

# MECH 5311/6311 - Advanced Finite Element Analysis

## Course Syllabus

### Spring 2023

**Time and Location:** MW 12:00 PM – 1:20 PM, Liberal Arts Building 122

**Instructor:** Prof. Zhengtao Gan  
E-mail: [zgan@utep.edu](mailto:zgan@utep.edu)

**Office hours:** Tu 11:00 – 12:00 (A117)  
Fr 11:00 – 12:00 (E226B)

#### Reference Textbooks and Websites:

- Fish, J. and Belytschko, T., 2007. A first course in finite elements (Vol. 1). New York: John Wiley & Sons.
- <https://www.math.colostate.edu/~bangerth/videos.html>
- <https://jsdokken.com/dolfinx-tutorial/>
- <http://solidmechanics.org/>

**Blackboard:** The instructor will use Blackboard for uploading lectures, updating the syllabus (if necessary), and communicating with students via “Announcements” and email.

**Required Material/Software:** Python

**Prerequisites:** MECH 4326 Finite Element Analysis

**Course Description:** This course is designed to provide a comprehensive introduction to the finite element method (FEM) and its applications in engineering analysis and design. The course will cover the fundamental concepts and principles behind the linear and nonlinear FEM as well as the implementation of the FEM using Python and an open-source library FEniCS. In the first half of the course, students will learn the basics of one-dimensional FEM through the analysis of an axially loaded elastic bar, and will then progress to the study of multi-dimensional FEM. The second half of the course will focus on the use of FEniCS to solve a variety of engineering problems, including the Poisson equation, heat equation, nonlinear Poisson equation, linear elasticity equation, Navier-Stokes equations, and J2 plasticity. The course will also include lectures on optimization methods and model calibration, and students will have the opportunity to apply their knowledge through the proposal and presentation of projects.

## Lectures Schedule:

Date	Week	Content	Homework Assignment
01/18 Wed	1	Introduction of FEM	
01/23 Mon	2	The ideas behind the finite element method: approximation and find an approximation	
01/25 Wed		1D FEM: an axially loaded elastic bar 1	Homework 1: weak form derivation of 1D FEM
01/30 Mon	3	1D FEM: an axially loaded elastic bar 2	
02/01 Wed		Python programming basic (Invited instructor: Xavier Hebol D Cruze)	Homework 2: Python coding for 1D FEM
02/06 Mon	4	Python implementation of 1D FEM 2	
02/08 Wed		Multidimensional FEM 1	Homework 3: weak form derivation of 3D FEM
02/13 Mon	5	Multidimensional FEM 2	
02/15 Wed		FEniCS: an open-source FEM library Example 1: Poisson equation	Homework 4: FEniCS coding I
02/20 Mon	6	FEniCS example 2: heat equation	
02/22 Wed		FEniCS example 3: nonlinear Poisson equation	Homework 5: FEniCS coding II
02/27 Mon	7	Linear elasticity equation	
03/01 Wed		FEniCS example 4: linear elasticity	
03/06 Mon	8	Optimization methods and model calibration 1	Homework 6: model calibration
03/08 Wed		Optimization methods and model calibration 2	
03/13 Mon	9	Spring Break	
03/15 Wed		Spring Break	
03/20 Mon	10	Proposal discussion	
03/22 Wed		Proposal discussion	
03/27 Mon	11	Projects Proposal Presentation	
03/29 Wed		Projects Proposal Presentation	
04/03 Mon	12	FEniCS example 5: hybrid boundary condition and subdomains	
04/05 Wed		Navier-Stokes equations for fluid mechanics	
04/10 Mon	13	FEniCS example 6: Navier-Stokes equations	
04/12 Wed		J2 plasticity	
04/17 Mon	14	FEniCS example 7: J2 plasticity and residual stress in additive manufacturing	
04/19 Wed		JAX-FEM: A differentiable GPU-accelerated 3D finite element solver for automatic inverse design and mechanistic data science (invited talk)	
04/24 Mon	15	Projects discussion	
04/26 Wed		Projects discussion	
05/01 Mon	16	Final Projects Presentation	
05/03 Wed		Final Projects Presentation	

**Exams:** No exams, but there are several homework assignments and a team project for this course.

**Project:** There will be a team project given in the semester. Each team typically includes 2-3 team members. A team including more than three team members should be permitted by the instructor. This project is of such a scope that it will take a few weeks to complete. Typically, they will involve using FEM model as a design tool and then involve design iteration. There will have a proposal presentation in the midterm and a final presentation for each team.

### Grading

Your final grade for this course will be based on the following activities

Assignments	Percentage
Homework (6x)	60%
Project	40%
Total	100%

Grade Scale	
100-90%	<b>A</b>
89-80%	<b>B</b>
79-70%	<b>C</b>
69-60%	<b>D</b>
<60%	<b>F</b>

The instructor reserves the right to revise this grading plan.

**NO** extensions are given in homework or quizzes.

**Exams:** Finding and submitting on the blackboard, proctoring via Zoom (Webcam needed).

**The instructor preserves the right to ask for explanation of the student's exam answers.**

### Academic Dishonesty

During exams and quizzes, you are not allowed to use any form of wifi enabled electronic device, including cell phones or other electronic communication devices or methods (wrist watches, earbuds, etc.). No wrist watch or other electronic device may be worn.

