Syllabus
Thermodynamics and Statistical Mechanics
(PHYS 4650, Section 001)
Spring Semester 2015

Instructor

Prof. Jens Oberheide, 102B Kinard Lab, Dept. of Physics and Astronomy, Clemson University, Tel. 864-656-5163, Email: joberhe@clemson.edu

Class Hours

Tuesday and Thursday, 11:00 – 12:15, 223 Kinard Lab. Students are expected to wait 15 minutes if the instructor is late for class.

Office Hours

MWF 1:30 – 2:30; Th 3:00 – 4:00; or simply come on an as needed basis. I have and open door policy! **Students are strongly encouraged to make use of the open door policy, to discuss homework assignments and for conceptual questions.**

Scope of Course

The course will provide an introduction to the main principles of thermodynamics and statistical mechanics including their relationship and applications. The level will be appropriate to prepare students for graduate studies in physics.

Prerequisite

PHYS 3210 (classical mechanics).

Required Text

Concepts in Thermal Physics (2nd Edition) by Stephen J. Blundell and Katherine M. Blundell; Oxford University Press, ISBN 978-0-19-956210-7, 493 pages; $55.

Recommended Text

An Introduction to Thermal Physics by Daniel V. Schroeder; Addison-Wesley, ISBN 9-780-201-38027-7, $69.

Learning Outcomes

1. Essentials of equilibrium thermodynamics:
    a. Be able to apply the 0th and 1st laws of thermodynamics and the concept of cyclic processes to derive the 2nd law and recognize (i) the resulting equilibrium condition for entropy and (ii) the importance of the fundamental relation in terms of system knowledge. This includes the concepts of reversible and irreversible processes and the 3rd law.

b. Recognize that intensive properties are derivatives of the fundamental relation with respect to the corresponding extensive quantities and apply the concept to derive the entropy of the ideal gas.

c. Be able to identify the appropriate thermodynamic potential for a given system/process and compute intensive and extensive variables from that. This includes the computation of specific heats, the derivation of equations of state and the proper use of the Maxwell relations for thermodynamic calculations.

d. Be able to identify the equilibrium conditions for 1st order phase transitions and apply the concept to find the pressure dependence of the transition temperature and to solve standard problems such as osmotic pressure, chemical reaction rates, latent heat, etc.

2. <u>Basic statistics and combinatorics:</u>

   a. Be able to compute the number of permutations for various subsets of distinguishable and indistinguishable particles.

   b. Be able to derive the binomial distribution, recognize its large number approximation as the normal distribution using the Sterling approximation, and appreciate the central limit theorem to an extent that allows him/her to apply the concept to a given problem. Be able to derive the Poisson distribution.

   c. Be able to compute the mean and standard deviation of a given variable if the probability distribution is known, for both the discrete and continuous cases.

3. <u>Foundations of statistical mechanics:</u>

   a. Recognize the concept of microstates and the resulting fundamentally important connection between thermodynamics (entropy) and statistical mechanics (microstates).

   b. Be able to compute the number of microstates for simple systems using combinatorics and derive thermodynamics properties for these systems.

   c. Be able to explain the reason for the Gibbs paradox and generally recognize its importance for distinguishable and indistinguishable particles when computing thermodynamic properties.

   d. Recognize phase-space as the appropriate framework for ensemble theory and be able to compute the number of microstates and the density of states for standard microcanonical ensembles using phase-space considerations. Examples include 1D, 2D, 3D classical ideal and ultrarelativistic gases, classical and quantum mechanical rotator, and the harmonic oscillator.

   e. Recognize the connection between microcanonical and canonical ensemble theory, be able to identify free energy as the appropriate thermodynamic potential, and be able to compute the partition function for standard systems of distinguishable and indistinguishable particles (such as the ideal gas, the harmonic oscillator, paramagnet, etc.) and derive thermodynamic properties from that.

4. <u>Ideal Fermi and Bose systems:</u>
    a. The student should recognize the concept leading to Bose-Einstein and Fermi-Dirac distributions and the difference between these systems.
    b. Be able to compute blackbody radiation from the ultra-relativistic Bose gas; and Fermi energy and occupation numbers for simple Fermi systems in the low temperature limit.

Disclaimer: "Students may vary in their competency levels on these abilities. They can expect to acquire these abilities only if they honor all course policies, attend class regularly, complete all assigned work in good faith and on time, and meet all other course expectations of them as a student."

Homework
Homework is very important to practice the theoretical concepts discussed in class. It will be assigned on a weekly basis. The lowest two homework grades will be dropped at the end of the semester before the final course grade is calculated. Homework is due on the date assigned. Late homework will not be accepted without a very good excuse. Each student will make an oral presentation of his/her written homework at least twice per semester in my office. The oral presentations (~30 min) count toward the final grade.

Exams
The will be one mid-term and one final exam.

Course Grades and Weights
- 50% Homework
- 10% Oral Homework Presentation
- 20% Mid-term exam
- 20% Final exam

A: 85-100; B: 70-85; C: 50-70; D: 40-50; F: 0-40

Attendance Policy
Attendance is required for the first class. Thereafter, it is not required but is *strongly recommended*. It is the responsibility of the student to be aware of what is announced in class, including changes to assignments. Please also see the general statement on attendance in the Undergraduate Announcements. The instructor reserves the right to make attendance mandatory for individual students on a case-by-case basis.

Class Web Page
The course web site can be accessed via Blackboard. Course announcements, assignments, instructional material etc. can be found there.

Academic Integrity Policy

The Clemson University statement on academic integrity applies, as posted in the Undergraduate Announcements. In addition, students may discuss homework problems with other students, but only in general terms. **Students may not look at another student's written solution before the due date, and the work the student turns in must be entirely his/her own.**

Disability Access Statement

Students with disabilities requesting accommodations should make an appointment with Dr. Arlene Stewart (656-6848), Director of Disability Services, to discuss specific needs within the first month of classes. Students should present a Faculty Accommodation Letter from Student Disability Services when they meet with instructors. Accommodations are not retroactive and new Faculty Accommodation Letters must be presented each semester.

Clemson University Title IX (Sexual Harassment) Statement

Clemson University is committed to a policy of equal opportunity for all persons and does not discriminate on the basis of race, color, religion, sex, sexual orientation, gender, pregnancy, national origin, age, disability, veteran's status, genetic information or protected activity (e.g., opposition to prohibited discrimination or participation in any complaint process, etc.) in employment, educational programs and activities, admissions and financial aid. This includes a prohibition against sexual harassment and sexual violence as mandated by Title IX of the Education Amendments of 1972. This policy is located at http://www.clemson.edu/campus-life/campus-services/access/title-ix/. Mr. Jerry Knighton is the Clemson University Title IX Coordinator. He also is the Director of Access and Equity. His office is located at 111 Holtzendorff Hall, 864.656.3181 (voice) or 864.565.0899 (TDD).