Advanced Thermodynamics (24-721)

Fall 2010

Advanced Thermodynamics is the Mechanical Engineering Department's graduate level introduction to statistical thermodynamics. Some classical thermodynamics will also be reviewed. Undergraduate thermodynamics (CMU *24-221,* or its equivalent) is the only prerequisite. In this class, we will reveal how probabilities at the microscale lead to macroscopic phenomena. Entropy, its definition from statistical probabilities, and its essential role in defining thermal, mechanical, and diffusive equilibrium will be described. Energy levels of microscopic systems, dictated by quantum mechanics, will then be used to predict macroscopic properties like internal energy and specific heat, as well as transport properties like electronic and thermal conductivity. Examples will include the ideal gas, the free electron gas, black body radiation, and Einstein and Debye solids. We will conclude by revisiting classical thermodynamics, including thermodynamic cycles, Maxwell's relations, phase transformations, and dilute solution laws. Problem sets will range from standard textbook questions to more complex questions, requiring intelligent assumptions, that relate to contemporary challenges in engineering.

- Professor: Jonathan A. Malen
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- Phone number: 412.268.4667
- Office: 305 Scaife Hall

- Class Hours: MW 9:30-11:20AM
- Classroom: A20 Porter Hall
- Office Hours: Tu 11AM-12PM, 305 Scaife Hall (or by appt. made through email)
- Blackboard: Blackboard is an online tool that will be used to distribute homework assignments, handouts, and solutions. The URL is : http://blackboard.andrew.cmu.edu

Textbook:
An Introduction to Thermal Physics, Daniel V. Schroeder (Addison-Wesley, 1999)

Supplemental References:
- An Introduction to Statistical Thermodynamics, Terrell L. Hill (Dover Publications, 1960, 1987). Note: this book is very inexpensive, and is on reserve at the E&S Library.
- Physical Chemistry, A Molecular Approach, Donald A. McQuarrie and John D. Simon (University Science Books, 1997). Note: this book is on reserve at MI Library.

Grading:
A: 90-100, B: 79-89, R < 79 (Plus and minus grades will be given at the instructor's discretion. The minimum score to earn a certain letter grade may be lowered, but it will not be raised.)
- 6 Homework assignments: 15% (absolutely no late homeworks will be accepted, lowest homework score will be dropped for calculation of final grade)
- Midterm 1 (Wed, 9/29): 25%
- Midterm 2 (Mon, 11/14): 25%
- Cumulative Final Exam (TBA): 35%

Course Policies:
There are two 2-hour meetings per week. You are responsible for all material discussed in class, whether you attended or not. Use of electronic devices (laptop computers, cell phones, mp3

players, dvd players, etc.) is not permitted in lecture. No student may record or tape any classroom activity without the express written consent of the instructor. If a student believes that he/she is disabled and needs to record or tape classroom activities, the student should contact the Office of Disability Resources to request an appropriate accommodation. In the event that such an accommodation has been arranged, the material may not be further copied, distributed, published, or otherwise used for any other purpose without the express written consent of the instructor.

Homework is intended to provide the students with a deeper understanding of the material covered in lecture. Since it is intended as practice for the student's benefit, it is not heavily weighted in the course grade, but its focal points will be reflected in the exams. Homework is due in class and will be graded based on apparent effort. You will receive credit for a problem, if, judging by what you have handed in, you made a good faith effort to do all or most of the problem. If a problem has more than one part, you can get credit for each part of the problem. Homework can be completed in groups, but it is my experience that students who work separately and struggle with the problems alone before discussing with the group, perform better on exams. Each student must hand in their own written solutions. If you have special needs or concerns about these policies, please discuss them with me.

Policy on Cheating and Plagiarism:
Cheating and plagiarism is unethical behavior that is not tolerated in this course or at Carnegie Mellon University. Students with questions about the definition of cheating or plagiarism are referred to the Carnegie Mellon Student Policies Handbook. URL:
http://www.cmu.edu/policies/documents/Cheating.html

Tentative Week by Week Schedule (subject to change):

Week of	***Lecture Topic***	***Reading (Schroeder) & Notes***
8/23	Energy, heat, and work	Sections 1.1-1.6
8/30	Probability and multiplicity	Sections 2.1-2.2
9/6	Entropy, a probability thing	Sections 2.2-2.4, 2.6 No Class 9/6 for Labor Day
9/13	Statistical interpretation of temperature, heat, and work	Section 3.1-3.2
9/20	Mechanical equilibrium and pressure, Diffusive equilibrium and chemical potential.	Sections 3.4-3.6
9/27	Review for Exam 1, Introduction to the Boltzmann Factor	***Exam 1 Wed 9/29*** Section 6.1
10/4	Partition functions and quantum mechanical energy levels	Section 6.2, Appendix A
10/11	Equipartition theorem and ideal gases	Sections 6.3-6.7
10/18	Bosons and Fermions, Example 1: the free electron gas	Sections 7.1-7.3
10/25	Bosons and Fermions, Example 2: the black body spectrum	Sections 7.4
11/1	Example 3: the Debye theory of solids	Section 7.5
11/8	Transport and review for exam 2	Section 1.7
11/15	Exam 2 and Thermodynamic cycles	***Exam 2 tentatively Mon 11/14*** Chapter 4
11/22	Thanksgiving Holiday	No Class for Thanksgiving
11/29	Free energy & Phase Transformations	Sections 5.1-5.3
12/6	Dilute Solutions, Final Review	Sections 5.5-5.5
	Cumulative Final Exam	***Final Exam Date TBA***