CHEMICAL ENGINEERING 141 Syllabus

Thermodynamics, Spring 2018

Instructor: Prof. Markita Landry, 106 Gilman Hall, 664-7627, landry@berkeley.edu

Graduate Student Instructors: Linda Chio, lchio@berkeley.edu
Whitney Loo, wloo@berkeley.edu
Darwin Yang, darwiny@berkeley.edu

Lectures: 2060 VLSB, T&Th 3:30 – 5:00 pm

Discussions: (1) 70 Evans, Mon 10:00 – 11:00 am GSI- Linda Chio
(2) 105 Latimer, Tues 2:00 – 3:00 pm GSI- Linda Chio
(3) 587 Barrows, Wed 8:00 – 9:00 am GSI- Whitney Loo
(4) B56 Hildebrand, Wed 1:00 – 2:00 pm GSI- Whitney Loo
(5) 179 Stanley, Thurs 11:00 – 12:00 pm GSI- Darwin Yang
(6) 105 Latimer, Fri 2:00 – 3:00 pm GSI- Darwin Yang

Online discussion:
We will be using Piazza for class discussion. The system is highly catered to getting you help fast and efficiently from classmates, the GSI, and the instructor. Rather than emailing questions to the teaching staff, post your questions on Piazza:

Signup Link: piazza.com/berkeley/spring2018/cbe141

Office hours: Prof. Markita Landry: **Wed** 10-11 am in 106 Gilman + by appointment
GSIs:
M 11-12pm, in Library Seminar Room 100E (Linda)
T 10-11am in Library Seminar Room 100E (Darwin)
W 11-12pm in Library Seminar Room 100F (Whitney)
Th 2-3pm in Library Seminar Room 100E (Whitney)
Th 5-6pm in Library Seminar Room 100D (Darwin)
F 6pm-7pm Library Seminar Room 100E (Linda)

Required Textbook:

Introduction to Chemical Engineering Thermodynamics – UC Berkeley CHMENG141, any edition (2005 edition on file in library) by J.M. Smith, H.C. Van Ness, and M.M. Abbott.

Course Website:

The course website is titled CHM ENG 141 – LEC 001 on bCourses. Here, you will find homework assignments, lecture slides, reading assignments, and other files and supplementary reading material to help you with the course.
Reading assignments are posted for every lecture on bCourses – see file marked *Reading Assignments*.
Lecture notes will be posted after every lecture on bCourses – see *Lecture Slides* folder.

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Homework assignments are posted one week before their due date on bCourses – see *Homework* folders. Homework assignments are due at 11:59 pm on Fridays, to be submitted online via bCourses.

Reference Texts

Introduction to Chemical Engineering Computing (2012) by Bruce Finlayson
The Properties of Gases and Liquids (2000) by B.E.Poling, J.M. Prausnitz, J.P. O'Connell
Chemical and Engineering Thermodynamics (1989) by S.I. Sandler.
Chemical and Process Thermodynamics (1992) by B.G. Kyle

Prerequisite:

CBE 140, Introduction to Chemical Engineering, with a grade of C- or higher, and Engineering 7 (concurrent enrollment permitted).

Sharing of course materials:

I will share my course notes with the course after each lecture. Posting of class materials online, which are meant for internal educational purposes only, is strictly prohibited by 1) copyright agreements we have with publishers from which we are drawing lecture materials, and 2) by a University of California policy statement executed by the vice provost here: https://campuspol.berkeley.edu/policies/coursenotes.pdf . If course materials are distributed outside of bCourses on sites such as coursehero, findmynotes, notehall, knewit, etc, lecture notes will no longer be shared with the class to avoid litigation issues.

Course Objectives:

By the end of this course, students will have learned:

- terminology of thermodynamics: system, properties, processes, reversibility, equilibrium, phases, components.
- relationship between heat and work by understanding the significance of the first law of thermodynamics.
- limitations imposed by the second law of thermodynamics on the conversion of heat to work.
- definitions and relationships among the thermodynamic properties of pure materials, such as internal energy, enthalpy, and entropy.
- how to obtain or to estimate the thermal and volumetric properties of real fluids.
- applications of energy balances in the analysis of batch, flow, and cyclical processes, including power cycles, refrigeration, and chemical reactors.
- thermodynamics of fluid mixtures and its application to separation processes.
- chemical-reaction thermodynamics and its application to homogenous and heterogeneous chemical reactions with multiple components.

