ChEN 307 A **FALL 2000**

FLUID MECHANICS

Course Description and Syllabus

INSTRUCTOR:	Prof. David Wu Office: 429 Alderson / 156 Coolbaugh e-mail: CR307@pioneer.mines.edu Tel: 384-2066 Office Hours: Mon 2-3 in 156 Coolbaugh Wed 2-5 in 429 Alderson Fri 2-3 in 429 Alderson
TEXTBOOK:	*Fluid Mechanics for Chemical Engineers*, Wilkes, Prentice-Hall, 1999. (Please bring your text to each class – we will often use figures and charts in class.)
COURSE TIMES:	MWF 9:00-9:50 Hill Hall 209
PREREQUISITES:	ChEN 201, MACS 315
QUIZZES:	Approximately once every one or two weeks.
HOMEWORK:	Due weekly, mostly on Monday. No late homework will be accepted. Since doing homework is an essential part of learning to solve problems, <u>you must have a homework score of at least 60% to pass the course.</u>
EXAMS:	Around week of 2 October and week of 13 November. Exams will be 2 hours and held in the evenings to reduce time pressure. To compensate, two class days will be cancelled. Exam format will be T/F + problems -- similar to homework. These will be part open and part closed book, but designed to test comprehension and problem solving skills.
COMPUTER & OTHER PROJECTS	Spreadsheet and simulation/visualization projects will be assigned to strengthen intuitive understanding and develop usage of tools in solving fluids problems. These will also require you to exercise your creativity and judgment for solving open-ended problems.

GRADING:

Quizzes	10%
Homework	15%
Exam 1	15%
Exam 2	15%
Computer & Other Projects	15%
Final	30%

COURSE PHILOSOPHY

Fluid mechanics is a subject which historically has two deep roots: one root which emerged from trying to systematize **macroscopic** observations of fluid phenomena, and one root which emerged from trying to understand fluid phenomena from a **microscopic** basis. In chemical engineering, both of these are essential. Macroscopic descriptions and principles are directly relevant for control and design of fluid-based processes, and in fact the range of observed fluid behavior far exceeds our current ability to explain from microscopic fundamentals. Nonetheless, the microscopic underpinnings allow us to generalize our knowledge, and describe fluid behavior, such as flow patterns, in much greater detail. This is particularly important today, with computer power extending our ability to use microscopic principles via simulation (computational fluid dynamics). In this course, we will approach the subject from both sides, starting with the macroscopics, and then returning to the microscopics.

The place of fluid mechanics in the chemical engineering curriculum is also important in that many physical concepts, in particular the macroscopic *and* microscopic balances of mass, energy and momentum, and the related mathematics, are recurring themes that you will see in your future chemical engineering classes. In fact, such a unified view is the one taken in the highly influential and classic textbook

Transport Phenomena, by R. B. Bird, W. E. Stewart, E. N. Lightfoot R. B. Bird, W. E. Stewart, E. N. Lightfoot. John Wiley and Sons, New York, (1960).

which I also recommend as a useful reference.

The effort you invest here to master the new concepts and techniques (solving problems!) introduced in this course will serve you well into the future.

ChEN 307 Learning Objectives

After completing this course, students will be able to:

1. Define shear stress, shear rate, and absolute viscosity and identify common classes of fluids (e.g. Newtonian, Bingham plastic, pseudoplastic, dilatant).

2. Write and apply macroscopic mass, energy, and momentum balances on chemical engineering flow processes and systems.

3. Compute average velocity in a conduit given an analytical velocity profile or experimental velocity profile point values.

4. Use the extended Bernoulli equation and macroscopic energy balance to evaluate frictional factor and pressure drop and size common fluid flow devices (e.g. pumps, piping, valves).

5. Describe the concept of choking in compressible flow and estimate pressure drop for compressible pipe flow of an ideal gas under isothermal and adiabatic expansion.

6. Apply the concept of drag coefficients to evaluate the drag force and settling velocity for spherical and non-spherical particles.

7. Compute the pressure drop through a packed bed and estimate the minimum fluidization velocity of the bed.

8. Describe boundary layer development for flow over a flat plate including velocity profile and boundary layer thickness and describe the phenomenon of pipe entrance length using boundary layer development.

9. Develop microscopic mass and momentum balances for chemical engineering systems. Use the Navier-Stokes equations and equation of continuity to evaluate shear stress profile, velocity profile, and friction factor for simple one-dimensional flows. Perform scaling analysis on the Navier-Stokes equations to non-dimensionalize them.

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Tentative Class Schedule

Week	Dates	Topics	Text Chapter
1	8/22 - 8/25	Introduction to fluid mechanics; review units & dimensions; fluid properties	1
2	8/28 - 9/1	Selected topics in fluid statics	1
3	9/4 - 9/8	Review of mass and energy balances	2
4	9/11 - 9/15	Bernoulli's equation and applications	2
5	9/18 - 9/22	Macroscopic momentum balances	2
6	9/25 - 9/29	One-dimensional fluid flow in pipes	3
7	10/2 - 10/6	Non-circular ducts and compressible flow	3
		Midterm Exam 1	
8	10/9 - 10/13	Pumps and compressors	4
9	10/16 - 10/20	Flow in chemical engineering equipment	4
10	10/23 - 10/27	Differential equations of fluid mechanics	5
11	10/30 - 11/3	Microscopic mass and momentum balances	5
12	11/6 - 11/10	Solution of viscous flow problems	6
13	11/13 - 11/17	Applications of Navier-Stokes	6,7
		Midterm Exam 2	
14	11/20 - 11/22	Boundary layers	8
		Thanksgiving Break: no class Nov. 24	
15	11/27 - 12/1	Introduction to turbulent flow	9
16	12/4 - 12/6	Non-Newtonian Fluids	11