

# MECH 5306 FLUID DYNAMICS

## Course Syllabus

Fall 2022

### COURSE DESCRIPTION

Basic Laws of fluid motion, kinematics of flow field, Navier-Stokes equations, vorticity and circulation, potential flow applications, exact solutions, fundamentals of boundary layer theory, and pipe flows

### SCHEDULED MEETING TIMES

Section CRN	Time	Location
16092	TR 12:00 pm - 1:20 pm	Psychology Building 306
<b>INSTRUCTOR:</b> Dr. Md Mahamudur Rahman		<b>E-MAIL:</b> <a href="mailto:mrahman15@utep.edu">mrahman15@utep.edu</a>
<b>OFFICE HOURS:</b> By Appointment (via e-mail)		<b>OFFICE:</b> Engr. Bldg. A#118

**TEXTBOOK:** Pijush K. Kundu, Ira M. Cohen, David R Dowling, *Fluid Mechanics*, 6th Edition, Academic Press, ISBN 9780124059351

**BLACKBOARD:** Instructor will be using Blackboard for uploading lecture videos, updating the syllabus (if necessary), and communicating with students via “Announcements” and email.

**COURSE OBJECTIVES:** The student, upon completion of this course, will be able to:

- Understand what the fundamental conservation equations are and how to apply them to fluid dynamics applications
- Understand the fundamental theories proposed by fluid dynamics experts
- Build your understanding such that you can later apply them using computational tools
- Value the complexity of engineering solutions and build your confidence in approaching, designing, and solving ‘real’ engineering problems.

### TOPICS

1. Control volume formulation
2. Mathematical analysis
3. Irrotational flow, vorticity, circulation
4. Potential flow applications
5. Fluid deformation and flow kinematics
6. Compressible Flows
7. Navier-Stokes equations
8. Exact solutions
9. Fundamentals of boundary layer theory
10. Pipe Flows

## COURSE SCHEDULE

Week	Week of	Reading	Lecture Topic	Due
1	08/22	1.5 – 1.6	<b>The Continuum Viewpoint and the Equations of Motion</b> 1. Introduction: Continuum Hypothesis 2. Thermophysical properties	
2	08/29	3.4 – 3.5	3. The Material Derivative, Lagrangian and Eulerian Descriptions 4. Kinematics of Deformation	
3	09/05	1.7	<b>Project#1: Develop CADs for Hydrodynamics and Aerodynamics Projects (NX/Fusion 360)</b> <b>Fluid Statics</b> 5. Forces & Stresses at a Point 6. Hydrostatic Pressure Variations 7. Rigid Body Motions <b>Inviscid Flow &amp; Bernoulli</b> 8. Steady Bernoulli Equation along/across streamlines 9. Unsteady/Generalized Forms of the Bernoulli Equation	<b>HW#1</b>
4	09/12	3.6, 4.2 – 4.4	<b>Control Volume Theorems &amp; Applications</b> 10. The Reynolds Transport Theorem 11. Conservation of Mass/Energy/Entropy 12. Conservation of Momentum	<b>HW#2</b>
5	09/19		<b>Project#1 Due</b> <b>Project#2: Hydrodynamics (ANSYS/StarCCM+)</b>	<b>Project#1</b>
6	09/26	4.5 – 4.10	<b>Equations of Viscous Flow</b> 13. Conservation of Mass in Differential Form 14. The Constitutive Equation for Newtonian Fluid 15. Mechanical vs. Thermodynamic Pressure 16. The Navier Stokes Equation 17. Boundary Conditions for Navier-Stokes Eq.	<b>HW#3</b>
7	10/03	4.11	18. Fully Developed Flows, Couette & Poiseuille Flows, Stability of Viscous Flows <b>Dimensional Analysis</b> 19. The Buckingham Pi Theorem 20. Physical Significance of Dimensionless Variables <b>Project#3: Gas Dynamics Laboratory Scale Modeling (analysis and ANSYS/StarCCM+)</b>	<b>HW#4</b>
8	10/10	9.1 – 9.4	<b>Complex Viscous-Dominated Flows</b> 21. Stokes Flows at Zero Reynolds Number 22. Start-Up and Transient Flows; Similarity solution for a flat plate (The Rayleigh problem) 23. Quasi-Fully Developed Flows: Lubrication Analysis	<b>Project#2</b>

