INSTITUTEOFAERONAUTICALENGINEERING

(Autonomous)

Dundigal,Hyderabad-500043

CIVIL ENGINEERING

TUTORIALQUESTION BANK

Course Name	:	**FINITE ELEMENT METHOD IN STRUCTURAL ENGINEERING**
Course Code	:	BST001
Class	:	M. Tech(StructuralEngineering) – IIsemester
Department	:	Civil Engineering
Academic Year	:	2018–2019
Course Faculty	:	Mr.Gude Rama krishna,Professor

I. COURSEOVERVIEW:

TheFiniteElementMethod(FEM)iswidelyusedinindustryforanalysingandmodellingstructuresandcontinua,whose physicalbehaviourisdescribedbyordinaryandpartialdifferentialequations.TheFEMisparticularlyusefulforenginee ringproblemsthataretoocomplicatedtobesolvedbyclassicalanalyticalmethods.Themainobjectiveofthiscourseistoi ntroducethemathematicalconceptsoftheFiniteElementMethodforobtaininganapproximatesolutionofordinaryand partialdifferentialequations.Inthiscourseyouwillattendlecturesonthefundamentalsoftheory FiniteElementMethod.Th elearningprocesswillbeenhancedbycompletingassignmentsusingmathematicalsoftware.Youwillalsobeintroduce dtoacommercialFiniteElementsoftwarepackage–ANSYS– duringlectureswithcomputerlaboratoriesprovidingopportunitiestopracticeon,andtocompletepracticalassignments ,usingANSYS.

II. COURSEOBJECTIVES:

Thecourseshouldenablethestudentsto:

I	EquipthestudentswiththeFiniteElementAnalysisfundamentals.
II	Enablethestudentstoformulatethedesignproblemsinto FiniteElementMethod(FEM).
III	Developtheabilitytogeneratethegoverningfiniteelementequationsforsystems.
IV	Developtheabilitytogeneratethegoverningfiniteelementequationsforsystems.
V	Understandtheuseofthebasicfiniteelementsforstructuralapplicationsusingtruss,beam,frameandplateelements.

COURSELEARNINGOUTCOMES:

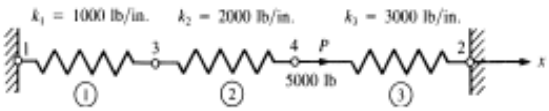
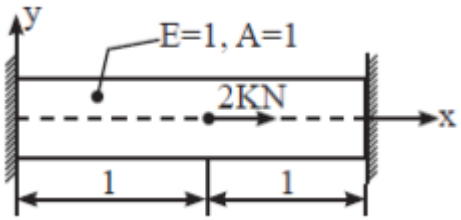
Students,whocompletethecourse,willhavedemonstratedtheabilitytodothefollowing:

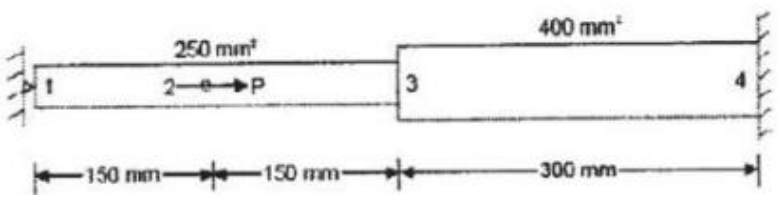
CLO Code	CLO's	At the end of the course, the student will have the ability to:	PO's Mapped	Strength of Mapping
CBST001.01	CLO 1	Understand the Concepts of FEM, steps involved merits and demerits.	PO 1	3
CBST001.02	CLO 2	Solve the problems using Raleigh-Ritz method of functional approximation.	PO 1	3