Course Outcomes:

At the end of this course, students will:

- understand and analyze processes such as isothermal, isobaric, isentropic, cyclic;
- analyze steam power cycles; refrigeration cycles, and liquefaction;
- use equations of state, correlations and tables for nonideal fluids;

- apply equilibrium criteria to systems
- relate thermodynamic properties via partial derivatives, Maxwell's relations;
- be able to interpret phase diagrams of binary systems;
- be able to calculate vapor-liquid equilibria for non-electrolyte systems;
- solve for equilibrium compositions in homogeneous and heterogeneous chemical reactions.

Grading:

5% Homework
10% Quizzes
25% Midterm Exam 1
25% Midterm Exam 2
35% Final Exam

Quizzes will be given in the last 10-15 minutes of class on most Tuesdays to assess your comprehension of the material covered by homework, lectures, discussions, and the reading. Quizzes cannot be made up. Your homework will be due to your GSI on Friday of the week's assignment to be turned in via bCourses, and will be graded for completion. Missed or late homework cannot be made up.

Exams will be challenging and you will need to study extensively to perform well. All exams will be written and consist of problem sets, short answer, multiple choice, and/or true/false questions. Midterm exams will be held according to the schedule below. All cell phones must be stored away during exams. Use of a cell phone or texting during an exam will lead to an automatic F. One equation sheet will be permitted at the discretion of the instructor; this may be provided or prepared by the student depending on the instructions prior to the exam. **Midterms and final exams cannot be made up.** If you are absent for an exam, you will receive a grade of zero. Students that must miss exams should consider dropping the course. The midterms will be held as follows:

Midterm Exam 1 is scheduled for February 13th, and Midterm Exam 2 is scheduled for March 22nd. Both will be held during lecture time in 2060 VLSB.

The Final Exam is scheduled for May 11, from 7 pm – 10 pm.

There will be no exam regrades. The course instruction staff grade all exams twice, once by the GSIs and once again by the instructor to ensure consistency in grading for all students. If you notice an error in *totaling the points* (this is NOT a regrade), attach the note to your exam and discuss the issue with the GSI. This procedure must be followed within one week of the time the exams are initially returned to the class; after that period the exam will not be retotaled. In addition, the GSI will review the entire exam when retotaling the score. If there is a disagreement with the GSI you can visit with the Instructor during office hours.

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Extra credit may be offered at the discretion of the instructor, and will be decided on the last day of the course (April 27th).

Grading scale for the course:

The course will be graded on a straight-scale as follows:

Letter Grade	From	To
A	93	100
A-	90	92.99999
B+	87	89.99999
B	83	86.99999
B-	80	82.99999
C+	77	79.99999
C	73	76.99999
C-	70	72.99999
D+	67	69.99999
D	63	66.99999
D-	60	62.99999
F	0	59.99999

The reason for not curving the course is to incentivize student discussion and collaborative learning. We encourage you to work with your classmates together in learning the material, completing the homework assignments, sharing resources, peer-teaching, and clarifying topics in the course that are unclear.

Tips for success:

The quizzes will be easier than the exams, and the homework will be harder than the exams. The quizzes are meant to gauge your surface-level understanding of the course material, whereas the homework will require you to extrapolate the topics learned in class to real-world thermodynamics problems. The lecture material will be presented in a fast-pace. Therefore, take advantage of the quizzes and homework sets as opportunities to benchmark your learning, and identify gaps in your understanding of the material in this class *well before* the midterms and final. Keep a list of items that are unclear as you proceed through the course, and discuss these items with your GSIs at discussion sections and office hours, and with your instructor at office hours.

Read the reading assignments *before* lecture, and *during* your completion of the homework sets. To study for your midterms and final, instead focus on setting up (not necessarily solving) practice problems.

Topics Covered

1. Concepts and definitions
2. First and second laws of thermodynamics
3. Fundamental equations of thermodynamics
4. Applications of the first and second laws to closed and open (steady and unsteady state) systems
5. Maxwell relations and other relations among properties
6. Volumetric properties and equations of state of pure fluids
7. Correlations of the thermal and volumetric properties of real fluids
8. Phase equilibrium in single-component systems
9. Power cycles; refrigeration cycles, and liquefaction of gases
10. Thermodynamics of fluid mixtures
11. Ideal and non-ideal mixtures
12. Chemical potential; fugacity and its calculation
13. Binary phase equilibria: vapor-liquid, liquid-liquid, vapor-liquid-liquid, and solid-liquid
14. Thermodynamics of chemical reactions
15. Third law of thermodynamics and its significance