INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal - 500 043, Hyderabad, Telangana

COURSE CONTENT

FINITE ELEMENT ANALYSIS								
II Semester: ST								
Course Code	**Category**	**Hours/Week**			**Credits**	**Maximum Marks**		
BSTE13	Core	**L**	**T**	**P**	**C**	**CIA**	**SEE**	**Total**
		3	0	0	3	40	60	100
Contact Classes: 45	**Tutorial Classes: Nil**	**Practical Classes: Nil**				**Total Classes: 45**		
Prerequisite: Construction Materials, Concrete Materials								

I. COURSE OVERVIEW:

The Finite Element Method (FEM) is widely used in industry for analyzing and modelling structures and continua, whose physical behavior is described by ordinary and partial differential equations. The FEM is particularly useful for engineering problems that are too complicated to be solved by classical analytical methods. The main objective of this course is to introduce the mathematical concepts of the Finite Element Method for obtaining an approximate solution of ordinary and partial differential equations. In this course you will attend lectures on the fundamentals of the Finite Element Method. The learning process will be enhanced by completing assignments using mathematical software. You will also be introduced to a commercial Finite Element software package–ANSYS during lectures with computer laboratories providing opportunities to practice on, and to complete practical assignments, using ANSYS.

II. COURSE OBJECTIVES:

The students will try to learn:

I. The fundamentals of domain discretization, interpolation, application of boundary conditions, assembly of global matrices, and solution of the resulting algebraic systems.
II. The element stiffness matrix for 1-D, 2-D and 3-D problems.
III. Formulation of simple structural problems in to finite elements.

III. COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1 Explain the concepts of matrix analysis of structures for understanding the FEM.

CO 2 Build and Analyse the FEA models for various engineering problems

CO 3 Analyze the one- and two-dimensional structures using beam and bar elements

CO 4 Identify the requirements and sources for analysis, design and evaluation

CO 5 Interpret the results obtained from FEA software, and arrive at the conclusions

CO 6 Use the standard finite element software to solve the structural engineering problems

IV. COURSE CONTENT:

MODULE-I: INTRODUCTION TO FINITE ELEMENT METHODS (9)

Types of Problems , Types of Materials, Elastic / Inelastic situations, Types of forces: Body forces / Surface Traction / Point loads, Deformable bodies, Types of Deformations, Homogeneous, Non-homogeneous Problems, Equations of equilibrium for elastic 2-D / 3-D continua, Equilibrium equations for 2-D / 3-D boundary elements, Boundary conditions, Strain- displacement relation for 2-D / 3-D Stress-strain relation for 2-D / 3-D Plane stress, Plane strain problems.

Virtual Work Formulation: Application to problems of plane trusses with static indeterminacy not exceeding three.

MODULE-II: VARIATIONAL FORMULATION (10)

Approximate methods of Analysis- Weighted residual method - RayleighRitz Method -Strong form weak form - Variational principle - Stationarity Functional or Differential equation.

Finite element formulation for1-D problems: Minimum Potential Energy Approach, week form approach, introduction to natural coordinates -Finite element approximations in one-dimension Lagrangian Approximation-Hermitian approximations, FE formulation for Axial bar, Euler Bernoulli beam -Numerical Examples.

Finite element formulation for 2-D problems: FE Approximation in 2-Dimension, Pascal's triangle, Convergence criterion, Compatible and incompatible elements, FE Formulation for plane stress, plane strain and Axi-symmetrical problems, Shape functions for 2-Dimensional CST Element-4 noded quadrilateral element - Higher order triangular and rectangular elements- Consistent Nodal load vector -Numerical Examples

MODULE-III: ISO-PARAMETRIC ELEMENTS (9)

Quadrilateral elements: FE Formulation for linear and quadratic isoperimetric elements Construction of shape functions using natural coordinates, Strain-displacement matrices, Load matrices for body force and surface traction, Expressions for stiffness matrix, load matrices for 4- noded quadrilateral elements.

Gauss Quadrature of numerical integration, Problems with rectangular elements, kinematic indeterminacy not exceeding three- Determination of shape functions for 2nd order quadrilateral elements and for elements of with serendipity, Strain-displacement matrices, Load matrices for body force and surface traction.

MODULE-IV: FINITE ELEMENT FORMULATION FOR 3 -D ELEMENTS (9)

FE Formulation for Tetrahedral and Hexahedral elements: Volume coordinates, Strain-displacement matrix, stiffness matrix, load matrices due to body force and surface traction/ introduction to Hexahedron (brick) elements. Galerkin's Method of Weighted Residuals, Application to problems of mathematics / structural engineering, number of trial functions not exceeding two. Weak form of Trial Function - Application to problems of mathematics / structural engineering, number of elements limited to two - Strain-displacement relationship/stress-strain relationship / determination of stiffness matrix for 3-noded ring element and load matrices for body force and surface traction/ Problems with kinematic indeterminacy not exceeding three for 3-noded ring elements only

MODULE-V: NUMERICAL EXAMPLES (9)

Simple 1-D model, 2-D model and a 3-D model/ analysis and post processing of the results using commercially available FEA software and available codes.

V. TEXTBOOKS:

1. Reddy, J. N. "*An Introduction to the Finite Element Method*". McGraw-Hill, 1993.
2. Cook, R. D. "*Concepts and Applications of Finite Element Analysis*". John Wiley & Sons, 1981.
3. Zienkiewicz, O. C., and R. L. Taylor. "*The Finite Element Method. Vol. 1"*. McGraw-Hill Company Limited, 1989.

VI. REFERENCE BOOKS:

1. Chandrupatla, T. R., and A. D. Belegundu. "*Introduction to Finite Elements in Engineering"*. Prentice Hall of India, 2001.
2. Seshu, P. "*Finite Element Analysis"*. Prentice Hall of India Pvt. Ltd., 2003.
3. Hutton, David V. "*Fundamentals of Finite Element Analysis"*. Tata McGraw-Hill Publishing Company Ltd., 2005.

VII. ELECTRONICS RESOURCES:

1. https://nptel.ac.in/courses/112104193
2. https://nptel.ac.in/courses/112106135

VIII. MATERIAL ONLINE:

1. Course Outline Description
2. Tutorial Question Bank
3. Assignments
4. Model Question Paper – I
5. Model Question Paper - II
6. Lecture Notes
7. Early Lecture Readiness Videos
8. Power point presentation