SEMESTER – IV

AP4C11 NUCLEAR PHYSICS AND ASTROPHYSICS Unit
I

Nuclear Properties and Forces (4 hrs)

Nuclear Angular Momentum – Parity – Nuclear magnetic dipole moment – electric quadrupole moment – Simple theory of Deuteron – Properties of Nuclear forces –Spin dependence of nuclear force.

Nuclear Models (14 hrs)

Binding energy, semi-empirical mass formula, liquid drop model. Evidence of shell structure, single-particle shell model, its validity and limitations, Spin orbit coupling, Schmidt's lines and prediction of angular momentum and parity of nuclear ground states. Collective model of Bohr and Mottelson – rotational States and Vibrational
levels. Text Books:

Introductory Nuclear Physics, K. S. Krane, Wiley.

Nuclear Physics, D. C. Thayal, Himalaya Pub. House.

Unit II

Radioactivity, Fission and Fusion (18 hrs)

Radio activity, Units, alpha and beta decay, Gamow's theory, neutrino, Fermi's theory of beta decay, Radiation hazards. Nuclear fission, controlled fission reactions, fission reactors, nuclear fusion, controlled Fusion reactors.

Detectors, accelerators

Particle detectors - Ionization chamber, GM counter, bubble chamber, cloud chamber. Particle accelerators -Van de Graff generator, Cyclotron, Synchrotron.

Text Books:

Introductory Nuclear Physics, K. S. Krane, Wiley.

Nuclear Physics, D. C. Thayal, Himalaya Pub. House.

Unit III

Particle Physics (18 hrs)

Elementary particles and their quantum numbers (charge, spin, parity, isospin, strangeness, etc.). Gellmann-Nishijima formula. Quark model, confined quarks, coloured quarks, quark-gluon interaction, baryons and mesons. C, P, and T invariance. Application of symmetry arguments to particle reactions. Parity non-conservation in weak interaction. Relativistic kinematics, Grand unified theories.

Text Books:

Introductory Nuclear Physics, K. S. Krane, Wiley.

Nuclear Physics, D. C. Thayal, Himalaya Pub. House.

Unit IV

Astrophysics (18

hrs) Sun

Solar structure - photosphere, chromosphere and corona. Activity in the sun - sunspots, flares, solar oscillations, helioseismology.

Expanding universe-red shift-Hubble's law. Fundamental assumptions - homogeneity and isotropy, the FRW metric, density evolution, critical density, cosmological constant. Conditions in the early universe – big bang nucleosynthesis.

Galaxies

Milky way galaxy-stellar population –spiral structure.

Compact Objects

Physical properties of black holes, white dwarfs, and neutron stars, formation of compact objects, pulsar phenomena, gravitational and neutrino radiation from supernova collapse and binary coalescence.

Text Books:

Introduction to Cosmology, J. V. Narlikar, Cambridge University Press.

Astrophysics: Stars and Galaxies, K.D.Abhyankar

Reference Books:

Introduction to High Energy Physics, D. H. Perkins.

Introduction to Elementary Particles, David Griffith, Harper and Row, N.Y, 1987.

B. L. Cohen, Concepts of Nuclear Physics, TMH, 1971.

R. R. Roy and B. P. Nigam, Nuclear Physics, New Age Int. ,1983.

Subatomic Particles, Frauenfelder and Henley, PHI.

The Ideas of Particle Physics, G. D. Coughlan and J. E. Dodd.

Introduction to Nuclear Physics, Herald A Enge, Addison, Wesley Pub, (1972).

Nuclear Physics, I. Kaplan, Narosa publishing House,(1962).

Nuclear Radiation detectors, Price.

Particle Hunters, Neeman, Y. Kirch ,Cambridge Univ. Press.

Elementary particles and symmetries, I. H. Ryder, Gordon and Breach, (1975) (Text).

The cosmic onion-Quarks and nature of Universe, Frank Close, AIP (1983).

Elements of Nuclear Physics, W. E. Burcham, Longmans (1981).

University Physics with Modern Physics, H. D. Young & R. A. Freedman, 11th Edn, (2004).

Elements of Nuclear Physics, M. L. Pandya & R. P. S. Yadav, 7th Edn, (2002).

The New Cosmology, Albrecht Unsold.

Astrophysics, B. Basu.

The Physical Universe, F. H. Shu.

Astrophysics: Stars and Galaxies. K. D. Abhyankar.

Black Holes, White Dwarfs and Neutron Stars, S.Shapiro & S. Teukolsky, Wiley, 1983.

Glendenning, Compact Stars: Nuclear Physics, Particle Physics and General Relativity, 2nd ed., Springer, 2000.

AP4C12 COMPUTATIONAL PHYSICS Unit I

Numerical Methods of Analysis (18 hrs)

Solution of algebraic and transcendental equations: Iterative, bisection and Newton-Raphson methods, Solution of simultaneous linear equations: Matrix inversion method, Interpolation: Newton and Lagrange formulas, Numerical differentiation, Numerical Integration, Trapezoidal, Simpson and Gaussian quadrature methods, Least-square curve fitting, Straight line and polynomial fits, Numerical solution of ordinary differential equations: Euler and Runge-Kutta methods.

Text Book:

Introductory Methods of Numerical Analysis, S. S. Sastry, Prentice Hall India.

Unit II

Fortran (18 hrs)

Flow charts, Algorithms, Integer and floating point arithmetic, Precision, Variable types, Arithmetic statements, Input and output statements, Control statements, Executable and non-executable statements, Arrays, Repetitive and logical structures, Subroutines and functions, Operation with files, Operating systems, Creation of executable programs.

Text Book:

Computer Programming in FORTRAN 77, Rajaraman.

Unit III

Object Oriented Analysis and C++ (18 hrs)

Principle of Object Oriented Programming, Software evaluation, OOP paradigm, Basic concept of OOP, Benefits of OOP, Application of OOP, Introduction to C++,Tokens, Keywords, Identifiers, Constants, Operators, Manipulators, Expressions and control structure, Pointers, Functions, Function prototyping, Parameters passing in functions, Values Return by functions, Inline functions – friend and virtual functions, Classes, objects, constructors and destructors, Operator overloading, Type conversions , Type of constructors , Function over loading

Text Books:

Object Oriented Programming with C++ , Balagurusamy, TMH.

Object Oriented Programming in Turbo C++ , Robert Lafore.

Unit IV

Matlab Programming (18 hrs)

Introduction-Matlab Features-Desktop Windows: Command, Workspace, Command History, Array Editor and Current Directory -Matlab Help and Demos- Matlab Functions, Characters, Operators and Commands. Basic Arithmetic in Matlab-Basic Operations with Scalars, Vectors and Arrays-Matrices and Matrix Operations-Complex Numbers- Matlab Built-In Functions-Illustrative Examples.

Control Flow Statements: *if, else, else if, switch* Statements-*for, while* Loop Structures-*break* Statement-Input/Output Commands-Function m Files-Script m Files-Controlling Output

Text Books:

Engineering and Scientific Computations Using Matlab, Sergey E. Lyshevski, Wiley

Matlab Programming-David Kuncicky, Prentice Hall.

Reference Books:

Numerical methods in Science and Engineering, M.K. Venkataraman, National Publishing Co. Madras.

Applied Numerical Analysis, Gerald, Person Educaton.

Numerical Methods for Engineers and Scientists, Joe D. Hoffman.

Numerical Methods For Scientific And Engineering Computation, M.K. Jain , New Age International.

Computational Methods in Physics and Engineering, Wong.

Computer Oriented Numerical Methods, Rajaraman.

Programming in C++, Schaum's Series.

A Guide to Matlab for Beginners & Experienced Users, B. Hunt, R. Lipsman, J. Rosenberg, Cambridge University Press.

Matlab Primer, T. A. Davis & K. Sigmon, Chapman & Hall CRC Press-London.

Getting Started With Matlab, Rudra Pratap, Oxford University Press, New Delhi.

An Introduction to Programming and Numerical Methods in MATLAB, S.R. Otto and J.P. Denier, Springer-Verlag-London.

Numerical Methods Using Matlab-John Mathews & Kurtis Fink, Prentice Hall-New Jersey.

AP4E03 PHOTONICS – II Unit

I

Fiber Optic Communication (18 hrs)

Fibre optic communication system- Advantages of fiber optic system-System design considerations for point to point links- Digital systems- Link power budget- Rise time budget- Line coding- Analog systems- System architecture- Point to point links- Distribution networks- Local area networks

Text Book:

Fibre Optics and Optoelectronics, R. P. Khare, Oxford University Press (2004).

Unit II

Optical Amplifiers and Detectors (18 hrs)

Qualitative ideas of semiconductor optical amplifiers, Erbium doped fiber amplifiers and Raman amplifiers

Optical detection principle-Absorption coefficient- Quantum efficiency-Responsivity- Long wavelength cutoff- PN photo diode- PIN photo diode-Avalanche photo diode- Photo transistor-Photo conducting detectors-Photomultiplier- CCD- Photo voltaic effect and solar cells- Noise- Thermal noise- Dark current noise- Quantum noise

Text Books:

Fibre Optics and Optoelectronics, R. P. Khare, Oxford University Press (2004).

Optical fiber Communications, John M. Senior, PHI (1995).

Unit III

Fiber Cables and Connections (18 hrs)

Fiber material requirements- Fiber fabrication methods- Liquid – phase(Melting) Methods – Vapour-phase deposition methods- OVPO method- VAD method- MCVD method- PCVD method-Fiber optic cables- Fiber connections and related losses- Loss due to Fresnel reflection- fiber to fiber misalignment losses- loss due to other factors- Connection losses due to intrinsic parameters- Fiber splices- Fusion splices- Mechanical splices- Multiple splices- Fiber optic connectors- Butt-jointed connectors- Expanded beam connectors- multi fiber connectors

Text Book:

Fibre Optics and Optoelectronics, R. P. Khare, Oxford University Press (2004).

Unit IV

Frequency Multiplication and other Nonlinear Effects (18 hrs)

Wave propagation in an anisotropic crystal- Polarization response of materials to light- Second harmonic generation- Sum and difference frequency generation- Parametric oscillation- Third harmonic generation- Self focusing- Nonlinear optical materials- Phase matching- Acive phase matching- Saturable absorption- Optical bistability-Two photon absorption- Stimulated Raman scattering- Harmonic generation in gases.

Text Book:

Laser Fundamental, W.T. Silfvast, Cambridge University Press (1996).

Reference Books:

Fiber Optic Communication, D.C. Agarwal, Wheeler Publications (1993).

Optical Fiber Communication System, J. Gowar, PHI (1995).

Fiber Optic Communication, Joseph Palais, PHI (1998).

Understanding Fiber Optics, J. Hecht, Pearson Edu. Inc. (2006).

Optoelectronic Devices and Systems, S. C. Gupta, PHI (2005).

AP4E04 FIBRE OPTICS Unit

I

Optical Waveguides (18 hrs)

Ray theory theory of transmission - Total internal reflection -Acceptance angle - Numerical aperture - Skew Rays. EM Theory for Optical propagation – Modes in a planar waveguide –Phase velocity and group velocity – Evanescent field - Optical fiber as a cylindrical waveguide- Modes – Mode coupling (elementary idea) – Classification of fibers – Step index fiber – Graded index fiber – Single mode fiber – Number of modes and cut off parameters – Mode field diameter and spot size

Text Book:

1. Optical Fiber Communications, John M. Senior,PHI (1994

Unit II

Transmission Characteristics of Optical Fibers (18 hrs)

Attenuation – Absorption losses – Linear scattering losses – Nonlinear scattering losses – Wavelengths for Communication – Fiber bend loss – Dispersion effects in fibers - Intra modal dispersion – Inter modal dispersion

– Over all fiber dispersion – Modal birefringence – Polarization maintaining fibers.

Text Book:

1.

Unit III
Optical Fiber Measurements (18 hrs)

Attenuation measurements – Dispersion measurements – Refractive index profile measurements – Cut off wavelength measurements – Numerical aperture measurements – Diameter measurements – Field measurements – OTDR – Eye pattern technique

Text Book:

1.

Unit IV
Optical Sensor Systems (18 hrs)

Intensity modulated sensors – Phase modulated sensors – Interferometric sensors – Sagnac effect and Fiber optic gyroscope – Polarization modulated sensors – Spectrally modulated sensors – Temperature, pressure, force and chemical sensors

Text Book:

1.

Reference Books:

Fiber Optics and Optoelectronics, R.P. Khare, Oxford University Press (2004).

Fiber Optic Communication, D.C. Agarwal, Wheeler Publications (1993).

Optical Fiber Communication System, J. Gowar, PHI (1995).

Fiber Optic Communication, Joseph Palais, PHI (1998).

Understanding Fiber Optics, J. Hecht, Pearson Edu. Inc (2006).

Optoelectronic Devices and Systems, S.C. Gupta, PHI (2005).

AP4P04 PHOTONICS PRACTICALS

Determination of Wavelength of laser beam using reflection and diffraction gratings

Beam profile of a laser

Bending laws of an optical fiber

Numerical aperture of an optical fiber

Data transmission and reception through optical fiber link

Coupling laws of an optical fiber

Michelson Interferometer

Comparison of resolving limit of optical instruments with human eye (A world view of Physics by Prof. D.P. Khandelwal et al – Page 300-301, South Asian Publishers Pvt. Ltd, New Delhi 1999)

Characteristics of photo diode, photo transistor, LDR, LED

Solar cell characteristics

Dispersion through a medium – C++

Young’s double slit – Interference - C++

Diffraction due to a grating – C++

Polarization birefringence – C++

4.3 M.Sc. PHYSICS - NEW AND RENEWABLE ENERGY 4.3.1 Course Code

The first two letters PH stand for Physics, and the letters C, P, E, D and V have the usual meaning. The letter R stands for Renewable Energy. Here the core courses, Electives and Practicals are numbered from 1 to 4. The third character of the Code running from 1 to 4 indicate the semester concerned. The Course and course code are given in Table 4.2

SEM	Name of the course with course code	No. of Hrs / week	No. of credit	Total Hrs/ SEM
I	**PH1RC1**: Mathematical Physics- I	4	4	72
I	**PH1RC2**: Classical Mechanics and Relativity	4	4	72
I	**PH1RC3**: Electro Dynamics and Nonlinear Optics	4	4	72
I	**PH1RC4**: Advanced Electronics	4	4	72
I	**PH1RP1**: General Physics Practicals	9	3	162
II	**PH2RC1**: Mathematical Physics- II	4	4	72
II	**PH2RC2**: Elementary Quantum Mechanics	4	4	72
II	**PH2RC3**: Thermodynamics and Statistical Mechanics	4	4	72
II	**PH2RC4**: Condensed Matter Physics	4	4	72
II	**PH2RP2:** Computational Physics Practicals	9	3	162
III	**PH3RC1**: Advanced Quantum Mechanics	4	4	72
III	**PH3RC2**: Numerical Methods in Physics	4	4	72
III	**PH3RE2**: Renewable Energy Sources	4	4	72
III	**PH3RE3**: Microprocessors and Microcontrollers	4	4	72
III	**PH3RP3**: Electronics Practicals	9	3	162
IV	**PH4RC1**: Atomic and Molecular Spectroscopy	4	4	72
IV	**PH4RC2**: Advanced Nuclear Physics	4	4	72
IV	**PH4RE3:** Solar Thermal Collection and Storage	4	4	72
IV	**PH4RE4:** Solar Photovoltaics	4	4	72
IV	**PH4RP4:** Renewable Energy Practicals	9	3	162
IV	**PH4D05**: Project/Dissertation	Nil	2	Nil
IV	**PH4V06**: Viva Voce	Nil	2	Nil

Table 4.2 Course and course code of M.Sc.Physics – New and Renewable Energy

SEMESTER – I

PH1RC1 MATHEMATICAL PHYSICS –I Unit

I

Vector Analysis (15 Hrs)

Rotation of the coordinate axes, Scalar and Vector products, Gradient, Divergence and Curl, Vector integration, Gauss' and Stokes theorems, Potential theory, Gauss' law, Poisson's equation, Helmholtz theorem, Orthogonal coordinates, Differential vector operators, Rectangular, Cylindrical and Spherical polar coordinates.

Error Analysis (3 Hrs)

Propagation of errors, Plotting of graphs, Least square fitting, Goodness of fit, Chi square test.

Unit II

Matrices (15 Hrs)

Basic properties of Matrices, Orthogonal Matrices, Hermitian and Unitary Matrices, Diagonalization of Matrices, Normal Matrices, Normal modes of vibration, Matrix inversion, Pauli spin matrices, Moment of inertia matrix.

