

# ChE 480

**Senior Unit Operations  
Lab  
Fall 2012**

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## **Objectives for this course: students will...**

- **Design and execute chemical engineering unit operations** in which the principles of fluid mechanics, heat and mass transfer, separation, reaction kinetics, and process control are applied.
- **Understand and execute the essential theoretical calculations for the experiments.** Heat exchanger calculation, pressure drop through a pipe, McCabe-Thiele calculations, CSTR kinetics. [exam = 10% ]
- **Use theory to understand what data to collect and correctly analyze.** Analysis of real data using the essential theory discussed above. Make sure to have multiple points collected for formation of an appropriate graph, averaging, statistical analysis, etc.
- **Perform open-ended experiments where decision making is needed to obtain optimal experimental design and results.**
- **Review necessary background and search the literature.** Be able to search the literature and use data collected by colleagues to further understand and improve experiment design, execution and analysis.
- **Follow safe lab practices.** ALWAYS wear goggles, closed-toed shoes, and long pants. Clean your lab area, label all solutions, execute safe work practices in the lab. [loss of 5-10 points on team lab grade for the experiment per offense]
- **Work effectively and professionally in a team.** Organize and manage team and time. Work effectively in a group. Reliable and responsible work practices are expected. [internal team performance evaluations are required]
- **Prepare and present a technically accurate and well-organized presentation.**
- **Communicate technical data and analysis in effective written reports.** Be able to write a progress report (short memo) as well as a final (long) report.

## Course information

Time:	Section-1: Tuesday 8:00-1:10pm Section-2: Thursday 8:00-1:10pm
Location:	140 Fenske (Lecture - 8AM); 14 Fenske and 10 Fenske (Lab – immediately following lecture) 133A Fenske (Oral reports – TBD)
Pre-reqs:	Engl 202C, ChE core courses (concurrent)
Required Items:	Individual lab notebook, safety goggles, close-toed shoes, long pants, long sleeves
Texts:	Your own textbooks from previous CHE classes Lab manuals printed from ANGEL Perry's Handbook is on the lab computers McCabe, Smith, and Harriott, <u>Unit Operations in Chemical Engineering</u> . (optional).
ANGEL:	<a href="https://cmp.psu.edu">https://cmp.psu.edu</a>

**Texts referenced in manuals are on reserve in the Mathematical and Physical Sciences Library in Davey Lab**

## Teaching assistants:

Krisada Ruanjaikaen (Kris)	HPLC, UF & Gel Electrophoresis	kur128@psu.edu
Huai-Suen Shiau	Fluid Flow / HX / Control, Kinetics	hus142@psu.edu
Helen Jing-Han Wang	Distillation, LLE	juw214@psu.edu

## Office Hours:

Professor Hillsley: TTh 9-1 in the lab, M 12-1, and by appointment  
(not available on Wednesday or Friday)

Professor Kumar: TTh 9-1 in the lab, T-Th 5-6 PM

TAs are available in the lab and by appointment.

You may come during the other lab section to consult the professor or TA. TAs and the professors may also be contacted via e-mail.

## Grading

Grading will consist of the following parts:

Pre-lab calculations	10%
Reports (2 oral, 4 short)	55%
Pre-lab quizzes	12%
HYSYS Project	8%
Lab notebook grade	4%
Lab grade (safety, lab work, and data processing)	10%
Homework (Writing review calibration)	1%

### Grading Scale (rounded grades):

93-100 A	83-86 B	70-75 C
90-92 A-	80-82 B-	60-69 D
87-89 B+	76-79 C+	0-59 F

- **Grades** Professors Hillsley and Kumar give the grades (0-100%) for all graded items. They will take input from the TAs, graders, and team evaluations.
- **Team work evaluation.** With each team assignment you will turn in a Team Activity Report in which your team collectively rates each person's effort on that assignment. This must be a consensus evaluation. In the case of a disagreement, a minority report may also be filed. The effort ratings on these evaluations will be used, with instructor input, to adjust the individual grade on each team assignment.
- **Excused absences.** Please discuss any absences prior to the absence with the instructors and your team members. Work for absences with prior approval may be made up. If you contract the flu, please do not come to class and spread the virus. E-mail the instructors and team members and go home to recover. Unexcused absences will result in a 0 (zero) for the lab grade for that day, and may also affect the individual report grade.
- **Late work.** None accepted.
- **Re-writes.** You have the option of re-writing one poor report for which you received a grade of 80% or less. The re-write grade will then be averaged with the original grade. Re-writes must be substantial revisions for an improved grade. Re-writes may be submitted at any time but no later than the last week of class. Please submit the original graded report with the re-write. The last report of the semester is not eligible for a re-write due to time constraints.
- **Re-grades.** Please submit requests and rationale for re-grades within one week. Small grading errors tend to balance, and so the entire work will be re-graded.

