AREN 2110 *Thermodynamics* *Spring 2011*

COURSE SYLLABUS

GENERAL INFORMATION

INSTRUCTOR

Professor JoAnn Silverstein, Dept. Civil, Environ. & Arch. Eng.
Email: joann.silverstein@colorado.edu
Office: ECOT 456, 303.492.7211
Office Hours: MW 10 AM – Noon, Tues, 6 - 8 PM i ECCE 1B52

TEACHING ASSISTANT

Katie Spahr
Email: Katie.Spahr@colorado.edu
Office hrs: Tues/Thurs, 3:30-5:30 PM ECCE 1B52

LECTURES

9:00 – 9:50 AM, MWF, Room ECCE 245

WEB PAGE

http://ceae.colorado.edu/~silverst/aren2110/

TEXTBOOK

Cengel, Yunus A., Robert H. Turner, and John Cimbala *Fundamentals of Thermal-Fluid Sciences*, 3rd Edition McGraw-Hill, 2007.

EMAIL LIST

If you are enrolled in the course you will be automatically subscribed to the course e-mail list using the address for your CU Plus account

---

OVERVIEW

The primary goal of AREN 2110 is for you to gain basic knowledge about fundamental concepts of energy and energy transformations with focus on engineering utilization of thermodynamic principles. Thermodynamics is used to analyze systems in virtually every

branch of civil and architectural engineering including applications in energy use and conservation in buildings and infrastructure systems, power generation, heating and cooling, fluid motion, behavior of chemical pollutants in soil, air and water, the hydrologic cycle, global climate change, and properties that determine the mechanical behavior of structural materials. In addition, energy has emerged as one of the dominant themes in society over the next decades. Decisions about the sources, generation and distribution of energy will drive much of society's actions and a fundamental understanding of the scientific and technical aspects of energy – thermodynamics – will be necessary for all citizens, especially engineers. My goal is to provide you with a variety of activities, in and outside of class, to enable you to learn fundamental theories and also engineering applications of thermodynamics.

OBJECTIVES

Students will

1. Learn to analyze energy transfer and transformation in systems using fundamental concepts of properties of materials, work, heat, internal energy, entropy, equilibrium, and relations derived from the First and Second Laws of Thermodynamics.
2. Learn the methods to measure thermodynamic properties and estimate values for properties using property tables and relations.
3. Learn to carry out thermodynamic analysis of engineering devices and systems such as piston-cylinders, compressors, turbines, pumps, heat exchangers, heat engine cycles, and refrigeration cycles using energy, materials, and entropy relations.
4. Learn applications of thermodynamic concepts in Civil, Environmental & Architectural Engineering such as sustainable energy technologies, energy conservation, and maintaining the global environment.

ACTIVITIES

- Information from lectures and the course text will be emphasized in weekly problem sets and assignments, and three exams (two midterms and a final).
- In-class problem-solving.
- Regular review sessions outside class.

Homework will generally be assigned each week on Friday and will usually be due one week after the assignment. Homework assignments will be handed in individually unless a group project is explicitly assigned. Study group discussions of homework are often helpful PROVIDED that each student turns in assignments that are their individual effort and that it is his or her responsibility to learn the material. Instructors and the teaching assistant will have regular office hours as well as review sessions. You are strongly encouraged to come to office hours with questions on material and assignments. Also, comments and suggestions on ways to improve your own (and others') understanding of

thermodynamics will be greatly appreciated at any time in the semester.

GRADING:

- **Assignments.....30%**
- **Exam 1..... 20%**
- **Exam 2..... 20%**
- **Final Exam..... 30%**

SCHEDULE: LECTURE TOPICS AND REQUIRED READING

DATE	TOPIC	TEXT/READ
M, 1/10	Introduction, Units, Dimensional Homogeneity	1-1 - 1-5
W-F, 1/12-1/14	Energy, Systems, Properties, Mass Balance Analysis	2-1 - 2-2
M, 1/17	No class, Martin Luther King Day	
W, 1/19	States, Equilibrium, Processes, Cycles,	2-3 - 2-10
F, 1/21	Pressure and Temperature	2-6 – 2-7
M, 1/24	Properties of pure substances,	4-1 - 4-3
W, 1/26	Property diagrams: P-v, T-v	4.4
F, 1/28	Property tables	4-5
M, 1/31	Phase mixtures, Equations of State	4-5
W, 2/2	Ideal gases and gas law	4-6
F, 2/4	Total energy, internal energy, and enthalpy.	5-3 - 5-5
M, 2/7	Specific heat	5-3 – 5.5
W, 2/9	Heat Transfer	3-3
F, 2/11	Work	5-1
M, 2/14	Calculation of Work	5-1
W, 2/16	Review	
F, 2/18	MIDTERM #1	Chap. 1 - 4
M - F, 2/21 -2/25	First Law of Thermodynamics, energy balances in closed systems	5-2
M, 2/28	Application to fixed volume and	5.2