Probability (3 Hrs)

Definitions, Simple properties, Binomial, Poisson and Normal distributions.

Unit III Tensors

(18 Hrs)

Definition of Tensors, Associated Tensors, Metric Tensor, Contraction, Direct Product, Quotient Rule, Covariant Differentiation, Christoffel Symbols, Levi Cevita Symbol, Pseudo Tensors, Dual Tensors, Geodesic.

Unit IV

Differential Equations and Special Functions (18 Hrs)

Beta, Gamma and Dirac Delta functions (Properties only), Series solution of linear second order differential equations – Frobenius method, Bessel function of the first kind (Generating function, Recurrence relations, Orthogonality), Neumann function, Spherical Bessel function, Legendre polynomials (Generating function, Recurrence relations, Orthogonality, Rodrigues' formula), Spherical Harmonics, Hermite polynomials, Laguerre polynomials.

Reference Books:

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

Mathematical Physics, B.S. Rajput, Y Prakash 9th Ed, Pragati Prakashan

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

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

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

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

PH1RC2 CLASSICAL MECHANICS AND RELATIVITY

Unit I

Hamiltonian Methods (18 Hrs)

Review of Lagrangian dynamics - applications of Lagrange’s equations to velocity dependent potentials - Hamilton's equations of motion - cyclic coordinates - conservation theorems - homogeneity of space and time- action for an arbitrary motion - variational principle and Hamilton’s equations - Physical significance of principle of least action –Proof-Physical significance- Canonical transformations – Lagrange brackets- Poisson brackets –Equation of motion in Poisson bracket form - Hamilton's characteristic function - Hamilton Jacobi theory - harmonic oscillator problem - action angle variables – Kepler problem- transition to Wave mechanics.

Unit II

Rigid Body Dynamics (12 Hrs)

Independent Coordinates – Orthogonal Transformations – Inertia Tensor – Euler’s Angles .

Force free motion of rigid body - Cases of symmetric top - Heavy Symmetric top, fast top- Sleeping top - Precession of Charged bodies in magnetic field - Infinitesimal rotation - Coriolis Force and its effects.

Theory of Small Oscillations (8 Hrs)

Formulation of the problem – Eigen value equation – Coupled oscillators – Normal coordinates.Oscillations of linear triatomic molecules – monoatomic chain lattice – diatomic chain lattice.

Unit III

Continuous Systems and Fields & Perturbation Theory (16 Hrs)

Lagrangian formulation for continuous systems - sound vibrations in gas - Hamiltonian formulation for continuous systems - description of fields. Classical perturbation theory - time dependent perturbation - illustration case of simple pendulum with finite amplitude – Kepler problem and precession of the equinoxes of satellite orbits - time independent perturbation - first order with one degree of freedom.

Unit IV Relativity

(18 Hrs)

Review of Lorentz transformation - variation of length, mass and time with velocity - law of addition of velocities - mass energy relation - relativistic Doppler effect - four vectors. Lagrangian and Hamiltonian of a relativistic particle - charged particle in electromagnetic field - invariance of Maxwell's equations - electromagnetic field tensor.

General theory of relativity - principle of equivalence - principle of general covariance - gravitational mass and inertial mass - curvature of space time - curvature tensor - Einstein's field equations - aberration of light. Perihelion of Mercury: -Schwarzschild Solutions.

Reference Books:

Classical Mechanics, N. C. Rana & P.S. Joag, Tata Mc Graw Hill

Classical Mechanics, H Goldstein, Poole & Safko, Pearson. 3rd Ed. Narosa Pub. Co.

Classical Mechanics, A.K. Raychauduri, Oxford Univ. Press

Dynamics, S.N. Rasband, John Wiley & Sons, 1983

Introduction to Dynamics, I.Percival & D Richards, Cambridge Univ. Press 1982

Lagrangian and Hamiltonian Mechanics, M.G. Calkin, Allied Pub. Ltd.

Theory of Relativity - R. K. Patharia, Dover Pub. Inc. NY, 2003

An Introduction to General Theory of Relativity, S.K. Bose, Wiley Eastern.

Mathematical Physics, B.S. Rajput, Pragati Prakashan.

PH1RC3 ELECTRODYNAMICS AND NON LINEAR OPTICS

Unit I

Electrostatic Fields in Matter and Electrodynamics (10 hours)

Review of Electrostatics and Magnetostatics, Time varying fields and Maxwell's equations, Potential formulations, Gauge transformations, boundary conditions, wave equations and their solutions, Poynting theorem, Maxwell's stress tensor

Electromagnetic Waves (8 hours)

Maxwell's equations in phaser notation. Plane waves in conducting and non-conducting medium, Polarization, Reflection and transmission (Normal and Oblique incidence), Dispersion in Dielectrics, Superposition of waves, Group velocity.

Text Book:

Introduction to Electrodynamics, D.J Griffiths, PHI.

Unit II

Relativistic Electrodynamics (18 hours)

Structure of space time: Four vectors, Proper time and proper velocity, Relativistic dynamics-Minkowiski force, Magnetism as a relativistic phenomenon, Lorentz transformation of electromagnetic field, electromagnetic field tensor, electrodynamics in tensor notation, Potential formulation of relativistic electrodynamics.

Text Book:

1.

Unit III

**Electromag
netic Radiation (20 hours)**

Retarded potentials, Jefimenkos equations, Point charges, Lienard-Wiechert potential, Fields of a moving point charge, Electric dipole radiation, Magnetic dipole radiation, Power radiated by point charge in motion.

Radiation reaction, Physical basis of radiation reaction.

Text Book:

1.

Unit IV

Non Linear Optics (16 hrs)

Introduction – Second Harmonis generation – phase matching condition – third harmonic generation – optical mixing – parametric generation of light – self focusing of light- multiquatum photoelectric effect- two photon process- three photon process- parametric light oscillator – frequency up conversion –

phase conjugate optics – sum frequency generation – difference in frequency generation – saturable absorption.

Text Book:

Electromagnetic waves and radiating systems, E.C. Jordan & K.G. Balmain PHI, 1968

Non Linear Optics, Robert W. Boyd, Academic Press.

Reference books:

Antennas, J.D. Kraus, Mc-Graw Hill.

Classical Electrodynamics, J. D. Jackson, Wiley Eastern Ltd.

Electromagnetic fields, S. Sivanagaraju, C. Srinivasa Rao, New Age International.

Introduction to Classical electrodynamics, Y. K. Lim, World Scientific, 1986.

Lasers and Non Linear optics, B.B Laud, New Age International.

Introduction to Optics, Germain Chartier, Springer.

Contemporary optics, A.Ghatak & K. Thyagarajan, McMillan India Ltd.

PH1RC4 ADVANCED ELECTRONICS

Unit I

Operational Amplifiers (18 Hrs)

Review of differential amplifiers - review of operational amplifiers - differential amplifier with one and two op amps - Frequency response of an op amp - compensating networks

General Linear Applications

DC and AC amplifiers – AC amplifier with single supply voltage – Peaking amplifier – Summing , Scaling, averaging amplifiers – Instrumentation amplifier using transducer bridge – Differential input and differential output amplifier – Low voltage DC and AC voltmeter - Voltage to current converter with grounded load – Current to voltage converter – Very high input impedance circuit – integrator and differentiator.

Text Book:

1. Op amps and linear Integrated Circuits, R.A.Gayakwad, PHI

Unit II

Active Filters and Oscillators (11 hrs)

Active filters – First order and second order low pass Butterworth filter - – First order and second order high pass Butterworth filter- wide and narrow band pass filter - wide and narrow band reject filter - All pass filter – Oscillators: Phase shift and Wien bridge oscillators – square, triangular and saw tooth wave generators- Voltage controlled oscillator.

Text Book:

1. Op amps and linear Integrated Circuits, R.A.Gayakwad, PHI (Chap 7)

Comparators and Converters (7 hrs)

Basic comparator - Zero crossing detector - Schmitt Trigger – Comparator characteristics - Limitations of op-amp as comparators - Voltage to frequency and frequency to voltage converters - D/A and A/D converters-Peak detector – Sample and Hold circuit.

Text Book:

1. Op amps and linear Integrated Circuits, R.A.Gayakwad, PHI (Chap 8)

Unit III

Power semiconductor Devices (18 Hrs)

Power Electronics - power semiconductor devices - power diodes, SCR, Power MOSFET, Types of Power Electronic Circuits.

Text Book:

Power Electronics, R.S Anandha Murthy, V Nattarasu, 2^{nd} Edn Pearson, (Chapter 1)

Thyristor commutation techniques - Natural commutation, forced commutation, self commutation, impulse commutation, external pulse commutation, load side commutation, line side commutation.

Controlled Rectifiers **-** Principle of phase - controlled connector operation - Single phase semi converter - single phase full converters - single phase dual converters - single phase series converters

Static Switches **-** Single phase AC switches - three phase AC switches - three phase reversing switches - DC switches

Text Book:

1. Power Electronics - Circuits - Devices and Applications, M.H. Rashid, PHI, 1988

Unit IV Inverters

(18 Hrs)

Principle of operation - performance parameters - single phase bridge inverters - three phase inverters - voltage control of single phase inverters - voltage control of three phase inverters -harmonic reductions - series resonant inverters - forced -commuted thyristor inverters - current - source inverters -variable DC link inverter.

Text Book:

1. Power Electronics - Circuits - Devices and Applications, M.H. Rashid, PHI, 1988

Reference books:

Op amps and linear Integrated Circuits, R.A. Gayakwad, PHI

Integrated Electronics,Millman J & Halkias CC, MGH

M H Rashid - Power Electronics - Circuits - Devices and Applications (PHI-1988)

Power Electronics R.S Anandha Murthy, V Nattarasu, 2^{nd} Edn. Pearson

PH1RP1 GENERAL PHYSICS PRACTICALS

(Error Analysis of the experiment is to be done)

By Cornu's method, set up elliptical/hyperbolic fringes, and hence determine Young's modulus, Rigidity modulus and Poisson's ratio of the given material.

Photograph the absorption spectrum of $KMnO_4$ with a standard spectrum superimposed over it.

Analyze the given absorption spectrum of $KMnO_4$ and determine the wavelengths of the absorption bands evaluating the Hartmann's constants using wavelengths of the superimposed standard spectrum.

By Frank-Hertz experiment determine the excitation potentials of a gas. Hence deduce the wavelengths of the spectral lines expected.

Determine the Hall coefficient, carrier concentration and mobility of the given specimen by the Hall probe method.

Determine the resistivity of the given semiconducting crystal at different temperatures by the Four Probe method. Hence calculate the band gap energy.

Determine the band gap energy of silicon.

Study the variation of magnetic susceptibility of the given solid by Gouy's method. Also calculate the magnetic moment per molecule/atom of the solid.

Study the variation of magnetic susceptibility with concentration of the given salt in water. Hence show that water is diamagnetic.

Determine λ and d λ of sodium light using Michelson Interferometer. Also determine the thickness of the given mica sheet.

Determine the hysteresis loss of the given specimen in the form of a ring by ballistic method. Also calculate the retentivity and coercivity of the material.

Determine the coefficient of viscosity of the given liquid by oscillating disc method.

Study the V-I characteristics of the given photodiode. Also study the variation of photodiode current with light intensity and determine the dark resistance of the diode.

Calibrate the given silicon diode as a temperature sensor.

Study the characteristics of the given thermistor. Determine the temperature coefficients α and β of the given thermistor.

Study the beam profile of the given LASER. Determine the spot size from the intensity distribution.

Study the bending losses in the given optical fiber for different bends.

SEMESTER – II

PH2RC1 MATHEMATICAL PHYSICS – II

Unit I

Functions of a Complex Variable (18 Hrs)

Complex algebra, Cauchy-Riemann conditions, Cauchy's integral theorem, Cauchy's integral formula, Taylor and Laurent expansion, Poles, Residues, Residue theorem, Evaluation of definite integrals.

Unit II

Integral Transforms (18 Hrs)

Laplace transforms, Solution of differential equations using Laplace transforms (LCR circuit, Electromagnetic waves in dispersive medium, Damped driven oscillator, and Earth's nutation), Fourier transform, Fourier transform of full wave rectifier, Square wave and finite wave train, Momentum representation for Hydrogen atom (ground state) and Harmonic oscillator.

Unit III

Group Theory (18 Hrs)

Review of introductory definitions and concepts, Unitary representations, Schur's lemmas, Orthogonality theorem and interpretations, Character of a representation, Character Tables and examples, Irreducible representations of Abelian and Non Abelian groups, Connection with quantum numbers, Symmetry group of the Schrodinger equation, Symmetry and degeneracy, Basic functions of irreducible representations, SU(2) group, SU(3) group, Applications to Nuclear and Particle Physics (qualitative only).

Unit III

Second Order Differential Equations & Green's Function (18 Hrs)

Partial differential equations of Physics, Boundary conditions, Hermitian operators and their properties, Schmidt orthogonalization, Heat equation, Laplace's and Poisson's equations, Nonlinear partial differential equations, Separation of variables (Cartesian, Spherical polar and Cylindrical coordinates),

Non homogeneous equations, Green's function eigenfunction expansion, 1-dimensional Green's function, Green's function integral-differential equation, eigenfunction, eigenvalue equation Green's function and Dirac delta function.

Reference Books

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

Mathematical Physics, B.S. Rajput, Y Prakash 9th Ed, Pragati Prakashan

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

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

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

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

PH2RC2 ELEMENTARY QUANTUM MECHANICS

Unit I

The Formation of Quantum Mechanics (22 Hrs)

Linear vector space, Orthonormality and linear independence, Schmidt's orthogonalization procedure, Hilbert space, dimension and basis, Operators and their properties, commuting operators, Eigen values and Eigen vectors, Bra and ket notation for vectors, representation theory, coordinate and momentum representation, fundamental postulates, Expectation values and probabilities, Superposition principle, observables and operators, The uncertainty principle.

Unit II

Quantum Dynamics (12 Hrs)

The equation of motion, Schrodinger Heisenberg and interaction pictures,
Linear harmonic oscillator in Schrodinger and Heisenberg pictures,
Hydrogen atom

Symmetry and Conservation laws

Space time symmetries, Displacement of space and conservation of linear momentum, translation in time and conservation of energy, Rotation in space and conservation of angular momentum, Space inversion time reversal, identical particles, Symmetry of Wavefunctions, Spin and statistics, Pauli's exclusion principle, the Helium atom.

Unit III

Theory of Angular Momentum (20 Hrs)

Angular momentum operators, matrix representation of angular momentum operators, Pauli spin matrices, orbital angular momentum, spherical harmonics, Addition of angular momenta, Clebch Gordon coefficients, calculation of C G coefficients j=1/2 and j=1 cases.

Unit IV

The Theory of Scattering (18 Hrs)

Scattering cross section and Scattering amplitude, Low energy scattering by a central potential, Partial wave analysis, phase shift and potential, scattering length, optical theorem, Scattering by a square well potential, The Ramsuoer Townsend effect, Scattering by hard sphere, resonance scattering, high energy scattering, The integral equation, Born approximation. Validity condition of Born approximation.

Text Book:

1.

Reference Books:

Quantum Mechanics, Concepts and applications, N. Zettili, John Wiley & sons

Quantum Mechanics, L.I.Schiff, MGH

A text book of Quantum Mechanics, P. M. Mathews & K. Venkatesan, TMGH

ModernQuantum Mechanics, J.J. Sakuerai, Pearson Education.

Quantum Mechanics, A Messiah, Wiley.

Quantum Physics, Stephen Gasiorowics, Wiley.

Quantum Mechanics A. Ghatak & S. Lokanathan, Kluwer Academic Publishers

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

Introductory Quantum Mechanics, Richard L. Liboff, Pearson.

PH2RC3 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, 2^{nd} 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:

1. Introductory Statistical Mechanics, R. Bowley & M.Sanchez, 2^{nd} 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:

1. Introductory Statistical Mechanics, R. Bowley & M.Sanchez, 2^{nd} 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, 2^{nd} 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, 2^{nd} 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, 2^{nd} 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, 2^{nd} 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, (Chap. 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).

PH2RC4 CONDENSED MATTER PHYSICS

Unit I

Crystal structure and Nanomaterials (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. Nanomaterials: Definition, Synthesis and properties of nanostructured materials

Text Book:

1. Solid State Physics: Structure and properties of materials, M.A. Wahab, Narosa 2^{nd} Edn. 2010, (Chapter 8 & Ref. Book 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 2^{nd} Edn. 2010, (Chapter 10)

Unit II

Band Theory of Metals (6 Hrs)

Bloch theorem - Kronig- Penney model - Brillouin zone construction of Brilloun 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 and 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.

