Ref No:

SRI KRISHNA INSTITUTE OF TECHNOLOGY

COURSE PLAN

Academic Year 2018-19

Program:	B E – Mechanical Engineering
Semester :	6
Course Code:	17ME61
Course Title:	Finite element Analysis
Credit / L-T-P:	4 / 4-0-0
Total Contact Hours:	50
Course Plan Author:	Sagar H N

Academic Evaluation and Monitoring Cell

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Table of Contents

Note : Remove “Table of Content” before including in CP Book
Each Course Plan shall be printed and made into a book with cover page
Blooms Level in all sections match with A.2, only if you plan to teach / learn at higher levels

A. COURSE INFORMATION

1. Course Overview

Degree:	BE	Program:	ME
Year / Semester :	3/VI	Academic Year:	2019-20
Course Title:	Finite element Analysis	Course Code:	17ME61
Credit / L-T-P:	04/-0-0	SEE Duration:	180 minutes
Total Contact Hours:	50	SEE Marks:	60 Marks
CIA Marks:	40	Assignment	1 / Module
Course Plan Author:	Sagar H N	Sign	Dt:
Checked By:		Sign	Dt:
CO Targets	CIA Target : ...%	SEE Target:	...%

Note: Define CIA and SEE % targets based on previous performance.

2. Course Content

Content / Syllabus of the course as prescribed by University or designed by institute. Identify 2 concepts per module as in G.

Module	Content	Teaching Hours	Identified Module Concepts	Blooms Learning Levels
1	**Introduction to Finite element Analysis :** General description of the Finite element Analysis. Engineering applications of Finite element Analysis. Boundary conditions: homogeneous and non-homogeneous for structural, heat transfer and fluid flow problems. Potential energy method, Rayleigh Ritz method, Galerkin's method, Displacement method of finite element formulation. Convergence criteria, Discretization process, Types of elements: 1D, 2D and 3D, Node numbering, Location of nodes. Strain displacement relations, Stress strain relations, Plain stress and Plain strain conditions, temperature effects. Interpolation models: Simplex, complex and multiplex elements, Linear interpolation polynomials in terms of global coordinates 1D, 2D, 3D Simplex Elements.	10	Elements and nodes	L2 Understand
2	**One-Dimensional Elements**-Analysis of Bars and Trusses, Linear interpolation polynomials in terms of local coordinate's for1D, 2Delements. Higher order interpolation functions for 1D quadratic and cubic elements in natural coordinates, Constant strain triangle, Four-Nodded Tetrahedral Element (TET 4), Eight-Nodded Hexahedral Element (HEXA8), 2D isoparametric element, Lagrange interpolation functions, Numerical integration: Gaussian quadrature one point, two point formulae, 2D integrals. Fore terms: Body force, traction force and point loads, **Numerical Problems:** Solution for displacement, stress and strain in 1D straight bars, stepped bars and tapered bars using elimination approach and penalty approach, Analysis of trusses.	10	Analysis of bars and trusses	L3 Apply
3	**Beams and Shafts:**Boundary conditions, Load vector, Hermite shape functions, Beam stiffness matrix based on Euler-Bernoulli beam theory, Examples on cantilever beams, propped cantilever beams, Numerical problems on simply supported, fixed straight and stepped beams	10	Stiffness matrix for beams and shaft	L3 Apply

	using direct stiffness method with concentrated and uniformly distributed load. **Torsion of Shafts:** Finite element formulation of shafts, determination of stress and twists in circular shafts.			
4	**Heat Transfer:** Basic equations of heat transfer: Energy balance equation, Rate equation: conduction, convection, radiation, energy generated in solid, energy stored insolid, 1D finite element formulation using vibrational method, Problems with temperature gradient and heat fluxes, heat transfer in composite sections, straight fins. **Fluid Flow:** Flow through a porous medium, Flow through pipes of uniform and stepped sections, Flow through hydraulic net works.	10	Heat transfer through 1 D	L3 Apply
5	**Axi-symmetric Solid Elements:** Derivation of stiffness matrix of axisymmetric bodies with triangular elements, Numerical solution of axisymmetric triangular element(s) subjected to surface forces, point loads, angular velocity, pressure vessels. **Dynamic Considerations:** Formulation for point mass and distributed masses, Consistent element mass matrix of one dimensional bar element, truss element, axisymmetric triangular element, quadrilateral element, beam element. Lumped mass matrix of bar element, truss element, Evaluation of eigen values and eigen vectors, Applications to bars, stepped bars, and beams.	10	stiffness matrix solid element	L3 Apply
-	**Total**	**50**	**-**	**-**

3. Course Material

Books & other material as recommended by university (A, B) and additional resources used by course teacher (C).
1. Understanding: Concept simulation / video ; one per concept ; to understand the concepts ; 15 – 30 minutes
2. Design: Simulation and design tools used – software tools used ; Free / open source
3. Research: Recent developments on the concepts – publications in journals; conferences etc.

Modules	Details	Chapters in book	Availability
A	**Text books (Title, Authors, Edition, Publisher, Year.)**	**-**	**-**
1, 2, 3, 4, 5	Logan, D. L., A first course in the Finite element Analysis,6 th Edition, Cengage Learning, 2016. Rao, S. S., Finite element Analysis in engineering, 5 th Edition, Pergaman Int. Library of Science, 2010. 3. Chandrupatla T. R., Finite Elements in engineering, 2nd Edition, PHI, 2013	3, 4	In Lib / In Dept
		2, 4	In Lib/ In dept
B	**Reference books (Title, Authors, Edition, Publisher, Year.)**	**-**	**-**
1, 2	J.N.Reddy, “Finite element Analysis”- McGraw -Hill International Edition.Bathe K. J. Finite Elements Procedures, PHI.	?	In Lib
1, 2	Cook R. D., et al. “Conceptsand Application of Finite Elements Analysis”- 4 th Edition, Wiley & Sons, 2003.	?	Not Available
3, 4, 5	Haleesh “Finite element Analysis”- McGraw -Hill International Edition	?	In lib
C	**Concept Videos or Simulation for Understanding**	**-**	**-**
C1	Numerical method https://www.youtube.com/watch?v=Fvud81pYGOg – 15 Mins		

	https://www.youtube.com/watch?v=TsBTI3tO5-8 – 5 Mins		
C2	Formation of stiffness matrices for bars ,beams ,trusses https://www.youtube.com/watch?v=Fvud91pYGOg – 10 Mins https://www.youtube.com/watch?v=TsBTI453tO5-8 – 15 Mins		
C3	Static and Dynamic analysis for bars and beams https://www.youtube.com/watch?v=Fvud8145pYGOg – 5 Mins https://www.youtube.com/watch?v=TsBTI34662tO5-8 – 5 Mins		
	Lab : https://www.youtube.com/watch?v=P9e7hUNPGVs -		
D	**Software Tools for Design**	-	-
	Klystron Oscillator - Vsim - https://www.txcorp.com/ -		
	Stripline - http://www.atlantarf.com/Stripline.php		
E	**Recent Developments for Research**	-	-
	Improve efficiency - https://ieeexplore.ieee.org/abstract/document/6891996		
F	**Others (Web, Video, Simulation, Notes etc.)**	-	-
1	How Electron / Vacuum Tubes work ? https://www.youtube.com/watch?v=nA_tglygvNo		
?			

4. Course Prerequisites

Refer to GL01. If prerequisites are not taught earlier, GAP in curriculum needs to be addressed. Include in Remarks and implement in B.5.

Students must have learnt the following Courses / Topics with described Content . . .

Modules	Course Code	Course Name	Topic / Description	Sem	Remarks	Blooms Level
3	15ME34	Mechanics of materials		3	-	Understand L2
3	15ME53	Heat transfer		5	-	Understand L2

5. Content for Placement, Profession, HE and GATE

The content is not included in this course, but required to meet industry & profession requirements and help students for Placement, GATE, Higher Education, Entrepreneurship, etc. Identifying Area / Content requires experts consultation in the area.

Topics included are like, a. Advanced Topics, b. Recent Developments, c. Certificate Courses, d. Course Projects, e. New Software Tools, f. GATE Topics, g. NPTEL Videos, h. Swayam videos etc.