	variable volume systems	
W, 3/2	Open systems: flow work, conservation of mass, steady-flow	6-1 – 6-3
F, 3/4	Open system (control volume) devices: turbines, compressors, pumps	6-4 and notes
M, 3/7	Nozzles, diffusers, throttling,	6.4
W, 3/9	Mixers, heat exchangers	6.4
F, 3/11	Second Law, Concepts,	7.1 – 7.5
M, 3/14	Reversible and irreversible Processes	7.6
W, 3/16	Review	
F, 3/18	MIDTERM #2	Chap 5 and 6
3/21-3/25	SPRING BREAK	
M, 3/28	Carnot Cycles: Heat Engines,	7-7 – 7-10
W, 3/30	Carnot Heat Pumps, Refrigerators	7-11
F, 4/1	Clausius Inequality and Entropy,	8-1
M, 4/4	Entropy analysis for closed and open systems	8-2
W, 4/6	Entropy in Thermodynamic Processes: ideal liquids, solids, and ideal Gases,	8-3 – 8-4, 8-8 – 8-9
F, 4/8	T-S Diagrams and TdS relations	8-5 – 8-7
M, 4/11	Power Cycles (I): Carnot Vapor Cycle, Rankine Cycle	.pdf chapter
W, 4/13	Rankine cycle enhancement: reheat	.pdf chapter
F, 4/15	Refrigerators and Heat Pumps	.pdf chapter
M-W, 4/18 – 4/20	Gas Mixtures and Psychrometrics	handouts
F, 4/22	Relative Humidity and Comfort	handouts
M, 4/25	Civil and architectural engineering applications (presentation)	Notes
W, 4/27	Civil and architectural engineering applications (presentation)	Notes
F, 4/29	Review	
Tues., 5/3	FINAL EXAM: 1:30 – 4:00 PM	Comprehensive, but emphasize material after spring break

Additional Information

HOMEWORK AND TESTS

You are strongly advised to read assigned portions of the text and do the homework. **DO NOT HESITATE TO COME TO THE PROFESSOR'S AND/OR THE TA'S OFFICE HOURS.** IF YOU CAN'T MAKE IT DURING THOSE TIMES, MAKE AN APPOINTMENT FOR A CONVENIENT TIME.

Homework will typically be assigned once a week (on /Fridays) and due one week later. Homework is due by 6 PM. LATE HOMEWORK WILL NOT BE ACCEPTED unless excused by the Professor. Homework solutions will be posted on the class web page.

Homework assignments may include problems from assigned reading material not yet covered in class.

All exams will be open book and notes. Review problems and solutions will be posted on the course web page. Be sure to organize your notes and mark reference sections of the text IN ADVANCE or the test for easy referral.

The grading for the homework and exams will value a good problem solving method. ALWAYS SHOW THE METHOD OR LOGIC YOU USED TO SOLVE THE PROBLEM. Solutions with an incorrect approach and the right answer placed at the end will receive a zero.

HOMEWORK FORMAT

All homework should be done on green "E-2" paper; use only the unlined side. Include problem set #, name, and date at top of first page

Each problem solution should have the following information:

- Problem statement, including:
- Sketch, process diagrams (if appropriate)
- "Given" information
- What is to be found
- Approach (appropriate equations, property tables used, etc.)
- Assumptions
- Solution steps
- Final Answer - boxed, highlighted or otherwise clearly indicate

Write clearly in #2 pencil in letters large enough to be read easily
Number problems and pages
Staple pages together

TURN IN HOMEWORK BY 6 PM ON THE DUE DATE. NO LATE HOMEWORK

WILL BE ACCEPTED WITHOUT A MEDICAL OR SIMILARLY COMPELLING REASON.

Partial credit is always assigned to problems, so be sure and make your solution approach and steps clear. You will get most of the credit for a problem that has the right method and clear solution steps. You will get NO CREDIT for showing the correct answer with no work before it.

HONOR CODE

Student conduct in AREN 2110 is expected to conform to the CU Honor Code, http://www.colorado.edu/academics/honorcode/, which was approved by the faculty of the College of Engineering and Applied Science in December 2001. All students of the University of Colorado at Boulder are responsible for knowing and adhering to the academic integrity policy of this institution.
Violations of this policy may include: cheating, plagiarism, aid of academic dishonesty, fabrication, lying, bribery, and threatening behavior. All incidents of academic misconduct shall be reported to the Honor Code Council (honor@colorado.edu; 303-725-2273). Students who are found to be in violation of the academic integrity policy will be subject to both academic sanctions from the instructors and non-academic sanctions (including but not limited to university probation, suspension, or expulsion). Other information on the Honor Code can be found at
http://www.colorado.edu/policies/honor.html

The following pledge will be explicitly included on tests for you to sign, and is also implied for any work you turn in for AREN 2110.

