I. Foundation

F1 : Classical Dynamics and Relativity

Unit 1 : Fundamental Principles and Lagrangian Formulation

Mechanics of a particle and system of particles – Examples – Conservation laws – Constraints – Generalized co-ordinates – D'Alembert's principle and Lagrange's equations – Hamilton's principle – Lagrange's equations of motion – Examples – Conservation theorems and symmetry properties

Unit 2 : Lagrangian Formulation : Applications

Motion under central force : General features – The Kepler problem – Scattering in a central force field.

Rigid body motion : Euler angles – Moments and products of inertia – Euler's equations – Symmetrical top – Applications.

Small oscillations : Theory of small oscillations – Frequencies of free vibrations – Normal modes – Two coupled oscillators – Linear triatomic molecule

Unit 3 : Hamilton's Formulation

Hamilton's canonical equations of motion – Hamilton's equations from variational principle – Principle of least action – Canonical transformations – Symplectic approach – Poisson brackets Infinitesimal canonical transformations – Hamilton – Jacobi method – Action and angle variables – Kepler's problem in action-angle variables

Unit 4 : Wave Motion

Continuous systems : Transition from discrete to continuous systems – Longitudinal vibrations in a long elastic rod – Lagrangian formulation for continuous systems – Hamiltonian formulation

Linear waves : Wave motion – Linear wave equations – Phase velocity – Dispersion – Fourier transform and wave packets – Group velocity

Nonlinear motion : Periodic motion – Perturbations and KAM theorem – Attractors – Chaotic trajectories and Liapunov exponents – Poincare maps

Unit 5 : Relativity

Postulates of special theory of relativity – Lorentz transformation – Velocity addition vectors and the metric tensor – Forces in the special theory : Electromagnetism – Relativistic angular momentum – Lagrangian formulation of relativistic mechanics – Elements of general theory of relativity

Books for Study and Reference

Relevant chapters in

1. H. Goldstein, C. Poole and J. Sofko, *Classical Mechanics,* 3^{rd} *Ed.* (Pearson Education, New Delhi, 2002).
2. H. Goldstein, *Classical Mechanics,* 2^{nd} *Ed.* (Narosa Publishing House, New Delhi, 1980).
3. M. Lakshmanan and S. Rajasekar, *Nonlinear Dynamics: Integrability, Chaos and Patterns* (SpringerVerlag, Berlin, 2003).
4. T. L. Chow, *Classical Mechanics* (John-Wiley, New York, 1995).

F2 : Mathematical Methods – I

Unit 1 : Vector Analysis

The scalar and vector fields – Gradient, Divergence, curl and Laplacian – Orthogonal and curvilinear co-ordinates – Rectangular, cylindrical and spherical co-ordinates. Vector integration – Line integrals, surface integrals and volume integrals – Gauss Divergence theorem – Stokes theorem and Greens theorem.

Unit 2 : Tensor Analysis

Definition – Transformation of co-ordinates – Summation convention – Contravariant, covariant and mixed tensors – Rank of a tensor – Symmetric and antisymmetric tensors – Tensor ellipsoid – Algebraic equation of a tensor. Associated tensors – Raising and lowering of suffixes – Metric tensor – Riemannian spaces – Christoffel's three index symbols – Law of transformation for Christoffel's symbols – Examples from physics.

Unit 3 : Matrix and Vector Space

Matrix : Characteristic equation of a matrix – Eigenvalues and eigenvectors – Cayley – Hamil-

ton theorem – Inverse of a square matrix – Reduction of a matrix to diagonal form.

Vector Space : Linear Vector Space – Basis – Change of basis – Inner product – Schmidt's orthogonalization process – Schwartz inequality.

Unit 4 : Differential Equations

Linear ordinary differential equations – Elementary methods – Linear second order differential equations with variable coefficients – Frobenius method – Variation of parameters – Sturm – Liouville differential equation – Linear partial differential equations – Separation of variables – Examples : the wave equation, Laplace equation and diffusion equation.

Unit 5 : Special Functions

Orthogonal functions – Bessel, Legendre, Hermite and Laugerre differential equations – Their series solutions – Recursion relations – Gamma and Beta functions – Dirac delta function.