Modules	Topic / Description	Area	Remarks	Blooms Level
1	Numerical methods	Higher Study	Gap A seminar on Finite element Analysis	Understand L2

B. OBE PARAMETERS

1. Course Outcomes

Expected learning outcomes of the course, which will be mapped to POs. Identify a max of 2 Concepts per Module. Write 1 CO per Concept.

Modules	Course Code.#	Course Outcome **At the end of the course, student should be able to . . .**	Teach. Hours	Concept	Instr Method	Assessment Method	Blooms' Level
1	17ME61.1	Understand the concept of elements and boundary conditions	10	Elements and nodes	Lecture	Slip Test	Understand L2
2	17ME61.2	Analysis of bars and trusses	10	Bars and	Lecture	Assignm	L4

		under different kind of loading.		trusses	/ PPT	ent	Analyze
3	17ME61.3	Analysis of beams and Shaft under different kind of loading.	10	Beams and Shafts	Lecture	Slip test	L4 Analyze
4	17ME61.4	Analysis of heat transfer in composite sections	10	Heat transfer in Composite wall	Lecture	Assignment and Slip Test	L4 Analyze
5	17ME61.5	Understand the stiffness matrix, eigen values and eigen vectors a xi-symmetric body	10	stiffness matrix solid element	Lecture	Assignment	Understand L2
	-	**Total**	**50**	**-**	**-**	**-**	

2. Course Applications

Write 1 or 2 applications per CO.
Students should be able to employ / apply the course learnings to . . .

Modules	Application Area Compiled from Module Applications.	CO	Level
1	Radial load fatigue analysis and Bending fatigue analysis	CO1	L2
2	Mechanical engineering discipline (such as aeronautical, biomechanical, and automotive industries.	CO1	L2
3	Analysis of temperature gradient in fins ,boilers	CO2	L2
4	Dynamic analysis of bars and beam	CO2	L2
5	Analysis of temperature gradient in fins ,boilers	CO3	L3
6	Heat conduction through composite wall and pipes in industries	CO3	L3
7	Heat conduction through composite wall and pipes in industries	CO4	L2
8	Analysis of temperature gradient in fins ,boilers	CO4	L2
9	Dynamic analysis of bars and beam	CO5	L2
10	Formulation for point mass and distributed masses in different element	CO5	L2

3. Mapping And Justification

CO – PO Mapping with mapping Level along with justification for each CO-PO pair.
To attain competency required (as defined in POs) in a specified area and the knowledge & ability required to accomplish it.

Modules	Mapping		Mapping Level	Justification for each CO-PO pair	Level
-	**CO**	**PO**	**-**	**'Area': 'Competency' and 'Knowledge' for specified 'Accomplishment'**	**-**
1	CO1	PO1	3	'Engineering Knowledge:' - Acquisition of Engineering Knowledge of element and nodes is essential to accomplish solutions to complex engineering problems in Mechanical Engineering.	L2
	CO1	PO2	2	'Problem Analysis': Analyzing problems require knowledge / understanding of Numerical methods and element and nodes is essential to accomplish solutions to complex engineering problems in Mechanical engineering.	L3
2	CO2	PO1	3	'Engineering Knowledge:' - Acquisition of Engineering Knowledge of cubic and Quad element is essential to accomplish solutions to complex engineering problems in Mechanical Engineering.	
	CO2	PO2	2	'Problem Analysis': Analyzing problems require knowledge / understanding of bars and Trusses and boundary condition is essential to solutions to complex engineering problems in Mechanical engineering.	
3	CO3	PO1	3	'Engineering Knowledge:' - Acquisition of Engineering Knowledge of Beams is essential to accomplish solutions to complex engineering problems in Mechanical Engineering.	
	CO3	PO2	2	'Problem Analysis': Analyzing problems require knowledge / understanding of Beams ,Shaft and boundary condition is essential to solutions to complex engineering problems in	

				Mechanical engineering.	
4	CO4	PO1	3	'Engineering Knowledge:' - Acquisition of Engineering Knowledge of Modes of heat Transfer is essential to accomplish solutions to complex engineering problems in Mechanical Engineering.	
	CO4	PO2	2	'Problem Analysis': Analyzing problems require knowledge / understanding of conduction and convection and boundary condition is essential to solutions to complex engineering problems in Mechanical engineering.	
5	CO5	PO1	3	'Engineering Knowledge:' - Acquisition of Engineering Knowledge of solid element is essential to accomplish solutions to complex engineering problems in Mechanical Engineering.	
	CO5	PO2	2	'Problem Analysis': Analyzing problems require knowledge / understanding of formulation of stiffness matrix for solid element is essential to solutions to complex engineering problems in Mechanical engineering.	

4. Articulation Matrix

CO – PO Mapping with mapping level for each CO-PO pair, with course average attainment.

-	-	Course Outcomes	Program Outcomes															-
Modules	CO.#	**At the end of the course student should be able to . . .**	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	Level
1	17ME61.1	Understand the concept of elements and boundary conditions	√	√	-	-	-	-	-	-	-	-	-	-	-	-	-	L2
2	17ME61.2	Analysis of bars and trusses under different kind of loading.	√	√	-	-	-	-	-	-	-	-	-	-	-	-	-	L3
3	17ME61.3	Analysis of beams and Shaft under different kind of loading.	√	√	-	-	-	-	-	-	-	-	-	-	-	-	-	L3
4	17ME61.4	Analysis of heat transfer in composite sections	√	√	-	-	-	-	-	-	-	-	-	-	-	-	-	L3
5	17ME61.5	Understand the stiffness matrix, eigen values and eigen vectors a xi-symmetric body	√	√	-	-	-	-	-	-	-	-	-	-	-	-	-	L2
-	**CS501PC**	**Average attainment (1, 2, or 3)**			-	-	-	-	-	-	-	-	-	-	-	-	-	**-**
-	*PO, PSO*	*1.Engineering Knowledge; 2.Problem Analysis; 3.Design / Development of Solutions; 4.Conduct Investigations of Complex Problems; 5.Modern Tool Usage; 6.The Engineer and Society; 7.Environment and Sustainability; 8.Ethics; 9.Individual and Teamwork; 10.Communication; 11.Project Management and Finance; 12.Life-long Learning; S1.Software Engineering; S2.Data Base Management; S3.Web Design*																

5. Curricular Gap and Content

Topics & contents not covered (from A.4), but essential for the course to address POs and PSOs.

Modules	Gap Topic	Actions Planned	Schedule Planned	Resources Person	PO Mapping
1	Numerical Methods	Seminar	2nd week / date	Dr XYZ, Inst	List from B4 above

6. Content Beyond Syllabus

Topics & contents required (from A.5) not addressed, but help students for Placement, GATE, Higher Education, Entrepreneurship, etc.

Modules	Gap Topic	Area	Actions Planned	Schedule Planned	Resources Person	PO Mapping
1	ANSYS HFSS - High Frequency Software Simulation Tool	Placement, GATE, Higher Study, Entrepreneurship.	Presentation by students & Mini Project	3rd week / date	Dr ABC, Inst. Self	List from B4 above

C. COURSE ASSESSMENT

1. Course Coverage

Assessment of learning outcomes for Internal and end semester evaluation. Distinct assignment for each student. 1 Assignment per chapter per student. 1 seminar per test per student.

Modules	Title	Teach. Hours	No. of question in Exam						CO	Levels
			CIA-1	CIA-2	CIA-3	Asg	Extra Asg	SEE		
1	Introduction to Finite Element	10	2	-	-	1	1	2	CO1	L2
2	One-Dimensional Elements-analysis of bar and trusses	102	2	-	-	1	1	2	CO2	L3
3	Beams and Shafts and Torsion of Shafts	8	-	2	-	1	1	2	CO3	L3
4	Heat Transfer and Fluid Flow	10	-	2	-	1	1	2	CO4	L3
5	Axi-symmetric Solid Elements: Dynamic Considerations	12	-	-	4	1	1	2	Co5	L2
-	**Total**	**50**	**4**	**4**	**4**	**5**	**5**	**10**	-	-

2. Continuous Internal Assessment (CIA)

Assessment of learning outcomes for Internal exams. Blooms Level in last column shall match with A.2.

