Course Syllabus

CHEMICAL ENGINEERING 141 Syllabus

Thermodynamics, Spring 2015

Instructors: Prof. Danielle Tullman-Ercek, 116 Gilman Hall, 642-7160, dtercek@berkeley.edu

Graduate Student Instructors: Dogan Gidon, dgidon@berkeley.edu

Michelle Liu, michelle.liu@berkeley.edu

Neelay Phadke, nphadke@berkeley.edu

Lectures: 120 Latimer, MWF 1:00 – 2:00 pm

Discussions: 209 Dwinelle, Mon 9:00 – 10:00 am Michelle Liu

123 Wheeler, Tues 8:00 – 9:00 am Neelay Phadke

130 Wheeler, Tues 8:00 – 9:00 am Dogan Gidon

182 Dwinelle, Wed 9:00 – 10:00 am Neelay Phadke

122 Wheeler, Wed 8:00 – 9:00 am Michelle Liu

182 Dwinelle, Thurs 8:00 – 9:00 am Dogan Gidon

Office hours:	Prof. Tullman-Ercek	M 2-3:30, W 2-3 in 116 Gilman
	Dogan Gidon	W 5-6 in Hildebrand 100-D
	Michelle Liu	Tu 4-5pm in Hildebrand 100-D, Th 4:30-5:30 in Bixby North
	Neelay Phadke	W 6-7 in Hildebrand 100-D, Th 5:30-6:30 in Bixby North

Required Textbook:

Introduction to Chemical Engineering Thermodynamics – UC Berkeley CHMENG141 Edition (2005)by J.M. Smith, H.C. Van Ness, and M.M. Abbott.

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).

Course Objectives:

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

- the terminology of thermodynamics: system, properties, processes, reversibility, equilibrium, phases, components.
- the relationship between heat and work by understanding the significance of the first law of thermodynamics.
- the limitations imposed by the second law of thermodynamics on the conversion of heat to work.
- the 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.
- the 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 such as distillation and extraction.
- chemical-reaction thermodynamics and its application to homogenous and heterogeneous chemical reactions with multiple components.
- osmotic behavior in systems containing membranes.

Course Outcomes:

At the end of this course, students will be able to:

- 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:

10% Homework Sets

5% Quizzes

5% Computational Projects

22.5% Midterm Exam 1

22.5% Midterm Exam 2

35% Final Exam

Homeworks will be assigned on Fridays and due on the following Friday at the beginning of lecture. Late homeworks will not be accepted or graded. Homework problems will not always be graded or corrected in full; it is your responsibility to compare the details of your answers with the solutions. The lowest homework score will be dropped.

Quizzes will be given occasionally in your assigned discussion section to assess your comprehension of the material covered by homeworks, lectures, discussions, and the reading. Quizzes cannot be made up. The lowest quiz score will be dropped.

Computational projects will be assigned during the semester in addition to the homework assignments, and will require an understanding of material presented during lecture and discussion to perform well. Due dates will be given when the projects are assigned, and late projects will not be accepted nor graded.

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. **Exams cannot be made up** - if an exam must be missed due to an excused absence such as illness then the Final Exam score will be substituted for the missed exam. This can only be done once and students that must miss more than one exam should consider dropping the course. The midterms will be held as follows:

Midterm Exam 1 is scheduled for Monday, March 2, and Midterm Exam 2 is scheduled for Wednesday, April 1. Both will be held during lecture.

The Final Exam is scheduled for Tuesday, May 12, from 8:00 am to 11:00 am.

There will be no exam regrades. 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.

Extra credit may be offered at the discretion of the instructor.

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

16. Osmotic systems

Reading list (to serve as an estimate only, as the pace and order will vary some as we move along):

Date	Section	Reading Assignment
21-Jan	Concepts, Definitions	Ch. 1, 2.5, 2.6, 2.8
23-Jan	Vol. Prop./EOS	Ch. 3.1-3.3, 2.7
26-Jan	Vol. Prop./EOS	Ch. 3.3-3.7
28-Jan	First Law	Ch. 2.1-2.4, 2.9

30-Jan	First Law	Ch. 2.10-2.11
2-Feb	First Law	Ch. 2.12
4-Feb	Heat effects	Ch. 4
6-Feb	Second Law	Ch. 5.1-5.6
9-Feb	Second Law	
11-Feb	Second Law	Ch. 5.7-5.9
13-Feb	Second Law	Ch. 5.10-5.11
16-Feb	Holiday	
18-Feb	Fluids/phases	Ch. 6.1-6.3
20-Feb	Fluids/phases	Ch. 6.4-6.7
23-Feb	Fluids/phases	
25-Feb	Review Session	
27-Feb	Flow	Ch. 7.1 - 7.3
2-Mar	Midterm 1	
4-Mar	No class	Instructor out
6-Mar	Flow	
9-Mar	Power from heat	Ch. 8
11-Mar	Refrig. Cycles	Ch. 9.1-9.2
13-Mar	Refrig. Cycles	Ch. 9.3-9.6
16-Mar	VLE	Ch. 10.1-10.3
18-Mar	VLE	Ch. 10.4-10.5
20-Mar	VLE	
23-Mar	Spring Break	
25-Mar	Spring Break	
27-Mar	Spring Break	
30-Mar	VLE/Chem Potential	Ch. 10.6
1-Apr	Midterm 2	
3-Apr	Partial Prop	Ch. 11.1-11.3
6-Apr	Fugacity	Ch. 11.4-11.5
8-Apr	Correlations, activity coefficient	Ch. 11.6-11.7
10-Apr	Excess properties	Ch. 11.8-11.9
13-Apr	Prop change of mixing	Ch. 12.1-12.3
15-Apr	Heat effect of mixing	Ch. 12.4
17-Apr	Rxn equil	Ch. 13.1-13.5
20-Apr	Rxn equil	Ch. 13.6-13.7

22-Apr	Rxn equil	Ch. 13.8-13.9
24-Apr	Rxn equil	
27-Apr	VLE applications	Ch. 14.1-14.4
29-Apr	VLE applications	Ch. 14.5
1-May	Molecular thermo	Ch. 16