Statistical Mechanics and Thermodynamics
PHYSICS 5163
Spring 2000

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1 Goals:

The goal of this course is to give the student competence in thermodynamics and statistical mechanics. My goals for the class include:

- Developing a working knowledge thermodynamics, including Legendre transforms and generalized free energies.
- Examining phase transitions and phase diagrams from both a classical thermodynamics and modern perspective.
- An introduction to kinetic theory, looking at some fundamental approaches such as the Boltzmann equation, and the Fokker-Planck equation.
- Develop a practical understanding of statistical mechanics, including the various partition functions and quantum statistical mechanics.
- An introduction to modern approaches to statistical mechanics such as the renormalization group, and perhaps path integrals.

The emphasis in the course will be pragmatic, i.e. we will be more interested in calculating the properties of equilibrium states rather than proving that equilibrium exists. The goal is to provide you with tools you will need in understanding your own and other's research.

2 Prerequisites:

You are expected to have:

- A thorough understanding of Classical Mechanics in the Newtonian, Lagrangian, and Hamiltonian formulations.

- An elementary knowledge of probability and statistics.
- A passing knowledge of thermodynamics and statistical mechanics at an undergraduate level including such concepts as heat, entropy, reversibility, and distribution functions. You are expected to be an expert on the ideal gas.
- A good background in quantum mechanics including the concepts of fermions and bosons, scattering, interference, and solving the Schrodinger equation.

If you feel weak in any of these areas, come see me. I'll help you decide if you need to brush up on anything or if it might be better to take this class at a later date.

3 Texts:

The text for the class is *A Modern Course in Statistical Physics* by L. Reichl. I chose it because it follows (to some extent) the flow of the course I wish to develop. It has a *lot* of material in it, more than we can cover in a semester. The book is fairly pedagogical so you can use it as a resource for your future physics career. However, any textbook serves only as a starting point. While this book does cover the material in the spirit I hope to follow, it is not the best text on every topic we will discuss. Rather than require three or four textbooks, I will put a variety of books on reserve, and I may do some photocopying. Suggested texts include:

- *Statistical Mechanics,* by K. Huang.

  This is the book I used last year. It's a classic, but a bit terse. It does an excellent job on going from a microscopic scattering picture to the dynamics of a real gas. Excellent on the fundamentals.

- *Classical Thermodynamics,* by Callen.

  The basic presentation of thermodynamics will be based on this book. Since I am only going to use about 5 of its chapters, I didn't require it.

- *Thermodynamics* by G. Weinreich, (out of print).

  A quirky, but wonderfully pedagogical book on basic thermodynamics. This text really makes sense of the bizarre business of internal constraints, extremization, Legendre transforms and other subtleties.

- *Statistical Mechanics and Thermodynamics* by C. Garrod.

  This was my second choice of text. It follows Callen's treatment of thermodynamics, and covers all of the topics we will touch on. It also has lots of worked problems in the back. Drawbacks: it *starts* with stastical mechanics and then develops thermodynamics; placing the problems at the end of the book makes the presentation a bit incoherent.

- *Entropy and its Physical Meaning*

  A delightful softcover book that really dives into the topic of entropy. It deals with many subtle issues in the third law and gives some nice applications.

- *Classical Thermodynamics,* by Pippard.

  A standard work. I'm not entirely sure why. But, hey, I'll put it on reserve.

- *Statistical Mechanics, Part 1* by L. Landau

  A standard work that I respect more than Pippard. Landau has his own way of doing things that is simple, brilliant, and not usually obvious to mere mortals. It's a great reference for Landau theory.

- *Principles of Condensed Matter Physics* by Chaikin and Lubensky.

  Despite its title, this book overlaps with a lot of the topics we'll discuss such as fermions and bosons, phase transitions, and the renormalization group. It's well written and pretty accessible, but sometimes does not give you all the mathematical details.

I will also photocopy some articles on more advanced topics. Since class discussion will be predicated on your having read the articles, I will have brief reading quizzes, which will be easy if you've read the material with any care.

While this is not a course on MATHEMATICA, I do expect that we will use it at times throughout the semester. I will schedule a special introductory session or two on MATHEMATICA. If you've never used MATHEMATICA, I strongly recommend that you get a copy of *The Beginner's Guide to Mathematica* by Gray and Glynn. It is required in a number of Physics classes, so it should be in the bookstore. It will give you a quick introduction into everything you need to know.

4 Evaluation:

The tentative plan for grading is based on the following:

25%	Two Midterm exams
25%	Final Exam
50%	Homework, Reading Quizzes, and Workshop problems.

I intend to assign final grades on a straight scale (100-90% =A, 80-89%=B, 70-79%=C, etc.). Although the final exam will not be intentionally cumulative, the nature of the course is that competence in the latter half depends upon mastery of the first half. Exams will be open book/open notes.

Homework will be assignments will be either weekly or bi-weekly, depending on the material, and will usually be due on Monday, in class. Late homework will be accepted up until the solutions are placed in the library. While students may wish to collaborate on homework, it should be stressed that simply copying the solutions of others will not prepare them for the exam. It is also considered cheating!

5 Final Notes:

Students who cannot take exams on scheduled dates should let me know at the earliest opportunity.

Any student in this course who has a disability that may prevent him or her from fully demonstrating his or her abilities should contact me personally as soon as possible so we can discuss accommodations necessary to ensure full participation and facilitate your educational opportunities.