Modules	Evaluation	Weightage in Marks	CO	Levels
1,2	CIA Exam – 1	30	CO1, CO2	L2,L3
3,4	CIA Exam – 2	30	CO3, CO4	L3,L3
5	CIA Exam – 3	30	Co5	L2
1,2	Assignment - 1	10	CO1, CO2	L2,L3
3,4	Assignment - 2	10	CO3, CO4	L3,L3
5	Assignment - 3	10	Co5	L2
	Seminar - 1	00		
	Seminar - 2	00		
	Seminar - 3	00		
	Other Activities – define – Slip test			
	Final CIA Marks	**40**	-	-

D1. TEACHING PLAN - 1

Module - 1

Title:	Introduction to Finite Element	Appr Time:	10Hrs
a	***Course Outcomes***	-	**Blooms**
-	Student should able to	-	**Level**
1	Understand the concept of elements and boundary conditions	CO1	L2
b	***Course Schedule***	-	-
Class No	**Module Content Covered**	**CO**	**Level**
1	General description of the Finite element Analysis. Engineering applications of Finite element Analysis. Boundary conditions: homogeneous and non homogeneous for structural, heat transfer and fluid flow problems.	C01	L2
2	Potential energy method, Rayleigh Ritz method, Galerkin's method, Displacement method of finite element formulation. Convergence criteria, Discretization process	CO1	L2
3	Types of elements: 1D, 2D and 3D, Node numbering, Location of nodes.	CO1	L2
4	Strain displacement relations, Stress strain relations, Plain stress and Plain strain conditions, temperature effects.	CO1	L2
5	Simplex, complex and multiplex elements, Linear interpolation polynomials in terms of global coordinates 1D, 2D, 3D Simplex Elements.	CO2	L2
c	**Application Areas**	**CO**	**Level**
1	Radial load fatigue analysis and Bending fatigue analysis	CO1	L2
2	Mechanical engineering discipline (such as aeronautical, biomechanical, and automotive industries.	CO1	L2
d	**Review Questions**		-
1	Explain plane stress and plain strain problems with suitable examples.	CO1	L2
2	Define FEM, explain basic steps involved in FEM.	CO1	L2
3	With an example, Explain node numbering scheme.	CO1	L2
4	Explain principle of minimum potential energy and principle of virtual work.	CO1	L2
5	Explain convergence requirement of a polynomial displacement model.	CO1	L2
6	Explain simplex, Complex and multiplex elements.	CO1	L2
7	what is geometric isotropy? Sketch and explain pascal triangle for 2D polynomials.	CO1	L2
8	Determine the maximum deflection of the beam as shown in fig 1.8 Take E = 200 GPa & I = $2x10^{-9}$ m^4. Use Rayleigh ritz method.	CO1	L2
9	Determine the displacement of the bar as shown in Fig. 1.9. use Rayleigh ritz method for the solution. Take E = 70 GPa.	CO1	L2
10	Explain steps involved in Galerkin's method.	CO1	L2
11	using Galerkin's method, obtain an approximate solution of the differential equation. $\frac{d^2u}{dx^2}-10x^2=5, 0\le x\le 1, at\, u(0)=0, u(1)=0$	CO1	L2
e	**Experiences**		-
1			L2

Module – 2

Title:	One-Dimensional Elements-analysis of bar and trusses	Appr Time:	10 Hrs
a	***Course Outcomes***	-	**Blooms**
-	Student should able to	-	**Level**
1	Analysis of bars and trusses under different kind of loading.	CO2	L3
b	***Course Schedule***	-	-
Class No	**Module Content Covered**	**CO**	**Level**
1	Linear interpolation polynomials in terms of local coordinate's for1D, 2Delements.	CO2	L3
2	Higher order interpolation functions for 1D quadratic and cubic elements in natural coordinates.	CO2	L3
3	Constant strain triangle, Four-Nodded Tetrahedral Element (TET 4), Eight-Nodded Hexahedral Element (HEXA28).	CO2	L3
4	2D isoparametric element, Lagrange interpolation functions, Numerical integration: Gaussian quadrature one point, two point formulae, 2D integrals. Fore terms: Body force, traction force and point loads.	CO2	L3
5	Solution for displacement, stress and strain in 1D straight bars, stepped bars and tapered bars using elimination approach and penalty approach.	CO2	L3
6	Analysis of trusses.	CO2	L3
		CO2	
c	**Experiences**	**CO**	**Level**
1			L3
d	**Review Questions**	-	-
1	What is an interpolation function?	CO2	L3
2	Derive the shape function of the bar element in local co-ordinate system.	CO2	L3
3	Derive the interpolation function of quadratic bar element in natural co-ordinate system.	CO2	L3
4	Derive the stiffness matrix for CST element.	CO2	L3
5	Explain the concepts of iso, sub and super parametric elements.	CO2	L3
6	Derive the shape function for the nine – noded quadrilateral element.	CO2	L3
7	Using lagrangian method, derive the shape functions of quadrilateral element.	CO2	L3
8	Evaluate the values of ω_1, $\omega_2, \xi_1, \wedge \xi_2$used in gauss quadrature two point method.	CO2	L3
9	Describe the general algorithm of Gaussian elimination method for the solution of linear algebraic equations.	CO2	L3
10	Explain in brief the penalty method of imposing boundary conditions.	CO2	L3
11	For the bar shown in Fig. 2.11 determine (i) nodal displacement & (ii) Stresses in each element Take E = 200GPa & A = 300 mm^2.	CO2	L3
12	For a stepped bar loaded as shown in Fig. 2.12 determine (i) Nodal displacements. (ii) elemental stresses (iii) support reactions. Take E= 200 GPa.	CO2	L3
13	For a plane truss shown in Fig.2.13 determine the horizontal and vertical displacement, stresses in each element take E = 20 GPa and A= 200 mm^2.	CO2	L3

14	write down the general guidelines for selecting the interpolation polynomial.	CO2	L3
15	derive stiffness matrix for a 1-D bar element under axial loading.	CO2	L3
16	Derive strain-displacement matrix [B] for a isoparametric linear triangular element.	CO2	L3
e	**Experiences**	-	-
1			

E1. CIA EXAM – 1

a. Model Question Paper - 1

Crs Code:	17ME61	Sem:	VI	Marks:	30	Time:	75 minutes
Course:	Finite elements analysis						

-	-	**Note: Answer any 2 questions, each carry equal marks.**	**Marks**	**CO**	**Level**
1	a	Define FEM, explain basic steps involved in FEM.	7	CO1	L2
	b	using Galerkin's method, obtain an approximate solution of the differential equation. $\frac{d^2u}{dx^2}-10x^2=5, 0\le x\le 1, at\, u(0)=0, u(1)=0$	8	CO1	L2
		OR			
2	a	Determine the maximum deflection of the beam as shown in fig 1.8 Take E = 200 GPa & I = $2x10^{-9}$ m^4. Use Rayleigh ritz method.	8	CO1	L2
	b	Explain simplex, Complex and multiplex elements.	7	CO1	L2
3	a	Derive the interpolation function of quadratic bar element in natural co-ordinate system.	8	CO2	L3
	b	Derive the stiffness matrix for CST element.	7	CO2	L3
		OR		CO2	
4	a	For a stepped bar loaded as shown in Fig. 2.12 determine (i) Nodal displacements. (ii) elemental stresses (iii) support reactions. Take E= 200 GPa.	7	CO2	L3
	b	For a plane truss shown in Fig.2.13 determine the horizontal and vertical displacement, stresses in each element take E = 20 GPa and A= 200 mm^2.	8	CO2	L3

b. Assignment -1

Note: A distinct assignment to be assigned to each student.

Model Assignment Questions							
Crs Code:	17ME61	Sem:	VII	Marks:	5 / 10	Time:	90 – 120 minutes
Course:	Finite element analysis						
Note: Each student to answer 2-3 assignments. Each assignment carries equal mark.							

