ME335A – Finite Element Analysis

"Fundamental concepts and their application to elliptic problems"

Instructor	Professor Adrian J. Lew 520-127, MC-3032 lewa@stanford.edu (650) 725-3585 Office hours: Mondays, 12:00 PM – 2:00 PM, in 520-127.
Teaching Assistants	Jose Solano Castellanos jsolanoc@stanford.edu
Class Time and Location	Tuesday, Thursday 10:30 AM-11:50 AM Y2E2 111 Spring quarter, 2023
Problem Sessions & Office Hours	Problem Sessions: Friday 4-5 PM, location to be announced. Office hours: Tuesday 12:15-2:15 PM, 520-127. Tuesday 4-6 PM Friday 5-6 PM Starting 4/7/23 During problem sessions the TA will solve more example problems to complement those seen in class. During office hours an open discussion of questions will take place, individually or in groups. Problem sessions will be held on selected weeks, and only when announced. On the weeks in which no problem session is held, office hours will be held instead. The office hours of the instructor will be online for the instructor to be available at a time at which most students are.

Prerequisites	Undergraduate preparation in basic calculus (partial derivatives, multiple integrals, basic notions on ordinary/partial differential equations, vectors, matrix algebra) and mechanics (e.g. elementary strength of materials and/or elementary solid mechanics and/or elementary fluid mechanics).
Textbook	A partial set of lecture notes by the instructor and Gustavo Buscaglia, Professor of Applied Mathematics at USP, Brazil. This and other relevant references for the class are linked in the Pages section of Canvas.
Website and Class Announcements	Canvas, http://canvas.stanford.edu Please register via Axess to make sure you get announcements
Teaching Team Email	Please email the entire teaching team using me335-staff@lists.stanford.edu
Matlab Projects	Three coding projects will require working with a supplied MATLAB framework and completing missing routines. Projects illustrate: (1) 1-D boundary value problem, (2) 2-D steady heat equation, and (3) 2-D heat equation with higher-order elements.
Exams	There will be a final exam. It will take place on Tuesday, June 13, 2023, 3:30 PM-6:30 PM.

Homework Assignments

Every week, see the schedule below. Due on Wednesdays at midnight of California (PDT). No credit for late turn-in (unless approved by instructor). You can count with one guaranteed approval for late homework during the quarter, normally to Monday. A second approval will be granted under reasonable circumstances. In view of the special times we are living in, please let the instructor know if your situation changes in a way that you would need a more flexible schedule, and we will do our best to accommodate it.

Homework assignments should be uploaded to Gradescope.

Collaboration in assignments between students is permitted only towards discussing the statement and the solution of a problem. The solution of each homework problem is an individual task and should be written independently by each student. Failure to honor this rule will result in the homework assignment receiving zero score.

In completing a part of a homework assignment in long form, make sure to clearly outline your thought process to the solution. This will enable us to assign you partial credit for an otherwise incorrect solution.

Long form solutions to homework assignments need to be NEATLY (meaning legibly and with a clear organizational structure) presented on a clean sheet of paper or document. Your assignments need to be easy to follow and understand. We will simply disregard as not turned-in and assign a minimum grade to any assignment that does not meet these requirements. I cannot emphasize this enough.

Grading Policy

Your class score is obtained by weighting the scores in the following way

- Problem Sets: 60%
- Computer Projects: 20%
- Final Exam: 20%

The final grade for the class is computed with both an absolute and relative (curve) scale. If you get above or equal to

- 98% of the maximum score you get an A+
- 90% of the maximum score you get an A
- 85% of the maximum score you get an A-
- 80% of the maximum score you get a B+
- 75% of the maximum score you get a B
- 70% of the maximum score you get a B-
- 65% of the maximum score you get a C+
- 60% of the maximum score you get a C
- 55% of the maximum score you get a C-
- 50% of the maximum score you get a D+
- 45% of the maximum score you get a D

If you get less than 45% of the maximum score you get an NP.

