Physics 524
STATISTICAL MECHANICS

This is the first year graduate course in Statistical Mechanics and Thermodynamics. It covers general material, including what you are expected to know for the Qualifying Exam. The second quarter of Statistical Mechanics, Ph525, is taught in the Fall quarter of the second year, and covers current topics in this active area of research.

Teaching Ph524 poses two challenges: To keep a balance between formalism and applications. To present the material in way that benefits all first year graduate students, those with a poor as well as excellent background in this topic.

The covered material falls roughly in three units:

- Thermodynamics and other introductory material.
- Classical Statistical mechanics (ensemble theory).
- Quantum Statistical Mechanics.

An approximately equal amount of time will be spent on each of those three areas.

Thermodynamics is often only barely covered at the undergraduate level (in particular in our department). It is the phenomological macroscopic formalism to describe systems with very-many degrees of freedom. Thermodynammics orginated from empirical oservations. Statistical mechanics bridges the gap between the macroscopic and the microscopic descriptions of such large collections of particles. It explains the laws of thermodynamics and also describes the fluctuations that appear when the number of degrees of freedom is smaller, as, e.g., in molecular motors at the nano-length scale.

Quantum statistical mechanics forms one of the corner stone of solid state physics, as well as particle and nuclear physics. In this course we will only be able to cover its basic features like Bose-Einstein and Fermi-Dirac statistics, and applications like the vibrational and electronic contributions to the specfic heat of solids like metals, as well as bose-einstein condensation in in gases and liquids (Helium-4).

Classical statistical mechanics is just as important. Collective phenomena like phase transitions are intrinsically classical (even Bose condensation, after identifying the ground state wave function as the order parameter). Moreover, quantum statistics tends to obscure essential issues, like hiding the Gibbs paradox behind `h-bars'.

TEXT BOOKS:
We will not follow one specific textbook in a linear chapter-by-chapter fashion, but instead will jump around between our two text books

- Ca: Thermodynamics and an Introduction to Thermostatistics, Callen (Wiley).

- Hu: Statistical Mechanics, Kerson Huang (Wiley).

The third text book on the list, Ku: Statistical Mechanics, Ryogo Kubo (North-Holland), is not required but contains many useful explicit problems.

Specific sections of the following list of secondary texts will be mentioned as well. They provide 'second opinions' for the same material.

- Ba: From Microphysics to Macrophysics, Vol.1, Balian (Springer).
- PB: Equilibrium Statistical Mechanics, Plischke and Bergersen, (Wiley).
- ZD: Heat and Thermodyamics, Zemansky and Ditmann (McGraw-Hill).
- LL: Statistical Physics, Landau and Lifschitz (Pergamon).
- RF: Statistical and Thermal Physics, Reif (McGraw-Hill).
- DS: Thermal Physics, Schroeder (McGraw-Hill).
- GR: Statistical Mechanics and Thermodynamics, Garrod (Oxford, 1995).

These titles will be on reserve in the Physics library.

CREDIT:
To qualify for credit you must participate in the six homework assignments, the two midterm exams, and the final exam. The homework counts for 30% of your grade, each midterm for 20% and the final exam for 30%.

All tests are closed book exams. You may prepare one page with notes for use during the test.

Working on the homework assignments in groups is encouraged. The condensed matter conference room B417 can be reserved a few hours of the week for that purpose (ask the Professor about specific times).