Spring 2020

CHE 342-002: Chemical Engineering Thermodynamics II

Gennady Gor

1. **ChE 342 - Chemical Engineering Thermodynamics II**
2. **Credits and contact hours:** 3-0-3 (3 lecture hr/wk - 0 lab hr/wk - 3 course credits)
3. **Course Coordinator:** Dr. Gennady Gor
4. **Course Instructor:** Dr. Richard T. Cimino
5. **Textbook:** Fundamentals of Chemical Engineering Thermodynamics, Kevin D. Dahm, Donald P. Visco, Cengage Learning, (2014). ISBN: 1111580707
6. **Specific course information**
    a. **Description:** The principles and methods developed in Chemical Engineering Thermodynamics I are extended to multicomponent systems, and used to treat phase and chemical equilibrium as well as such applications as chemical reactors and refrigeration systems.
    b. **Prerequisites:** ChE 230, Math 211 (or Math 213), Chem 236
    c. **Required, Elective, or Selective Elective** - Required
7. **Specific goals for the course**
    a. A student should be able to:
        1. Calculate efficiencies for reversible and practical cycles, such as Carnot, Rankine & Brayton
        2. Calculate heat absorption and heat rejection rates for cycles
        3. Calculate work of turbines & pumps
        4. Analyze internal combustion engines & gas turbine engines
        5. Analyze refrigeration cycles & liquefaction processes
        6. Apply Raoult's law and Henry's law to solve thermodynamics problems
        7. Predict behavior from liquid/vapor phase diagrams including azeotropes
        8. Carry out bubble and dew point calculations for a given mixture
        9. Calculate partial properties of binary solutions, such as partial molar volumes
        10. Calculate activity coefficients using correlating equations such as Margules and van Laar
        11. Determine VLE using ideal gas and ideal solution models
        12. Analyze appropriate models for calculating phase equilibrium
        13. Interpret phase diagrams of binary systems
        14. Calculate vapor-liquid equilibria for non-electrolyte systems
        15. Predict equilibrium compositions of mixtures under phase equilibria
        16. Apply concepts of equilibria of multi-component, multi-phase systems to the evaluation and design of separation processes, such as distillation
        17. Estimate the fugacity coefficients for given mixtures
        18. Analyze ideal gas/solution models that reflect behavior of real mixtures based on concepts of excess free energy and chemical potential
    b. This course explicitly addresses the following ABET student outcomes:
        1. An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics
8. **Topics**
    1. Heat Engines
    2. Refrigeration Processes
    3. Vapor-Liquid Equilibrium
    4. Solution Thermodynamics

5. Solution Thermodynamics Applications
6. Chemical Reaction Equilibria

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Instructor: Dr. Richard T. Cimino, Senior Lecturer
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Class: Tuesday, Thursday, 4-5:20 PM; Room: Kupfrian 103
Office Hours: By arrangement only - please sign up online at https://drcimino.youcanbook.me

Course Description and Requirements

This course will cover heat engines, refrigeration, thermodynamics of mixtures, phase equilibrium and chemical-reaction equilibrium. Solid knowledge of chemical engineering thermodynamics including these topics is necessary to succeed in more advanced chemical engineering courses. In particular, the current course is a pre-requisite for ChE 349 Kinetics and Reactor Design and ChE 360 Separation Processes I.
Pre-Requisites: ChE 230, Math 211 (or Math 213), Chem 236

Course Objectives

Taking this course, a motivated student will learn to:

- Use the laws of thermodynamics to analyze basic power and refrigeration cycles.
- Apply both fundamental and practical knowledge of thermodynamics to the design of basic power and cooling cycles.
- Apply concepts of thermodynamics to solutions.
- Determine equilibrium compositions of chemical reaction products and two-phase liquid/vapor mixtures.

Learning Materials

Textbook Required: Fundamentals of Chemical Engineering Thermodynamics, Kevin D. Dahm, Donald P. Visco (2014). ISBN: 1111580707

Other Learning Material: The textbook is the main source for preparing for classes and reading the textbook before each class is necessary. Additional materials will be posted on Canvas.
Calculator: A high-end calculator (TI-83, TI-84 or TI-84SE) is required for solving exam problems.
Computer: A portable laptop computer running MS Office is strongly recommended for in-class activities and homework assignments.
Required Software: In this course you will learn to solve computational problems with MS Excel. You are required to have a working version installed on your computer.

