



Department of Physics and Astronomy

PHY330 Metals, Semiconductors and Electrons in Solids

Autumn Semester

Credits: 10

Lecturer(s) and Course(s):

Prof M S Skolnick

Dr D N Krizhanovskii

Outline Syllabus

The aims of this unit are to provide a comprehensive understanding of the properties of electrons in metals, semiconductors and insulators. The course will enable students to appreciate the importance of the periodic crystal lattice in giving rise to observable properties, and will explain how the band theory of solids is able to provide a profound understanding of electrical and optical phenomena in crystalline materials.

Prerequisites Required: PHY204 Solids.

Recommended: PHY202 Quantum Mechanics.

Assessment

Written examination	85%
Two homeworks	15%

Time Allocation

Lectures:	22
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Recommended Books

J R Hook and H E Hall "Solid State Physics" (Wiley)

C Kittel "Introduction to Solid State Physics" (Wiley)

Other useful books are:

H M Rosenberg "The Solid State" (Oxford)

N W Ashcroft and N D Mermin "Solid State Physics" (Saunders College Publishing)

J S Blakemore "Solid State Physics" (Cambridge)

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Objectives

On successful completion of the course a student will be able to:

1. describe the physical reasons for the existence of bands and band gaps in crystalline solids
2. explain the importance of the concepts of Bragg diffraction, Brillouin zones and Fermi surfaces in giving rise to those properties
3. describe the behaviour of electrons in solids in applied electric and magnetic fields
4. understand the factors which control electron mobility in metals and semi-conductors.
5. understand the importance of different experimental techniques such as Hall effect, cyclotron resonance and de Haas van Alphen effect in determining the band structure of solids
6. understand the phenomenon of plasma reflectivity
7. understand the properties of amorphous materials

Lecture notes will be distributed and will be available on the web

Syllabus

1. The distinction between insulators, semiconductors and metals. The periodic table. Quantitative aspects.
2. Basic crystal structures
3. Density of states, Fermi-Dirac statistics. Free electron model
4. Electrical transport. Resistivity and scattering mechanisms in metals. Temperature dependence
5. The nearly free electron model. The periodic lattice, Bragg diffraction, Brillouin zones. Bloch functions.
6. Prediction of metallic, insulating behaviour: periodic potential and tightbinding descriptions.
7. Real metals, shapes of Fermi surfaces. Measurement of Fermi surfaces. De Haas van Alphen effect and soft x-ray emission.
8. Semiconductors. Effective mass. Electrons and holes.
9. Optical absorption in semiconductors. Excitons. Comparison with metals
10. Doping, donors and acceptors in semiconductors. Hydrogenic model
11. Semiconductor statistics. Temperature dependence.
12. Temperature dependence of carrier concentration and mobility. Compensation. Scattering mechanisms.
13. Hall effect, cyclotron resonance. Landau levels in magnetic field
14. Plasma reflectivity in metals and semiconductors
15. Semiconductor heterojunctions. Quantum wells.
16. Amorphous materials