

Syllabus  
Thermodynamics and Statistical Mechanics  
(Physics 8150)  
Spring Semester 2014

**Instructor**

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**Class Hours**

MWF 11:15 – 12:05, 116 Kinard.

**Office Hours**

MWF 1:30 – 2:30; Th 10:00 – 12:00; or simply come on an as needed basis. **Students are strongly encouraged to make use of the office hours, to discuss homework assignments and for conceptual questions.**

**Scope of Course**

An advanced graduate level foundation for any research involving statistical mechanics. The intention is to give the student the theoretical basis, including quantum statistics, for more advanced topics such as criticality, complex magnetic systems, Brownian motion, etc.

**Prerequisite**

There is no formal prerequisite for this course. However, I will assume that students know about undergraduate level thermodynamics, and graduate level mechanics and quantum mechanics.

**Required Texts**

*Statistical Mechanics* (Third Edition) by Pathria & Beale; Elsevier, ISBN 978-0-12-382188-1, 718 pages, 2011; List Price US\$ 94.95; it is important that you have the 3<sup>rd</sup> edition. **The major part of the lecture will follow this book!** For errata see: <http://www.elsevierdirect.com/v2/companion.jsp?ISBN=9780123821881>

*Thermodynamics and Statistical Mechanics* by Greiner, Neise, Stöcker; Springer, ISBN 0-387-94299-8, 463 pages, 1994; List Price US\$ 79.20. **The first part of the course (review of thermodynamics) will follow this book before switching to Pathria & Beale.** It also provides a comprehensive summary of statistical mechanics although on a somewhat lower level than Pathria & Beale.

## Recommended Texts

*Statistical Mechanics* by R. Kubo; North Holland Personal Library (now Elsevier), ISBN 0-444-87103-9, 425 pages, 2004; Lots of problems with solutions: excellent for practicing; not suitable as stand-alone textbook.

Other commonly used texts are: *Statistical Mechanics and Thermal Physics* by Reif; *Statistical Mechanics in a Nutshell* by Peliti; and *Statistical Physics* by Landau and Lifshitz

## Course Outline

1. Review of thermodynamics (about 3 weeks): introduction, macroscopic vs. microscopic variables, extensive and intensive thermodynamic variables, densities and fields, kinetic theory of the ideal gas, first and second laws of thermodynamics, reversible and irreversible cycles, entropy, thermodynamic assemblies and potentials, stability, Legendre transformations between assemblies, Maxwell relations, coexistence, Clausius-Clapyron equation, van der Waals equation of state, Maxwell construction.
2. Statistics (about 1 week): random variables, averages and variances, binomial distribution, continuous distributions, normal distribution, central limit theorem, pseudo-random numbers.
3. Foundations of statistical mechanics with applications (remainder of the semester):
  - i. Statistical basis of thermodynamics, classical ideal gas, correct enumeration of microstates,...
  - ii. Microcanonical ensemble, phase space, Liouville's theorem,...
  - iii. Canonical ensemble, partition function, equipartition and virial theorems, paramagnetic systems, harmonic oscillators in heat bath,...
  - iv. Grand canonical ensemble, fluctuations, phase equilibrium,...
  - v. Essentials of quantum statistics, indistinguishable particles, density matrix,...
  - vi. Theory of simple gases in a quantum mechanical ensemble context, internal motions,...
  - vii. Ideal Bose systems, ultra-relativistic case, Bose-Einstein condensation, blackbody radiation, liquid helium,...
  - viii. Ideal Fermi systems, ultra-relativistic case, magnetic behavior, electron gas, statistical model of the atom,...
  - ix. Thermodynamics of the early universe

## 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 count toward the final grade

## **Course Grades and Weights**

- 25% Homework
- 10% Oral Homework Presentation
- 25% Mid-term exam
- 40% Final exam

A: 85-100; B: 70-85; C: 50-70; F: 0-50 (no D)

## **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 homework assignments. Please also see the general statement on attendance in the Graduate Announcements.

## **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 Graduate 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**

It is University policy to provide, on a flexible and individualized basis, reasonable accommodations to students who have disabilities. Students are encouraged to contact Student Disability Services to discuss their individual needs for accommodation.