ME 310 Fundamentals of Fluid Dynamics
Fall 2025

Instructor: Prof. Ke Tang
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Course Website: via Canvas https://canvas.illinois.edu/

Lectures: 9:00–9:50 am, MWF, 124 Burrill Hall
iClicker will be used in class for polling questions as classwork. Please refer to the iClicker website for guidance (https://www.iclicker.com/students/).

Required Text: Munson, Young and Okiishi's Fundamentals of Fluid Mechanics, 9th Edition, by Andrew L. Gerhart, John I. Hochstein, and Philip M. Gerhart

Course Description:
This course focuses on the fluids at rest or in motion with forces on them. Students will learn how to understand, predict, and design for scenarios involving fluids. Beyond fluids, students will strengthen their general understanding of forces and motion, sharpen their mathematical skills, improve their experimental data collection and analysis, and learn how to use dimensional analysis to dramatically simplify complex parameter spaces. Prerequisite: MATH 285 or MATH 441; credit or concurrent registration in ME 200

Topics include:
1) Introduction (Fluid: definitions; properties)
2) Fluid Statics (Fluids that don't flow: manometry; hydrostatics; buoyancy)
3) Fluid Kinematics (How fluids flow: velocity; acceleration; streamlines)
4) Fluid Dynamics (Why fluids flow: conservations of mass, momentum, and energy)
   - Elementary fluid dynamics (streamline and Bernoulli equation)
   - Finite control volume analysis ("chunks" of fluid)
   - Differential analysis ("points" of fluid)
5) Dimensional Analysis and Similitude (Buckingham PI theorem and similarity principle)
6) Internal Flow (Applications: pipes and ducts; head loss)
7) External Flow (Applications: drag and lift; boundary layers)
8) Compressible Flow (Applications: steady isentropic flow of ideal gas)

At the end of this class, students will be able to:

1) Identify and explain the concepts of fluid and fluid properties;
2) Calculate and analyze the scenarios involving the manometry, the hydrostatic force on the plane and curved surfaces, the buoyancy, and the rigid body motion of fluid from the viewpoint of fluid statics for real-world problems;
3) Identify and explain the Lagrangian description and the Eulerian description, as well as apply material derivative and Reynolds Transport Theorem, from the viewpoint of fluid kinematics;
4) Identify and apply the Bernoulli equation, the finite control volume analysis, and the differential analysis from the viewpoint of fluid dynamics for real-world problems;
5) Apply the Buckingham PI Theorem to conduct systematic dimensional analysis and apply the similarity principle to design lab models;
6) Identify and explain the internal flow and the corresponding concepts of flow regime, major loss and minor loss, and apply the extended Bernoulli equation to conduct analysis and design of pipelines for closed-conduit flows in the real world;
7) Identify and explain the external flow and the corresponding concepts of boundary layer and boundary layer separation, and apply the concepts and correlations to calculate the drag and the lift;
8) Identify and explain the compressible flow and the corresponding concepts of stagnation properties, sound speed, and Mach number, apply the concepts to analyze the 1-D steady isentropic flow of ideal gas.

Course Grading:

Laboratory 25%

Lecture 75%

- Classwork 5%
- Homework 10%
- Midterm Exam 1 15%
- Midterm Exam 2 15%
- Final Exam 30%

The final letter grade will be assigned using the following numerical cutoffs:

97 – 100 A+	93 – 97 A	90 – 93 A-
87 – 90 B+	83 – 87 B	80 – 83 B-
77 – 80 C+	73 – 77 C	70 – 73 C-
67 – 70 D+	63 – 67 D	60 – 63 D-
0 – 60 F		

Classwork is usually polling questions performed via iClicker and the completion grade will be assigned to classwork. You can email me ahead of time to request a leave of excused absence and in this way you can be exempt from classwork. No classwork assignments will be dropped off.

Homework must be an electronic version in a single PDF file and must be submitted on the course website via Canvas. Homework must be submitted on time. An extension of

one day can be automatically granted, but it will be accompanied by a 20% reduction in your score. No homework will be accepted after an extension. Homework will be graded on correctness. Your work must be neat and complete to receive full credit. “Complete” means all the steps showing how you reach your final answer must be presented. If a free body diagram (FBD) or a control volume (CV) is involved in your analysis, the FBD and CV must be presented in your work. The steps of plugging the given numbers with units into the equations must be presented in your work and the units must be included with the numerical results. Words must be used to explain your thoughts, not just equations. There will be some chances to earn extra homework points, however, no homework assignments will be dropped off.

