SEMESTER – II

PH2C05 MATHEMATICAL METHODS IN PHYSICS – II

Unit I

Complex Analysis (18 Hrs)

Functions of a complex variable - Analytic functions - Cauchy-Riemann equation - integration in a complex plane – Cauchy's theorem-deformation of contours - Cauchy's integral formula - Taylor and Laurent expansion-poles, residue and residue theorem – Cauchy's Principle value theorem - Evaluation of integrals.

Text Books:

Mathematical Physics, B.D. Gupta, Vikas Pub.House, New Delhi

Mathematical methods in Classical and Quantum Physics, T. Dass & S. K. Sharma, Universities Press (2009)

Introduction to Mathematical physics, Charlie Harper, PHI

Unit II

Integral Transforms (18 Hrs)

Introduction to Fourier series and Fourier integral form - Fourier transform - square wave, full wave rectifier and finite wave train – momentum representation of hydrogen atom ground state and harmonic oscillator. Laplace transform –inverse Laplace transform-properties and applications – Earth's nutation, LCR circuit, wave equation in a dispersive medium, damped, driven oscillator, solution of differential equations.

Text Books:

Mathematical Methods for Physicists, G.B. Arfken &H.J. Weber 4th Edition, Academic Press.

Mathematical Physics, H.K Dass & Dr. Rama Verma, S. Chand &Co.

Unit III

Group theory (18 Hrs)

Introductory definition and concepts of group - point group, cyclic group, homomorphism and isomorphism-classes, reducible and irreducible representations- Schur's Lemmas and Great Orthogonality theorem. Group character table- C2V, C3V and C4V groups, Lie group, concept of generators- rotation group SO(2), SO(3), Unitary Group SU(2) and SU(3) Homomorphism between SU(2) and SO(3) – Irreducible Representation of SU(2).

Text Books:

Elements of Group Theory for Physicists, A.W. Joshi, New Age India

Mathematical Physics, Sathyaprakash, Sultan Chand & Sons, New Delhi.

Group theory- Schaum's series, Benjamin Baumslag & Bruce Chandler, MGH.

Unit IV

Partial Differential Equations (18 Hrs)

Characteristics and boundary conditions for partial differential equations.

Nonlinear partial differential equations – separation of variables in Cartesian,

cylindrical and spherical polar coordinates. Heat equation, Laplace's equation and Poisson's equation. Nonhomogeneous equation - Green's function - symmetry of Green's function - Green's function for Poisson equation, Laplace equation and Helmholtz equation - Application of Green's function in scattering problem

Text Books:

Mathematical Methods for Physicists, G.B. Arfken & H.J. Weber 4th Edition, Academic Press.

Mathematical Physics, B.S Rajput, Pragati Prakashan

Reference Books:

(Given Under **PH1C01**)

PH2C06 QUANTUM MECHANICS – I

Unit I

Basics of Quantum Mechanics (14 Hrs)

Stern - Gerlach experiment leading to vector space concept, Dirac notation for state vectors- ket space, bra space, inner products - algebraic manipulation of operators – unitary operators, eigenkets and eigenvalues – Hermitian operators-concept of complete set-representation of an operator by square matrix – matrix elements of an operator - expectation values of Hermitian and anti-Hermitian operators – generalized uncertainty product — change of basis-orthonormal basis and unitary matrix, transformation matrix-unitary equivalent observables-eigenkets of position-infinitesimal operator and its properties – linear momentum as generator of translation – canonical

commutation relations – properties of wave function in position space and momentum space - relations between operator formalism and wave function formalism-momentum operator in position basis – momentum space wave function – computation of expectation values x, x^2, p and p^2 for a Gaussian wave packet.

Text Book:

1. Modern Quantum Mechanics, J. J. Sakurai, Pearson Education (Chapter 1)

Unit II

Quantum Dynamics (18Hrs)

Time evolution operator and its properties-Schrodinger equation for the time evolution operator - energy eigenkets - time dependence of expectation values - time energy uncertainty relation - Schrodinger picture and Heisenberg picture - behaviour of state kets and observables in Schrodinger picture and Heisenberg picture - Heisenberg equation of motion - Ehrenfest's theorem - time evolution of base kets - transition amplitude - energy eigenket and eigen values of a simple harmonic oscillator using creation and annihilation operators

Text Book:

1. Modern Quantum Mechanics, J.J. Sakurai, Pearson Education (Chapter 2)

Identical particles

Identity of particles - spin and statistics-Pauli's exclusion principle - Helium atom

Text Book:

1. Quantum Mechanics, V. K. Thankappan, New Age International, 1996, (Chapter 9)

Unit III

Angular momentum (20 Hrs)

