PHYSICS 653 (STATISTICAL PHYSICS): FALL 2007

Rock 110, TuTh 10:10-11:25
Chris Henley, 531 Clark, 5-5056, clh@ccmr.cornell.edu
Office hour: TBA (Mon. 2:45 PM?)
Grader: (Probably) Steve Hicks

A survey of topics in (unrigorous, non-quantum) stat physics. Goal: convey the common knowledge (largely from the last $\sim$ 40 years) needed to follow a seminar on statistical physics. Philosophy: focus on the simplest examples ("toy models"), avoid unnecessary formalisms; frequent questions are solicited. I leave quantum phenomena – superfluids, Fermi liquids, quantum spins – to other courses (e.g. Physics 636 or ?); also I omit liquids and chaos theory (see spring courses Chem 796 or TAM 578).

This version of P653 has a biological flavor: 40% of it (Units I, IV) is motivated by biology/soft matter. But I don't give a connected grounding in biological physics, I rarely invoke the name of a specific chemical or species, and I avoid genomics altogether.

Most likely I'll cancel all or most of the dates from Oct. 11-23 for travel (as it happens, that's just when you should be writing term paper drafts!). My tentative plan is make-up lectures, mostly Fridays but sometimes Mondays: the first one **next week** on Fri. 8/31, the second one in Sept., and the rest after my trip.

The **prerequisite:** is Physics 562 (stat mech) or the equivalent.

We have three significant kinds of work.

1) Weekly **homework** assignments. We skip homework the peak weeks for term paper or other tasks. *Start* thinking about homework problems individually, till you have a plan for solution, or are stalled. Then, you're *strongly encouraged* to discuss them together. The final writeup should be done on your own. We aim for a quick turnaround: any extensions (of $\sim$ 1 day) must be requested on the due date.

2) Participation. I give **"Teaser questions"** (or "thought question") on the current lecture, which should take just 10 minutes. These involve qualitative or back-of-the-envelope thinking, or just locating a relevant passage in readings. Hand them in at the next class: any serious response is OK, whether "right" or "wrong." I also demand brief email **Questions**, submitted by you (in pairs or teams) the night before Tuesday's lecture.

3) A **term paper** is required. Topic proposal due Fri. Sept 19. Draft paper tentatively due Mon. Oct. 27, to allow time for "peer review" comments on each others' drafts.

4) I haven't had exams in the past, but am considering an oral exam.

Grades: This course has recently been reclassified to S/U or Letter grades. Even S/U students are expected to do work in **all three** categories. [Roughly: HW 40%, termpaper 30%, particip. 20%, but weights may be adjusted a few %.] To do *only* a term paper – a couple have chosen that in past years – and get formal credit, please consult me within the next week to set up a "reading course".

Textbooks: "Required" text is borrow Chaikin & Lubensky; it covers more of my topics than any other, and it's a valuable reference if you'll work on soft matter; unfortunately, many readers find its exposition awkwards. For critical phenomena topics

(Unit II and some of III, V) Goldenfeld's text is very readable and corresponds well to my viewpoint. Other books are mentioned below.

Lecture handouts: I don't hand out complete lecture notes, but tend to pass out lots of paper. A spare of **every** handout will be posted by my door marked "DNR" (Do Not Remove, except briefly to photocopy.) I *may* post handouts on the web this year.

Topics

I. Random walks (∼ 4 days)
Walks with absorption, diffusion/electrostatics analogy,
(Hidden) Markov processes, detailed balance, channel protein kinetics.

II. Spin models and critical phenomena (∼ 7 days)
Critical exponents, Landau-Ginzburg free energy, correlation functions;
Renormalization groups, flows and fixed points;

III. Stochastic differential equations (∼ 6 days)
Langevin equation; Fluctuation-dissipation theorem

IV. Polymers and entropic forces (∼ 4 days)
Self-avoiding walks; polymer collapse; DNA elasticity.

V. 2D continuum systems (∼ 4 days)
Kosterlitz-Thouless criticality in vector spin systems, interface roughening

VI. (∼ 2 days) One of the following, depending on interest:
a) Percolation theory and disordered systems.
b) Collective dynamics models, including the **Kardar-Parisi-Zhang equation**, with applications to surface growth, cellular automata, and genomics;

Reserve Books

All these books *will* be on reserve in Clark Library. Additional books will be noted for each unit. Web site will post the longer, annotated list of books I handed out in P 653 (2000).

*: ordered at the bookstores
† : in LASSP theory library on 5th floor of Clark.

*† Paul M. Chaikin and Tom C. Lubensky, *Principles of Condensed Matter Physics* (Cambridge University Press, 1993)

*† Nigel Goldenfeld, *Lectures on Phase Transitions and the Renormalization Group* (Addison-Wesley "Frontiers in Physics", 1992). *Unit II*

*John L. Cardy, *Scaling and Renormalization in Statistical Physics* (Cambridge, 1996.) QC 174.85.S34.C37x 1996 *Unit II*

† Julia Yeomans, *Statistical Physics of Phase Transitions* (Oxford, 1992). *Unit II*

† N. G. van Kampen, *Stochastic processes in physics and chemistry* (North-Holland, 1981; 2nd ed c 1992) QC20.7.S8 K15 1992 *Unit III*

Pierre-Gilles de Gennes, *Scaling concepts in Polymer Physics* (Cornell Univ. Press, 1979) QD381.G33 *Unit IV*