All the exams will be closed-book exams. The tentative schedule for the exams can be found in the teaching calendar. The students who need the accommodation of extra time for exams must schedule and take their exams at the DRES TAC (Testing Accommodations Center of Disability Resources and Educational Services). Please complete scheduling the exams at the DRES TAC as soon as possible, especially for the final exam, since the DRES TAC may not accept your application and schedule when they reach the capacity limit. If students fail in scheduling exams at the DRES TAC, they must attend the regular exams without the accommodation of extra exam time.

The excused absence from class and the late submission beyond a one-day extension can be considered only if you ask for leave or an additional extension in advance. It is the student’s responsibility to make sure of a successful submission of their work. After the submission of your work on the Canvas course website, please immediately check if your work has been submitted successfully. If not, please redo the submission. If the resubmission online fails, you must email me your work for submission, as well as the evidence of the work completion on time, by the following day of the due date. The instructor will decide whether the work can be accepted or not. It is also the student’s responsibility to make sure that their work is submitted correctly and completely. 0 points will be assigned for a wrong submission. No resubmission will be accepted for an incomplete submission.

Do not duplicate anyone’s work. Any duplication identified during the grading process will result in sanctions according to the Academic Integrity Policy in the Student Code.

ADDITIONAL INFORMATION FOR THE UNIVERSITY OF ILLINOIS AND THE GRAINGER COLLEGE OF ENGINEERING

Academic Integrity

The University of Illinois at Urbana-Champaign Student Code should also be considered as a part of this syllabus. Students should pay particular attention to Article 1, Part 4: Academic Integrity. Read the Code at the following URL: http://studentcode.illinois.edu/.

Academic dishonesty will result in a sanction proportionate to the severity of the infraction, with possible sanctions described in 1-404 of the Student Code (https://studentcode.illinois.edu/article1/part4/1-404/). Every student is expected to review and abide by the Academic Integrity Policy as defined in the Student Code: https://studentcode.illinois.edu/article1/part4/1-401/. As a student, it is your responsibility to refrain from infractions of academic integrity and from conduct that aids others in such infractions. A short guide to academic integrity issues may be found at https://provost.illinois.edu/policies/policies/academic-integrity/students-quick-reference-guide-to-academic-integrity/. Ignorance of these policies is not an excuse for any academic dishonesty. It is your responsibility to read this policy to avoid any misunderstanding. Do not hesitate to ask the instructor(s) if you are ever in doubt about what constitutes plagiarism, cheating, or any other breach of academic integrity.

Anti-Racism and Inclusivity Statement

The Grainger College of Engineering is committed to the creation of an anti-racist, inclusive community that welcomes diversity along a number of dimensions, including, but not limited to, race, ethnicity and national origins, gender and gender identity, sexuality, disability status, class, age, or religious beliefs. The College recognizes that we are learning together in the midst of the Black Lives Matter movement, that Black, Hispanic, and Indigenous voices and contributions have largely either been excluded from, or not recognized in, science and engineering, and that both overt racism and micro-aggressions threaten the well-being of our students and our university community.

The effectiveness of this course is dependent upon each of us to create a safe and encouraging learning environment that allows for the open exchange of ideas while also ensuring equitable opportunities and respect for all of us. Everyone is expected to help establish and maintain an environment where students, staff, and faculty can contribute without fear of personal ridicule, or intolerant or offensive language. If you witness or experience racism, discrimination, micro-aggressions, or other offensive behavior, you are encouraged to bring this to the attention of the course director if you feel comfortable. You can also report these behaviors to Campus Belonging Resources (https://diversity.illinois.edu/diversity-campus-culture/belonging-resources/). Based on your report, Members of the Office of the Vice Chancellor for Diversity, Equity & Inclusion staff will follow up and reach out to students to make sure they have the support they need to be healthy and safe. If the reported behavior also violates university policy, staff in the Office for Student Conflict Resolution may respond as well and will take appropriate action.

Community of Care

As members of the Illinois community, we each have a responsibility to express care and concern for one another. If you come across a classmate whose behavior concerns you, whether in regards to their well-being or yours, we encourage you to refer this behavior to the Student Assistance Center (217-333-0050 or http://odos.illinois.edu/community-of- care/referral/). Based on your report, the staff in the Student Assistance Center reaches out to students to make sure they have the support they need to be healthy and safe.

Further, we understand the impact that struggles with mental health can have on your experience at Illinois. Significant stress, strained relationships, anxiety, excessive worry, alcohol/drug problems, a loss of motivation, or problems with eating and/or sleeping can all interfere with optimal academic performance. We encourage all students to reach out to talk with someone, and we want to make sure you are aware that you can access mental health support at McKinley Health Center (https://mckinley.illinois.edu/). Or the Counseling Center (https://counselingcenter.illinois.edu/). For urgent matters during business hours, no appointment is needed to contact the Counseling Center. For mental health emergencies, you can call 911.

