26MA801 FINITE ELEMENT METHOD WITH LARGE LANGUAGE MODELS

3-0-2-4

Course Objectives:

- Introduce the mathematical foundations of the Finite Element Method (FEM).
- Develop finite element models for engineering applications.
- Understand computer implementation of FEM.
- Introduce the fundamentals of Generative AI and Large Language Models (LLMs).
- Apply LLMs as intelligent assistants for FEM modelling, coding, and verification.

Course Outcomes:

CO1: Understand governing equations and FEM formulation.
CO2: Analyse structural and thermal problems using FEM.
CO3: Implement FEM using numerical software.
CO4: Explain the fundamentals of LLMs and prompt engineering.
CO5: Apply LLMs for mesh generation, MATLAB programming, debugging and verification.

CO-PO Mapping

PO/ PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO 11	PO 12
CO1	3	3	2	2	-	-	-	-	-	-	-	-
CO2	3	3	2	2	2	-	-	-	-	-	-	-
CO3	3	3	2	2	2	-	-	-	-	-	-	-
CO4	3	1	-	2	1	-	-	-	-	-	-	-
CO5	3	3	2	2	2	-	-	-	-	-	-	-

SYLLABUS

Unit 1: Basic finite element procedures: Stiffness and Flexibility approach, Direct Stiffness Method, Principle of Minimum Potential Energy, Strong form, Weak form, Variational formulation, Weighted Residual Method – Galerkin formulation, Formulation of the finite element equations – Element types – Basic and higher order elements – 1D, 2D, 3D coordinate systems.

Unit 2: Finite element in solid Mechanics: Analysis of trusses, beams and frames, plane stress, plain strain and axisymmetric elements, plate and shell elements. Isoparametric formulation.

Finite element in Heat transfer: Steady state heat transfer analysis: 1-D heat conduction of slab 1D fin elements, 2D heat conduction, analysis of thin plates, and analysis of a uniform shaft subjected to torsion, problems.

Unit 3: Computer implementation of Finite element method: Pre-processing, element calculation, equation assembly – assembly flowchart, formulation to 1D and 2D problems in stress analysis in MATLAB, convergence requirements, mesh generation, techniques such as semi-automatic and fully automatic use of software such as ANSYS, COMSOL, NASTRAN, etc.

Unit 4: Introduction to Artificial Intelligence, Generative AI and Large Language Models, understand how LLMs work: tokens, prompts, context window, hallucinations and responsible use (conceptual only), Prompt engineering for FEM. LLM-assisted MATLAB programming for mesh generation and finite element workflow: problem definition, element selection, boundary conditions, verification and post-processing.

TEXT BOOKS:

1. Thomas J. R. Hughes, "The Finite Element Method – Linear Static and Dynamic Finite Element Analysis", Dover Publications Inc, 2000.
2. Rao S. S., "The Finite Element Method in Engineering", Fourth Edition, Elsevier, 2007.
3. Daryl L. Logan, "A first Course in Finite Element Method", Fourth Edition, Cengage Learning, 2007.
4. David V. Hutton, "Fundamentals of Finite Element Analysis", McGraw Hill, 2005.
5. Jacob Fish and Ted Belytschko, "A First Course in Finite Elements", Wiley Inter Science, 2007.
6. Huyen, Chip, "AI engineering: Building applications with foundation models", O'Reilly Media, Inc., 2024.
7. Zhang, Aston, et al. "Dive into deep learning." Cambridge University Press, 2023, ISBN-13: 9781009389433.
8. Practical Deep Learning, Fast.ai (https://course.fast.ai/)

EVALUATION SCHEME

Sl. No.	**Type of Assessment**	Weightage
1	Quizzes and Assignments (Internal)	30%
2	MATLAB-FEM Lab Exam (Internal)	20%
3	Mid-term Exam (Internal)	20%
4	End Semester Exam (External)	30%