No electronic version of the book, loose paper print-outs of the book or extra sheets of paper of any kind are allowed unless explicitly mentioned in writing by the instructor. As a part of the zero-tolerance policy, if you have a cellphone or other electronic device capable of communication on your person; or if any proctor sees or hears any electronic device during the exam or if you share your work with someone else, you will be reported to the proper authorities and you may receive a zero on the exam and an F in the class. Other actions including suspension may also be perused. If you have a disability that requires the use of an electronic device during exams you must have a letter of accommodation from the Center for Accommodations and Support Services (CASS). This accommodation must be coordinated in advance with the instructor.

During exams, you will not be allowed to leave the examination room until you complete the exam. This includes restroom breaks. Students with disabilities must have a letter of accommodation and coordinate this in advance with the instructor.

Instructors and/or proctors may record and/or use their personal cell phones to document activity during the exam. Recording devices may also be located at various locations in the room and may be out of sight of the students. These recordings will be managed according to the UTEP approved regulations for such media.

If you are suspected of scholastic dishonesty you may not be directly confronted about your conduct by the instructor or proctor. You will however, be reported to the Office of Student Conduct and Conflict Resolution (OSCCR) and your exam will not be admissible. Your grade in the class may not be available until OSCCR makes a final ruling, this may adversely impact your ability to enroll in other classes.

If you arrive more than 15 minutes late to an exam, you will not be allowed to enter the examination room.

There will be no makeup exams administered. If you have a university approved excuse, your instructor will have a process for determining how to handle the missing grade outlined in the syllabus. However, no makeup exams will be given.

If you miss more than one exam, the instructor may choose to administratively drop you from the class. This may adversely impact a visa and financial aid.

No food or drinks will be allowed in the examination room.

Departmental policy allows for the use of assigned seats. All students must present their UTEP issued ID prior to and during every exam and may be required to sign in. Not having a UTEP issued ID when asked will result in forfeiture of the exam.

Scholastic dishonesty on homework, lab assignments and all other class assignments will be held to the same standards and requirements of academic honesty as quizzes and exams.

### **Class Attendance Policy**

Attendance is mandatory (there is an exceptional for those who cannot participate for acceptable excuse). Anyone with 5 or more absences will be dropped from the class. A drop for not attending will count toward the State Allowed Six Drop Limit. If you are failing the class at the time of the drop you may also be given a WF designation. Be advised that a drop could adversely impact visa status, financial aid and other programs.

As per UTEP rules, you may be asked to show a UTEP ID at any time during class. Anyone who is present and not registered in the class will be subject to disciplinary action unless the instructor gives prior approval.

### **Harassment Policy**

The department has a zero-tolerance policy for harassment. Engagement in any behavior considered harassment will be reported to the proper authorities. In addition to generally understood forms of harassment, the department also treats the following behavior as harassment:

- Repeated emails and/or calls regarding subjects that have already been addressed. Once a decision has been made or a question answered, a student who continues to ask the same question will be given a warning by the recipient of the email/call. If the student continues, the behavior will be reported. Questions that seek understanding of course material are not harassment; but repeated questions about a grade or an administrative decision are.
- Grades are NOT negotiable, ever. If you believe a grading mistake has been made, you must follow the process described in the UTEP catalog. Any request for a grade elevation that is NOT based on a mistake is considered harassment and will be reported immediately.
- Remaining in an office after the occupant requests you leave is considered harassment and potentially threatening. You will be reported immediately without warning and depending on the severity, may be reported to law enforcement.
- Similar behavior towards department staff, and student advisors will also be treated as harassment, including persistent phone calls, emails, and badgering. Department staff and student advisors are there to help students, and should be treated with due respect.

**Reasonable Accommodation Policy:** If you have a disability and need classroom accommodations, please contact the Center for Accommodations and Support Services (CASS) at 747-5148, or by email to [cass@utep.edu](mailto:cass@utep.edu), or visit their office located in UTEP Union East, Room 106. For additional information, please visit the CASS website at [www.sa.utep.edu/cass](http://www.sa.utep.edu/cass).

**Course Calendar:** May be updated throughout the semester. Always see the current version of the syllabus on Blackboard.

### **Department of Mechanical Engineering Safety Statement**

The Department of Mechanical Engineering at the University of Texas at El Paso is committed to a model of excellence in education that includes providing a safe and healthy environment for its students, staff, faculty and the general public.

Our goal is to maximize education and research training that can only occur if you, the individual, minimize hazards and risks. This can be done by:

- Providing adequate control of the health and safety risks arising from any and all activities;
- Consulting with employees on matters affecting their health and safety
- Providing and maintaining safe laboratories and equipment;
- Ensuring safe handling and use of substance;
- Ensuring all employees are competent to do their task and have adequate training; and
- Maintaining clean, safe and healthy working conditions

The principal investigator or individual in charge of each laboratory is ultimately responsible for safety in that respective lab. This includes training and ultimate release of the laboratory. Within the Department, we hold every employee (staff, faculty, student) responsible for implementing our safety practices and our departmental safety policy. We hold every employee (staff, faculty, student) responsible for providing leadership within our department to establish effective environmental safety and occupational health standards.