Disruptive Behavior

Behavior that persistently or grossly interferes with classroom activities is considered disruptive behavior and may be subject to disciplinary action. Such behavior inhibits other students' ability to learn and an instructor's ability to teach. A student responsible for disruptive behavior may be required to leave class pending discussion and resolution of the problem and may be reported to the Office for Student Conflict Resolution (https://conflictresolution.illinois.edu; conflictresolution@illinois.edu; 333-3680) for disciplinary action.

Emergency Response Recommendations

Emergency response recommendations can be found at the following website: http://police.illinois.edu/emergency-preparedness/. I encourage you to review this website and the campus building floor plans website within the first 10 days of class. http://police.illinois.edu/emergency-preparedness/building-emergency-action-plans/.

Family Educational Rights and Privacy Act (FERPA)

Any student who has suppressed their directory information pursuant to Family Educational Rights and Privacy Act (FERPA) should self-identify to the instructor to ensure protection of the privacy of their attendance in this course. See https://registrar.illinois.edu/academic-records/ferpa/ for more information on FERPA.

Mental Health

Significant stress, mood changes, excessive worry, substance/alcohol misuse or interferences in eating or sleep can have an impact on academic performance, social development, and emotional wellbeing. The University of Illinois offers a variety of confidential services including individual and group counseling, crisis intervention, psychiatric services, and specialized screenings which are covered through the Student Health Fee. If you or someone you know experiences any of the above mental health concerns, it is strongly encouraged to contact or visit any of the University's resources provided below. Getting help is a smart and courageous thing to do for yourself and for those who care about you.

- Counseling Center (217) 333-3704
- McKinley Health Center (217) 333-2700
- National Suicide Prevention Lifeline (800) 273-8255
- Rosecrance Crisis Line (217) 359-4141 (available 24/7, 365 days a year)

If you are in immediate danger, call 911

*This statement is approved by the University of Illinois Counseling Center

Religious Observances

Illinois law requires the University to reasonably accommodate its students' religious beliefs, observances, and practices in regard to admissions, class attendance, and the scheduling of examinations and work requirements. You should examine this syllabus at the beginning of the semester for potential conflicts between course deadlines and any of your religious observances. If a conflict exists, you should notify your instructor of the conflict and follow the procedure at https://odos.illinois.edu/community-of-care/resources/students/religious-observances/ to request appropriate accommodations. This should be done in the first two weeks of classes.

Sexual Misconduct Reporting Obligation

The University of Illinois is committed to combating sexual misconduct. Faculty and staff members are required to report any instances of sexual misconduct to the University's Title IX Office. In turn, an individual with the Title IX Office will provide information about rights and options, including accommodations, support services, the campus disciplinary process, and law enforcement options.

A list of the designated University employees who, as counselors, confidential advisors, and medical professionals, do not have this reporting responsibility and can maintain confidentiality, can be found here: https://wecare.illinois.edu/resources/students/#confidential.

Other information about resources and reporting is available here: https://wecare.illinois.edu/.

Students with Disabilities

To obtain disability-related academic adjustments and/or auxiliary aids, students with disabilities must contact the course instructor and the as soon as possible. To ensure that disability-related concerns are properly addressed from the beginning, students with disabilities who require assistance to participate in this class should contact Disability Resources and Educational Services (DRES) and see the instructor as soon as possible. If you need accommodations for any sort of disability, please speak to me after class, or make an appointment to see me or see me during my office hours. DRES provides students with academic accommodations, access, and support services. To contact DRES you may visit 1207 S. Oak St., Champaign, call 333-4603 (V/TDD), or e-mail disability@illinois.edu. http://www.disability.illinois.edu/.

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This tentative schedule will be continually updated throughout the semester.