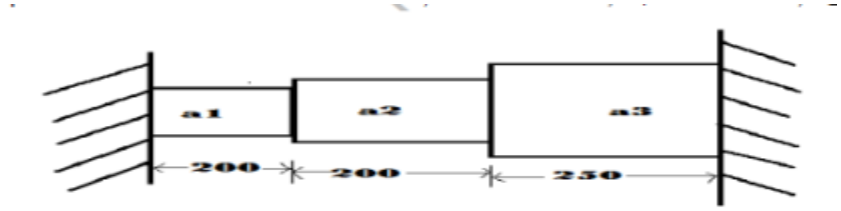
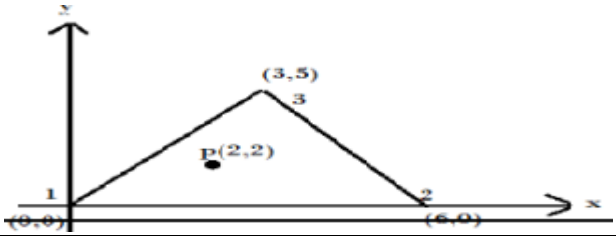
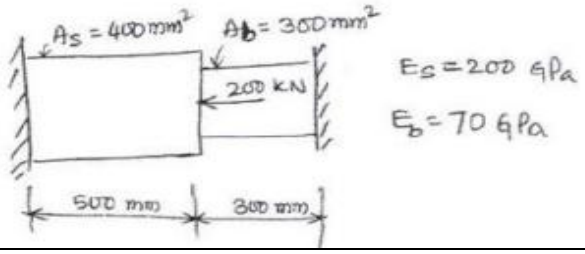
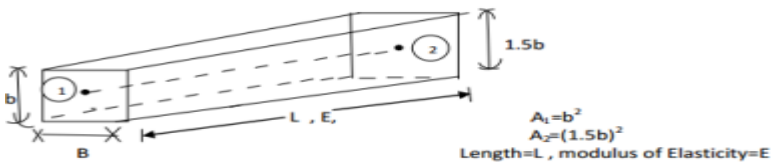
CBST001.03	CLO 3	Understand the concept of One dimensional FEM Stiffness matrix for beam and bar elements.	PO 1	3
CBST001.04	CLO 4	Know the generalized coordinates, shape functions.	PO 3	2
CBST001.05	CLO 5	Different types of elements for plane stress and plane strain analysis, displacement models.	PO 3	2
CBST001.06	CLO 6	Generalized coordinates, shape functions, convergent and compatibility requirements.	PO 4	2
CBST001.07	CLO 7	Understand the generation of element stiffness and nodal load matrices.	PO 4	2
CBST001.08	CLO 8	Know the natural coordinate system, area and volume coordinates.	PO 4	2
CBST001.09	CLO 9	Concept of Axisymmetric bodies of revolution, axisymmetric modeling.	PO 1	2
CBST001.10	CLO 10	Know the different 3-D elements strain, displacement relationship.	PO 4	2
CBST001.11	CLO 11	Concept of Axisymmetric bodies of revolution, axisymmetric modeling.	PO 1	3
CBST001.12	CLO 12	Understand the strain displacement relationship, formulation of axisymmetric elements.	PO 4	3
CBST001.13	CLO 13	Concept of isoparametric formulation, different isoparametric elements for 2D analysis.	PO 4	2
CBST001.14	CLO 14	Concept of Axisymmetric bodies of revolution, axisymmetric modeling.	PO 4	3
CBST001.15	CLO 15	Understand the strain displacement relationship, formulation of axisymmetric elements.	PO 3	2
CBST001.16	CLO 16	Concept of Plane Stress, CST Element, Plane Strain Rectangular Element	PO 3	3
CBST001.17	CLO 17	Understand the Principle Isoperimetric Formulation of the Plane Quadrilateral Element, Axi- Symmetric element.	PO 1, PO 4	2
CBST001.18	CLO 18	Introduction to Computer Implementation of FEM ,use of commercial FEA Software.	PO 1, PO 3	2

