M.Sc. IV Semester

Total Teaching hours=50

Course PHST 4.1: Classical Electrodynamics

Unit I **12 hrs**

Electrostatics:

Divergence and curl of electrostatic field, Gauss law in integral and differential forms, Poisson and Laplace equations, Boundary conditions and uniqueness theorem, electrostatic potential energy and energy density of a continuous charge distribution. Multipole expansion of the potential and energy of a localized charge distribution, monopole and dipole terms, electric field of a dipole, dipole-dipole interaction. Electrostatic fields in matter, polarization.

Macroscopic Field equations : Electrostatic energy in dielectric media.

Unit II **12 hrs**

Magnetostatics:

Current density, continuity equation, magnetic field of a steady current, the divergence and curl of B, Ampere's law, magnetic vector potential, multipole expansion of vector potential of a localized current distribution, magnetic moment. Torques and forces on magnetic dipoles, effect of a magnetic field on atomic orbits. Magnetic fields in matter, macroscopic equations, magnetostatic boundary conditions, magnetic scalar potential. Energy in the magnetic field.

Unit III **13 hrs**

Electrodynamics:

Faraday's law of induction, displacement current, Maxwell's equations. Vector and scalar potentials. Gauge transformations, Lorentz gauge, Coulomb gauge. Poynting's theorem and conservation of energy and momentum for a system of charged particles and electromagnetic fields.

Electromagnetic Waves:

The wave equation foe a homogenius isotropic medium, plane electromagnetic waves in free space. Plane waves in non-conducting and conducting medium, skin depth. Linear circular polarisations. Reflection and refraction of plane waves at plane interface, total internal reflection, reflection from a surface of a metal.

Unit-IV **13 hrs**

Wave guides:

Fields at the surface and within a conductor, cylindrical cavities and wave guides, modes in rectangular wave guides.

Electromagnetic radiation:

Retarded Potentials. Radiation from an oscillating dipole, linear antenna. Lenard-Wiechert potentials, potentials for a charge in uniform motion, power radiated by an accelerated charge at low velocities, Larmor's formula , radiation from a charged particle with collinear velocity and acceleration, Bremsstrahlung radiation, radiation from a charged particle moving in a circular orbit, cyclotron and synchrotron radiation.

Plasma Physics:

Plasma behavior in magnetic field, plasma as a conducting fluid-magnetohydrodynamics, magnetic confinement-Pinch effect.

Reference Books:

1. Classical Electrodynamics: J.D.Jackson , Wiley Eastern Ltd., Bangalore (1978)
2. Introduction to Electrodynamics: D.J.Griffiths, Prentice Hall of India, Ltd., New Delhi (1995).
3. Electromagnetics: B.B. Laud. Wiley Eastern Ltd., Bangalore (1987)
4. Classical Electromagnetic Radiation: J.B. Marion, Academic press, NewYork (1968).
5. Classical Electrodynamics; S P Puri, Tata McGraw –Hill Publishing Company Ltd., New Delhi, (1999)

M.Sc. IV Semester

Total Teaching Hours=50

Course PHST 4.2: Quantum Mechanics – II

Unit I **13 hrs.**

Linear Vector Algebra :

Orthonormality, linear independence. Operators - Eigenvalues, eigenvectors; Hermitian, Unitary and Projection operators. Bra and Ket notation for vectors. The elements of Representation Theory. Idea of Measurements, Observables; and the Generalized Uncertainty relation. Coordinate and Momentum representations. Quantum Poisson Bracket.

Quantum Dynamics:

The Schrödinger and Heisenberg pictures; Interaction picture; the Heisenberg equation of motion. Linear harmonic oscillator problem by matrix method.

Unit II **12 hrs**

Angular Momentum :

Commutation relations between angular momentum operators. Eigen values and Eigenvectors of J^2,and Jz. Matrix elements for J^2, Jx, Jy, and Jz. Theory of addition of two angular momenta; properties of Clebsch-Gordan coefficients . Parity transformation, Wigner Eckart theorem

Unit III **12 hrs**

Approximation Methods:

First-order stationary perturbation theory for a degenerate case; the secular equation; applications: Stark effect in hydrogen atom and Zemaan effect in hydrogen atom in the presence of week uniform magnetic field. Second order perturbation theory and its application to a linear harmonic oscillator subject to a potential. W.K.B. approximation: Connection formulas; application to a potential well and alpha decay. The Variation method and its application to the ground state of hydrogen atom and helium atom.

Unit IV **13 hrs.**

Relativistic Quantum Mechanics:

Klein–Gordon equation. Dirac's relativistic equation for a free particle: commutation relations and matrices for α and β; free-particle solutions; probability charge and current densities; positive and negative energy states; the spin of the Dirac particle, Zitterbewegung. Dirac equation in electromagnetic potentials and magnetic moment. Dirac equation for a central field; the hydrogen atom: energy levels and fine structure (with derivation).

