



MR301: Concepts in Materials Science I

Materials Research Centre, IISc Bangalore

Semester I, 2007–2008

COURSE OUTLINE

The main objective of this course is to provide an overview of electric, magnetic and superconducting properties of solids.

0. Advertisement – Why bother?
1. Motivation to Study Quantum/Statistical Mechanics
 - (a) Electrical Conductivity of Metals
 - (b) Drude Theory - Success and Surprise!
2. Review of Classical Physics/Mathematics
 - (a) Mechanics
 - (b) Electrodynamics
 - (c) Linear Algebra
3. Basics of Quantum Mechanics
 - (a) Need for Quantum Mechanics Experiments
 - (b) States and Operators
 - (c) Schrodinger Equation
 - (d) Application: Quantum Well Structures
 - (e) Application: Contacts and Field Emission Devices
 - (f) Application: Phonons
4. The Hydrogen Atom and Periodic Table
 - (a) Angular Momentum
 - (b) Atomic Structure
 - (c) Periodic Table
 - (d) Application: Zeeman Effect
 - (e) Application: van der Waals Forces
5. Time Dependent Problems
 - (a) Basics of Perturbation Theory
 - (b) Two State System
 - (c) Application: Masers
 - (d) Application: Fluorescence and Phosphorescence

6. Statistical Mechanics

- (a) Review of Thermodynamics
- (b) Basic Principles of Stat. Mech.
- (c) Application: Ideal Gas
- (d) Application: Paramagnetism
- (e) Application: Thermal Expansion in Polymers
- (f) Quantum Statistical Mechanics
- (g) Application: Free Electron Theory of Metals
- (h) Application: Phonons and Thermal Expansion

7. Band Theory of Solids - Electrical Properties

- (a) Origin of Bands
- (b) Bloch's Theorem
- (c) Metals
- (d) Semiconductors

8. Magnetic Properties

- (a) Diamagnetism
- (b) Paramagnetism
- (c) Ferromagnetism, Antiferromagnetism, Ferrimagnetism
- (d) Hard and Soft Magnetic Materials

9. Superconductivity

- (a) Phenomenology
- (b) Type I and Type II Superconductors
- (c) Ginzburg-Landau Theory
- (d) BCS theory

10. Physics of Electronic Devices

- (a) P-N Junction
- (b) MOSFET
- (c) SQUID

Prerequisites

- Mathematics: You *MUST* be familiar with linear algebra to credit this course.
- Physics: I will assume that you are familiar with the concept of states, observables and Schrödinger equation etc. Also, some I will assume that you have seen some elementary statistical mechanics (both classical and quantum) before.

We will spend about six to seven lectures to *revise* these materials; this cannot be a substitute for prerequisite courses.

Course Instructors

- V. B. Shenoy, Physics (120 Raman Building), x2888, Office Hours: 4:00PM to 5:00PM on Tuesdays.
- Prof. S. A. Shivashankar, MRC, x2782.

Course Information/Notes/Help

- E-mail : mr301@mrc.iisc.ernet.in. Please use this address for any course related information.
- Web Page: <http://mrc.iisc.ernet.in/~mr301/index.html>. This page will contain notes, problem sets and other information.
- Shri. Somnath Bhowmick is the Teaching Assistant for this course. You may contact him at bsomnath@mrc.iisc.ernet.in.

Books and Reference Materials

- Beiser, *Concepts of Modern Physics*. You *MUST* be familiar with the material of this book and be comfortable with the mathematics level of this book. If not, you should go through a more elementary course before crediting this course.
- Kittel, *Solid State Physics*. Elementary Classic!
- Ashcroft and Mermin, *Solid State Physics*. Intermediate Classic!
- Ibach and Lüth, *Solid State Physics – An Introduction to Principles of Materials Science*. Excellent book at the level of Ashcroft and Mermin. Has treatments of superconductivity and quantum well structures etc.
- Elliot, *The Physics and Chemistry of Solids*. A very recent book with excellent coverage of a verity of topics. Very useful reference.
- Abrikosov, *Fundamentals of the Theory of Metals*. Top class exposition of metal theory from a Nobel laureate!
- Anderson, *Concepts in Solids*. An advanced treatment! A real gem.

Indian editions Elliot, Abrikosov and Anderson are not available.