Course Type	Course Code	Name of Course	L	T	P	Credit
DE	OMED615	Finite Element Method	3	0	0	3

Course Objective

1. Introduce Finite Element Method (FEM) as a numerical technique for solving partial differential equations.
2. Enable comprehension of FEM applications to physical phenomena in structural engineering.
3. Provide hands-on training in translating FEM formulations into MATLAB computational code.
4. Develop skills in FEM model creation, analysis, and result interpretation.
5. Cover FEM theory from basic elements to advanced structural applications.
6. Teach implementation of boundary conditions, loads, and material properties in FEM.
7. Facilitate practical coding exercises for structural engineering problems.
8. Build proficiency in validating FEM results against analytical solutions.

Learning Outcomes

On successful completion of this course, the students will be able to:

1. Solve Boundary value problems using Rayleigh Ritz, Galerkin, Petro-Galerkin and other weighted residual methods
2. Formulate finite element model for 1 D bar element and solve practical problems
3. Formulate finite element model for Euler-Bernoulli, Timoshenko beam and plane truss elements and solve practical problems
4. Formulate finite element model for various 2 D elements and solve practical problems
5. Formulate finite element model for various 3 D element and solve practical problems

Unit No.	Topics to be Covered	Lecture Hours	Video time (minutes)	Learning Outcome
1	Introduction, Boundary value problems and solution methods, Direct approach – example, advantage and limitations.	5	155	Understand the solution methods for boundary value problems
2	Elements of calculus of variation, Strong form and weak form, equivalence between strong and weak forms, Rayleigh-Ritz method.	6	220	Develop weak form and solve problems by Rayleigh-Ritz method
3	Method of weighted residuals – Galerkin and Petrov-Galerkin approach; Axially loaded bar, governing equations, discretization, derivation of element equation, assembly, imposition of boundary condition and solution, examples.	5	222	Solve problems using Method of weighted residuals – Galerkin and Petrov-Galerkin approach and develop FEM formulation for 1D bar element
4	Finite element formulation for Euler-Bernoulli beams.	5	196	Develop Finite element formulation for Euler- Bernoulli beams.
5	Finite element formulation for Timoshenko beams.	5	200	Develop Finite element formulation for Timoshenko beams.
6	Finite element formulation for plane trusses and frames computer implementation.	5	165	Develop Finite element formulation for plane trusses and frames
7	Finite element formulation for two-dimensional problems - completeness and continuity, different elements (triangular, rectangular, quadrilateral etc.), shape functions, Gauss quadrature technique for numerical integration.	6	248	Develop Finite element formulation for different 2D (triangular, rectangular, quadrilateral etc.) elements

8	Finite element formulation for two-dimensional scalar field problems; Iso-parametric formulation Application to Heat conduction and torsion problems.	4	137	Develop Iso-parametric formulation and solve scalar problems in heat conduction and torsion problems
9	Finite element formulation for two-dimensional problems in linear elasticity; Formulation.	5	202	Develop Finite element formulation for two- dimensional problems in linear elasticity
10	Finite element formulation for two-dimensional problems in linear elasticity; Examples and computer implementation.	5	140	Application and solution to linear elasticity problems
11	Implementation issues, locking, reduced integration, B-Bar method.	5	242	Implementation of B-Bar method
12	Finite element formulation for three-dimensional problems; Different elements, shape functions, Gauss quadrature in three dimension, examples.	4	88	Develop Finite element formulation for three-dimensional problems
Total		60	2215	

Text Books:

1. An Introduction to the Finite Element Method, J.N. Reddy, McGraw-Hill Education.

Reference Books:

1. A First Course in Finite Elements, Jacob Fish and Ted Belytschko, John Wiley & Sons.
2. Concepts and Applications of Finite Element Analysis, Robert D. Cook, David S. Malkus, Michael E. Plesha, Robert J. Witt, John Wiley & Sons.
3. The Finite Element Method: Linear Static and Dynamic Finite Element Analysis, Thomas J.R. Hughes, Dover Publications.An Introduction to Finite Element Method by J. N. Reddy.
4. A First Course in Finite Elements by Jacob Fish and Ted Belytschko.
5. Concept and Applications of Finite Element Analysis by Robert D. Cook, David S. Malkus, Michael E. Plesha, Robert J. Witt.
6. The Finite Element Method: Linear Static and Dynamic Finite Element Analysis by Thomas J. R. Hughes.