ChE 450: Unit Operations Laboratory
Section 001: Thursday 12:30 – 16:45
Fall 2013

Course Instructor: Dr. David J. Klinke II
Office Location: 427 Engineering Sciences Building
Office Hours: Tuesday 3:00 - 5:00 PM or by appointment

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Recommended Texts: Texts for all previous ChE courses

W. L. McCabe, J. C. Smith and P. Harriott, *Unit Operations of Chemical Engineering*, 6th Edition, McGraw-Hill (2001)

J. M. Haile, *Technical Style*, Macatea (2002)

This Outline must be read in conjunction with the Laboratory Manual for the course, as well as handouts on oral reports and written reports, all of which detail specific requirements and information. There is necessary overlap between these materials. In case of a discrepancy between this Outline and the other material, this Outline will generally govern. Please inform the instructors of any such discrepancy.

Course Goal: To consolidate and solidify the concepts and knowledge you have acquired during the undergraduate program, in a hands-on and communications framework.

1. Learning Outcomes

In partial fulfillment of *ChE Educational Outcomes 2, 3, 4, 5 and 7* (see "Undergraduate Program Mission, Outcomes and Objectives" statement), at the conclusion of this course, you will:

- develop the ability to design and to perform laboratory experiments from a general problem statement and relevant literature suggested;
- become familiar with process equipment and instrumentation similar to that found in actual plant environments;
- integrate the principles learned in classes with laboratory operation and practice;
- learn how to document data and ideas appropriately in a laboratory notebook;
- analyze experimental data using basic chemical-engineering principles;
- communicate effectively in both written and oral formats;
- improve technical-writing skills by receiving written feedback and revising written reports;
- develop interpersonal skills necessary for team performance;
- practice standard laboratory safety procedures and follow good environmental practice.

2. Summary of Important Course Policies

a) Laboratory work must be carried out on the scheduled dates with all members present. Schedule job interviews and work on the design project accordingly.

b) The team is responsible for reading and understanding the laboratory manual and any supplemental or reference material provided.

c) An approved Pre-laboratory Report ("Pre-lab") must be given to the Graduate Teaching Assistant (GTA) during a meeting the week before the experiment is scheduled to be initiated. A Preliminary Written Report must be submitted to the instructor at the start of the experiment. A Calculations Appendix must be submitted to the GTA one week after the experiment, during the data review session. A Final Written Report (including the Appendix) is handed in and an Oral Presentation is made a week after that. More details on all of these are provided below and in the Laboratory Manual.

d) All written reports (except the Calculations Appendix) must be neatly printed double-spaced using word-processor software in the format described in the manual. The Preliminary Written Report and the Final Written Report must be returned to the instructor after the comments of the instructor have been reviewed. No grade will be recorded until these reports are returned.

e) Each team member must participate in every Oral Report. A PowerPoint presentation must be used.

f) You may examine equipment during normal working hours but under no circumstances are you to work on or to operate an experiment alone or without proper supervision.

g) Laboratory safety procedures are of paramount importance and will be strictly enforced. If you are not sure about something, please ask!!!

3. Course Schedule

The three laboratory cycles for this course are shown in Table 1. Each 4-week cycle represents a different experiment which will be identified later in this document. Three different reports and an oral presentation are associated with each cycle. The due dates (cycle weeks) and grade weighting of each of these are shown in Table 2.

Table 1. Course Schedule

Week #	Cycle #	Activity	Date	Location
1		Introduction and Laboratory Overview	22-Aug	MRB 205*
2	1	Pre-laboratory Report	29-Aug	Galli Lab
3		Preliminary Report & Experiment	5-Sep	Galli Lab
4		Appendix and Data Review & Experiment	12-Sep	Galli Lab
5		Oral & Written Report	19-Sep	MRB 205*
6	2	Pre-laboratory Report	26-Sep	Galli Lab
7		Preliminary Report & Experiment	3-Oct	Galli Lab
8		Appendix and Data Review & Experiment	10-Oct	Galli Lab
9		Oral & Written Report	17-Oct	MRB 205*
10	3	Pre-laboratory Report	24-Oct	Galli Lab
11		Preliminary Report & Experiment	31-Oct	Galli Lab
12		No class – AIChE Meeting	7-Nov	---
13		Appendix and Data Review & Experiment	14-Nov	Galli Lab
14		Oral & Written Report	21-Nov	MRB 205*

***Oral Reports begin at 2:00 PM in room 205 Mineral Resources Building**

Table 2. Laboratory Report Grade Weighting

Cycle Activity	Due Date	Points
Pre-laboratory Report	Cycle Week 1	50
Preliminary Report	Cycle Week 2	50
Oral Presentation	Cycle Week 4	50
Final Report	Cycle Week 4	100
Total per Cycle		**250**

4. Student and Team Performance

At the beginning of the semester, each student has been assigned to a student team group. In a given cycle, the student group will perform the assigned laboratory experiment. The experiments and group assignments are given in Tables 3 and 4, respectively. The group members will plan and perform the experiment together but they will submit individually written reports (pre-laboratory, preliminary and final) to the instructor or graduate teaching assistant (GTA). Reports will be individually graded, using the criteria outlined below, and handed back. In some cases, a rewrite may be required.

