



## Unit Operations Laboratory

### Catalog Description

Laboratory experiments demonstrate the principles of process measurement and instrumentation through the determination of thermodynamic properties, transport phenomena properties, heat transfer, and material physical properties. Treatment of data includes regression techniques, analysis of error, and statistical analysis. Prerequisites are IE 311; corequisite: CHME 306.

### Textbook

None. Course materials are available on Canvas.

### Course Objectives

- Understand and apply engineering experimentation techniques and safety procedures common to the chemical industry.
- Apply principles developed in chemical engineering courses to the analysis of chemical engineering processes and unit operations.
- Improve technical writing skills.
- Improve skills necessary for group work—interpersonal skills, coordination of the efforts of several persons, leader and subordinate roles, etc.
- Introduce students to practical skills needed to be able to apply the scientific and engineering concepts acquired in earlier coursework.

### Topics Covered

- Linear and radial heat conduction
- Scanning Electron Microscopy
- Vapor-liquid equilibrium
- Thermocouple fabrication/calibration
- Energy balance & efficiency
- Inflow control
- Laminar Flow
- Viscosity of Newtonian Fluids
- Thermogravimetric Analysis
- Dynamic Mechanical Analysis
- Differential Scanning Calorimetry

### Class/Laboratory Schedule

2 credit hour; meets for 2.5 hours per week based on Banner Course Schedule for each section.

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**Office:** 158 Jett Hall (notebook return)      **Office Hours:** by appointment

## Canvas Site

Please check the course Canvas site regularly for announcements and course material. Canvas may also be used to communicate with the course instructor and teaching assistant (TA).

## Common Syllabus Addendum

The NMSU Department of Chemical and Materials Engineering maintains online a syllabus addendum containing course requirements common to all courses with the CHME prefix. This document is accessible at the URL: <http://chme.nmsu.edu/academics/syllabi/chme-common-syllabus-addendum/>

The Addendum covers Attendance Policy, Student Accessibility Services, Misconduct, Cell Phone Use, ReGrades, Student Work Products, Communication, Video Surveillance, Computer Resources, Etiquette, and Firearms.

## Performance Evaluation

There are eleven (11) exercises. **One lab period is assigned to each exercise.** Introductions for each exercise are on Canvas. Reporting formats\* for the exercises consists of:

1. maintaining a research quality note book (each student),
2. writing team executive letters with appendices, (3)
3. creating team research posters, (3)
4. writing team full-length publication-style reports, and (2)
5. deliver a group oral presentation (1)

Note: There are eleven exercises, and you will maintain notebook entries for all ELEVEN exercises (three of which are graded), write THREE executive letters, create THREE research poster presentations, write TWO publication-style reports, and deliver one final ORAL PRESENTATION (*dress code: business formal*) based on one of the two publication-style reports.

\*Reports will follow the guidelines explained in the rubrics for each style of report.

All reports must be submitted electronically through Canvas, in **Microsoft Word (.doc or .docx) format**. MS Word allows for feedback of report content using the REVIEW Markup feature. PDFs do not offer the same feedback mechanism.

Expectations of report content are described below; specific details are provided in the grading rubrics. Read the rubrics before asking for additional guidance from the instructor or TA. Minimal layout formats for these reports are provided. The layout of your reports is left to you, as a group, to decide how best to convey your findings and your interpretation of these, ***based on accepted best-practices found in the literature.***

With the exception of the laboratory notebooks, each team submits a single report for each exercise. **Individual grades** are determined based on the weighted scores of the team report score: **25% on individual contribution and 75% on collective team effort.** See examples below.

**Points Per Exercise:** Each exercise is worth 100 points. A total of 1200 points is available to students over the 12 assignments in the course.

Each group rates the contribution effort of individual teammates, on each exercise report, for all members of the group. Ideally, in a group of three students, each teammate should contribute a 33.3% effort. The score given to a particular student is calculated as follows:

**Individual grade = 75% \* group report score + 25% \* group report score \* percent effort reported divided by expected contribution.**

- For example, if a group report score is 80 and the percent effort for a student on a team of three (3) is 20%, then the student's score is  $0.75*80+0.25*80*20/33.3=72$ .
- However, if the student's percent effort in the same example were 30%, the student's score is  $0.75*80+0.25*80*30/33.3=78$
- If the student's percent effort in the same example were 40%, the student's score is  $0.75*80+0.25*80*40/33.3=84$