Simultaneously, at least 25% of the class will get an A, at least 50% of the class will get a B or higher, and at least 75% of the class will get a C or higher, as long as the minimum of 45% of the maximum total score is achieved. This distribution will be achieved by uniformly shifting everyone's grade up by the same amount.

Class Policy

Reminder: We should all abide by Stanford's honor code.

Suspected infractions will be referred to Judicial Affairs – please do not make us do this.

Communication with the instructor

Please let the instructor know if you need a one-to-one meeting during the quarter aside from office hours or the lecture. Comments and suggestions on the progress of the class are always welcome.

Learning Objectives

By the end of the course you should be able to:

1. Formally construct variational equation for a problem starting from the partial differential equation.
2. Formulate a Finite Element Method from a variational form of a linear elliptic problem.
3. Construct and implement finite element spaces, assemble elemental contributions, and find the finite element solution; all in Matlab, and in 1D, 2D (and 3D).
4. Formally understand: (a) why FEM as a method to approximate solutions to boundary value problems works, at least in simple linear elliptic problems, and (b) what convergence rates to expect and how to use this knowledge to test whether a numerical solution is good enough.
5. Be familiar with some common finite element classes.

Students with documented dissabilities

Students who may need an academic accommodation based on the impact of a disability must initiate the request with the Student Disability Resource Center (SDRC) located within the Office of Accessible Education (OAE). SDRC staff will evaluate the request with required documentation, recommend reasonable accommodations, and prepare an *Accommodation Letter* for faculty dated in the current quarter in which the request is being made. Students should contact the SDRC as soon as possible since timely notice is needed to coordinate accommodations. The OAE is located at 563 Salvatierra Walk (phone: 723-1066).

Schedule and Syllabus:

Wk	Mo	Tu	We	Th	Fr
1		Apr 4 1		Apr 6 2	
2		Apr 11 3	Apr 12 HW#1 Due	Apr 13 4	
3		Apr 18 5	Apr 19 HW#2 Due	Apr 20 6	
4		Apr 25 7	Apr 26 HW#3 Due	Apr 27 8	
5		May 2 9	May 3 CP#1 Due	May 4 10	
6		May 9 11	May 10 HW#4 Due	May 11 12	
7		May 16 13	May 17 HW#5 Due	May 18 14	
8		May 23 15	May 24 CP#2 Due	May 25 16	
9		May 30 17	May 31 HW#6 Due	Jun 1 18	
10		Jun 6 19	Jun 7 HW#7 Due CP#3 Due		
11		Jun 13 Final Exam			

Nomenclature for the next table:
IN – Instructor's notes

Legend:
May 4 (date)
2 (lecture #)

#		Date		Topic	References
1	Tu	Apr	4	Presentation of the Course	
2	Th	Apr	6	Partial Differential and Variational Equations	IN 1.1.1, 1.1.2
3	Tu	Apr	11	Vector Spaces of Functions	IN 1.2
4	Th	Apr	13	Variational Numerical Methods	IN 1.3
5	Tu	Apr	18	Variational Numerical Methods	IN 1.3
6	Th	Apr	20	The Simplest C^0 Finite Element Space in 1D	IN 1.4.1, 1.4.2
7	Tu	Apr	25	Construction of Finite Element Spaces	IN 1.4.3
8	Th	Apr	27	Assembly	IN 1.4.4
9	Tu	May	2	Fourth-Order Problems	IN 1.5
10	Th	May	4	Diffusion Problems in 2D	IN 2.1, 2.2, 2.3
11	Tu	May	9	The Simplest C^0 Finite Element Space in 2D	IN 2.4
12	Th	May	11	The FEM for the Difussion Equation	IN 2.5
13	Tu	May	16	Integration/Quadrature	IN 2.6
14	Th	May	18	Numerical Analysis of FEM	IN 3
15	Tu	May	23	Numerical Analysis of FEM	IN 3
16	Th	May	25	The Linear Elasticity Problem	IN 4.1
17	Tu	May	30	The FEM for Linear Elasticity	IN 4.2
18	Th	Jun	1	Isoparametric Elements	IN 5
19	Tu	Jun	6	A Finite Element Zoo	IN 5