

Process Thermodynamics

ECH 3101 Section 11977

Class Periods: MWF | Period 6 (1:55 PM – 2:45 PM)

Location: WEIM 1084

Academic Term: Spring 2024

Instructor:

Kirk Ziegler

kziegler@che.ufl.edu

421 ChE

Office Hours: Tue/Thu 11 – 12:30

Supervised Teacher:

Cynthia Ezeh

cynthia.ezeh@ufl.edu

406 ChE

Office Hours: Mon/Fri 3:15 – 4:45 PM

Course Description

An introduction to the fundamental principles of classical thermodynamics including the first and second laws of thermodynamics. Applications to modeling and analysis of physical and chemical processes undergoing change. (Credits: 3)

Course Pre-Requisites / Co-Requisites

All students should have successfully passed Physical Chemistry (CHM 4411), Computer Model Formulation (COT 3502), and Material and Energy Balances (ECH 3023) prior to enrollment.

Course Objectives

Upon completion the student should be able to:

- Understand the fundamental basis of the first and second laws of thermodynamics.
- Estimate thermodynamic properties of pure gases and liquids using equations of state.
- Develop mass and energy balance equations necessary to solve reactive and non-reactive steady-state and transient systems by hand or by computer using process simulation software.
- Use tables, charts, or software to estimate physical property data needed to solve material and energy balances.
- Apply pertinent mathematical concepts required to develop general thermodynamic equations of change.
- Estimate thermodynamic properties of fluid mixtures.
- Work ethically with other students, both engaging in discussions and group reports and working independently.

Materials and Supply Fees

None

Relation to Program Outcomes (ABET):

The contribution of the course to meeting the professional components of the ABET-accredited degree is:

| Outcome | Coverage* |
|---|-----------|
| 1. An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics | High |
| 2. An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors | |
| 3. An ability to communicate effectively with a range of audiences | |

| | |
|---|------|
| 4. An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts | |
| 5. An ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives | |
| 6. An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions | |
| 7. An ability to acquire and apply new knowledge as needed, using appropriate learning strategies | High |

*Coverage is given as high, medium, or low. An empty box indicates that this outcome is not covered or assessed in the course.

Required Textbooks and Software

- Title: Chemical, Biochemical, and Engineering Thermodynamics
Author: Stanley I. Sandler
Publication date and edition: 2017 and 5th edition
ISBN number: 978-1-119-32128-6

NOTE: There are some additional sections, which are available at the E-learning site.

Recommended Materials

- Chemical and Process Thermodynamics, B. G. Kyle, Prentice Hall
- Introductory Chemical Engineering Thermodynamics, J.R. Elliott and C.T. Lira, Prentice Hall, Englewood Cliffs, New Jersey
- Introduction to Chemical Engineering Thermodynamics, J. M. Smith and H. C. Van Ness, McGraw-Hill

Tentative Course Schedule

| | Week | Lectures | Reading assignments |
|------------------|-------------|--|---------------------------|
| First Exam | 1 | Introduction Equilibrium states State variables | Sections 1.1-1.3; 1.6 |
| | 2 | Pressure and temperature Heat and work A generalized balance equation Conservation of mass | Sections 1.4-1.5; 2.1-2.2 |
| | 3 | Conservation of energy First Law of Thermodynamics Enthalpy Thermodynamic properties of matter | Sections 3.1-3.3 |
| | 4 | State variables and path-dependent variables Reference state Applications of the mass and energy balances Joule-Thomson expansion | Sections 3.2-3.4 |
| Tentative | 2/12 | EXAM (evening TBD) | |

| | Week | Lectures | Reading assignments |
|------------------|------------|--|---------------------|
| Second Exam | 5 | Entropy Second Law of Thermodynamics | Sections 4.1-4.2 |
| | 6 | Reversible and irreversible processes Relationships between S and other state variables Application of the entropy balance | |
| | 7 | Heat engines Carnot cycle Turbines | Sections 4.3-4.5 |
| | 8 | Power generation cycles Refrigeration cycles Thermodynamic efficiency | Sections 5.1-5.3 |
| Tentative | 3/6 | EXAM (evening TBD) | |

