Process Fluid Transport CHE06 310-01

Syllabus and Tentative Schedule for Fall 2010

INSTRUCTOR: Robert P. Hesketh
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COURSE HOMEPAGE: See Engineering Homepage

COURSE SESSIONS: Monday 12:15-1:30 PM and Wednesday **12:40PM - 3:00PM** Rowan Hall 340

Required Textbook and supplies:

Transport Processes and Separation Process Principles (Includes Unit Operations), 4th Edition, by Christie J. Geankoplis, Prentice Hall, PTR, 2003.

Fluid Mechanics for Chemical Engineers, 3rd Ed. By Noel de Nevers, McGraw-Hill, 2005. (**FMChE**)

Problem Solving in Chemical and Biochemical Engineering with POLYMATH, Excel, and MATLAB (2nd Edition), Publisher: Prentice Hall PTR; (September 22, 2007) ISBN-10: 0131482041 or ISBN-13: 978-0131482043, by Michael B. Cutlip and Mordechai Shacham. (**C&S2nd**)

Engineering Paper for Homework

Date:	Proposed Topics for Monday - Wednesday Class **(THIS WILL BE UPDATED ON BLACKBOARD)**
September 9/1/10 Wednesday	Review of fluid mechanics – in class demos and experiments Statics and Bernoulli Course Introduction
9/8/10 Wednesday	Chapter 3.3 Pumps and Gas-Moving Equipment – Geankoplis Chapter 10: Centrifugal Pumps - FMChE **Single Pump Lab: Standard Pump Curve**
9/13/10 Monday	Chapter 10: Centrifugal Pumps NPSH (continued) – **FMChE**
9/15/10 Wednesday	Chapter 10: Introduction to Positive Displacement Pumps (Syringe and Squirt Gun) – **FMChE** **Multiple Pump Lab: Variable Speed Pump Curve, Series Pumps, Parallel Pumps**
9/20/10 Monday	Complex Flow Networks C&S2nd 8.11 and **FMChE** pages 213-214
9/22/10 Wednesday	Pipe Flow Video Demonstration Momentum Balance Derivation for Laminar flow in a pipe C&S2nd 8.1 Geankoplis 2.9B Review Chapter 7 The Momentum Balance sections through 7.2 and Geankoplis 2.8
9/27/10 Monday	Laminar Flow Between Parallel Plates Geankoplis 2.9C Laminar Flow in an Annulus
9/29/10 Wednesday	Chapter 20 Computational Fluid Dynamics- **FMChE** Comsol Fluids Computer Labs **Comsol Fluids Computer Lab - Intro**
October 10/4/10 Monday	Vertical Laminar Flow of a Liquid Film – Newtonian fluid (continued) C&S2nd 8.3 Vertical Laminar Flow of a Liquid Film – Newtonian fluid Geankoplis 2.9C
10/6/10 Wednesday	Navier Stokes Equations: Geankoplis 3.6 – 3.7, 3.8B and Chapter 15: Two and Three Dimensional Fluid Mechanics- FMChE Flow Between two coaxial Cylinders, Fluid flow in a rotating cylinder, Geankoplis 3.8C **Review for exam**
10/11/10 Monday	**Exam 1: Pumps and Newtonian Flow**
10/13/10 Wednesday	C&S2nd 8.3 Vertical Laminar Flow of a Liquid Film – Non-Newtonian fluid Geankoplis 3.5 Non-Newtonian Fluids **Comsol Fluids Computer Lab– Rotational Flows**

