

**ICTP DIPLOMA PROGRAMME IN CONDENSED MATTER
PHYSICS
2011-12**

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 Surface
Density of States
Fermi-Dirac Distribution
Energy and 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 Equations
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 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