ME 322, Applied Fluid Mechanics and Thermodynamics   Winter 2007

Portland State University
Maseeh College of Engineering and Computer Science

Course Objectives

In ME 322 we apply the fundamentals established in EAS 361 to flow systems encountered in engineering design. Topics covered include viscous flow in pipes, external flow (boundary layers), compressible flow, and turbomachines (pumps). The final part of the course covers the thermodynamics of gas mixtures, with special emphasis psychometrics and air-conditioning processes.

Prerequisites

Admission to ME or CE Programs, EAS 361, ME 321

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/ME322`

Textbooks

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

Yunus A. Çengel, and Michael A. Boles, *Thermodynamics: An Engineering Approach*,
fifth edition, 2006 (?), McGraw-Hill, New York

Policies

Two, twenty-minute, in-class quizzes will be given. 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 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: two Quizzes 10% each, Homework 15%, Midterm Exam 30%, Final Exam 35%.

Course Outline

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!

"MYO" indicates the Fluid Mechanics text by Munson, Young, and Okiishi. "CB" indicates the Thermodynamics text by Çengel and Boles.

Class	Topic	Reading
	Internal viscous flow	
1	Overview of differential analysis of fluid motion	MYO: 6.1 — 6.3
2	General characteristics, laminar and turbulent regimes, exact solution for laminar flow in round pipes	MYO: 8.1 — 8.2
3	Turbulent, viscous flow in pipes. Darcy-Weisbach equation, Moody Chart. Design procedure for viscous flow in a straight pipe	MYO: 8.3
4	Minor Losses, Noncircular ducts, Applications	MYO: 8.4
5	Pipe systems, Flow metering	MYO: 8.5 — 8.6
	External viscous flow	
6	Flow over immersed bodies. Introduction to lift and drag. Flat plate boundary layer	MYO: 9.1 — 9.2
7	Momentum integral, transition to turbulence	MYO: 9.2
8	Turbulent boundary layers. Separation	MYO: 9.2
9	Boundary layer stability, terminal velocity, test prep	MYO: 9.3
10	Midterm Exam	
	Turbomachinery	
11	Introduction to turbomachines. Energy and angular momentum considerations. Centrifugal pumps.	MYO: 12.1 — 12.4
12	Pump characteristics. NPSH, matching systems and pumps	MYO: 12.4
13	Pump characteristics. Turbines. Similarity laws. Axial flow and mixed flow pumps	MYO: 12.5 — 12.6
	Compressible Flow	
14	Ideal gas relationships. Mach number. Speed of sound.	MYO: 11.1 — 11.3
15	Isentropic flow of an ideal gas. Converging-diverging nozzles.	MYO: 11.4
16	Non-isentropic flow. Adiabatic flow with friction in constant area ducts. Normal shocks. Examples.	MYO: 11.5

Class	Topic	Reading
	Gas Mixtures	
17	Introduction to real gases. Mass and mole fractions. p-V-T behavior of ideal and real gases. Properties of real gas mixtures.	CB: 13.1 — 13.3
18	Gas-Vapor and Psychometrics. Dry and moist air. Specific and relative humidity. Dew point. Adiabatic saturation temperature. Wet-bulb temperature. Psychometric chart.	CB: 14.1 — 14.5
	Flows with Chemical Reactions	
19	Fuels and combustion, theoretical and actual combustion processes, enthalpy of formation, enthalpy of combustion	CB: 15.1 — 15.3
19	First law analysis of reacting systems. Adiabatic flame temperature	CB: 15.1 — 15.3

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.

Internal Viscous Flow:

1. Be able to apply the substantial derivative, and the differential form of the continuity equation to a given velocity vector field. Be able to interpret the stream function for two-dimensional incompressible flow.

2. Be able to describe the basic characteristics of laminar and turbulent flow in pipes. Be able to explain the meaning of *entrance length* and calculate the entrance length for both laminar and turbulent flows.

3. Be able to use the Moody chart *or* the Colebrook equation to compute the head loss in a long straight duct given the hydraulic diameter and wall material (or roughness). Be able to compute the head loss for a pipe system consisting of straight segments and fittings.

4. Be able to qualitatively describe the rules governing networks of pipes in series and parallel. Be able to perform simple manual calculations on simple pipe networks.

5. Be able to compute flow rate through obstruction-type flowmeters given the dimensions and pressure drop. Be able to choose a practical size for an obstruction flowmeter given a specified flow rate.