Books for Study and Reference

Relevant chapters in

1. M. R. Spiegel, *Vector Analysis, Schaum's outline series* (McGraw-Hill, New York, 1974)
2. I. A. Pipes and L. R. Harvill, *Applied Mathematics for Engineers and Physicists* (McGraw Hill, London, 1970).
3. P. K. Chattopadhyay, *Mathematical Physics* (Wiley Eastern, New Delhi, 1992).
4. E. Kveyszig, *Advanced Engineering Mathematics* (Wiley Eastern, New Delhi, 1983).
5. R. Bronson, *Differential Equations* (Schaum's outline series, McGraw-Hill, New York, 1973).
6. H. K. Dass, *Mathematical Physics* (S. Chand & Co, New Delhi, 2003).
7. A. W. Joshi, *Matrices and Tensors in Physics* (Wiley Eastern, New Delhi, 1995).

F3T: Electronics – Theory

Unit 1: Semiconductor Devices

Semiconductor diodes – Characteristics – Zener diode – Schottky – Tunnel – Junction transistors – UJT–SCR – JFET – MOSFET – Opto electronic devices – Photodiode – Solar Cell – LED, LCD and phototransistor – Principle of integrated circuits – Fabrication processes: Diodes, transistors, resistors, capacitors – Linear and digital ICs – LSI, MSI.

Unit 2: Applications of Semiconductor Devices

Amplifiers: Junction (Bipolar) transistor amplifiers in three configurations – Types of coupling: DC, RC and transformer couplings – FET and MOSFET amplifiers – DC amplifier – Power amplifiers: Class B – Push-pull amplifier – Two-port Newton analysis using 'h' parameters – CE, CC, CB amplifiers – Measurement of 'h' parameters.

Oscillators: General theory – Feed back requirements – Phase shift oscillator – Crystal controlled oscillator – Negative resistance oscillator – Relaxation oscillators.

Unit 3: Operational Amplifier and its Applications

Linear ICs – OPAMPS – Characteristics – Basic applications – Inverting and noninverting amplifiers – Adder – subtracter – Integrator – Differentiator – Phase shifter – Comparator – Butterworth active filters – Waveform generator – Multivibrators: Bistable, Monostable – Schmitt trigger – Solutions of differential equations – Analog computation.

Unit 4: Digital Principles, Analog and Optical Communication

Flip-flops – R-S, J-K, D-T, Master-Slave flip-flops, Shift registers – Counters – A/D, D/A Converters – Memory devices – Structure and operations of RAM – ROM – PROM, EPROM – Microprocessor Architecture (Qualitative ideas only).

Modulation – Demodulation – Principles of Amplitude, Frequency and Phase modulations – Simple circuits for amplitude and frequency modulation and demodulation – Digital modulation: Pulse modulation – PAM, PPM, PDM, PCM modulators.

Optical communication: Fundamentals – Optical fibres – Optical sources: Lasers – characteristics.

Unit 5: Linear and Nonlinear circuits

V-I characteristic of two terminal linear and nonlinear elements – resistors, capacitors, inductors – example – PWL circuit elements – Chua's

diode – nonautonomous and autonomous nonlinear circuits – Nonlinear oscillations – Dynamics of Murali-Lakshmanan-Chua(MLC) and Chua's nonlinear circuits.

Books for study and Reference

1. J. Millman & C. C. Halkias, *Electronic Devices and Circuits* (McGraw Hill, Singapore, 1972).
2. A. P. Malvino, *Electronic Principles* (TMH Edition, New Delhi, 1995).
3. A. P. Malvino & D. P. Leech, *Digital Principles and Applications* (Tata McGraw Hill, New Delhi, 1994).
4. Robert Bolyestad and Louis Nashelsky *Electronic Devices and circuit theory*, (Prentice–Hall of India, New Delhi, 1996).
5. George Kennedy, *Electronic Communication Systems* (Tata McGraw Hill, New Delhi, 1995).
6. L. O. Chua, C. A. Desoer & E. S. Kuh *Linear and Nonlinear circuits* (McGraw Hill, Singapore, 1987).
7. M. Lakshmanan and K. Murali, *Bifurcation and Chaos: Controlling and Synchronization* (World Scientific, Singapore, 1995).