Reference Books:

1. Quantum Mechanics (2nd Edition) : L. I. Schiff, McGraw – Hill Co, New York (1955)
2. Quantum Mechanics (Vol. I) : A. Messiah, North Holland Pub Co, Amsterdam (1962)
3. Quantum Mechanics – Theory and Applications (3rd Edition) : A. Ghatak and S. Lokanathan, Mac Millan India Ltd. New Delhi (1984)
4. A Text book of quantum Mechanics : P. M. Mathews and K. Venkateshan, Tata Mc Graw – Hill, New Delhi (1987)
5. The Principles of Quantum Mechanics (4th Edition) : P.A.M. Dirac, Oxford Univ Press, New York (1958)
6. Quantum Mechanics (1st Edition) : V. K. Thankappan, New Age Intl. Pvt Ltd., New Delhi (1985)
7. Quantum Mechanics : E. Merzbacher., John Wiley, New York (1970)
8. Quantum Mechanics : Amit Goswami, Tata Mc Graw Hill (1999)
9. Quantum Mechanics : S.N.Biswas, Books and Allied (P) Ltd, 2nd edition (2004)

M.Sc. IV Semester

Total Teaching Hours=50

Course PHST 4.3: Condensed Matter Physics – II (Special Subject)

Unit – I **15 hrs**

Dielectrics:

Review of basic formulae, Sources of polarizability, Dielectric constant and polarizability, local field. Clausius – Mossotti relation. Dipolar polarizability: dipolar dispersion, Debye's equations, dielectric loss, dipolar polarization in solids, dielectric relaxation, ionic polarizability Lyddane- Sachs-Teller relation and its implications, polarization catastrophe. Electronic polarizability: classical treatment, quantum theory, interband transitions in solids.

Unit – II **10 hrs**

Ferroelectrics:

General properties of Ferroelectrics, classification and properties of representative ferroelectric crystals, dielectric constant near Curie temperature, microscopic source of ferroelectricity, thermodynamics of ferroelectric phase transitions, ferroelectric domains, Sawyer and Tower circuit to measure ploarization, cyclic voltametry to measure ferroelectricity. Piezoelectricity and its applications

Optical Properties:

Inter band and intraband absorption, fundamental absorption, absorption edge, exciton absorption, free carrier absorption, impurity involved absorption. Photoconductivity, luminescence. Solar cells and their efficiencies .

Unit – III **13 hrs**

Photovoltaics :

Solar Energy : Elemental and compound semiconductors : Band gap Engineering. Sun- a green source of energy, construction and working of solar cell, parameters of solar cell- short circuit current (I_{sc}), open circuit voltage (V_{oc}) and fill factor (FF).

Types of solar cells: Crystalline and amorphous silicon photovoltaic cells, thin film solar cells- Cd-Te and CIGS, Pervoskite Solar cells and Dye Sensitised solar cell. Comparison of their efficiencies

Unit – IV **12 hrs**

Magnetic Resonance:

Basic principles of paramagnetic resonance, susceptibility in a. c magnetic field, power absorption. spin – spin and spin – lattice relaxation, Bloch equations and its steady state solutions. Electron paramagnetic resonance, Spin – Hamiltonian, determination of g-factor, line width and spin – lattice relaxation time. Nuclear magnetic resonance. Fast Induction Decay (FID), Spin echo and determination of spin lattice relaxation time.

Reference Books:

1. Introduction to Solid State Physics: C.Kittel. Wiley Eastern Ltd., Bangalore (1976).
2. Elementary Solid State Physics: M.A. Omar.Addison-Wesley Pvt.,Ltd.,New Delhi (1993).
3. Solid State Physics: A.J. Dekker, Macmillan India Ltd., Bangalore, (2000).
4. Solid State Physics: F.W.Ashcroft & N.D. Mermin. Saunders College Publishing, New York (1976).
5. Introduction to Solids: L.V. Azaroff. McGraw-Hill inc, New york (1960).
6. Solid State and Semiconductor Physics: J.P.McKelvey. Harper and Row, Newyork (1966)
7. Elements of Solid State Physics (2nd Ed): J.P. Srivastava, PHI Learning Pvt. Ltd., New Delhi (2009)
8. Solar photovoltaic technology and system (5^{th} edition)- Chetansingh Solanki, PHI 2016

M. Sc. IV Semester

Total teaching Hours =50

Course PHST 4.4 : Condensed Matter Physics – III (Special Subject)

Unit – I **16 hrs**

Low- Dimensional Semiconductor Structures:

MOSFET, Inversion layer, Modulation doping. Quantum well. quantum wire, quantum dot and super lattice. Two dimensional electron gas, energy levels and density of states. Derivation for 3D, 2D, 1D and zero D. Quantum Hall effect – Integer and fractional quantum Hall Effect

Thin Film Physics :

Preparation : Chemical vapour deposition, MOCVD, MBE and thermal evaporation methods, Thickness measurements-optical methods (optical absorption and interference) and vibrating quartz method. Magnetoresistance : GMR, CMR and their applications

Properties of Thin films:

Electrical and optical properties

Semiconductor Devices :

Tunnel diode, Gunn diode, Photocell, LED and semiconductor lasers. Homojunction and heterojunction with energy level diagram.

