PHYS 452/626
Solid State Physics
Course Outline

1. Crystal Structure

Crystal Structure: Fundamental types of lattices, Primitive lattice, Bravais lattices, Miller Indices, Simple crystal structures in three dimensions

2. Wave Diffraction and the Reciprocal Lattice

Diffraction techniques, Bragg's Law, Reciprocal lattice vectors, Laue diffraction conditions, Laue equations, Ewald construction, Brillouin zones, Reciprocal lattices, Structure factors, X-ray diffraction techniques.

3. Lattice Dynamics and Phonons

Elastic waves, Atomic displacements and Phonons, Vibrational modes of a monatomic lattice and a lattice with a basis of two atoms – Acoustic and optical branches

4. Thermal Properties

Classical model of lattice energy and heat capacity,
Planck's distribution, Einstein model and Debye model of heat capacity.
Lattice thermal conductivity, Umklapp processes, Imperfections

5 Electrons in Metals

Quantum mechanical description of a gas of free electrons, Temperature effects on the Fermi-Dirac distribution function, Heat capacity of the electron gas, Electrical conductivity and Ohm's law, Thermal conductivity of metals, Motion in a magnetic field, Pauli paramagnetism

6. Band Theory and its Applications

Nearly free electron model – origin of energy gap,
Wave functions of electron in a periodic potential – Bloch functions and Bloch theorem, Kronig-Penney model, Tight binding approximation, Metals and insulators.
Fermi surfaces, Electron orbits, hole orbits and open orbits, Effective mass of electrons in crystals, cyclotron resonance, de Haas–van Alphen effect

7. Superconductivity

Experimental survey – infinite conductivity, Meissner effect, energy gap, heat capacity, isotope effect, etc.
Theory – thermodynamics of superconducting transition, London theory, two fluid model, elements of Bardeen, Cooper and Schrieffer theory

8. Semiconductors

Intrinsic semiconductors, Electron density and Fermi level for a simple band, Mobility in intrinsic region, Impurity or Extrinsic semiconductors, Impurity states, Thermal ionization of impurities, Cyclotron resonance in semiconductors, p-n junctions, Rectification, Transistors.