10/18/10 Monday	Geankoplis 3.5 Non-Newtonian Fluids Chapter 13 Non-Newtonian Fluid Flow in Circular Pipes - **FMChE** C&S2nd 8.2 Non-Newtonian laminar flow in a horizontal pipe
10/20/10 Wednesday	Geankoplis 3.5H Non-Newtonian laminar flow in a horizontal pipe C&S2nd 8.4 Laminar Flow of Non-Newtonian Fluids in a Horizontal Annulus **Comsol Fluids Computer Lab-Non Newtonian Flows**
10/25/10 Monday	Non-Newtonian Fluid Flow Continued
10/27/10 Wednesday	Geankoplis 3.1C Flow in Packed Beds Chapter 11: Flow Through Porous Media- FMChE Experiment: Flow through adsorption column (gravity driven flow)
November 11/01/10 Monday	Geankoplis 3.1D Flow in Fluidized Beds Chapter 11: Fluidization – **FMChE** Review: 6.13 Flow around Submerged Objects - **FMChE**
11/03/10 Wednesday	Fluidization (continued) Fluidized Bed Experiments
11/8/10 Monday	AIChE Annual Meeting – Salt Lake City, UT Special Assignments – Turn in any 2 previously assigned challenge problems not previously completed
11/10/10 Wednesday	AIChE Annual Meeting – Salt Lake City, UT Special Assignments – Turn in any 2 previously assigned challenge problems not previously completed
11/15/10 Monday	Geankoplis 3.4 Agitation and Mixing of Fluids and Power Requirements Chapter 19 Mixing – **FMChE**
11/17/10 Wednesday	Mixing (continued) **Mixing Experiment** and Gas Sparged Tank Demonstration
11/22/10 Monday	Chapter 12 Gas-Liquid Flow- **FMChE** (or 2-phase flow)
11/24/10 Wednesday	Chapter 12 continued Flow of fluids of Foods: Examine flows of, milk, cream, whipped egg whites or cream, freshly prepared cranberry sauce. Write a short report on the fluid mechanics involved.
11/29/10 Monday	Chapter 12 continued
December, 12/1/10 Wednesday	Chapter 12 continued Geankoplis 3.10 Boundary Layer Flow and Turbulence Chapter 18 Turbulence – **FMChE** Reynolds Experiment
12/6/10 Monday	Exam 2: Momentum Balance: Newtonian and Non-Newtonian Fluids (FMChE Ch 7.2, 13 through 13.3, Geankoplis 2.8-2.9 & 3.5 - 3.8), Navier Stokes Equations (FMChE Ch 15, Geankoplis 3.5 - 3.8), and Flow Through Porous Media (FMChE Ch 11 & Geankoplis 3.1)
12/8/10 Wednesday	Chapter 18 Turbulence continued
12/13/10 Monday	Evaluations Review for final
December, 15-21	Wednesday – Tuesday Final Exam Week
Wednesday 12/15/10 December	**FINAL EXAM** (based on Fall 2010 Schedule of Courses published Spring 2010) 2:45 – 4:45 PM Final Exam: Comprehensive (Closed Book and Notes)
	Go out and make your holiday process fluid transport toys – They make great gifts!

Absolute Grading Scale

In this course we would like to create an atmosphere of positive cooperation between students. Most of the exercises in this course will require you to work in teams and you will be expected to help each other learn the material. To encourage and support cooperative learning you will be graded on an absolute grading scale as given below. The net result is that it is in your interest to help your classmates become successful engineers. You will learn through teaching others.

Letter Grade	University Point System	Percentage	Additional Requirements
A	4.0	93	and achieving a score of 85% on at least 3 Challenge Homework Problems.
A-	3.7	90	and achieving a score of 80% on at least 1 Challenge Homework Problems
B+	3.3	87	
B	3.0	83	
B-	2.7	80	
C+	2.3	77	
C	2.0	73	
C-	1.7	70	
D+	1.3	67	
D	1.0	63	
D-	0.7	60	
F	0.0	< 60	

Your final numerical grade in the course will be determined as follows:

Quizzes	10%
Exam 1	20%
Exam 2	20%
Final Exam	20%
Homework	30%

Explanation of Grading System:

Homework: All Homework will be done and handed in by teams unless specified by the professor. Teams of 3 or 4 will be assigned by professors teaching the junior courses. One team member will be designated the leader for each assignment and only one homework assignment per team will be accepted unless specified otherwise.

On the top right hand corner of the first page of the homework specify the team leader and all *participating* team members names. The Rowan Engineering homework format must be followed. The team leader will be responsible for coordinating the work and making sure ***everyone*** in the team ***understands all the problem solutions*** before they are submitted to the professor. After being a team leader, an individual may not be a leader again until everyone else in the team has held the position. If a student's name appears on a solution set, it certifies that he/she has participated in solving some of the problems and ***understands all the solutions***.