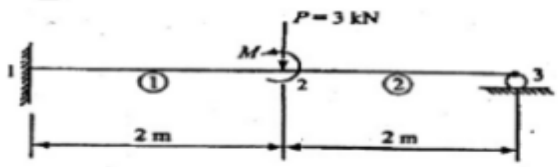
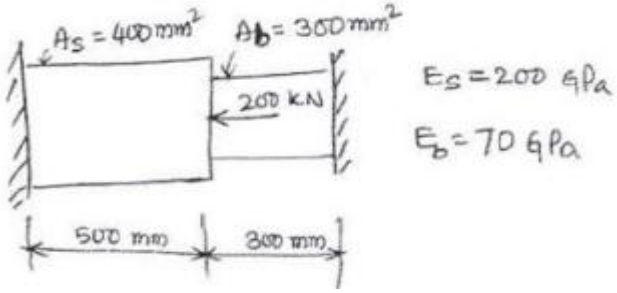
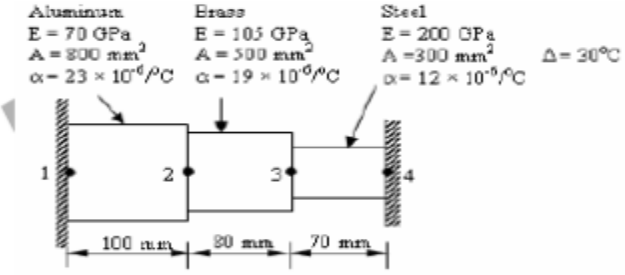
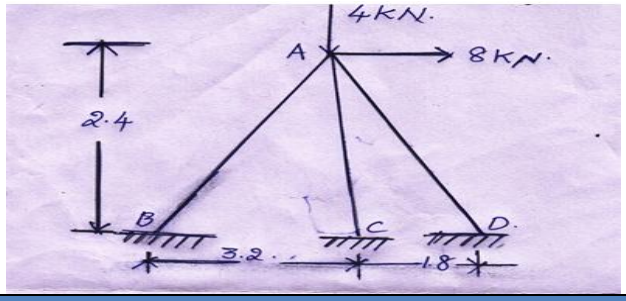
TUTORIALQUESTIONBANK

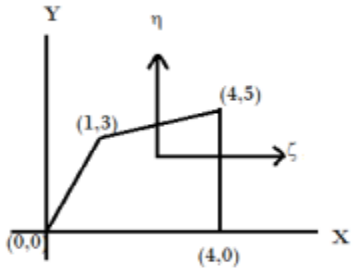
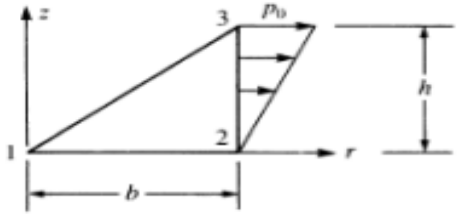
UNIT–I			
INTRODUCTION			
Part-A(ShortAnswerQuestions)			
1	Briefly explain about Finite Element Method?	Remember	CBST001.01
2	Defineabout volume co- ordinates.	Remember	CBST001.02
3	WhatisRaleigh-RitzmethodFiniteElementMethod?	Remember	CBST005.03
4	What are the steps involved in Finite Element Method?	Remember	CBST001.02
5	Define Degree of freedom and priciple of nvirtual work.	Remember	CBST001.04
6	Explain about potential energy principle.	Remember	CBST001.02
7	Explain about descretization of finiteelementmethod?	Remember	CBST001.02
8	Explain about descretization of finiteelementmethod?	Remember	CBST001.01
9	Distinguish between the problems of'Planestress'and'Planestrain'	Remember	CBST001.02
Part-B(LongAnswerQuestions)			
1	Find out deflection at centre of a simply supported beam of span length(L) subjected to uniformly distributed load through out its length of intensity w per	Apply	CBST001.01

