SEMESTER - V

Subject Title: Solid State Physics
Subject Code: PCMP-511
Weekly Load/Credits: 3h/03

L	T	P
3	0	0

Course Outcomes (COs): After successful completion of the course, the students will be able to:

CO1: Explain crystal structures, lattice geometry, Miller indices, reciprocal lattice and X-ray diffraction principles.
CO2: Describe lattice vibrations and analyze classical and quantum theories of specific heat in solids.
CO3: Explain magnetic behavior of materials and apply classical and quantum models to diamagnetism, paramagnetism and ferromagnetism.
CO4: Analyze dielectric polarization mechanisms, dispersion relations and dielectric constants in materials.
CO5: Explain band theory, semiconductor behavior, Hall effect and charge transport in solids and superconductor.

UNIT – I

Crystal Structure: Solids, amorphous materials, crystalline materials, lattice translation vectors, lattice with basis, unit cell, Miller indices, reciprocal lattice, types of lattices, Brillouin zone, diffraction of X-Ray by crystals, Bragg's Law, atomic and geometrical factor. **(10 Lectures)**

Elementry Lattice Dynamics: Dulong and Petit's Law, Einstein and Debye theories of specific heat of solids, T^3 law. **(4 Lectures)**

Dielectric Properties of Materials: Polarization, local electric field at an atom, depolarization field, electric susceptibility, polarizability, normal and anomalous dispersion, Cauchy and Sellmeir relations, Langevin -Debye equation, complex dielectric constant. **(7 Lectures)**

UNIT – II

Magnetic Properties of Matter: Diamagnetic, paramagnetic, ferrimagnetic materials, classical Langevin theory of diamagnetic and paramagnetic domains, quantum mechanical treatment of para magnetism, Curie's law, Weiss's theory of ferromagnetism and ferromagnetic domains, discussion of B-H curve, Hysteresis and energy loss.

(11 Lectures)

Elementary Band Theory: Kronig Panney model, band gaps, conductors, semiconductors and insulators, types of semiconductors (P type, N Type), conductivity of semiconductors, mobility, Hall Effect, Hall Coefficient. **(6 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. **(4 Lectures)**

Theory: 42 hrs

Reference Books:

- Introduction to Solid State Physics, Charles Kittel, 8 th Ed., 2004, Wiley India Pvt. Ltd.
- Elements of Solid-State Physics, J.P. Srivastava, 2 nd Ed., 2006, Prentice-Hall of India.
- Introduction to Solids, Leonid V. Azaroff, 2004, Tata Mc-Graw Hil.
- Solid State Physics, Neil W. Ashcroft and N. David Mermin, 1976, Cengage 14 Learning.
- Solid State Physics, Rita John, 2014, McGraw Hill.
- Solid-state Physics, H. Ibach and H Luth, 2009, Springer.
- Elementary Solid-State Physics, 1/e M. Ali Omar, 1999, Pearson India.
- Solid State Physics, M.A. Wahab, 2011, Narosa Publications.

Subject Title: Solid State Physics Lab
Subject Code: PCMP-512
Weekly Load/Credits: 4h/02

L	T	P
0	0	4

Course Outcomes (COs): After successful completion of the course, the students will be able to:

CO1: Understand properties of magnetic and dielectric materials.
CO2: Perform experiments on magnetic and electrical measurements.
CO3: Analyze hysteresis, resonance and Hall effects.
CO4: Determine key material parameters experimentally.
CO5: Interpret data and present experimental results.

List of Practicals:

1. Measurement of susceptibility of paramagnetic solution (Quinck`s tube method).
2. To measure the magnetic susceptibility of solids.
3. To determine the coupling coefficient of a piezoelectric crystal.
4. To measure the dielectric constant of a dielectric materials with frequency.
5. To determine the value of Boltzmann constant.
6. To determine the Curie temperature of a ferroelectric material.
7. To study the PE hysteresis loop of a ferroelectric crystal.
8. To draw the BH curve of iron using a solenoid and determine the energy loss from hysteresis.
9. To measure the resistivity of a semiconductor (Ge) crystal with temperature by four probe method (from room temperature to 150°C) and to determine its band gap.

