

MATHEMATICS 4180
INTRODUCTION TO FLUID DYNAMICS

Undoubtedly you have observed the movement of clouds in the atmosphere, the flight of birds through the air, the flow of water in streams, and the breaking of waves at the seashore or the flow of water around the hull of a fast-moving vessel. Fluid mechanics phenomena are involved in all of these. Fluids include gases and liquids, with air and water as the most prevalent. Some of the many other aspects of our lives that involve fluid mechanics are flow in pipelines and channels, movements of air and blood in the body, air resistance or drag, wind loading on buildings, motion of projectiles, jets, shock waves, lubrication, combustion, irrigation, sedimentation, and meteorology and oceanography. The motions of moisture through soils and oil through geological formations are other applications.

Fluid mechanics may be divided into three branches: fluid statics is the study of the mechanics of fluids at rest; kinematics deals with velocities and streamlines without considering forces or energy; and fluid dynamics is concerned with the relations between velocities and accelerations and the forces exerted by or upon fluids in motion.

Classical hydrodynamics is largely a subject in mathematics, since it deals with an imaginary ideal fluid that is completely frictionless. Much of the mathematics is classical, being more than one hundred years old. Fluid mechanics is the combination of classical hydrodynamics and the study of real fluids. In modern fluid mechanics the basic principles of hydrodynamics are combined with experimental data. The experimental data can be used to verify theory or to provide information supplementary to mathematical analysis. With the advent of the computer the entirely new field of computational fluid mechanics (CFD) has developed. Various numerical methods such as finite differences, finite elements, and boundary elements are used to solve advance problems in fluid mechanics. The business of CFD applications alone now employs several tens of thousands of people and has a turnover of some billions of dollars a year.

This course is a basic introduction to the subject of fluid mechanics and is intended for undergraduate and beginning graduate students of applied mathematics and physics. This course introduces the general equations, both integral and differential, that result from the conservation of mass principle, Newton's second law, and the first law of thermodynamics. From these a number of particular situations will be considered that are of special interest. After completing this course the students should be able to apply the basic principles and methods of mechanics to new and different situations.

Reference books.

Fluid Mechanics by P.K. Kundu and I.M. Cohen, Academic Press
Elementary Fluid Dynamics by D.J. Acheson, Oxford University Press

Evaluation.

The exact scheme may vary from semester to semester, but typically it is this (when it is offered by the department of mathematics and statistics):

5 Assignments	30%
Midterm exam	35%
Final exam	35%

Mid-term test covers the first half of the class material. Final exam covers the second half.

Calendar description. **4180 Introduction to Fluid Dynamics** (same as Physics 4205) covers basic observations, mass conservation, vorticity, stress, hydrostatics, rate of strain, momentum conservation (Navier-Stokes equation), simple viscous and inviscid flows, Reynolds number, boundary layers, Bernoulli's and Kelvin's theorems, potential flows, water waves, thermodynamics.

Prerequisites: Physics 3220 and either Mathematics 4160 or Physics 3821.

Offered. Winter