

Diploma Course in Condensed Matter Physics 2013-14

Electrons and Phonons in Solids (EPS)

(24 Lectures = 36 hours)

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