FINITE ELEMENT ANALYSIS

ENAS 355

Lecture	**: 3**	**Year : III**
Tutorial	**: 1**	**Part : II**
Practical	**: 0**	

Course Objectives:

The objective of this course is to introduce fundamental concepts of finite element methods and their applications. Students will develop finite element models for structural, non-structural, and continuum problems such as heat transfer and plane elasticity, and gain experience using both custom programs and commercial software for analysis.

1 Overview (2 hours)

- 1.1 History and development
- 1.2 Mathematical modeling of the physical system
- 1.3 Finite element method (FEM) analysis process and its steps
- 1.4 Applications and advantages of the finite element method

2 Mathematical Background (2 hours)

- 2.1 Vector analysis
- 2.2 Matrix theory
- 2.3 Differential equations

3 Direct Stiffness Method: Discrete Finite Elements (10 hours)

- 3.1 Spring/bar element
- 3.2 Truss element
- 3.3 Beam element
- 3.4 Frame element
- 3.5 Analogous problems in one dimension

4 Continuum Problems (6 hours)

- 4.1 Trail solution procedures
- 4.2 Weighted residual methods
- 4.3 Point collocation method
- 4.4 Subdomain collocation method
- 4.5 Least square method
- 4.6 Galerkin method

5 One-Dimensional Elements (5 hours)

- 5.1 Linear elements

5.2 Quadratic elements
5.3 Cubic elements
5.4 Global, local and natural coordinates
5.5 Isoparametric elements
5.6 Numerical integration: Gauss-Legendre quadrature

6 Analysis of One-Dimensional Problems (10 hours)

6.1 Physical examples
6.2 Weak form of the differential equation
6.3 Interpolation shape functions
6.4 Bar under axial loading
6.5 Heat transfer problems
6.6 Fluid Mechanics: Irrotational flow

7 Two-Dimensional Heat Transfer Problem (10 hours)

7.1 Rectangular elements; Quadrilateral elements
7.2 Steady state 2D heat flow
7.3 Boundary conditions: Dirichlet, Neumann, Cauchy
7.4 Divergence theorem
7.5 Isoparametric mapping

Tutorial (30 hours)

1. Direct stiffness method: Spring and bar elements
2. Analysis of 2D plane trusses
3. Beam element formulation and bending
4. Weighted residual methods: Galerkin and least squares
5. Weak form and one-dimensional problems
6. Isoparametric mapping and numerical integration
7. Steady-state 1D heat transfer (Conduction and convection)
8. Two-dimensional heat flow: Rectangular elements
9. Use of CFD (Some available software) in fluid flow calculations

Final Exam

The questions will cover all the chapters in the syllabus. The evaluation scheme will be as indicated in the table below:

Chapters	Hours	Mark distribution*
1 and 2	4	5
3	10	15
4	6	10
5 and 6	15	15
7	10	15
Total	**45**	**60**

* There may be minor deviation in marks distribution.

References

1. Logan, D. L. (2022). A first course in the finite element method: Enhanced edition. Cengage Learning.
2. Hutton, D. V. (2004). Fundamentals of finite element analysis. McGraw-Hill Education.
3. Reddy, J. N. (2019). An introduction to the finite element method. McGraw-Hill Education.
4. Fish, J., Belytschko, T. (2007). A first course in finite elements. John Wiley & Sons.
5. Chandrupatla, T. P., Belegundu, A. D. (1991). Introduction to finite elements in engineering. Prentice Hall.