EAS 361, Fluid Mechanics — Fall 2006

Portland State University
Maseeh College of Engineering and Computer Science

Course Objectives

To provide mechanical and civil engineering majors with basic knowledge of fluid mechanics. To expose the basic equations and methods used to analyze fluid statics and dynamics. To analyze fluid mechanics in technologically important, situations.

Prerequisites

Admission to ME or CE Programs, EAS 215 (Dynamics), Math 256 (Applied Differential Equations)

Instructor

Gerald Recktenwald, Associate Professor, Mechanical and Materials Engineering Department
Engineering Building, Room 400, 725-4290, `gerry@me.pdx.edu`
Web site for the course: `http://web.cecs.pdx.edu/~gerry/class/EAS361`

Textbooks

B.R. Munson, D.F. Young, and T.H. Okiishi, *Fundamentals of Fluid Mechanics*, fifth edition, 2006 Wiley, New York.

Mechanical Engineering Department, *Lab Manual for EAS 361*, Portland State University, Fall 2006.

Policies

Three, twenty-minute, in-class quizzes will be given. The top two quiz scores will be counted toward your grade. The midterm exam will last one class period. The final exam will be comprehensive. Discuss any potential conflicts *well before the exam dates.* **There will be no make-up quizzes or exams**.

If you have a disability and are in need of academic accommodations, please notify me (G. Recktenwald) immediately to arrange needed supports. If you need information about disabilities, please contact the Disability Resource Center on campus at 503-725-4150.

Students are expected to turn in laboratory assignment and homework problems that are substantially the result of their own work. Study groups, discussion of assignments among students, collective brainstorming for solutions, and sharing of advice is encouraged. Copying of assignments, computer files, graphs, or other means of duplicating material that is turned in for grading is *expressly* forbidden. *Cheating on exams will result in a zero grade for the exam.*

Grading

Cumulative grades will be based on the following weights: Laboratory 15%, two Quizzes 10% each, Homework 15%, Midterm Exam 25%, Final Exam 25%.

Learning Objectives

The Learning Objectives are what I expect that you will be able to do at the end of Quarter. If you can do each of the following activities very well, then you will get an "A" grade.

1. Perform analysis of fluid problems in SI and BG units. Properly convert between SI (kg, m, s), BG (slug, ft, s) and English Engineering units ($\mathrm{lb_m}$, ft, s).
2. Define basic fluid properties (ρ, γ, μ, ν, σ) and obtain numerical values for these properties from reference tables.
3. Apply Newton's law of viscosity to analyze simple shear flows of liquids and gases. Given an analytical expression for the velocity profile, compute the shear stress on a solid-fluid interface.
4. Use the definition of surface tension to predict the height a liquid will rise in a capillary tube. Use the definition of surface tension to compute the pressure difference across a bubble or droplet.
5. Convert pressure quantities between units of stress and head. Convert pressure between absolute and gage units. Know when gage pressure *can* be used and when absolute pressure *must* be used.
6. Use the ideal gas equation to analyze gas behavior. Use the ideal gas equation to compute a numerical value of gas density given the pressure and temperature.
7. Use the hydrostatic pressure equation to predict pressure variations in fluid columns. Apply the hydrostatic equation to the measurement of pressure with u-tube and inclined manometers.
8. Apply the hydrostatic pressure equation to the variation of air pressure in the atmosphere.
9. Use engineering formulas derived from the hydrostatic pressure equation to compute forces and moments on submerged surfaces. Be able to apply this analysis to simple engineering design problems.
10. Compute fluid acceleration at a point given a mathematical formula for the velocity field.
11. Identify the limited circumstances under which the Bernoulli equation applies. Correctly apply the Bernoulli equation when its use can be justified. Distinguish cases where the energy equation must be used instead of the Bernoulli equation.
12. Use the integral form of the continuity equation to determine flow rates and velocities entering and leaving a duct. Compute the average velocity crossing a surface given an analytical expression for the velocity profile.
13. Use control volume analysis to determine forces, flow rates and flow property changes in free jets and confined flows.
14. Apply the steady flow energy equation to determine head loss, work input/output and other fluid properties of fluids entering and leaving piping systems. Use the steady flow energy equation to compute the power input required by a pump, or the power output of a turbine, when these machines are part of a pipe system.
15. Understand operating principles of devices used to measure local fluid velocity and volumetric flow rate.

16. Identify the Reynolds number, Froude number, Mach number, and compute these numbers given appropriate length scales, velocities, and fluid properties.
17. Convert dimensional data to dimensionless form, and give appropriate definitions for standard dimensionless variables.

Course Outline

The course outline lists the topics and the corresponding sections of the textbook that will be covered in this class. Class lectures may not always fit neatly into the time periods given in the outline, so students should consider the outline as a tentative guide to class lectures. In particular, the date of the exams and quizzes will be confirmed by an announcement in lecture. Do not claim that you missed the exam because it did not occur at the date implied by this outline!

Class	Topic	Reading
1	Introduction, units, fluid properties	§1.1 — §1.5
2	Fluid properties, fluid statics	§1.5 — §1.10, §2.1
3	Fluid statics: pressure field in a fluid, manometers	§2.2 — §2.6
4	Fluid statics: hydrostatic forces on submerged surfaces	§2.7 — §2.8
5	Fluid statics: hydrostatic forces on submerged surfaces, buoyancy	§2.9 — §2.11
6	Fluid statics: rigid body motion, summary of fluid statics	§2.12
7	Elementary fluid kinematics and dynamics:	§4.1 — §4.14, §3.1 — §3.4
8	Bernoulli equation and its applications	§3.5 — §3.6
9	Bernoulli equation and its applications	§3.7 — §3.8
10	Midterm Exam	
11	Fluid Kinematics: Velocity and Acceleration Fields	§4.1 — §4.2
12	Control Volume Analysis: Reynolds Transport Theorem	§4.3 — §4.4
13	Control Volume Analysis: conservation of mass, and conservation of Momentum	§5.1 — §5.2.2
14	Control Volume Analysis: conservation of momentum, and conservation of energy	§5.2.2, §5.3
15	Control Volume Analysis: Applications	§5.1 — §5.3
16	Differential Analysis of Flow: Overview	§6.1 — §6.3
17	Dimensional Analysis: Buckingham Pi Theorem	§7.1 —§7.4
18	Dimensional Analysis: Dimensionless Groups	§7.4 —§7.6
19	Review	