SNo	**USN**	**Assignment Description**	**Marks**	**CO**	**Level**
1	1KT15ME	Explain plane stress and plain strain problems with suitable examples.	7	CO1	L2
2	1KT15ME	Define FEM, explain basic steps involved in FEM.	7	CO1	L2
3	1KT15ME	With an example, Explain node numbering scheme.	7	CO1	L2
4	1KT15ME	Explain principle of minimum potential energy and principle of virtual work.	7	CO1	L2
5	1KT15ME	Explain convergence requirement of a polynomial displacement model.	7	CO1	L2
6	1KT15ME	Explain simplex, Complex and multiplex elements.	7	CO1	L2
7	1KT15ME	what is geometric isotropy? Sketch and explain pascal	7	CO1	L2

		triangle for 2D polynomials.			
8	1KT15ME	Determine the maximum deflection of the beam as shown in fig 1.8 Take E = 200 GPa & I = $2x10^{-9}$ m^4. Use Rayleigh ritz method.	8	CO1	L2
9	1KT15ME	Determine the displacement of the bar as shown in Fig. 1.9. use Rayleigh ritz method for the solution. Take E = 70 GPa.	8	CO1	L2
10	1KT15ME	Explain steps involved in Galerkin's method.	8	CO1	L2
11	1KT15ME	using Galerkin's method, obtain an approximate solution of the differential equation. $\frac{d^2u}{dx^2} - 10x^2 = 5, 0 \le x \le 1, at\, u(0) = 0, u(1) = 0$	8	CO1	L2
12	1KT15ME	What is an interpolation function?	7	CO1	L2
13	1KT15ME	Derive the shape function of the bar element in local co-ordinate system.	7	CO1	L2
14	1KT15ME	Derive the interpolation function of quadratic bar element in natural co-ordinate system.	8	CO1	L2
15	1KT15ME	Derive the stiffness matrix for CST element.	8	CO1	L2
16	1KT15ME	Explain the concepts of iso, sub and super parametric elements.	8	CO1	L2
17	1KT15ME	Derive the shape function for the nine – noded quadrilateral element.	8	CO1	L2
18	1KT15ME	Using lagrangian method, derive the shape functions of quadrilateral element.	8		
19	1KT15ME	Evaluate the values of ω_1, $\omega_2, \xi_1, \wedge \xi_2$used in gauss quadrature two point method.	8	CO1	L2
20	1KT15ME	Describe the general algorithm of Gaussian elimination method for the solution of linear algebraic equations.	8	CO1	L2
21	1KT15ME	Explain in brief the penalty method of imposing boundary conditions.	8	CO1	L2
22	1KT15ME	For the bar shown in Fig. 2.11 determine (i) nodal displacement & (ii) Stresses in each element Take E = 200GPa & A = 300 mm^2.	8	CO2	L2
23	1KT15ME	For a stepped bar loaded as shown in Fig. 2.12 determine (i) Nodal displacements. (ii) elemental stresses (iii) support reactions. Take E= 200 GPa.	7	CO2	L2
24	1KT15ME	For a plane truss shown in Fig.2.13 determine the horizontal and vertical displacement, stresses in each element take E = 20 GPa and A= 200 mm^2.	7	CO2	L2
25	1KT15ME	write down the general guidelines for selecting the interpolation polynomial.	8	CO2	L2
26	1KT15ME	derive stiffness matrix for a 1-D bar element under axial loading.	8	CO1	L2
27	1KT15ME	Derive strain-displacement matrix [B] for a isoparametric linear triangular element.	8	CO1	L2
28	1KT15ME	Explain principle of minimum potential energy and principle of virtual work.	8	CO2	L2
29	1KT15ME	Explain convergence requirement of a polynomial displacement model.	8	CO2	L2
30	1KT15ME	Explain simplex, Complex and multiplex elements.	8	CO2	L2
31	1KT15ME	what is geometric isotropy? Sketch and explain pascal triangle for 2D polynomials.	8	CO2	L2
32	1KT15ME	Determine the maximum deflection of the beam as shown in fig 1.8 Take E = 200 GPa & I = $2x10^{-9}$ m^4. Use Rayleigh ritz method.	8	CO2	L2

33	1KT15ME	Determine the displacement of the bar as shown in Fig. 1.9. use Rayleigh ritz method for the solution. Take E = 70 GPa.	8	CO2	L2
34	1KT15ME	Explain steps involved in Galerkin's method.	8	CO2	L2
35	1KT15ME	using Galerkin's method, obtain an approximate solution of the differential equation. $\frac{d^2u}{dx^2} - 10x^2 = 5, 0 \le x \le 1, at\, u(0) = 0, u(1) = 0$	8	CO2	L2
36	1KT15ME	What is an interpolation function?		CO2	L2
37	1KT15ME	Derive the shape function of the bar element in local co-ordinate system.	8	CO2	L2
38	1KT15ME	Derive the interpolation function of quadratic bar element in natural co-ordinate system.	8	CO2	L2
39	1KT15ME	Derive the stiffness matrix for CST element.	8	CO2	L2
40	1KT15ME	Explain the concepts of iso, sub and super parametric elements.		CO2	L2
41	1KT15ME	Derive the shape function for the nine – noded quadrilateral element.	8	CO2	L2
42	1KT15ME	Using lagrangian method, derive the shape functions of quadrilateral element.	8	CO2	L2
43	1KT15ME	Evaluate the values of ω_1, $\omega_2, \xi_1, \wedge \xi_2$used in gauss quadrature two point method.	8	CO2	L2
44	1KT15ME	Describe the general algorithm of Gaussian elimination method for the solution of linear algebraic equations.	8	CO2	L2
45	1KT15ME	Explain in brief the penalty method of imposing boundary conditions.		CO2	L2
46	1KT15ME	For the bar shown in Fig. 2.11 determine (i) nodal displacement & (ii) Stresses in each element Take E = 200GPa & A = 300 mm^2.	8	CO2	L2
47	1KT15ME	For a stepped bar loaded as shown in Fig. 2.12 determine (i) Nodal displacements. (ii) elemental stresses (iii) support reactions. Take E= 200 GPa.	8	CO2	L2
48	1KT15ME	For a plane truss shown in Fig.2.13 determine the horizontal and vertical displacement, stresses in each element take E = 20 GPa and A= 200 mm^2.	8	CO2	L2
49	1KT15ME	write down the general guidelines for selecting the interpolation polynomial.	8	CO2	L2
50	1KT15ME	derive stiffness matrix for a 1-D bar element under axial loading.	8	CO2	L3
51	1KT15ME	Derive strain-displacement matrix [B] for a isoparametric linear triangular element.		CO2	L3
52	1KT15ME	Using lagrangian method, derive the shape functions of quadrilateral element.	8	CO2	L3
53	1KT15ME	Evaluate the values of ω_1, $\omega_2, \xi_1, \wedge \xi_2$used in gauss quadrature two point method.	8	CO2	L3
54	1KT15ME	Describe the general algorithm of Gaussian elimination method for the solution of linear algebraic equations.		CO2	L3
55	1KT15ME	Explain in brief the penalty method of imposing boundary conditions.	8	CO2	L3
56	1KT15ME	For the bar shown in Fig. 2.11 determine (i) nodal displacement & (ii) Stresses in each element Take E = 200GPa & A = 300 mm^2.	8	CO2	L3

D2. TEACHING PLAN - 2

Module – 3

Title:	Beams and Torsion of Shafts	Appr Time:	8Hrs
a	***Course Outcomes***	-	**Blooms**
-	The student should be able to:	-	**Level**
1	Analysis of beams and Shaft under different kind of loading.	CO3	L4
b	***Course Schedule***	-	-
Class No	**Module Content Covered**	**CO**	**Level**
1	Boundary conditions, Load vector, Hermite shape functions, Beam stiffness matrix based on Euler-Bernoulli beam theory.	CO3	L2
2	Examples on cantilever beams, propped cantilever beams	CO3	L2
3	Numerical problems on simply supported, fixed straight and stepped beams using direct stiffness method with concentrated and uniformly distributed load.	CO3	L2
4	Finite element formulation of shafts, determination of stress and twists in circular shafts.		
c	**Application Areas**	**CO**	**Level**
1	Analysis of shaft parts	CO3	
2	Structural analysis of bars and beams	CO3	
d	**Review Questions**	-	-
1	Derive the stiffness matrix for a beam element.		
2	Derive Hermite shape functions of a beam element and show the variation of the shape function over the element.	CO3	
3	Determine the maximum deflection in the uniform c/s of cantilever beam Shown in Fig 3.3 by assuming a beam as a single element. Take $E = 7x10^9$ N/m^2 & $I = 4x10^{-4}$ m^4.	CO3	
4	Derive the stiffness matrix for a circular shaft subjected to pure torsion.	CO3	
e	**Experiences**	-	-
1			

