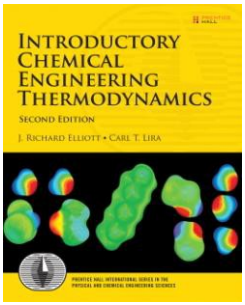
ChE 320: Chemical Engineering Thermodynamics

INSTRUCTOR: Dr. Brown ordel.brown@mail.wvu.edu
OFFICE: ESB-163 (floor above the ELC)

CLASS SCHEDULE AND LOCATION:

CRN	Time	Day	Location
80699	11:00-11:50 a.m.	TR	MRB-205
	11:00 a.m. – 12:50 p.m.	F	ASB – 1001 (Agricultural Sc. Bldg)



OFFICE HOURS: M & F – 3:00-4:00 p.m.
W– 1:00-2:00 p.m. and 3:00-4:00 p.m.

REQUIRED TEXT: Elliott, J. R. and C. T. Lira, *Introductory Chemical Engineering Thermodynamics*, 2nd Edition, Prentice Hall, 2012

COURSE OBJECTIVES

Students completing this course will be able to:

1. Apply the energy balance to practical engineering problems such as compressors, turbines, and valves.
2. Apply the entropy balance to the practical situations described in #1.
3. Apply the knowledge in #1 and #2 to the analysis of power and refrigeration cycles.
4. Solve problems in #1-#3 for ideal gases, for real gases if a thermodynamic diagram or table is available, and for ideal gases if a thermodynamic diagram or table is not available.
5. Understand the criterion for equilibrium and be able to solve problems involving phase equilibrium for a single component.
6. Understand the issues involved in thermodynamic calculations of mixtures and be able to solve problems in #1-#3 for mixtures.
7. Understand the criterion for equilibrium in mixtures and be able to solve equilibrium problems involving multiphase mixtures such as dew point, bubble point, and flash vaporization.
8. Gain an appreciation for the environmental and safety aspects of chemical engineering through solution of applicable thermodynamics problems.
9. Use ChemCAD to solve the above problems.
10. Apply the above knowledge to the solution of a design problem.
11. Increase their proficiency in oral and written communication.

GRADING

10%	Problem Sets
52.5%	Exams (3 @ 17.5% each)
20%	Final Exam
17.5%	Design Project

GRADING SCALE

Letter grades are assigned according to the following scale:

A	≥ 90%
B	≥ 80%
C	≥ 70%
D	≥ 60%
F	< 60%

COURSE POLICIES (exceptions at discretion of instructor):

1. There are no make-up exams.
2. All problem sets are due at the beginning of class or at the stated time.
3. No late assignment will be accepted.
4. Classes canceled due to inclement weather (or any other reason) will be rescheduled.
5. If the fire alarm goes off during an exam, the resolution of the situation is solely at the discretion of the instructor.
6. You may (and are encouraged to) work in groups on problem sets. However, what you submit must be your own work except for assignments that are designated as group assignments. Assignments that are obviously copied will receive no credit.
7. Problem sets and exams must be neat and easy to follow. Each problem should start on a new page. Your answer must be boxed, have units as appropriate, and have the correct number of significant figures. Problems should be worked in the units provided (SI or American). No credit will be given for answers without work. Credit will be deducted for missing or incorrect units, sloppy work that is hard to follow and for the incorrect number of significant figures. You should round off the final answer to the correct number of significant figures. If you round off intermediate calculations, thereby making your final answer inaccurate, significant credit will be deducted.
8. Use of cell phones in class is distracting and disruptive and therefore strictly prohibited.
9. If you do not participate in the design project as part of your assigned group, your grade for the entire course will automatically be an F, regardless of other grades earned in this class.
10. You must be in the audience for all of the junior design presentations. This means in the classroom, not in the hall or in the computer room. Failure to do so will result in reduction by one full letter on your design project grade.

DAYS OF SPECIAL CONCERN

WVU recognizes the diversity of its students and the needs of those who wish to be absent from class to participate in Days of Special Concern, which are listed in the Schedule of Courses. Students should notify their instructors by the end of the second week of classes or prior to the first Day of Special Concern, whichever is earlier, regarding Day of Special Concern observances that will affect their attendance. Further, students must abide by the attendance policy of their instructors as stated on their syllabi. Faculty will make reasonable accommodation for tests or field trips that a student misses as a result of observing a Day of Special Concern.

ACADEMIC INTEGRITY

In taking this course, it is assumed you aspire to a professional career in which you will lead people and manage resources. As a result, your personal integrity is an integral component of your preparation for such a career. Therefore, I will require that you adhere to the academic guidelines specified in the University Catalog and at the following website: http://www.arc.wvu.edu/admissions/integrity.html
If you have any questions, please do not hesitate to contact me.

WVU STATEMENT OF INCLUSIVITY

West Virginia University is committed to creating and fostering a positive learning and working environment based on open communication, mutual respect and inclusion.

STATEMENT ON DISABILITY ACCOMMODATION

If you are a person with a disability and anticipate needing any type of accommodation in order to participate in this class, please advise me and make appropriate arrangements with the Office of Disability Services (304-293-6700). For more information on West Virginia University's Diversity, Equity, and Inclusion initiatives, please see http://diversity.wvu.edu.

