N/mm^2 calculate the following 1)Displacement at each nodal point 2)stress in each element  	
5	The axial load of $4*10^5$ newton is applied at 30^0c to the rod as shown in fig . The temperature is then raised to 60^0c calculate the following 1)assemble the k & f matrix 2)nodal displacement 3)stress in each element 4)reaction at each point For aluminum A_1=1000mm^2, E_1=$0.7*10^5$N/mm^2,α_1=$23*10^{-6}/^0$c Steel = A_2 =1500 mm^2, E_2=$2*10^5$N/mm^2, α_2=$12*10^{-6}/^0$c  	**PO1,PO2**
6	A spring assemblage with a numbered nodes are shown in fig .The nodes ‘1’ &’2’ are fixed and a force of 500KN is applied at node’4’ in x-direction . calculate the following 1) Global stiffness matrix 2) Nodal displacement 3) Reaction at each nodal point, spring constant k_1=100KN/m , k_2=200KN/m k_3=300KN/m  	**PO1,PO2**

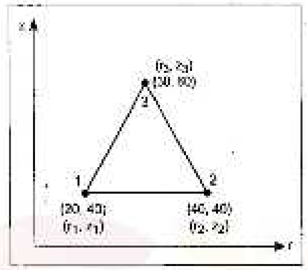
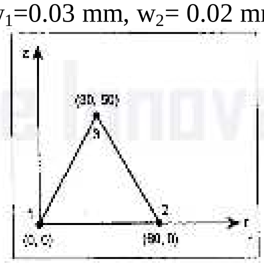
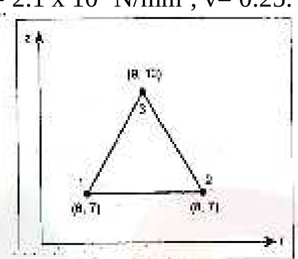
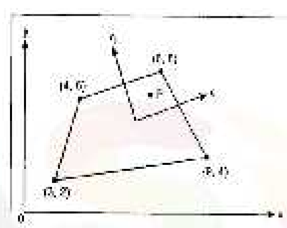
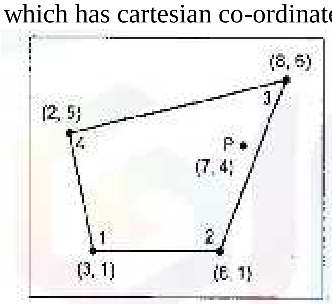
7	Consider a tapper steel plate of uniform thickness t=25mm as shown in fig. The young modulus $E=2*10^5$ n/mm^2 and weight density $\rho=0.82 \times 10^{-4}$N/mm^2 in addition to the self-weight the plate is subjected to a point load of 100N at its mid-point. calculate the following by modeling the plate 1) Global force vector 'F' 2) Global stiffness matrix 'K' 3) Displacement in each element 4) stress in each element 	**PO1,PO2**

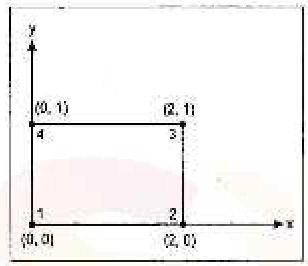
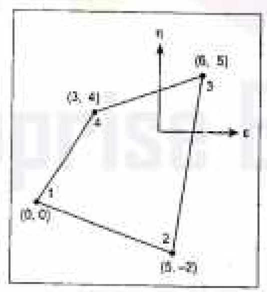
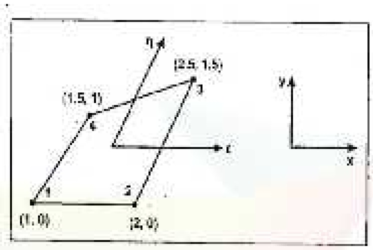
Question No.	Questions	PO Attainment
UNIT 3 – TWO DIMENSIONAL SCALAR PROBLEMS		
PART-A (Two Marks Questions)		
1	How do you define two dimensional elements?	**PO1**
2	What is meant by plain stress analysis?	**PO1**
3	What is a CST element?	**PO1**
4	Write a displacement function equation for CST element?	**PO1**
5	Write a strain-displacement matrix for CST element.	**PO1**
6	Write down the stress-strain relationship matrix for plane stress condition.	**PO1**
7	Define a plane stress condition.	**PO1**
8	Define plane strain with suitable example.	**PO1**
9	Write down the stress-strain relationship matrix for plane strain condition.	**PO1**
10	Write down the stiffness matrix equation for two-dimensional CST element?	**PO1**
11	Write down the expression of shape function, N and temperature function, T for one dimensional heat conduction element.	**PO1**
12	Define heat transfer?	**PO1**
PART-B (Ten Marks Questions)		
1	Derive the shape function for the constant strain triangular element.	**PO1**
2	Determine the shape functions N_1, N_2 and N_3 at the interior point P for the triangular element shown in figure.	**PO1,PO2**