Module – 4

Title:	Heat Transfer and Fluid Flow	Appr Time:	10 Hrs
a	***Course Outcomes***	-	**Blooms**
-	The student should be able to	-	**Level**
1	Analysis of heat transfer in composite sections	CO4	L4
b	***Course Schedule***	-	-
Class No	**Module Content Covered**	**CO**	**Level**
1	Basic equations of heat transfer: Energy balance equation, Rate equation: conduction, convection, radiation, energy generated in solid, energy stored insolid.	CO4	L2
2	1D finite element formulation using vibrational method, Problems with temperature gradient and heat fluxes	CO4	L3
3	heat transfer in composite sections, straight fins.	CO4	L2

4	Flow through a porous medium, Flow through pipes of uniform and stepped sections, Flow through hydraulic net works.	CO4	L3
5			
c	**Application Areas**	**CO**	**Level**
1	Analysis of temperature gradient in fins ,boilers		
2	Heat conduction through composite wall and pipes in industries		
d	**Review Questions**	-	-
1	Explain types of boundary conditions in heat transfer problems.	CO4	L2
2	Derive the element conductivity matrix for one dimensional heat flow element.	CO4	L2
3	Derive the element matrix, using Galerkin's approach for heat conduction in one dimensional element.	CO4	L2
4	Discuss the various steps involved in the finite element analysis of one dimensional heat transfer problem with reference to a straight uniform fin.	CO4	L2
5	Derive the stiffness matrix for one dimensional fluid element.	CO4	L2
6	Determine the temperature distribution in the rectangular fin as shown in Fig.4.6. Assume steady and only conduction process. Take heat generated inside the fin as 400 w/m°C.	CO4	L2
7	Determine the temperature distribution in the composite wall using 1D heat elements use penalty approach of handling boundary conditions as shown in Fig.4.7 Given K_1 = 25 W/m°C, k_2 = 35 W/m°C, k_3 = 55 W/m°C, h = 30 W/m^{2}C, T_∞ = 900°C, A = unit area.	CO4	L3
8	For the smooth pipe of variable cross section shown in Fig. 4.8 determine the fluid heads at the junctions, the velocities in each pipe and the volumetric flow rate. The fluid heads at the junctions, the velocities in each pipe and the volumetric flow rate. The fluid heads at the junctions.	CO4	L3
e	**Experiences**	-	-
1			

E2. CIA EXAM – 2

a. Model Question Paper - 2

Crs Code:	17ME61	Sem:	VI	Marks:	30	Time:	75 minutes
Course:	Finite element analysis						

-	-	**Note: Answer any 2 questions, each carry equal marks.**	**Marks**	**CO**	**Level**
1	a	Derive the stiffness matrix for a beam element.	7	CO3	L2
	b	Determine the maximum deflection in the uniform c/s of cantilever beam Shown in Fig 3.3 by assuming a beam as a single element. Take E = 7x10^9 N/m^2 & I = 4x10^{-4} m^4.	8	CO3	L2
		OR		CO3	
2	a	Derive the stiffness matrix for a circular shaft subjected to pure torsion.	7	CO3	L2
	b	Derive Hermite shape functions of a beam element and show the variation of the shape function over the element.	8	CO3	L2
3	a	Derive the element conductivity matrix for one dimensional heat	7	CO4	L2

		flow element.			
	b	Determine the temperature distribution in the composite wall using 1D heat elements use penalty approach of handling boundary conditions as shown in Fig.4.7 Given K_1 = 25 W/m°C, k_2 = 35 W/m°C, k_3 = 55 W/m°C, h = 30 W/m^{2}C, T_∞ = 900°C, A = unit area.	8	CO4	L2
		OR		CO4	
4	a	Derive the stiffness matrix for one dimensional fluid element.	7	CO4	L2
	b	Determine the temperature distribution in the rectangular fin as shown in Fig.4.6. Assume steady and only conduction process. Take heat generated inside the fin as 400 w/m°C.	8	CO4	L2

b. Assignment -2

Note: A distinct assignment to be assigned to each student.

Model Assignment Questions							
Crs Code:	17ME61	Sem:	VI	Marks:	5 / 10	Time:	90 – 120 minutes
Course:	Finite element analysis						
Note: Each student to answer 2-3 assignments. Each assignment carries equal mark.							

SNo	USN	Assignment Description	Marks	CO	Level
1	1KT15ME	Derive the stiffness matrix for a beam element.	7	CO4	L2
2	1KT15ME	Derive Hermite shape functions of a beam element and show the variation of the shape function over the element.	8	CO4	L2
3	1KT15ME	Determine the maximum deflection in the uniform c/s of cantilever beam Shown in Fig 3.3 by assuming a beam as a single element. Take E = 7x10^9 N/m^2 & I = 4x10^{-4} m^4.	7	CO4	L2
4	1KT15ME	Derive the stiffness matrix for a circular shaft subjected to pure torsion.	8	CO4	L2
5	1KT15ME	Explain types of boundary conditions in heat transfer problems.	7	CO4	L2
6	1KT15ME	Derive the element conductivity matrix for one dimensional heat flow element.	8	CO4	L2
7	1KT15ME	Derive the element matrix, using Galerkin's approach for heat conduction in one dimensional element.	7	CO4	L2
8	1KT15ME	Discuss the various steps involved in the finite element analysis of one dimensional heat transfer problem with reference to a straight uniform fin.	8	CO4	L2
9	1KT15ME	Derive the stiffness matrix for one dimensional fluid element.	7	CO4	L2
10	1KT15ME	Determine the temperature distribution in the rectangular fin as shown in Fig.4.6. Assume steady and only conduction process. Take heat generated inside the fin as 400 w/m°C.	8	CO4	L2
11	1KT15ME	Determine the temperature distribution in the composite wall using 1D heat elements use penalty approach of handling boundary conditions as shown in Fig.4.7 Given K_1 = 25 W/m°C, k_2 = 35 W/m°C, k_3 = 55 W/m°C, h = 30 W/m^{2}C, T_∞ = 900°C, A = unit area.	7	CO4	L2