**Grading scale:** 85-100 A-, A; 70-84 B-, B, or B+; 60-69 C-, C, or C+; 50-59 D-, D, D+, <50 F.

### How the Course will Operate

**Safety is of prime importance in this laboratory.** Eye protection is *mandatory* the moment you enter the lab. While the experimental apparatus is generally well-behaved, you will at times be working with gases or liquids under pressure as well as at elevated temperatures. **Make notes ahead of time in your lab notebook as to the necessary Personal Protective Equipment (PPE) appropriate to safely perform each exercise.** *Be aware of the other experiments going on around you.*

### General Safety Rules:

1. **PPE:** Safety glasses with side shields or safety goggles are **required at all times**. If you have your own prescription safety glasses, please bring them lab. Non-prescription safety glasses are available for use during the laboratory meeting times. Neckties, dangling clothing or jewelry, and other items of clothing of a similar nature are prohibited. In accordance with industry standard PPE, students are expected to **wear long pants and long sleeves**, however long sleeve laboratory smocks are available to use during laboratory meeting times. **Closed-toed shoes are required at all times**. If you arrive with any other kind of footwear (sandals, flip-flops, etc.), you will be required to find alternate footwear before entering the laboratory and performing any work.
2. Horseplay of any sort is prohibited in the laboratory.
3. Open flames are prohibited in the laboratory.
4. Safety precautions in the experimental plan must be followed.
5. Operating equipment will NEVER be left unattended. At least two members of the group must be present while the equipment is operating.
6. The laboratory floor must be kept dry, clean, and uncluttered at all times. Any spills should be cleaned up immediately.

7. Familiarity is expected with the safety aspects of all the chemicals used in the laboratory and with the coding system used to label containers and pipelines. **Make note of chemical hazards in your notebook!**
8. Any accident or hazardous situation must be reported to the teaching assistant or laboratory instructor immediately.

Note on the schedule that you will have time off during the semester (**3/15 and 3/29**). You are not expected to attend the lab during off weeks, but please pay attention to the schedule so that you are ready for the date on which you do have an exercise and when your next report is due.

Please keep close track of the course schedule. Make sure all team members agree on the preparation for each week's exercise.

- Notebooks will be *collected* at the conclusion of each laboratory meeting.
- Notebooks must be *picked up* from instructor's office the **following Monday** morning.

**Reports are due before the beginning of class**, the week following completion of the exercise (Ex. Report for exercise performed on Feb. 2 is due on or before start of class on Feb. 9.) Late reports will be docked 10% each day (or fraction of a day) that they are submitted after the deadline.

**Notebooks** must demonstrate each individual's understanding of the exercise principles and experimental set up. Notebook must include sections describing:

Pre-lab

- Summary/background of the exercise
- objective of the investigation
- detailed procedures

Investigation/analysis & post-lab

- results (data tables & figures)
- analysis and interpretations
- discussion (met investigation goals)

The "Pre-lab" portion of the notebook is likely 4 to 5 pages in length. However, it is up to each individual to determine how best to organize and present that information. Students should prepare tables ahead of each exercise to progress efficiently through the exercises.

#### Notebook - Pre-Lab Expectations

Prior to arriving to perform the laboratory exercise, each team member is responsible for preparing their individual notebook. The notebook\* should contain *at least* the following sections: summary and/or background of the experiment, objective of the investigation, detailed procedure (***make sure all team members agree on this section***), results demonstrating the data collected, analysis and interpretation of the data, and discussion of the investigation outcomes. The content should offer a complete description of the work that is performed, and include how the data is analyzed, graphed, and so forth, as well as sample calculations. Data tables should be prepared ahead of time so that as data is collected it is recorded into your notebook.

\*Research notebooks are legal documents that indicate the manner, time and place where experiments took place. In patent law, laboratory notebooks can easily be worth millions of dollars.

A properly recoded notebook provides you the information that is used in your final report. The more detailed your recordings and observations, the more easily you can report your findings without having to rely on your memory. “A picture is worth a thousand words.” Take advantage of camera technology to take photographs (and/or videos) that can be included as part of your reporting.