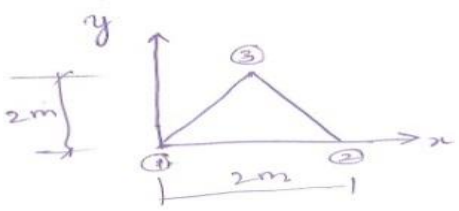
	unit length. Use Rayleigh Ritz method.Take EI is constant		
2	Write the potential energy for beam of span 'L 'simply supported a tends, subjected to a concentrated load 'P' at mid span. Assume EI is constan	Apply	CBST001.01
3	Solve the following differential equation using Ritz method. $d^2y/dx_2=\sin(\pi x)$ boundary condition su(0)=0 and u(1)=0	Apply	CBST001.02
3	Using Rayleigh Ritz method, find the maximum deflection of simply supported beam with point load at center.	Apply	CBST001.02
5	Determinethedeflectionofcantileverbeamoflength'Landloadedwithaverticalload atthefreeendbyRayleigh-Ritzmethod.Useatrailfunction	Apply	CBST001.03
6	Determinethedeflectionofcantileverbeamoflength1landloadedwithverticalloadpa tthefreeendbyRayleighRitzmethod	Apply	CBST001.04
7	Derivethefiniteelementequationusingthepotentialenergyapproach.	Apply	CBST001.04
8	Statetheprincipleofminimumpotentialenergy.Explainthepotential,with usualnotation	Apply	CBST001.05
9	Ifadisplacementfieldisdescribedbyu=$(x^2-2y^2+6xy)10^{-4}$andv=(6x+3y)10-4.Determine$\varepsilon_x,\varepsilon_yand\gamma_{xy}$atthepointx=2andy=1.	Apply	CBST001.01
	Part-C(ProblemSolvingandCriticalThinkingQuestions)		
1	Forthespringassemblagewitharbitrarilynumberednodesshowninfigureobtain(a)t heglobalstiffnessmatrix,(b)thedisplacementsofnodes3and4,(c)thereactionforces atnodes1and2,and(d)theforcesineachspring.Aforceof5000lbisappliedatnode4int hexdirection.Thespringconstantsaregiveninthefigure.Nodes1and2arefixed. 	Analyze& evaluate	CBST001.01
2	Obtain stiffness matrix for truss element with 2-degree of freedom.	Analyze& evaluate	CBST001.01
3	AsimplysupportedbeamofspanL,young'smodulus,momentofinertiaIissubjected toauniformlydistributedloadofP/unitlength.DeterminethedeflectionWatthemids pan.UseRayleighRitzmethod.	Analyze& evaluate	CBST001.01
4	WhatarethestepsinvolvedinRayleigh-Ritzmethod?Determinethedisplacementatmidpointandstressinlinearone-dimensionalrodasshowninfigure.Useseconddegreepolynomialapproximation,fo 	Analyze& evaluate	CBST001.03
5	Determinethedeflectionofcantileverbeamoflength'Landloadedwithaverticalload PatthefreeendbyRayleigh-Ritzmethod.Useatrailfunction $y = a\left[1 - \cos\left(\frac{\pi x}{2L}\right)\right]$	Analyze& evaluate	CBST001.03