Course Outline

	Date	**Topic** (preliminary, subject to minor changes)
1.	Jan. 21	Review of Energy and Entropy Balances
2.	Jan. 23	Carnot Cycle.
3.	Jan. 28	Rankine Cycle.
4.	Jan. 30	Rankine Cycle cont'd.
5.	Feb. 4	Refrigeration Cycle
6.	Feb 6	Refrigeration Examples
7.	Feb. 11	Refrigeration cont'd.
8.	Feb. 13	Review of Heat Engines and Refrigeration
9.	Feb. 18	Midterm 1.
10.	Feb. 20	Phase Equilibrium for Pure Components: Gibbs Free Energy.
11.	Feb. 25	Phase Equilibrium for Pure Components: Vapor Pressure.
12.	Feb. 27	Chemical Potential and Fugacity.
13.	Mar. 3	Poynting Method.
14.	Mar. 5	Introduction to Mixtures.
15.	Mar. 10	Properties of Mixing. Partial Molar Properties.
16.	Mar. 13	Partial Molar Properties of Binary Mixtures.
	Mar. 17-19	Spring Break - No Class
17.	Mar. 24	Raoult's law. Bubble and Dew Point Calculations.
18.	Mar. 26	Pxy and Txy Diagrams. Two-component PT Flash.
19.	Mar. 31	Review of Binary Mixtures.
20.	Apr. 2	Midterm 2.
21.	Apr. 7	Three-component Flash.
22.	Apr. 9	Phase Equilibrium for Mixtures. Mixture Fugacity.
23.	Apr. 14	Raoult's and Henry's Laws from Mixture Fugacities.
24.	Apr. 16	Gibbs Free Energy Models. One- and Two-parameter Margules Equation.
25.	Apr. 21	Data Reduction Procedure Using Margules Equation.
26.	Apr. 23	Regular Solution Theory - Van Laar Equations.
27.	Apr. 28	Basics of Chemical Reaction Equilibrium.
28.	Apr. 30	P and T Effects on Reaction Equilibrium. Van't Hoff Equation.
29.	May 5	Final Review.

Assessment and Grading

Exams: There will be two midterm exams (80 min long) and one final exam (2.5 hours long). All exams will be closed book, however a handwritten sheet (double-sided, letter size) with materials used to prepare for midterm exams will be allowed. For the final exam two sheets are allowed. Shared or copied preparation sheets, as well as use of any electronic materials will be considered as a violation of academic integrity.

Homework: Homework assignments will be posted weekly on Canvas. Homework assignments are due one week after they are assigned, and must be submitted electronically on Canvas. No late homework will be accepted. Students may complete and submit homework either individually or as a pair.

Quizzes: Regular quizzes will be given based on the course material, including both concepts and problems. The quizzes will be announced in advance. No make-up quizzes will be allowed. All quizzes will be closed book with no material allowed. The quizzes will take place at the beginning of class, so being on time is strongly encouraged.

Homework and quizzes are evaluated using the following scale:
✓+ The solution is 100% correct and presented in a thorough, logical fashion.

✓Solutions contain some errors but present a reasonable attempt at solving all problems.

Each homework or quiz that receives at least a ✓will count as full credit (100%) towards your homework and quiz total.

✓− Solutions contain multiple substantial conceptual errors, and/or give only a cursory attempt at solving some problems. Each homework or quiz that receives a ✓− will count as half credit (50%) towards your homework and quiz total.

Zero - No submission. A zero is equivalent to three ✓− grades, and is counted as a zero (0%) towards your homework and quiz total.

Final Course Grades: Your grade for the class will be determined from your homework & quiz total plus your exam grades, as follows:

For students who have more ✓+ scores than ✓− scores, the grade will be calculated by:

Homework and Quizzes	30%
Lowest Exam Score	10%
Other Two Exams	30% ea.
	100%

For students who have at least as many ✓− scores as ✓+ scores, the grade will be calculated by:

Homework and Quizzes	25%
Midterm Exam 1	25%
Midterm Exam 2	25%
Final Exam	25%
	100%

Letter grades corresponding to your numerical score will be assigned according to the following:

Percent	Grades
90.0% or higher	A
85.0-89.9%	B+
80.0-84.9%	B
75.0-79.9%	C+
70.0-74.9%	C
60.0-69.9%	D
below 60.0%	F

Important Dates

- Midterm exam #1: February 18, 2020
- Midterm exam #2: April 2, 2020
- Final exam: between May 8 and 14, 2020
- Withdraw Deadline: April 6, 2020