Unless otherwise stated, each team member must submit their initial attempt at the homework. Place name on page and staple each team member's attempts to the back of the homework.

Team homework should be done following this outline for a typical week:

5 minute - Initial meeting after class. In this meeting major homework responsibilities are assigned. - **Assign**

Students attempt **all** homework problems individually. **Define, Generate**

2nd Meeting – 1 hr: Discuss homework problems and **Decide** on solution strategy.

Solve assigned homework problem plus any additional if time permits. **Implement**

3rd Meeting 1 hr: Discuss and **Evaluate** all solutions. It is the team leaders responsibility to make sure all team members are able to complete all assigned homework problems.

(Hint: Cooperative learning is not students sitting around a table and doing homework together.)

Individual Effort Assessments for Team Homework: All students will periodically be asked to submit evaluations of how well they and their teammates performed as team members. These evaluations will be incorporated into the assignment of homework grades. If repeated efforts to improve team functioning (including faculty intervention) fail, a nonparticipant may be fired by unanimous consent of the rest of the team, and a team member doing essentially all the work may quit. Individuals who quit or are fired *must* find a team of two or three that are unanimously willing to accept them; otherwise they will receive zeros for the remainder of the homework.

Homework will be assigned randomly throughout the semester and must be submitted to the professor at the beginning of each class on the day it is due. Late homework will be penalized according to the following system:

• 15 minutes late - 5 PM on due date:	Maximum grade: 80% of total points
• After 5 PM and before 5 PM on day following due date	Maximum grade: 50% of total points
• After 5 PM on the day following the due date.	Maximum grade: 0% of total points

Exceptions will be made in case of illness or other emergency. Homework solutions will be posted on the course website.

Challenge Homework Problems: A minimum of 4 challenge homework problems will be given. Each of these problems will be worth 0.5% of the absolute grading scale. These challenge problems may be worked individually, in pairs or with your assigned team.

Quizzes: *Unannounced* quizzes will be given through out the semester. These quizzes will begin at the start of the class period and have a duration of approximately 5-10 minutes. No make-up quizzes will be given for unexcused absences. (See Attendance Policy section.) Unless announced otherwise, all quizzes are closed book and notes.

Bonus points worth 5 quiz points will be given on quizzes if all team members have a score above the criterion announced in class before the quiz. This extra credit is designed to encourage team interaction and increase overall student achievement. The default quiz score for all members to receive the bonus points is 80%.

Exams: Two exams and a comprehensive final examination will be given. Exams will be closed-book and notes unless otherwise announced. Absence at examination time is excusable only in case of illness of the student or similar emergency. An unexcused absence from an exam will result in a zero grade on that exam. If an error has been made in grading your exam, you must resubmit your entire exam for regrading.

Bonus points worth 5 exam points will be given on exams if all team members have a score above the criterion announced in class before the exam. This extra credit is designed to encourage team interaction and increase overall student achievement. The default exam score for all members to receive the bonus points is 80%.

ATTENDANCE POLICY: In keeping with published policy (see p. 40 in the Student Information Guide http://www.rowan.edu/studentaffairs/infoguide/ or the 2008-2010 *Rowan University Undergraduate Catalog*), attendance is required because substantial in-class material is presented and because attendance is needed to develop teamwork and cooperative learning skills, and accomplish project work. The instructor must be notified of an excused absence in advance of the class. Your project manager may require you to complete a work log to demonstrate your attendance.

ACADEMIC CONDUCT: The policy in this class in matters of academic misconduct will follow that stated in "Rowan University Student Handbook." Any student cheating in this class will receive a grade of F for the course. If another student is involved in the offense knowingly, he or she will receive the same penalty.

Course Withdraw Schedule

Dates	Designations on Transcript	Signature(s) Required
9 September to 19 October	W	Student, Professor
20 October to 22 November	WP/WF	Professor, Dept. Chair
23 November to 21 December	WP/WF	Professor, Dept. Chair, Dean

For a complete description of this procedure please refer to the Rowan University Student Information Guide
http://www.rowan.edu/studentaffairs/infoguide/pdf/infoguide0810.pdf

COURSE OBJECTIVES:

The following is a partial list of objectives that you are expected to master by the end of this course.