Text Book:

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

Unit III

Lattice dynamics (12 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 and 9)

Dielectric properties of solids (4 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)

Optical properties of solids (4 Hrs)

Drude model - ionic conduction - optical refractive index and relative dielectric constant - optical absorption in metals, insulators and semiconductors.

Text Book:

1. Solid State Physics, S.O. Pillai, New Age International 6th Edn. 2010, (Chapter 12).

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. Novel magnetic materials: GMR-CMR materials (qualitative)

Text Book:

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

Superconductivity (8 Hrs)

Thermodynamics of superconducting transition - London equations – coherence length - BCS th theory (qualitative) – BCS ground state – energy gap- flux quantization - single particle tunneling - Josephson superconductor tunneling - macroscopic quantum interference - high Tc superconductivity and its applications.

Text Book:

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

Reference Books:

Solid State Physics, N.W. Ashcroft & N.D. Mermin, Cengage Learning Pub.11^{th} 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)
Nanoclusters and Nanocrystals, Edited by Hari Singh Nalwa, American Scientific Publishers, 2003.

PH2RP2 COMPUTATIONAL PHYSICS PRACTICALS

[Programs are to be written in C++ language for experiments in section A and Section B. Method, algorithm and flow chart are to be developed.For Section C suitable simulation software can be used.]

Section - A: (Graphics)

Write and execute a program to demonstrate the motion of a spherical body in a viscous medium. Study the effect on motion by changing the mass, size of the body and the medium.

Write and execute a program for the motion of a projectile in air. Study the motion for different angles of projection.

Write and execute a program to find the variation in position, velocity and acceleration of a damped harmonic oscillator. How do the oscillations go from the undamped to the critically damped and to over damped with variation in damping coefficient?

Write and execute a program to find the variation in acceleration, velocity, position and energy of a driven oscillator. Plot the position versus time graph for different driving conditions.

Write and execute a program to generate a pattern of standing waves. Run this program with different values of amplitude, wavelength and velocity.

Write and execute a program to analyze a series LCR circuit with an AC source. Verify the resonance condition.

Section – B: (Numerical methods)

Write and execute a program for solving a system of linear equations using Gauss elimination method.

Write and execute a program to find the root of a non linear equation by bisection method.

Write and execute a program for the numerical integration of a function using trapezoidal method.

Write and execute a program for the numerical integration of a function using Simpson's 1/3 rule.

Write and execute a program to solve the given ordinary differential equation by using Euler method.

Write and execute a program to solve the given ordinary differential equation by using Runge-Kutta fourth order method.

Section – C: (Circuit Simulation)

Design and simulate a single stage RC coupled amplifier with feedback. Study the frequency response

Design and simulate a two stage RC coupled amplifier with feedback. Study the frequency response.

Design and simulate an RC phase shift oscillator using BJT and observe the sinusoidal output waveform.

Design and simulate the first order and second order low pass Butterworth filter for a cut off frequency of 1KHz. Obtain the frequency response curve and determine the roll off rate.

Design and simulate a differential amplifier using transistors with constant current source. Study its frequency response. Also determine its CMRR.

Design and simulate a differentiator and integrator using Op-amp. Obtain the output waveform for an input square wave.

SEMESTER – III

PH3RC1 ADVANCED QUANTUM MECHANICS

Unit I

Approximation Methods for Time-Independent Problems (18 Hrs)

Time-independent perturbation theory, Non-degenerate and degenerate cases, Anharmonic oscillator, Stark and Zeeman effects in hydrogen. The WKB approximation, connection formulae, validity of the approximation, barrier tunnelling, application to decay - Bound states, Penetration of a potential barrier,

Variational method

The variational equation, ground state and excited states, the variation method for bound states, application to ground state of the hydrogen and Helium atoms.

Unit II

Time Dependent Perturbation Theory (18 Hrs)

Time dependent perturbation theory Transition probability, constant perturbation, Transition to continuum, Harmonic perturbation, Interaction of an atom with the electromagnetic field, Induced emission and absorption, The electric dipole approximation, The Born approximation and scattering amplitude.

Unit III

Relativistic Quantum Mechanics (22 Hrs)

The Dirac equation, Dirac matrices, Solution of the free-particle Dirac equation, The Dirac equation with potentials, Equation of continuity, Spin of the electron, Non-realistic limit, Spin-orbit coupling, Covariance of the Dirac equation, Hole theory, The Weyl equation for the neutrino, Non-conservation of parity, The Klein-Gordon equation, Charge and current densities, The Klein-Gordon equation with potentials, Wave equation for the photon, Charge conjugation for the Dirac, Weyl and Klein-Gordon equation.

Unit IV

Quantization of fields (14 Hrs)

The principles of canonical quantization of fields, Lagrangian density and Hamiltonian density, Second quantization of the Schrodinger wave field for bosons and fermions, Quantization of Electromagnetic waves Coulomb's gauge.

Text Book:

1. Quantum Mechanics, V.K. Thankappan, Wiley Eastern

Reference Books:

Quantum Mechanics, Concepts and applications, N. Zettili, John Wiley & sons

Relativistic Quantum Mechanics, J.D. Bjorken & S. Drell, MGH, (1998)

Quantum Mechanics, L.I.Schiff, MGH

Advanced Quantum Mechanics, J.J. Sakuerai, Pearson Education.

A text book of Quantum Mechanics, P. M. Mathews & K. Venkatesan, TMGH

Quantum Physics, Stephen Gasiorowics, Wiley

PH3RC2 NUMERICAL METHODS IN PHYSICS

Unit I (18 Hrs)

Interpolation and Curve fitting - Errors in Polynomial Interpolation - Finite differences(Forward differences, Backward differences, Central differences) - Detection of errors by use of difference tables-Differences of a polynomial – Newton's formulae for interpolation - Central difference interpolation formulae (Gauss central difference formulae, Stirlings formulae, Evretts formula) - Interpolation with unevenly spaced points (Lagrange's interpolation formulae, Error in Lagrange's interpolation formulae, Hermite's interpolation formulae)

Least squares curve fitting procedures (Fitting a straight line, Nonlinear curve fitting, Curve fitting by a sum of exponentials) - Weighted least squares approximation (Linear Weighted least squares approximation, Nonlinear Weighted least squares approximation) – Method of least squares for continuous Functions (Orthogonal polynomials, Gram-Schmidt orthogonalization process)

Unit II (18 Hrs)

Numerical differentiation and integration - Numerical differentiation - Errors in Numerical differentiation - Trapezoidal rule-Simpson's 1/3 rule - Simpson's 3/8 rule - Romberg Integration-Gaussian Integration - Monte Carlo evaluation of integrals - Double Integration -Newton-cotes integration formulae.

Unit III (18 Hrs)

Linear system of equations - Solution of linear systems-Matrix inversion method - Gauss elimination method - Gauss-Jordan Method - Modification of Gauss method to compute the inverse of a matrix - Solution of linear systems-Iterative methods - The eigen value problem-Power method and Jacobi's method to solve eignvalue problems. (10 Hrs)

Numerical solution of ordinary differential equations - Solution by Taylor's series - Picards method of successive approximations - Euler's method - Runge-Kutta methods-Predictor-Corrector methods. (8 Hrs)

Unit IV (18 Hrs)

Numerical Solutions of partial differential equations - Finite difference approximations to derivatives - Laplace equation-Jacobi's method - Gauss Seidal method - Successive over relaxation - The ADI method - Parabolic equations - Iterative methods for the solution of equations - Hyperbolic equations

Text Books:

Mathematical Methods, G. Sanker Rao, K. Keshava Reddy, I.K.International Publishing House, Pvt. Ltd.

Introductory Methods of Numerical Analysis, S.S. Sastry, PHI Pvt. Ltd.

Reference Books:

An Introduction to Computational Physics, Tao Pang, CUP

Numerical Recipes in C++,W.H. Press, Saul A. Teukolsky, CUP

Numerical methods for scientific and Engineering computation M.K Jain,S.R.K Iyangar: New Age International Publishers

Computer Oriented Numerical Methods, V. Rajaraman, PHI, 2004.

Numerical Methods, Balaguruswami, Tata McGraw Hill, 2009.

Numerical Mathematical Analysis, 4^{th} Edn, J.B. Scarborough, 1958.

PH3RE2 RENEWABLE ENERGY SOURCES

Unit I

Wind Power (18 Hrs)

Energy and power in wind - wind turbines - power and energy from wind turbines - commercial development and wind energy potential - economics - cost calculation - capital cost.

Wave Energy

Wave energy - wave motion - power from wave energy

Unit II

Hydroelectricity (18 Hrs)

Stored potential energy - power head and flow rate - world resource - types of hydrolectric plants - low, medium and high heads - estimation of power - economics of hydrolectric projects.

Tidal Power

Nature of resource - basic physics - power generation -economical and environmental factors.

Ocean Thermal Energy Conversion (OTEC)

Introduction - OTEC power generation

Unit III

Geothermal Energy (18 Hrs)

Earth as a heat engine – miming of geothermal heart - physics of geothermal resources – technologies for geothermal exploration - economics and world potential- of geothermal energy.

Biomass

Biomass as a fuel – extraction of energy agricultural resides – energy from refuse - energy from crops new technologies - gas turbine - biomass fuel cell – photo biological fuel production - economics of biomass.

Unit III

Fuel Cells (18 Hrs)

Design and principle of operation of a Fuel Cell (H_2, O_2 cell), Classification of Fuel Cells, Types of Fuel Cells, Advantages and Disadvantages of Fuel Cells, Conversion efficiency of Fuel Cells, Work output and EMF of Fuel Cells, Applications of Fuel Cells.

Hydrogen Energy

Hydrogen production (Electrolysis method, Thermo-chemical methods, Fossil fuel methods, solar energy methods), Hydrogen storage, Hydrogen transportation, Utilization of Hydrogen Gas, Safety and management, Hydrogen technology development.

Reference Books:

Solar Energy Priciples of Thermal Collection and Storage, S.P. Sukhatme,2nd Ed. TMH

Solar Engineering of Thermal Process, J.A. Duffie & W. A Beckman,2nd Ed. John Wiley & sons.

Solar energy, H. P. Garg and J Prakashi,TMH 1997

Solar Energy Utilization, G D Rai, Khanna Publishers, 1997.

Renewable Energy Source and Conversion Technology, N.K Bansal, M. Kleemanm & M. Melss, TMH.

Renewable Eneregy, Godfrey Boyle, Oxford Univ. Press, 1996

Renewable Energy 2000, G.T. Wrixon, A.M.E. Rooney & W. Palz, Springer Verlag 1993.

Solar Power Plants, C.J. Winter, R.L. Sizmann & L.L Vant-Hull, Springer Verlag.

PH3RE3 MICROPROCESSORS AND MICROCONTROLLERS

Unit I

8085 Architecture and Data Transfer Schemes. (18 Hrs)

8085 architecture - instruction set (assignment &discussion)) - instruction timings and execution - 8085 interrupts - 8085 Input /Output - standard I/O-memory mapped I/O - address space partitioning - memory interfacing - bus contention - data transfer schemes - classification of data transfer schemes - programmed data transfer - synchronous transfer -asynchronous transfer - interrupt driven data transfer- multiple interrupts - multiple devices, single interrupt level - software polling - hardware polling - direct memory access data transfer.

Text Books:

Microprocessor Architecture Programming and Applications, R.S. Gaonkar, Wiley Eastern.

Introduction to Microprocessors 3rd Ed. Aditya P. Mathur, TMH

Unit II

Interfacing Devices & Memory Devices (18 Hrs)

Basics of programmable I/O - the 8155 IC - the 8255 PPI - key board and display interface 8279 - serial communication -The USART - 8251 - DMA controller - 8257 - Programmable Interrupt controller – 8259- (Architecture and programming for all devices) – EPROM and RAM memory devices - 2764 and 6264.

Text Books:

Microprocessors and Microcomputer Based System Design, M. Rajiquzzaman, Universal book stall, New Delhi

Fundamentals of Microprocessors and Microcomputers,J.S. Ram, DhanpatRai Publications, New Delhi.

Unit III

Interfacing 8055 & Architecture of 8086 (18 Hrs)

Review of operational amplifier characteristics – transducers and its classification-lightsensors–Eg(1)Photoconductivecell (2)

Semiconductor photo diode - temperature sensors –Eg (1) Thermocouple (2) Thermister – force sensors – Eg - Strain gauges - the 8085 based data acquisition system - interfacing ADC (0808) – concept of sample and hold circuit (LF 398) - clock for A/D converter – (circuit) - ADC 0808 (internal diagram) - interfacing circuit for 8085.

8086 IC

Architecture of IC 8086 - addressing modes - instruction set (assignment and discussion) - pin layout – (sample programs using debug utilities) - minimum mode and minimum system mode interface – comparison 8086 & 8088.

Text Books:

Fundamentals of Microprocessors and microcomputers, B. Ram, DhanpatRai Publications, New Delhi.

Electronic Instrumentation, H.S. Kalsi, 2nd Edn. TMH.

The 8088 and 8086 microprocessors, W.A. Triebel & A.Singh, PHI

Advanced Microprocessors and Peripherals, Architecture Programming and Interfacing. A.K Ray, K.M Bhurchandi, TMH.

Unit IV

Micro Controllers (18 Hrs)

Introduction - Difference between microprocessors and micro controllers - types of micro controllers (MC) - internal architecture of typical MC (Intel 8051) - peripheral features - programming concepts – assembly language programming – jump – loop - call instructions - I/O port programming – Address modes – Arithmetic, logic instructions and programs – 8051 programming in C - (sample programs using Kiel utilities) - LCD interfacing.

Text Books:

The 8051 Micro Controller, Architecture Programming and Applications, Kenneth J. Ayala, Penram Int, Pub., Mumbai

The 8051 Microcontroller and Embedded Systems Using Assembly and C, Muhammad Ali Mazidi, 2nd Ed, Pearson.

Reference Books:

Microprocessor Architecture Programming and Applications, R.S. Goankar, Wiley Eastern.

Introduction to Microprocessors, 3rd Ed. Aditya P. Mathur, TMH.

0000 to 8085 - Introduction to Microprocessors for Engineers and Scientists, P.K Ghosh, P.R. Sridhar, PHI Learning Pvt. Ltd.

The 8086 Microprocessor: Programming and interfacing the P.C., K.J. Ayala, Penram Pub. India

The 8051 Microcontroller and Embedded systems Using Assembly and C, 2nd Ed. Muhammad Ali Mazidi, R. Mckinlay, J.G. Mazidi, Pearson.

PH3RP3 ELECTRONICS PRACTICALS

(Use of Bread Boards for assembling electronics circuits is permitted. For Microprocessor experiments microprocessor kit, suitable simulation software or convenient Hex editors are permitted)

Design and construct a two stage RC coupled amplifier with feedback. Study the frequency response.

Design and construct a differential amplifier using transistors with constant current source. Study its frequency response. Also determine its CMRR.

Design and construct a push-pull power amplifier using transistors in complementary symmetry arrangement. Plot load impedance versus output power graph and determine the optimum load. Also study the frequency response.

Design and construct an RF amplifier. Study the effect of damping on the frequency response.

Design and construct a voltage controlled oscillator (VCO) using transistors. Plot the graph connecting frequency and control voltage. Repeat the experiment covering the entire audio frequency range.

Design and construct a differential amplifier using suitable operational amplifier (Op-amp) and study its frequency response. Also determine its CMRR.

Design and construct the first order and second order low pass Butterworth filter for a cut off frequency of 800 Hz. Draw the frequency response curve and determine the roll off rate.

Design and construct the first order and second order high pass Butterworth filter for a cut off frequency of 2 kHz. Draw the frequency response curve and determine the roll off rate.

Design and construct a band pass filter with multiple feedback using an operational amplifier (Op-amp) so that f_0 = 2 kHz. Q =3 and A_F =10. Draw the frequency response curve and determine the pass band.

Design and construct a Wein Bridge Oscillator incorporating the amplitude stabilization for a frequency of 2 kHz. Using an operational amplifier (Op-amp). Repeat the experiment for different frequencies.

Using an operational amplifier (Op-amp) design and construct a voltage regulator with short circuit protection to obtain a regulated output of 6 volt. Study the load regulation and source regulation.