Policies

NJIT Honor Code: The NJIT Honor Code will be upheld and any violations will be brought to the immediate attention of the Dean of Students.
Special Needs: If you need accommodations due to a disability please contact Chantonette Lyles, Associate Director of Disability Support Services, Fenster Hall Room 260 to discuss your specific needs. A Letter of Accommodation Eligibility from the Disability Support Services office authorizing your accommodations will be required.
Lectures

- Attendance is strongly recommended. Missing class will have consequences for preparation for quizzes and exams.
- Class starts at 4:00 PM, and students must be in class by that time. Being late to class may have consequences for the grade, since several of the classes will start with quizzes.
- Electronic devices other than calculators (laptops, tablets, cell-phones etc.) are not permitted during the classes. No audio or video recording is allowed.
- Cellphones should be turned off during both lectures and exams and not allowed under any circumstances.
- Laptops will be permitted only if necessary for class activities.
- No distracting eating any time during the classes.

Course materials, office hours and correspondence

- The course Canvas page is the main platform for delivering information about the course. All relevant course materials and assignments will be posted on Canvas, so a student should check it regularly.
- The students have to upload a professional-looking head shot for their Canvas profile.
- The students are strongly encouraged to attend Office Hours. Long questions, which require derivations will be discussed only during the Office Hours and will not be answered by email. Questions regarding grades can be discussed only during the Office Hours.
- E-mail and Canvas correspondence is intended only for quick questions. Questions which require a detailed discussion should be discussed in person during the Office Hours.
- All correspondence should be conducted in a professional style, using formal English.
- To help assure quick response to your emails, please add "ChE342" in the subject of your emails.
- The instructor reserves the right not to respond to emails if the email does not have a greeting or a signature.

Exams, Quizzes, Homeworks and Grades

- A letter grade is based on the final score, calculated using an Excel spreadsheet in accordance with the Tables given in this syllabus. The assigned letter grade is final and cannot be negotiated.

- A student can dispute the exam scores within a week after the announcement of the score. Exam scores can be disputed during Office Hours, not during class time or via email.
- The graded exams must be returned within a week to be saved for the department course assessment initiative. If a student does not return the exam, the grade for this exam is zeroed.
- Students will get zero for not coming to quizzes, exams, or any other course activity. If students miss an exam due to extreme circumstances (such as a medical problem), they need to bring proof of the circumstance to the Dean of Student's office. Only in the case of official approval from the Dean of Student's office, may a make-up be given at the discretion of the instructor.
- A student must show as many details as possible when solving a problem during an exam or a quiz. Not showing the work will cause losing points even if the final answer is correct.
- Partial credit can be given for solving exam problems.
- No partial credit will be given if there is not enough details to follow.
- The final answer should be always evaluated with respect to its reasonability. No partial credit will be given if the final answer is wrong and unreasonable, and it is not stated.
- Each quiz or homework is worth an equal amount of the overall homework & quiz grade.
- If a student misses a quiz or homework submission due to a legitimate reason (absence approved by the Dean of Students), this item is excluded from the calculation, and the weights of the remaining items are scaled proportionally.
- Student handwriting must be legible in order to receive points.
- A student coming to dispute a grade has to bring completed work. No discussion of grades will be held without completed work.

Homework Format

- Homework involving calculations must be done on Engineering paper.
- All homework involving Excel calculations must be presented with original Excel worksheets.
- All homework submissions must be through Canvas. I will not accept emailed or hard-copy homework.
- Headers - The top of each sheet of a homework assignment must contain the following printed information from left to right:

Name(s)	Course & Section No.	Date Due	Page number/total pages

- Writing Mechanics - All homework should be carefully written using proper English.
- Calculations - All homework calculations should be consistent with the following.
  - Include complete calculations for every calculation presented to demonstrate how results were obtained.
  - Include all units for each term in each equation. The units must balance.
  - Use the appropriate number of significant figures (often two or three) for all results (but use at least two extra significant figures in calculations).
  - Clearly indicate the final solution by boxing it in with a rectangle.
- Problem Order - Problems should clearly labeled, and presented in the order assigned (one, two, three, etc.).
- Problem Essentials - Problem solutions should include the following items in order.
  - Homework problem number listed at the beginning of the problem.
  - Brief problem statement. Provide bullet points of key aspects of the problem if it is longer than a few sentences.

– The required information - the information or solution that we are looking for.
– A straight-edge or carefully drawn diagram(s) that clearly illustrates the problem. Optional, but often needed.
– The boxed solution of the problem including all required steps and calculations.