Physics 114 – Statistical Physics Seminar
Introduction
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MTW 9 - 11 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, etc.). 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. 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 curriculum makes more sense. As in many courses, one could use a chronological organization which would present thermodynamics first. This can be a wonderful way to learn thermodynamics because the topic can stand alone without any knowldge of statistics. Enrico Fermi's book *Thermodynamics* is a good example of this approach. However, it doesn't draw on the our knowledge base of classical and quantum physics and it takes a lot longer to gain an intuition for implementation (i.e. solving problems). Alternatively, an approach that mixes statistical arguments and thermal subjects is used in our texbooks (Schroeder, and Blundell & Blundell, as well as the old standard by Reif) and is probably better at explaining not only how the macroscopic world works, but why it works.

We will follow the organization in Schroeder and start with an overview of basic observations in thermodynamics–ideal gas law, heat/energy relations, transport phenomena– followed by statistical explanation of entropy. The text by the Blundells starts with a statistical development of kinetic theory but uses a thermodynamics approach to entropy.

Seminar Organization

I would like to try something completely different this year. Instead of the usual seminar organization around problem sets and presentations, I would like to lecture and lead discussions about the book material for part of the seminar, but still do problems and "recitation". The lecture/discussion will take about an hour, the same time that it usually takes for presentations. 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 exams (30%) and a Final (30%). The examinations will cover three segments of the curriculum: Basic Statistics/Thermo, Classical Statistical Mechanics, and Quantum Statistical Mechanics/Advanced Topics. The seminar is small enough that we might be able to schedule at least one of the exams at single time "outside" of our seminar schedule and not take up any seminar time. We can discuss this schedule during the first seminar.

Textbooks

There are two textbooks, *An Introduction to Thermal Physics* by Daniel Schroeder and *Concepts in Thermal Physics* by Stephen Blundell and Katherine Blundell. 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 *Fundamentals of Statistical and Thermal Physics* by Fredrick Reif, *Statistical Mechanics and Thermodynamics* by Claude Garrod, *Introduction to Statistical Physics* by Kerson Huang, *Elementary Statistical Physics* by Charles Kittel, *Statistical Mechanics* by R. K. Pathria, *Statistical Physics* by Franz Mandl, and *Thermal Physics* by Ralph Baierlein. .

Breaks

Last, but not least, is the subject of break goodies. I will make up a schedule at the first meeting and try to include a reminder with each seminar assignment. The first break is on me.

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

Date #	Sem #	Chapter	Subject
1/21	1	Schroeder 1	The First Law of Thermodynamics
1/28	2	Schroeder 2	Statistical Approach to Macroscopic Ensembles and the Second law of Thermodynamics
2/4	3	Schroeder 3	Applications of the Second Law
2/11	4	Schroeder 4	Heat Engines, Cycles
2/18	5	Schroeder 6 Blundell&Blundell 19-20	Basic Statistical Mechanics, Boltzmann Statistics The Partition Function
2/25	6	Schroeder 6 Blundell&Blundell 21-22	Applications, Ideal Gas, Paramagnetism
3/3	7	Schroeder 5 Blundell&Blundell 26	Non-ideal van der Waals gases, phase transitions
3/10	–	———	Spring Break
3/17	8	Schroeder 7 Blundell&Blundell 29-30	Quantum Statistical Mechanics, Photon, Fermi, and Bose Gas
3/24	9	Schroeder 7 Blundell&Blundell 29-30 Huang 8-10	Bose-Einstien Condensation
3/31	10	-	Honors Problem Jam
4/7	11	Blundell&Blundell 23-24	Blackbody Radiation, CMB, Debye Solid
4/14	12	Schroeder 8 Garrod 8	Mean Field, Ising Model, Liquid Crystals
4/21	13	Garrod 9	Critical Phenomena, Renormalization
4/28	14	Blundell&Blundell 33-34 Garrod 10	Transport, Brownian Motion, Diffusion, Non-Equilibrium Thermodynamics

Physics 114 – Statistical Physics
Seminar 1
Monday
January 21, 200

Reading — Schroeder Chapter 1

Break — Carl

Problem	Comments
1.12	personal space for a gas molecule
1.16	(omit part d) - law of atmosphere derivation
1.17	(omit part a) - van der Waals equation of state and the virial coefficients
1.31	simple engine cycle
1.37	diesel engines get hot
1.38	expanding bubbles
1.39	we did this problem last semester, believe it or not
1.40	son of law of atmosphere
1.46	too much pressure!
1.51	enthalpy of metabolism
1.57	heat resistance
1.69	what the Fick?