F3P : Electronics – Practice

List of Experiments

A. Workshop

1. Lathe Work-Step turning
2. Lathe Work-Tapper turning
3. Welding-Butt-Jointt
4. Glass blowing

B. Electronics Lab

1. Characteristics of (a) LED (b) Phototransistor (c) Photo diode
2. Characteristics of FET & FET oscillator
3. Characteristics of UJT and relaxation oscillators using UJT
4. Construction of 12v-Dual and variable power suppliers
5. OP-AMP – Mathematical operations (1) Inverting (2) Summing (3) Difference (4) Integration (5) Differentiation
6. OP-AMP – Solving simultaneous equations
7. OP-AMP – filters (1) Low pass (2) High pass (3) Band pass (4) Notch filter and D/A Converter – Ladder Type
8. Multivibrator using 555 IC & sine wave generator
9. (i) Truth table verification for NOT, AND, OR, NAND, NOR & XOR (ii) NAND & NOR as universal gates
10. Half adder, full adder, half subtractor, full subtractor, using gates
11. Shift register using 7476 IC serial in – serial out
12. 7490 Counter decoder, 7-segment display studies
13. Multiplier & demultiplier using AND and NOT gates
14. LCR circuit and study equivalent oscillator

F4T : Numerical Methods and Computer Practicals: Theory

Unit 1: Programming in Fortran 77 and other Languages

Fortran constants and variables – Arithmetic expressions – Input – Output statements – Control statements – Subscripted variables – Do statement – Logical expressions – Functions and subroutines – Simple computer programmes.

Unit 2 : The Solution of Numerical, Algebraic and Transcendental Equation

The iteration method – The method of false position – Newton-Raphson method – Convergence and rate of convergence – FORTRAN program for finding roots using Newton-Raphson method and by the method of false positions

Simultaneous Linear Algebraic Equations – Gauss elimination method – Jodan's modification – Computation of the inverse of a matrix by Gauss elimination method – Iterative methods – Jacobi method of iteration - Gauss – Seidel method of iteration – FORTRAN program for solutions of linear equations using Gauss elimination method

Unit 3 : Interpolation

Linear interpolation – Lagrange interpolation – Gregory-Newton forward and backward interpolation formulas – Error in interpolation - Central difference interpolation formula – Gauss's forward as well as backward interpolation formula – Bessel's formula – Lalplace-Everett's formula – Relation between Bessel's and Everett's formula

– Interpolation with unequal intervals – Divided differences – properties – Newton's interpolation formula for unequal intervals – FORTRAN program for Lagrange interpolation – FORTRAN program to construct a divided difference table – FORTRAN program for interpolation in uniformly spaced table using Newton-Gregory Formula

Unit 4 : Numerical Differentiation and Integration

Newton's forward and backward difference formulas to compute derivatives Numerical Integration. The trapezoidal rule – Simpson's rule – Extended Simpson's one-third rule – Truncation error – Practical applications of Simpson's rule – FORTRAN Program to evaluate integrals using Simpson's and Trapezoidal rules

Unit 5 : Numerical Solution of Ordinary Differential Equations

N^{th} order Ordinary Differential Equations – Power series approximations – Pointwise method – Solutions by Taylor Series – Euler's method – Improved Euler's method – Modified Euler's method – Runge-Kutta method II, III and IVth orders – R-K Method for solving first order differential equations – FORTRAN Program for solving ordinary differential equations using Runge-Kutta method

Books for Study and Reference

Relevant chapters in :

1. V. Rajaraman, *Computer Programming in Fortran 77, 3^{nd} Ed.* (Prentice Hall of India, New Delhi, 1993)
2. M. K. Venkataraman, *Numerical Methods in Science & Engineering* (The National Publishing Co., Madras, 1993)
3. M. K. Jain, S. R. K. Iyengar & R. K. Jain, *Numerical Methods for Scientific & Engineering Computation* (Wiley Eastern, New Delhi, 1990)
4. V. Rajaraman, *Computer Oriented Numerical Methods* (Prentice Hall of India , New Delhi, 1989)
5. V. N. Vedamurthy, N. ch. S. N. Iyengar, *Numerical Methods* (Vikas Publishing House, New Delhi, 1998)

F4P : Numerical Methods and Computer Practicals: Practice

List of experiments

1. False Position Method (to solve an algebraic equation)
2. Newton-Raphson Method (to solve an algebraic equation)
3. Jacobi Method (system of equations)
4. Gauss-Seidal Method (system of equations)
5. Simpson's rule (to solve an integration)
6. Trapezoidal rule (to solve an integration)
7. Lagrange interpolation
8. Euler Method (to solve a differential equations)
9. Runge-Kutta (second order) method (to solve a differential equations)
10. Runge-Kutta (fourth order) method (to solve a differential equations)

II. Core

C1 : Mathematical Physics – II

Unit 1 : Group Theory

Basic definitions – Subgroups – Cosets – Factor groups – permutation groups – Cyclic groups – Homomorphism and isomorphism – Classes of the group – Group representations – Reducible and irreducible representations – Schur's lemnas – Orthogonality theorem – Character of representation – Construction of character table – C_{2V} and C_{3V} point groups – Group theoretic application to molecular physics and crystallography.