1) Given a description of a physical process, students will be able to construct and use a mathematical model to predict the performance of the process.
2) Specify a pump for a given process with the aid of a pump curve.
3) Describe the purpose of baffles in a mechanically agitated tank.
4) Specify the operating conditions of an agitated tank to suspend particles of a given density and size.
5) Calculate the minimum fluidization velocity given fluid and particle physical properties.
6) Determine the pressure drop of a fluid flowing through a packed bed.
7) List at least six flow regimes for horizontal gas-liquid pipeline flow.
8) Derive a mathematical description of a process using shell balances.
9) Define viscosity, shear stress, strain, and momentum.
10) Write the constitutive equations for momentum for a Newtonian fluid and a power law fluid.
11) Predict the resultant force on a nozzle.
12) Derive the velocity profile for laminar flow of a Newtonian fluid in a pipe.
13) Predict the average velocity of a vertical falling film.
14) Describe how the viscosity of a fluid can be determined using a cone and plate viscometer.
15) Determine the velocity profile of a non-newtonian fluid through a complex geometry using advanced software tools.

Rowan Engineering Homework Format

All homework problems, unless otherwise directed by your instructor, should follow the Rowan Engineering Format. This format is used for most professional engineering work. Unless otherwise directed by your instructor, you should use engineering paper or the equivalent for all homework assignments.

1) **Headers:** The five boxes at the top of each sheet of engineering paper that you use for a homework assignment should contain the following information from left to right:
   a) put the staple (which is the required homework binder) in the first (small) box
   b) print the team leaders name in the 2nd box and the names of each *participating* team member below this box
   c) print the course name in the third (large) box
   d) print the date that the assignment was completed in the fourth box.
   e) print the page number / total number of pages in the fifth (small) box
2) **Writing Mechanics**: All homework should be:
   a) carefully printed and not written in cursive
   b) printed in pencil and not in ink
   c) neat and clean, i.e. printed on the lines with no smudges or cross-outs
3) **Calculations:** All homework calculations should:
   a) include at least one complete sample for every type of calculation presented
   b) include all units for each term in each equation and the units must balance
   c) use the appropriate number of significant figures (usually three) for all numbers
   d) clearly indicate the final solution by boxing it in with a rectangle
4) **Problem Order:** Problems should be presented
   a) in the order assigned (one, two, three, etc.)
   b) with a new problem starting on a new page of engineering paper
   c) with the designated problem number, from textbook or professor, under box 2.
   d) using only the front side of each sheet of engineering paper
5) **Problem Essentials:** Problem solutions should include the following items in order:
   a) homework problem number listed at beginning of problem
   b) the given information - the information that will be used to solve the problem
   c) the required information - the information or solution that we are looking for
   d) a straight-edge diagram or diagrams that clearly illustrate the problem
   e) the solution of the problem including all required steps and calculations
6) **Evaluation:** Double-check all of your calculations to make sure that:
   a) all of your math is correct, i.e. you made no errors in using the calculator or computer
   b) all of your equations are correct, i.e. you made no errors in manipulating equations
   c) all of your units balance, i.e. you derived the correct units for the desired solution
   d) your final answer is reasonable. (e.g. is your reactor bigger than the empire state building, is the temperature of any liquids much higher than the mixture boiling point. Is the pressure drop greater than 10% of the total pressure.
7) **Computers**: Homework Assignments using Computers
   a) Show sample calculations (with units) for each spreadsheet or POLYMATH calculation on engineering paper.
   b) Do not printout raw data from data acquisition experiments. A summary of the data in the form of a table and/or a graphical presentation of this data is sufficient unless otherwise requested from the professor.
   c) For homework requiring **POLYMATH**, the following additional printouts are required:
      i) A printout of the program you have written. To reduce the number of printouts, you must paste this output into a word document containing all tables and graphs required for a particular homework.
      ii) A summary table of the solution.
   d) For homework requiring ASPEN: i) A summary table of the solution ii) a process flow diagram iii) electronic file uploaded on blackboard or otherwise instructed by professor.
   e) For homework requiring COMSOL: i) handwritten setup of the problem showing geometry and equations ii) required graphs and tables iii) electronic *.mph file uploaded on blackboard or otherwise instructed by professor

