Gyanmanjari Innovative University

Course Syllabus
Gyanmanjari Science College
Semester-3 (M.Sc.)

Subject: Condensed Matter Physics-MSCPH13514

Type of course: Major

Prerequisite: Basics of crystallography and magneto statics in matter.

Rationale: The course aims to train the learner lattice vibrational and electronic properties of solid-phase materials. and introduce the learners to the concept of dielectric properties of semiconductors with reference to some technological applications.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks					Total Marks
CI	T	P	C	Theory Marks		Practical Marks		CA	
				ESE	MSE	V	P	ALA	
4	0	0	4	60	30	10	00	50	150

Legends: CI-Class Room Instructions; T – Tutorial; P - Practical; C – Credit; ESE - End Semester Examination; MSE- Mid Semester Examination; V – Viva; CA - Continuous Assessment; ALA- Active Learning Activities.

Continuous Assessment:

Sr. No	Active Learning Activities	Marks
1	**Crystallography and Brillion Zones Workshop** Students need work in groups to construct crystal structures using models, simulate lattice vibrations for mono- and di-atomic lattices, and visualize Brillion zones in different schemes (reduced, periodic, extended) and upload outcome on GMIU web portal.	10
2	**Band Theory Simulation and Analysis** Students have to use simulation software to model energy bands using the nearly-free-electron model, Kronig-Penney model, and pseudo potential method. They will analyze the results and compare them with theoretical predictions and upload outcome to the GMIU web portal.	10

3	**Dielectric Properties and Plasmon Experiment** Students have to perform experiments or simulations to measure and analyze the dielectric constant, frequency-dependent dielectric response, Plasmon oscillations and calculate the Hall effect, band effective mass and upload outcome in GMIU web portal.	10
4	**Superconductivity Case Study and Demonstration** Students will investigate real-world applications of superconductivity, such as magnetic levitation or MRI technology and prepare report and upload it to GMIU web portal.	10
5	**Integrate concepts from crystallography, electron theory, semiconductors, and superconductivity into a cohesive project:** Students will work in teams to develop a project that involves designing a hypothetical material or device based on the principles learned and upload outcome in GMIU web portal.	10
	Total	**50**

Course Content:

Unit No	Course content	Hrs	% Weightage
1	**Chapter-1 Elements of Solid State Physics-I:** Resume of crystallography, Classification of crystals, Symmetry elements–Point group and Space group. Vibration of mono- and di-atomic lattice, First Brillouin zone, group velocity and continuum limit, Quantization of phonons–Einstein and Debye theory of lattice vibration, Elastic properties–Stress and Strain components, Dilation, Elastic compliance, Stiffness, Elastic constants for cubic isotropic crystal. Structure of Brillouin zones, Reduced zone scheme, Periodic zone scheme, Extended zone scheme, Construction of free electron Fermi surfaces, Measuring the Fermi surfaces–The de Haas-van Alphen effect	15	25%
2	**Chapter-2 Electron Theory of Solid State Physics:** Nearly–free–electron model, Formation of energy bands, Band gap, The empty-lattice energy bands, Bloch function and Bloch theorem, The Kronig-Penney model, Motion of electrons in one dimension according to band theory, Plane-Wave method, Orthogonalized Plane-Wave (OPW) method, The pseudopotential method	15	25%

3	**Chapter-3 Semiconductors, Plasmon and Dielectrics:** Band gap in semiconductor, Equation of motion for electrons in energy band, The band effective mass and holes, Hall effect. Free electron Fermi gas: Longitudinal plasma oscillation, Concept of Plasmon, Electrostatic screening, Screened Coulomb potential, Lindhard static dielectric function. Polarization, Static dielectric constant, Local field and Clausius-Mossotti relation, Sources of polarizability, Theory of electronic polarization, Ionic polarization, Theory of dipolar polarization, Frequency dependent complex dielectric constant, Concept of relaxation time, dielectric loss, Piezoelectricity, Ferroelectricity.	15	25%
4	**Chapter4 Superconductivity:** Superconductivity–Meissner effect, London equations, London penetration depth, coherence length, Critical field, Type-I and type-II superconductors, Thermodynamic properties, Energy gap, Electron-phonon coupling, Isotope effect, Cooper pair, BCS theory, Flux quantization in a superconducting ring, Ginzburg-landau theory, Josephson tunneling, Applications.	15	25%

Suggested Specification table with Marks (Theory):60

Distribution of Theory Marks **(Revised Bloom's Taxonomy)**						
Level	Remembrance (R)	Understanding (U)	Application (A)	Analyze (N)	Evaluate (E)	Create (C)
Weightage	20%	40%	30%	10%	-	-

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

Course Outcome:

After learning the course the students should be able to:	
CO1	Understand crystallography, lattice vibrations, Brillouin zones, and elastic properties of solid materials.
CO2	Apply models like nearly-free-electron, Kronig-Penney, and pseudopotential methods to describe energy bands and electronic structure.
CO3	Analyze semiconductor band gaps, plasmons, dielectric functions, and various forms of polarization and their frequency dependence.
CO4	Grasp the Meissner effect, London equations, BCS theory, and applications of superconductivity including flux quantization and Josephson tunneling.

Instructional Method:

The course delivery method will depend upon the requirement of content and need of students. The teacher in addition to conventional teaching method by black board, may also use any of tools such as demonstration, role play, Quiz, brainstorming, MOOCs etc.

From the content 10% topics are suggested for flipped mode instruction.

Students will use supplementary resources such as online videos, NPTEL/SWAYAM videos, e-courses, Virtual Laboratory

The internal evaluation will be done on the basis of Active Learning Assignment

Practical/Viva examination will be conducted at the end of semester for evaluation of performance of students in laboratory.

Reference Books:

[1] Elements of X-ray Diffraction: B. D. Cullity (Addison-Wesley Publishing Co. INC)
[2] Applied Solid State Physics: Rajnikant (Wiley India Pvt. Ltd.).
[3] Introduction to Solid State Physics: C. Kittle (John Wiley & Sons).
[4] Elements of Solid State Physics: J. P. Srivastava (Prentice Hall of India).
[5] Solid State Physics: Structure and Properties of Materials: M. A. Wahab (Narosa Pub).
[6] Elementary Solid State Physics: M. A. Omar (Addison-Wesley Publishing Company).
[7] Solid State Physics: Aschroft and Mermin (Harcourt College Publishers).
[8] Intermediate Quantum Theory of Crystalline Solids: A. O. E. Animalu (Prentice Hall of India).