FINITE ELEMENT METHODS

V Semester: AE

Course Code	Category	Hours / Week			Credits	Maximum Marks		
		L	T	P	C	CIA	SEE	Total
AAE009	Core	3	1	-	4	30	70	100
Contact Classes: 45	Tutorial Classes: 15	Practical Classes: Nil				Total Classes: 60		

COURSE OBJECTIVES:

The course should enable the students to:

I. Introduce basic concepts of finite element methods including domain discretization, polynomial interpolation and application of boundary conditions.
II. Understand the theoretical basics of governing equations and convergence criteria of finite element method.
III. Develop of mathematical model for physical problems and concept of discretization of continuum.
IV. Discuss the accurate Finite Element Solutions for the various field problems
V. Use the commercial Finite Element packages to build Finite Element models and solve a selected range of engineering problems.

COURSE OUTCOMES (COs):

CO 1: Describe the concept of FEM and difference between the FEM with other methods and problems based on 1-D bar elements and shape functions.
CO 2: Derive elemental properties and shape functions for truss and beam elements and related problems.
CO 3: Understand the concept deriving the elemental matrix and solving the basic problems of CST and axi-symmetric solids.
CO 4: Explore the concept of steady state heat transfer in fin and composite slab.
CO 5: Understand the concept of consistent and lumped mass models and slove the dynamic analysis of all types of elements.

COURSE LEARNING OUTCOMES (CLOs):

1. Describe the basic concepts of FEM and steps involved in it.
2. Understand the difference between the FEM and Other methods.
3. Understand the stress-strain relation for 2-D and their field problem.
4. Understand the concepts of shape functions for one dimensional and quadratic elements, stiffness matrix and boundary conditions
5. Apply numerical methods for solving one dimensional bar problems
6. Derive the elemental property matrix for beam and bar elements.
7. Solve the equations of truss and beam elements
8. Understand the concepts of shape functions for beam element.
9. Apply the numerical methods for solving truss and beam problems
10. Derive the element stiffness matrices for triangular elements and axi- symmetric solids and estimate the load vector and stresses.
11. Formulate simple and complex problems into finite elements and solve structural and thermal problems
12. Understand the concept of CST and LST and their shape functions.

13. Understand the concepts of steady state heat transfer analysis for one dimensional slab, fin and thin plate.
14. Derive the stiffnes matrix for for fin element.
15. Solve the steady state heat transfer problems for fin and composite slab.
16. Understand the concepts of mass and spring system and derive the equations for various structural problems
17. Understand the concept of dynamic analysis for all types of elements.
18. Calculate the mass matrices, Eigen values, Eigen vectors, natural frequency and mode shapes for dynamic problems

UNIT-I	INTRODUCTION	Classes: 10

Introduction to Finite Element Method for solving field problems. Stress and Equilibrium. Boundary conditions. Strain - displacement relations. Stress-strain relations for 2-D and3-D elastic problems. One Dimensional Problems: Finite element modeling coordinates and shape functions. Assembly of Global stiffness matrix and load vector. Finite element equations – Treatment of boundary conditions, Quadratic shape functions.

UNIT-II	ANALYSIS OF TRUSSES AND BEAMS	Classes: 10

Analysis of Trusses: Stiffness matrix for plane Truss Elements, stress calculations and problems. Analysis of beams: Element stiffness matrix for two noded, two degrees of freedom per node beam element and simple problems.

UNIT-III	CONTINUUM ELEMENTS	Classes: 09

Finite element modeling of two dimensional stress analysis with constant strain triangles and treatment of boundary conditions. Estimation of load vector and stresses.

Finite element modeling of Axi-symmetric solids subjected to Axi-symmetric loading with triangular elements Two dimensional four noded isoparametric elements and problems.

UNIT-IV	STEADY STATE HEAT TRANSFER ANALYSIS	Classes: 09

Steady state Heat Transfer Analysis: one dimensional analysis of slab, fin and two dimensional analysis of thin plate. Analysis of a uniform shaft subjected to torsion.

UNIT-V	DYNAMIC ANALYSIS	Classes: 07

Dynamic Analysis: Formulation of finite element model, element –Mass matrices, evaluation of Eigen values and Eigen Vectors for a stepped bar, truss. Finite element-formulation to 3D problems in stress analysis, convergence requirements, mesh generation, techniques such as semi automatic and fully automatic use of software such as ANSYS,NISA,NASTRAN etc.

Text Books:

1. Tirupathi. R. Chandrapatla, Ashok D. Belegundu, "Introduction to Finite Elements in Engineering", Printice Hall India, 3rd Edition, 2003.
2. Rao. S.S., "Finite Element Methods in Engineering," Butterworth and Heinemann, 2001.
3. Reddy J.N., "An Introduction to Finite Element Method", McGraw Hill, 2000.

Reference Books:

1. Krishnamurthy, C.S., "Finite Element Analysis", Tata McGraw Hill, 2000.
2. K. J. Bathe, E. L. Wilson, "Numerical Methods in Finite Elements Analysis", Prentice Hall of India, 1985.
3. Robert D Cook, David S Malkus, Michael E Plesha, "Concepts and Applications of Finite Element Analysis", 4th edition, John Wiley and Sons, Inc., 2003.
4. Larry J Segerlind, "Applied Finite Element Analysis", 2nd Edition, John Wiley and Sons, Inc. 1984.

Web References:

1. www.home.iitk.ac.in/~sbasu/me623_2006/fem_notes_me623.pdf
2. www.nptel.ac.in/courses/112104116/
3. www.me.berkeley.edu/~lwlin/me128/FEMNotes.pdf

E-Text Books:

1. www.civilenggforall.com/2015/09/finite-element-analysis-by-ss-bhavikatti-free-download-pdfcivilenggforall.com.html
2. https://www3.nd.edu/~powers/ame.20231/planckdover.pdf