Determine experimentally the following parameters of an operational amplifier (Op-amp). (a). Input offset current (b). Input offset voltage (c). CMRR (d).Slew rate.

Using an operational amplifier (Op-amp) design and construct a triangular wave from generator for 1 kHz. With amplitudes 5 V. Measure the amplitude and frequency. Compare with theoretical values. Repeat the experiment for the frequencies of 500 Hz, 2 kHz, 3 kHz and 4 kHz.

Design and construct a voltage controlled oscillator (VCO) using IC555. Study variation of output frequency with control voltage and compare with the theoretical value. Also determine the duty cycle and compare with the theoretical value.

Design and construct a 4-bit binary synchronous counter using JK flip flops. Construct the up counter and convert it to a down counter.

Design and construct an amplitude modulator. Determine the percentage modulation. Trace the wave forms. Repeat the experiment for different amplitudes of the modulating signal.

Write and execute a program to control the speed of the stepper motor interfaced with a microprocessor. Rotate the motor in the clockwise and anticlockwise directions using the program. Repeat the experiment for various time delays.

Write and execute a program to measure an analog voltage using a microprocessor kit with an ADC. Repeat for five different analog voltages. Draw a graph connecting the theoretical and measured values.

Write and execute a program for generating any two types of wave forms (triangular, square, saw-toothed, sine etc.) using microprocessor in association with a D/A interfaced card. Observe the wave forms using CRO. Measure the frequencies using the CRO and compare it with theoretical values.

SEMESTER – IV

PH4RC1 ATOMIC AND MOLECULAR SPECROSCOPY

Unit I

Atomic Spectra (18 Hrs)

Quantum states of electrons in atoms. electron spin, spectroscopic terms and selection rules. Spectrum of helium and alkali atoms. Hyperfine structure and isotopic shift. Width of spectral lines. Spin orbit interaction. Derivation of spin orbit interaction energy, fine structure in sodium atom, Landau g-factor, Zeeman effect. Paschen–Bach effect and Stark effect in one electron system, LS and JJ coupling schemes (Vector diagram), Hund’s rule, Derivation of interaction energy, examples of LS and JJ coupling, Lande interval rule, Hyperfine structure, Width of spectral lines.

Text Book:

1. SpectroscopyStraughan & Walker, Vol. 1- John Wiley & Sons
2. Introduction of atomic spectra, H.E. White, Mc Graw Hill

Unit II

Microwave and Infra Red Spectroscopy (18hrs)

Microwave Spectroscopy: Rotational spectra of diatomic molecules. Intensity of spectral lines, effect of isotopic substitution.

Non–rigid rotator, rotational spectra of polyatomic molecules - linear, symmetric and asymmetric top molecules. Information derived from rotational spectra.

IR Spectroscopy: Vibrating diatomic molecules as anharmonic oscillators, diatomic vibrating rotator – break down of Born Oppenheimer approximation, vibrations of polyatomic molecules, overtone and combination frequencies, influence of rotation on the spectra of polyatomic molecules - linear and symmetric top molecules, analysis by IR technique, IR spectrometer, Fourier Transform Spectroscopy.

Text books:

Fundamentals of molecular spectroscopy, C.N. Banwell, MGH.

Molecular structure and spectroscopy, G. Aruldas, PHI Learning Pvt. Ltd.

Unit III

Raman and Electronic Spectroscopy (18 Hrs)

Pure rotational Raman Spectra - linear and symmetric top molecules, vibration Raman spectra – Raman activity of vibrations, mutual exclusion principle, rotational fine structure, structure determination from Raman and IR spectroscopy. Non-linear Raman effects - hyper Raman effect, classical treatment, stimulated Raman effect, CARS

Electronic Spectroscopy: Electronic spectra of diatomic molecules, intensity of spectral lines, Frank–condon principle, dissociation energy and dissociation products, rotational fine structure of electronic-vibrational transition, Fortrat diagram, pre-dissociation.

Text books:

Fundamentals of molecular spectroscopy, C.N. Banwell, MGH

Molecular structure and spectroscopy, G.Aruldas, PHI Learning Pvt. Ltd.

Lasers and Non-Linear Optics, B.B Laud, Wiley Eastern

Raman Spectroscopy, D.A. Long, MGH.

Unit IV

Spin Resonance Spectroscopy. (18 Hrs)

NMR: Quantum mechanical description, classical description, the Bloch equations - relaxation processes, Chemical shift, spin–spin coupling for hydrogen molecule, experimental technique – CW and FTNMR spectrometer, applications.

ESR: Theory of ESR, thermal equilibrium and relaxation, experimental techniques, g- factor, hyperfine structure, applications, – Mossbauer effect, recoilless emission and absorption, experimental methods, hyperfine interactions – chemical isomer shift, magnetic hyperfine interactions, electronic quadrupole interactions, applications.

Text Book:

Spectroscopy Straughan & Walker, Vol.1&2, John Wiley & Sons

Reference Books:

Introduction to molecular spectroscopy, G.M. Barrow, Mc Graw Hill.

Mol. Spectra and Mol. Structure, Vol. 1, 2 & 3, G. Herzberg, Van Nostard, London.

Photoluminescence of solutions, C.A. Parker, Elsevier Pub.Co. 1968.

Elements of spectroscopy, Gupta, Kumar & Sharma, Pragathi Prakshan.

Spectroscopy, Experimental Techniques, B.K. Sharma, Goel Pub. House.

The Infra Red Spectra of Complex Molecules, L.J. Bellamy, Wiley & Sons. Vol. 1&2.

Elementary Organic Spectroscopy, Y.R. Sharma, S. Chand and Co.

Spectroscopy of organic compounds, P.S. Kalsi, New age.

Laser Spectroscopic Techniques and Applications, E.R. Menzel, Practical spectroscopic series vol. 18 – Mracel Dekker.

Molecular structure and spectroscopy, G.Aruldas, PHI

PH4RC2 ADVANCED NUCLEAR PHYSICS

Unit I

Nuclear Decay (18 Hrs)

Beta decay – introduction, energy release in beta decay, Fermi theory of beta decay, Fermi-Kurie plot, mass of the neutrino, comparative half-life, allowed and forbidden transitions, selection rules, parity violation in beta decay, neutrino Physics.

Gamma decay – energetics, multipole moments, transitions and radiations – classical and quantum mechanical aspects, selection rules, angular correlation and internal conversion.

Nuclear radiation detectors : Gas detectors – Ionization chamber, Proportional counter and G. M. counter, Scintillation detector, Photo Multiplier Tube (PMT).

Text Books:

Introductory Nuclear Physics, K.S. Krane, Wiley

Nuclear Radiation Detection, Measurements and Analysis, K. Muraleedhara Varier, Narosa

Unit II

Nuclear Forces (18 Hrs)

General characteristics of nuclear forces, The Deuteron – binding energy, spin, parity, electromagnetic moments, simple theory of the deuteron structure, spin dependence, tensor force, and two nucleon scattering experimental data, scattering cross sections, low energy n-p scattering, partial waves, phase shift, singlet and triplet potentials, scattering length and its sign, effective range theory, low energy p-p scattering, exchange forces and Yukawa theory (Qualitative only).

Text Books:

Introductory Nuclear Physics, K.S. Krane, Wiley

Nuclear Physics- Theory and Experiment, R.R. Roy & B.P. Nigam, Wiley Eastern

Unit III

Nuclear Models, Nuclear Fission and Fusion (18 Hrs)

Nuclear models: Shell model, single particle potentials, spin-orbit coupling, single particle models, spins and parities of ground states, qaudrupole moments, magnetic moments and Schmidt limits, Nordheim's rules, isospin symmetry,

Nuclear fission and Fusion: Compound nucleus reactions, fission process, characteristics, energy released, neutrons released in fission, cross sections, types of nuclear reactors, fusion process, characteristics of fusion, solar fusion, controlled fusion reactors.

Text Books:

Introductory Nuclear Physics, K.S. Krane, Wiley

Nuclear Physics- Theory and Experiment, R.R. Roy & B.P. Nigam, Wiley Eastern

Unit IV

Particle Physics (18 Hrs)

Types of interactions between elementary particles - hadrons and leptons, their masses, spin parity decay structure, the quark model, the confined quarks, coloured quarks, experimental evidences for quark model. The quark-gluon interaction. Gell-mann-Nishijima formula, Symmetries and conservation laws, C, P and CPT invariance and applications of symmetry arguments to particle reactions, parity non conservation in weak interactions. Exchange bosons of the weak interaction, electroweak unification.

Text Books:

The Particle Hunters, Yuval Ne'eman and Yoram Kirsh, , 2nd Ed.,Cambridge University Press,1996

Introduction to Elementary Particles, David Griffiths, John Wiley & Sons,1987

Reference Books:

Nuclear Physics: An Introduction, S.B .Patel, New Age International.

Introductory Nuclear Physics, Samuel S.M. Wong, PHI.

Concepts of Nuclear Physics, B.L. Cohen, Tata McGraw Hill

Nuclear Physics, Irvin Kaplan, Addison Wesley, 1962

Atomic Nucleus, R.D. Evans, McGraw-Hill, New York.

Introduction to Nuclear Physics, H.A. Enge, Addison Wesley, London 1975.

Introductory Nuclear Physics, Y.R. Waghmare Oxford-IBH, New Delhi 1981.

Atomic and Nuclear Physics, S.N. Ghoshal, Volume 2, S.Chand &Co.

Nuclear and Particle Physics, W.E. Burcham and M. Jobes, John Wiley & Sons.

Particles and Nuclei, B. Povh, K. Rith, C. Scholz & F. Zetche, Springer(2002)

Theideasofparticlephysics–Anintroductionforscientist, G.D.Couoghlan, J.E.Dodd. & Ben M. Gripaios, 2nd Edn. 1991 or 3rd Edn. 2006, CUP.

PH4RE3 SOLAR THERMAL COLLECTION AND STORAGE

Unit I

Solar Energy Solar Radiation (18Hrs)

Structure of the sun - solar radiation outside the earth’s atmosphere - solar radiation at the earth's surface - instruments for measuring solar radiation and sunshine - solar radiation geometry - solar radiation on titled surfaces

Text Books:

Solar Energy - Principles of Thermal Collection and Storage, S.P. Sukhatme, 2nd Edn. TMH, (Chapter 3)

Thermal Applications Of Solar Energy - An Overview

Devices for thermal collection and storage - thermal applications, water heating, space heating, space cooling and refrigeration, power generation, distillation, drying and cooking

Text Books:

Solar Energy - Principles of Thermal Collection and Storage, S.P. Sukhatme, 2nd Edn. TMH, (Chapter 2)

Selective Surfaces For Solar Energy Conversion

Introduction - heat balance - physical characteristics - use of selective solar energy collectors - anti-reflection coatings -solar reflector materials - type of selective coatings -preparations of selective coatings

Text Books:

1. Solar Energy Utilization, G.D. Rai, Khanna Publ., 1997 (Chap. 17).

Unit II

Flat Plate Collectors (18Hrs)

Performance analysis of fluid flat plate collectors - transmissivity of cover system - transmissivity absorptivity product - overall loss coefficient and heat transfer correlation -collector efficiency factor - collector heat removal factor - effects of various parameters performance - testing procedures performance analysis of conventional air heater - other types of air heaters, testing procedures

Text Books:

Solar Energy - Principles of Thermal Collection and Storage, S.P. Sukhatme, 2nd Edn. TMH, (Chapter 4 & 5)

Unit III

Concentrating Collectors (18 Hrs)

Parameters characterizing solar concentrators - types of concentrating collectors – cylindrical, parabolic concentrators - performance analysis of cylindrical parabolic concentrators -parametric study of cylindrical concentrating collectors - compound parabolic collector (CPC), CPC geometry -performance analysis - central receiver collector (basic ideas)

Text Books:

Solar Energy - Principles of Thermal Collection and Storage, S.P. Sukhatme, 2nd Edn. TMH, (Chapter 6)

Unit IV

Solar Refrigeration and Air-Conditioning (18 Hrs)

Carnot refrigeration cycle - principle of absorption cooling - lithium bromide water absorption system - aqua - ammonia absorption system intermittent absorption refrigeration system) - vapour compression refrigeration – desiccant cooling

Text Books:

1 Solar Energy, H.P. Garg & J. Prakash, TMGH 1997 (Chapter 12)

Thermal Energy Storage

Sensible heat storage - Latent heat storage - thermo - chemic$_{V}$ storage - Solar pond - performance analysis of solar pond

Text Books:

Solar Energy, H.P. Garg & J. Prakash, TMGH 1997 (Chapters 7 & 8)

Reference Books:

John A Duffie and W. A. Beckman, Solar Engineeering of thermal process 2nd Edition John Wiley & Sons, INC.

N K Bansal, M. Klemmann and M. Meliss, Renewable Energy sources and Conversion technology, TMH

Godfrey Boyle Renewable Energy, Oxford Univ. Press 1996

G T Wrixon, A M E Roney and W. Palz, Renewable energy 2000, Springer Verlag 1993.

C. J. Winter, R. L. Sizmann and L L Vaithull, Solar Power Plants, Springer Verlag.

PH4RE4 SOLAR PHOTOVOLTAICS

Unit I

SolarCellFundamentals(18Hrs)

Extrinsic semiconductor, controlling carrier concentration – carrier concentration and distribution – density of energy states – carrier distribution function-number of electrons and holes- electron hole concentration – carrier motion in semiconductors- drift: motion due to electric fields - electric field and energy band bending - diffusion current - diffusion current density – drift and diffusion together – diffusion coefficient – generation of carriers – recombination of carriers – continuity of carrier concentrations.

P-N Junction Diode: An Introduction to Solar Cells - equilibrium condition – space charge region - energy band diagram – junction potential-width of depletion region – carrier movements and current densities – carrier concentration profile – p-n junction non - equilibrium condition - I-V relation

(qualitative).

Text Book:

1.Solar Photovoltaic:
Applications, Chetan
Singh and 4)

Unit II (18 Hrs)

P-N junction I-V relation: quantitative analysis - P-N junction under illumination – generation of photo voltage (PV) – light generated current – I-V equation for solar cell – solar cell characteristics.

Design of Solar Cells: upper limits of solar cell parameters - short circuit current – open circuit voltage – fill factor – efficiency – losses in solar cell – model of solar cell – effect of series and shunt resistance, solar radiation and temperature on solar cell efficiency – solar cell design - design of high short circuit current – choice of junction depth and orientation – minimisation of optical losses and recombination – Design for high open circuit voltage – design for high fill factor – base resistance – emitter resistance – analytical techniques – solar simulator: I-V measurement – quantum efficiency measurement – minority carrier life time and diffusion length measurement.

Text Book:

1. Solar Photovoltaic: Fundamentals, Technologies and Applications, Chetan Singh Solanki, PHI, 2nd Edn. (Chap 4 & 5)

Unit III (18 Hrs)

Solar Cell Technologies:

Production of silicon (Si) – Silicon requirement –production of metallurgical grade Si - production of electronic grade Si - production of Si wafers – Si sheets – Si feedstock for solar cell industry – Solar grade production of Si wafers – Si usage in solar SPV - Si wafer based solar cell technology - development of commercial Si solar cells – process flow of commercial Si cell technology – processes used in solar cell technology – high efficiency Si solar cells.

Thin Film Solar Cell Technologies:

Generic advantages of thin film technologies – materials for thin film technologies – thin film deposition techniques – common features of thin film technology - amorphous Si solar cell technology – cadmium telluride collar cell technology – chalcopyrite solar cell technology – thin film crystalline Si solar cell – microcrystalline Si thin film solar cell – thin film polycrystalline Si solar cell – large grain thin film crystalline Si solar cell – thin film epitaxial Si solar cell

Concentrator PV Cells and Systems:

light concentration – concentration ratio – series resistance optimisation of concentrator cells - optics for concentrator SPV.

Emerging Solar Cell Technologies and Concepts. Organic solar cells - Gallium Arsenide solar cells - Thermo photovoltaics.

