

# Chemical Engineering Thermodynamics

06310-1

Tuesdays and Thursdays 10:10 am – 12:05 pm, Rowan 340

**INSTRUCTOR:** Dr. Mariano J. Savelski, Associate Professor  
Department of Chemical Engineering  
328 Rowan Hall  
Office phone: 256-5317  
email: savelski@rowan.edu

**TEXT:** **Chemical, Biochemical, and Engineering Thermodynamics**  
S. I. Sandler, 4<sup>th</sup> Edition  
Wiley, 2006.

## OFFICE HOURS

Students are welcome (and encouraged) to come as needed. If I am in my office and not on the phone or with another student, I will make time for you. At minimum, we will arrange a time to meet that will accommodate both of our schedules.

## RESPONSIBILITIES

To succeed in this class, you should read the relevant material before coming to class, make a reasonable effort to do the assigned homework, hand in what you accomplish, and ask questions on points that you do not understand. I will lecture on points in the book and on supplemental topics, attempt to answer all serious questions, make myself available to anyone needing extra help, administer fair but demanding exams, and grade and return assignments in a reasonable time. All exams will be graded within a week.

<b>GRADING:</b>	4 exams (drop 1)	75%
	Workshops/Quizzes (drop 2)	10%
	Homework	10%
	Professional Behavior	5%

## **ABSOLUTE GRADING SCALE**

In this course we would like to create an atmosphere of positive cooperation between students. In addition, most of the exercises in this course will require you to work in teams and you will be expected to help each other learn the material. To encourage and support cooperative learning you will be graded on an absolute grading scale as given below. The net result is that it is in your interest to help your classmates become successful engineers. You will learn through teaching others.

Letter Grade ranges	Percentages between	
A	90	100
B	80	89
C	70	79
D	60	69

## **ATTENDANCE**

Regular attendance is expected. You are responsible for all material whether you are in class or not, and whether it is also in the textbook or not.

## **QUIZZES**

Periodically, closed-book quizzes will be given. If a student is absent on a day a quiz is given he/she will receive a zero on that quiz. There are no makeups for these quizzes.

## **WORKSHOPS**

These are in-class problem solving sessions. The class will be randomly divided into groups of 2 or 3 students. Problems related to the past week's material will be distributed to each group. Each group will work on their problem, develop their solution, and submit the problem solution to the instructor. Groups may help each other, but each group must write up its own solution and submit it. All submissions are due 15 minutes before the end of the class period. After the submission, the instructor will present the solution to one of the assigned problems.

## **TEAM HOMEWORK**

Each student will be assigned to a collaborative study group of 3-4 students. If every member of that group scores above 83 on an exam, each group member will receive four bonus points on the exam.

Homework will be periodically assigned. Each team/study group should only submit one homework assignment, and all listed team members will receive the same grade. Late work of any kind will not be graded. Collaboration on homework is acceptable and encouraged, but all tests must be done independently. All students will periodically be asked to submit evaluations of how well their peers performed as team members. These evaluations will be used at the end of the semester to adjust the final grading. Also, this periodic assessment will help identify problems in teams. The grade received on all team assignments is a "raw score". Raw scores will be adjusted according to each individual's contribution to the overall team effort. Each team member will be evaluated by every member of the team, including him/herself. The adjusted score (not the raw score) will be used in calculation of course grades. Thus, the student who

consistently demonstrates a higher level of effort may be rewarded. Likewise, the student who does not contribute substantially to team assignments may be penalized.

*Please be aware that the adjustment of grades for team assignments can substantially impact the overall course grade, either positively or negatively.*

## **WORKSHOPS AND HOMEWORK GRADING**

Solutions will be scored according to the following scale:

- 4 points – Correct solution method, equations and tables properly cited, units clearly shown throughout the entire problem, and correct numerical answer.
- 3 points – Correct solution method, equations and tables properly cited, units clearly shown throughout the entire problem, and incorrect numerical answer.
- 2 points – Partially correct solution method, equations and tables properly cited, units clearly shown throughout the entire problem.
- 1 point – Incorrect solution method.
- 1 point – Equations and/or tables are NOT all properly cited.
- 1 point - Units are missing in two or more instances.
- 0 points - Problem not done.

At the end of the semester homework and workshops points will be added and normalized based on the maximum attainable points.

## **EXAMS**

Four equally weighted exams will be given. *All exams are comprehensive with an emphasis on material covered since the previous exam.* All exams will be open-book and notes unless otherwise announced. Absence at examination time is excusable only in case of well-documented illness of the student or similar emergency. An unexcused absence from an exam will result in a zero grade on that exam.

If you feel that a test problem has been graded improperly (except for misadding points), you must resubmit the problem **within 72 hours** along with a **written** appeal and explanation. Upon receipt of this formal appeal, I will regrade the problem. This means that your score may go up or down.

