CHE 110A: Chemical Engineering Thermodynamics

UCSB Department of Chemical Engineering

meeting times:	MW 12:00-12:50pm, Phelps Hall 1260
	F 12:00-1:50pm, Phelps Hall 1260
web page:	www.engr.ucsb.edu/~shell/che110a/
course announcements:	thermopia.blogspot.com (You should subscribe to updates via email.)

Course description

Credits: 3

Prerequisites: ChE 10, Mathematics 5A. Engineering majors only.

This course provides an overview of thermodynamics and its role in analyzing processes encountered in engineering practice, including cycles and flows. Basic thermodynamic laws and property models of pure substances are discussed. Several applications will be addressed, including engines, turbines, and power plant cycles.

Instructor

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Office hours: Th 11am-12pm, F 2-3pm (or drop by if my office door is open, or by appointment)

Teaching assistants

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Office hours: M 10:30-11:30am, Engr. II 3301
M 5:00-6:00pm, Engr. II 3301
Tu 12:20-2:20pm, Engr. II 1519

Course text

Introduction to Chemical Engineering Thermodynamics (7th edition)
J. M. Smith, H. C. Van Ness, and M. M. Abbott, McGraw-Hill (2004).

Course policies

1. The basis of grading will be 30% homework and other assignments / 25% midterm / 45% final.
2. *Recitations are considered normal lecture times for this course.*
3. Come to class on time, and please turn off all mobile telephones during the lecture.
4. Homework will be assigned and collected on Wednesdays in class. *Late homework will not be accepted unless there is an excellent reason that is given in advance (e.g., by email) of the due date*.
5. For questions on homework grading, please see the TA within one week of receiving the graded homework back. For exams, see the instructors within one week after exams are returned.
6. Your integrity as a student and future engineer is of upmost importance. Cheating will not be tolerated and may lead to university expulsion. Moreover, taking shortcuts to get answers to homework problems—by copying previous years' solutions or other students' work, or by searching the internet for answers—is a significant disservice to your learning and absolutely unacceptable.

Important dates

Monday, Jan 17: university holiday; no class
Friday, Feb 4: midterm exam (tentative)
Monday, Feb 21: university holiday; no class
Wednesday, Mar 16: final exam (12-3 pm)

Course outline (with approximate lecture schedule)

Lecture number	*Book chapter and topic*
1-2	Chapter 1: Introduction
3-8	Chapter 2: The First Law and Other Basic Concepts
9-15	Chapter 3: Volumetric properties of fluids
16-19	Chapter 4: Heat Effects
20-24	Chapter 5: The Second and Third Laws of Thermodynamics
25-30	Chapter 6: Thermodynamic Properties of Fluids
31-33	Chapter 7: Applications of Thermodynamics to Flow Processes
34-37	Chapter 8: Production of Power from Heat

How to succeed in this course

This class is among the most challenging you will take as a chemical engineer. It is important to work hard, develop good study habits, and not fall behind. Be disciplined and manage your time well. Here are some healthy habits that will help you succeed:

1. **Invest time.** Thermodynamics requires time and practice to become familiar with the concepts and mathematics involved. You will benefit from working through examples in the book. Your goal should not be to master individual problems, but to understand the material as a whole. Expect to devote a minimum of 10 hrs/week into reading the book, reviewing your notes, and assignments.
2. **Read the book.** In many courses you may have succeeded without reading the book. This approach generally fails for thermodynamics. *Do not attempt to do the homework without reading the book first and do not read only those sections that you think are relevant to doing the homework.* Reading carefully the material before doing problems will ultimately save you time.
3. **Take note of concepts and statements that you do not understand.** Write them down, jot things in the margins, constantly keep tabs sources of difficulty and confusion for you. Then, seek answers. Work through problems a second time. Consult a different book. Ask a peer. Use office hours.
4. **Be independent.** Work on problems by yourself first. Try to resolve difficulties by taking different approaches, working on related examples, or consulting other texts. *Then*, consult your peers for discussion of the best approach. Working in groups on homeworks from the outset tends to let things you don't understand slip by unnoticed.
5. **Think carefully and deeply.** It is important to know the concepts and assumptions on which the equations are based. Do not try to find or memorize formulas in the book and apply them blindly to problems. Pose yourself questions. After working through a problem, ask yourself, "What would happen in that problem if X were changed to Y?" Challenge yourself to think of possible variations beyond the examples in the lectures and homeworks.
6. **Attend all classes. Utilize the office hours.** Use all of the resources available to you to help you understand and master the course material.