10. To determine the Hall coefficient of a semiconductor sample.
11. To study the magnetic field produced by a current carrying solenoid using a pick-up coil/Hall sensor and to find the value of permeability of air.
12. To determine the Curie temperature (T°c) of a ferromagnetic material.

Total: 56 hrs

Reference Books:

- Advanced Practical Physics for students, B.L. Flintand H.T.Worsnop, 1971, Asia Publishing House.
- Advanced level Physics Practicals, Michael Nelsonand Jon M. Ogborn, 4thEdition, reprinted 1985, Heinemann Educational Publishers.
- A Text Book of Practical Physics, Indu Prakash and Ramakrishna, 11th Ed., 2011, Kitab Mahal, New Delhi.
- Elements of Solid State Physics, J. P. Srivastava, 2nd Ed., 2006, Prentice-HallofIndia.

Subject Title: Quantum Mechanics
Subject Code: PCMP-513
Weekly Load/Credits: 4h/04

L	T	P
3	1	0

Course Outcomes (COs): After successful completion of the course, the students will be able to:

CO1: Understand the time-dependent and time-independent Schrödinger equations and the physical interpretation of wave functions.
CO2: Analyze stationary states, energy eigenvalues, wave packets, and uncertainty relations in quantum systems.
CO3: Solve bound-state problems in one-dimensional potentials and explain the origin of discrete energy levels.
CO4: Explain the quantum theory of hydrogen-like atoms, angular momentum operators and associated quantum numbers.
CO5: Understand atomic behavior in electric and magnetic fields, electron spin, Zeeman effect and the structure of many-electron atoms.

UNIT - I

Time Dependent Schrodinger Equation: Time dependent Schrodinger equation and dynamical evolution of a quantum state, properties of wave function, interpretation of wave function probability and probability current densities in three dimensions, conditions for physical acceptability of wave functions, normalization, linearity and superposition principles, eigen values and eigen functions. **(7 Lectures)**

Time Independent Schrodinger Equation: Hamiltonian, stationary states and energy eigen values; expansion of an arbitrary wave function as a linear combination of energy eigen functions, general solution of the time dependent Schrodinger equation in terms of linear combinations of stationary states, application of the spread of

Gaussian wave packet for a free particle in one dimension, wave packets, Fourier transforms and momentum space wave function, position-momentum uncertainty principle. **(10 Lectures)**

General Discussion of Bound States in an Arbitrary Potential: Continuity of wave function, boundary condition and emergence of discrete energy levels; application to one-dimensional problem-square well potential. **(4 Lectures)**

UNIT - II

Quantum Theory of Hydrogen-like Atoms: Time independent Schrodinger equation in spherical polar coordinates, separation of variables for the 2^{nd} order partial differential equation, angular momentum operator and quantum numbers. **(6 Lectures)**

Atoms in Electric and Magnetic Fields: Electron angular momentum, space quantization. electron spin and spin angular momentum, Larmor's theorem, spin magnetic moment, Stern-Gerlach experiment, Zeeman effect, electron magnetic moment and magnetic energy, gyromagnetic ratio and bohr magneton. **(8 Lectures)**

Atoms in External Magnetic Fields: Normal & anomalous Zeeman Effect. **(2 Lectures)**

Many Electron Atoms: Pauli's exclusion principle, symmetric and antisymmetric wave functions, periodic table, fine structure, spin orbit coupling, spectral notations for atomic states, total angular momentum, vector model, spin-orbit coupling in atoms, L-S and J-J couplings. **(5 Lectures)**

Theory: 42 hrs

Reference Books:

- A Textbook of Quantum Mechanics, P. M. Mathews & K. Venkatesan, 2^{nd}Ed., 2010, McGraw Hill.
- Quantum Mechanics, Robert Eisberg and Robert Resnick, 2^{nd}Edn., 2002, Wiley.
- Quantum Mechanics, Leonard I. Schiff, 3^{rd}Edn.2010, Tata McGrawHill.
- Quantum Mechanics, G. Aruldhas, 2^{nd}Edn. 2002, PHI Learning of India.
- Quantum Mechanics, Bruce Cameron Reed, 2008, Jones and Bartlett Learning.
- Quantum Mechanics for Scientists & Engineers, D. A. B. Miller, 2008, Cambridge University Press.

