BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE, Pilani

Pilani Campus

Second Semester 2020-2021
AUGS Division
Course Handout (Part II)

Date: 15/01/2020

In addition to Part I (General Handout for all courses appended to the Time Table), this portion gives further specific details regarding the course.

Course No. **: PHY F341**
Course Title **: Solid State Physics**
Instructor In-charge **: Subhashis Gangopadhyay**
Instructor(s) :

1. Course Description

The course covers the physical aspects of the matter in condensed state from an atomistic view point. It is an introduction to the solid state physics, begins with the basic concepts of crystallography along with lattice vibrations and related thermal properties, energy states and electronic band theory, free electron models and related electrical properties and magnetism. This course also dealt with various important class of materials such as semiconductors, insulators and superconductors. Thus overall topics covered here includes the structural, thermal and electrical properties of matter.

2. Scope and Objectives

- To provide physical as well as mathematical understanding of various phenomena in solid state physics associated mainly with crystalline solids
- Lay the foundation for a working and understanding of solids through fundamental theoretical concepts.

3. Prescribed Text Book

- T1: Introduction to Solid State Physics, C. Kittel, 8th ed., Wiley (2005)

4. Reference Book

- R1: Solid State Physics, N W Ashcroft and N D Mermin, 1st ed., Thomson (1976) (for theoretical understanding)
- R2: Elementary Solid State Physics: Principles and Applications by M Ali Omar Pearson Publications (for materials aspect and theory)
- R3: Materials Science and Engineering: An introduction by W D Callister (Materials aspect)
- R4: Solid State Electronic Devices Ben G Streetman Pearson seventh edition (Device aspect of SSP)

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5. Course Plan

Module Number	Lecture session/Tutorial session	Reference	Learning Outcome
1. Crystal Structure	• L1.1-2. Concept of lattice, Periodic array of atoms, fundamental types of crystal structures. • L 1.3-4. Planes and Directions in crystals, Miller indices, Planar and linear densities, family of planes and directions • L1.5 Primitive cells, unit cell, Wigner-Seitz cell and translation operations, crystal symmetry • L1. 6-7 Some ceramic structures NaCl, CsCl, ZnS, Carbon based materials etc, their planar, linear densities, packing fraction • T. Exercise problems	T 1: Kittel Chapter 1 and R1, R4 Based on T1, R1-4	To understand the basic crystallography and atomic arrangement in solids, extending this knowledge to the structures in semiconductor technology (silicon) and crystalline solids in other fields.
2. Wave diffraction and the reciprocal lattice	• L2.1 Bragg Diffraction, Structural factor calculation • L2.2 Reciprocal space, reciprocal lattice, examples (BCC, FCC), Brillouin Zones • L2.3 Zone plane and zone axis	T 1: Kittel Chapter 2 and R1	Understanding of reciprocal lattice, Bragg diffraction applicable in electron, neutron and X-ray diffraction.
3. Crystal binding	• L3.1 Crystals of inert gases, Van der Waals interaction, repulsive interaction, cohesive energy • L3.2. Ionic crystals, covalent crystals and metals, hydrogen bonds. **Chapter excludes elastic constants.** • T: On problems from chapter 3	T1: Kittel chapter 3, R3	To understand the crystal bonds in various types of solids, which will further help to know the advanced materials for technology.
4. Crystal Vibrations: Phonons I	• 4.1 Monatomic Crystals, wave propagation and dispersion relation • 4.2 Diatomic Crystals wave propagation and dispersion relation • T: Problems of Chapter 4	T1: Kittel Chapter 4	Basics understanding of lattice vibrations
5. Crystal Vibrations: Phonons II	• L5.1: Thermal properties, Einstein and Debye Models of Heat Capacity-I thermal expansion, thermal conductivity • L5.2: Thermal properties Einstein and Debye Models, T^3 law of Heat Capacity-II • L5.3: Thermal expansion, thermal conductivity, thermal resistivity of phonon gas • T. Problems on Chapter 5	T1: Kittel Chapter 5	Lattice vibrations and their effect on thermal properties
6.Free electron Fermi Gas	• L6.1: Drude's model, electrical and thermal conductivity of metals • L6.1: Somerfield's model, Fermi Dirac Distribution, Free electron gas in 3D, Fermi energy	T1: Kittel Chapter 6 and R1	In depth understanding of electrical transport in metals. Identification of charge carriers, sign and concentration using Hall

