Department of Mechanical Engineering
ME EN 5510/6510 · Introduction to Finite Elements
Fall 2016

Syllabus

Instructor: Dr. Spear
Office hours: MEK 2151, T/H (9:30-10:30am) or by appointment
Email: *via Canvas only*

TAs: Sameer Nandikar
Office hours: MEK Computer Lab, M (4:30-5:30pm) or by appointment
Email: *via Canvas only*

Nik Benko
Office hours: MEB 1420, W (3:00-4:00pm) or by appointment
Email: *via Canvas only*

Units: 3

Meeting times and locations:

	Group A	Group B
Class-only days (C)	T,H 3:40pm-5:00pm (MEK 3550)	
Lab-only days (L)	2:30pm-3:45pm (WEB L210)	3:45pm-5:00pm (WEB L210)
Class/Lab days (C/L)	2:30pm-3:40pm (WEB L210) 3:45pm-4:15pm (MEK 3550)	3:45pm-4:15pm (MEK 3550) 4:20pm-5:30pm (WEB L210)

Recommended text: *A First Course in the Finite Element Method*. Daryl Logan, 5^{th} ed.
Concepts and Applications of Finite Element Analysis. Robert Cook, et al.
Finite Element Analysis: Theory and Application with Ansys. Saeed Moaveni

Prerequisites: ME EN 1300 (Statics), ME EN 3300 (Mechanics of Materials), ME EN 2450 (Numerical Methods), MATH 2250 (Linear Algebra, PDEs, ODEs), MATH 3150 (Boundary-value Problems), CS 1000 (Basic Programming, Intro. to Matlab)

Course website:
Outside of class, we will communicate with one another via Canvas. On Canvas, I will post supplementary documents, you can initiate discussion topics, and you may also contact me or the TAs if you have any questions or want to set up a time to meet outside of lab and office hours.

Official course description:
A practical approach to finite element analysis (FEA). The course will provide an introduction to the theoretical basis of the *direct stiffness*, *potential energy*, and *weighted residual* formulation methods of simple elements (1D, 2D). Students will also get exposure to commercial finite element software (**ANSYS** or **ABAQUS**) and will learn to critically evaluate finite element models. Examples will be provided for solid, fluid, and heat transfer applications. A brief introduction to some advanced methods (multiphysics, design optimization, and combined Eulerian-Lagrangian formulations) will be provided.

Course objectives:
By the end of this course, you should be able to:
1) Implement the various numerical methods of FEA for basic 1D and 2D elements;
2) Understand the ability of FEA to be easily implemented in multiple disciplines;
3) Develop an understanding of the structure of 1D and 2D elements;
4) Understand the limitations of FEA and the importance of ***verification and validation***;
5) Successfully create a finite element model using commercial software;
6) Critically evaluate finite element models developed by yourself and others.

Deliverables and grading:

Homework	15%
Lab Assignments	15%
Exams	30%
Final Project	40%

≥93.0	<93.0 ≥90.0	<90.0 ≥87.0	<87.0 ≥83.0	<83.0 ≥80.0	<80.0 ≥77.0	<77.0 ≥73.0	<73.0 ≥70.0	<70.0 ≥67.0	<67.0 ≥63.0	<63.0 ≥60.0	<60.0
A	A-	B+	B	B-	C+	C	C-	D+	D	D-	E

The total score is the weighted average of the homework, lab assignments, exams, and final project, as described in the table above. A curve (upward) will be applied only if the overall scores are lower than expected; otherwise, no curve will be applied.

Homework (HW), Lab Assignments (LA), Project Assignments (PA):
Generally, there will be one homework or lab/project assignment due each week. The homework assignments are meant to test and affirm your understanding of the theoretical background provided during lecture. Many of these assignments will be completed using MATLAB/Python, ABAQUS, or ANSYS (or any other program of your choice). Lab assignments are short assignments associated with lab tutorials. Project assignments will consist of a component required for your final FEA project. A significant portion of lab time will be allotted for you to work on the project and lab assignments, but these assignments will likely require additional out-of-class time.

HW – Homework will be turned in with a cover page that is provided. Each problem is to be worked on a separate page. Instructions for submitting your HW will be provided at the top of every assignment.