### Pre-lab calculations

Pre-lab calculations/research must be submitted in person (entire group) to the TA for grading the week before the assigned lab period (in the lab). The TA will grade the

calculations. Any errors must be corrected in the lab before the group is dismissed. Groups turning in pre-lab calcs during the 2<sup>nd</sup> week of class will do so at 9 AM, all others will arrange a time between 11 AM and 12 PM with the appropriate TA the week before pre-lab calcs are due. Pre-lab calculations ensure that you are prepared for the lab (and pre-lab quiz) and allow you to start promptly and thus finish on time. All labs have pre-lab calculations. They vary in length. Be aware that Fluid Flow pre-lab calculations are quite extensive. Video lectures on each experiment, found on ANGEL, can assist you with the pre-lab preparation.

### **Lab Notebook**

The lab notebook is an important part of lab work. Each individual team member will be required to keep a dedicated lab notebook (bound). You must document your work well: label experiments, indicate methods used and deviations from the manual. Document the composition of all solutions made (i.e. mass and volume), measurements made (mass, final volume, etc.) in making solutions, and any other relevant data and observations. These notebook entries may be referred back to when problems arise in later calculations, or when unexpected results need to be explained. Poor documentation will result in loss of points. The lab notes must be initialed by a TA or professor before leaving the lab, and one copy must be included in any reports turned in. Keep the notes neat. (see separate handout for more details on lab notebook requirements.)

### **Lab Grade (includes lab safety, lab work, and data processing).**

The lab grade consists of 3 parts. See grading rubric for more details.

- **Lab safety.** Lab safety is very important. All people in the lab are expected to use safe practices. Infractions will result in a deduction from the team lab grade. Serious infractions that result in the student being sent home (ie open toed shoes) will result in major point deductions. Briefly, safety glasses must be worn at all times in the lab, absolutely no food or drink in the lab at any time, gloves must be worn when handling hazardous material, and all solutions must be labeled.
- **Lab work.** Lab work will be graded on preparedness, teamwork within the lab, and effectiveness in the lab.
- **Data processing.** Data processing will be graded on team participation in the processing and/or discussion there off, the efficient work on processing in the lab, and the effective use of the TA for completing the processing. Asking the TA questions is encouraged, but excessive dependence on the TA for processing the data will result in loss of points. The post lab calculations should be done in excel in a standardized layout. A sample spreadsheet for you to follow may be found on ANGEL.

## **Safety requirements**

All students are expected to understand and do their best to avoid any hazards associated with their particular equipment and experiment. MSDS (Material Safety Data Sheets) for chemicals used in the experiment can be found on ANGEL. Students are expected to look these over before coming to the lab. Students must investigate their instruments prior to operation and data collection and report any potential hazards to the TA or professor. If unsafe practice is witnessed, the student will be warned and a 5-10 point lab grade deduction will be made per infraction. If infractions persist, the student and/or team will be dismissed from their particular experiment on that day and a zero grade will be given. All students must observe the following safety precautions:

1. Safety goggles will be worn AT ALL TIMES by all participants. Sunglasses are prohibited.
2. Each student must know the position and operation of fire extinguishers, safety showers, and eye flush fountains. You should be able to determine whether use of this equipment is necessary or not; and if needed, you should be able to use this equipment properly. Please notify your TA or professor immediately in the event of exposure so that we can properly cope with the situation.
3. To avoid chemical burns, skin should be covered as much as possible. Long pants and long sleeves must be worn by all participants. Closed-toed footwear is required. Gloves should be worn when working with hazardous materials.
4. All solutions made in the lab must be labeled. Each experiment has a color tape assigned to it. Use this to label your solutions.
5. Eating, drinking, and smoking are not allowed in the lab. You may take a snack break (if agreed to by the team) in the student lounge or other suitable area in Fenske.
6. Cellular phones must be turned off because they are distracting and therefore hazardous. Newspapers are not allowed in the lab.

## **Lab Cleaning (every lab week)**

You are not just a user of the 480 lab; you are the “owner”. Without your “responsible” lab manners, we cannot keep the lab in good working conditions. Please clean up your mess and instrument. Report any malfunction to the TA or professor. Your TAs will check waste disposal, chemical storage, work area cleanliness, and instrument conditions after you leave the lab every week. In the event of a problem, your lab grade for that experiment will be reduced 2 points per event.

## **Significant Figures**

It is expected that the appropriate number of significant figures are used in all material turned in. This includes pre-lab and post-lab calculations as well as final reports. Points will be deducted for inappropriate, or lack of, significant figures.

## **Report Writing**

Since this is a writing intensive course, you will be writing a report or making an oral presentation for each experiment performed. All reports will be team effort. You will write a total of 4 team short reports. In an effort to help improve your writing, one of these reports with a grade of 80% or less will be eligible for an optional re-write. The re-write grade will be averaged with the original grade. Reports are due electronically to the ANGEL drop box by 8 AM on the due date. The due date is generally 11 days after the experiment. Rewrites must be submitted no later than the last week of class. Earlier submission is encouraged. The last written report of the semester is not eligible for a rewrite due to time constraints.

Reports must be submitted electronically, along with a copy of the Excel Data Processing file and 1 copy of signed lab notebook pages.