How to work homework sets and exams

To obtain maximum credit and avoid mistakes, follow the strategies below. These are simple steps that you should internalize and apply to every assignment.

1. **Work neatly and professionally.** Write your name on the first page of your work. Use legible handwriting and clearly indicate the progression of ideas in your solution. It is better to use more pages and have a clearly presented solution than to cram all of your work onto a single page. *Homework that is not properly stapled or otherwise messily prepared will automatically incur a 25% deduction.*
2. **Add explanations and commentary where appropriate.** For lengthy problems, outline your strategy, draw diagrams, and comment to explain your approach. If you run out of time and your approach is correct, you will receive partial credit even if you did not get the correct final answer.
3. **Start with fundamental equations.** Be careful not to take special-case equations "off the shelf" when working problems, unless you are fully sure they apply. It is always better to start working each problem from the fundamental equations.
4. **Wherever possible, maintain your solutions in analytic form until the final answer.** Avoid plugging in numbers before reaching a final solution.
5. **Watch your units.** Always check to make sure that units in equations combine appropriately. Check that the order of magnitude of your answer is reasonable.
6. **On exams, always first devote 5-10 minutes to reading over the entire exam.** Then, allocate your time to each problem accordingly. You should *always* write something down for each problem, even if you don't have time to work it in detail. At the very least, you can write a quick explanation of what approach you would have taken, which may earn you significant partial credit.

The Big Concepts: what you will learn in this course

Important thermodynamic quantities relevant to equilibrium and energy transfer:

Q	heat transfer	$H = U + PV$	enthalpy
W	work performed	$S^t = \frac{\delta Q_{\text{rev}}}{T}$	entropy
U	internal energy		

How to compute work performed in processes:

$$W = -\int P dV^t$$

How to compute energy transfers between a system and surroundings using the first law:

closed systems

$$dU^t + dE_K^t + dE_P^t = \delta Q + \delta W$$

open systems

$$\frac{d(mU)_{\text{cv}}}{dt} + \Delta\left[\left(H + \frac{1}{2}u^2 + zg\right)\dot{m}\right]_{\text{fs}} = \dot{Q} + \dot{W}_{\text{S}}$$

How to compute efficiencies and limits of processes using the second law:

closed systems

$$dS_{\text{universe}} \geq 0$$

open systems

$$\frac{d(mS)_{\text{cv}}}{dt} + \Delta[S\dot{m}]_{\text{fs}} - \sum_j \frac{\dot{Q}_j}{T_{\sigma,j}} = \dot{S}_{\text{G}} \geq 0$$

How to model pressure-density-temperature relationships for ideal and real single-component systems, for use in process calculations:

$$P^{ig} = \frac{RT}{V} \qquad P^{\text{CEOS}} = \frac{RT}{V-b} - \frac{a(T)}{(V+\epsilon b)(V+\sigma b)}$$

How to compute enthalpy and entropy changes for ideal and real single-component systems, for use in process calculations:

$$\Delta H(T_1, P_1 \to T_2, P_2) = \Delta H^{ig}(T_1 \to T_2) + \Delta H^R(T_1, P_1 \to T_2, P_2)$$

$$\Delta S(T_1, P_1 \to T_2, P_2) = \Delta S^{ig}(T_1, P_1 \to T_2, P_2) + \Delta S^R(T_1, P_1 \to T_2, P_2)$$

total change — ideal gas part (low density) — residual part (correction)

$$\Delta H^{ig}(T_1 \to T_2) = \int_{T_1}^{T_2} C_P^{ig}(T) dT$$

$$\Delta S^{ig}(T_1, P_1 \to T_2, P_1) = \int_{T_1}^{T_2} \frac{C_P^{ig}(T)}{T} dT - R \ln\left(\frac{P_2}{P_1}\right)$$