Diploma Course in Condensed Matter Physics 2012-13

Electrons and Phonons in Solids - (24 Lectures = 36 hours)

N. Binggeli & N. Stojic

Syllabus

1. CRYSTAL STRUCTURES
Bravais Lattices
Wigner-Seitz Unit Cell
Lattices with a Basis
Close Packed Lattices

2. RECIPROCAL LATTICE
Plane Waves with Lattice Periodicity
Definition of Reciprocal Lattice
Brillouin Zone

3. ELECTRONIC STATES IN A CRYSTAL
Bloch Theorem
K-dependent Hamiltonian
Band Structure
Fermi Level and Fermi Surface
Density of States
Fermi-Dirac Distribution
Heat Capacity of Free Electrons

4. QUASI-FREE-ELECTRON MODEL
Free-Electron Bands in a Ghost Lattice
Splitting Degeneracies
Estimate of Splitting with Bare Ionic Potential
Thomas-Fermi screening

5. TIGHT-BINDING APPROXIMATION
Derivation of Secular Equation
Matrix Elements between s and p States
Examples including Graphene, fcc and bcc Lattices with s, p Orbitals

6. APPLICATION OF BAND THEORY
Optical Properties of Crystals
Vertical Transitions

Direct and Indirect Gap
Velocity of a Bloch State
Semiclassical Transport
Bloch Oscillations

7. BORN-OPPENHEIMER APPROXIMATION
Full Hamiltonian (Electrons + Ions)
Electronic Hamiltonian
Newton's Equation as Classical Limit & Ion Dynamics

8. PHONONS
Expansion of Total Energy
Force Constants and Dynamical Matrix
Normal Modes
Linear Monoatomic Chain
Linear Chain with Two Springs
Acoustic and Optical Modes