| | Week | Lectures | Reading assignments |
|------------|-------------|---|---------------------|
| Third Exam | 9 | Thermodynamic properties of real fluids Properties of partial derivatives Evaluation of thermodynamic partial derivatives | Sections 6.1-6.2 |
| | 10 | Maxwell Relations Fundamental equations of state | Sections 6.1-6.2 |
| | 11 | Volumetric Equations of State Obtaining the heat capacity of real fluids | Sections 6.3-6.5 |
| | 12 | Evaluating ΔU , ΔH , and ΔS for real fluids | Sections 6.3-6.5 |
| | 13 | Departure functions | Sections 6.3-6.5 |
| | 14 | Principles of corresponding states Generalized equations of state | Sections 6.6-6.9 |
| | 15 | Criteria for equilibrium Fugacity of pure components Calculating fugacity | Sections 7.1-7.5 |
| | 4/24 | EXAM (evening TBD) | |

Attendance Policy, Class Expectations, and Make-Up Policy

Attendance of all lectures is highly recommended. It is the student's responsibility to obtain any notes, assignments, etc. that they may have missed during their absence. Repeated absences may lead to a lower grade in the class. Excused absences must be consistent with university policies in the undergraduate catalog (<https://catalog.ufl.edu/UGRD/academic-regulations/attendance-policies/>) and require appropriate documentation.

As a courtesy to the other students and to the instructor, the students should turn off the ringers for all cell phones during class and they should not answer incoming calls. If a student is expecting an emergency call, please notify the instructor prior to class.

Students who do not attend an exam at the scheduled time will receive a score of zero for that exam. Exceptions will be made only in extraordinary circumstances, such as religious holidays or emergencies. It is required that, whenever possible, the student notifies the instructor about the situation prior to the exam, preferably at least two weeks in advance.

Evaluation of Grades

| Assignment | Percentage of Final Grade |
|------------|---------------------------|
| Homework | 0% |
| Quizzes | 25% |
| Exam 1 | 25% |
| Exam 2 | 25% |
| Exam 3 | 25% |
| | 100% |

Homework: Homework will be assigned throughout the semester but will not be graded. The homework solutions will be posted on the class website after the assignment due date but before any quizzes.

Quizzes: Quizzes will be assigned throughout the semester. The material on quizzes will cover problems closely related to the previous homework assignment. No make-up quizzes will be given. Excused absences will not count against the final grade. Each quiz is equally weighted. All quizzes will be approximately 15 – 20 min and be closed book and closed notes.

Exams: Each exam will be open book and open notes. No credit will be given for problems that have a solution but all the work leading to this solution is not shown.

Grading Policy

| Percent | Grade | Grade Points |
|-------------|-------|--------------|
| 93.4 - 100 | A | 4.00 |
| 90.0 - 93.3 | A- | 3.67 |
| 86.7 - 89.9 | B+ | 3.33 |
| 83.4 - 86.6 | B | 3.00 |
| 80.0 - 83.3 | B- | 2.67 |
| 76.7 - 79.9 | C+ | 2.33 |
| 73.4 - 76.6 | C | 2.00 |
| 70.0 - 73.3 | C- | 1.67 |
| 66.7 - 69.9 | D+ | 1.33 |
| 63.4 - 66.6 | D | 1.00 |
| 60.0 - 63.3 | D- | 0.67 |
| 0 - 59.9 | E | 0.00 |

More information on UF grading policy may be found at:

<https://catalog.ufl.edu/ugrad/current/regulations/info/grades.aspx>

Students Requiring Accommodations

Students with disabilities requesting accommodations should first register with the Disability Resource Center (352-392-8565, <https://www.dso.ufl.edu/drc>) by providing appropriate documentation. Once registered, students will receive an accommodation letter which must be presented to the instructor when requesting accommodation. Students with disabilities should follow this procedure as early as possible in the semester.