Unit 2 : Green's Function Techniques and Integral Equations

Green's Functions – Properties – Methods of solutions in one, two and three dimensions – Applications – Linear integral equations – Hilbert-Schmidt kernels – Fredholm alternative – Neumann series – Eigen function expansion – Applications.

Unit 3 : Complex Analysis

Complex functions and variables – Condition for a function to be analytic – Complex integration – Cauchy's theorem – Cauchy's integral formula – Taylor expansion – Laurent expansion – Residue and contour integration – Cauchy's

residue theorem – Computations of residue – Evaluation of integrals.

Unit 4 : Fourier Series and Fourier Transform

Fourier Series : Determination of Fourier coefficients – Fourier series for periodic functions – Half range series – Fourier cosine and Fourier sine series – Physical Applications.

Fourier Transform : Fourier Integral Theorem – Fourier cosine and sine – Integrals – Fourier transforms – Fourier cosine and sine Transforms – Physical applications – Heat equation (one dimension) – Solution of parial differential equations by Fourier transform.

Unit 5 : Laplace Transform

Properties of Laplace transform – Inverse Laplace transform – Laplace transform derivatives – Convolution theorem – solution of second-order linear ordinary differential equations by Laplace transform – Applications.

Books for study and reference

Relevant chapters in

1. E. Kreyszig, *Advanced Engineering Mathematics* (Wiley Eastern, New Delhi, 1983)
2. Pipes and L. R. Harvill, *Applied Mathematics for Engineers and Physicists* (McGraw Hill Book Company, Singapore, 1970)
3. P. K. Chattopadhyay, *Mathematical Physics* (Wiley Eastern, New Delhi, 1992)
4. M. Hammernesh, *Group Theory* (Addision – Wesley, New York, 1962)
5. Harper, *Introduction to Mathematical Physics* (Prentice Hall of India, New Delhi, 1993)
6. H. K. Dass, *Advanced Engineering Mathematics* (S. Chand & Co., New Delhi, 1998)
7. K. Dass, *Mathematical Physics*, (S. Chand & Co., New Delhi, 2003)

C2 : Quantum Mechanics

Unit 1 : The Schrodinger Equation and Stationary States

Physical basis of quantum mechanics – The Schrodinger Equation – Physical meaning and conditions on the wave function – Expectation values and Ehrenfest's theorem – Stationary states and energy spectra – Particle in a square well potential.

General Formulation : The fundamental postulates of wave mechanics – Dirac notation : Bra and Ket – Hilbert space – Hermitian operators and their properties – Commutator relations and uncertianity principle – Schrodinger, Heisenburg and interaction pictures.

Unit 2 : Exactly Solvable Bound State Problems

Linear harmonic oscillator : Eigen function by solving the one dimensional Schrodinger equation – Abstract operator method – Orbital angular momentum and parity commutation relations – Rigid rotator – Particle in a central potential – Hydrogen atom.

Unit 3 : Approximation Methods

Time Independent Problems : Non degenerate and degenerate perturbation theory – Stark effect – Variational method – WKB Approximation : Application to tunneling problem and quantization rules.

Time Dependent Problems : Time dependent perturbation theory – Harmonic perturbation – Transition probability.

Unit 4 : Angular Momentum and Matrix Representation and all that

Matrix Representation of angular momentum J and Spin angular momentum – Commutation relations – Eigen values – Addition of angular momenta – Clebsch-Gordan coefficients (basic ideas only).