CHE 451 is designated as a writing course and meets Objective 1 in the General Education Curriculum. As such, each student is expected to produce 30-60 pages of original writing over the course of the semester. Students are expected to receive feedback on their writing and to revise reports to improve their writing skills. It is expected that carrying out the revision of an earlier report will make you a better writer, and should result in an improved grade in the report for the subsequent experiment(s). The initial grade will count but, as mentioned earlier, will not be entered until the revised report is received.

Numerical grades, not letter grades, will be issued for individual reports. Letter grades will be issued only for the overall performance in the course, following the weighting above.

The following serve as "ceilings" of minimum performance to receive the corresponding grades:
"A"=90
"B"=80
"C"=70
"D"=60.

They are "ceilings" in that they may be adjusted (or "curved") downwards. So, if you receive the number specified, you are assured of receiving the grade, but you may receive the grade even if you have a lower number.

4. Cycle Sequence and Report Preparation

A short memorandum to each student team will initiate each of the three laboratory cycle. This memo will provide a brief description of a problem (experiment number) and will describe the task assigned. Each team needs to discuss this memorandum and to do the background work necessary to start the project. A list of the experiments (and experiment numbers) is given in Table 3, and the assignments for each team are given in Table 4.

Table 3. List of Experiments

Experiment #	Name of Experiment
1	Process Control
2	Convective Heat Transfer
3	Distillation Column
4	Cross-Flow Filtration
5	New experiment
6	Residence Time Distribution
7	Enzyme Kinetics
8	Tank Drainage
9	Fluidized Bed
10	Thermal Conductivity in Spheres

Table 4. Student Team and Experiment Assignments for Each of the Three Lab Cycles

Team #	Team Members	Experiment # Lab Cycle 1	Experiment # Lab Cycle 2	Experiment # Lab Cycle 3
1	Corathers,William I. Kuzmar, Areej A. Smearman, Jonathan T.	10	8	6
2	Cayo, Bradley J. Gupta, Neha Lilly, Brittany N.	9	7	3
3	Alhumaid, Suliman A. Clark, Benjamin M. Miles, Jason R.	8	6	2
4	Al-Awami, Muhammad Alawami, Fidaa J. Riley, Jarrett A.	7	3	10
5	Taylor, Kyle D. Taylor, Roman M. Ozkan, Levent	6	2	9
6	Albright, Jacob T. Brown, Sean W. Butt, Ahmed Saleen	3	10	8
7	Hall, Megan C. Lyvers, Thomas M.	2	9	7

Each cycle consists of the following activities:

A. Pre-laboratory Report (Cycle Week 1)

A neatly written experimental plan (Pre-laboratory Report, "Pre-lab") must be submitted to the GTA or instructor at the Pre-laboratory meeting one week before the experiment is performed. The Pre-laboratory schedule is given in Table 5.

The Pre-laboratory Report consists of a brief (2-5 page) written description of the theory and experimental procedures planned, important variables and ranges of parameters to be measured, and a discussion of important safety aspects. Pre-laboratory Reports will be graded for content, and the writing will be critiqued. See Appendix I for grading criteria.

Table 5. Pre-laboratory Schedule (Cycle Week 1)

Team #	Cycle #1	Cycle #2	Cycle #3
Team 1	12:30	1:30	2:10
Team 2	12:50	1:50	2:30
Team 3	1:10	2:10	12:30
Team 4	1:30	2:30	12:50
Team 5	1:50	12:30	1:10
Team 6	2:10	12:50	1:30
Team 7	2:30	1:10	1:50

The Pre-laboratory meeting with the instructor or GTA should clearly reflect the level of planning the team has done for the experiment. No experiment can be performed until the Pre-laboratory Report is approved.

B. Preliminary Report and Lab Day (Cycle Week 2)

A Preliminary Report must be submitted at the start of the experiment. It should consist of as complete a body of the report as possible, understanding that the experiment has not yet been done. The instructor will evaluate this report for technical content and writing style. It will be returned within one week so that comments can be integrated into the Final Report. Hence the Preliminary Report should be made as complete as possible, to take advantage of input from the instructor prior to the Final Report. See Appendix II for the Preliminary Report grading criteria.

The team group will carry out the experiment in the Senior Laboratory at this time.

