Physics 526 Statistical Physics
Textbook: Statistical Mechanics, 3rd Edition
by R. K. Pathria and Paul D. Beale
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CONTENT

Read the Historical Introduction—p. xxi-xxvi.

1. Principles of Thermodynamics (Review your undergraduate Thermodynamics)
   1.1 Entropy Maximum Principle S(E,V,N)
   Internal variables, Equilibrium conditions, Concavity of entropy
   1.2 Energy Minimum Principle E(S,V,N)
   $dE = TdS - PdV + \mu dN$, Euler relation, Gibbs-Duhem relation, Stability conditions
   1.3 Free Energy Minimum Principles
   Legendre transformation, Susceptibilities, Maxwell relations, Differentials (math)

2. Principle of Statistical Mechanics (Chap 2-6)
   2.1 Quantum phase space, Boltzmann's definition of entropy, Microcanonical ensemble
   2.2 Canonical Ensemble, Grand Canonical Ensemble
   Partition functions, First derivatives, Second derivatives, Correlation functions
   2.3 Simple applications
   Quantum gases versus classical gases, Classical limit of quantum gases, Quantum corrections of the classical limit. Equipartition principle, Internal degrees of freedom, Interacting systems, Ising model

3. Boson gases (Chap 7)
   3.1 Black-body radiation,
   Thermodynamic consideration, discovery of quantum theory, cosmic microwave backgroud radiation (CMBR)
   3.2 Lattice heat capacity
   Einstein model, Debye theory of phonons
   3.3 Bose-Einstein condensation

4. Fermion gases (Chap 8)
   4.1 Electron gas at low temperature
   4.2 Electron gas in magnetic field
   Magnetism, Heisenberg's exchange interaction, Bohr-van Leeuwen's theorem, Pauli paramagnetism, Landau diamagnetism, Quantum Hall effect

5. Phase Transitions and Critical Phenomena (Chap 12, 13, 14)
   5.1 $F = E - TS$; Order-disorder phase transitions
   First-order phase transition: Maxwell construction, Phase equilibrium, Gibbs' phase rules, Clapeyron-Clausius relation
   5.2 Second-order phase transition: Mean Field Theory
   5.2.1 Van der Waals's description of gas-liquid transitions.
   5.2.2 Paramagnetic-ferromagnetic transition: Bragg-William approximation, Weiss approximation

5.2.3 Landau Theory, order parameter, broken symmetry, correlation functions, critical exponents, universality

5.3 Scaling Hypothesis

Homogeneous functions, Widom's scaling laws, Kadanoff's spin block renormalization

5.4 Renormalization group theory

1D Ising model

Gaussian model

Wilson's k-space renormalization

5.5 Topological transitions

Absence of long-range order in 2D,

XY model

Kosterlitz-Thouless transition

5.6 Quantum phase transitions at $T = 0$

Quantum Ising chain in a transverse field