Scattering Theory: The scattering cross section – Born Approximation – Differential and total cross sections

Unit 5 : Relativistic Quantum Mechanics

Klein – Gordon equation for a free particle and in an electromagnetic field – Dirac equation for a free particle and in electromagnetic field – Dirac matrices – Plane wave solutions – Negative energy states

Books for Study and Reference

Relevant chapters in

1. L. Schiff, *Quantum Mechanics* (Tata McGraw Hill, New Delhi, 1968)

2. P. M. Mathews & K. Venkatesan *A Text Book of Quantum Mechanics* (Tata McGraw Hill, New Delhi, 1987)
3. V. K. Thankappan, *Quantum Mechanics* (Wiley-Eastern, New Delhi, 1985)
4. Richard L. Liboff, *Introductory Quantum Mechanics,* 3^{rd} *Ed.* (Addison – Wesley, New York, 1998)
5. Jaspirit Singh, *Quantum Mechanics : Fundamentals and Applications to Technology* (John-Wiley, New York, 1997)
6. Amit Goswami, *Quantum Mechanics* (Won C. Brown, Dubuque, 1992)

C3 : Thermal and Statistical Physics

Unit 1 : Thermodynamics

Laws of Thermodynamics – Some consequences of the laws of thermodynamics – Entropy – Calculation of entropy changes in reversible processes. The principle of increase of entropy – Thermodynamic potentials – Ehthalpy, Helmholtz and the Gibbs functions – Phase transitions – The Clausius-Clayperon equation – Van der Waals equation of state.

Unit 2 : Kinetic Theory

Distribution function and its evolution – Boltzmann transport equation and its validity – Boltzmann's H-theorem – Maxwell-Boltzmann distribution – Transport phenomena – Mean free path-Conservation laws – Hydrodynamics (No derivation).

Unit 3 : Classical Statistical Mechanics

Review of probability theory – Macro and micro states – Statistical equilibrium – Phase space ensembles – Density function – Liouville's theorem – Maxwell-Boltzmann distribution law – Microcanonical ensemble – Ideal gas – Entropy – Partition function – Principle of equipartition of energy – Canonical and grand canonical ensembles.

Unit 4 : Quantum Statistical Mechanics

Basic concepts – Quantum ideal gas – Bose Einstein and Fermi-Dirac statistics – Distribution laws – Sackur-Tetrode equation – Equations of state – Bose-Einstein condensation.

Unit 5 : Applications of Quantum Statistical Mechanics

a. Ideal Bose gas : Photons – Black body and Planck radiation – Photons – Specific heat of solids – Liquid Helium.

b. Ideal Fermi gas : Properties – Degeneracy – Electron gas – Pauli paramagnetism

c. Ferromagnetism : Ising and Heisenberg models.

Books for study and Reference

Relevant chapters in

1. K. Huang, *Statistical Mechanics* (Wiley Eastern Limited, New Delhi, 1963)
2. B. K. Agarwal and M. Eisner, *Statistical Mechanics* (Wiley Eastern Limited, New Delhi, 1994)
3. F. Reif, *Fundamentals of Statistical and Thermal Physics* (McGraw Hill International Edition, Singapore, 1985)
4. N. Sears and L. Salinger, *Thermodynamics,* 3^{rd} *Ed.* (Narosa Publishing House, New Delhi, 1989)
5. W. Greiner, L. Neise and H. Stocker, *Thermodynamics and Statistical Mechanics* (Springer Verlag, New York, 1995)

C4 : Atomic and Molecular Physics

Unit 1 : Atomic Spectra

Quantum states of electron in atoms – Hydrogen atom spectrum – Electron spin – Stern-Gerlach experiment – Spin-orbit interaction – Lande interval rule – Two electron systems – $LS - JJ$ coupling schemes – Fine structure – Spectroscopic terms and selection rules – Hyperfine structure

Exchange symmetry of wave functions – Pauli's exclusion principle – Periodic table – Alkali type spectra – Equivalent electrons – Hund's rule

Unit 2 : Atoms in External Fields and Quantum Chemistry

Zeeman and Paschen Back effect of one and two electron systems – Selection rules – Stark effect – Inner Shell vacancy – X-ray – Auger transitions – Compton effect

Quantum Chemistry of Molecules : Covalent, ionic and van der Waal's interactions – Born-Oppenheimer approximation – Heitler- London

and molecular orbital theories of H_2 – Bonding and anti bonding MOs – Huckel's molecular approximation – Application to butadine and benzene

Unit 3 : Microwave & IR Spectroscopy

Rotational spectra of diatomic molecules – Intensity of spectral lines – Effect of isotopic substitution – The non-rigid rotor – Rotational spectra of poly atomic molecules – Linear, symmetric top and asymmetric top molecules – Experimental techniques – Vibrating diatomic molecule – Diatomic Vibrating rotator – Linear and symmetric top molecules – Analysis by infrared techniques – Characteristic and group frequencies –