Commutation relationbetweeninfinitesimalandrotation-infinitesimal rotationsinquantummechanics-fundamental commutation relations of angular momentum - rotation operator for spin ½ system - Pauli two component formalism - Pauli spin matrices - 2x2 matrix representation of rotation operator – commutation relations for J^2, J_x – eigenvalues of $J^2$and J_x - matrix elements of angular momentum operators - representation of the rotation operator – rotation matrix-properties of the rotation matrix-orbital angular momentum as a rotation generator - addition of angular momentum and spin angular momentum - addition of spin angular momenta and Clebsch-Gordon coefficients for two spin ½ particles

Text Book:

1. Modern Quantum Mechanics, J.J. Sakurai, Pearson Education,

Unit IV

Solutions of Schrodinger equation and Approximation Methods (20 Hrs)

Motion in a central potential - Hydrogen atom WKB approximation - WKB wave function –validity of the approximation - connection formula (proof not needed) potential well - barrier penetration variational methods - bound states – hydrogen molecule ion - stationary state perturbation theory - non

degenerate case - anharmonic oscillator - degenerate case -applications - first order Stark effect and Zeeman effect in hydrogen

Text Book:

Quantum mechanics, V.K. Thankappan New Age International 1996 (Chapter 4, 8)

Quantum Mechanics, G Aruldhas, PHI, 2002, (Chapter 10)

Reference Books:

A Modern approach to quantum mechanics, John S. Townsend, Viva Books MGH.

Basic Quantum Mechanics, A. Ghatak, Macmillan India 1996

Quantum Mechanics, an Introduction, W Greiner, Springer Verlag

Quantum Mechanics, E. Merzbacher, John Wiley, 1996

Introduction to Quantum Mechanics, D.J. Griffiths, Pearson.

Quantum Mechanics, L.I. Schiff, Tata McGraw Hill

A Text Book of Quantum Mechanics, P.M. Mathews & K. Venkatesan, TMGH.

Quantum Mechanics, Concepts and Applications, N. Zettily, John Wiley & Sons.

Fundamentals of Quantum Mechanics Y.R. Waghmare, S Chand & Co.

PH2C07 THERMODYNAMICS AND STATISTICAL MECHANICS

Unit I

Fundamental of Thermodynamics (10 Hrs)

Fundamental definitions – different aspects of equilibrium – functions of state – internal energy – reversible changes – enthalpy – heat capacities – reversible adiabatic changes in an ideal gas – second law of thermodynamics – the Carnot cycle - equivalence of the absolute and the perfect gas scale of temperature – definition of entropy- measuring the entropy – law of increase of entropy – calculations of the increase in the entropy in irreversible processes – the approach to equilibrium.

Text Book:

1. Introductory Statistical Mechanics, R. Bowley & M. Sanchez, 2nd Edn. 2007, Oxford University Press, Indian Edition, (Chapter 1 and 2)

Foundations of Statistical Mechanics (8 Hrs)

Ideas of probability – classical probability – statistical probability – the axioms of probability theory – independent events – counting the number of events – statistics and distributions – basic ideas of statistical mechanics - definition of the quantum state of the system – simple model of spins on lattice sites – equations of state – the second law of thermodynamics.

Text Book:

Introductory Statistical Mechanics, R. Bowley & M.Sanchez, 2nd Edn. 2007, Oxford University Press, Indian Edition, (Chapter 3 and 4)

Unit II

The Canonical Ensemble (12 Hrs)

A system in contact with a heat bath – the partition function – definition of the entropy in the canonical ensemble – the bridge to thermodynamics through partition function – condition for thermal equilibrium – thermodynamic quantities from partition function – case of a two level system – single particle in a one dimensional box – single particle in a three dimensional box – expression for heat and work – rotational energy levels for diatomic molecules – vibrational energy levels for diatomic molecules – factorizing the partition function – equipartition theorem – minimizing the free energy.

Text Book:

Introductory Statistical Mechanics, R. Bowley & M.Sanchez, 2nd Edn. 2007, Oxford University Press, Indian Edition, (Chapter 5)

Statistics of Identical Particles (4 Hrs)

Identical particles – symmetric and antisymmetric wavefunctions - bosons – fermions – calculating the partition function for identical particles – spin – identical particles localized on lattice sites.

Text Book:

1. Introductory Statistical Mechanics, R. Bowley & M.Sanchez, 2nd Edn. 2007, Oxford University Press, Indian Edition, (Chapter 6)

Unit III

Maxwell Distribution and Planck's Distribution (12 Hrs)

The probability that a particle is in a quantum state – density of states in k space – single particle density of states in energy – distribution of speeds of particles in a classical gas – blackbody radiation – Rayleigh-Jeans theory –

Planck's distribution – derivation of the Planck's distribution – the free energy – Einstein's model vibrations in a solid – Debye's model of vibrations in a solid.