6	ForasimplysupportedBeamofuniformlydistributedloadofIntensityPoperunitlengthandaconcentratedloadPatcenter,FindtheTransversedeflectionusingRaleigh-RitzmethodofFunctionalEvaluationandcomparetheresultwithexactAnalyticalsolution.	Analyze& evaluate	CBST001.04
7	Inaplanestressproblemσx=60MPa,σy=-35MPa,τxy=50MPa,E=200,GPa,μ=0.3. i)Determinestraincomponentεz ii)Iftheproblemisacaseofplanestraincasedeterminestresscomponentσz	Analyze& evaluate	CBST001.04
8	IllustratetheRayleigh-Ritzmethodindetailbyapplyingitonanaxiallyloadedbaratoneendandfixedatoneendasshownin fig. 	Analyze& evaluate	CBST001.05
9	DerivetheconstitutivematrixforPlaneStressandPlanestrainelements.Giveatleasttwopracticalexamplesfor PlanestresssandPlanestrainanalysis.	Analyze& evaluate	CBST001.05
	UNIT–II		
	BEAM ELEMENTS		
	Part-A(ShortAnswerQuestions)		
1	Whatarethepropertiesofshapefunctions?	Remember	CBST001.06
2	Writetheshapefunctionforconstantstraintrianglebyusingpolynomialfunction?	Remember	CBST001.06
3	Writedowntheshapefunctionsforfournodedrectangularelements?	Remember	CBST001.06
4	Whatisdisplacementandshapefunction?	Remember	CBST001.07
5	Deriveshapefunctionsfora2Dbeamelement.	Remember	CBST001.07
6	Distinguishbetween1Dbarelementand1Dbeamelement	Remember	CBST001.09
7	Writetheshapefunctionforconstantstraintrianglebyusingpolynomialfunction?	Remember	CBST001.09
8	Writetheshapefunctionforconstantstraintrianglebyusingpolynomialfunction?	Remember	CBST001.10
9	Writethe natural coordinatesforthepointPofthetriangularelement.ThepointPistheC.Gofthetriangle.	Remember	CBST001.11
	Part-B(LongAnswerQuestions)		
1	Derivethestrain-displacementmatrix(B-matrix)forplanestressanalysisofthreenodetriangularelement	Apply	CBST001.06
2	Determinenodaldisplacement,elementstressesandsupportreactionsoftheaxiallyloadedbarasshowninfig 	Apply	CBST001.06
3	Thenodalcoordinatesofthetriangularelementare1(1,1),2(4,2),3(3,5).Attheinterior pointP,thex-coordinateis3.5andN1is0.4.DetermineN2,N3andy-coordinateatpointP.	Apply	CBST001.07
4	Thenodalcoordinatesofthetriangularelementare1(2,2),2(5,3),3(6,7).Attheinterior pointP,thex-coordinateis3.5andN1is0.4.DetermineN2,N3andy-coordinateatpointP.	Apply	CBST001.07
5	Explain steps involved or procedure to obtain general stiffness matrics and strain-displacement relation.	Apply	CBST001.07
6	Driv ethe shape function for a Quadratic model for triangular element with neat sketch	Apply	CBST001.08

7	DerivetheshapefunctionsforIDcubicelement.Shapefunctionsshouldspecifiedinboth naturalandglobalcoordinatesystems.	Apply	CBST001.09
8	Deriveshapefunctionsandtheirderivativesforalineelementwithquadraticinterpolation function.	Apply	CBST001.10
9	Atwonodedlineelementwithonetranslationaldegreeoffreedomissubjectedtouniformlyvaryingloadofintensity P1atnode1andP2atnode2.Evaluatethenodalloadvector usingnumericalintegration.	Apply	CBST001.11
	Part-C(ProblemSolvingandCriticalThinkingQuestions)		
1	Forthesteppedbarshowninthefigurebelow,determinethenodaldisplacements,element stressandsupportreactions.TakeP=500kN,E=210GPa,a1=200mm2,a2=300mm2anda3=500mm2. 	Analyze& evaluate	CBST001.06
2	EvaluatetheshapefunctionsN1,N2andN3attheinteriorpointPforthetriangularelementshowninthefigurebelow. 		CBST001.06
3	Findthenodaldisplacement,stressesandreactionofaFig.useapenaltyapproachmethod 	Analyze& evaluate	CBST001.07
4	Explain what you understand by convergence requirements, and conditions To be satis fied by the assumed displacement function. What are compatibility requirements and geometric isotropy	Analyze& evaluate	CBST001.07
5	Explainformulationofonedimensionalnonprismaticbarelement.Assumecrosssectionaldimensionsb×batnode 1)And1.5b×1.5batnode 2)Andstraightedgesconnectionsthecrosssectionasshowninfigure 	Analyze& evaluate	CBST001.08
6	Determinethedisplacementsandslopesatthenodesforthebeamshowninfigure.Find		

	themomentatthemidpointofelement1. 		
7	EvaluatetheshapefunctionsN_1,N_2,N_3at theinteriorpointP(3.85,4.8)forthetriangularelementshowninfig 		
8	Forthethreesteppedbarshowninfig.2,thefitssnuglybetweentherigidwallsatroomtemperature.Thetemperatureisthenraisedby300C.Determinethedisplacementsatnodes2and3,stressesinthethreesections 		
9	Using 2 DOF truss element determine the horizontal and vertical displacement of joints and the forces in all the members of the plane pin jointed frame shown in fig. joints B,C,D are at the same level as shown in figure, c/s area =24oo mm^2, E=2x10^5 N/ mm2 		
UNIT–III			
METHOD OF WEIGHTED RESIDUALS			
Part-A(ShortAnswerQuestions)			
1	Brieflyexplainthetypesofelementsbasedongeometry.	Remember	CBST001.12
2	List some disadvantages of using 3-Delements.	Remember	CBST001.12
3	Whataretheconditionsforaproblemtobeaxisymmetric?	Remember	CBST001.13