Additional Books for Reference:

- Quantum Mechanics, Eugen Merzbacher, 2004, John Wiley and Sons, Inc.
- Introduction to Quantum Mechanics, David J. Griffith, 2^{nd}Ed. 2005, Pearson Education.

Subject Title: Laser and Fiber Optics
Subject Code: PCMP-514
Weekly Load/Credits: 3h/03

L	T	P
3	0	0

Course Outcomes (COs): After successful completion of the course, the students will be able to:

CO1: Understand laser characteristics and basic radiation processes.

CO2: Explain laser principles, population inversion, and pumping methods.
CO3: Describe types of lasers and their working with applications.
CO4: Explain optical fiber structure, modes, and transmission losses.
CO5: Understand optical fiber communication systems and their applications.

UNIT – I

Characteristics of Lasers: Directionality, monochromaticity, intensity, coherence and related numerical problems. **(3 Lectures)**

Basics of Lasers: Absorption of radiation, spontaneous and stimulated emission of radiation, Einstein's coefficients, relation between Einstein's coefficients, condition for light amplification population inversion, components of a laser cavity, concept of line shape function and line width, pumping methods, pumping scheme and lasing action for two, three and four level lasers (basic concept and comparison), types of optical resonators, stable and unstable resonators, longitudinal modes (based on standing waves), continuous and pulsed lasers. **(13 Lectures)**

Types of Lasers and Applications: Working and applications of Ruby laser, He–Ne laser, semiconductor laser, basics of Holography. **(5 Lectures)**

UNIT – II

Optical Fibers: Basic theory and physical structure of optical fiber, acceptance angle and numerical aperture, fiber materials-glass fiber, plastic fiber, modes in an optical fiber, single mode fibers, multimode fibers, step index fibers, pulse dispersion in step index fibers, graded index fibers, V-number and classification of optical fibers, losses in optical fibers, attenuation in optic fibers, materials or impurity losses, Rayleigh scattering losses, absorption loss, leaky modes, bending losses, radiation induced losses, temperature dependence of fiber losses, core and cladding losses. **(9 Lectures)**

Optical Fiber Communication: Optical fiber communication system and its components, fiber coupling, splices and connectors, windows in optical fiber communication, first and second generation fiber optic communication system, single mode fibers and the third generation optical communication system operation at 1.5 um wavelength, fourth generation optical fibers, applications fiber optic system, advantage of fiber optic system over conventional communication system. **(7 Lectures)**

Other Applications of Optical Fibers: Fiber in cable TV and internet, Fiber optic sensors (basic idea), medical applications (endoscopy), industrial applications, defence and aerospace uses. **(5 Lectures)**

Theory: 42 hrs

Reference Books:
- Lasers — A. E. Siegman
- Understanding Lasers: An Entry-Level Guide — Jeff Hech
- Optical Fiber Communications — Gerd Keiser
- Fiber-Optic Communication Systems — Govind P. Agrawal
- Fundamentals of Photonics — Saleh & Teich
- Optics and Lasers: Including Fibers and Optical Waveguides — Matt Young
- Optoelectronics and Photonics: Principles & Practices — S. O. Kasap

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Subject Title: Mathematical Physics
Subject Code: PCMP-515
Weekly Load/Credits: 3h/03

L	T	P
3	0	0

Course Outcomes (COs): After successful completion of the course, the students will be able to:

CO1: Apply partial differentiation, exact differentials, and Lagrange multipliers to solve multi-variable problems.
CO2: Expand functions using Fourier series and apply them to solve physical and mathematical problems.
CO3: Understand special functions and their properties relevant to physical systems.
CO4: Solve partial differential equations using separation of variables.
CO5: Analyze functions of a complex variable and apply Cauchy's theorems and integral formula in problem solving.