Text Book:

1. Introductory Statistical Mechanics, R. Bowley & M.Sanchez, 2nd Edn. 2007, Oxford University Press, Indian Edition. (Chapter 7 and 8)

Grand Canonical Ensemble (8 Hrs)

Systems with variable number of particles – the condition for chemical equilibrium – the approach to chemical equilibrium – chemical potential – reactions – external chemical potential – grand canonical ensemble – partition function – adsorption of atoms on surface sites – grand potential.

Text Book:

1. Introductory Statistical Mechanics, R. Bowley & M. Sanchez, 2nd Edn. 2007, Oxford University Press, Indian Edition, (Chapter 9)

Unit IV

Fermi and Bose Particles (6 Hrs)

Statistical mechanics of identical particles – thermodynamic properties of a Fermi gas – examples of Fermi systems – non-interacting Bose gas.

Text Book:

1. Introductory Statistical Mechanics, R. Bowley & M.Sanchez, 2nd Edn. 2007, Oxford University Press, Indian Edition, (Chapter 10)

Phase Transitions (12 Hrs)

Phases – thermodynamic potential – approximation – first order phase transition - Clapeyron equation – phase separation – phase separation in

mixtures – liquid gas system – Ising model – order parameter – Landau theory- symmetry breaking field – critical exponents.

Text Book:

1. Introductory Statistical Mechanics, R. Bowley & M.Sanchez, 2nd Edn. 2007, Oxford University Press, Indian Edition, (Chaptr 11& 12)

Reference Books:

Statistical Mechanics, R.K. Pathria, & P.D. Beale, 2nd Edn, B-H (Elsevier) (2004).

Introductory Statistical Physics, S.R.A. Salinas, Springer (2000).

Fundamentals of Statistical and Thermal Physics, F. Rief, McGraw Hill (1986).

Statistical Mechanics, Kerson Huang, John Wiley and Sons (2003).

Statistical Mechanics, Satyaprakash & Agarwal, Kedar Nath Ram Nath Pub. (2004).

ProblemsandsolutionsonThermodynamicsandStatistical mechanics, Yung Kuo Lim, World Scientific Pub. (1990)

Fundamentals of Statistical Mechanics, A.K. Dasgupta, New Central Book Agency Pub. (2005)

Statistical Mechanics: a survival guide, A.M. Glazer and J.S. Wark, Oxford University Press. (2001).

PH2C08 CONDENSED MATTER PHYSICS

Unit I

Elements of Crystal Structure (6 Hrs)

Review of crystal lattice fundamentals and interpretation of Bragg's equation, Ewald construction, the reciprocal lattice, reciprocal lattice to SC, BCC and FCC lattices, properties of reciprocal lattice, diffraction intensity - atomic, geometrical and crystal structure factors- physical significance.

Text Book:

1. Solid State Physics: Structure and properties of materials, M.A. Wahab, Narosa 2nd Edn. 2010, (Chapter 8)

Free Electron Theory of Metals (12 Hrs)

Review of Drude-Lorentz model - electrons moving in a one dimensional potential well - three dimensional well - quantum state and degeneracy - density of states - Fermi-Dirac statistics - effect of temperature on Fermi-Dirac distribution - electronic specific heat - electrical conductivity of metals - relaxation time and mean free path - electrical conductivity and Ohm's law - Widemann-Franz-Lorentz law - electrical resistivity of metals.

Text Book:

1. Solid State Physics: Structure and properties of materials, M.A. Wahab, Narosa 2nd Edn. 2010, (Chapter 10)

Unit II

Band Theory of Metals (6 Hrs)

Bloch theorem - Kronig-Penney model - Brillouin zone construction of Brillouin zone in one and two dimensions – extended, reduced and periodic

zone scheme of Brillouin zone (qualitative idea only) - effective mass of electron - nearly free electron model – conductors - semiconductors - insulators.

Text Book:

1. Solid State Physics: Structure and properties of materials, M.A. Wahab, Narosa 2nd Edn. 2010, (Chapter 11)

Band theory of semiconductors (10 Hrs)

Generation and recombination - minority carrier life-time - mobility of current carriers - drift and diffusion - general study of excess carrier movement- diffusion length.

Text Book:

1. Solid State Physics, S.O. Pillai, New Age International 6th Edn. 2010,(Chapter 10).

Free carrier concentration in semiconductors - Fermi level and carrier concentration in semiconductors - mobility of charge carriers - effect of temperature on mobility - electrical conductivity of semiconductors - Hall effect in semiconductors - junction properties- metal-metal, metal-semiconductor and semiconductor-semiconductor junctions.

