University of Michigan — 交大密西根学院 UM-SJTU Joint Institute — Shanghai Jiao Tong University

VM320 (Fluid Mechanics) Syllabus

Degree Program:

☐ECE-Electrical & Computer Engineering
√ ME-Mechanical Engineering
☐General Courses for Both ECE & ME Degree Programs

Course Name and code: Fluid Mechanics, VM320
Course Credits: 3
Course Category: √ Required ☐ Elective

Instructor: Zijie Qu (屈子杰)
Office: Room 517, Longbin Building
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Office Hours: Monday and Wednesday 14:00 – 15:30 at Zijie's office.

Course Schedule:
Monday and Wednesday 16:00-17:40 at 东上院 404.

Academic Integrity: Academic integrity is one of the central tenets of the JI. Any violations of JI academic honor code (https://www.ji.sjtu.edu.cn/academics/academic-integrity/honor-code/) are strictly prohibited and will lead to corresponding penalties.

Course Pre/Co-requisites:
Mathematic courses: calculus, vector analysis
Mechanics courses: theoretical mechanics, thermodynamics

Textbook and references:
Textbook: Fluid Mechanics, 5th edition (or newer), by Pijush K. Kundu, Ira M. Cohen and David R. Dowling, Academic Press, 2012.
References: Fluid Mechanics, Frank M. White, 8th Edition, McGraw-Hill, 2017.
Fox and McDonald's introduction to fluid mechanics Fox, Robert W., Alan T. McDonald, and John W. Mitchell. John Wiley & Sons, 2020.

Grading Policy:
- Homework assignment (30% with bonus problems up to 5%).
- One midterm exam (30%, ~Nov 8): close book, one equation sheet is allowed.
- One quiz for bonus points (5%, TBD).
- One final exam (35%, TBD): close book, one equation sheet is allowed.

Some requirements and suggestions:

- It is very necessary to show up in the class. If you are taking this course online, please turn on your camera at all time during the lecture.
- Homework assignments need to be finished independently and submitted on time. Homework is collected every week at the beginning of the lecture. No late homework is allowed.
- Lecture notes will be uploaded on Canvas after the lecture, however, please do NOT share them on any public platforms.
- Frequent discussions with the instructor are strongly encouraged. Additional office hours will be held during the week before both the exams.
- To make a fair judgment of learning, rules related to homework assignments, quiz and exams are formulated without exception.

Course objectives and outcomes:

- Understand the basic physical concepts in fluid mechanics.
- Master required theories and analysis methods for solving fluid problems.
- From some typical engineering examples, obtain the capacity of extracting essential physics from complex phenomena.

Towards the end of this course, you are expected to learn something about fluid mechanics and related physics. For those who wish to continue their study along this direction, the course will assist you in laying a foundation. For those who no longer pursue a career related to fluid mechanics, the knowledge you gained could help you see the beautiful world around us better and more scientifically.

Scheduled teaching contents:

Introduction

Introduction of fluid mechanics; unit system, solids and fluids, continuum hypothesis; transport phenomena and shear stress; surface tension; fluid statics; thermodynamics.

Bases of vector analysis

Space and coordinate; rotation of axes; second-order tensor and tensor contraction; Kronecker Delta and alternating symbol; dot and cross product; divergence and gradient operators; symmetric and antisymmetric tensors; Eigenvalues and eigenvectors of a symmetric tensor or a symmetric matrix; Multi-variables functions; Force on a surface; Gauss and Stokes' theorems.

Kinematics

Eulerian and Lagrangian descriptions; Streamline, path line streak line; Strain rate; Vorticity and circulation; Relative motion near a point; Strain rate and angular velocity; Galilean transformation; Solid body motion and irrotational vortex; Reynolds transport theorem, including the 1D Leibnitz theorem.

Conservation laws

Conservation of mass; Momentum conservation; constitutive equation for Newtonian fluids; Navier-Stokes equation; Application of the Reynolds transport theorem; rotating coordinate system; mechanical energy equation; Bernoulli equation; Boussinesq approximation; Boundary conditions; applications of the Reynolds transport theorem; dynamic similarity (for systems with deterministic governing equations &systems without explicit governing equations);common nondimensional parameters.

Laminar flow

Steady flow between parallel plates; steady flow in a pipe; rotating flows; impulsive started plate; flow due to an oscillating plate; elementary lubrication theory; creeping flow around a spherical surface.

Boundary layers and related topics

Basic idea; different measures of boundary layer thickness; boundary layer on a flat plate; structure of boundary layers; Von Karman momentum integral; boundary layer with pressure gradient; flow past a cylinder, sphere and the applications; secondary flows, 2D jets.

Optional

Compressibility; speed of sound; basic relations for 1D flow; area-velocity relations; normal shock wave; some basic concepts for turbulence; advanced experimental and computational techniques and methods in fluid mechanics.