The Pennsylvania State University
Department of Chemical Engineering

CH E 220 – Summer 2018
Introduction to Chemical Engineering Thermodynamics

https://psu.instructure.com
[Last updated: May 20, 2018]

Course Information CH E 220 is a 3-credit course that covers the theory and application of thermodynamics to pure fluids. The course requires material from Math 230 (partial derivatives, functions of multiple variables). Math 231 is accepted as prerequisite. The course is offered entirely on the Web and consists of 44 videotaped lectures, regular homework, and three exams.

All course communication will be via Canvas (https://psu.instructure.com. Assignments will be uploaded to Canvas and all graded papers will be returned to you via Canvas as well. The Discussion board on Canvas will be the forum for all discussions regarding the course and will also serve as office hours. Do not email your questions to the instructor unless they are about private matters (grades, course performance etc.)

To finish the course comfortably within the allotted time you should plan to do one lecture per day, Monday through Friday.

Instructor Prof. Themis Matsoukas, 8H Thomas Building (matsoukas@engr.psu.edu).

Teaching Assistant Ivan Manzano, (JIM16@PSU.EDU)

Textbook *Fundamentals of Chemical Engineering Thermodynamics*, T. Matsoukas, Prentice Hall, First edition (required). A list of known typos will be posted on on the course web site.

Objectives This course is the first of two thermodynamics courses in chemical engineering. It covers the first and second law and its applications to pure fluids. It covers chapters 1-6 in the book (see schedule of topics below). In this course you will learn:

1. How to read the phase diagram of pure fluids
2. How to calculate thermodynamics properties using a variety of methods (tables, charts, equations of state, appropriate approximations) and how to decide which method to use.
3. How to perform energy calculations in closed and open processes.
4. How to evaluate the thermodynamic performance of a process.

Homework All homework assignments and their due dates are on Canvas. The homework will be submitted electronically as a PDF file. You may type your homework in a word processor and convert it to PDF for submission, or you may write it by hand and use one of the various apps available for converting into a PDF. Your graded homework will be available for you on Canvas, typically within a week.

Weekly homework will be due each Sunday based on the lectures of the previous week. The submission window will open on each Monday and will close the following Sunday at **11:59 PM** (eastern time). **No late homework will be accepted.** To avoid technical glitches or other misfortune, submit you homework within a safe margin ahead of the deadline.

Homework should be *neat* and well *organized*. Final results should be boxed and the units should be given. Solutions should be in the order in which the problems were assigned. Homework that it illegible or disorganized will receive a zero grade without further review. Please follow these guidelines:

1. Each homework set must be submitted as a single PDF file. PDF is the only acceptable format.
2. Submit solutions in the same order as the problems in the assignment.
3. All important calculations should be shown. Raw computer printouts (excel, mathematica, etc) are not acceptable.

4. If the problem asks for a computer graph, the graph must be made entirely on the computer, should be properly annotated (axes, labels, units, etc.) and must contain no hand-written material. Graphs and other such material should be incorporated into a single PDF file.

Exams There will be two 75-min long midterm exams and one comprehensive final 110 min long. Each midterm will cover material since the previous midterm; the final will be based on the entire course.

All exams are *open-book*. Only the textbook is allowed. Personal lecture notes, homework solutions or other material are *not* allowed in the exam.

Exam	Duration	Students at University Park†	All other students‡
#1	75 min, (Proctored)	June 4 (time & room TBA)	Exam window: June 2–4
#2	75 min, (Proctored)	June 25 (time & room TBA)	Exam window: June 23–25
#3	110 min, (Proctored)	July 16 (time & room TBA)	Exam window: July 14–16

†Students at UP will take the proctored at University Park.

‡ Students at all other locations and UP students who have a conflict with the UP exam must secure a proctor and take the exam within the above window. Proctoring information can be found on the course web site.

Grading The final grade will be based on a weighted average calculated as follows:

Homework:	15%
Three exams:	85% (each worth 28.3%)

A final score of 90 and above guarantees an A; 85 and above an A-; 80 and above a B+; 75 and above a B; 70 and above a B-; 65 and above a C+; 60 and above a C (but see note below); 50 and above a D; below 50 is F.

Academic Integrity Students are expected to understand the difference between collaboration (throwing ideas on the table, brainstorming, answering each other's questions), and copying someone else's work (cheating). Collaboration in *studying* the material is encouraged. Copies of the same solutions submitted by multiple students will not be accepted.