The following aspects are considered as the **Notebooks are examined and graded:**

1. Writing style is professional throughout, and only uses jargon as appropriate. Do NOT use casual or informal language or terms. Use the appropriate tense and “person” at all times. Write down *your* observations (always use ball point pen).
  - a. “We” is very polite, but at the end of the day, only you are responsible for the data contained within your notebook.
2. The exercise objective(s) is clearly and concisely stated.
3. Experimental design and methods are described in adequate detail including a test matrix or something similar if appropriate.
4. The level of English is at or above what is expected from writers at the college level. There are NO grammar or spelling errors. Use single line strike-through for corrections.
5. Figures, tables, references, and equations are properly displayed, formatted, labeled, and captioned as appropriate, following standard conventions found in literature.
6. Clearly explain how the data is analyzed with sample calculations presented as appropriate.
7. Safety issues, including electrical, mechanical, and chemical hazards, are identified and addressed.

### **Report Expectations**

The reports in CHME 323L build on the various reporting methods developed in earlier laboratory courses and concentrate on developing your communication skills to deliver the results obtained, data analysis, and consideration for sources of error.

An “**executive letter**” or “memo” is written as though it were a letter to your boss or your boss’s boss. He or she is likely constrained for time and is primarily interested in your outcomes and analysis. Therefore, there is no Procedure section, which should otherwise be included as an appendix. The report should reference the procedure (appendix) and note any deviations that might have been done once the work was actually performed and why. Otherwise, the executive letter consists of a brief introduction to the work, mentioning the goals and objectives, and then goes straight into analysis and interpretation. In other words, it consists of what would have been in the “Results,” “Discussion,” and “Conclusions” sections of the more broad, formal report.

The following will be considered as the Executive Letters are examined and graded:

1. Writing style is professional throughout: does not use unnecessary jargon, OR casual/informal language or terms, AND uses the appropriate tense and “person” at all times, and reads as though written by one person.
2. The level of English is at or above what is expected from writers at the college level. There are no grammar, spelling, or typographic errors.
3. The experimental objective is clearly and concisely stated. At the conclusion of the letter, discussion returns to the objective and *addresses whether or not it was met.*

4. Experimental methodology only addresses, explains, and justifies any changes or deviations from what was presented in the Procedure appendix.
5. Experimental results are clearly and concisely presented and defined appropriately as quantitative versus qualitative. References appendices that show how results are tabulated and/or calculated.
6. Figures, tables, references, and equations are referenced in the appendices, AND are properly displayed, formatted, labeled, and captioned, as appropriate following best-practices conventions found in literature.
7. Discussion includes comparison of results with expectations, AND references appendices with sample calculations and analysis of error, where appropriate.
8. Conclusions do NOT introduce results not already presented earlier in the report. No surprises! Conclusions DO address all areas of the experimental work, and DO address whether or not the objectives were met or how conclusions deviated from expectations.

See the Executive Letter Report Grading Rubric for additional details.

A **Poster** presentation is a way to visually deliver the value of your work in person to superiors, clients, and, in academia, to a broad audience. The value of a poster is, when done well, that it conveys a story in “pictures”. The poster presenter should convey the same ideas described above for the Executive Letter, in a compact form limited to 36” x 48”, AND in a legible font. A key goal of a poster is to minimize the written language to what is necessary. To meet that goal, the use of bullets over sentences is preferred. Always use high resolution images, to avoid the need for “squinting”. Use the template provided to present the expectations, processes, outcomes and conclusions of your exercise.

See the Poster Presentation Report Grading Rubric for additional details.

Sharing your findings with the broad scientific community validates your efforts in designing and performing scientific exercises. Just like the other forms of oral and written presentations, the **Full-length publication-style report** provides the opportunity to describe the “Why” behind your effort and the growth you have gained through the collection, analysis, and interpretation of the data. A formal report consists of various sections broadly accepted in scientific literature. It is left to the group members to decide which journal format is used as a template to report on their exercise(s).

See the Full-length publication-style Lab Report Grading Rubric for additional details

An **Oral Presentation** offers the best of the speakers’ full repertoire of knowledge with dynamic visual aids, and builds on your experience of public speaking. The content of an oral presentation addresses the same key elements outlined earlier for the Executive Letter. The benefit of a dynamic oral presentation over a poster session is the ability to include additional information that creates a clear understanding of the content you wish to deliver. The story you narrate is weaved using not just the power of words, but augmented by the power of imagery through tables, figures, images, etc. The 40-60 rule should be applied, which dictates that 40% of your presentation should be about bringing the audience into your space (background, motivation, outcomes of interest, instrumentation, etc.), while the balance of your presentation tells the story of your measurements, data analysis, interpretations, sources of error, etc. While oral presentations vary in length, for the purposes of this course, **oral presentations will be limited to 12-15 minutes with a brief Q&A to follow.**