CEE-ME 327 Finite Element Methods in Mechanics Fall 2022

Instructor: **Professor Wing Kam Liu**
Guest Instructor: **Professor Mark Fleming (Fusion Engineering)**
Days and Times: Tu, Th 12:30-13:50,
Place: University Hall 122
Office hours: Professor Wing Kam Liu: By appointment, Tech A326
Zoom: https://northwestern.zoom.us/s/97947520811
TA hours: Mon : 5:00 pm - 6:00 pm
Wed: 5:00 pm - 6:00 pm (ZOOM: TBD based on requests)
Teaching Assistants: Xiaoyu Xie and Subhadeep Pal
Graders: Xiaoyu Xie, Subhadeep Pal, Jiachen Guo, Yuhui Lyu

COURSE OBJECTIVES

To learn a) the basic theory behind the finite element method (FEM), b) how to program the FEM using MATLAB, c) how to use a general commercial FEM code to solve practical engineering problems, and d) how to use data science techniques for the interpretation of the FEM solutions and in the solving mechanics of materials problems.

	Topics	Problems
Week 1 Sept 20 (TU) & 22 (TH)	**Introduction and overview of the course** **Fish and Belytschko:** Ch. 2 (Sections 2.1-2.3): 1D problems, element stiffness matrix, assembly	**HW1:** 2.1, 2.2 (**due Sep 29**)
Week 2 Sept 27 (TU) & 29 (TH)	**Fish and Belytschko:** Ch. 3 (Sections 3.1-3.6): Strong and weak forms	**HW2:** 3.1, 3.2, 3.3, 3.7 (**due Oct 06**)
Week 3 Oct 04 (TU) & 06 (TH)	**Fish and Belytschko:** Ch. 4 (Sections 4.1-4.5): Element shape functions, **Fish and Belytschko:** Ch. 5 (Sections 5.1-5.2): FEM for 1D elasticity **Optional reading:** 1D elasticity, heat conduction	**HW3:** 3.10, 4.1, 5.17 (a, b) (**due Oct 13**) **Comp HW1:** 1D FEM in MATLAB part 1 (**due Oct 21**)
Week 4 Oct 11 (TU) & 13 (TH)	**Fish and Belytschko:** Ch. 6: Strong and weak forms in 2D **ABAQUS Tutorial 1** **Supplementary:** FEM for 2D & 3D problems with Laplace equation	**HW4: 5.16**, 6.1, 7.1 (**Due Oct 27**)
Week 5 Oct 18 (TU) & 20 (TH)	**Fish and Belytschko:** Ch. 7 (Sections 7.1-7.2): Shape functions in 2D, Ch. 4 (Section 4.6): Gauss quadrature method **Supplementary:** Lagrangian polynomials and numerical integration **Optional reading**: Ch. 7 (Sections 7.3-7.8)	**Comp HW2:** 2D ABAQUS (**due Nov 03**)
Week 6 Oct 25 (TU) & 27 (TH)	**Review** **Midterm**	
Week 7 Nov 01 (TU) & Nov 03 (TH)	**Principle of Virtual Work** **Fish and Belytschko:** Ch. 4 (Section 4.6) **Supplementary reading:** Elasticity tensor notes, principle of virtual work in multiple dimensions **Optional reading**: Ch. 9: Stress analysis in 2D (supplementary reading) **Viscoelasticity and Hyperelasticity**	**Comp HW3:** 1D FEM in MATLAB part 2 (**Due Nov 10**)
Week 8 Nov 08 (TU) & 10 (TH)	**ABAQUS Tutorial 2** **ABAQUS Tutorial 3**	**Comp HW4:** 2D & 3D stress analysis in ABAQUS **(due Nov 17)**
Week 9 Nov 15 (TU) & 17 (TH)	**Introduction to Mechanistic Data Science and application to Finite Element Analysis and Design 1 & 2**	**Comp HW5**: Viscoelasticity in ABAQUS (**due Nov 24**)
Week 10 Nov 22 (TU) & Nov 24 (TH, Thanksgiving)	**Application of Mechanistic Data Science**	
Week 11 Nov 29 (TU) & Dec 01 (TH)	**Review**	
Week 12	**Final Exam/Final Project Submission**	

GRADING: Class participation 10%, Written homework 15%, computer assignments 30%, exams 45% (midterm 20%, Final Project/Exam 25%) (Strict following of the format is required for the computer assignments and final project report)

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.

Review Materials: All the review materials' source will be found on CANVAS. TAs will discuss any questions that a student has on the review materials.