

# MECH 5306 FLUID DYNAMICS

## Course Syllabus

Fall 2024

### 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
16203	M W 12:00 pm - 1:20 pm	Education Building 303

**INSTRUCTOR:** Dr. Md Mahamudur Rahman

**E-MAIL:** [mrahman15@utep.edu](mailto:mrahman15@utep.edu)

**OFFICE HOURS:** By Appointment (via e-mail)

**OFFICE:** 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	08/26	1.4, 3.2	<b>The Continuum Viewpoint and Fluid Kinematics</b> 1. Continuum Hypothesis 2. The Material Derivative, Lagrangian and Eulerian Descriptions	
2	09/02	3.6, 2.1, 2.8, 2.9, 2.12	3. <b>No class on 09/02- Labor Day holiday</b> <b>Cartesian Tensors (Math Review)</b> 4. Scalar, vector, tensors, notation 5. Vector dot and cross products 6. Gradient, divergence, and curl 7. Gauss Theorem 8. <b>Projects Assignment</b>	<b>Quiz-1</b> <b>HW-1</b>
3	09/09	3.6, 4.2	9. Reynolds Transport Theorem <b>Fluid Kinematics and Conservation Laws</b> 10. Conservation of Mass 11. Conservation of Mass in Differential Form	<b>Quiz-2</b> <b>HW-2</b>
4	09/16	4.4	<b>Control Volume Theorem &amp; Conservation Laws</b> 12. Conservation of Momentum 13. Conservation of Momentum Differential Form	
5	09/23	2.10, 4.5 4.6, 9.2	<b>Fluid Kinematics and Conservation Laws</b> 14. Cauchy Momentum Equation 15. Euler Equation 16. Constitutive Equation for a Newtonian Fluid 17. Mechanical vs. Thermodynamic Pressure 18. Stokes hypothesis <b>Conservation Laws</b> 19. Navier-Stokes momentum equation <b>Exact Solutions for Steady Incompressible Viscous Flow</b> 20. Fully Developed Flows and Poiseuille Flows	<b>Quiz-3</b> <b>Project#1</b>
6	09/30	9.2	21. Couette Flow 22. Example problem: Jet pump	<b>HW-3</b>
7	10/07	9.4	<b>Similarity Solutions for Un-Steady Incompressible Viscous Flow</b> 23. Stokes' first problem, Rayleigh flow	
8	10/14	9.4, 9.5	24. Stokes' first problem, Rayleigh flow 25. Stokes second problem	<b>HW-4</b>
9	10/21	9.4, 11.6	26. Stokes' first problem, Rayleigh flow 27. Circular Couette Flow 28. Centrifugal instability: Taylor problem	<b>Project#2</b>
10	10/28	5.1-5.2 7.1 – 7.2	29. <b>Exam#1 (Ch. 1 – 5, 9)</b> <b>Incompressible Inviscid Flow</b> 30. Streamline, pathline and streaklines	<b>Quiz-4</b> <b>Exam-1</b> <b>HW-5</b>

			31. Definition of Circulation; Connection to Inviscid Flow and Vorticity 32. Rotational and Irrotational flows 33. The Velocity Potential and Stream Function 34. Stagnation point and pressure coefficient	
11	11/04	7.3	35. Elementary flows: uniform flow, source and sink flow, doublet flow, and vortex flow 36. Ideal flow past 2-D semi-infinite body 37. Ideal flow past a circular cylinder, non-lifting and lifting flow	<b>Quiz-5</b> <b>HW-6</b>
12	11/11	14.1 – 14.3, 14.5, 14.7	<b>Vorticity, and Lift and Drag in Aerodynamics</b> 38. Kelvin’s Circulation Theorems 39. Aircraft and airfoil terminology 40. Kutta-Zhukhovsky lift theorem 41. Lift, Induced Drag	<b>Quiz-6</b> <b>HW-7</b>
13	11/18	10.1 – 10.3 10.7 – 10.9	<b>Boundary Layers, Separation &amp; Drag</b> 42. Introduction and Boundary Layer Equations 43. Boundary Layer Thickness 44. Boundary layer on flat plate, Blasius solution 45. Flow separation 46. Turbulent Boundary Layers 47. Cricket ball, Tennis ball and Baseball dynamics	<b>Quiz-7</b> <b>Project#3</b>
14	11/25	1.11	<b>Dimensional Analysis</b> 48. The Buckingham Pi Theorem 49. Physical Significance of Dimensionless Variables 50. Similitude for an airplane	<b>Quiz-8</b> <b>HW-8</b>
15	12/02	15.1 – 15.9	<b>Compressible Flow of Inviscid Fluids</b> 51. Speed of sound and Mach number 52. Rankine-Hugoniot equations 53. Normal and oblique shock waves 54. Prandtl-Meyer flow 55. <b>Exam#2 (Ch. 1, 7, 10, 14, 15)</b>	<b>Exam-2</b>

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

Exams	10%	× 2	20%
Class Project	15%	× 3	45%
Quizzes	10%		10%
Homework	15%		15%
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!**

**Relax and Smile!**