		
3	Determine the x and y co-ordinates of point P for the triangular element shown in figure. The shape functions N_1 and N_2 are 0.2 and 0.3 respectively. 	**PO1,PO2**
4	For the constant triangular element shown in figure below, assemble strain-displacement matrix. Take t=20mm and E=2 x 10^5 N/mm^2. 	**PO1,PO2**
5	Calculate the stiffness matrix for the elements shown in figure below.  The coordinates are given in units of millimeters. Assume plane stress conditions. Take E= 2.1 x 10^5 N/mm^2, v= 0.25, t=10mm.	**PO1,PO2**
6	For the plane stress elements shown in figure below, the nodal displacements are: u_1= 2.0mm, u_2= 0.5mm, u_3= 3.0mm v_1= 1.0mm, v_2= 0.0 mm, v3= 1.0mm  Determine the elemental stresses $\sigma_x,\sigma_y,\tau_{xy}$. Let E=210 GPa, v= 0.25 and t=10mm. All co-ordinates are in millimeters.	**PO1,PO2**

7	Calculate the elemental stresses $\sigma_x, \sigma_y, \tau_{xy}$ for the element shown in figure below.  The nodal displacements are: u_1= 2.0mm, u_2= 0.5mm, u_3= 3.0mm v_1= 1.0mm, v_2= 0.0 mm, v3= 1.0mm Take E= 2.1 x 10^5 N/mm^2, v= 0.25. Assume plane stress condition.	**PO1,PO2**
8	For the triangular element shown in figure, obtain the strain-displacement relation matrix [B] and determine the strains e_x ,e_y and Υxy.  The nodal displacements are: u_1= 0.001 mm, u_2= 0.003 mm, u_3= 0.002 mm v_1= -0.004 mm, v_2= 0.002 mm, v3= 0.005 mm	**PO1,PO2**
9	Calculate the strain-displacement relation matrix[B], stress-strain relationship matrix [D] and the temperature force vector for the plane stress element shown in figure. The element experiences a 20°C increase in temperature. Assume coefficient of thermal expansion is 6 x 10^{-6}/°C.  Take E= 2.1 x 10^5 N/mm^2,poisson's ratio v= 0.25, thickness t= 5 mm	**PO1,PO2**
10	The two-dimensional propped beam shown in figure below is divided into two CST elements. Determine the nodal displacements and element stresses using plane stress conditions for any one CST element. Body force is neglected in comparison with the external forces. Take thickness t = 10mm, Young's Modulus E = 2 x 10^5 N/mm^2, v= 0.25  	**PO1,PO2**

Question No.	Questions	PO Attainment
	UNIT 4 – VECTOR VARIABLE PROBLEMS AND ISOPARAMETRIC ELEMENTS	
	PART-A (Two Marks Questions)	
1	What is axisymmetric element?	**PO1**
2	What are the conditions for the problems to be in axisymmetric?	**PO1**
3	Write down stress-strain relationship matrix for axisymmetric triangular element	**PO1**
4	What are the ways in which three dimensional problems can be reduced into two-dimensional approach?	**PO1**
5	Give the stiffness matrix equation for axisymmetric triangular element.	**PO1**
6	Write down the shape function for 4 noded rectangular element using natural coordinate system	**PO1**
7	Write down the jacobian matrix for four noded quadrilateral element.	**PO1**
8	Write down the element force vector equation for four noded quadrilateral element.	**PO1**
9	What is the purpose of isoparametric element?	**PO1**
10	Write down the gaussian quadrature expression for numerical integration.	**PO1**
	PART-B (Ten Marks Questions)	
1	Determine the stiffness matrix for the axisymmetric element shown in fig.Take $E = 2.1 \times 10^5$ N/mm^2 and Poisson's ratio v= 0.25. All dimensions are inmm. 	**PO1,PO2**
2	The nodal coordinates of an axisymmetric triangular element is given below. Evaluate strain-displacement matrix[B] for the element. r_1= 10mm, r_2= 30mm, r_3= 30mm z_1=10mm, z_2= 10mm, z_3= 40mm 	**PO1, PO2**
3	The nodal coordinates of an axisymmetric triangular element is given below. r_1= 20mm, r_2= 40mm, r_3= 30mm z_1=40mm, z_2= 40mm, z_3= 60mm Evaluate strain-displacement matrix[B] for the element.	**PO1, PO2**