Exam and homework problems may *not* be shared with others, including web sites that purport to offer solutions. Unauthorized circulation of course material will be treated as a breach of academic integrity and a violation of copyright.

Cheating in exams is a serious offence and could risk a failing grade.

Please familiarize yourselves with the University Policies on Academic Integrity.

Students with disabilities Penn State welcomes students with disabilities into the University's educational programs. If you have a disability-related need for reasonable academic adjustments in this course you should visit Student Disability Resources (SDR) and submit the required documentation. If the documentation supports the need for academic adjustments, SDR will provide a letter identifying appropriate academic adjustments. Share this letter with your instructor as early in the course as possible to discuss the adjustments.

Topics The course will cover chapter 1-6 according to the schedule below. Reading numbers refer to sections in the book.

Date	Lecture	Reading	Topics
5/14/18	1	1.1,1.2	Scope and molecular basis of thermodynamics
5/15/18	2	1.3–1.5	Basic definitions and terms.
5/16/18	3	2.1	PVT graph; Antoine;
5/17/18	4	2.2	Lever rule; steam tables
5/18/18	5	2.2	Examples with steam tables; interpolation
5/21/18	6	2.3–2.4	Compressibility factor, ZP graph; Lee-Kesler method
5/22/18	7	2.5–2.7	Ideal gas law; virial equation; cubic equations
5/23/18	8	2.8	Calculations with cubic EoS
5/24/18	9	2.10–2.11	Condensed phases; review of chapter 2
5/25/18	10	3.1–3.2	Energy and work
5/28/18			*(Memorial Day)*
5/29/18	11	3.3–3.4	Formulation of first law for closed system
5/30/18	12	3.5–3.6	Enthalpy
5/31/18	13	3.5–3.7	Heat capacities; heat of vaporization, examples
6/1/18	14	3.5–3.7	Examples

Exam 1; Lectures 1–14; Exam window 6/2–6/4

Date	Lecture	Reading	Topics
6/4/18	15	3.8	Ideal-gas state (1)
6/5/18	16	3.8	Ideal-gas state (2)
6/6/18	17	3.9	Review examples
6/7/18	18	4.1–4.2	Formulation of second law; examples
6/8/18	19	4.3	Energy balances using entropy; ideal gas entropy;
6/11/18	20	4.3	Reversible adiabatic and reversible isothermal process
6/12/18	21	4.4,4,7,4,8	Entropy generation; lost work
6/13/18	22	4.5,4.6*,4.7	Examples with lost work; Carnot cycle
6/14/18	23	4.8*,4.9*,4.10*	Heat pumps; review of chapter 4
6/15/18	24	5.1,5.2,5.3	Exact differential, Maxwell relationships
6/18/18	25	5.4,5.5,5.6	Derivations of equations for dH and dS
6/19/18	26	5.6,5.7	Residual properties, derivations of equations for H^R, S^R
6/20/18	27	5.8,5.9,5.10	H^R, S^R using Lee Kesler, SRK
6/21/18	28	5.11,5.12	Reference states; review of chapter 5
6/22/18	29	6.1,6.2,6.3,6.4	Energy and entropy balances in flow processes

Exam 2; Lectures 15–29; Exam window 6/23–6/25

Date	Lecture	Reading	Topics
6/25/18	30	6.4-6.5	Energy and entropy balances in open systems; lost work
6/26/18	31	6.6 (pp 272-76)	Flow through pipes; Bernoulli equation
6/27/18	32	6.6 (pp 276-81)	Adiabatic mixing; heat exchangers
6/28/18	33	6.6 (pp 282-87)	Steam turbines; Mollier chart; examples
6/29/18	34	6.6 (pp 290-92)	Gas compressors; examples
7/2/18	35	6.6 (pp 287-89, 292-94)	Throttling valves and pumps
7/3/18	36	6.7	The Rankine power plant
7/4/18			*(Independence Day)*
7/5/18	37	6.7	Power plants on the TS graph; improving efficiency
7/6/18	38	6.7	Power plant with regeneration (Problem 6.29)
7/9/18	38	6.7	Power plant with regeneration (Problem 6.29) continued
7/10/18	39	6.8	Vapor compression refrigeration (1)
7/11/18	40	6.8	Vapor compression refrigeration (2)
7/12/18	41	6.9	Liquefaction (problem 6.39)
7/13/18	42	–	Review of chapter 6

Exam 3; Lectures 1–42; Exam window 7/14–7/16

*Optional reading.