12	1KT15ME	For the smooth pipe of variable cross section shown in Fig. 4.8 determine the fluid heads at the junctions, the velocities in each pipe and the volumetric flow rate. The fluid heads at the junctions, the velocities in each pipe and the volumetric flow rate. The fluid heads at the junctions.	8	CO4	L2
13	1KT15ME	Derive the stiffness matrix for a beam element.	7	CO4	L2
14	1KT15ME	Derive Hermite shape functions of a beam element and show the variation of the shape function over the element.	8	CO4	L2
15	1KT15ME	Determine the maximum deflection in the uniform c/s of cantilever beam Shown in Fig 3.3 by assuming a beam as a single element. Take $E = 7x10^9$ N/m^2 & $I = 4x10^{-4}$ m^4.	7	CO4	L2
16	1KT15ME	Derive the stiffness matrix for a circular shaft subjected to pure torsion.	8	CO4	L2
17	1KT15ME	Explain types of boundary conditions in heat transfer problems.	7	CO4	L2
18	1KT15ME	Derive the element conductivity matrix for one dimensional heat flow element.	8	CO4	L2
19	1KT15ME	Derive the element matrix, using Galerkin's approach for heat conduction in one dimensional element.	7	CO4	L2
20	1KT15ME	Discuss the various steps involved in the finite element analysis of one dimensional heat transfer problem with reference to a straight uniform fin.	8	CO4	L2
21	1KT15ME	Derive the stiffness matrix for one dimensional fluid element.	7	CO4	L2
22	1KT15ME	Determine the temperature distribution in the rectangular fin as shown in Fig.4.6. Assume steady and only conduction process. Take heat generated inside the fin as 400 w/m^oC.	8	CO4	L2
23	1KT15ME	Determine the temperature distribution in the composite wall using 1D heat elements use penalty approach of handling boundary conditions as shown in Fig.4.7 Given K_1 = 25 W/m^oC, k_2 = 35 W/m^oC, k_3 = 55 W/m^oC, h = 30 W/m^2C, T_∞ = 900^oC, A = unit area.	7	CO4	L2
24	1KT15ME	For the smooth pipe of variable cross section shown in Fig. 4.8 determine the fluid heads at the junctions, the velocities in each pipe and the volumetric flow rate. The fluid heads at the junctions, the velocities in each pipe and the volumetric flow rate. The fluid heads at the junctions.	8	CO4	L2
25	1KT15ME	Derive Hermite shape functions of a beam element and show the variation of the shape function over the element.	7	CO4	L2
26	1KT15ME	Determine the maximum deflection in the uniform c/s of cantilever beam Shown in Fig 3.3 by assuming a beam as a single element. Take $E = 7x10^9$ N/m^2 & $I = 4x10^{-4}$ m^4.	8	CO4	L2
27	1KT15ME	Derive the stiffness matrix for a circular shaft subjected to pure torsion.	7	CO4	L2
28	1KT15ME	Explain types of boundary conditions in heat transfer problems.	8	CO4	L2
29	1KT15ME	Derive the element conductivity matrix for one	7	CO4	L2

		dimensional heat flow element.			
30	1KT15ME	Derive the element matrix, using Galerkin's approach for heat conduction in one dimensional element.	8	CO4	L2
31	1KT15ME	Discuss the various steps involved in the finite element analysis of one dimensional heat transfer problem with reference to a straight uniform fin.	7	CO4	L2
32	1KT15ME	Derive the stiffness matrix for one dimensional fluid element.	7	CO4	L2
33	1KT15ME	Determine the temperature distribution in the rectangular fin as shown in Fig.4.6. Assume steady and only conduction process. Take heat generated inside the fin as 400 w/m°C.	8	CO4	L3
34	1KT15ME	Determine the temperature distribution in the composite wall using 1D heat elements use penalty approach of handling boundary conditions as shown in Fig.4.7 Given K_1 = 25 W/m°C, k_2 = 35 W/m°C, k_3 = 55 W/m°C, h = 30 W/m^{2}C, T_∞ = 900°C, A = unit area.	7	CO4	L3
35	1KT15ME	For the smooth pipe of variable cross section shown in Fig. 4.8 determine the fluid heads at the junctions, the velocities in each pipe and the volumetric flow rate. The fluid heads at the junctions, the velocities in each pipe and the volumetric flow rate. The fluid heads at the junctions.	8	CO4	L3

D3. TEACHING PLAN - 3

Module – 5

Title:	Axi-symmetric Solid Elements	Appr Time:	8 Hrs
a	***Course Outcomes***	-	**Blooms**
-	The student should be able to:	-	**Level**
1	Understand the stiffness matrix, eigen values and eigen vectors a xi-symmetric body	CO5	L2
b	***Course Schedule***	-	-
Class No	**Module Content Covered**	**CO**	**Level**
1	Derivation of stiffness matrix of axisymmetric bodies with triangular elements.CO5	CO5	L2
2	Numerical solution of axisymmetric triangular element(s) subjected to surface forces, point loads, angular velocity, pressure vessels.	CO5	L2
3	Formulation for point mass and distributed masses, Consistent element mass matrix of one dimensional bar element, truss element, axisymmetric triangular element.	CO5	L2
4	quadrilateral element, beam element. Lumped mass matrix of bar element, truss element, Evaluation of eigen values and eigen vectors, Applications to bars, stepped bars, and beams.	CO5	L2
		CO5	L2
c	**Application Areas**	**CO**	**Level**
1	Dynamic analysis of bars and beam	CO5	L2
2	Formulation for point mass and distributed masses in different element	CO5	L2
d	**Review Questions**	-	-
1	What is an axi-symmetric element? Mention its characteristics.	CO5	L2
2	Derive the stiffness matrix of an axi-symmetric element using	CO5	L2

	potential energy approach.		
3	Explain the evaluation of eigen values and eigen vectors using characteristic polynomial technique.	CO5	L2
4	Derive the Consistent mass matrix for bar element	CO5	L2
5	Derive the Consistent mass matrix for bar element	CO5	L2
6	Derive the consistent mass matrix for truss element	CO5	L2
7	what are the properties of eigen vectors	CO5	L2
8	Differentiate between Consistent mass matrix and lumped mass matrix.	CO5	L2
9	Determine the eigen value of the stepped bar as shown in Fig. 5.8 Take E = 200 GPa, weight density 7850 kg/m^3	CO5	L2
e	**Experiences**	-	-
1			

E3. CIA EXAM – 3

a. Model Question Paper - 3

Crs Code:	17ME61	Sem:	VI	Marks:	30	Time:	75 minutes
Course:	Finite element analysis						

-	-	Note: Answer any 2 questions, each carry equal marks.	Marks	CO	Level
1	a	What is an axi-symmetric element? Mention its characteristics.	7	CO5	L2
	b	Derive the Consistent mass matrix for bar element	8	CO5	L2
					L2
2	a	Derive the stiffness matrix of an axi-symmetric element using potential energy approach.	8	CO5	L2
	b	Differentiate between Consistent mass matrix and lumped mass matrix.	7	CO5	L2
					L2
3	a	Explain the evaluation of eigen values and eigen vectors using characteristic polynomial technique.	7	CO5	L2
	b	Derive the consistent mass matrix for truss element	8	CO5	L2
					L2
4	a	Determine the eigen value of the stepped bar as shown in Fig. 5.8 Take E = 200 GPa, weight density 7850 kg/m^3	7	CO5	L2
	b	what are the properties of eigen vectors	8	CO5	L2

b. Assignment – 3

Note: A distinct assignment to be assigned to each student.

Model Assignment Questions							
Crs Code:	17ME61	Sem:	VI	Marks:	5 / 10	Time:	90 – 120 minutes
Course:	Finite element analysis						
Note: Each student to answer 2-3 assignments. Each assignment carries equal mark.							

SNo	USN	Assignment Description	Marks	CO	Level
1	1KT15ME	What is an axi-symmetric element? Mention its characteristics.	7	CO5	L2
2	1KT15ME	Derive the stiffness matrix of an axi-symmetric element using potential energy approach.	8	CO5	L2
3	1KT15ME	Explain the evaluation of eigen values and eigen vectors using characteristic polynomial technique.	7	CO5	L2
4	1KT15ME	Derive the Consistent mass matrix for bar element	8	CO5	L2