		
4	For the axisymmetric element shown in figure below, determine the element stresses. Take $E = 2.1 \times 10^5$ N/mm^2 and Poisson's ratio v= 0.25. All dimensions are in mm. The nodal displacements are: u_1= 0.05mm, u_2= 0.02 mm, u_3= 0 mm w_1=0.03 mm, w_2= 0.02 mm, w_3= 0 mm 	PO1, PO2
5	Calculate the element stiffness matrix and the thermal force vector for the axisymmetric triangular element shown in figure. The element experiences a 15°C increase in temperature. The coordinates are in mm. Take α= 10 x 10^{-6}/°C, E = 2.1 x 10^5 N/mm^2, v= 0.25. 	PO1, PO2
6	Evaluate the cartesian co-ordinate of the point P which has local coordinates ε= 0.6, Ƞ = 0.8, as shown in fig below. 	PO1, PO2
7	For the isoparametric quadrilateral element shown in figure below, determine the local co-ordinates of the point P which has cartesian co-ordinates (7,4). 	PO1, PO2
8	A four noded rectangular element is shown in figure below. Determine the following: 1) Jacobian matrix 2) Strain-displacement matrix 3) Element stresses	PO1, PO2

		
9	For the element shown in fig below, determine the Jacobian matrix 	**PO1,PO2**
10	Evaluate the Jacobian matrix for the isoparametric quadrilateral element shown in figure below. 	**PO1, PO2**

Question No.	Questions	PO Attainment
	UNIT 5 NUMERICAL INTEGRATION AND APPLICATIONS IN HEAT TRANSFER	
	PART-A (Two Marks Questions)	
1	Write down the stiffness matrix equation for one dimensional head conduction element	**PO1**
2	What is numerical integration ?	**PO1**
3	Define element capacitance matrix for unsteady state heat transferproblems.	**PO1**
4	Name a few boundary conditions involved in any heat transfer analysis.	**PO1**
5	Mention two natural boundary conditions as applied to thermalproblems.	**PO1**
6	Name any four finite element anaylsis software.	**PO1**
7	What is the structure of finite element analysis program.	**PO1**
8	What are the various input required to define a problem in FEA software.	**PO1**
9	What is meant by Isoparametric effect?	**PO1**
10	Is beam element is anisoparametric element?	**PO1**
	PART-B (Ten Marks Questions)	
1	Evaluate $\int_{-1}^{1}(x^4+x^2)\,dx$ by applying Gaussian quadrate	**PO1, PO2**
2	Evaluate $\int_{-1}^{1}(x^4-3x+7)dx$ by using Gaussian quadrate	**PO1, PO2**
3	A) I = $\int_{-1}^{1} e^{-x}dx$ by using 3 points method	**PO1, PO2**

	B) I = $\int_{-1}^{1} \cos(\frac{x}{2})\,dx$ by using 3 point method	
4	Explain numerical integration and evaluate integral by using Gaussian quadrature $\int_{-1}^{1} x^2\,dx$	**PO1, PO2**
5	Evaluate $\int_{-1}^{1}(2 + x + x^2)dx$ and compare with exact solution.	**PO1, PO2,**
6	Evaluate $\int_{-1}^{1} \frac{\cos x}{1-x^2}\,dx$ by applying 3 point Gaussian quadrature.	**PO1, PO2**

Prepared by
Mr.P.Gnana Prakash,
Asst Professor,
SITAMS.

*****ALL THE BEST*****