

Course Title: CEE-ME 327 Finite Element Methods in Mechanics Fall 2025

Instructor: Bahador Bahmani

Course Level: Undergraduate / Graduate

Prerequisites: Basic computer programming (in Python) and basic linear algebra.

Tools & Software: Python (NumPy, scikit-learn), Abaqus, Jupyter Notebooks

Course Description: This course provides a practical introduction to the Finite Element Method (FEM), with an emphasis on hands-on implementation using Python. It covers the basic theoretical concepts necessary to understand and apply FEM, without going into extensive mathematical detail. Students will learn how to build FEM solvers with minimal external dependencies and how to use a general-purpose framework (Abaqus). The course focuses on solving elliptic partial differential equations, with applications in heat conduction, linear elasticity, and potential flow, covering a broad range of topics relevant to students of civil and mechanical engineering..

Tentative Plan:

Topics	Duration	Problems
Introduction and review basic numerical methods (differentiation and integration), matrix operations, calculus of variations, etc.	3 sessions	HW 1 (written + programming)
Strong and weak forms, boundary conditions, Rayleigh-Ritz, weighted residuals, and Galerkin methods.	3 sessions	HW 2 & 3 (written)
One-dimensional FEM for scalar fields	3 sessions	HW 4 & 5 (written + programming)
Two-dimensional FEM for scalar fields (heat conduction)	4 sessions	HW 6 (written + programming)
Two-dimensional FEM for vector fields (planar elasticity)	4 sessions	HW 7 (written + programming)
Advanced topics: locking, reduced integration, machine learning techniques, etc.	4 sessions	

Grading: Homework 30%, Exams 70% (Quiz 10%, Midterm 30%, Final Project 30%), Class participation bonus (+10%)

Textbooks:

- **(Required)** J. Fish and T. Belytschko. *A first course in finite elements*. Wiley & Sons Ltd., West Sussex, UK, 2007.
- **(Highly Recommended)** T.J.R. Hughes, *The Finite Element Method: Linear Static and Dynamic Finite Element Analysis*. Dover Publications, Inc., Mineola, NY, 2000.

Other References:

- Prof. Wing Kam Liu's FEM lecture notes