Unit – II **10hrs**

Superconductivity:

Occurrence of superconductivity, destruction of superconductivity by magnetic field, heat capacity and energy gap, microwave and infrared properties, Type –I and Type-II superconductors, Thermodynamics of superconductors, London equations, coherence length, flux quantization in superconducting rings, duration of persistent current.

Unit – III **10 hrs**

BCS theory:

Introduction, Attraction between Cooper- pairs, accomplishments of BCS theory.

Tunneling:

Basic concepts of tunneling, metal-insulator tunneling, metal- insulator superconductor tunneling, superconductor- insulator – superconductor tunneling, Cooper- pair tunneling.AC and DC Josephson effect, macroscopic quantum interference - DC SQUID, high T_c superconductors and their applications

Unit – IV **14 hrs**

Nano structured materials:

Introduction, electronic and optical properties: quantum confinement effect. Synthesis of nano particles: Carbon based nano- materials. Metal Nanoclusters, Nanostructured zeolites, Porous silicion. Magnetic nano structures. Applications of nano materials.

Characterization techniques:

Scanning electrons and transmission electron and atomic force microscopies. X-ray diffraction and optical spectroscopy.

Reference Books:

1. Introduction to Solid State Physics: C. Kittel, Editions: 2,5,6,7, Wiley Eastern Ltd., Bangalore.
2. Elementary Solid State Physics: M.A. Omar Addison-Wesley Pvt. Ltd., New Delhi, (2000).
3. Amorphous Semiconductors: D. Adler, CRC, London, (1972).
4. Introduction to Nanotechnolgy: C.P. Poole Jr. and F.J. Owens, John Wiley and Sons, Singapore (2006).
5. Nano: The Essentials: T. Pradeep, Tata McGraw-Hill Publishing New Delhi (2007).
6. Solid State Physics : A. J. Dekker, Macmillan India Ltd., Bangalore (1981)
7. Solid State Physics: F. W. Aschroft and N. D. Mermin, Saunders College Publishing, New York, (1976).
8. Electronic processes in Non Crystalline Materials : N. F. Mott and E. A. Davis, Clarendon press, Oxford, (1979).
9. Nanoscale Materials – (Ed) L.M. Liz-Marzan and P.V.Kamat, (Kluwer, 2003)
10. Nanostructured Materials and Nanotechnology, (Ed) H.S.Nalwa, (Academic,2002)
11. Elements of Solid State Physics (2nd Ed): J.P. Srivastava, PHI Learning Pvt. Ltd., New Delhi (2009)
12. Solid State Physics, J.D. Patterson and B.C. Bailey, Springer-Verla
13. The Nanoscope (1st edition)- Santhi A, MEDTECH 2016
14. Handbook of Thinfilm deposition process and technology (2nd edition)- Krishna Seshan Intelscope- USA

Course PHSP 4.5: Practical - Solid State Physics – III

1. Indexing of Hexagonal systems.
2. Calculation of relative integrated intensity.
3. Precise parameter determination.
    a. Extrapolation method
    b. Cohen's method
4. Structure determination of Cd Te.
5. Spontaneous polarization of ferroelectrics
6. Universal curves for ferromagnets
7. Assignments using C – Programming.
8. Susceptibility determination by Gouy's method.
9. Electron Spin Resonance
10. Temperature dependence of susceptibility of a paramagnetic substance.
11. Phase transition in ferroelectric crystals.
12. Solar cells.

(NEW EXPERIMENTS MAY BE ADDED)

Reference Books

1. X-Ray Diffraction : B.D.Cullity,Addison – Wesley,New York(1972)
2. X – Ray diffraction Procedures: H. P. Klug and L.E.Alexander,John Wiley and Sons inc . New York.
3. Interpretation of X-ray powder diffraction pattern : H.P. Lipson and H.Steeple,Macmillan, London (1968)
4. Elementary Solid State Physics : M.A.Omar,Addison – Wesley Pvt. Ltd.,New Delhi (1993)
5. Elementary Solid State Physics : C.Kittle,Wiley Eastern Ltd., Bangalore (1976)

Course PHSP 4.6: Project - Solid State Physics

Topic(s) for the Project may be selected in consultation with the Supervisor.