			24. Free Surfaces & other Lubrication Flows <b>Project#2 Due</b>	
9	10/17	7.1 – 7.5	<b>Potential Flow Theory</b> 25. The Velocity Potential and Stream Function 26. Complex Variable Formulation 27. Examples of Potential Flow Solutions	<b>HW#5</b>
10	10/24		<b>Quiz#1</b> <b>Project#3 Due</b> <b>Project#4: Aerodynamics (ANSYS/StarCCM+)</b>	<b>Quiz#1</b> <b>Project#3</b>
11	10/31	5.1 – 5.5	<b>Vorticity and Circulation</b> 28. Definition of Circulation; Connection to Inviscid Flow and Vorticity 29. Rotational and Irrotational flows 30. Kelvin’s Circulation Theorems 31. Lift, Induced Drag 32. Airfoils, Lifting Lines, Propellers, Windmills	<b>HW#6</b>
12	11/07	10.1 – 10.5	<b>Boundary Layers, Separation &amp; Drag</b> 33. Motivation & scaling of the Boundary Layer Equations 34. Measures of Boundary Layer Thickness 35. Boundary layer on a flat plate	<b>HW#7</b>
13	11/14		<b>Project#4 due</b>	<b>Project#4</b>
14	11/21	10.7 – 10.8	36. Effect of a Pressure Gradient 37. Flow separation 38. Turbulent Boundary Layers	<b>HW#8</b>
15	11/28	1.6	<b>Surface Tension and Its Importance</b> 39. Free surface force balance 40. Scaling and dimensional analysis 41. Capillarity: Simple static solutions <b>Exam#1</b>	<b>Exam#1</b>

**GRADING:** Your grade for the course will be determined using the following formula:

Exams	20%	× 1	20%
Class Project	10%	× 4	40%
Quizzes	05%		05%
Homework	25%		25%
Class Participation	10%		10%

***A (100-90): B (89-80): C (79-70): D (69-60): F (59 and Below)***

**ACCOMODATIONS:** 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).

# Department's Policies

## ACADEMIC HONESTY

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. Calculators and watches may be subject to inspection. You may be asked to temporarily remove glasses to allow for their inspection.

You may not bring backpacks, hats, bulky coats or hoodies into the exam room. Lockers are not available at the exam site so plan and leave your belongings in a secure location. You may NOT sit them in a corner of the exam room.

You must show your work for all problems. You must use the paper provided by the instructor. If no work is shown you may not receive credit. After the exam, the instructor may require you to explain how you solved a problem on the exam. If you refuse to or cannot explain your work you may be subject to disciplinary action.

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 or an F in the class. Other actions including suspension may also be pursued.

No one will be allowed to leave the room during an exam. This includes restroom breaks.

University approved recording devices may 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. The instructor may create a record of your activity during the exam and may take photographs of your work during the exam.

If you are suspected of scholastic dishonesty you may or 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 may 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 take the examination. 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 drink may be brought into 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. No other IDs will be accepted.

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. 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.

### **EXCUSED ABSENCE FOR EXAMS**

The UTEP catalog allows Exam Absence to be excused ONLY for University-Recognized Activities and very specific other situations. Medical absence is NOT allowed in the UTEP catalog. For consistency with the catalog, students will NOT be excused from exams due to illness.

### **HARASSMENT POLICY**

The University (see Handbook of Operating Procedures 1.2.2.4) 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.

**Best of Luck!**

**I am always with you to help!**

**Stay Safe and Take Care of Your Family!**

**Relax and Smile!**