5	1KT15ME	Derive the Consistent mass matrix for bar element	7	CO5	L2
6	1KT15ME	Derive the consistent mass matrix for truss element	8	CO5	L2
7	1KT15ME	what are the properties of eigen vectors	7	CO5	L2
8	1KT15ME	Differentiate between Consistent mass matrix and lumped mass matrix.	8	CO5	L2
9	1KT15ME	Determine the eigen value of the stepped bar as shown in Fig. 5.8 Take E = 200 GPa, weight density 7850 kg/m^3	7	CO5	L2
10	1KT15ME	What is an axi-symmetric element? Mention its characteristics.	8	CO5	L2
11	1KT15ME	Derive the stiffness matrix of an axi-symmetric element using potential energy approach.	7	CO5	L2
12	1KT15ME	Explain the evaluation of eigen values and eigen vectors using characteristic polynomial technique.	8	CO5	L2
13	1KT15ME	Derive the Consistent mass matrix for bar element	7	CO5	L2
14	1KT15ME	Derive the Consistent mass matrix for bar element	8	CO5	L2
15	1KT15ME	Derive the consistent mass matrix for truss element	7	CO5	L2
16	1KT15ME	what are the properties of eigen vectors	8	CO5	L2
17	1KT15ME	Differentiate between Consistent mass matrix and lumped mass matrix.	7	CO5	L2
18	1KT15ME	Determine the eigen value of the stepped bar as shown in Fig. 5.8 Take E = 200 GPa, weight density 7850 kg/m^3	8	CO5	L2
19	1KT15ME	What is an axi-symmetric element? Mention its characteristics.	7	CO5	L2
20	1KT15ME	Derive the stiffness matrix of an axi-symmetric element using potential energy approach.	8	CO5	L2
21	1KT15ME	Explain the evaluation of eigen values and eigen vectors using characteristic polynomial technique.	7	CO5	L2
22	1KT15ME	Derive the Consistent mass matrix for bar element	8	CO5	L2
23	1KT15ME	Derive the Consistent mass matrix for bar element	7	CO5	L2
24	1KT15ME	Derive the consistent mass matrix for truss element	8	CO5	L2
25	1KT15ME	what are the properties of eigen vectors	7	CO5	L2
26	1KT15ME	Differentiate between Consistent mass matrix and lumped mass matrix.	8	CO5	L2
27	1KT15ME	Determine the eigen value of the stepped bar as shown in Fig. 5.8 Take E = 200 GPa, weight density 7850 kg/m^3	7	CO5	L2
28	1KT15ME	What is an axi-symmetric element? Mention its characteristics.	8	CO5	L2
29	1KT15ME	Derive the stiffness matrix of an axi-symmetric element using potential energy approach.	7	CO5	L2
30	1KT15ME	Explain the evaluation of eigen values and eigen vectors using characteristic polynomial technique.	8	CO5	L2
31	1KT15ME	Derive the Consistent mass matrix for bar element	7	CO5	L2
32	1KT15ME	Derive the Consistent mass matrix for bar element	8	CO5	L2
33	1KT15ME	Derive the consistent mass matrix for truss element	7	CO5	L2
34	1KT15ME	what are the properties of eigen vectors	8	CO5	L2
35	1KT15ME	Differentiate between Consistent mass matrix and lumped mass matrix.	7	CO5	L2
36	1KT15ME	Determine the eigen value of the stepped bar as shown in Fig. 5.8 Take E = 200 GPa, weight density 7850 kg/m^3	8	CO5	L2

F. EXAM PREPARATION

1. University Model Question Paper

Course:	Finite element analysis					Month / Year	DEC /2019
Crs Code:	17ME61	Sem:	VI	Marks:	100	Time:	180 minutes

-	Note	Answer all FIVE full questions. All questions carry equal marks.	Marks	CO	Level
1	a	Define FEM, explain basic steps involved in FEM.	7	CO1	L2
	b	using Galerkin's method, obtain an approximate solution of the differential equation. $\frac{d^2u}{dx^2}-10x^2=5, 0\leq x\leq 1, at\, u(0)=0, u(1)=0$	8	CO1	L2
		OR			
	a	Determine the maximum deflection of the beam as shown in fig 1.8 Take E = 200 GPa & I = $2x10^{-9}$ m^4. Use Rayleigh ritz method.	8	CO1	L2
	b	Explain simplex, Complex and multiplex elements.	7	CO1	L2
2	a	Derive the interpolation function of quadratic bar element in natural co-ordinate system.	7	CO2	L2
	b	Derive the stiffness matrix for CST element.	8	CO2	L2
		OR			
	a	For a stepped bar loaded as shown in Fig. 2.12 determine (i) Nodal displacements. (ii) elemental stresses (iii) support reactions. Take E= 200 GPa.	8	CO2	L3
	b	For a plane truss shown in Fig.2.13 determine the horizontal and vertical displacement, stresses in each element take E = 20 GPa and A= 200 mm^2.	7	CO2	L2
			8		
3	a	Derive the stiffness matrix for a beam element.	7	CO3	L2
	b	Determine the maximum deflection in the uniform c/s of cantilever beam Shown in Fig 3.3 by assuming a beam as a single element. Take E = $7x10^9$ N/m^2 & I = $4x10^{-4}$ m^4.	8	CO3	L3
		OR			
	a	Derive the stiffness matrix for a circular shaft subjected to pure torsion.	8	CO3	L2
	b	Derive Hermite shape functions of a beam element and show the variation of the shape function over the element.	7	CO3	L2
4	a	Derive the element conductivity matrix for one dimensional heat flow element.	7	CO4	L2
	b	Determine the temperature distribution in the composite wall using 1D heat elements use penalty approach of handling boundary conditions as shown in Fig.4.7 Given K_1 = 25 W/m°C, k_2 = 35 W/m°C, k_3 = 55 W/m°C, h = 30 W/m^2C, T_∞ = 900°C, A = unit area.	8	CO4	L3
		OR			
	a	Derive the stiffness matrix for one dimensional fluid element.	8	CO4	L2
	b	Determine the temperature distribution in the rectangular fin as shown in Fig.4.6. Assume steady and only conduction process. Take heat generated inside the fin as 400 w/m°C.	7	CO4	L2
5	a	What is an axi-symmetric element? Mention its characteristics.	7	CO4	L2
	b	Derive the Consistent mass matrix for bar element	8	CO4	L2
	c	Derive the stiffness matrix of an axi-symmetric element using potential energy approach.	7	CO4	L2
		OR			
	a	Differentiate between Consistent mass matrix and lumped mass matrix.	7	CO5	L2
	b	Explain the evaluation of eigen values and eigen vectors using characteristic polynomial technique.	8	CO5	L2
	c	Derive the consistent mass matrix for truss element	7	CO5	L2

		8	

2. SEE Important Questions

Course:	Finite element analysis					Month / Year	DEC/2019
Crs Code:	17ME61	Sem:	VI	Marks:	80	Time:	180 minutes

	Note	Answer all FIVE full questions. All questions carry equal marks.	-	-	
Module	Qno.	Important Question	**Marks**	**CO**	**Year**
1	1	Define FEM, explain basic steps involved in FEM.	7	CO1	
	2	With an example, Explain node numbering scheme.	8	CO1	
	3	Explain principle of minimum potential energy and principle of virtual work.	7	CO1	
	4	Explain convergence requirement of a polynomial displacement model.	8	CO1	
2	1	What is an interpolation function?	7	CO2	
	2	Derive the shape function of the bar element in local co-ordinate system.	8	CO2	
	3	Derive the interpolation function of quadratic bar element in natural co-ordinate system.	7	CO2	
	4	Derive the stiffness matrix for CST element.	8	CO2	
	5	Explain the concepts of iso, sub and super parametric elements.	7	CO2	
	6	Derive the shape function for the nine – noded quadrilateral element.	8	CO2	
3	1	Derive the stiffness matrix for a beam element.	8	CO3	
	2	Derive Hermite shape functions of a beam element and show the variation of the shape function over the element.	7	CO3	
	3	Determine the maximum deflection in the uniform c/s of cantilever beam Shown in Fig 3.3 by assuming a beam as a single element. Take $E = 7x10^9$ N/m^2 & $I = 4x10^{-4}$ m^4.	8	CO3	
	4	Derive the stiffness matrix for a circular shaft subjected to pure torsion.	7	CO3	
4	1	Discuss the various steps involved in the finite element analysis of one dimensional heat transfer problem with reference to a straight uniform fin.	7	CO4	
	2	Derive the stiffness matrix for one dimensional fluid element.	8		
	3	Determine the temperature distribution in the rectangular fin as shown in Fig.4.6. Assume steady and only conduction process. Take heat generated inside the fin as 400 w/m°C.	7	CO4	
	4	Determine the temperature distribution in the composite wall using 1D heat elements use penalty approach of handling boundary conditions as shown in Fig.4.7 Given K_1 = 25 W/m°C, k_2 = 35 W/m°C, k_3 = 55 W/m°C, h = 30 W/m^{2}C, T_∞ = 900°C, A = unit area.	8		
	5	For the smooth pipe of variable cross section shown in Fig. 4.8 determine the fluid heads at the junctions, the velocities in each pipe and the volumetric flow rate. The fluid heads at the junctions, the velocities in each pipe and the volumetric flow rate. The fluid heads at the junctions.	7	CO4	
5	1	Derive the stiffness matrix of an axi-symmetric element using potential energy approach.	7	CO5	