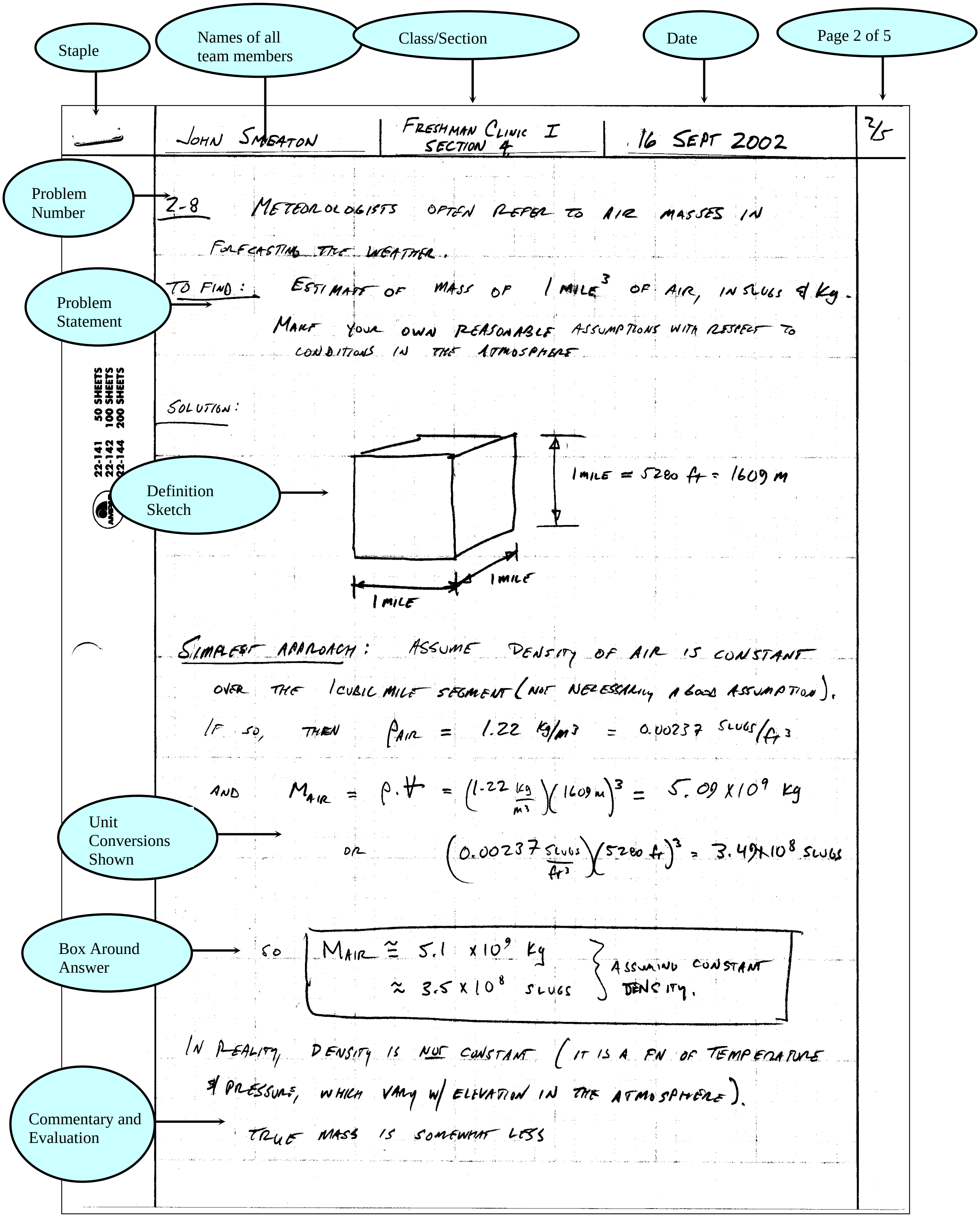

Figure 1: Sample homework on engineering paper in proper format.