Physics 540: Statistical Mechanics Spring, 2009

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. P117

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Teaching Assistant: Dharmesh Jain, Rm. B-130, email: jkmsmkj@yahoo.com

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

Textbooks - We will not follow any one book, but the following two texts would be useful to purchase: M. Plischke and B. Bergersen, *Equilibrium Statistical Physics* (3rd ed); H. Eugene Stanley, *Introduction to Phase Transitions and Critical Phenomena*

Course requirements will include homework, a midterm exam, and a final exam

This course will cover modern statistical mechanics, including topics chosen from the list below:

- Thermodynamics: concepts of thermal equilibrium, temperature; state variables; equations of state; applications to fluids and magnetic systems; thermodynamic potentials; internal energy, free energy, entropy; response functions (specific heat, compressibility, susceptibility); conditions for stability; laws of thermodynamics; Carnot cycle and heat engines.
- 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; 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, and rudiments of Monte Carlo simulations.
- 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; basics of superfluidity and superconductivity, as time permits.
- Other examples of phase transitions: superconductivity, superfluidity, Kosterlitz-Thouless (defect-driven) transition, liquid crystals and orientational ordering, percolation.

The following is from the university administration:

If you have a physical, psychological, medical or learning disability that may impact on your ability to carry out assigned course work, you are urged to contact the staff in the Disabled Student Services office (DSS), Room 133 Humanities, 632-6748/TDD. DSS will review your concerns and determine, with you, what accommodations are necessary and appropriate. All information and documentation of disability is confidential. Stony Brook University expects students to maintain standards of personal integrity that are in harmony with the educational goals of the institution; to observe national, state, and local laws and University regulations; and to respect the rights, privileges, and property of other people. Faculty are required to report to the Office of Judicial Affairs any disruptive behavior that interrupts their ability to teach, compromises the safety of the learning environment, and/or inhibits students's ability to learn.