	• L6.3: Density of States in 1 , 2 and 3 dimensions • L6.4-5 Hall Effect, Heat capacity • T Problems on chapter 6		effect. Vast applications in semiconductors industry.
7. Energy Bands and Nearly free electron model	• L7.1 Energy Bands, Bloch Functions, Kronig-Penney Model-I • L7.2 Energy Bands, Bloch Functions, Kronig-Penney Model-II • L7.3 Energy Bands, Bloch Functions, Kronig-Penney Model-III • L7.4 Energy Bands, Bloch Functions, Kronig-Penney Model-IV • T Problems on chapter 7	T1: Kittel Chapter 7, R4 Chap. 3	Clear understanding of the energy band formation in solids. Behavior of materials in low dimensions, mesoscopic systems
8. Semiconductor crystals	• L8.1 Intrinsic Carrier Concentration, Mobility, Donor and Acceptor States • L8.2 p-n junctions and bands • L8.3: Electrical conductivity in semiconductors • T Problems on chapter 8	T1: Kittel Chapter 8, R4 Chap. 3	Bands in semiconductors, p-n Junctions, formation and bands, charge carrier concentration and electrical transport and doping in semiconductors.
9. Fundamentals of Superconductivity	• L9.1 Occurrence of superconductivity and its destruction by magnetic fields. • L9.2.Meissner Effect, Type I and II superconductors • L9.3. Elementary BCS theory, cooper pairs • L9.4 High Tc superconductors and properties • T Problems on Chapter 10	T1: Kittel Chapter 10	To get an idea of superconductivity and some theories that can explain this phenomenon. Also to know some interesting properties of Superconductors.
10. Diamagnetism and Paramagnetism	• L10.1 Langevin diamagnetism equation, paramagnetism, and quantum theories – I • L10.2 Langevin diamagnetism to explain the same. equation, paramagnetism, and quantum theories – II • L10.3-5 Langevin diamagnetism equation, paramagnetism, and quantum theories – III • T problems on chapter 11	T1: Kittel Chapter 11	To understand magnetic nature of materials and theories to explain the same.

6. Evaluation Scheme:

Evaluation Components	Weightage (%)	Date & Time	Remarks
Mid-semester test	30		Online mode
Comprehensive	40	15/05/2021 (FN)	Online mode
Tutorials and assignments	30	TBA in lecture class	Online mode

After completing this course the students will be able to

1) Understand basics of the crystallography.
2) Understand the lattice vibrations and their consequences on electrical and structural properties
3) Energy Band formation in solids, basic theories
4) Compare the electrical properties of metals, semiconductors, insulators and superconductors.

Open Book Exam: Use of the textbook (T1) and reference book (R1) will be allowed. Photocopy of these books will also be allowed. Besides, only **hand-written class notes** are permitted. Use of calculators will be allowed in all exams. No exchange of any material will be allowed during exams.

Note:

Class will be conducted in online mode through Google meet link. All study related materials will be uploaded and the exams will be conducted through a specified Google class room. It shall be the responsibility of the individual student to be regular in maintaining the self study schedule as given in the course handout, attend lectures. Mid Semester Test and Comprehensive Examination are according to the Evaluation Scheme given in the respective Course Handout. If the student is unable to appear for the Regular Test/Examination due to genuine exigencies, the student must refer to the procedure for applying for Make-up Test/Examination. No make up for the tutorials or assignments.

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PHY F341.

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