Text Book:

1.Solar Photovoltaic: Fundamentals, Technologies and Applications, Chetan Singh Solanki, PHI, 2nd Edn. (Chapters 6,7,8 and 9)

Unit IV

Solar Photovoltaic Applications (18 Hrs)

Solar Photovoltaic (SPV) Modules – SPV from solar cells – series and parallel connections – mismatch in cell module – mismatch in series connection – hot spots in modules – bypass diode- mismatching parallel connection – design and structure of PV modules - number of solar cells- wattage of modules – fabrication of modules – PV module power output – I-V equation of PV modules – rating of PV modules - I-V and power curves of module – effect of solar irradiation and temperature - Balance of Solar PV Systems – electrochemical cells –factors affecting battery performance – batteries for SPV systems

Photovoltaic System Design and Applications.- introduction to SPV systems – stand alone SPV system configurations – design methodology of SPV systems – wire sizing in SPV systems - price sizing of SPV systems - hybrid SPV systems - grid connected SPV systems - simple payback period

– life cycle costing

Text Book:

1.Solar Photovoltaic: Fundamentals, Technologies and Applications, Chetan Singh Solanki, PHI, 2nd Edn. (Chapters 12,13 and 14)

Reference Books:

PracticalPhotovoltaics:ElectricityfromSolarCells Practical Photovoltaics: Electricity from Solar Cells Richard J. Komp 3rd Edn. aatec Publishers, Michigon.

The Physics of Solar Cells (Properties of Semiconductor Materials), Jenny Nelson, Imperial College Press, London.

PH4RP4 RENEWABLE ENERGY PRACTICALS

Solar Cell characteristics

Efficiency of Solar Flat Plate Collectors

Improvement of Power Factor

Efficacy of Lamps

Study of Bio-gas plant (Lab Model)

Stefan - Boltzmann Constant

Fluidized Bed Heat Transfer

Microprocessor based Sun-tracking System (Lab Model)

Performance evaluation of a Single Basin Solar Still

Thermal testing of Box-type Solar Cooker

Determination of heat Loss Factor $F'U_L$ of linear Solar Absorbers using Indoor Test Facility

Determination of Time Constant of Solar Flat Plate Collector

Measurement of Solar Reflectance and Absorptance of surfaces

Study of Effect of Anti-reflection Coatings of Solar Cells

Performance Analysis of a Paraboloid Concentrator

Testing of a Solar Cabinet Drier

Determination of Optical Efficiency of a Seasonally Adjusted Linear Solar Concentrator

Four more experiments of equal standard can be added

4.4 M.Sc. PHYSICS - MATERIAL SCIENCE 4.4.1 Course Code

The first two letters PH stand for Physics, and the letters C, P, E, D and V have the usual meaning. The letter M stands for Material Science. Here the core courses, Electives and Practicals are numbered from 1 to 4. The third character of the Code running from 1 to 4 indicates the semester concerned.

Course and Coure code of M.Sc. Physics - Material Science are given in Table 4.3

SEM	Name of the course with course code	No. of Hrs/ week	No. of credit	Total Hrs/ SEM
I	**PH1MC1:** Applied Mathematics for Physics - I	4	4	72
I	**PH1MC2:** Quantum Mechanics - I	4	4	72
I	**PH1MC3:** Advanced Nuclear Physics	4	4	72
I	**PH1MC4**: Condensed Matter Physics	4	4	72
I	**PH1MP1**: General Physics Practicals	9	3	162
II	**PH2MC1**:Applied Mathematics for Physics - II	4	4	72
II	**PH2MC2**: Electrodynamics and nonlinear Optics	4	4	72
II	**PH2MC3**: Advanced Electronics	4	4	72
II	**PH2MC4**: Classical Mechanics and Relativity	4	4	72
II	**PH2MP2**: Electronics Practicals	9	3	162
III	**PH3MC1**: Computer Application in Physics	4	4	72
III	**PH3MC2**: Atomic and Molecular Spectroscopy	4	4	72
III	**PH3ME1**: Solid State Physics	4	4	72
III	**PH3ME2**: Crystal Growth Techniques	4	4	72
III	**PH3MP3**: Computational and Advanced Electronic Practicals	9	3	162
IV	**PH4MC1**: Quantum Mechanics - II	4	4	72
IV	**PH4MC2**: Statistical Physics and Astrophysics	4	4	72
IV	**PH4ME3:** Nanostructres and Characterisation	4	4	72
IV	**PH4ME4:** Thin Film and Nanoscience	4	4	72
IV	**PH4MP4:** Material Science Practicals	9	3	162
IV	**PH4D05**: Project/Dissertation	Nil	2	Nil
IV	**PH4V06**: Viva Voce	Nil	2	Nil

Table 4.3 Course and Coure code of M.Sc.Physics - Material Science

SEMESTER – I

PH1MC1 APPLIED MATHEMATICS FOR PHYSICS- I

Unit 1

Complex Analysis (20 Hrs)

Function of a complex variable Cauchy-Rieman equation for analyticity – Integration in a complex plane – Cauchy's integrant theorem – Cauchy's integral formula -Taylor and Laurent expansions – Poles, residues & residue theorem -Evaluation of integrals.

Unit II

Group theory (18 Hrs)

Introductory definitions and concepts- cyclic groups - point groups - reducible and irreducible representations - orthogonality theorem - group character table - applications in molecular and crystal physics - 3d rotational group - lie group and lie algebra - Poincare and Lorentz group - SU(2) and SU(3) - examples from particle physics.

Unit III

Integral transforms (18 Hrs)

Laplace & Fourier transforms – universe transforms – solution of differential equation, wrong L T Earth's mutation, LCR circuit, EM wave in dispersive medium – driven oscillator with damping – FT of square wave, full wave rectifier & finite wave train – momentum representation for hydrogen atom ground state & harmonic oscillator.

Unit IV

Partial Differential Equations (16 hrs)

Partial differential equation – characteristics - boundary conditions - classes of partial differential equations- heat equation- Laplace's equation - Poisson's equation - non linear partial differential equation and boundary conditions - separation of variables in Cartesian, circular cylindrical and spherical polar coordinates - non homogeneous equation - Green's function- symmetry of Green's functions- forms of Green functions.

Reference Books:

Mathematical Physics, B.D. Gupta, Vikas Pub. House, New Delhi 1997.

Mathematical Methods in Classical & Quantum Physics, Tulsi Dass & S.K.Sharma, University Press Ltd. Hyderabad 1998.

Elements of Group Theory for Physicists, A.W. Joshi, New Age India Pub.. 1997.

Mathematical Physics, Satyaprakash, S. Chand & Sons

Mathematical Method for Physicists, G.B. Arfken & H.J. Weber - 6th Edition: A Comprehensive Guide, Academic Press, San Diego 2005.

Mathematical Physics, H. K. Das, S. Chand & Co. Ltd. New Delhi. 1999.

Mathematical Physics, B.S Rajput, Pragati Prakasan

Complex Variables- Introduction & Applications, M. J. Ablowitz & A.S. Fokes CUP, Foundation Books.

Complex Variables, Schaum's outline, M.R. Spiegel, TMH.

Advanced Mathematics for Eng. & Physics, L.A. Pipes & L.R. Harvill, MGH.

Mathematical methods of Physics, J. Mathew & R.L. Walker, India Book House Pvt. Ltd.

Mathematical Methods for Physics & Enginneering, K . F. Riley, M.P. Hobon & S. J. Bence, CUP (low price edition)

Advanced Engineering Mathematicsc, E. Keryzing, 7 th ed. John Wiley, 1993.

Introduction to Mathematical Methods in Physics, G. Fletcher, TMGH.

Advanced Engineering Mathematics, C.R. Wylie, Tata Mc Graw Hill.

PH1MC2 QUANTUM MECHANICS – I

Unit I

Schrodinger Wave equation and Matrix Formulation of Quantum Mechanics (20Hrs)

Schrodinger Wave equation - The one dimensional Wave equation - Extension to three dimensions - Interpretation of the wave function- Energy Eigen functions - One dimensional square well potential. Eigen functions and Eigen values **-** Interpretive Postulates and Energy Eigen functions momentum Eigen functions.- Discrete Eigen values **–** Linear Harmonic oscillator – Spherically symmetric potentials in three dimensions – Three dimensional Square well potential – The Hydrogen atom

Matrix Formulation of Quantum Mechanics

Matrix representations of operator Row and Column matrices – Hilbert space - Dirac's Bra and Ket notation. The Eigen value equation - Ortho normality of Eigen functions – The completeness Condition - Equations of motion **-** Schrodinger picture – Heisenberg picture - Interaction picture-Energy representation – Poisson's bracket and Commutator brackets - Quantisation of a classical system - Evaluation of Commutator brackets - velocity and acceleration of a charged particle - The Lorentz Force - Virial theorem – Matrix theory of Harmonic oscillator.

Unit II

Symmetry in Quantum Mechanics (18 Hrs)

Space and time Displacements -Unitary Displacement operator - Equation of motion – Symmetry and Degeneracy - Matrix elements for displaced states - Time displacement.

Angular momentum - Angular momentum operators - angular momentum matrices – spin angular momentum-Total angular momentum operators - Eigen values of Total angular momentum – Clebsch-Gordon coefficients - Recursion relations – Construction procedure calculation of C G coefficients j=1/2 and j=1 cases - Matrix elements for rotated states – Product of Tensor operators- Combination of operator and Eigen state - Wigner-Eckart Theorem.

Unit III

The Quantum theory of Scattering (18 Hrs)

The scattering matrix: The Green's functions propagator - Freeparticle Green's functions - Integral equation for Ψ - Integral equation for the propagator - Use of the advanced Green's function - differential equation for the Green's functions - Symbolic relations - Application to scattering - Unitarity of the S matrix - Symmetry properties of the S matrix - Stationary collision theory- Transition matrix - Transition Probability- scattering cross section - Green's functions for Stationary case - Green's functions as inverse operators- Stationary propagator – Free particle propagator - scattering amplitude - ingoing waves - S matrix for Stationary case – Angular momentum representation.

Approximate calculations- The Born approximation – Validity of Born approximation Scattering from two potentials - Distorted wave Born approximation – Partial wave analysis of DWBA - Approximate expression for the phase shifts - Scatterer with internal Degrees of freedom - Elastic and inelastic cross sections - Electron scattering from Hydrogen - Production of a cloud chamber track - Second order Perturbation theory - Evaluation of the Second order matrix element - Discussion of the cross section - Eikonal approximation. Scattering by a square well potential - Scattering by a perfectly rigid sphere - Scattering by a Coulomb field: Rutherford Formula-from Born approximation – scattering of Identical particles The Lippmam - Schwinger Equation.

Unit IV

Approximation Methods for Stationary Problems (16 Hrs)

Stationary perturbation theory – Non degenerate case - First order perturbation- Second order perturbation - Perturbation in an Oscillator-Degenerate case –Removal of degeneracy in Second order - Zeeman effect without electron spin- First order Stark effect in Hydrogen atom – Perturbed energy levels- Occurrence of permanent electric dipole moments. The Variation method – Expectation value of the energy - Application to excited states – Ground state of Helium - Electron interaction energy - Variation of the parameter Z - Vander-Waals interaction- Perturbation calculation - Variation calculation. Alternative treatment of the perturbation Series - Second order Stark effect in Hydrogen - Polarizability of Hydrogen - Method of Dalgarno and Lewis - Third order Perturbed energy - Interaction of a Hydrogen atom and a point charge - The WKB Approximation - Classical limit - Approximate solutions - Asymptotic nature of the solutions- solution near a turning point – linear turning point - Connection at the turning point - Asymptotic Connection formula - Energy levels of a potential well - A quantisation rule – Special boundary conditions- tunneling through a barrier.

Reference Books:

Quantum Mechanics, L.I. Schiff, 3rd Edn. McGraw Hill.

Quantum Mechanics-Theory and applications, A. Ghatak & S.Lokanathan,4th Edn. Mc Millan.

Quantum Mechanics, V.K. Thankappan 2rd Edn. Wiley Eastern.

ModernQuantum Mechanics, J.J. Sakurai. Pearson Education

A text book of Quantum Mechanics. P.M. Mathews & K. Venkatesan,TMGH

Quantum Mechanics, A. Messiah, North-Holland Publication Company.

Quantum Mechanics, G Aruldhas, Prentice Hall of India, 2002.

Advanced Quantum Mechanics, Satya Prakash, Kedar Nath Ramnath.

Quantum Mechanics –Concepts and applications, N. Zettili, John Wiley & Sons.

Introduction to Quantum Mechanics, R.H. Dicke & J.P Wittke, Addison Wesley.

Quantum Mechanics, B.N. Srivastava, Pragati Prakashan.

PH1MC3 ADVANCED NUCLEAR PHYSICS Unit I

Nuclear Structure and Models (18Hrs)

Basic properties of nuclei: Masses and relative abundances, mass defect, size and shape, binding energy, magnetic dipole moments and electric quadrupole moments. Liquid drop model - Semi-empirical mass formula of Weizsacker - Nuclear stability Mass parabolas - Bohr-Wheeler theory of fission – Fermi gas model Shell model - Spin-orbit coupling - Magic numbers - Angular momenta and parities of nuclear ground state - qualitative discussion and estimates of transition rates - Magnetic moments and Schmidt lines - Collective model of Bohr and Mottelson - Nilsson Model - oblate and prolate.

Unit II

Nuclear Interactions (18Hrs)

Nuclear forces - Two body problem - Ground state of deuteron - Magnetic moment - Quadruple moment - Tensor forces - Meson theory of nuclear forces - Yukawa potential - Nucleon-nucleon scattering, scattering cross section - Low energy n-p scattering-phase shift - proton-proton scattering - Effective range theory - Characteristics of nuclear force - Spin dependence, charge independence and charge symmetry - Isospin formalism.

Unit III

Nuclear Reactions and Nuclear Decay (18Hrs)

Reaction dynamics, the Q value of Nuclear reaction, Scattering and reaction cross sections Compound nucleus formation and breakup, nuclear fission and heavy ion induced reactions, fusion reactions, types of nuclear reactors. Theory of striping reactions.

Beta decay - Fermi's theory - Fermi-Kurie Plot - Fermi and Gamow - Teller selection rules - Allowed and forbidden decays - Decay rates - Theory of Neutrino - Helicity of neutrino - Helicity measurement - Theory of electron capture - Non-conservation of parity - Gamma decay - Internal conversion - Multipole transitions in nuclei - Nuclear isomerism - Angular correlation in successive gamma emissions.

Unit IV

Particle Physics (18Hrs)

Types of interactions between elementary particles - Hadrons and leptons, their masses, spin parity decay structure, the quark model, the confined quarks, coloured quarks, Experimental evidences for quark model. The quark-gluon interaction. Gell-mann-Nishijima formula, Symmetries and conservation laws, C, P and CPT invariance and applications of symmetry arguments to particle reactions, parity non conservation in weak interactions. Exchange Bosons of the weak interaction, electroweak unification.

Reference Books:

Introductory Nuclear Physics, Kenneth S. Krane, Wiley, New York (1987).

Introduction to Elementary Particle Physics, D. Griffiths, Harper and Row, New York.

Nuclear Physics, R.R. Roy and B.P. Nigam,New Age International, New Delhi(1983).

The particle Hunters, Yuval Ne'eman & Yoram kirsh, Cambridge University Press.

Concepts of Nuclear Physics, B.L. Cohen, TMH, New Delhi(1971).

Theory of Nuclear Structure, M.K. Pal, Scientific and Academic Edn (1983).

Atomic Nucleus, R.D. Evans, McGraw-Hill, New York.

Nuclear Physics, I. Kaplan, 2^{nd} Edn, Narosa, New Delhi (1989).

Introduction to Nuclear Physics, H.A. Enge, Addison Wesle, London (1975).

Introductory Nuclear Physics, Y.R. Waghmare, Oxford-IBH, New Delhi (1981).

Atomic and Nuclear Physics, S.N. Ghoshal, Volume 2, S. Chand & Co.

Elementary Particles, J.M. Longo, McGraw-Hill, New York (1971).

Nuclear and Particle Physics, W.E. Burcham & M. Jobes, Addison-Wesley, Tokyo.

Subatomic Physics, Frauenfelder &Henley, Prentice-Hall.

Particles and Nuclei, B. Povh, K. Rith, C. Scholz & F. Zetche, Springer (2002)

PH1MC4 CONDENSED MATTER PHYSICS

Unit I

Lattice Vibrations (16 Hrs)

Vibrations of monatomic and diatomic lattices - acoustic and optical modes - Quantization of lattice vibrations - Phonon Momentum - Inelastic scattering of neutrons by phonons.

Lattice Heat Capacity - Einstein model, Density of modes in one and three dimensions -Debye model of lattice heat capacity – Debye's T^3 law - Anharmonic crystal Interactions - Thermal Expansion - Thermal conductivity.