C. Data Review & Another Lab Day (Cycle Week 3)

The experimental data and calculations (both hand calculations and Excel) will be presented in an appendix of the final report. The schedule for GTA review of the appendix is given in Table 6. The team will meet with the GTA at the designated time slot on Monday of the third cycle week in the Senior Laboratory. The team will show the experimental results and calculations to the GTA. At that time it will be determined whether or not the experiment needs to be repeated (or you may wish to repeat the experiment anyway!!) See comments in Appendix III.

Table 6. Schedule for Appendix Review (Monday, Cycle Week 3)

Team #	Lab #1	Lab #2	Lab #3
Team 1	1:30	2:30	3:10
Team 2	1:50	2:50	3:30
Team 3	2:10	3:10	1:30
Team 4	2:30	3:30	1:50
Team 5	2:50	1:30	2:10
Team 6	3:10	1:50	2:30
Team 7	3:30	2:10	2:50

After having consulted with the GTA, groups are encouraged to repeat the experiment on the 3rd Tuesday, Second Laboratory Day. Even if the team finished the experiment, there may be "bad data" for a variety of conditions, (e.g., correct conditions and/or procedures were not used). In many cases, it is possible to improve the data collection technique. In any case, a second (or more) set of data will improve the statistics.

D. Final Report and Oral Presentation (Cycle Week 4)

The Final Written Report must be submitted at the beginning of the class when Oral Presentations are given. Late reports will be penalized. Reports will be corrected for writing and technical content, graded, and returned by the instructor within one week. See Appendix IV for grading criteria. You should carefully read the instructor's remarks to determine how you can improve reports. Make corrections and submit a revised report to the instructor as necessary.

Guidelines for oral and written reports are provided in the Laboratory Manual and handouts on oral reports and written reports, and are not repeated here. Example formats for title pages in written reports are given in Appendix VI.

Oral Presentations with visual aids (PowerPoint format for projection system) will be made by all team members on the fourth week of the cycle. See Appendix V for grading criteria. Presentations will be held in room 205 MRB beginning at 2:00 PM.

5. Social-Justice Statement

"WVU is committed to social justice. I concur with that commitment and expect to maintain a positive learning environment based upon open communication, mutual respect, and nondiscrimination. WVU does not discriminate on the basis of race, sex, age, disability, veteran status, religion, sexual orientation, color or national origin. Any suggestions as to how to further such a positive and open environment in this class will be appreciated and given serious consideration. If you are a person with a disability and anticipate needing any type of accommodation in order to participate in this class, please advise me and make appropriate arrangements with the Office of Disability Services (304-293-6700)"

Appendix I: Pre-Laboratory Report (0-50 points)

Pre-laboratory planning requires a review of literature and an inspection of the apparatus in the laboratory. All aspects of the experiment must be planned. The pre-laboratory report should include, but is not necessarily limited to, the number of data points, range of data points, experimental procedure, and variables to be measured and/or fixed. Remember that these estimates may need to be revised as you perform the experiment.

One key to success in experimental work is to ask continually:

- *What am I looking for?*
- *Why am I measuring this?*
- *Does the measurement really answer any of my questions?*
- *What does the measurement tell me?*

These questions may seem rather elementary, but they should be asked frequently throughout the progress of any experimental program. Some particular points, which should be addressed in experimental planning, are shown below. Also see the Laboratory Manual.

Note that an experiment will not be permitted to be run until an acceptable pre-laboratory plan is approved.

Pre-Laboratory Report Grading

A. Overall Objectives (20%)

Summarize the goals of the experiment, and your proposed approach to those goals.

B. Details of Experimental Work (60%)

1. Outline the experiment and identify important process variables and measurements. Relate them briefly to important theoretical concepts.
2. Speculate on the more difficult aspects of the experiment.
3. Quantify the range of the more important process variables that you intend to cover in the experiment.
4. Outline procedures for data reduction and calculations needed to transform experimental information into a useful form to answer the question(s) posed.
5. Outline how you intend to assess the quality of the experimental information.
6. Discuss how you will assess quantitatively the impact of errors in experimental (and literature?) data on your conclusions and recommendations.
7. Summarize the safety considerations and outline emergency procedures.

C. Appearance and Exposition (20%)

Report should have neat appearance and be free of grammatical errors.

Appendix II: Written Preliminary Report (50 points)

In addition to addressing the three items in your pre-laboratory report, the Preliminary Report should contain a draft of the Introduction, Theory and Experimental sections to be included in your final report. The instructor will check this report for both technical accuracy as well as writing style. For specific details regarding these portions of a report, refer to the section explaining the information needed.

Introduction: You should be able to write this section based upon your preliminary research into the experiment being performed.

Theory: If you have researched the experiment fully, you should be able to write a draft of this section before performing the experiment.

Experimental: If you familiarize yourself with the equipment, you should be able to write a draft of this section before performing the experiment.

For specific details regarding these sections, refer to the Laboratory Manual.

