Physics 6562: Statistical Mechanics
http://www.physics.cornell.edu/sethna/teaching/562/

Course Description
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We will attempt to provide a broad view of statistical mechanics, with applications to not only physics and chemistry, but to computation, mathematics, dynamical and complex systems, and biology. Some traditional focus areas will not be covered in detail (thermodynamics, phase diagrams, perturbative methods, interacting gasses and liquids). Instead, we will focus on statistical ideas and methods that have found uses in a broad variety of fields.

Flipped format: The former lectures for this course have been carefully turned into chapters in the text. We take this opportunity to ‘flip the classroom’ – we will ask you to read the lecture material before the class, and spend class time on exercises, projects, and discussion. National research, and much local experience in Cornell’s Physics department, suggests that this approach can make for significant improvements in learning (and be more interesting). Those of you headed for academic careers should watch me in this transition to see if you like the approach.

- **Load:** This class traditionally demands around fifteen hours of out-of-class work each week. (Physics graduate students work hard.) We will make every effort to monitor the total effort. We anticipate around four hours per week of pre-class preparation (reading and pre-class questions), and will try to keep the remaining challenging homework questions to around ten hours per week.

- **Pre-class questions:** By 9:30pm the day before class, we ask you to upload the answer to a pre-class question testing a key point in the reading. (Log in to the Cornell Blackboard site with your netid; select this course; select ‘Content’; type or upload a file for that day.) I will be using your responses to decide how to start class the next day. Also please provide feedback on confusing bits in the reading; I’m always looking to improve the text.

- **Blackboard, and the course Web site:** The main site for distributing homework, hints files, and course information will be my Web site http://www.physics.cornell.edu/sethna/teaching/562/ I have also set up access to a Blackboard site, which will be used for uploading and keeping track of the ‘pre-class questions’ and feedback.

- **Feedback:** We are exploring this new flipped format; it is a big effort for us, and we want to get it right. Feedback from you will be crucial, both on the pre-class readings (in Blackboard, above) and more broadly about the course organization.

**Prerequisites:** The course presumes a high level of sophistication, equivalent to but not necessarily the same as that of a first-year physics graduate student (undergrad-level quantum,
classical mechanics, and thermodynamics). Only a small portion of the course (roughly one and a half weeks) will demand a knowledge of quantum mechanics; students with no quantum background have found the rest of the course comprehensible and useful, if challenging.

**Audience**: This graduate statistical mechanics course has four audiences, all of whom this course will attempt to accommodate:

1. *Physics, astrophysics, and chemistry audiences* need to (i) understand how thermodynamics emerges from atomistic processes [fundamental concepts of temperature, entropy, and free energy, defining the microcanonical, canonical, and grand canonical ensembles], and (ii) understand quantum statistical mechanics [Bose-Einstein and Fermi statistics, black-body radiation, Bose condensation, superfluidity metals, neutron stars, black hole entropy, etc.].

2. *Biology and soft-condensed matter physicists* needs an emphasis on fluctuations [random walks, diffusion equations, the fluctuation-dissipation theorem] with applications to problems like polymer physics, membranes, and molecular motors. The soft-condensed matter audience, facing a bewildering variety of phases and defects, need the organizing theoretical principles we use to understand them [order parameters, phases, Landau theory, and the homotopy theory of defects].

3. *Mathematicians and computer scientists* need to understand how statistical mechanical ideas apply to computation and communications [information theory and Shannon entropy], mathematics [ergodicity and the KAM theorem, Markov chains, entropy in dynamical systems].

4. *Complex systems* theorists need an exposure to the statistical origins of large-scale structures in space and time [avalanches, scaling, critical phenomena and continuous phase transitions, self-organized criticality. universality and the renormalization group].

**Alternatives**: Chemistry 7960 is a more traditional graduate statistical mechanics class, taught by Roger Loring (8:30-9:55 TTh, Baker 219). Physics 3341 and A&EP 4230 are undergraduate statistical mechanics courses taught in the fall.