Unit II

Free Electron Theory and Band Theory (18 Hrs)

Energy levels and density of orbitals in one dimension - Free electron gas in three dimensions - Heat capacity of the electron gas - Electrical conductivity and Ohm's law - Motion in magnetic fields - Hall effect-Thermal conductivity of metals - Wiedemann-Franz law - Nearly free electron model - Wave equation of electron in a periodic potential - Number of orbitals in a band - Construction of Fermi Surfaces -Calculation of Energy Bands - Experimental methods in Fermi surface studies.

Unit III

Dielectric, Ferroelectric and Magnetic properties (20 Hrs)

Theory of Dielectrics: Polarisation, Dielectric constant, Local Electric field, Dielectric polarisability, Clausius-Mossotti relation, Polarisation from dipole orientation, Dielectric losses, Ferroelectric crystals, Order-disorder type ferroelectrics, Properties of $BaTiO_3$, Polarisation catastrophe, Displacive type ferroelectrics, Landau theory of ferroelectric phase transitions, Ferroelectric domain, Antiferroelectricity, Piezoelectricity, Applications of Piezoelectric Crystals.

Diamagnetism and Para magnetism: Langevin's diamagnetism equation, Quantum theory of diamagnetism of mononuclear systems, Quantum theory of paramagnetism, Hund's rule, Paramagnetic susceptibility of conduction electrons, Ferro, Anti and Ferri magnetism: Curie point and the exchange integral, Magnons, Ferrimagnetic order, Curie temperature and susceptibility of ferrimagnets, Antiferromagnetic order. Weiss theory of ferromagnetism, Ferromagnetic domains, Bloch walls, Origin of domains, Novel magnetic materials: GMR-CMR materials (qualitative)

Unit IV Superconductivity

(18 Hrs)

Meissner effect - Type I and Type II superconductors, Heat capacity, Microwave absorption, Energy gap, Isotope effect, Free energy of superconductor in magnetic field and the stabilization energy, London equation and penetration of magnetic field, Cooper pairs and the BCS ground state and BCS Hamiltonian - Flux quantization, Single particle tunnelling, DC and AC Josephson effects, High T_c superconductors - description of the cuprates - Applications of Superconductivity.

Reference Books:

Introduction to Solid State Physics, C. Kittel, Wiley Eastern.

Introduction to Theory of Solids, H.M. Rosenberg, Prentice Hall

Solid State Physics, A.J.Dekker, Macmillan, 1967

Solid State Physics, N.W.Ashcroft and N.D. Mermin, Cengage Learning Pub.

Elements of Solid State Physics, J.P. Srivastava, Prentice Hall of India (2nd Edition)

Solid State Physics-J.S. Blakemore, Cambridge University Press.

Solid State Physics, Gupta Kumar, Pragati Prakasan

Solid State Physics-Structure and Properties of materials, M.A. Wahab. Narosa.

Solid State Physics, S.O.Pillai, New Age International 6^{th} Edn. 2010

Elementary Solid State Physics, M. Ali Omar, Pearson.

PH1MP1 GENERALPHYSICS PRACTICALS

Magnetic susceptibility- Quincke's method

Magnetic susceptibility- Guoys method

Young's modulus and Poisson's ratio – Cornu's method, (Elliptical or Hyperbolic fringes)

Young's modulus and Poisson's ratio – Koenig's method

Michelson interferometer – thickness of mica sheet

Verification of Hartman's relation – Mercury and $KMnO_4$ spectrum

e/m of electron – Thomsons method

Study of thermistor – computation of response equation

Determination of e/k – silicon transistor

Hydrogen spectrum – Rydberg constant

Ultrasonics – velocity of sound in liquids

Oscillating disc – viscosity of liquid

Determination of e – Milliken's method

Characteristics of a photodiode

B-H curve – Anchor ring

Mutual inductance – Carey Foster's bridge

Self and mutual inductance – Anderson's bridge

Arc spectrum of Iron, Copper and Brass

Absorption spectrum of Iodine

Raman effect in liquids – plate measurement

Identification of elements by spectroscopic method

SEMESTER – II

PH2MC1 APPLIED MATHEMATICS FOR PHYSICS - II

Unit I

Vector and Vector Spaces (16 hrs)

Vector algebra and vector calculus, Orthogonal curvilinear co–ordinates – Spherical, Cylindrical and Polar co–ordinates – Line, Surface and Volume integral – Stokes, Gauss' and Green's theorems – equation of continuity – application in potential theory – Scalar potential, gravitational potential and centrifugal potential. Linear vector space – Hermtian - unitary and projection operators – inner products space – Schmidt Orthogonalisation – vector space of functions – Hilberts space – Schwartz inequality.

Unit II

Matrices, Error analysis and Probability (20 Hrs)

Diagonalisation – Jacobi's method – solution of linear equations – Gauss elimination method – Matrix inversion – Hermitian and unitary matrices – Pauli spin matrices – Orthogonal matrices – Euler angles –Moment of Inertia matrix – normal modes of vibration.

Error analysis and hypothesis testing – propagation of errors – Standard deviations - Statistical distribution – Poisson, Binomial and Gaussian – least square fitting –criteria for goodness of fit – Chi square test.

Unit III

Differential Equations and Special Functions (20 Hrs)

Gamma and Beta Functions (review of properties) – Dirac delta function – its property and integral forms. Bessel's differential equations – Legendre differential equations – Associated Legendre functions – Hermite differential equation – Laguerre differential equation – associated Laguerre polynomial – Generating Functions – recurrence relation –orthonormality – Rodrigue's formula – to be discussed for all equations.

Unit IV Tensors

(16 hrs)

Transformation of coordinates – contravariant, covariant and mixed tensor – symmetric and anti symmetric tensor – associated tensor – raising and lowering of indices – metric tensor – curvilinear coordinates – Riemannian Space – Covariant differentiation – Christoffel Symbols – geodesic.

Reference Books:

Mathematical Method for Physicists, G.B. Arfken & H.J. Weber, 6^{th} Edn. 2005

Mathematical Physics, P.K. Chattopadhyya, New Age International.

Theory and Problems of Vector Analysis, M.R. Spiegel, Schaum's Series

Mathematical Methods for Physics & Engineering, K.F. Riley, M P Hobson and S. J. Bence, Cambridge University press.

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

Mathematical Physics - B.S Rajput, Y Prakash 9^{th} Ed, Pragati Prakashan

Differential Equations with Applications & Programme,,Balachandra Rao & H.R.,Anuradha, University Press 1999.

Tensor Calculus, Theory & Problems, A.N. Srivastava, University Press, 1992

Vector Analysis and Tensors, M.R. Spiegel, Schaum's Series

Advanced Mathematics for Eng.& Scientists, Schaum's outline, M.R. Spiegel,TMH.

Vector Analysis,M. R Spiegel, Schaum's Series

Data Reduction & Errors Analysis for the Physical Sciences, P.Bevington, D.K.Robinson, MGH.

Differential Equations with Applications & Programme, B. Rao & H.R. Anuradha, University Press 1999.

Tensor Calculus – Theory & Problems, A.N. Srivastava University Press, 1992
Algebra, M. Artin, Prentice Hall of India Pvt. Ltd. N. D. 1999.

PH2MC2 ELECTRODYNAMICS AND NON LINEAR OPTICS

Unit I

Electrostatics and Magnetostatics (18Hrs)

Laplace's Equation – in one, two, three dimensions and its solutions. Boundary conditions and Uniqueness theorems - Conductors and the second Uniqueness theorem. Multipole expansion **-** Approximate Potentials at large distances - The Monopole and Dipole terms - Origin of coordinates in Multipole expansions - The electric field of a dipole. Linear Dielectrics - Susceptibility, Permittivity, Dielectric Constant - Boundary value problem with linear dielectrics - Energy in dielectric systems - Forces on dielectrics.

Magnetostatics **-** The divergence and Curl of B - Straight line currents - Applications of Ampere's law - Comparison of magnetostatics and electrostatics. Magnetic vector potential - The vector potential - Magnetostatic boundary conditions- Multipole expansion of the vector potential - The auxiliary field H- Ampere's law in magnetized materials- A deceptive parallel - Boundary conditions.

Unit II

Electrodynamics and Electromagnetic Waves (20Hrs)

Maxwell's Equations - Electrodynamics before Maxwell - How Maxwell fixed up Ampere's law - Maxwell's equations - Magnetic charge - Maxwell's equations in matter- Boundary conditions. Conservation Laws **-**

charge and energy - The continuity equation - Poynting`s theorem – Momentum - Newton’s third law in Electrodynamics - Maxwell’s Stress Tensor - Conservation of Momentum - Angular Momentum.

Electromagnetic Waves - Waves in one dimension - Electromagnetic waves in vacuum - Electromagnetic waves ion matter - Absorption and Dispersion - Guided waves.

Potentials and Fields -The Potential formulation - Continuous Distributions - Retarded Potentials – Jefimenko’s equations - Point Charges - Lienard-Wichert Potentials.

Unit III

Radiation and Relativistic Electrodynamics (16Hrs)

Dipole radiation - Electric dipole radiation and Magnetic dipole radiation - Radiation from an Arbitrary source. Point Charges - Power radiated from a point charge - Radiation reaction - Abraham Lorentz formula.

Relativistic Mechanics **-** Proper time and velocity-Relativistic energy and Momentum- Relativistic Kinematics- Relativistic dynamics. Relativistic Electrodynamics - Magnetism as a relativistic phenomenon - Transformation of the field - Electromagnetic field tensor - Electrodynamics in tensor notation, Potential formulation of relativistic electrodynamics**.**

Unit IV

Non Linear Optics (18Hrs)

The self focusing phenomenon of light - Harmonic generation - Second Harmonic generation – phase matching condition – third harmonic generation – optical mixing – parametric generation of light –- multi quantum photoelectric effect - two photon processes - three photon processes

- parametric generation of light – frequency up conversion – phase conjugate optics – generation of sum and difference frequencies.

Reference Books:

Introduction to Electrodynamics, David J Griffiths, PHI Learning, 2009

Classical Electrodynamics, J.D. Jackson 3rd Ed. Wiley, 1993.

Lasers and Non Linear optics, B.B Laud, Wiley eastern.

Optical Electronics, Ajoy Ghatak & K. Thyagarajan, Cambridge 2003.

Contemporary optics, Ajoy Ghatak & K. Thyagarajan, Plenum, New York.

Introduction to Optics, Germain Chartier, Springer.

The Feynman Lectures in Physics,Vol 2, Feynamn, Leighton, Sands.

Quantum Electronics, Amion Yariv, Wiley.

Introduction to Classical Electrodynamics, Y K Lim, World Scientific.

Non Linear Optics, Robert W. Boyd, Academic Press.

PH2MC3 ADVANCED ELECTRONICS

Unit I

Multistage Amplifiers (18 Hrs)

Gain of a Multistage Amplifier - RC coupled two stage Amplifiers - Advantages and disadvantages – Applications - Impedance coupled Amplifier - Transformer coupled Amplifier - Direct coupled Amplifier - Darlington pair - Comparison between Darlington pair and Emitter follower.

Power Amplifiers – Difference between voltage and Power Amplifier - Performance parameters - AC Load line - Classification of Power Amplifiers - Class A - Characteristics & power relations for Class A amplifiers – Transformer coupled Class A Amplifier - Class B Amplifier- Transformer less Class B Push-pull Amplifier - Class C Amplifier. Tuned Amplifiers – Parallel Resonant circuit – Single tuned Voltage Amplifier Double tuned Voltage Amplifier - Stagger tuned Voltage Amplifier.

Unit II

Operational Amplifiers (18 Hrs)

Differential amplifier- Basic circuit – Operation - Common-mode and Differential mode signals – Double ended input Operation of DA - voltage gain - CMRR-DC Analysis of DA - Overview of DA - Input bias Current - AC Analysis of DA – Common mode voltage gain. Operational amplifiers- Overview - Op-amp Parameters - Frequency response of an op amp - Op-amp with negative feedback - compensating networks.

Applications – Op-amp as a Voltage amplifier – Inverting amplifier - Non-Inverting amplifier - Voltage Follower - Multistage Op-amp circuits - Summing amplifier – Peaking amplifier – Summing, Scaling, averaging amplifiers – Instrumentation amplifier using transducer bridge – Differential input and differential output amplifier – Comparators - The Integrator - The Differentiator –Audio Amplifier - OP-amp based Wein-Bridge Oscillator, Colpitt's Oscillator & Crystal Oscillator – Triangular wave Oscillator – A voltage controlled saw tooth Oscillator VCO – A square wave relaxation Oscillator - High impedance voltmeter.

Unit III

Active filters, Oscillators and Integrated Circuits (18 hrs)

Active filters – First order and second order low pass Butterworth filter - First order and second order high pass Butterworth filter - wide and narrow band pass filter - wide and narrow band reject filter - All pass filter

.Oscillators - Phase shift and Wien bridge oscillators using transistor – Tunnel diode oscillator – UJT Sawtooth generator - Multivibrators – astable, monostable & bistable multivibrators- Schmitt Trigger - Transistor blocking oscillator - The 555 Timer - Voltage controlled oscillator.

Integrated Circuits **-** Advantages and Disadvantages of IC's - IC classification by structure and functions - Linear Integrated circuits - Digital Integrated circuits - Fabrication of IC components - Complete Monolithic Integrated circuits - MOS Integrated circuits.

Unit IV

Field effect Transistors, Amplifiers And Digital Signal Processing (18 Hrs)

Junction field effect Transistor - working principles of JFET- difference between JFET bipolar transistor- JFET as an amplifier - output characteristics of JFET- advantages of JFET- parameters JFET.

Amplifiers **-** Biasing the JFET- gate bias - self bias - setting a Q-point - voltage divider bias- Sourcebias- biasing theenhancementtype MOSFET's-biasing thedepletiontypeMOSFET's-smallsignalFET models- small signal low-frequency andhigh frequencyFETmodels- common source amplifier—common drain .

Digital Signal Processing -Mathematical representations of continuous time (CT) and discrete time (DT) signals – basic concepts of sampling of signals – sampling theorem - Signal energy and power – periodic signals – even and odd signals – exponential and sinusoidal signals – discrete time unit impulse and unit step sequences – examples of DT signal processing systems - interconnections of systems – DT systems with and without memory – invertability and inverse systems – causality – stability – time invariance – linearity.

Reference Books

Op amps and linear Integrated Circuits, R.A. Gayakwad, PHI

A text book of Applied Electronics, R.S. Sedha, S. Chand & Co.

Principles of Electronics, V.K.Mehta and Rohit Mehta S. Chand & Co.

BasicElectronics, B.L. Theraja, S. Chand & Co.

Integrated Electronics, J. Millman and C.C. Halkias, MGH

Signals and Systems Alan S. Willsky, Alan V. Oppenheim, S. Hamid 2nd Edn PHI

Digital Signal Processing, P.Ramesh Babu, Scitech Publishing.

Digital Signal Processing, A. Nagaroor Kani, TMGH.

Digital Signal Processing, Principles, Algorithms and Applications, John G. Proakis,Dimitris G Manolakis, PHI

Digital Signal Processing- A Modern Introduction, Ashok Ambardar, Thomson.

Introduction Digital Signal Processing, Johnny R Johnson, PHI

PH2MC4 CLASSICAL MECHANICS AND RELATIVITY Unit I

The motion of Rigid Bodies and Theory of Small Oscillations (20 Hrs)

Independent co-ordinates of a rigid body - Orthogonal transformations - Inertia Tensor – Euler's angles - Euler's theorem on the motion of a rigid body - Force free motion of a symmetric top - Motion of a heavy symmetric top - Infinitesimal rotation - Precession of Charged bodies in magnetic field - Coriolis Force and its effects. Independent Coordinates – Orthogonal Transformations – Euler's Angles. Force free motion of rigid body - Cases of symmetric top - Heavy Symmetric top, fast top - Sleeping top.

Theory of Small Oscillations - Formulation of the problem – Eigen value equation – Coupled oscillators – Normal coordinates. Oscillations of linear triatomic molecule

Unit II

Hamiltonian Mechanics (18 Hrs)

Hamilton's equations of motion - cyclic coordinates and conservation theorems - Hamilton's equations from variational principle - Physical significance of principle of least action -Canonical transformations – Poisson brackets – Equation of motion in Poisson bracket formulation- The canonical invariance of Poisson bracket - Lagrange brackets.

The Hamilton Jacobi equation - Hamilton's characteristic function – The Harmonic oscillator in Hamilton Jacobi method - Action angle variables – Kepler's problem in action angle variables - Transition to Wave mechanics.