LA – Lab assignments will be turned in electronically via Canvas in a PDF format. Templates will be provided.

Late submission policy – Late submissions will be accepted up to five days past the original deadline, with a penalty of 10% reduction per day, for example:

$$HW_{Penalized\ \ Score} = HW_{Your\ Score} \cdot \left(1 - 0.1 \cdot \#_{Days}\right) \forall (0 \leq \#_{Days} < 5)$$

Partial-term exams: Three exams will be given for this course and will cover topics discussed during lecture and/or lab sessions. All exams are **closed-book, closed-notes**. There will be no make-up exams unless arranged in advance.

Final project: There will be no final exam for this course. Instead, a final project will be due at the end of the semester. The topic of the project is up to each student and will utilize knowledge gained during the labs. More information regarding the final project will be provided later in the semester.

WEEK-BY-WEEK SCHEDULE

Lecture	Date	Where? (Class or Lab)	Topic	Reading*	Assignment Due	
	WEEK 1					
1	T: Aug. 23	C	Course overview, Intro. to FEM	1.4-6		
2	Th: Aug. 25	C	Direct method - 1D axial bar, 2D truss	2.1-5, 3.4-6		
	WEEK 2					
3	T: Aug. 30	C	Variational methods - 1D bar, 2D truss	2.6, 3.10-13	HW1	
4	Th: Sep. 1	C/L	Variational methods (cont.), Intro. to FE software			
	WEEK 3					
5	T: Sep. 6	C	1D beams (direct, energy, Galerkin methods)	4.1-3, 4.7-8	LA1	
6	Th: Sep. 8	C/L	Shape functions, 1D beams (cont.)		HW2	
	WEEK 4					
7	T: Sep. 13	C	1D elements, shape functions, coordinates	2.2, 4.8	LA2	
	Th: Sep. 15	C	**EXAM 1**			**Theory**
	WEEK 5					
8	T: Sep. 20	C/L	1D problems (heat transfer, fluid mech)	13.1-4, 14.1-4	HW3	
9	Th: Sep. 22	C	2D elements, axisymmetric elements	8.1-2, 9.1-3		
	WEEK 6					
10	T: Sep. 27	C	2D elements, isoparametric elements, Gauss quadrature	10.1-5	HW4	
11	Th: Sep. 29	C	Plane-stress, plane-strain elements	6.2-4		
	WEEK 7					
12	T: Oct. 4	C/L	2D problems (heat, solid, fluid)	13.5, 14.3	HW5	
13	Th: Oct. 6	C	3D elements	Handout, 11.1-3		
	WEEK 8		**NO CLASS (FALL BREAK)**			
	Oct. 10-14					
	WEEK 9					
14	T: Oct. 18	C	3D elements (cont.), Intro. to modeling process	7.1, 7.4-8	HW6, PA1	
	Th: Oct. 20	C	**EXAM 2**			
	WEEK 10					
15	T: Oct. 25	C/L	Geometry, material properties, loads/BCs			
16	Th: Oct. 27	L	Geometry, material properties, loads/BCs			
	WEEK 11					
17	T: Nov. 1	C	Meshing, mesh quality evaluation		PA2	
18	Th: Nov. 3	L	Meshing, mesh quality evaluation			
	WEEK 12					
19	T: Nov. 8	C	Convergence studies	7.3, 8.3	PA3	
20	Th: Nov. 10	L	Convergence studies			
	WEEK 13					**Application**
21	T: Nov. 15	C/L	Error analysis, verification, validation		PA4	
22	Th: Nov. 17	L	Error analysis, verification, validation			
	WEEK 14					
	T: Nov. 22	C	**EXAM 3**			
	Th: Nov. 24		**NO CLASS (THANKSGIVING)**			
	WEEK 15					
23	T: Nov. 29	C/L	Intro. to advanced topics in FE		PA5	
24	Th: Dec. 1	L	Work on projects			
	WEEK 16					
25	T: Dec. 6	L	Work on projects			
	Th: Dec. 15		**FINAL PROJECTS DUE (5:00PM)**			

*Suggested reading corresponds to *A First Course in the Finite Element Method* by Daryl Logan