

Department of Applied Mechanics, IIT Delhi
Second Semester, 2023-2024

Introduction to Finite Element Method (APL 311) 3-0-2

Course Co-ordinator: Gaurav Singh (E: gsingh@am.iitd.ac.in, O: IV-255, P: 011-2659-1184).

Teaching Assistants: Sunil Kumar Dutta (amz198723@am.iitd.ac.in), Sachin Yadav (amz208677@am.iitd.ac.in), Naveen Kumar (amz218558@am.iitd.ac.in) & Ayan Basu (amz218552@am.iitd.ac.in).

Schedule: *Lecture:* C slot, TWF 8:00-8:50 am & *Practical:* PC4 slot, T 3:00-4:50 pm.

Venue: *Lecture:* LHC TBA & *Practical:* LHC 502.

Text: *Lecture:* Johnson, C. (2012) Numerical Solution of Partial Differential Equations by the Finite Element Method. Dover & *Practical:* SFePy Documentation.

Background Reference: *Text:* Kreyszig, E. (2021) Advanced Engineering Mathematics. Wiley. & *Practical:* SciPy and NumPy Documentation.

Lecture Outline:

#	Topic	#	Topic
	Background & Motivation	8	Abstract Formulation
	Elliptic PDEs	9	Discretization (Error Estimate)
1	Variational Formulation of 1D problem	10	Energy Norm
2	Piecewise Linear Function	11	Regularity in some finite elements
3	Error Estimate	12	Interpolation with piecewise linear functions
4	Poisson Equation	13	Interpolation with polynomials of higher degree
5	Hilbert Spaces	14	Adaptive Methods
6	Geometric Interpretation	15	Application to Linear Elasticity problem
7	Neumann Problem (Natural and Essential BCs)		Parabolic PDEs

Practical Outline:

#	Topic
a	Numerical Method: Solution, Interpolation, Integration & Differentiation
b	Numerical Method: Linear Algebra (Direct & Indirect Methods, Ill-conditioning)
c	Numerical Method: ODE (Single-step & Multi-step methods, Systems and Higher-order ODEs)
d	Numerical Method: PDE (Elliptic, Parabolic & Hyperbolic PDE, Neumann and Mixed BC for Elliptic)
e	Numerical Method: Curve Fitting (Least Squares) & Unconstrained Optimization (Steepest Descent)
A	Finite Element Method: Poisson Equation (Element level stiffness matrix, Load vector and Assembly)
B	Finite Element Method: Neumann Problem (Boundary Conditions)
C	Finite Element Method: Linear Elasticity Problem (Post Processing)
D	Finite Element Method: Convergence Study (Mesh Refinement)
E	Finite Element Method: Iso-parametric analysis
F	Finite Element Method: Solution for 1D Parabolic (Heat Conduction) PDE
	+ 3 buffer practical sessions to be taken as per need throughout the semester

Evaluation: Quiz (20%), Minor (20%), Practical (30%) & Major (30%).

Note:

- All evaluative components of this course are open book in nature with access only to the hand-written notes. Any book/photocopy is not allowed.
- The course-coordinator and TAs are available for in-person consultation after prior appointment taken through email.
- Institute rules apply for any aspect of the course which is not specifically mentioned here.