Physics 114 – Statistical Physics Seminar
Introduction
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Carl Grossman
Office Phone: x7790
Home Phone: 543-3541

Office: SC L38
Office Hours:
MTW 10 - 12 AM

Overview of syllabus

Statistical physics is very different from other physics topics in its approach to describing the physical world and in the tools that are needed to quantify it. Briefly, statistical physics makes the connection between the microscopic relations of particles (velocity, potential energy, electric and magnetic forces and torques) and macroscopic quantities (temperature, pressure, work, magnetization, phases, et cetera). The microscopic relations are well described by the laws and postulates of mechanics, E&M and quantum mechanics, while the macroscopic quantities maintain relations according to the laws of thermodynamics. The great achievement of statistical physics is the derivation of thermodynamic relations in terms of first principles from the other fields of physics. This bridge between two vastly different worlds is considered one of the most beautiful creations of physics, modern or otherwise.

A course in statistical and thermal physics can be organized several ways based on the "parallel" nature of the discipline. i.e. that there are two independent approaches to formulating macroscopic phenomena: Thermodynamic relations between macroscopic quantities and a "first principles" approach from basic microscopic physics using statistics. This can seem, at first, somewhat disorganized in that there isn't a unique, ABC... path to presenting the topics. Frederick Reif's old standard textbook *Fundamentals of Statistical and Thermal Physics* is jokingly called a holographic book because you can find elements of any one topic scattered among its chapters. Once you get a foothold on the subject, the logic of the book's presentation makes more sense. As in many courses, one might consider a chronological organization which would present thermodynamics first. This could be a way to learn thermodynamics because the topic can stand alone without any knowledge of statistics. Enrico Fermi's book *Thermodynamics* is a good example of this approach. However, this approach doesn't draw on the our knowledge of classical and quantum physics and it takes a lot longer to gain an intuition for implementation (i.e. solving problems).

Alternatively, our textbook by Daniel Schroeder uses an approach that mixes statistical arguments and thermal subjects. I find that this strategy does a good job at explaining not only how the macroscopic world works, but why it works.

Seminar Organization

We will use a slightly different organization than is used in other seminars. In addition to the usual problem set discussions and presentations, I would like to lecture and lead discussions about the book material for part of the seminar. The lecture/discussion will be about 15 $\sim$ 20 minutes, the same time that it usually takes for one presentation. Here's my reasoning: The material in this course is unusual compared to the other seminars. The topics of Mechanics, Electrodynamics and Quantum Mechanics were covered in earlier courses and the seminars raised the level or expanded the topics. This material in Phys 114 is almost entirely new and "problems and presentations" may not give a solid foundation. In past years, some students have suggested that I lecture for part of the course. It makes sense to lecture about the material that will become the following week's "problems" so that you see a lecture before you work on seminar problems.

Problem sets. The number of problems depends on the difficulty of the chapter but I figure assignments will range from eight to twelve problems each week, total. These will be split into two problem assignments each week. One assignment everyone solves all problems and hands them in at seminar time (sort of like a warm up set and a seminar set combined). The second assignment is for seminar discussion. I expect everyone to work on each of the problems before seminar so that the discussion is meaningful. If you are having trouble with a problem solution (or don't even know where to start!), then I want you to see me, individually or as a group, at least a day before the seminar, preferable several days in advance. Since we have a Monday seminar, I will be around on Sunday night to help with problem sets. During the seminar I want everyone to contribute to the discussion of problems, either by presenting a solution, aiding the presenter or providing useful commentary. Based on last semester, I don't think that we'll have any problem keeping a lively, engaged discussion.

Homework counts for 40% of the grade, so be sure to hand in all of the assignments. The rest of the grade is made up of two exams (30% each). There is no final. The examinations will cover the segments of the curriculum: I) Basic Statistics/Thermo and II) Classical Statistical Mechanics and Quantum Statistical Mechanics. The advanced material will be challenging, doing the problems will be tough enough. At least one of the exams will be during seminar, a standard in-class, timed exam. I might also give a take-home exam that is untimed, but hard (I don't want to deal with timed take home exams, rumors about people taking longer than they should, and so on. Feh!). We can discuss this during the first seminar.

As far as break goodies, I will make up a schedule at the first meeting and try to include a reminder with each seminar assignment. I'll post the schedule on the Blackboard server. The first break is on me.

Textbooks

As mentioned before, we will use Daniel Schroeder's textbook *An Introduction to Thermal Physics*. I will also use material from the texts *Concepts in Thermal Physics* by Stephen Blundell and Katherine Blundell, *Fundamentals of Statistical and Thermal Physics* by Fredrick Reif, *Statistical Mechanics and Thermodynamics* by Claude Garrod, and *Introduction to Statistical Physics* by Kerson Huang. All of these books are on honors reserve and I have copies in my office in case the reserve copies are getting heavy use. Schroeder is a well written book and is pretty easy to understand. He goes through a lot of trouble to explain clearly what is often confusing. He brings some very nice approaches into the discussion. Other books that I'll put on Honors Reserve are *Elementary Statistical Physics* by Charles Kittel, *Statistical Mechanics* by R. K. Pathria, *Statistical Physics* by Franz Mandl, and *Thermal Physics* by Ralph Baierlein.

Physics 114 Syllabus — Tentative list of chapters and seminar dates.

Date #	Sem #	Chapter	Subject
1/20, 21	1	Schroeder 1	The First Law of Thermodynamics, Heat, Work, Ideal Gas, Heat Capacities, Heat Conduction, ...
1/27, 28	2	Schroeder 2	Statistical Approach to Macroscopic Ensembles, Entropy, Second Law of Thermodynamics, Einstein Model of Phonons, Stirling's Approx.
2/3, 4	3	Schroeder 3	Applications of the Second Law, Temperature, Pressure, Paramagnetism, Chemical Potential
2/10, 11	4	Schroeder 4	Heat Cycles, Engines, Refrigerators, Throttling
2/17, 18	5	Schroeder 5	Thermodynamic Relations, Free Energies, Non-ideal Gases, Phase Transitions
2/24, 25	6	Schroeder 5	Mixtures, Chemical Equilibrium Exam I
3/3, 4	7	Schroeder 6	Basic Statistical Mechanics, Boltzmann Statistics, Partition Function, Applications
3/10, 11	–	———	Spring Break
3/17, 18	8	Schroeder 7	Quantum Statistical Mechanics, Bose-Einstein Statistics, Fermi Statistics
3/24, 25	9	Schroeder 7 Huang 8-10	Bose-Einstien Condensation
3/31, 4/1	10	Schroeder 8 Garrod 8	Phase Transitions, Mean Field, Ising Model, Liquid Crystal Transitions
4/7, 8	11	-	Exam II
4/14, 15	12	Garrod 9	Critical Phenomena, Renormalization
4/2, 221	13	Garrod 9	Critical Phenomena, Renormalization
4/28, 29	14	Reif, Garrod	Transport, Basic Fluid Dynamics