Michigan Technological University

Course Syllabus

CM3230 – Thermodynamics for Chemical Engineers

College of Engineering

Fall 2011

Instructor Information

Instructor:	Dr. Tom Co, Associate Professor
Office Location:	202G ChemSci Building
Telephone:	Office – (906)487-2144
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Office Hours:	MWF 2 – 3pm or by appointment
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Course Identification

Course Number:	CM3230-0A
Course Name:	Thermodynamics for Chemical Engineers
Course Location:	102 ChemSci Building
Class Times:	MTWF 11:05am – 11:55am
Prerequisites:	CH 3510 and MA 3160 and (MA 3520(C) or MA 3521(C) or MA 3530(C) or MA 3560(C))

Course Description/Overview

First and second law applied to closed and open systems. Topics include energy conversion, power cycles, entropy and enthalpy calculations on engineering systems; property estimation for non-ideal vapors, liquids, and other substances, non-ideal multicomponent equilibria, chemical reaction equilibria.

Course Learning Objectives

1. Master the principles of thermodynamics of ideal and non-ideal mixtures of gases and liquids;
2. Master the principles of the fundamental equations governing thermodynamics: e.g., the Maxwell equations, equations of state;
3. Master the application of energy balances on process systems recognizing the constraints implied by the second law;
4. Familiarity with heat engines and common gas-cycle engines.
5. Familiarity with the analysis of Rankine and refrigeration cycles;
6. Mastery of the principles and application of fugacity and activity coefficients to non-ideal multiphase equilibrium;

7. Mastery of the application of thermodynamics principles to common chemical engineering process problems;
8. Familiarity with and understanding of thermodynamic packages in design software.

Course Resources

Course Website(s)

- Blackboard <http://www.courses.mtu.edu>
- Class Website <http://www.chem.mtu.edu/~tbco/cm3230/cm3230_2011.html>

Required Course Text

- Engineering and Chemical Thermodynamics, by Milo Koretsky, ©2004 John Wiley & Sons, Inc., ISBN 0-471-38586-7

Grading Scheme

Grading System

Letter Grade	*Percentage*	*Grade points/credit*	*Rating*
A	92% and above	4.00	Excellent
AB	85% – 91%	3.50	Very good
B	80% – 84%	3.00	Good
BC	75% – 79%	2.50	Above average
C	70% – 74%	2.00	Average
CD	60% – 69%	1.50	Below average
D	50% - 59%	1.00	Inferior
F	49% and below	0.00	Failure
I	Incomplete; given only when a student is unable to complete a segment of the course because of circumstances beyond the student's control. A grade of incomplete may be given only when approved in writing by the department chair or school dean.		
X	Conditional, with no grade points per credit; given only when the student is at fault in failing to complete a minor segment of a course, but in the judgment of the instructor does not need to repeat the course. It must be made up within the next semester in residence or the grade becomes a failure (F). A (X) grade is computed into the grade point average as a (F) grade.		

Grading Policy

Grades will be based on the following:

Quizzes (6 to 8 as time permits)	200
Exams (3)	300
Final Exam	100
Total Points	**600**

Course Policies

1. Exams and quizzes will be closed-books and closed-notes. However, one two-sided 8-1/2" x 11" sheet containing notes and equations will be allowed. If necessary, plots and tables will either be provided prior to the exam or quiz via email or during the exam.
2. Quizzes will mainly be multiple-choice type, and administered during class hours.
3. Exams will require calculations, analyses and conclusions. These will be administered off-class hours.
4. Exams and quizzes may be taken before the designated time. A letter of request has to submitted to the professor at least two days before for approval. (See next item for examples of approved excuses).
5. Make-up exams and quizzes will be allowed based on professor's approval. Examples of approved excuses are health issues, family emergencies, approved university-related functions, course conflicts. A letter of request has to be submitted to the professor for approval.
6. Extra bonus computer projects will be made available as the course progresses. These will have to be submitted individually in a memorandum format containing an executive summary with details supplied as appendices. The due dates of these projects will be strictly enforced.

Collaboration/Plagiarism Rules

1. Bonus projects can be discussed with other students. However, the project must be performed individually and the report must be written individually.
2. Cell phones, Blackberries, iPods, PDAs, or any other electronic devises are not to be used in the classroom and examination room. Please make sure to bring a calculator with you to class and during the exams and quizzes. Calculators on other devices are strictly prohibited. Information exchanges on these devices during class are also prohibited and violate the Academic Integrity Code of Michigan Tech.

