CEE-ME 327 Finite Element Methods in Mechanics Fall 2019

Instructors: **Professor Wing Kam Liu and Professor Mark Fleming of Fusion Engineering**

Days and Times: Tu, Th 12:30pm-1:50pm, Tech LR2

Office hour: Professor Wing Kam Liu: Tu Th 11:15am-12:15pm, Fri 9-10am, Tech A327
TAs: Mon Wed 3:30pm-5:00pm, Tech A311 or by appointment

TAs and Graders/ Computer Instructors: Satyajit Mojumder and from CEE, Graders: Mahsa Tajdari, Sourav Saha

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 Sep 24 & 26	**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 Oct 3**)
Week 2 Oct 1 & 3	**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 10**)
Week 3 Oct 8 & 10	**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 17**) **Comp HW1:** 1D FEM in MATLAB part 1 (**due Oct 24**)
Week 4 Oct 15 & 17	**Fish and Belytschko:** Ch. 6: Strong and weak forms in 2D **ABAQUS Tutorial 1 (Oct 17)** **Supplementary:** FEM for 2D & 3D problems with Laplace equation	**HW4:** 5.16, 6.1, 7.1 (**due Oct 31**)
Week 5 Oct 22 & 24	**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 7**)
Week 6 Oct 29 & 31	**Review** **Midterm**	
Week 7 Nov 5 & 7	**Neural Network (NN), NN-based shape function** **Fish and Belytschko:** Ch. 4 (Section 4.6) **ABAQUS Tutorial 2 (Nov 7)**	**Comp HW3:** 1D FEM in MATLAB part 2 (**due Nov 21**)
Week 8 Nov 12 & 14	**Principle of Virtual Work** **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 HW4:** 2D & 3D stress analysis in ABAQUS **(due Nov 26) and Using Neural Network on FEM data (due Dec 3)**
Week 9 Nov 19 & 21	**Introduction to Data Science-I (Dimension reduction method: Principle Component Analysis (PCA))** **ABAQUS Tutorial 3 (Nov 21)**	**Comp HW5**: Viscoelasticity in ABAQUS (**due Dec 5**)
Week 10 Nov 26 Nov 28 no lecture (Thanksgiving)	**Introduction to Data Science-II (Clustering methods: K-means, Self-Organizing Map)**	
Week 11 Dec 3 & 5	**Introduction to Data Science-III (Application of data science in mechanics of materials)** **Review**	
Week 12	**FINAL EXAM**	

GRADING: Written homework 15%, computer assignments 35%, exams 50%

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.