UNIT - I

Calculus of Functions of More Than One Variable: Partial derivatives, exact and in exact differentials, integrating factor, with simple illustration, constrained maximization using Lagrange multipliers. **(6 Lectures)**

Fourier Series: Periodic functions, orthogonality of sine and cosine functions, Dirichlet conditions (statement only), expansion of periodic functions in a series of sine and cosine functions and determination of Fourier coefficients, complex representation of Fourier series, expansion of functions with arbitrary period, expansion of non-periodic functions over an interval, even and odd functions and their Fourier expansions, application, summing of infinite series. **(10 Lectures)**

Special Functions: Legendre, Bessel, Hermite and Laguerre differential equations, properties of Legendre polynomials, Rodrigues formula, orthogonality, simple recurrence relations. **(5 Lectures)**

UNIT - II

Partial Differential Equations: Solutions to partial differential equations, using separation of variables, Laplace's equation in problems of rectangular, cylindrical and spherical symmetry. **(10 Lectures)**

Complex Analysis: Brief revision of complex numbers and their graphical representation, Euler's formula, De Moivre's theorem, roots of complex numbers, functions of complex variables, analyticity and Cauchy-Riemann conditions, examples of analytic functions, singular functions, poles and branch points, order of singularity, branch cuts, integration of a function of a complex variable, Cauchy's inequality, Cauchy’s integral formula. **(11 Lectures)**

Theory: 42 hrs

Reference Books:

- Mathematical Methods for Physicists: Arfken, Weber, 2005, Harris, Elsevier.
- Fourier Analysis by M. R. Spiegel, 2004, Tata McGraw-Hill.
- Mathematics for Physicists, Susan M. Lea, 2004, Thomson Brooks/Cole.
- An Introduction to Ordinary Differential Equations, Earl A Coddington, 1961, PHI Learning.
- Differential Equations, George F. Simmons, 2006, Tata McGraw-Hill.
- Essential Mathematical Methods, K. F. Riley and M. P. Hobson, 2011, Cambridge University Press.
- Partial Differential Equations for Scientists and Engineers,S. J. Farlow, 1993, Dover Publications.
- Mathematical methods for Scientists and Engineers, D. A. Mc Quarrie, 2003,Viva Books.

Subject Title: Introduction to Nanoscience and Nanotechnology
Subject Code: PCMP-516
Weekly Load/Credits: 3h/03

L	T	P
3	0	0

Course Outcomes (COs): After successful completion of the course, the students will be able to:

CO1: Explain basic concepts of nanoscience, nanoscale dimensions and types of nanostructures.
CO2: Analyze size dependent electronic, optical, mechanical and thermal properties of nanomaterials.
CO3: Compare and apply top-down and bottom-up synthesis methods for making nanomaterials.
CO4: Interpret results from XRD, Raman, SEM, TEM, FTIR, UV-Vis and EDAX for structural and morphological analysis.
CO5: Evaluate applications of nanotechnology in energy, electronics, water purification, biomedical fields and agriculture.

UNIT –I

Background to Nanoscience and Nanotechnology: Definition of nano, scientific revolution, atomic structure and Size, emergence and challenges in nanoscience and nanotechnology, definition and classification based on dimensions: zero dimensional (0D), one dimensional (1D), two dimensional (2D) and three dimensional (3D) nanostructures.

(11 Lectures)

Advanced Nanostructured Materials: Allotropes of carbon- graphene, carbon nanotubes (CNT's), carbon dots (C-dots), fullerenes, quantum dots shell structures, metal oxides, semiconductors and their nanocomposites. **(5 Lectures)**

Properties of Nanostructured Materials: Size effect of nanomaterials, size shape density, melting point, wettability and specific surface area, electronic and optical properties, electronic conductivity, band gap tuning, electroluminescence and photoluminescence. **(5 Lectures)**

UNIT – II

Synthesis of Nanomaterials: Top down and bottom-up approaches, chemical routes: co-precipitation, polyol method, sol-gel synthesis, hydrothermal and solvothermal synthesis techniques, physical methods: ball milling, chemical vapour deposition, inert gas condensation, RF plasma, plasma arc technique, ion sputtering. **(8 Lectures)**