Fall 2025

Date	Weekday	Topic	Reading	HW Problem	HW
8/25	M	1.1 Introduction and Big Idea	1.1		
8/27	W	1.2 Dimensions and Viscosity	1.2-1.6	1.2.13, 1.2.26, 1.A	
8/29	F	1.3 Viscosity and Surface Tension	1.6, 1.9	1.6.21 1.6.34	
9/1	M	Labor Day			
9/3	W	1.4 Surface Tension	1.9	1.9.3, 1.B	HW1
9/5	F	2.1 Fluid Statics Introduction, Pressure Equation, and Manometry	2.1-2.3, 2.5-2.6	2.6.6, 2.6.14, 2.8.7, 2.A	
9/8	M	2.2 Hydrostatic Force on Plane Surfaces	2.8		HW2
9/10	W	2.3 Hydrostatic Force on Plane and Curved Surfaces	2.8, 2.10	2.8.16, 2.B, 2.8.21	
9/12	F	2.4 Hydrostatic Force on Curved Surfaces and Buoyancy	2.10, 2.11	2.10.17, 2.C	
9/15	M	2.5 Buoyancy and Rigid Body Acceleration	2.12	2.11.11, 2.12.9, 2.D, 2.E	HW3
9/17	W	3.1 Newton's 2nd Law in Elementary Fluid Dynamics	3.1-3.4		
9/19	F	3.2 Elementary Fluid Dynamics Analysis with Newton's 2nd Law	3.1-3.4	3.2.8, 3.3.3, 3.3.5	
9/22	M	3.3 Stagnation Pressure Problems (Bernoulli Equation)	3.5	3.5.9, 3.5.13	HW4
9/24	W	3.4 Free Jet and Siphon (Bernoulli Equation)	3.6	3.6.13, 3.6.19, 3.6.28, 3.6.83, 3.A	
9/26	F	4.1 Fluid Kinematics, Material Derivative, and RTT	4.1-4.4	4.A	
9/29	M	5.1 Finite CV Analysis Equations	5.1, 5.2.1	5.1.26, 5.A	HW5
10/1	W	5.2 Finite CV Analysis with Linear Momentum Equation	5.2.2	5.2.12	
10/3	F	Exam 1 (Ch1-3), and Informal Early Feedback			
10/6	M	5.3 Moving CV Problems	5.2.2	5.2.36, 5.B	HW6
10/8	W	5.4 Mechanical Energy Equation for Finite CV	5.3.1-5.3.3	5.3.31, 5.C	
10/10	F	6.1 Differential Analysis and Relevant Concepts	6.1	6.1.1	
10/13	M	6.2 Differential Form of Continuity Equation	6.2	6.1.8, 6.2.1, 6.2.2, 6.A	HW7
10/15	W	6.3 Stream Function	6.2	6.2.6, 6.B	
10/17	F	6.4 Velocity Potential and Irrotational Bernoulli Equation	6.4	6.4.1, 6.4.7, 6.4.12	
10/20	M	6.5 Basic Plane Potential Flows and the Method of Superposition	6.5, 6.6.1	6.6.1	HW8
10/22	W	6.6 Navier-Stokes Equation and Viscous Flow in Slit	6.3, 6.8, 6.9	6.4.6, 6.9.2, 6.9.5	
10/24	F	6.7 Viscous Flow in Circular Pipe	6.9	6.9.23	
10/27	M	7.1 Dimensional Analysis and Buckingham Pi Theorem	7.1-7.4	7.1.2, 7.1.4, 7.3.3, 7.A	HW9
10/29	W	7.2 Similitude and Scale Models	7.8	7.B	
10/31	F	7.3 Common Dimensionless Groups and Dimensionless Equations	7.6, 7.10	7.6.1, 7.8.1	
11/3	M	8.1 Viscous Flow in Pipes: Flow Regime and Entrance Length	8.1	8.1.5, 8.1.6	HW10

11/5	W	8.2 Fully Developed Flow, Major Loss and Minor Loss	8.2-8.4	8.4.8, 8.A	
11/7	F	Exam 2 (Ch4-7)			
11/10	M	8.3 Example: Noncircular Pipes, Δp With and Without loss	8.5	8.4.22, 8.5.14, 8.B, 8.C	HW11
11/12	W	8.4 Example: Determine Flowrate	8.5	8.D, 8.E	
11/14	F	9.1 External Flow: Concepts of Drag and Lift	9.1.1, 9.3, 9.4	9.A	
11/17	M	9.2 Examples: Drag and Lift	9.3, 9.4	9.3.44, 9.4.12, 9.4.13, 9.B	HW12
11/19	W	9.3 Boundary Layer Concept and Examples	9.1.2, 9.2	9.2.2, 9.C	
11/21	F	9.4 More Discussion on Boundary Layer Concept	9.2		
11/24	M	Fall Break			
11/26	W	Fall Break			
11/28	F	Fall Break			
12/1	M	10.1 Thermodynamics Review and Stagnation Properties	11.1, 11.2	11.2.3	HW13
12/3	W	10.2 Sound Speed and Mach Number	11.3	11.3.1, 11.3.3, 11.A	
12/5	F	10.3 Steady Isentropic Flow of Ideal Gas	11.6, 11.7	11.B, 11.C	
12/8	M	10.4 Operation of Nozzles	11.7		HW14
12/10	W	Review			
		Final Exam, Comprehensive			