4	ExplainLagrangeelementsandSerendipityelements.	Remember	CBST001.13
5	Explaintheisoparametricelementsanditstypes	Remember	CBST001.14
6	Obtaintheshapefunctionsofaninenodedquadrilateralelement.	Remember	CBST001.14
7	Stateandexplainthethreebasiclawsonwhichisoparametricconceptisdeveloped	Remember	CBST001.16
9	Explaintheisoparametricelementsandtheiradvantages	Remember	CBST001.17
9	Define drilling degree of freedom.	Remember	CBST001.18
	Part-B(LongAnswerQuestions)		
1	Derivetheshapefunctionsforthefournodedquadrilateralisoparametricelementandindicatethepurposeforthecomputingitsstiffnessmatrix.	Apply	CBST001.12
2	Writeanoteonisoparametricformulationsandhowthegeometricaswellasfieldvariablesaretakenintoaccount	Apply	CBST001.12
3	Derivetheshapefunctionsforthefournodedquadrilateralisoparametricelementandindicatethepurposeforthecomputingitsstiffnessmatrix	Apply	CBST001.13
4	UsingtheLagrangeinterpolationformulaconstructtheshapefunctioninnaturalcoordinateforonedimensionalaxialelementwith4nodes.Sketchtheshapefunction.	Apply	CBST001.14
5	Explainwithsuitableexampleswhyweresorttoisoparametrictransformation.Differentiatebetweenisoparametric,subparametricandsuperparametricelements.	Understand	CBST001.15
6	Derivethestress-strainrelationshipmatrix(D)fortheaxisymmetrictriangularelement.	Understand	CBST001.16
7	Derivetheelementstiffnessmatrixforafournodedisoparametricplanstresselement.	Understand	CBST001.17
8	Derivetheshapefunctionsfortwonodedonedimensionalelementusing Lagrangeinterpolationformula	Understand	CBST001.18
	Part-C(ProblemSolvingandCriticalThinkingQuestions)		
1	EvaluatetheJacobianmatrixatthelocalco-ordinatesζ,ηare(0,0)fortheelementshowninthebelow 	Apply	
2	Explainfiniteelementformulationfor8-nodedisoperimetricsolidelement.Explainstepbystepprocedureandelaborateallthesteps	Apply	
3	Evaluatethenodalforcesusedtoreplacethelinearlyvaryingsurfacetractionshownin Figure 	Apply	
4	a)Explain about plain stress and plane strain in finite element method. b)Explain about drilling degree of freedom and interpolation constant.		
5	Explain briefly about material and geometric non –linearities		
6	Obtain the formulation finite element method using principle of virtual work.		