Characterization Techniques: X-ray diffraction spectroscopy (XRD), Raman spectroscopy, Fourier transform electron microscopy, scanning electron microscopy (SEM), transmission electron microscopy (TEM), energy dispersive X-ray analysis (EDAX), ultraviolet- visible spectroscopy (UV-Vis). **(8 Lectures)**

Applications: Energy conservation and storage, nanoelectronic devices, semiconductor nanodevices, solar cells, nanoporous polymers and their applications in water purifications, biomedical nanotechnology, nanotechnology in agriculture. **(5 Lectures)**

Theory: 42 hrs

Reference Books:

- Chemistry of nanomaterials: Synthesis, properties and applications by CNR Rao et.al.
- Nanoparticles: From theory to applications – G. Schmidt, Wiley Weinheim 2004.
- Instrument E L Principe, P Gnauck and P Hoffrogge, Microscopy and Microanalysis (2005), 11: 830-831, Cambridge University Press.
- Processing & properties of structural nanomaterial's - Leon L. Shaw, Nano chemistry: A Chemical Approach to Nanomaterials, Royal Society of Chemistry, Cambridge UK 2005.
- Ferziger, J. H., Numerical Methods for Engineering Applications, 2nd ed., Wiley-Interscience (1998).
- Characterization of Nanophase materials – Z.L Wang (ed), Wiley-VCH, New York , 2000.
- Nanocrystalline Materials, A.I. Gusev and A. A. Rempel, Viva Books, New Delhi, 2008.
- Properties of Materials, Robert E. Newnham,Oxford University Press, 2005.

Subject Title: Waves and Oscillations
Subject Code: PCMP-517
Weekly Load/Credits: 3h/03

L	T	P
3	0	0

Course Outcomes (COs): After successful completion of the course, the students will be able to:

CO1: Explain SHM and analyze mechanical, torsional, electrical and coupled oscillations.
CO2: Describe damped motion, types of damping, and calculate damping parameters.

CO3: Analyze forced oscillators, resonance, phase variation and power frequency behavior.
CO4: Explain coupled oscillators, normal coordinates and normal modes.
CO5: Describe wave motion, solve the wave equation and analyze reflection, transmission and standing waves.

UNIT - I

Simple Harmonic Motion: Simple harmonic motion, energy of a SHO, compound pendulum, torsional pendulum electrical oscillations, transverse vibrations of a mass on string, superposition of two perpendicular SHM having periods in the ratio 1:1 and 1:2.

(10 Lectures)

Damped Harmonic Motion: Decay of free vibrations due to damping, differential equation of damped harmonic motion, types of motion and damping, determination of damping coefficient logarithmic decrement, relaxation time and Q–factor, electromagnetic damping. **(11 Lectures)**

UNIT - II

Electrical Oscillator: Differential equation for forced mechanical and electrical oscillators, transient and steady state behaviour, displacement and velocity variation with driving force frequency, variation of phase with frequency, resonance, power supplied to an oscillator and its variation with frequency, Q value and band width, Q value as an amplification factor, stiffness coupled oscillators, normal coordinates and normal modes of vibration, inductive coupling of electrical oscillators. **(11 Lectures)**

Waves: Types of waves, wave equation (transverse) and its solution characteristic impedance of a string, impedance matching, reflection and transmission of waves at boundary, reflection and transmission of energy, reflected and transmitted energy coefficients, standing waves on a string of fixed length, energy of vibrating string, wave and group velocity. **(10 Lectures)**

Theory: 42 hrs

Reference Books:

- Fundamentals of Optics, F A Jenkins and H E White, 1976, McGraw-Hill
- Principles of Optics, B.K. Mathur, 1995, Gopal Printing
- Fundamentals of Optics, H.R. Gulati and D.R. Khanna, 1991, R. Chand Publication
- University Physics. FW Sears, MW Zemansky and HD Young 13/e, 1986. Addison-Wesley

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