Date	Class #	Week #	Topics	Problem Set Due	Reading Assignment
			Unit I – First and Second Laws		
T 8/20	1	1	**Introduction, Definitions** Course overview and expectations Notation, units and nomenclature Types of systems and boundaries Heat and work interactions State functions versus path dependent functions Reversible and irreversible processes Concept of equilibrium and stability Phase and chemical transitions and reactions Types of thermodynamic problems Properties of pure substances and mixtures Application of thermodynamics		Ch 1
R 8/22	2	1	**Energy Balances** Heat and work interactions at system boundaries as path dependent parameters Extensive and intensive properties Energy as derived, state function property Closed and open system examples Steady state and transient processes		Ch 2
F 8/23	3	1	**Energy Balance Problems** 1st Law example problems for closed and open systems		
T 8/27	4	2	**Entropy Balance, Reversibility** Basic idea of quasi-static, reversible, and irreversible processes, calculating entropy changes		Ch 4
R 8/29	5	2	**Entropy Balance, Reversibility** Applications to turbines and compressors	1	
F 8/30	6	2	**Entropy Balance Problems**		

Date	Class #	Week #	Topics	Problem Set Due	Reading Assignment
T 9/3	7	3	**Power Cycles** Carnot Cycle, Rankine Cycle, Refrigeration, Internal Combustion Engines		Ch 5
R 9/5	8	3	**Power Cycles** Steam Engine, Carnot Cycle, The Rankine Cycle, Refrigeration, Internal Combustion Engines	2	Ch 5
F 9/6	9	3	**Power Cycle Problems**		
			Unit II – Generalized Analysis of Fluid Properties		
T 9/10	10	4	**Power Cycle Problems**		
R 9/12	11	4	**Classical Thermodynamics** Partial derivatives, properties for state functions, Maxwell/Euler reciprocity relationships Triple product	3	Ch 6
F 9/13	12	4	**Exam 1:** 2 hr, in class • Closed book section (20 pts) T/F and Multiple Choice • Open Book section (80 points) • Covers Chaps 1-5 and Problem Sets 1-3		
T 9/17	13	5	**Equations of State** Corresponding States, Virial, Cubic EOS, van der Waals, Peng-Robinson		Ch 7
R 9/19	14	5	**Equations of State**		Ch 7
F 9/20	15	5	**EOS Example Problems**	4	
T 9/24	16	6	**Property Changes for Real Gases** Departure Functions		Ch 8
R 9/26	17	6	**Departure Function Example Problems**		
F 9/27	18	6	**Single Component Phase Equilibria** Criteria for equilibrium, Clausius-Clapeyron Equation	5	Ch 9

Date	Class #	Week #	Topics	Problem Set Due	Reading Assignment
T 10/1	19	7	**Departure Functions and Clapeyron Equation**		
R 10/3	20	7	**Fugacity** Fugacity criteria for equilibrium Fugacity coefficient		Ch 9
F 10/4	21	7	**Fugacity** Calculation of fugacity	6	
T 10/8	22	8	**Fugacity Example Problems**		
			Unit III – Fluid Phase Equilibria in Mixtures		
R 10/10	23	8	**Multicomponent Systems** Phase diagrams, partial molar properties, equilibrium criteria, mixture fugacities, activity coefficients		Ch 10
F 10/11	24	8	**Multicomponent Systems** **Ideal Phase Equilibrium** Ideal solutions	7	
T 10/15		9	**Fall Break, no class**		
R 10/17	25	9	**Ideal Phase Equilibrium** Dew point, bubble point, flash calculations		
F 10/18	26	9	**Exam 2:** 2 hr, in class • open book • covers Chaps 6-9 and Problem Sets 4-7		
T 10/22	27	10	**Ideal Phase Equilibrium** Example Problems		
R 10/24	28	10	**Phase Equilibrium using Equations of State** Mixing rules for Virial and Cubic EOS, Fugacity and chemical potential from EOS		Ch 15
F 10/25	29	10	**Phase Equilibrium using Equations of State**		
T 10/29	30	11	**Phase Equilibrium Problems**		
R 10/31	30	11	**Phase Equilibrium Problems**	8	

Date	Class #	Week #	Topics	Problem Set Due	Reading Assignment
F 11/1	30	11	**Phase Equilibrium Problems** **Phase Equilibrium using Activity Models** Excess properties, activity coefficients, predictive methods, correlative methods, regular solutions		Ch 11
T 11/5	31	12	**Activity Model Problems**		Ch 12
R 11/7	32	12	**Exam 3 Review**	9	
F 11/8	33	12	**Exam 3:** 2 hr, in class • open book • covers Chapters 10-11, 15 and Prob Sets 7-9		
T 11/12	35	13	**Liquid-Liquid Phase Equilibrium** Liquid-liquid instability		Ch 14
R 11/14	36	13	**LLE Example Problems**		
F 11/15	37	13	**SLE** **Solubility of a Solid and Freezing Point Depression**		Ch 14
T 11/19	38		**Osmotic Pressure**		
R 11/21	39		Design Project		
F 11/22	40		-		
11/25-29			Thanksgiving Break		
T-F 12/3-6	41		Project Presentations	10	
M 12/16			Final Exam, 2 hrs 11:00 a.m – 1:00 p.m.		