Physics 504: Statistical Mechanics and Kinetic Theory

Nigel Goldenfeld

1. Course Information.

The course meets in LLP 158 Mondays and Wednesdays 2.00-3.20pm.

My office hour is posted on the class website or I can see you outside of that time by appointment; I am sometimes a few minutes late if another meeting has run over, so please be understanding and wait. *I strongly encourage you to take advantage of this opportunity to talk about physics with me.* Feel free to come and talk with me at other times too, although it may be necessary to make an appointment if I am busy or have a meeting in progress.

Web site

The course has a web site that is used to post materials of extra-curricular interest. In addition, I will distribute homework assignments and sometimes issue announcements concerning the course by email. To facilitate this, please click on the sign-up link on the web page so that I have your email address. **Please do this, even if you are only auditing the course. If you do not register on my web page, you will not receive homework or the occasional but important announcements.**
Here is the link:

http://guava.physics.uiuc.edu/∼nigel/courses/504

Email is the best way to reach me. Please do not phone me at home under any circumstances.

2. Grading.

Homework should be submitted to the 504 HW box, located near the corridor between the Loomis Laboratory of Physics and the MRL. We will not accept homework by email, except occasionally if a student has to be off campus for a research-related reason (such as doing an experiment at CERN). Questions about the grading of homework assignments should be directed to the Grader in the first instance, and then, if necessary to me. Information about the Grader office hour, contact info etc. is on the class website.

3. Pre-requisites.

It is an unfortunate fact that it is possible to become proficient at advanced statistical mechanics without having mastered the more elementary material. However, this tends to result in a rather formal and fragile grasp of the subject. Physics 504 is an advanced, but self-contained course; nevertheless, you are strongly encouraged to have first attended an undergraduate physics course in statistical physics and thermodynamics.

A reasonable textbook which covers all the elementary material is *Thermal Physics* by C. Kittel and H. Kroemer.

4. Texts.

Here are some books that like in varying degrees and which some of your predecessors have found useful. Some of the older ones are on reserve in the library or you may pick up a reasonably-priced copy.

- D.C. Mattis and R. Swendsen, *Statistical Mechanics Made Simple* (2nd edition).
- M. Kardar, *Statistical Physics of Particles*.
- L.P. Kadanoff, *Statistical Physics: Statics, Dynamics and Renormalization*.
- N.D. Goldenfeld, *Lectures on Phase Transitions and the Renormalization Group*.
- D.J. Amit and Y. Verbin, *Statistical Physics*.
- M. Plischke and B. Bergerson, *Equilibrium Statistical Physics*.
- L.D. Landau and E.M. Lifshitz, *Statistical Mechanics (Part 1)*.
- L.D. Landau and E.M. Lifshitz, *Physical Kinetics*.
- K. Huang, *Statistical Mechanics*.
- R. Kubo, M. Toda and N. Hashitsume, *Statistical Physics (Parts 1 and 2)*.

There is no text book for this course. Instead, you can see my typed notes on the class website, in quasi-book form. *The availability of my notes is not meant to substitute for your own notes.* Note-taking is a valuable and important skill to learn. Sometimes, I will make extemporaneous comments or discussions, or respond to questions; these are just as important to record as the actual notes that I write up on the blackboard. My notes are intended to be a back-up.

5. Homework.

Homework assignments will be distributed at regular intervals, typically about once a week to ten days. I strongly recommend that you develop a regular schedule for doing these assignments, and do not wait until the due date before attempting the problems. Some of the problems are quite tricky conceptually, although none involve lots of tedious algebra.

The homework assignments should be handed in to the 504 box, situated in the corridor connecting the Loomis Laboratory with the Materials Research Laboratory. Each assignment will have a due date, *with late work penalised*. If you know that you will have a conflict with the due date (*e.g.* you have 'beam time' at Argonne National Lab, or some other valid reason), please let me and the Grader know *in advance.*

The homework is an essential part of the course; you cannot learn physics from lectures unfortunately.

I will not distribute solutions to the homework in class, because these have been abused in the past. The Grader will provide substantive comments on your work so that you may learn from your inevitable mistakes.

There will be no midterm, but there will be a final exam, which will be either in exam conditions or a take-home final.

6. Feedback.

Please let me know if you have any suggestions or comments about the class, or if I mistakenly assume that you are familiar with some basic material. There is no point in waiting until the end of the semester (or when you fill in an evaluation), because by then it is too late for me to consider acting on the feedback.

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Course Outline

Week 1	**Scope and History of Statistical Mechanics**.
	Formal Theory: Basic assumptions;
Week 2	Coarse-graining; Equal A Priori Probabilities; Entropy;
Week 3/4	Counting states; Detailed balance;
Week 5	Thermal equilibrium; Boltzmann and Gibbs distributions;
Week 6	Fluctuations; classical statistical mechanics; quantum limit;
Week 7	**Ideal systems**; Classical and quantum gases, paramagnets;
Week 8	Quantum statistical mechanics; density matrix;
Week 9	**Interacting Systems:** Non-ideal gases; cluster expansion;
Week 10	Liquid state theory; Charged fluids;
Week 11	Phase transitions; Interacting spin systems;
Week 12	Disordered systems.
Week 13	**Near Equilibrium:** Brownian motion;
Week 14	Langevin equation; Fluctuation-Dissipation theorem;
Week 15	Kubo formula; Long time tails;
Week 16	Origin of irreversibility.

This course outline is tentative only.

Final: The date will be announced during the semester. (Takehome final may be given at the discretion of the instructor).