Ref. Text:

1. Solid State Physics: Structure and properties of materials, M.A. Wahab, Narosa 2nd Edn. 2010, (Chapter 13)

Unit III

Lattice Dynamics (14 Hrs)

Vibrations of crystals with monatomic basis – diatomic lattice – quantization of elastic waves – phonon momentum.

Text Book:

1. Introduction to Solid State Physics, C. Kittel, 3rd Edn. Wiley India. (Chapter 4).

Anharmonicity and thermal expansion - specific heat of a solid - classical model - Einstein model - density of states - Debye model - thermal conductivity of solids - thermal conductivity due to electrons and phonons - thermal resistance of solids.

Text Book:

1. Solid State Physics: Structure and properties of materials, M.A. Wahab, Narosa 2nd Edn. 2010, (Chapter 7 &9)

Dielectric Properties of Solids (6 Hrs)

Review of basic terms and relations, ferroelectricity, hysteresis, dipole theory - Curie-Weiss law, classification of ferroelectric materials and piezoelectricity.

Text Book:

1. Solid State Physics, S.O. Pillai, New Age International 6th Edn. 2010, (Chapter 11).

Ferroelectric domain, antiferroelectricity and ferrielectricity. Text Book:

1. Solid State Physics: Structure and properties of materials, M.A. Wahab, Narosa 2nd Edn. 2010, (Chapter 14)

Unit IV

Magnetic properties of solids (10 hrs)

Review of basic terms and relations, Quantum theory of paramagnetism - cooling by adiabatic demagnetization – Hund's rule – ferromagnetism -

spontaneous magnetization in ferromagnetic materials - Quantum theory of ferromagnetism –Weiss molecular field - Curie- Weiss law- spontaneous magnetism - internal field and exchange interaction – magnetization curve – saturation magnetization - domain model.

Text Book:

1. Solid State Physics, S.O. Pillai, New Age International 6th Edn. 2010, (Chapter 9).

Superconductivity (4 Hrs)

Thermodynamics and electrodynamics of superconductors- BCS theory- flux quantization-single particle tunneling- Josephson superconductor tunneling-macroscopic quantum interference

Text Book:

Introduction to Solid State Physics, C. Kittel, 3rd Edn. Wiley India. (Chapter 12).

Solid State Physics, S.O. Pillai, New Age International 6th Edn. 2010, (Chapter 8).

Nanotechnology and Metamaterials (Qualitative) (4 Hrs)

Properties of metal, semiconductor, rare gas and molecular nanoclusters- superconducting fullerene- quantum confined materials-quantum wells, wires, dots and rings- metamaterials- graphene

Text Book:

1.Introduction to Nanotechnology, Charles P Poole and Frank J Owens, Wiley India (Chapter 4, 5, 9)

Reference Books:

Solid State Physics, N.W. Ashcroft & N.D. Mermin, Cengage Learning Pub.11th Indian Reprint (2011).

Solid State Physics, R.L. Singhal, Kedar Nath Ram Nath & Co (1981)

Elementary Solid State Physics, M. Ali Omar, Pearson, 4th Indian Reprint (2004).

Solid State Physics, C.M. Kachhava, Tata McGraw-Hill (1990).

Elements of Solid State Physics, J. P. Srivastava, PHI (2004)

Solid State Physics, Dan Wei, Cengage Learning (2008)

Solid State Physics, A.J. Dekker, Macmillan & Co Ltd. (1967)

PH2P02 ELECTRONICS PRACTICALS

(Minimum of 12 experiments should be done)

R C Coupled CE amplifier - Two stages with feedback - Frequency response and voltage gain.

Differential amplifiers using transistors and constant current source - Frequency response, CMRR.

Push-pull amplifier using complementary - symmetry transistors-power gain and frequency response.

R F amplifier - frequency response & band width - Effect of damping.

Voltage controlled oscillator using transistors.

Voltage controlled oscillator using IC 555

R F Oscillator - above 1 MHz frequency measurement.

Differential amplifier - using op-amp.

Active filters – low pass and high pass-first and second order-frequency response and rolloff rate.

Band pass filter using single op-amp-frequency response and bandwidth.

Wein-bridge Oscillator – using op-amp with amplitude stabilization.

Op-amp-measurement of parameters such as open loop gain - offset voltage – open loop response.

Crystal Oscillator

RC phase shift oscillator

AM generation and demodulation

Solving differential equation using IC 741

Solving simultaneous equation using IC 741

Current to voltage and voltage to current converter (IC 741)

Temperature measurement using ADC and microprocessor.

Op-amp-triangular wave generator with specified amplitude.

µp - stepper motor control.

µp- measurement of analog voltage.

µp-Digital synthesis of wave form using D/A Converter.

Analog to digital and digital to analog converter ADC0800 & DAC0800