	2	Explain the evaluation of eigen values and eigen vectors using characteristic polynomial technique.	8	CO5	
	3	Derive the Consistent mass matrix for bar element	7	CO5	
	4	Derive the Consistent mass matrix for bar element	8	CO5	
	5	Derive the consistent mass matrix for truss element	7	CO5	
	6	what are the properties of eigen vectors	8	CO5	
	7	Differentiate between Consistent mass matrix and lumped mass matrix.	7	CO5	
	8	Determine the eigen value of the stepped bar as shown in Fig. 5.8 Take E = 200 GPa, weight density 7850 kg/m^3	8	CO5	

G. Content to Course Outcomes

1. TLPA Parameters

Table 1: TLPA – Example Course

Module-#	Course Content or Syllabus (Split module content into 2 parts which have similar concepts)	Content Teaching Hours	Blooms' Learning Levels for Content	Final Blooms' Level	Identified Action Verbs for Learning	Instruction Methods for Learning	Assessment Methods to Measure Learning
A	*B*	*C*	*D*	*E*	*F*	*G*	*H*
1	**Introduction to Finite element Analysis :** General description of the Finite element Analysis. Engineering applications of Finite element Analysis. Boundary conditions: homogeneous and non-homogeneous for structural, heat transfer and fluid flow problems. Potential energy method, Rayleigh Ritz method, Galerkin's method, Displacement method of finite element formulation. Convergence criteria, Discretization process, Types of elements: 1D, 2D and 3D, Node numbering, Location of nodes. Strain displacement relations, Stress strain relations, Plain stress and Plain strain conditions, temperature effects.	5	- L2	L2	- Underst Elements and nodes	- Lecture - -	- Slip Test - -
1	**Interpolation models:** Simplex, complex and multiplex elements, Linear interpolation polynomials in terms of global coordinates 1D, 2D, 3D Simplex Elements.	5	-L2		- Underst simplex elements - complex elements -Pascale triangle		
2	**One-Dimensional Elements**-Analysis of Bars and Trusses,	5	- L2	L2	- Underst	- Lecture	- Assignmen

	Linear interpolation polynomials in terms of local coordinate's for1D, 2Delements. Higher order interpolation functions for 1D quadratic and cubic elements in natural coordinates, Constant strain triangle, Four-Nodded Tetrahedral Element (TET 4), Eight-Nodded Hexahedral Element (HEXA8), 2D isoparametric element, Lagrange interpolation functions, Numerical integration: Gaussian quadrature one point, two point formulae, 2D integrals. Fore terms: Body force, traction force and point loads,				and - Cubic and quadratic elements	- Tutorial -	t - -
2	**Numerical Problems:** Solution for displacement, stress and strain in 1D straight bars, stepped bars and tapered bars using elimination approach and penalty approach, Analysis of trusses.	5	-L2 -L3	-L3	- Apply -- stiffness matrix for bars - boundary condition		
3	**Beams and Shafts:**Boundary conditions, Load vector, Hermite shape functions, Beam stiffness matrix based on Euler-Bernoulli beam theory, Examples on cantilever beams, propped cantilever beams, Numerical problems on simply supported, fixed straight and stepped beams using direct stiffness method with concentrated and uniformly distributed load.	6	- L2 - L3	L3	- Apply - stiffness matrix for beams - boundary condition	- Lecture -	- Assignment -
3	**Torsion of Shafts:** Finite element formulation of shafts, determination of stress and twists in circular shafts.	6	- L2 - L3	-L3	- Apply - stiffness matrix for Shaft		
4	**Heat Transfer:** Basic equations of heat transfer: Energy balance equation, Rate equation: conduction, convection, radiation, energy generated in solid, energy stored insolid, 1D finite element formulation using vibrational method, Problems with temperature gradient and heat fluxes, heat transfer in composite sections, straight fins.	5	- L2	L2	- Apply - stiffness matrix for conduction ,convection and heat generation	- Lecture -	- Slip Test -
4	**Fluid Flow:** Flow through a porous medium, Flow through pipes of uniform and stepped sections, Flow through hydraulic net works.	5	- L2	L2	- Understand - properties of fluid		

					-fluid flow		
5	**Axi-symmetric Solid Elements:** Derivation of stiffness matrix of axisymmetric bodies with triangular elements, Numerical solution of axisymmetric triangular element(s) subjected to surface forces, point loads, angular velocity, pressure vessels.	4	- L2	L2	- Understand - Axi symmetry solid elements	- Lecture -	- Slip Test -
5	**Dynamic Considerations:** Formulation for point mass and distributed masses, Consistent element mass matrix of one dimensional bar element, truss element, axisymmetric triangular element, quadrilateral element, beam element. Lumped mass matrix of bar element, truss element, Evaluation of eigen values and eigen vectors, Applications to bars, stepped bars, and beams.	4	- L2	L2	- Understand - Dynamic response of beam elements		

2. Concepts and Outcomes:

Table 2: Concept to Outcome – Example Course

Module-#	Learning or Outcome from study of the Content or Syllabus	Identified Concepts from Content	Final Concept	Concept Justification (What all Learning Happened from the study of Content / Syllabus. A short word for learning or outcome)	CO Components (1.Action Verb, 2.Knowledge, 3.Condition / Methodology, 4.Benchmark)	Course Outcome **Student Should be able to ...**
A	*I*	*J*	*K*	*L*	*M*	*N*
1	- Study of Numerical Method - Study of elements and nodes	- elements - nodes - boundary condition	Elements and nodes	Understand the concept of elements and boundary conditions	- Understand - Elements and nodes	Understand the concept of elements and boundary conditions
	- Study of Boundary condition -Study of Simplex and complex elements - Study of pascal triangle	-simplex elements -complex elements -Pascale triangle	Complex and simple elements	Under the concept of complex and multiplex elements	- Understand - simplex elements -complex elements -Pascale triangle	Under the concept of complex and multiplex elements
	-Study of tet 4 and quad element - Study of interpolation model	-tet 4 element -Quad elements - Interpola	Cubic and quadratic elements	Understand the hexa and tet 4 elements	- Understand - Cubic and quadratic elements	Understand the hexa and tet 4 elements

2	-Study of bars - study of stiffness matrix for bars	tion model				
		-Bars -stiffness matrix for bars - boundary condition	Analysis of bars and trusses	Apply elimination and penalty approach for bars and trusses	- Apply --stiffness matrix for bars - boundary condition	Apply elimination and penalty approach for bars and trusses
3	-Study of Beam - study of stiffness matrix for beams -Study of shaft - study of stiffness matrix for torsion of shaft	-Beams -stiffness matrix for beams - boundary condition	loading conditions on beams	Apply the suitable loading condition on beams	- Apply -stiffness matrix for beams - boundary condition	Apply the suitable loading condition on beams
		-torsion of shaft -stiffness matrix for shaft - boundary condition	Stiffness matrix for beams and shaft	Apply the suitable boundary condition of shaft	- Apply -stiffness matrix for Shaft	Apply the suitable boundary condition of shaft
4	-Study of mode of heat transfer - study of stiffness matrix for conduction , convection and heat generation -Study fluid flow	-Modes of heat transfer -stiffness matrix for conduction, convection.	Heat transfer through 1 D	Understand the heat transfer in composite sections	- Apply -stiffness matrix for conduction ,convection and heat generation	Understand the heat transfer in composite sections
		- properties of fluid -fluid flow	Analysis of flow	Understand flow through pipes Of sections	- Understand -properties of fluid -fluid flow	Understand flow through pipes Of sections
5	-Study of axi symmetry solid element -Study of dynamic response of beam elements	-axi symmetry solid elements	stiffness matrix solid element	Understand the stiffness matrix of axi-symmetric body	- Understand - Axi symmetry solid elements	Understand the stiffness matrix of axi-symmetric body
		-dynamic response of beam elements	Dynamic considerations	Understand the eigen values and eigen vectors of bars and beam	- Understand - Dynamic response of beam elements	Understand the eigen values and eigen vectors of bars and beam