## **Excel Data Processing File**

All reports must be turned in with an Excel file containing clearly labeled calculations (data processing) and all figures required in the data processing section of the manual. The figures should be publication quality (NOT the default Excel format) with captions and appropriate formatting and enhancements/annotations. All the figures should be grouped on the first sheet of the spreadsheet with reference in the caption as to where the calculations may be found. There is an example Excel spreadsheet found on ANGEL for your reference. Make sure the calculations are clear and easy to follow. They must be correct (and understandable) to get full credit on the graded report. (see additional handout for more information.)

## **Oral Reports**

Each team will present 2 formal oral presentations on experiments performed in the lab. Generally, the reports will be given in room 133A Fenske, one week after the experiment date (time TBD). Please consult schedule for exact dates and times for oral reports. The first oral report will be presented to instructors and TAs only. The second oral report may be presented to another team(s) as well as to the instructor(s).

## **Pre-lab Quiz**

At the start of each lab period, you will take a 15 minute pre-lab quiz. This quiz will be taken in room 140 promptly at 8 AM. The purpose of this quiz is to ensure that each member of the group is prepared for the lab experiment to be performed that day. The quiz may cover any of the pre-lab questions for that experiment. Video lectures on each experiment may be found on ANGEL.

## **In Lab Procedure**

### **Upon Arrival**

You must review your assigned lab with a TA or the professor before starting the lab. In this review you will relate your experimental plan, review your pre-lab calculations for accuracy, and have the opportunity to clear up anything in the procedure that is unclear to you. In addition, you should start each experiment by drawing a block flow diagram of your equipment and/or process in your notebook. You should ensure that you can locate all the parts of your diagram on the actual equipment.

### **Before Leaving the Lab**

When you have completed the lab, processed your data, and cleaned up your equipment and glassware; report to the TA or professor to review your data and check out. At this time the TA will sign your lab notes. **A copy of these signed lab notes will need to be submitted with your report.** Failure to check out will result in a 5 point deduction from your report grade (as well as deductions from your lab grade).

## **Plagiarism**

Plagiarism will not be tolerated under any circumstances. Reports or presentations containing plagiarism will receive zero points.

## **References**

Please ensure that material obtained from other sources is properly referenced. When quoting specific numbers from a source, an endnote should be used when the data is given. Material taken from other teams, or supplied by the TAs, should also be referenced by author and team name. This is applicable especially for the LLE and HPLC reports. When taking graphics from the web and using it in a presentation, the slide should contain a reference to the source of the material. A guide to citing web references is posted on ANGEL.

## **Team Work**

As the entire semester will be spent working on experiments and reports as a team, effective team work will be of extreme importance. Remember that some team conflict is normal in working towards an effective team (forming, storming, norming, performing), but you want to move to a performing team as quickly as possible. In choosing your team, please keep in mind your individual goals for the course and schedules for meeting opportunities, as these two things tend to present the greatest conflict. Please work towards resolving any conflict as quickly as possible.

## **Experiments in the lab**

The experiments found in the lab are fluid flow (FF), heat exchanger (HX), process control, kinetics, distillation, liquid-liquid extraction (LLE), high performance liquid chromatography (HPLC), and ultrafiltration and gel electrophoresis (UF and gel). Some of these have lengthy pre-lab calculations (FF and kinetics, especially). Some of these experiments will require the full length of the lab (LLE, HPLC, UF and gel, and distillation), and much longer if you come unprepared. Make sure to come very well prepared for these experiments so that you can finish in a timely fashion.

## **Useful References:**

**General references** (first book is on reserve in library, and is optional book in bookstore)

McCabe; Smith; Harriott. Unit Operations of Chemical Engineering [TP155.7.M393 1993; TP155.7.M3 2001; TP155.7.M3 2005].

Russell and Denn. Introduction to Chemical Engineering Analysis [TP155.R88]

## **Materials Data**

Perry's chemical engineers' handbook Eds. R. H. Perry and D. W. Green [TP151.P45 1997]. **Copy on lab computer.**

CRC Handbook of Chemistry and Physics. [QD65.H301]

## **Thermodynamics**

Sandler. Chemical and engineering thermodynamics, [QD504.S25 1999].

Smith; Van Ness; Abbott. Introduction to Chemical Engineering Thermodynamics [TP149.S582 1987].

## **Transport phenomena**

Bird; Stewart; Lightfoot. Transport Phenomena. [QA929.B5 2002].

Welty; Wicks; Wilson; Rorrer. Fundamentals of Momentum, Heat, and Mass Transfer. [TA357.F87 2001]

**Chemical reactions** (first book is reserved in the library)

Fogler. Elements of chemical reaction engineering. [TP157.F65 1999]

Levenspiel. Chemical reaction engineering, [TP157.L4 1999].

## **Process Design**

Biegler; Grossmann; Westerberg. Systematic methods of chemical process design. [TP155.7.B47 1997].

Riggs. Chemical process control. [TP155.75.R54 1999].

**Process Control** (book is on reserve in library)

Svrcek; Mahoney; Young. Real time approach to process control. [TS156.8.S86 2006].

## **Data Analysis and Statistics**

Bevington; Robinson Data reduction and error analysis for the physical sciences [QA278.B48 1992].

## **Report Writing**

Jeter; Donnell. Writing Style and Standards in Undergraduate Reports.