

MECH 5305/6305 Computational Fluid Dynamics

Course Syllabus

Fall 2023

Time and Location: MW 10:30 AM - 12:00 PM, Liberal Arts Building 305

Instructor: Prof. Zhengtao Gan
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Reference Textbooks and Websites:

- <https://lorenabarba.com/blog/cfd-python-12-steps-to-navier-stokes/>
- <https://github.com/google/jax>
- <https://github.com/tianjuxue/jax-am>

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 2351

Course Description: This course offers a deep and hands-on introduction to Computational Fluid Dynamics (CFD), marrying theory with practice through a blend of lectures and experiential exercises. Beginning with a foundational session on the core concepts of CFD, the course quickly delves into practical Python programming skills to prepare students for subsequent exercises. As students progress, they will be engaged in a series of coding tests and exercises, aimed at enhancing their understanding and capability in handling various equations such as convection, diffusion, Burgers’, Laplace, and Poisson equations. Within this course, students will also explore the complexities of array operations with NumPy, facilitating an understanding of 2D equations and cavity flow simulations using various schemes including the Navier-Stokes and Chorin’s projection methods. Later in the course, learners will be introduced to advanced topics like Phase field modeling, ODE-constrained optimization, and Smoothed Particle Hydrodynamics, fostering a deep understanding of the specialized aspects of CFD. Furthermore, the integration of JAX as a tool for more complex operations will be highlighted. Towards the end of the course, students will have the opportunity to delve into special topics, bringing together the knowledge and skills acquired throughout the course in a series of challenging and rewarding exercises. This structured yet flexible approach makes this course suitable for individuals keen on gaining a profound and hands-on expertise in Computational Fluid Dynamics.

Lectures Schedule:

Date	Week	Lec.	Content
09/04 Mon	1		Labor Day Holiday- University Closed
09/06 Wed		1	Introduction of CFD
09/11 Mon	2		No class
09/13 Wed		2	Python intro
09/18 Mon	3		Hands-on 1: Python coding test (10%)
09/20 Wed		4	1D convection equation
09/25 Mon	4	5	CFL condition and upwind scheme
09/27 Wed			Hands-on 2: QUICK scheme (10%)
10/02 Mon	5	6	1D diffusion and Burgers' equation
10/04 Wed			Hands-on 3: improve Burgers' solver (10%)
10/09 Mon	6	7	Array Operations with NumPy
10/11 Wed		8	2D convection equation
10/16 Mon	7	9	2D diffusion equation
10/18 Wed		9	Hands-on 4: 2D Burgers' equation and Array Operations (10%)
10/23 Mon	8	10	2D Laplace and Poisson equation
10/25 Wed		11	Cavity flow with Navier-Stokes equation
10/30 Mon	9	12	Cavity flow with Chorin's projection
11/01 Wed		13	Cavity flow with upwind scheme
11/06 Mon	10	14	Poiseuille channel flow
11/08 Wed		15	Hands-on 5: improve Poiseuille solver (10%)
11/13 Mon	11		JAX-basic
11/15 Wed		16	2D diffusion – Numpy and JAX
11/20 Mon	12	17	Hands-on 6: Poiseuille solver using JAX (10%)
11/22 Wed			Special topic 1: Implicit solver: Poisson and N-S equation
11/27 Mon	13	18	Special topic 2: Phase field modeling
11/29 Wed		19	Special topic 3: ODE-constrained optimization
12/04 Mon	14	20	Special topic 4: Smoothed Particle Hydrodynamics (SPH)
12/06 Wed			Hands-on 7: implicit solver or phase-field or constrained optimization or SPH (20%)

Exams: In this course, there will be no traditional examinations. Instead, student evaluations will be predominantly based on their active participation and performance during the hands-on sessions.

Grading

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

Assignments	Percentage
Hands-on sessions (7x)	80%
Attendance	20%
Total	100%

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

The instructor reserves the right to revise this grading plan.

NO extensions are given in homework or quizzes.

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, 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.

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.