Unit III

Canonical Perturbation Theory and Lagrangian Formulation for Continuous Systems And Fields (16 Hrs)

Time dependent perturbation and illustrations - Time independent perturbation theory in first order with one degree of freedom. Time independent perturbation theory to higher order - Kepler problem and precession of the equinoxes of satellite orbits. Lagrangian formulation for continuous systems - sound vibrations in gas - Hamiltonian formulation for continuous systems - description of fields – Noether's theorem.

Unit IV

The Special Theory of relativity (18 Hrs)

The postulates of Special Theory of relativity-Lorentz transformation – Velocity transformation - Length contraction-Time dilation - Mass in relativity - mass and energy -Relativistic Lagrangian and Hamiltonian of a particle-Lorentz co-variance - four vectors - Invariance of Maxwell's equations under Lorentz transformations - Electromagnetic field tensor - Principle of Equivalence- Precession of the Perihelion of planetary orbits.

Reference Books:

Classical Mechanics, Goldstein, Poole & Safko, 3rd Edn. Pearson.

Classical mechanics,G. Aruldas, Prentice Hall

Classical mechanics, N. C. Rana & P.S. Joag - TMGH

Classical mechanics, J.C. Upadhyaya, Himalaya.

Classical mechanics, Satyaprakash, Sultan Chand & Company.

Classical mechanics, Gupta & Kumar, Pragati Prakasan.

Classical Mechanics, A.K. Raychauduri, Oxford Univ. Press

Dynamics, S.N. Rasband. John Wiley 1983
Introduction to Dynamics,I. Percival & D. Richards, Cambridge Univ. Press 1982
Lagrangian and Hamiltonian mechanics, M. G. Calkin - Allied Pub. Ltd.
Theory of Relativity - R. K. Ptharia, Dover Pub. Inc. NY,2003
An Introduction to General Theory of Relativity, S.K. Bose, Wiley Eastern.

PH2MP2 ELECTRONICS PRACTICALS

RC coupled CE amplifier – two stages with feed back – frequency response and voltage gain

Differential amplifier – using transistors – constant current source – frequency response

Active filters – low pass and high pass – first and second orders – frequency response and roll of rate

Band pass filter using single op-amp

Voltage controlled oscillator using transistors

Voltage regulation using op-amp with short circuit protection

UJT characteristics

Relaxation oscillator using UJT

RF amplifier- frequency response and band width

Op – amp monostable multivibrator , square wave generator

IC 555 monostable multivibrator and astable multivibrator

IC 555 pulse width modulation and linear RAMP generator

Voltage controlled oscillator using IC 555

Shift registers Binary sequence generator

Thermistor characteristics

Synchronous counters and divide by N counters

Op – amp mathematical operations

Op – amp Wein bridge oscillator

Amplitude modulation using transistors

Precision rectifiers – measurement of rectifier efficiency at different frequencies

Op- amp triangular wave generator with specified amplitude

SEMESSTER – III

PH3MC1 COMPUTER APPLICATION IN PHYSICS

Unit I

Numerical Methods (20 Hrs)

Numerical solution of Non-linear equations **-** The method of iteration - Newton-Raphson method – Method of successive approximation.

Numerical solution of system of linear equations **-** Gauss Elimination Method – Gauss -Jordan method, matrix inversion method – Jacobi's method - Gauss-Seidel method - Eigen value problem - Power method.

Curve Fitting -The method of least squares - for fitting a straight line- Fitting a polynomial- Fitting a non-linear function – Fitting a geometric curve - Fitting an exponential curve - Fitting a Hyperbola - Fitting a trigonometric function. Interpolation - Lagrange’s interpolation - Finite differences - Forward Backward and Divided differences - Difference Tables - Newton's methods of interpolation- Cubic spline interpolation.

Unit II

Numerical Differentiation and Integrations (16 Hrs)

Numerical Differentiation, Errors in numerical differentiation, Cubic spline method, Finding maxima and minima of a tabulated function. Newton-Cotes formulae for integration - Trapezoidal Rule, Simpson's Rule, Romberg's integration, Gauss’s Quadrature formula - Double integration.

Unit III

Object Oriented Programming in C++ (16 Hrs)

Review of C++ - Structures – Functions - Classes and objects – Constructors and Destructors

Unit IV

Operator overloading, Type Conversion and Graphics (20Hrs)

Operator overloading – overloading unary operators - overloading binary operators - Data conversion - Manipulation of strings using Operators - Rules for overloading operators. Inheritance- Derived class and Base class - Derived class Constructors – overriding member Functions - Class Hierarchies - Public and Private Inheritance - levels of Inheritance – Multiple Inheritance.

Pointers – Pointers and Functions - Pointers to objects- Pointers to Pointers – Virtual Functions – Friend Functions - The this pointer. Graphics –Text mode Graphics Functions – Graphics mode Graphics Functions – rectangles and lines - Motion -Text in Graphics Mode.

Reference Books:

Introductory Methods of Numerical Analysis,S.S. Sasthry, PHI.

Computer oriented Numerical Methods, R.S. Salaria,Khanna Pub.

Computer oriented Numerical Methods, V. Rajaraman, PHI.

Mathematical Methods, G. Sanker Rao, I.K. International Publishing House.

Object Oriented Programming in Microsoft C++,Robert Lafore, Pearson.

Object Oriented Programming in C++, E. Balagurusamy, TMGH.

Computer Science C++ Sumita Arora ,Gautam Sarkar, Dhanpat Rai & Co.

PH3MC2 ATOMIC AND MOLECULAR SPECTROSCOPY

Unit I

Molecular Vibrations, Infra Red Spectroscopy and Microwave Spectroscopy (18hrs)

Basic principles of Vibrational Spectroscopy - Diatomic molecule - Harmonic Oscillator and Anharmonic Oscillator - Vibrations of Polyatomic molecules - Energy levels and spectral transitions - Description of internal Vibrations - Spectra of some simple molecules- Vibrational assignments - Coupled Vibrations – Time scale.

Infra Red Spectroscopy – The diatomic Vibrating rotator - Asymmetry of rotation- Vibration band - The Vibration-rotation spectrum of carbon monoxide – The interaction of rotations and Vibrations – Linear molecules - Nuclear spin effect- symmetric top molecules- Interpretation of vibrational spectra - Group Frequencies. Microwave Spectroscopy - Theory of Microwave Spectroscopy – The diatomic molecule as a Rigid Rotator - The diatomic molecule as a Non – rigid rotator - Rotational spectra of polyatomic molecules - linear molecule - Symmetric and asymmetric top molecules.

Unit II

Electronic Spectroscopy of Atoms, Photoelectron Spectroscopy and UV Spectroscopy (18hrs)

Electronic Spectroscopy - Electronic spectra of diatomic molecules, Intensity of spectral lines, Frank – condon principle, Dissociation energy and dissociation products, Rotational fine structure of electronic vibrational transition, The Fortrat Parabolae, Pre-dissociation.

Photoelectron Spectroscopy **-** Principle – Instrumentation and Information from Photoelectron spectra.

UV Spectroscopy **-** Origin and Theory of Ultraviolet Spectra - Choice of Solvents- Instrumentation – Applications of UV absorption Spectroscopy.

Unit III

Atomic Spectra (18hrs)

Quantum states of electrons in atoms - Electron spin - spectroscopic terms and selection rules. Spectrum of helium and alkali atoms - Relativistic corrections for energy levels of hydrogen atom - Hyperfine structure and isotopic shift - Width of spectral lines - spin orbit interaction - Derivation of spin orbit interaction energy, fine structure in sodium atom, Landau g-factor, Zeeman effect. Paschen – Bach effect and Stark effect in one electron system, LS and JJ coupling schemes (Vector diagram), Hund’s rule, Derivation of interaction energy, examples of LS and JJ coupling, Lande interval rule, Hyperfine structure, Width of spectral lines.

Unit IV

X-Ray Spectroscopy, Fluorescence Phosphorescence and Raman Spectroscopy (18hrs)

X-Ray sources and Detectors- Interaction of X-rays with matter— Instrumentation - Applications of X-Ray Absorption methods - X-Ray Diffraction methods and Applications to complexes – Particle size determination.

Fluorescence**,** Phosphorescence, Excitation spectra, Experimental methods, and Applications. Raman spectroscopy- Characteristic properties of Raman lines- Differences between Raman Spectra and Infra red spectra-Mechanism of Raman Effect- intensity of Raman lines.

Reference Books

Introduction of Atomic Spectra, H.E. White, Mc Graw Hill.

Vibrational Spectroscopy, D. N. Satyanarayana, New Age International.

Fundamentals of Molecular Spectroscopy, C.N. Banwel. McGraw Hill, 1994.

Spectroscopy (Vol. 1,2&3), B.P. Straughan, & Walker, Science paperbacks 1976.

Molecular Structure and Spectroscopy, G. Aruldas, Prentice Hall of India.

Instrumental Methods of Chemical Analysis, G. Chatwal and S. Anand, Himalaya

Introduction to Infrared and Raman Spectroscopy, Norman D Colthup, Lawrence H Daly and Stephen E Wiberley- Academic press NY.

Instrumental Methods of Analysis,Willard, Merrit, Dean and Settle,CBS Pub.

Instrumental Methods of Chemical Analysis, G.W. Ewing, McGraw Hill

Introduction to Spectroscopy, Pavia, Lampman, Kriz. 3rd Edn.

Raman Spectroscopy, D.A. Long, McGraw Hill international, 1977 .

Introduction to Molecular Spectroscopy, G.M. Barrow, McGraw Hill.

Mol. Spectra and Mol. Structure, Vol. 1, 2 & 3. Herzberg G, Van Nostard, London.

Photoluminescence of Solutions, C.A. Parker, Elsevier Pub.Comp. 1968.

Elements of Spectroscopy, Gupta, Kumar and Sharama, Pragathi Prakasan.

Spectroscopy, Experimental techniques, BK. Sharma, Goel Pub. House.

The Infra Red Spectra of Complex Molecules, L.J. Bellamy, Chapman & Hall Vol. 1&2.

Elementary Organic Spectroscopy, Y.R. Sharma, S. Chand & Co.

Spectroscopy of organic compounds, P.S. Kalsi, New Age International.

Laser spectroscopic techniques and applications, E.R. Menzel, Practical spectroscopic series vol. 18, Marcel Dekker.

PH3ME1 SOLID STATE PHYSICS Unit

I

Crystals and Symmetry Properties (20 Hrs)

Crystalline state – Anisotropy - Symmetry elements – Translational, Rotational, Reflection – Restrictions on Symmetry elements – Possible combinations of Rotational Symmetries - Crystal systems - 14 Bravais lattices.

Stereographic projection and point groups – principles – Constructions - Construction with the Wulff net - Macroscopic Symmetry elements- Orthorhombic system- Tetragonal system- Cubic system - Hexagonal system - Trigonal system - Monoclinic system- Triclinic system - Laue groups - Space groups.

Unit II

Optical Properties and Crystal Lasers (16 Hrs)

Lattice vacancies – diffusion – colour centres – F-centre and other centres in alkali halides – ionic conductivity – colour of crystals – excitons in molecular crystals – model of an ideal photoconductor – traps – space charge effects – experimental techniques – transit time excitation and emission Aicalf mechanism – model for thallium activated alkali halides - electroluminescence.

Lasers: Properties of laser beams - temporal coherence - spatial coherence – directionality – single mode operation - frequency stabilization - mode locking - Q-Switching - measurement of distance - Ruby laser - four-level solid state lasers - semiconductor lasers - Neodymium lasers (Nd:YAG, Nd:Glass) .

Unit III

Semiconductor crystals (18 Hrs)

Classification of materials as semiconductors - band Gap - band structure of Silicon and germanium - equations of motion - intrinsic carrier concentration impurity conductivity- Thermoelectric effects in semiconductors – semimetals - amorphous semiconductors - p-n junctions.

Plasmons, Polaritons and Polarons: Dielectric function of the electron gas – plasmons - electrostatic screening- **p**olaritons and the LST relation – electron electron interaction - Fermi liquid - electron-phonon interaction - Polarons- Peierls instability of linear metals.

Unit IV

Imperfections and Dislocations (18 Hrs)

Typesofimperfectionsincrystals-thermodynamictheoryofatomic imperfections – experimental proof – diffusion mechanisms - atomic diffusion theory – experimental determination of diffusion constant – ionic conduction – shear strength of single crystals - slip and plastic deformations. Dislocations - Burgers vectors – edge and screw dislocations – motion of dislocation – climb - stress and strain fields of dislocation – forces acting on a dislocation – stress and strain fields of dislocation – forces acting on a dislocation – energy of dislocation – interaction – between dislocation densities – dislocation and crystal growth – Dislocation – Frank – Read mechanism - point defects - twinning.

Reference Books:

Crystallography and crystal defects, A. Kelley, G.W. Groves & P. Kidd, Wiley

Crystallography applied to Solid State Physics, A.R. Verma, O.N. Srivastava, NAI

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

Lasers Theory and Applications, K.Thyagarajan, A.K. Ghatak, Plenum Press

Lasers and Non-Linear Optics, B B Laud, New Age International.

Solid State Physics, S.L. Gupta and V.Kumar, Pragati Prakashan.

Introduction to Theory of Solids, H.M. Rosenberg, Prentice Hall.

Solid State Physics,J.S. Blakemore, W.B.Saunders & Co. Philadelphia.

Solid State Physics, N.W. Ashcroft & N.D. Mermin, Brooks/ Cole (1976).

Crystal Defects and Crystal Interfaces, W. Bollmann, Springer Verlag.

A short course in Solid State Physics, Vol. I, F.C Auluck, Thomson Press,India, Ltd.

Crystalline Solids, Duncan Mc Kie, Christine Mc Kie, Wiley

PH3ME2 CRYSTAL GROWTH TECHNIQUES Unit I

Crystal Growth phenomena (18 Hrs)

The historical development of crystal growth – significance of single crystals crystal growth techniques - the chemical physics of crystal growth. Theories of nucleation - Gibb’s Thompson equation for vapour, melt and solution- energy of formation of spherical nucleus- heterogeneous nucleation kinetics of crystal growth, singular and rough faces, KSV theory, BCF theory - periodic bond chain theory- The Muller- Krumbhaar model.

Unit II

Crystal Growth from Melt and Solution Growth (18Hrs)

Growth from the melt - the Bridgmann technique – crystal pulling - Czocharalski method- experimental set up - controlling parameters advantages and disadvantages.- convection in melts – liquid solid interface shape - crystal growth by zone melting - Verneuil's flame fusion technique.

Low temperature solution growth - methods of crystallization - slow cooling, solvent evaporation, temperature gradient methods - crystal growth system - growth of KDP, ADP and KTP crystals - high temperature solution growth, gel growth.

Unit III

Vapour Growth and Epitaxial Growth (18 Hrs)

Physical vapour deposition - chemical vapour transport – definition, fundamentals, criteria for transport, Specifications, STP, LTVTP & OTP - advantages and limitations of the technique, hydrothermal growth, design aspect of autoclave – growth of quartz, sapphire and garnet.

Advantages of epitaxial growth, epitaxial techniques - liquid phase epitaxy, vapour phase epitaxy, molecular beam epitaxy, chemical beam epitaxy and atomic layer epitaxy

Unit IV

Materials for Semiconductor Devices (18Hrs)

Semiconductor optoelectronic properties - band structure - absorption and recombination, semiconductor alloys - group III-V materials selection - binary compounds, ternary alloys, lattice mismatch - lattice mismatched ternary alloy structures - compositional grading, heteroepitaxial ternary alloy structure - Quarternary alloys.

Semiconductor Devices **-** Laser diodes, light emitting diodes (LED), photocathodes, microwave Field-Effect Transistors (FET).

Reference Books:

The Growth of Single Crystal, R.A. Laudise, Prentice Hall, NJ.

Crystal Growth: Principles and Progress , A.W. Vere, Plenum Press, NY.

CrystalGrowthProcessesandmethods,P.S.RaghavanandP. Ramasamy, KRU Publications.

A Short course in Solid State Physics, Vol. I, F.C. Auluck, Thomson Press India Ltd.

