Physics 551 Statistical Mechanics, Fall 2014

Lectures: 3:40-4:55 PM on Tuesday and Thursday at Nielsen Physics 306
Instructor: Jaewook Joo
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Office Hours: by appointment

Recommended textbooks:

Mehran Kardar, Statistical Physics of Particles (Cambridge, 2007) is the main textbook for this course and its presentation style is mathematical and concise. The electronic version is available at the following website: http://ocw.mit.edu/courses/physics/8-333-statistical-mechanics-i-statistical-mechanics-of-particles-fall-2007/lecture-notes/.

Jim Sethna, Statistical Mechanics: entropy, order parameters and complexity (Oxford, 2011) explains the similar topics in an easier yet less rigorous manner. It contains many good exercise problems on modern statistical physics topics. The electronic book can be found at http://pages.physics.cornell.edu/~sethna/StatMech/EntropyOrderParametersComplexity.pdf.

R. K. Pathria, Statistical Mechanics (Butterworth-Heinemann, second edition) is the student-friendly and pedagogical textbook.

Course description: Many systems in nature are far too complex to analyze directly. Solving for the behavior of all the atoms in a block of ice, or the boulders in an earthquake fault, or the nodes on the Internet, is simply infeasible. Despite this, such systems often show simple, striking behavior. Statistical mechanics explains the simple behavior of complex systems. The concepts and methods of statistical mechanics have infiltrated into many fields of science, engineering, and mathematics; Ensembles, entropy, Monte Carlo, phase transitions, fluctuations and correlations, nucleation, and critical phenomena are central to physics and chemistry, but also play key roles in the study of dynamical systems, communications, bioinformatics, and complexity. This course will cover the concepts and methods of statistical mechanics, which can be readily applicable to not only traditional physics but also interdisciplinary sciences. Note that Statistical Mechanics is by nature a very mathematical subject and sometimes requires mathematical sophistication and rigor that goes beyond the level of a typical Physics course. Whenever it happens, I will try my best to link mathematics with physical examples.

Final grade: Attendance 25% + homework 25% + midterm exam 25% + final exam 25%

Attendance: Students are expected to attend all classes. One point will be deducted out of 25 points for each absence. If you need to travel for your research, please let me know ahead of time. Absence due to illness will be excused only if the doctor's note is provided.

Homework: will be handed out on a regular basis and will be due in one week. If your homework is submitted later than the due date, your score will be reduced to 50% for the first one week overdue and to zero thereafter.

In-class midterm exam & take-home final exam: In-class midterm exam will be taken at 3:40-5:00 PM on October 14th at Nielsen Physics 306. The in-class final exam will be at 5-7 PM on December 4th at Nielsen Physics 306.

University's honor Statement: "An essential feature of the University of Tennessee is a commitment to maintaining an atmosphere of intellectual integrity and academic honesty. As a student of the University, I pledge that I will neither knowingly give nor receive any inappropriate assistance in academic work, thus affirming my personal commitment to honor and integrity".

Students with disabilities: the Office of Disability Services (ODS) assists students with Disabilities. To have this service, contact the ODS: 2227 Dunford hall, 915 Volunteer Blvd, 964-6087 or ods@utk.edu. For more details, see the Hiltopics or contact the ODS.

Class schedule:
Based on students' feedback, some topics may be dropped or added and thus this schedule is subject to change. There will be no classes on October 16 (Fall break), November 27 (Thanksgiving holiday), and December 2 (My travel).

Date	Topics to be covered	Reading Assignment
L1-L2 lectures	**Probability**: binomial, Poisson, and Gaussian distributions, central limit theorem	Kardar: Ch 2 Sethna: Ch 2
L3-L4 Lectures	**Thermodynamics:** the zeroth law, the first law, the second law, Carnot engines, entropy, thermodynamic potentials, (Stability conditions, third law)	Kardar: Ch 1 Sethna: Ch 5 Pathris: Ch 1
L5-L8 lectures	**Kinetic theory of gases:** Liouville's theorem, BBGKY hierarchy, Boltzmann equation, H-theorem, equilibrium properties, conservation laws	Kardar: Ch 3 Sethna: Ch 4 Pathria: Ch 2.1-2.2
L9-L11 Lectures	**Classical statistical mechanics:** microcanonical ensemble, two level systems, ideal gas, Gibbs' paradox, canonical and grand canonical ensemble	Kardar: Ch 4 Sethna: Ch 3 and 6 Pathria: Ch 2 and 3
L12-L14 lectures	**Quantum Statistical Mechanics:** dilute polyatomic gases, black-body radiation, vibrations of a sold, quantum macrostates and microstates	Kardar: Ch 6 Sethna: Ch 7 Pathria: Ch 5 and 6
L15-L19 lectures	**Ideal quantum gases:** Hilbert space, grand canonical formulation, degenerate idea Fermi & Bose, Bose Einstein condensation	Kardar: Ch 7 Pathria: Ch 7 and 8
L20-L22 Lectures	**Interacting particles:** cluster expansion, second virial coefficient and Van der Waals equation, critical point behavior.	Kardar: Ch 5 Pathria: Ch 9
L23-L24 Lectures	Landau Mean field theory; order parameter, mesoscopic equation, scaling laws, critical phenomena, phase transition	Kardar Vol II: Ch 2
L25-L26 lectures	**Phase Transitions and Renormalization Group:** Position space RG for Ising model in one and two dimensions, crossover, Momentum RG, perturbative RG	Pathria: Ch 11 and 13 Kardar Vol II: Ch 3-4
L27-L28 lectures	**Non-equilibrium Stochastic Dynamics:** Master equation, Fokker-Planck equation, Langevin equation, fluctuation-dissipation theorem, Onsager relations	Pathria: Ch 14