Course: M.Sc (Physics)

Semester	3
Paper Number	14 (MPHC4315)
Paper Title	Elective (For Condensed Matter Physics: Crystallography (Group Theoretical and Structural Aspects)) and Advanced lab II
No. of Credits	6
Course description/objective	**Group A:** The course is an introduction to the group theoretical and structural aspects of crystallography. X-ray diffraction is a widely used technique for the determination of crystal structures at the atomic level. The first part of the course introduces the concept of symmetry operators, projections, crystallographic point groups and their irreducible representations. The second part deals with the theoretical aspects of diffraction by crystals, geometry of diffraction, experimental aspects of XRD and techniques of solving single crystal structures. **Group B:** The purpose of including this topic in the syllabus is to make the students familiar with some standard experimental methods or techniques to verify some theories of physics and to study the characteristics of some systems. The objective of this course is to help the students to develop the skills necessary to perform experiments and also to learn how to analyze the experimental data for the following purposes or experimental schemes: to study the temperature dependence of dielectric constant, to find the magnetic susceptibility of a paramagnetic specimen using Guoy's balance, to study the characteristics of a solar cell, to study the characteristics of Hall effect in metal, to study the surface roughness using a surface profilometer, to determine the band gap of a given semiconductor material, to study viscosity using a rotating viscometer, to study thermo-luminescence of alkali halides, to study viscous fingering in Hele-Shaw cell.
Course Outcome	**Group A** CO1: Understanding the concept of symmetry operators and symmetry elements, idea of projections, detailed study of crystallographic point groups with their stereographic projections. CO2: Study of irreducible representations of simple point groups, understanding the rotation and translation groups. CO3: Derivation of expression for Thomson's scattering by a single electron, scattering by an atom, Laue and Bragg equation, structure factor, data collection technique, systematic absences, L-p factors, extinction, absorption correction. CO4: Application of Fourier series method in structure determination, phase problem. Brief descriptions of Heavy-atom method and direct method. **Group B** The Course Outcome of Advanced Lab-II is given below in the form of a list of experiments that the students will be taught to perform. While performing each of these experiments (listed below), they are expected to learn the experimental techniques as well as the theories required for the analysis of experimental data. Students will learn to represent their experimental findings properly. As an obvious outcome of the course, the experimental skill of each student is expected to be sufficiently enhanced. CO1: An experimental studyof the temperature dependence of dielectric constant. CO2: An experimental study of the determination of magnetic susceptibility of a paramagnetic specimen using Guoy's balance. CO3: An experimental studyto characterize a solar cell. CO4: An experimental studyto find the characteristics of Hall effect in metal CO5: An experimental studyto measure the surface roughness using a surface profilometer.

	CO6: An experimental study to determine the Band gap of a given semiconductor. CO7: An experimental study of viscosity of a given sample using rotating viscometer. CO8: An experimental study of thermo-luminescence of alkali halides. CO9: An experimental study of viscous fingering in Hele-Shaw cell.
Syllabus	**<u>Group A: (Elective)</u>** **<u>Crystallography (Group Theoretical and Structural Aspects)[36 lectures]</u>** Symmetry groups and group representation: Crystal symmetry operators, symmetry elements and interrelations, stereographic projection, crystallographic point groups, Schoenflies notation, Hermann – Mauguin notation, irreducible representation of point groups, three dimensional rotational groups, translation group and space groups, crystal field splitting of atomic energy levels. [14 lectures] Diffraction of x-rays: Scattering by a single electron and an atom, integrated intensity, Laue and Bragg equation, limiting sphere, structure factor equation, limiting conditions and systematic absences, space group determination. Data collection techniques for single crystals and polycrystalline material, data reduction, Lorentz and polarization factors, extinction, absorption correction, temperature factor. [8 lectures] Fourier series method in structure determination, phase problem, methods for structure solution, Heavy-atom method, Patterson function & its properties, Harker lines, Harker planes, isomorphous replacement and anomalous scattering methods. Direct method, structure invariants & semi-invariants, Hasker-Kasper inequality, sign relationship, Sayre’s equation, Karle-Hauptmann procedure, Tangent formula, least squares refinement, Goodness of fit. Elements of neutron diffraction. [14 lectures] **<u>Group B: Advanced lab II</u>** **<u>List of Experiments</u>** 1. To study the temperature dependent Dielectric constant of a given specimen. 2. To find the magnetic susceptibility of a paramagnetic specimen using Guoy's balance or other suitable method. 3. Characterization of a Solar cell. 4. To study the Hall effect in metal. 5. To study surface roughness using a surface profilometer. 6. Determination of Band gap of a given semiconductor material. 7. Rotating viscometer. 8. Study of colour centers and thermo-luminescence of alkali halides. 9. Viscous fingering in Hele-Shaw cell.
References	**<u>Group A</u>**: 1. Group Theory and Quantum Mechanics – Michael Tinkham 2. Group Theory and its application to the Quantum Mechanics of Atomic Spectra – Eugene P. Wigner 3. Elements of Group Theory for Physicists – A. W. Joshi 4. Structure determination by X-ray crystallography – M. Ladd & R. Palmer

	5. X-ray diffraction – B. E. Warren **Group B:** 1. Physics of Semiconductor Devices by S.M. Sze, Wiley. 2. Solid State Electronic Devices by Streetman, Pearson Education India. 3. Semiconductor Optoelectronic Devices by P. Bhattacharya, Prentice Hall. 4. Semiconductor Devices, Physics & Technology, Sze & Lee, Wiley. 5. The Hall Effect and Its Applications by Chien & Westgate, Springer 6. The Hall Effect in Metals and Alloys, By Colin M. Hurd, Springer. 7. Viscometry for Liquids by S.V. Gupta, Springer.
Evaluation	Total: 100 **Group A:** CIA: 10 End Semester Examination: 40 **Group B:** CIA: 30 marks (10 (LNB) + 20 (Lab performance)) End Semester Examination: 20