Preliminary Report Grading

The instructor will review the Preliminary Report as a draft of the Final Written Report. It is due on the day the experiment is performed. The report will be edited, commented on and returned by the instructor within one week, when the Appendix is due to the GTA. The grade will be based upon the technical content and the research to be performed on the experiment, the degree and thoroughness of the experimental plan, and the writing style and mechanics. While it is recognized that this draft is incomplete at the time of submission, the student is expected to do a thorough job in preparation.

If a Preliminary Report needs revision, it will be returned to you to be rewritten. The Preliminary Report will be used to prepare the Final Written Report, which will address all instructor comments. A thorough job on the Preliminary Report allows you to take full advantage of the instructor's comments in writing your Final Report, and has the potential to improve your grade for the Final Report. Try to keep these reports brief, concise and to the point!!

Appendix III: Meeting with Graduate Teaching Assistant (not graded)

Data and calculations (both and Excel) will be checked by the GTA and will be initialed by him/her. Initialed hand-calculations along with all data must be included in an appendix of the final report. The person making the hand-calculations should use the initialed original; other team members should use a photocopy containing the initials.

Students are encouraged to repeat the experiment on the Second Laboratory Day (3rd Tuesday). Students should not repeat experiments alone, but must arrange for supervision by the GTA or instructor.

Appendix IV. Written Final Reports (100 points)

Grades will be assigned based on an overall review of the report using the following criteria. Try to keep your reports as BRIEF as possible by using a concise writing style. See the handout on Written Reports for expectations and details.

A. Presentation: (30%)

1. Organization: the assembly of information and facts into a logical and understandable sequence of statements leading to definite objectives and conclusions.
2. Completeness and conciseness: inclusion of absolute essentials as a minimum. Omission of irrelevant, nonessential, and trivial material.
3. Judgment: selection of material to be discussed, order of presentation, direct statements of importance, length of presentation, etc.
4. Neatness.

B. Exposition: (30%)

1. Clarity
2. Good choice of words
3. Economy of words (including absence of typographical errors)
4. Correct spelling
5. Precision
6. Correct interpretation of the meaning of words
7. Correct grammar
8. Correct punctuation
9. Freedom from use of jargon or slang
10. Freedom from awkward expressions

C. Technical Competence: (40%)

1. Correctness and clarity of thought: explanation of the relevant physical and chemical phenomena and economic factors at play.
2. Quality of results: a reflection on the quality of experimental design of the experiment, treatment of data, and analysis of the design problem.
3. Discussion and conclusions: the recognition and interpretation of the significance of the information presented; judgment in stating technically sound conclusions; and judgment in the omission of trivia. Address specifically the uncertainty of the data and how it affects your calculated results.
4. Suggestions for Improvements: As you know, not all the experiments work perfectly. Be sure to include a section on how the experiment can be improved or operated in a way to yield better data/results. This section will be passed along to the next group doing the experiment at the time of your oral presentation.

Appendix V: Oral Presentation (50 points)

An overall grade will be given on orals using the following general criteria. Percentages are approximate.

A. Presentation: (40%)

1. Organization: presentation of the major segments of the project in an easily understandable and logically connected way.
2. Clarity: transmission of ideas and information in clear, uncomplicated sentences; absence of obscure and ambiguous statements.
3. Figures and Tables: properly sized; readable; conveying important information.
4. Poise: self-assurance; non-frivolous and natural demeanor; adequate voice volume.

B. Technical Content: (40%)

1. Completeness: coverage of the important technical matters relevant to the experiment.
2. Correctness: use of appropriate principles, factual information, and technically sound reasoning.

C. Response to Questions: (20%)

1. Knowledge of the project: knowledge of all aspects of the project and the ability to give a technically sound answer.
2. Defense of methods and procedures: ability to argue soundness and appropriateness of methods and procedures when challenged.

NOTE. You are encouraged to prepare simple visual aids (PowerPoint slides) that will help make your presentation more effective and "professional."

Appendix VI: Sample Cover Page for Reports

For Pre-laboratory Report:

CHE 450 - Pre-laboratory Report
Cycle #, Experiment #, Experiment Name
Written by Name
Lab Partners: Names
Submitted to Dr. D. J. Klinke
Date Submitted

For Preliminary Report:

CHE 450 - Preliminary Report
Cycle #, Experiment #, Experiment Name
Written by Name
Lab Partners: Names
Submitted to Dr. D. J. Klinke
Date Submitted

For Final Report:

CHE 450 - Final Report
Cycle #, Experiment #, Experiment Name
Written by Name
Lab Partners: Names
Submitted to Dr. D. J. Klinke
Date Submitted

For Revised Report:

CHE 450 - Final Report (Revision #)
Cycle #, Experiment #, Experiment Name
Written by Name
Lab Partners: Names
Submitted to Dr. D. J. Klinke
Date Submitted