Physics 418, Spring 2009
Statistical Mechanics

Instructor: Andrew N. Jordan
Office: Bausch & Lomb 317
Text: H. B. Callen *Thermodynamics and Introduction to Thermostatistics*
R. K. Pathria *Statistical Mechanics*
Course Website: `http://www.pas.rochester.edu/~jordan/Phys418/phys418.html`
Class: B&L 270, Monday and Wednesday 11:00 - 12:30 hours, commencing Wed. 13 January.
Office Hours: Thursday 3:00 - 5:00

Welcome to Statistical Mechanics! The basic plan for the course is outlined below. I will draw mainly from my own lecture notes, but the books above cover the basic material. In addition, there are a variety of books on reserve in the POA library that you may wish to consult. Depending on time and interest, I will also try and cover some more sophisticated topics in statistical mechanics, such as stochastic theory and elements of quantum information. I will post my lecture notes on the blackboard system: `http://my.rochester.edu/webapps/portal/frameset.jsp`

Grades.— There will be homework (40%), a midterm (25%), and a final (35%).

Tentative plan for the course:

Lecture 1 - Postulates of classical thermodynamics, entropy, temperature, pressure, chemical potential

Topic 2 - Conditions for thermal, mechanical and chemical equilibrium; concavity of the entropy, the Euler relation, equations of state, the Gibb-Duhem relation, entropy of the ideal gas

Topic 3 - Energy minimum principle, Legendre transformations, Helmholtz free energy

Topic 4 - Enthalpy, Gibbs free energy, Grand Potential, heat reservoir, extrema principles for thermodynamic potentials, Maxwell's relations

Topic 5 - Response functions (specific heat, compressibility, thermal expansion) and relations between them, stability and curvature of free energies

Topic 6 - Kinetic theory of the ideal gas, Maxwell's velocity distribution, statistical ensembles and the ergodic hypothesis

Topic 7 - Liouville's theorem, microcanonical ensemble, density of states and number of states, connection to entropy

Topic 8 - Entropy of the ideal gas, entropy of mixing and Gibbs paradox, indistinguishable particles, Sackur-Tetrode equation

Topic 9 - Canonical ensemble, energy fluctuations and specific heat, equivalence of microcanonical and canonical ensembles

Topic 10 - Average energy vs most probably energy, proof of Stirling's formula, factorization of canonical partition function for non-interacting particles, ideal gas

Topic 11 - Virial and equipartition theorems, elastic vibrations of solids and the Law of Dulong and Petit, paramagnetism and the Curie Law

Topic 12 - Entropy and information theory

Topic 13 - The grand canonical ensemble, fluctuations of energy and number of particles

Topic 14 - The grand canonical partition function for non-interacting degrees of freedom, chemical equilibrium, adsorption sites

Topic 15 - The density operator and quantum ensembles

Topic 16 - Quantum many particle systems, symmetry of the wavefunction, boson and fermions, non-interacting particles

Topic 17 - Two particle density matrix in real space, N particle partition function in real space representation, grand canonical partition function for non-interacting fermions and bosons

Topic 18 - Average occupation numbers, comparison with and validity of the classical limit of a quantum ideal gas, the harmonic oscillator and bosons

Topic 19 - Debye model for the specific heat due to ionic vibrations, black body radiation

Topic 20 - Ideal quantum gas of fermions or bosons, density, pressure, energy, classical limit

Topic 21 - Degenerate fermi gas, Sommerfeld model of electrons in a metal, Fermi energy, specific heat

Topic 22 - Pauli paramagnetism of an ideal fermi gas

Topic 23 - Ideal gas of bosons, Bose-Einstein condensation

Topic 24 - Bose-Einstein condensation in laser cooled atomic gases, classical spin models and ensembles

Topic 25 - Ising model, phase transitions and the thermodynamic limit, phase diagram

Topic 26 - Mean field approximation for the Ising model, graphical solution

Topic 27 - Critical exponents, Maxwell construction, Landau's theory of phase transitions

Topic 28 - Critical exponents in Landau theory, exact solution of 1D Ising model

Topic 29 - Landau-Ginzburg theory, correlation length, fluctuations and the upper critical dimension