Course Evaluation

Students are expected to provide feedback on the quality of instruction in this course by completing online evaluations at <https://evaluations.ufl.edu/evals>. Evaluations are typically open during the last two or three weeks of the semester, but students will be given specific times when they are open. Summary results of these assessments are available to students at <https://evaluations.ufl.edu/results/>.

University Honesty Policy

UF students are bound by The Honor Pledge which states, "We, the members of the University of Florida community, pledge to hold ourselves and our peers to the highest standards of honor and integrity by abiding by the Honor Code. On all work submitted for credit by students at the University of Florida, the following pledge is either required or implied:

On my honor, I have neither given nor received unauthorized aid in doing this assignment.

The Honor Code (<https://www.dso.ufl.edu/sccr/process/student-conduct-honor-code/>) specifies a number of behaviors that are in violation of this code and the possible sanctions. Furthermore, you are obligated to report any condition that facilitates academic misconduct to appropriate personnel. If you have any questions or concerns, please consult with the instructor or TAs in this class.

A non-passing letter grade will be assigned to students who violate academic honesty standards, regardless of the violator's performance on exams, quizzes, and homework assignments. Official sanctions issued by the Office of Student Judicial Affairs will become permanently noted in the student's official transcript.

Commitment to a Safe and Inclusive Learning Environment

The Herbert Wertheim College of Engineering values broad diversity within our community and is committed to individual and group empowerment, inclusion, and the elimination of discrimination. It is expected that every person in this class will treat one another with dignity and respect regardless of gender, sexuality, disability, age, socioeconomic status, ethnicity, race, and culture.

If you feel like your performance in class is being impacted by discrimination or harassment of any kind, please contact your instructor or any of the following:

- Your academic advisor or Graduate Program Coordinator
- Jennifer Nappo, Director of Human Resources, 352-392-0904, jpennacc@ufl.edu
- Curtis Taylor, Associate Dean of Student Affairs, 352-392-2177, taylor@eng.ufl.edu
- Toshikazu Nishida, Associate Dean of Academic Affairs, 352-392-0943, nishida@eng.ufl.edu

Software Use

All faculty, staff, and students of the University are required and expected to obey the laws and legal agreements governing software use. Failure to do so can lead to monetary damages and/or criminal penalties for the individual violator. Because such violations are also against University policies and rules, disciplinary action will be taken as appropriate. We, the members of the University of Florida community, pledge to uphold ourselves and our peers to the highest standards of honesty and integrity.

Student Privacy

There are federal laws protecting your privacy with regards to grades earned in courses and on individual assignments. For more information, please see: <https://registrar.ufl.edu/ferpa.html>

Campus Resources:

U Matter, We Care: If you or a friend is in distress, please contact umatter@ufl.edu so that the U Matter, We Care Team can reach out to the student in distress. A nighttime and weekend crisis counselor is available by phone at 352-392-1575. In case of emergency, call 9-1-1.

Counseling and Wellness Center: <https://counseling.ufl.edu>, and 392-1575; and the University Police Department: 392-1111 or 9-1-1 for emergencies.

Sexual Assault Recovery Services (SARS)
Student Health Care Center, 392-1161.

University Police Department at 392-1111 (or 9-1-1 for emergencies), or <http://www.police.ufl.edu/>.

Academic Resources

E-learning technical support, 352-392-4357 (select option 2) or e-mail to Learning-support@ufl.edu.
<https://lss.at.ufl.edu/help.shtml>.

Career Resource Center, Reitz Union, 392-1601. Career assistance and counseling; <https://career.ufl.edu>.

Library Support, <http://cms.uflib.ufl.edu/ask>. Various ways to receive assistance with respect to using the libraries or finding resources.

Teaching Center, Broward Hall, 392-2010 or 392-6420. General study skills and tutoring.
<https://teachingcenter.ufl.edu/>.

Writing Studio, 302 Tigert Hall, 846-1138. Help brainstorming, formatting, and writing papers.
<https://writing.ufl.edu/writing-studio/>.

Student Complaints Campus: https://www.dso.ufl.edu/documents/UF_Complaints_policy.pdf.

On-Line Students Complaints: <http://www.distance.ufl.edu/student-complaint-process>.