"On my honor, as a University of Colorado at Boulder student, I have neither given nor received unauthorized assistance on this work."

ADDITIONAL INFORMATION

If you qualify for accommodations because of a disability, please submit to Professor Silverstein a letter from Disability Services in a timely manner so that your needs may be addressed. Disability Services determines accommodations based on documented disabilities. Contact: 303-492-8671, Willard 322, and
http://www.Colorado.EDU/disabilityservices

Please contact Professor Silverstein in advance if possible, or on the day of, if you cannot turn in homework, assignment, or take a test due to illness, family emergency or other unresolvable conflict.

Campus policy regarding religious observances requires that faculty make every effort to reasonably and fairly deal with all students who, because of religious obligations, have conflicts with scheduled exams, assignments or required attendance. Please notify Professor Silverstein in advance if your observance of a religious holiday or obligation

conflicts with class attendance or an assignment and we will accommodate you so that you do not lose credit or get behind in class. See full details at http://www.colorado.edu/policies/fac_relig.html

Students and faculty each have responsibility for maintaining an appropriate learning environment. Students who fail to adhere to such behavioral standards may be subject to discipline. Faculty have the professional responsibility to treat all students with understanding, dignity and respect, to guide classroom discussion and to set reasonable limits on the manner in which they and their students express opinions. Professional courtesy and sensitivity are especially important with respect to individuals and topics dealing with differences of race, culture, religion, politics, sexual orientation, gender variance, and nationalities. Class rosters are provided to the instructor with the student's legal name. I will gladly honor your request to address you by an alternate name or gender pronoun. Please advise me of this preference early in the semester so that I may make appropriate changes to my records. See polices at and at http://www.colorado.edu/studentaffairs/judicialaffairs/code.html#student_code

The University of Colorado at Boulder policy on Discrimination and Harassment http://www.colorado.edu/policies/discrimination.html, the University of Colorado policy on Sexual Harassment and the University of Colorado policy on Amorous Relationships applies to all students, staff and faculty. Any student, staff or faculty member who believes s/he has been the subject of discrimination or harassment based upon race, color, national origin, sex, age, disability, religion, sexual orientation, or veteran status should contact the Office of Discrimination and Harassment (ODH) at 303-492-2127 or the Office of Judicial Affairs at 303-492-5550. Information about the ODH and the campus resources available to assist individuals regarding discrimination or harassment can be obtained at http://www.colorado.edu/odh

---

ABET Accreditation

The Accreditation Board for Engineering and Technology (ABET) is a professional accrediting organization that accredits specific academic programs to assure quality in education. Receiving a degree from an accredited program is an important first step towards attaining the Professional Engineer's license.

ABET "a-k" outcomes

As part of the accreditation process, ABET sets general criteria for students, faculty, facilities, educational objectives, and institutional support, as well as program criteria for specific engineering disciplines. One major criterion established by ABET is a set of desired program outcomes, the so-called "a-k" outcomes. These are listed in their entirety below. Specific objectives for individual courses in the CEAE Department are mapped to these ABET outcomes, and course instructors assess the relative importance of each outcome for their courses. The designation in parentheses after each outcome shows the importance of that outcome for the AREN 2110 course: S for small, M for moderate, L for large, N/A for not applicable.

ABET-accredited engineering programs must demonstrate that their graduates have:

(a) an ability to apply knowledge of mathematics, science, and engineering (L)

- Quantify thermodynamic properties of materials and systems
- Apply conservation of energy to thermodynamic systems
- Solve applications of the First and Second Laws of Thermodynamics

(b) an ability to design and conduct experiments, as well as to analyze and interpret data (N/A)

(c) an ability to design a system, component, or process to meet desired needs (S)

- Size components and predict energy yields for devices and cycles employing energy transfers

(d) an ability to function on multi-disciplinary teams (N/A)

(e) an ability to identify, formulate, and solve engineering problems (L)

- Application of thermodynamic laws to engineering problems in heat transfer, power generation, and material transformations due to energy transfer

(f) an understanding of professional and ethical responsibility (S)

(g) an ability to communicate effectively (M)

- Written assignments

(h) the broad education necessary to understand the impact of engineering solutions in a global and societal context (S)

- Understanding thermodynamic constraints on natural and engineered systems
- Exploration of consequences of novel energy technologies

(i) a recognition of the need for, and an ability to engage in life-long learning (N/A)

(j) a knowledge of contemporary issues (S)

- Exposure to current concerns related to thermodynamics: energy conservation, global climate change, sustainability of energy production

(k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice. (N/A)