UNIT–IV			
TYPES			
Part-A(ShortAnswerQuestions)			
1	What are the required conditions for a problem to be axisymmetric, and explain.	Remember	CBST001.19
2	Explain about Interpolation or shape functionand poly nomonal shape function	Remember	CBST001.19
3	Explain about plain stress trangles	Remember	CBST001.20
4	What are the types of elements used in finite element analysis.	Remember	CBST001.20
5	Whatarethe dvantages and dis advantages of finite element method	Remember	CBST001.20
6	Write on area co ordinats and volum co ordinates.	Remember	CBST001.21
7	Explain about plain stress and plain strain condition	Remember	CBST001.21
8	Explain about Von mises stresses.	Remember	CBST001.21
9	What are the interpolation functions.		
Part-B(LongAnswerQuestions)			
1	Derive general stiffness matrix for 4 noded quadrilateral element.		
2	Derive Jacobian matrix for 4-noded Iso[parametric quadrilaterial two dimentional element.		
3	Explain Reliegh – Ritz method and obtain strain displacement relation matrix.		
4	Obtaon eqalibrium equation for 3D elastic medium and in 2D elastic medium.		
5	Explain about steps involved in finite element analysis with examples.		
6	Obtain the formulation of finite element method using principle of virtual work.		
7	What are the isoparametric element,derive the B matrix for the 4 noded Isoparametrci quadrilateral element.		
8	a)Write down finite element analysis procedure and engineering applications . b)Explain about plane stress triangle.		
Part-C(ProblemSolvingandCriticalThinkingQuestions)			
1	Obtain strain displacement relatioon for the non-zero strains and explain about various Axisymmetric elements.	Apply	
2	Obtain the stiffness matrix for three 3 triangular element with noded as shown  for plane strain saturation (cartician co-ordinates) $E=1.2x10^6$ Kg/cm^2	Apply	
3	Determine the shape functionsN1,N2andN3forthetriangularelement with co-ordinates(2,3),(5,7)and(4,5) all the units are in meters.hence determine the value of N1,N2,N3@centroid of the element	Apply	
4	An axisymmwtric solid subjected to axisymmetric loading .Obtain stress strain displacement matrix and potential energy of two dimensional region defind by there revolving area is divided into triangular element.	Apply	
UNIT–V			
APPLICATION TO SOLID MECHANICS & COMPUTER IMPLEMENTATION			
Part-A(ShortAnswerQuestions)			

1	Explain about various axisymetryc element	Remember	CBST001.22
2	What are the isoparametric elements and advantages.	Remember	CBST001.22
3	DiscussaboutMaterialandGeometricnonlinearity.	Remember	CBST001.22
4	Givet wo examples of geometric nonlinear problems.	Remember	CBST001.22
5	Explain about super isoparametric and sub isoparametricelement.	Remember	CBST001.22
6	Explain about interpolation and shape function.	Remember	CBST001.22
7	Explain about Von mises stress and Volume Co-ordinates.	Remember	CBST001.22
Part–B(LongAnswerQuestions			
1	Generate stiffness matrix for 4 noded tetrahedral element(3D problem).	Understand	CBST001.22
2	Obtain Generate stiffness matrix for 4 noded Qudrilateral element.	Understad	CBST001.22
3	Derive element stiffnesss matrics for an axisymmetric triangular ring element.	Understand	CBST001.22
4	Obtain Generate stiffness matrix for3 noded triangular element for a plane strain saturation condition(Cartition co-ordinates) $E=1.2 \times 10^6$ Kg/cm^2 and $\mu=0.15$	Understand	CBST001.22
5	a)What are the various applications of finite element methods n various engineering fileds.List out any four softwares related to finite element method	Understand	CBST001.22
6	Obtain: a)strian-displacement relation in 2d problem. b)plain strain 2D problem	Understand	CBST001.22
Part–C(ProblemSolvingandCriticalThinkingQuestions			
1	A quadrilaterial finite element has nodes at 1(1,1), 2(4,0), 3(5,4) and 4(0,3)determine $\frac{\partial N1}{\partial x}$ and $\frac{\partial N2}{\partial Y}$ at location $\xi=0$, $\eta=0$ where ξ and η are natural co ordinates	Apply	CBST001.23
2	Derive B matrix (strain –displacement) for a CST(Constant Strain Triangle) element	Apply	CBST001.23
3	What are the isoparametric element derive the B-matrics for 4 nodeed Isoparametric quadrilateral element	Understand	CBST001.23
4	What are the steps involved and uses of general purpose Finite element analysis software	Understand	CBST001.23
5	a)describe properties of shape function b)write short notes on: i)Lagrangrian Elements ii)Serendipity Elements	Understand	CBST001.23
6	a)Explain various axi-symmetric elements. b)Differentiate between isoparametric,super parametric and sub parametric elements.	Understand	CBST001.23
7	a)Explain briefly non-linear analysis,with one application. b)What are the different methods to solve a non-linear problem.	Understand	CBST001.23