Course: Core Paper XII– HPHCR5122T & HPHCR5122P

Semester	V
Paper Number	HPHCR5122T & HPHCR5122P
Paper Title	SOLID STATE PHYSICS
No. of Credits	06 (Theory – 4, Lab – 2)
Theory/ Composite	Composite
No. of periods assigned	Th:4 periods/week Pr:3 periods/week
Name of Faculty member(s)	
Course description/ objective	The solid state physics course conveys an understanding of how it has contributed to the existence of a number of important technological developments of importance in our lives now and in the future and will enable the student to employ classical and quantum mechanical theories needed to understand the physical properties of solids. Emphasis is put on building models able to explain several different phenomena in the solid state. On completion of the course, the student should have the following learning outcomes defined in terms of knowledge, skills and general competence: From the Knowledge point of view, the student is able to explain the structural (crystallographic), mechanical (elastic), thermal (lattice vibration), electrical (Free electron theory) & electronic (band theory) and magnetic (Dia, Para and Ferro) properties of solid matter and special phenomena like superconductivity. From the Skill point of view, the student is able to critically evaluate the approximations needed to build models to understand the solid state. And finally in terms of General competence, the student should 1) Have insight into classical and quantum mechanical laws which can be applied to explain the properties of the solid state. 2) Formulate and understand theories explaining the behavior of the solid state. 3) Know the role of solid state physics in important technological developments. 4) Read and be able to understand research articles in certain fields of physics
Syllabus	As enclosed
Texts	As enclosed

Reading/ Reference Lists	As enclosed
Evaluation	Total – 100 (Theory – 60, Practical – 40) Theory – CIA – 10 Semester Examination – 50 Group A (25 marks) Group B (25 marks) One 10 marks qs out of two qs One 10 mark qs out of two qs Three 5 mark qs out of five qs Three 5 mark qs out of five qs

Syllabus:

HPHCR5122T - SOLID STATE PHYSICS (Credits – Theory – 04, Practical – 02)

Module – A [26 lectures]

Crystal Structure

Solids: Amorphous and Crystalline Materials, Lattice Translation Vectors, Lattice with a Basis – Central and Non-Central Elements, Unit Cell, Types of Lattices (2D & 3D), Miller Indices, Packing fraction, Reciprocal Lattice, Brillouin Zone, Diffraction of X-rays by Crystals - Bragg's Law, Atomic scattering factor & Structure factor. [10 lectures]

Elementary band theory

Kronig Penney model, Band Gap, Effective mass, Conductor, Semiconductor and insulator, Semiconductor – Conductivity, mobility, Hall Effect - Hall coefficient, Measurement of conductivity (Four probe method). [10 lectures]

Superconductivity

Experimental Results, Critical Temperature, Critical magnetic field, Meissner effect, Type I and type II Superconductors, London's Equation and Penetration Depth, Isotope effect, Basics of BCS theory (No derivation) [6 lectures]

Module – B [26 lectures]

Elementary Lattice Dynamics

Lattice Vibrations and Phonons: Linear Monoatomic and Diatomic Chains, Acoustical and Optical Phonons, Qualitative Description of the Phonon Spectrum in Solids, Specific Heat of Solids - Dulong and Petit's Law, Einstein and Debye theories - T^3 law. [8 lectures]

Magnetic Properties of Matter

Dia-, Para- and Ferromagnetic Materials, Classical Langevin Theory of dia– and Paramagnetic Domains, Curie's law, Weiss's Theory of Ferromagnetism and Ferromagnetic Domains, Curie-Weiss law, B-H Curve - Hysteresis and Energy Loss. [8 lectures]

Dielectric Properties of Materials

Polarization, Local Electric Field at an Atom, Depolarization Field, Electric Susceptibility, Polarizability, ClausiusMossotti Equation, Classical Theory of Electric Polarizability, Normal and Anomalous Dispersion, Complex Dielectric Constant. [6 lectures]

Ferroelectric Properties of Materials

Structural phase transition, Classification of crystals, Ferroelectric effect, Curie-Weiss Law, PE Hysteresis loop. [4 lectures]

Reference Books

1. Introduction to Solid State Physics, Charles Kittel, 8th Edition, 2004, Wiley India Pvt. Ltd.
2. Introduction to Solids, Leonid V. Azaroff, 2004, Tata Mc-Graw Hill.
3. Solid State Physics, N.W. Ashcroft and N.D. Mermin, 1976, Cengage Learning.
4. Solid-state Physics, H. Ibach and H. Luth, 2009, Springer.
5. Solid State Physics, A. J. Dekker, 2000, Macmillan.
6. Introduction to Superconductivity, Michael Tinkham

HPHCR5122P - Solid State Physics Lab ; Credits – 2 (39 periods)

1. To measure the Dielectric Constant of a Dielectric Material.
2. To study the P-E Hysteresis loop of a Ferroelectric Crystal.
3. To measure the magnetic susceptibility of solids.
4. To draw the B-H Hysteresis curve of a Ferromagnetic material & determine its energy loss.
5. To measure the resistivity of a semiconductor with temperature by four-probe method and to determine its band gap.
6. To investigate the magnetic field between the pole pieces of an electromagnet using a ballistic galvanometer and calibration of a Hall probe.
7. To study temperature coefficient of a semiconductor (NTC thermistor)
8. Lattice Dynamics

Reference Books:

1. Advanced Practical Physics, Ghosh&Mazumdar, 2004, SreedharPublishers,Kolkata.
2. An Advanced Course in Practical Physics,Chattopadhyay& Rakshit,2011, Central, Kolkata
3. A Textbook of Advanced Practical Physics Samir Kumar Ghosh, 2008, NCBA, Kolkata.
4. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House.
5. Elements of Solid State Physics, J.P. Srivastava, 2nd Ed., 2006, Prentice-Hall of India.

Paper Structure for laboratory

(a) Marks for experiment : **30 marks**
   (i) Class performance on any one expt. – 8
   (ii) Lab. Viva on the same experiment as (i) - 7
   (iii) LNB for each of the three experiments - 5 x 3 = 15

(b) Grand Viva – **8 marks**

(c) Attendance – **2 marks**

[Students are to complete 3 experiments]