University Policies

Academic regulations and procedures are governed by University policy. Academic dishonesty cases will be handled in accordance the University's policies.

If you have a disability that could affect your performance in this class or that requires an accommodation under the Americans with Disabilities Act, please see me as soon as possible so that we can make appropriate arrangements. The Affirmative Action Office has asked that you be made aware of the following:

Michigan Tech complies with all federal and state laws and regulations regarding discrimination, including the Americans with Disabilities Act of 1990. If you have a disability and need a reasonable accommodation for equal access to education or services at Michigan Tech, please call the Dean of Students Office, at 487-2212. For other concerns about discrimination, you may contact your advisor, department head or the Affirmative Action Office, at 487-3310

Academic Integrity:http://www.studentaffairs.mtu.edu/dean/judicial/policies/academic_integrity.html

Affirmative Action:
http://www.admin.mtu.edu/aao/

Disability Services:http://www.admin.mtu.edu/urel/studenthandbook/student_services.html#disability

Equal Opportunity Statement:
http://www.admin.mtu.edu/admin/boc/policy/ch3/ch3p7.htm

Course Schedule

Week 1

Chapter 1 – Introduction and Basic Concepts

- Systems, boundaries and surroundings
- Intensive and extensive properties
- PvT surface for pure substances
- Steam tables
- Ideal Gas Law

Chapter 2 – First Law of Thermodynamics

- Forms of energy : kinetic, potential and internal
- Modes of energy transfer: work and heat
- Reversible and irreversible processes
- First law for closed systems
- Enthalpy and first law for open systems
- Thermochemical data: heat capacity, latent heats and heats of reaction

Week 2

- Application to process equipment
- Thermodynamic Cycles : Carnot and Rankine Cycles

Quiz 1

Week 3

Chapter 3 – Entropy and Second Law of Thermodynamics

- Entropy
- Second law of thermodynamics
- Application to closed systems
- Application to open systems
- Entropy change for ideal gas systems
- Mechanical energy balances
- Power cycles and refrigeration cycles : efficiencies and COP

Week 4

Quiz 2

Problem Solving Sessions

Exam 1

Week 5

Chapter 4 – Equations of State (EOS)

- Principle of corresponding states
- Van der Waals EOS
- Cubic EOS : Redlich-Kwong, Peng-Robinson, Soave-Redlich-Kwong
- Virial EOS : Beattie-Bridgeman, Benedict-Webb-Rubin
- EOS for liquids and solids
- Generalized compressibility charts: Lee-Kesler

Week 6

Chapter 5 – Thermodynamic Properties and Relationships

- Fundamental properties
- Maxwell relations and cyclic rules
- The thermodynamic web
- Change in thermodynamic properties based on EOS

Week 7

- Departure functions
- Joule-Thomson expansion and liquefaction

Quiz 3

Week 8

Problem Solving Sessions

Exam 2

Week 9

Chapter 6 – Phase Equilibria 1

- Phase equilibrium criteria for pure substances
- Application: Clapeyron equations
- Partial molar properties
- Gibbs-Duhem equations
- Property changes of mixing

Quiz 4

Week 10

- Determination of partial molar properties
- Multicomponent phase equilibria

Chapter 7 – Phase Equilibria 2

- Fugacity : definition
- Fugacity in vapor phase
  - Fugacity coefficients
  - Mixing of ideal gases

Quiz 5

- Fugacity in liquid phase
  - Ideal Solutions (Lewis/Randall) and Henry's Law

Week 11

  - Acitivity coefficients
  - Excess Gibbs energy
  - Models for binary activity coefficients: Margules, Van Laar, Wilson, NTRL
- Fugacity in solid phase

Quiz 6

Week 12

Chapter 8 – Phase Equilibria 3

- Vapor-liquid equilibrium
  - Raoult's Law
  - Bubble-point and dew-point calculations
  - Non-ideal liquids and azeotropes
  - Applications for flash and distillation process
  - Activity coefficients from VLE data
  - Solubility of gases in liquids

Quiz 7

- Liquid-liquid equilibrium
- Vapor-liquid-liquid equilibrium
- Solid-liquid and solid-solid equilibrium
- Colligative properties

Week 13

Quiz 8

Problem solving sessions

Exam 3

Week 14

Chapter 9 – Chemical Reaction Equilibria

- Equilibrium for single reaction
- Equilibrium constants and their temperature dependence
- Heterogenous reaction
- Multiple reactions
- Gibbs phase rule
- Reaction equilibria via minimization of Gibbs energy

Summary and Review

Finals Week

Wednesday, December 14, 10:15am-12:15pm