Crystal Growth, B.R. Pamplin, Pergamon, (1980)

Crystal Growth in Gel, Heinz K Henish, Dover Publication

PH3MP3 COMPUTATIONAL AND ADVANCED ELECTRONICS PRACTICALS

(Experiments from 1 to 15 are C++ programs)

Motion of a spherical body in a viscous medium

Projectile motion and motion of a satellite

SHM – damped and forced

Formation of standing waves

Young’s double slit – interference

Diffraction due to a grating

Polarisation and birefringence

Electric field due to a point charge and equipotential surface

Motion in electric and magnetic fields – cyclotron

Circuit analysis using Kirchoff's laws – LCR circuit with AC & DC sources

Solution of Schrodinger equation for harmonic and anharmonic potential

Finding the roots of a non-linear equation by bisection method

Solving an ordinary differential equation

Numerical integration of a function

Integration by using Monte Carlo method

RF oscillator above 1 MHz – frequency measurement

Pulse width modulator

Microprocessor – multiplication of two 8 bit binary numbers

Microprocessor – Sorting of data in ascending and descending order

Microprocessor – measurement of analogue voltage

Microprocessor – stepper motor control

Fullwave controlled rectifier

Frequency modulation and demodulation

OPAMP – Inverting amplifier

OPAMP – Low distortion sine wave generator

OPAMP – Difference amplifier

JK flip flop – four bit binary counter

JK flip flop – shift register

Amplitude modulation

Pulse amplitude modulation

Attenuators

Half adder and full adder

SEMESTER – IV

PH4MC1 QUANTUM MECHANICS -II

Unit I

Methods for Time-dependent Problems (18 Hrs)

Time-dependent perturbation theory- Interaction Picture- – First order perturbation - Harmonic perturbation – Transition probability– constant perturbation – The electric dipole approximation- Ionization of a hydrogen atom - Density of final states - Ionization probability – Second order perturbation- Adiabatic approximation - Choice of phases - Connection with perturbation theory- Discontinuous change in H – Sudden approximation – Disturbance of an Oscillator.

Unit II

Relativistic Quantum Mechanics (20Hrs)

Schrodinger's relativistic equation – Free particle - Electromagnetic potentials – Separation of the equation - energy levels in a Coulomb field. Klein–Gordon equation – Physical Interpretation - Charge and current densities - Charged spin -zero free particle - charge conjugation - Eigen values of operators- Interaction with electromagnetic field - Bound states in a Coulomb field.

The Dirac's relativistic equation - free particle equation - Dirac matrices for α and β - free particle solutions – charge and current densities – Electromagnetic potentials. Dirac's equation for a central field - Spin angular momentum - spin orbit energy - Zitterbewegung - Separation of the equation The Hydrogen atom - Classification of energy levels - Negative energy states- electron hole theory - Weyl equation for neutrino and non conservation of parity – the tau matrices - bilinear covariants.

Unit III

Identical particles and Spin (16Hrs)

Identical particles - Physical meaning of identity - Symmetric and anti symmetric wave functions - Construction from unsymmetrized functions - The symmetric group - Distinguishability of Identical particles – Pauli's exclusion principle - Connection with statistical mechanics - collisions of Identical particles. Spin angular momentum – Connection between spin and statistics - spin matrices and eigen functions - collisions of identical particles electron spin functions- the helium atom - spin functions for three electrons.

Density operator and density matrix – Expectation value and projection operator - density operator - equations of motion - Projection operator for a spin ½ particle - density matrix for a spin ½ particle - polarization vector for a spin s particle - Precession of the Polarization vector. Rearrangement collisions – Notation for Rearrangement collisions - Alternative expression for the T Matrix element - T Matrix element for Rearrangements – Presence of a core Interaction - Elimination of the core term - Exchange collisions of electrons with Hydrogen - Relation between amplitude and Matrix element - Effects of identity and spin - Exchange collisions with Helium.

Unit IV

The Quantization of Wave Fields (18Hrs)

Classical and Quantum field equations **-** Coordinates of the field - Time derivatives – Classical Lagrangian and Hamiltonian equations - Quantum equations for the field - Fields with more than one component - Complex field - Quantization of non-relativistic Schrodinger equation **-** Classical Lagrangian and Hamiltonian equations - Quantum equations - creation annihilation and number operators – Connection with the many particle Schrodinger equation - anti commutation relations - physical implication of anti commutation - representation of the anti commuting a_k operators .

Electromagnetic field in vacuum - Lagrangian equations - Hamiltonian equations - Quantum equations - Commutation relations for E and H - Plane wave representation - Quantized field energy - Quantized field momentum - Commutation relations at different times - Interaction between charged particles and Electromagnetic field - Lagrangian and Hamiltonian equations - Elimination of φ - Quantization of the fields - Perturbation theory of the interparticle interaction- Einstein-Bose case - Fermi-Dirac case - radiation theory - Transition probability for absorption and emission.

Reference Books:

Quantum Mechanics, L.I. Schiff, 3rd Edn. MGH

Quantum Mechanics, B.K. Agarwal , Hari Prakash, PHI

A text book of Quantum Mechanics, P.M. Mathews and K. Venkatesan, TMGH.

Quantum Mechanics, V.K. Thankappan 2rd Edn. Wiley Eastern.

Quantum Mechanics,G. Aruldhas, Prentice Hall of India 2002.

Advanced Quantum Mechanics, J.J. Sakurai, Pearson Education

Advanced Quantum Mechanics, Stya Prakash, Kedar Nath Ramnath Company.

Quantum Field theory, Claude Itzykson, McGraw Hill

Quantum Field theory, Lewis H. Ryder, Cambridge University Press.

Introduction to Quantum Mechanics, R.H. Dicke & J.P. Wittke, Addison Wesley.

Quantum Mechanics, A Messiah, Dover Publication.

Quantum Mechanics, R.K. Srivastava, PHI.

PH4MC2 STATISTICAL PHYSICS AND ASTROPHYSICS

Unit I

Quantum Statistical Mechanics and Ideal Gas Systems (18 Hrs)

The postulates of Quantum statistical mechanics – indistinguishability of particles - exchange degeneracy - Density matrix - Ensembles in Quantum statistical mechanics - statistical distribution – The ideal gas in quantum mechanical micro canonical and other quantum mechanical ensemble – Partition functions and other thermodynamic quantities of monatomic and diatomic molecules. Thermodynamic behaviour of an ideal Fermi gas - Pauli Para magnetism - Thermodynamic behavior of a Bose gas – Bose Einstein condensation — Theory of white dwarf stars.

Unit II

The Canonical and Grand Canonical Ensemble (18 Hrs)

Equilibrium between a system and heat reservoir – a system in the canonical ensemble – thermo dynamical relations in a canonical ensemble – the classical systems – energy fluctuations in the canonical ensemble: correspondence with micro canonical ensemble – equilibrium between a system and a particle energy reservoir – a system in the grand canonical ensemble – physical significance of statistical quantities – density and energy fluctuations in the grand canonical ensemble: correspondence with other ensembles.

Unit III

Fluctuations and Phase Transitions (18 Hrs)

Energy fluctuations in canonical ensemble - Density fluctuation in grand canonical ensemble - one dimensional random walk problem - Brownian motion and Random walk- correlation functions- Spectral analysis of fluctuations: Wiener-Khintchine theorem - Fokker Planck equation. Phase transitions - First and second order phase transition – Bragg–Williams approximation - critical phenomena - critical exponents - scaling hypothesis - Ising model and its solution for a linear chain – equivalence of Ising model to other models - lattice gas and binary alloy- solution of one dimensional Ising model – Liquid crystals and Liquid Helium.

Unit IV Astrophysics

(18 Hrs)

Stellar spectrum - stellar types - electromagnetic radiation from stars - measuring temperature and distances - excitation and ionization -

application of Saha's Equation - Hertz Sprung Russell diagram- star formation - life of a star - Virial theorem- stellar energy and nuclear reactions - stellar structure - final stages of stellar evolution - white dwarfs - neutron stars - black hole - pulsars.

Reference Books:

Fundamentals of Statistical Mechanics, B. B. Laud, New Age International.

Elements of Statistical Mechanic, Kamal Singh, S P. Singh, S. Chand & Co.

Statistical mechanics, Kerson Huang, John Wiley and Sons.

Statistical mechanics, R..K. Pathria, Butterworth-Heinemann

Statistical Mechanics, B.K. Agarwal and M. Eisner, Wiley Eastern.

Introduction to Statistical Mechanics, S.K. Sinha, Alpha Science International.

Statistical Mechanics, Tung Tsang, Rinton Press.

Introductory Statistical Mechanics, R. Bowley & M. Sanchez, 2nd Edn. Oxford University Press

Statistical Mechanics, Gupta, Kumar, Pragati Prakasan.

Astrophysics: Stars and Galaxies, K D Abhyenkar, Universities Press.

Introduction to Astrophysics, Baidyanath Basu, PHI.

PH4ME3 NANOSTRUCTURES AND CHARACTERIZATION

Unit I

Low Dimensional Structures (18hrs)

Preparation of quantum nanostructures - size and dimensionality effects - size effects - potential wells - partial confinement - conduction electrons and dimensionality - Fermi gas and density of states - properties dependent on density of states - excitons - single-electron tunneling - applications - infrared detectors - quantum dot lasers - superconductivity.

Microelectromechanical Systems (MEMS) - Nanoelectromechanical Systems (NEMS) –Fabrication of nanodevices and nanomachines - Molecular and Supramolecular Switches.

Unit II

Carbon Nanostructures (18hrs)

Carbon Molecules - Nature of the Carbon Bond - New Carbon Structures - Carbon Clusters -Small Carbon Clusters - Carbon Nano tubes - Fabrication - Structure – Electrical Properties - Vibrational Properties - Mechanical Properties - Applications of Carbon Nano tubes - Computers - Fuel Cells - Chemical Sensors - Catalysis – Mechanical Reinforcement - Field Emission and Shielding. Solid Disordered Nanostructures - Methods of Synthesis - Failure Mechanisms of Conventional Grain sized Materials - Mechanical Properties – Nano structured Multi layers -Electrical Properties - Porous Silicon - Metal Nano cluster - Composite Glasses.

Unit III

Thermal, Microscopic and Infrared Analysis (18 Hrs)

Thermal analysis – DTA, DSC and TGA – methodology of DTA, DSC and TGA and Instrumentation.

Microscopy – Electron microscopy – Principles and instrumentation – resolution limit – scanning tunnelling microscopy – principles – scanning tunnelling microscope - SEM & TEM. Atomic force microscope – Instrumentation.

IR spectrophotometers – Theory and Instrumentation- Applications. Fourier transform techniques – FTIR principles and instrumentation. Raman spectroscopy – Principles, Instrumentation and Applications. Microwave Spectroscopy -Instrumentation and Applications

Unit IV

Mass Spectrometry, Resonance Spectroscopy (18 Hrs)

Mass Spectrometry - Principle – Instrumentation – Types of ions produced in a Mass spectrometer - Interpretation of Mass spectra – Applications.

NMR – Principles and Instrumentation – Chemical shift - Spin-spin coupling - Applications of NMR - Electron spin resonance spectrometry – Theory of ESR –Instrumentation - Interpretation of ESR spectra - Applications.

Reference Books:

Introduction to Nanotechnology, Charles P. Poole, Jr. and Frank J. Owens, Wiley, (2003)

MEMS/NEMS:microelectromechanicalsystems/nanoelectro mechanical systems Volume 1, Design Methods, Cornelius T. Leondes, Springer, (2006).

Instrumental methods of Chemical Analysis, G. Chatwal & Sham Anand, Himalaya

Introduction to Infrared and Raman spectroscopy, Norman D Colthup, Lawrence H Daly and Stephen E Wiberley, Academic press, NY.

Instrumental methods of analysis, H.H. Willard, L.L. Merrit, J.A. Dean & F.A. Settle, CBS Pub.

Principles of Instrumental analysis, Skoog and West – Hall – Sanders Int.

Instrumental methods of chemical analysis, G W Ewing, MGH

8. Scanning Tunnelling Microscopy, R. Wiesendanger & H.J. Guntherodt, Springer
9. Thermal Analysis, Wesley W.M. Wendlandt , Wiley.

PH4ME4 THIN FILM AND NANO SCIENCE

Unit I

Thin Film (18 Hrs)

Nucleation – Langmuir theory of condensation – Theories of nucleation – Liquid like coalescence and growth process – Epitaxial growth – Structural defects in thin films – Electrical conduction in metallic, semiconducting and insulator films. Optical properties of thin films.

Unit II

Deposition of Films (18 Hrs)

Production of Vacuum, Different types of vacuum pumps, Measurement of Vacuum Gauges, Working principle, Deposition of thin films, Various deposition techniques, Thickness measurement – optical methods, thickness monitors - Thin film applications.

Unit III

Nano materials and Applications (18 hours)

Nano structured Crystals -Natural Nano crystals -Crystals of Metal-Nano particles –Nano particle Lattices in Colloidal Suspensions -Photonic Crystals.

Synthesis and purification of carbon nanotubes, Single-walled carbon nanotubes and multiwalled carbon nanotubes, Structure-property relationships, physical properties, applications.

Overview of different nano materials available, Potential uses of nano materials in electronics, robotics, computers, sensors in textiles, sports equipment, mobile electronic devices, vehicles and transportation. Medical applications of nano materials.

Unit IV

Synthesis of Nano materials (18hrs)

Top-down techniques: photolithography, other optical lithography (EUV, X-Ray, LIL), particle-beam lithographies (e-beam, focused ion beam, shadow mask evaporation), probe lithographies, Bottom-up techniques: self-assembly, self-assembled mono layers, directed assembly, layer-by-layer assembly. Combination of Top-Down and Bottom-up techniques: current state-of-the-art.

Pattern replication techniques: soft lithography, nano imprint lithography. Pattern transfer and enhancement techniques: dry etching, wet etching, pattern growth techniques (polymerization, directed assembly).

Reference Books:

Thin film phenomena, K.L Chopra, McGraw Hill, New York

Thin film fundamentals,A. Goswami, New Age International

Vacuumm deposition of Thin films, L. Holland, Chapman Hall, London

Handbook of thin film Technology, L.I Maissel and R Glang, McGraw Hill

Optical Properties of Thin Films, O. S. Heaven, Dover Publications

Nano:the essentials, T. Pradeep, TMH, 2007

Nanoscale Materials, L.M. Liz-Marzán & P.V. Kamat, Kluwer Academic Pub. (2003)

Nanoscience, Nanotechnologies and Nanophysics, C. Dupas, P. Houdy & M. Lahmani, Springer-Verlag , (2007).

Nanotechnology 101, John Mongillo, Greenwood Press, (2007).

What is What in the Nanoworld A Handbook on Nanoscience and Nanotechnology, Victor E. Borisenko and Stefano Ossicini , WILEY-VCH Verlag, (2008).

Introduction to Nanotechnology, Charles P. Poole, Jr. and Frank J. Owens, Wiley

Semiconductor Nanostructures for Optoelectronic Applications, Todd Steiner, ARTECH HOUSE, (2004).

Nanotechnology and Nano-Interface Controlled Electronic Devices, M. Iwamoto, K. Kaneto, S. Mashiko Elsevier Science, Elsevier Science, (2003).

SemiconductorsforMicroandNanotechnology—An Introduction for Engineers Jan G. Korvink and Andreas Greiner, WILEY-VCH Verlag, (2002).

PH4MP4 MATERIAL SCIENCE PRACTICALS

Ultrasonic Interferometer – ultrasonic velocity in liquids

Ultrasonic Interferometer – Young's modulus and elastic constant of solids

Determination of dielectric constant

Determination of forbidden energy gap

Determination of Stephan's constant

Determination of Fermi energy of copper

Study of ionic conductivity in KCl / NaCl crystals

Thermo-emf of bulk samples of metals (aluminium or copper)

Study of physical properties of crystals (specific heat, thermal expansion, thermal conductivity, dielectric constant)

Study of variation of dielectric constant of a ferro electric material with temperature (barium titanate)

Study of variation of magnetic properties with composition of a ferrite specimen

Four probe method – energy gap

Energy gap of Ge or Si

Hall effect – Hall constant

Thin film coating by polimerisation

Measurement of thickness of a thin film

Study of dielectric properties of a thin film

Study of electrical properties of a thin film(sheet resistance)

Growth of single crystal from solution and the determination of its structural, electrical and optical properties (NaCl,KBr,KCl,NH_4Cl etc.)

Determination of lattice constant of a cubic crystal with accuracy and indexing the Bragg reflections in a powder X-ray photograph of a crystal

Observation of dislocation – etch pit method

Michelson Interferometer – Thickness of transparent film

X-ray diffraction – lattice constant

Optical absorption coefficient of thin films by filterphotometry

Temperature measurement with sensor interfaced to a PC or a microprocessor

ESR spectrometer – g factor

Beam profile of diode laser

Track width of a CD using laser beam

He – Ne laser- verification of Malus law , measurement of Brewster angle,refractive index of a material