

AML2020 : FLUID MECHANICS (3-1-0, E-SLOT)

Department of Applied Mechanics, 2026-2027, Semester-I

Instructor:	Prof. Prateek Gupta	Contact:	prgupta@iitd.ac.in, Block IV 342B
Time (L):	TWF 10-11 AM	Place (L):	LH 422
Time (T):	MTThF 1-2 PM	Place (T):	LH 621

Course Page: <https://web.iitd.ac.in/~prgupta/teaching/FM.html>

Office Hours: Tuesday 5 pm - 6 pm. Flexible hours by appointment only (based on availability)

References: Course content may be covered in several texts with emphasis on different topics. Primary texts for this course are,

1. F. M. White, Fluid Mechanics
2. Fox & McDonald, Introduction to Fluid Mechanics

Other texts that maybe useful for some specific topics (an incomplete list)

- Currie, I. G., Fundamental Mechanics of Fluids
- Kundu, P.K., Cohen, I.M., Fluid Mechanics
- Panton, R.L., Incompressible Flow

Objectives: This is an introductory level course in fluid dynamics. The primary goal (on-paper) of this course is to develop understanding related to dynamics of fluids of engineering and practical importance. The realistic goal (as per the instructor) ends up being convincing students why they can not apply Bernoulli's equation without careful thought! Primary take-aways of this course are understanding of Navier-Stokes equations, various approximation regimes (inviscid flows, low Reynolds number flows, turbulent flows, compressible flows), and fluid machines such as turbomachinery.

Prerequisites: An undergraduate-level understanding of calculus of single and multiple variables, vector algebra, ordinary differential equations, and partial differential equations. Following texts maybe referred for a review of engineering mathematics

- Advanced Engineering Mathematics - E. Kreyzig

Course content as per courses.iitd.ac.in: Introduction to fluids and the concept of viscosity, flow visualization, fluid statics, physical laws for a control volume including continuity, momentum and energy equations, Bernoulli equation, differential equations of fluid motion, Navier Stokes equations, vorticity and potential flows, dimensional analysis and similitude, boundary layer theory, introduction to fluid machines.

Course Outline:

- Module 1 - Introduction 3 lectures
 ■ Defining fluids, Newton's laws for a system of particles, from rigid bodies to deformable bodies, continuum hypothesis, viscosity, molecular view of viscosity, index notation,
 ■ Chapter 1 in F.M. White, Chapters 1 and 2 in Fox & McDonald, Chapters 1 and 2 in R. L. Panton
- Module 2 - Fluid flow kinematics 3 lectures
 ■ Lagrangian and Eulerian descriptions, streamlines, streaklines, pathlines, material derivatives, deformation rate, Reynolds Transport Theorem
 ■ Chapter 3 in F.M. White, Chapters 2 and 4 in Fox & McDonald, Chapter 1 in I.G. Currie, Chapter 3 in R.L. Panton
- Module 3 - Dynamical laws of motion 4 lectures
 ■ Continuity and Momentum equations, Cauchy stress tensor, Stokes' assumption, Navier-Stokes equations for incompressible flow, Review of Thermodynamics, Energy Equation, Equation of State, Navier-Stokes equations for compressible flow, Equations in non-inertial frames
 ■ Chapter 1 in I.G. Currie, Chapter 5 in R.L. Panton, Chapter 4 in F.M. White, Chapter 5 in Fox & McDonald
- Module 4 - Hydrostatics 2 lectures
 ■ Fluid statics (with no flow and rigid body motion), Bodies submerged in fluids, forces and stability, surface tension
 ■ Chapter 2 in F.M. White, Chapters 2 and 3 in Fox & McDonald
- Module 5 - Differential analysis 4 lectures
 ■ Boundary conditions, assumptions for simplified analytical solutions, A few analytical solutions
 ■ Chapter 4 in F.M. White, Chapter 5 in Fox & McDonald
- Module 6 - Integral analysis 3 lectures
 ■ Integral analysis on an arbitrary control volume, deforming control volumes, Angular momentum equation,
 ■ Chapter 4 in Fox & McDonald, Chapter 3 in F.M. White
- Module 7 - Dimensional analysis and similarity 3 lectures
 ■ Dimensionless numbers, Pi theorem, Dynamic similarity and scaling laws, non-dimensionalization of governing equations, order of magnitude analysis
 ■ Chapter 5 in F.M. White, Chapter 6 in Fox & McDonald
- Module 8 - Stokes' flow 3 lectures
 ■ Low Reynolds number approximation, Stokes flow past a sphere, flow in a slot with varying cross-section
 ■ Chapter 21 in R. L. Panton
- Module 9 - Potential flows 3 lectures
 ■ High Reynolds number approximation, Potential flows, Bernoulli's equation, simple potential flows and superposition
 ■ Chapter 4 in F.M. White, Chapter 6 in Fox & McDonald, Chapters 4 and 5 in I.G. Currie, Chapters 18 and 19 in R.L. Panton

Module 10 - Boundary layer theory	4 lectures
■ Boundary layer equations, momentum integral, self-similar solution	
■ Chapter 9 in Fox & McDonald, Chapter 7 in F.M. White, Chapter 20 in R.L. Panton, Chapter 9 in I.G. Currie	
Module 11 - Applications: Internal incompressible flows	3 lectures
■ Pipe flow, Generalized Bernoulli's equation, head loss and friction factor, turbulent pipe flows, flow measurement, wind tunnel design	
■ Chapter 6 in F.M. White, Chapter 8 in Fox & McDonald	
Module 12 - Applications: External incompressible flows	3 lectures
■ Flow past a cylinder, sphere, airfoil, Boundary Layers with pressure gradient, External aerodynamics	
■ Chapter 9 in Fox & McDonald, Chapter 7 in F.M. White	
Module 13 - Turbomachinery and compressible flows	4 lectures
■ Pumps, wind turbines, propellers, compressible flows (time allowing)	
■ Chapter 11 in F.M. White, Chapter 10 in Fox & McDonald	

Assessment:

- Mid-term exam (30%)
- Major exam (30 %)
- Best 4 out of 5 quizzes (40 % combined weightage of best 4 quizzes).

There will be one make-up mid-term exam (in the final 1-2 weeks of the semester). There will be no make-up quizzes. No student will be allowed to sit in the make-up exam without submission of a valid medical certificate.

Course Policy:

- Please sign up for AML2020 (APL107 for 2024 entry Civil Engg. students), only then you will receive regular updates and announcements via emails.
- Recorded lectures will be made available by the ETSc office at <https://manthan.iitd.ac.in/course.php?code=AML2020>. Lectures with less than 50% of class attendance will not be uploaded.
- Tentative audit-pass criterion - 30%
- **Students are expected to attempt the tutorial sheets before the tutorial session and ask doubts. Doubts do not constitute just asking “How to solve a particular given problem?”. Doubts need to start with showing what you have done and pin-point the exact problem being faced. In absence of a discussion/doubts, surprise quizzes might be taken. These quizzes will be used to normalize the quiz score out of 40% at the end.**

Class Policy:

- 75% attendance in lectures is mandatory as per institute norms. Grade penalty will be awarded for short-attendance.

Academic Honesty: Lack of knowledge of the academic honesty policy is not a reasonable explanation for its violation. Each student must go through the honour code of IIT-Delhi and adhere to it.