Physics 540: Statistical Mechanics   Spring, 2012

Instructor: Prof. R. Shrock, tel. 632-7986, email: robert.shrock@stonybrook.edu office hrs. - after class, 1:45-2:45, Tue. Thu.

Meeting Time/Place: Tu-Th 11:20-12:40, Rm. to be determined

webpage: http://insti.physics.sunysb.edu/(tilde)shrock

Teaching Assistant: to be determined

Recommended preparation: an intermediate-level undergraduate course in thermodynamics/statistical mechanics

Textbooks - Textbooks - We will not follow any one book, but H. Eugene Stanley, *Introduction to Phase Transitions and Critical Phenomena* will be useful to have. We will provide a list of other books and articles that students may wish to consult throughout the course.

Course requirements include homework and either a final exam or a research paper.

This course will cover modern statistical mechanics, including topics chosen from the list below (in different years we will cover a different subset of topics)

- Brief review of thermodynamics
- Statistical ensembles: microcanonical, canonical, grand canonical; Boltzmann distribution.
- Ideal gases; kinetic theory; Maxwell velocity distribution.
- Phase transitions and critical phenomena: examples with liquid-gas-solid systems and magnetic systems; experimental data; phase diagrams; order of transition; critical singularities; correlation length.
- van der Waals theory of liquid-gas transition; mean field and Ginzburg-Landau theory.
- Analysis of some models, including Ising, q-state Potts, $O(N)$ vector, and ice models; connection of Potts model and Tutte and chromatic polynomials in graph theory; exact solutions for 1D and quasi-1D cases; transfer matrix method.
- Modern theory of second-order phase transitions: universality classes and critical exponents, dependence on spatial dimensionality and symmetry group of Hamiltonian; scaling relations, renormalization group; upper and lower critical dimensionalities; conformal algebra.
- Approximate methods: series expansions, Padé approximants
- Quantum statistics: Fermi-Dirac and Bose-Einstein distribution functions; Einstein-Debye model for phonons; Planck distribution function for blackbody radiation; Bose-Einstein condensation; Fermi gas model of metals.
- Simulation methods: Monte Carlo techniques and molecular dynamics methods, with some applications to condensed matter and structural biology
- Other examples of phase transitions chosen from among the following: superconductivity, superfluidity, Kosterlitz-Thouless (defect-driven) transition, liquid crystals and orientational ordering.