Course Code	Course Name	Credits
MEC504	**Finite Element Analysis**	**03**

Prerequisite:

Knowledge of:

- Differential equations (Formulation and solution, Types-Ordinary, Partial, Order and degree of the DE and the boundary conditions)
- Matrix algebra (Matrix operations, gauss elimination method to get inverse the inverse of matrix)
- Basics of the core field (Governing laws, relationship between the various variables and constants –like in structural field stress-strain,Thermal field-temp, heat transfer rate etc

Objectives:

1. To understand the concepts of FEA and its applicability to different engineering field problems.
2. To understand the representation of the physical model into an equivalent FEA model and steps to solve it.
3. To acquaint with application of numerical techniques for solving problems.

Outcomes: Learner will be able to…

1. Solve differential equations using weighted residual methods.
2. Develop the finite element equations to model engineering problems governed by second order differential equations.
3. Apply the basic finite element formulation techniques to solve engineering problems by using one dimensional elements.
4. Apply the basic finite element formulation techniques to solve engineering problems by using two dimensional elements.
5. Apply the basic finite element formulation techniques to find natural frequency of single degree of vibration system.
6. Use commercial FEA software, to solve problems related to mechanical engineering.

Module	Details	Hrs
1	**Introduction:** 1.1 Introductory Concepts: Introduction to FEM, Historical Background, General FEM procedure, Applications of FEM in various fields Advantages and disadvantages of FEM 1.2 Mathematical Modelling of field problems in engineering, Governing Differential equations, primary/secondary variables, boundary conditions-types-essential/natural etc. 1.3Approximate solution of differential equations, Weighted residual techniques (Galerkin , Subdomain method).	**05**
2	**FEA Procedure:(Pre-processing, Processing, Post-processing)** 2.1 Discrete and Continuous Models, Weighted Residual Methods - Ritz Technique- Basic Concepts of the Finite Element Method. 2.2 Definitions of various terms used in FEM like element, order of the element, internal and external node/s, degree of freedom. 2.3 Minimization of a functional, Principle of minimum total potential, Piecewise Rayleigh-Ritz method, Formulation of 'stiffness matrix', assembly concepts to develop system equation.	**08**

3	**One Dimensional Problems:** 3.1 One dimensional second order equations - discretization-element types - linear and higher order elements -derivation of shape functions and stiffness matrices and force vectors. 3.2 Assembly of Matrices- solution of problems in one dimensional structural analysis, heat transfer and fluid flow (stepped and taper bars, fluid network, spring-Cart Systems) 3.3 Analysis of Plane trusses, Analysis of Beams	**10**
4	**Two Dimensional Finite Element Formulations:** 4.1 Introduction, three node triangular element, four node rectangular element 4.2 Natural coordinates and coordinates transformations: serendipity and Lagrange's methods for deriving shape functions for triangular element. 4.3 Convergence criterion, sources of errors	**05**
5	**Two Dimensional Vector Variable Problems:** 5.1 Equations of elasticity - Plane stress, plane strain and axi-symmetric problems 5.2 Jacobian matrix, stress analysis of CST.	**06**
6	**Finite Element Formulation of Dynamics and Numerical Techniques:** 6.1 Applications to free vibration problems of rod and beam, Lumped and consistent mass matrices. 6.2 Solutions techniques to Dynamic problems, longitudinal vibration frequencies and mode shapes, Fourth order beam equation, transverse deflections and natural frequencies of beams.	**05**

Assessment:

Internal Assessment for 20 marks:

Consisting**Two Compulsory Class Tests**

First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I)

End Semester Examination:

Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

1. Question paper will comprise of total **six questions**, **each carrying 20 marks**
2. **Question 1** will be **compulsory** and should **cover maximum contents of the curriculum**
3. **Remaining questions will be mixed in nature** (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3
4. Only **Four questions need to be solved**

Text/Reference Books:

1. Textbook of Finite Element Analysis by Seshu P, Prentice Hall of India
2. Finite Element Method by J N Reddy, TMH
3. 'Introduction to Finite Elements in Engineering, Chandrupatla and Belegundu, Pearson Education
4. Finite Element Methods by R Dhanraj and K Prabhakaran Nair, Oxford University Press
5. A first course in Finite Element Method by Logan D L, Thomson Asia PvtLtd
6. 'Concepts and Applications of Finite Element Analysis by Cook R D, Malkus D S, Plesha ME, John- Wiley Sons
7. The Finite Element Method in Engineering by S. S. Rao, Butter Worth Heinemann
8. Fundamental Finite Element Analysis and Application with Mathematica and MATLAB Computations by M. Asghar Bhatti, Wiley India Pvt. Ltd.

Links for online NPTEL/SWAYAM courses:

https://nptel.ac.in/courses/112/104/112104193/
https://nptel.ac.in/courses/105/106/105106051/
https://nptel.ac.in/courses/112/104/112104115/
https://nptel.ac.in/courses/112/103/112103295/
https://nptel.ac.in/courses/112/106/112106135/
https://nptel.ac.in/courses/112/106/112106130/
https://nptel.ac.in/courses/105/105/105105041/
https://nptel.ac.in/courses/112/104/112104116/