## **PROFESSIONAL BEHAVIOR**

All students are expected to behave professionally, unprofessional behavior includes but is NOT limited to, being late to class, walk in and out of class while in session, cell phone ringing in class, working on assignments foreign to the class, sleeping in class, disrupting the class, chatting in class, and horseplay.

## **ACADEMIC MISCONDUCT**

Any student engaged in an act of academic misconduct, which includes but is NOT limited to, cheating, plagiarism, use of written or oral offensive language, tempering with other student's files, and tempering with other student's computer accounts, will receive a grade of **F** for this

course. Depending on the nature of the offense, the student's case may also be forwarded to the Dean of Students for University review.

If another student is knowingly involved in the offense, he or she will receive the same penalty.

**STUDENTS WITH DISABILITIES:** If you have a documented disability that may have an impact on your work in this class, please contact me. Students must provide documentation of their disability to the Academic Success Center in order to receive official University services and accommodations. The Academic Success Center can be reached at 856-256-4234. The Center is located on the 3rd floor of Savitz Hall.

## CLASS TOPICS

This is the general schedule for the class.

*Module 1: Thermodynamics of Processes-* This module will cover chapters 3-5 of your book, and will be approximately three (four) weeks long. Topics include energy balances, forms of work, reversibility, entropy, thermodynamics of process equipment, and cycles.

*Module 2: Analysis of Fluid Properties-* This module will cover chapters 6-7 of your book, and will be approximately four weeks long. Topics include thermodynamics of pure fluids, equations of state, reference states, departure functions, and phase equilibrium.

*Module 3: Fluid Phase Equilibria-* This module will cover chapters 8-10 of your book and will be approximately five weeks long. Topics include multi-component fluids, phase equilibria of mixtures, and activity models.

## IMPORTANT DATES

Date	Time	Room	Event
02-15	10:10 AM	ROW 340	Exam 1
03-29	10:10 AM	ROW 340	Exam 2
05-03	10:10 AM	ROW 340	Exam 3
TBA	TBA	TBA	Exam 4

## INSTRUCTIONAL OBJECTIVES

These are the instructional objectives for the first module and first exam. Students completing the first module of the course should be able to:

- Define the terms internal energy, potential energy, kinetic energy, work, heat, entropy, and reversibility in their own words.
- Describe in words the physical behavior of an ideal gas and identify practical situations in which the ideal gas law would be a reasonable approximation.
- Use the steam tables to quantify the inter-relationships between P, V, T, U, H and S for liquid water and steam.
- Apply energy and entropy balances to calculate work, heat, and changes in energy and entropy for open and closed systems.
- Describe the functions of process equipment such as pumps, turbines, throttling valves, compressors and heat exchangers, and apply energy and entropy balances to any of these systems.
- List and explain the steps in the following cycles: Carnot, Rankine, Refrigeration, Linde liquefaction, and Internal combustion.
- Quantify the overall efficiency or performance of any of the above cycles, as well as the individual steps within the cycle.

These are the instructional objectives for the second module:

- Write a total derivative expression that relates an intensive property of interest (H, U, S etc.) to known information.
- Transform a total derivative expression into a function of measurable properties using such tools as fundamental property relationships, Maxwell's equations, triple product rule, and expansion rule.
- Find  $\Delta H$ ,  $\Delta S$  etc. for a process, given an equation of state that describes the working fluid.
- Explain in words what a departure function measures.
- Use departure functions to find  $\Delta H$ ,  $\Delta S$  etc. for a process, given an equation of state describing the fluid and its ideal gas heat capacity.
- Explain in words what the fugacity measures.
- Estimate the boiling point of a pure compound at a specific pressure, or the vapor pressure at a specific temperature.
- Compute the fugacity of a vapor or liquid at a particular set of conditions, given an equation of state that describes the liquid or vapor.
- Relate the fugacities of two phases that are in equilibrium with each other.
- Use the Poynting correction factor to approximate liquid fugacity.

These are the instructional objectives for the third module:

- Calculate the fugacities of pure liquids and vapors, given an Equation of State.
- Recognize when the Poynting correction factor is applicable and use it to compute liquid fugacity.
- Distinguish between pure component fugacity and fugacity of a component within a mixture, and which is applicable in a given situation.
- Compute fugacity for a component within an ideal gas mixture or ideal solution, given a composition and sufficient information to compute the pure component fugacities.
- Describe in words the distinctions between ideal gases, ideal solutions and real solutions, and identify physical situations in which each is likely to apply.
- Recognize that component fugacities are identical in phases at equilibrium, and use this fact to assess equilibrium conditions and compositions.
- Identify situations in which the Raoult's Law and Modified Raoult's Law are applicable and use them to perform equilibrium calculations.
- Use mixing rules to find EOS a and b values for mixtures, given compositions and the pure-component values.
- Fit the one and two parameter Margules equations to VLE data.
- Use the Margules equation, or activity coefficient values given in some other form, to assess equilibrium conditions and compositions for real mixtures.
- Use the UNIQUAC method to compute molecular volume and surface area fractions for mixtures.