Unit 4 : Raman Spectroscopy and Electronic Spectroscopy of Molecules

Raman effect – Polarizability theory – Pure rotational Roman's Spectrum : vibrational Raman Spectrum diatomic molecules :- Structure determination from Raman & IR Spectrometer – Experimental Techniques

Electronic spectra of diatomic molecules – Intensity of spectral lines – The Franck- Condon principle – Dissociation energy and dissociation products – Rotational fine structure of electronic vibration transitions – Predissociation

Unit 5 : Masers and Lasers

Spontaneous and stimulated emission – Ammonia maser – Interaction of radiation with atomic systems – Einstein coefficients – Population inversion – Laser threshold condition – Rate equations for 3 and 4 level lasers – Laser resonators – Ruby laser – He- Ne laser – CO_2 laser – Semiconductor lasers – Laser applications

Books for study and Reference

Relevant chapters in

1. C. N. Banwell, *Fundamentals of Molecular Spectroscopy* (McGraw Hill, New York, 1981)
2. B. P. Straughan & S. Walker *Spectroscopy: Vol. I* (Chapman and Hall, 1976)
3. R. P. Feynman et al. *The Feynman Lectures on Physics: Vol. III.* (Narosa Book Distributors, New Delhi, 1989)
4. H. S. Mani and G. K. Mehta, *Introduction to Modern Physics* (Affiliated East West, New Delhi, 1991)
5. A. K. Chandra, *Introductory Quantum Chemistry* (Tata McGraw Hill, New Delhi, 1989)
6. F. Pilar, Elementary *Quantum Chemistry* (McGraw Hill, New York, 1968)
7. Manas Chanda, *Atomic Structure and Chemical Bond* (Tata McGraw Hill, New Delhi, 1991)
8. Ira N. Levine, *Quantum Chemistry* (Prentice-Hall of India, New Delhi, 1994)
9. Arthur Beiser, *Concepts of Modern Physics* (McGraw Hill, New York, 1995)

C5 : Electromagnetic Theory

Unit 1 : Introduction to Electrostatics

Coulomb's law – Electric field – Gauss Law – Scalar potential – Surface distribution of charges and dipoles – Poisson and Laplace Equations – Green's theorem – Dirichlet and Neumann boundary conditions – Electrostatic boundary value problems : Solution using Green's function – Method of Images – Illustrations : Point charge in the presence of (i) a grounded conducting sphere (ii) a charged, insulated, conducting sphere and (iii) near a conducting sphere at fixed potential and (iv) conducting sphere in a uniform electric field – Green's function for the sphere – Solution of Laplace equation in cartesian, spherical and cylindrical coordinates

Unit 2 : Electrostatics of Macroscopic Media

Multipole expansion – Elementary treatment of electrostatics with ponderable media – Boundary value problems with dielectrics – Illustrations : (i) a point charge embedded at a distance away from a dielectric interface (ii) dielectric sphere in a uniform electric field (iii) spherical cavity in a dielectric medium with applied electric field – Molecular polarizability and electric susceptibility – Electrostatic energy in dielectric media

Unit 3 : Magnetostatics

Biot and Savart law – Force between current carrying conductors – Differential equations of magnetostatics and Ampere's law – Vector potential – Magnetic field of a localized current distribution, magnetic moment – Force and torque and energy of a localized current distribution in an

external magnetic induction – Macroscopic equations – Boundary conditions on B and H – Methods of solving boundary value problems in magnetostatics – Uniformly magnetized sphere

Unit 4 : Electromagnetics

Faraday's law of induction – Maxwell's displacement current – Maxwell equations – Maxwell equations in terms of vector and scalar potentials – Gauge transformations – Lorentz gauge, Coulomb gauge – Poynting's theorem – Conservation of energy and momentum for a system of charged particles and electromagnetic fields

Unit 5 : Plane Electromagnetic Waves and Wave Propagation

Plane waves in a nonconducting medium – Linear and circular polarization – Stokes parameters – Reflection and refraction of electromagnetic waves at a plane interface between dielectrics – Fields at the surface of and within a conductor – Propagation of electromagnetic waves in hollow metallic cylinders : Cylindrical and rectangular wave guides – TM and TE modes – Wave propagation in optical fibers

Books for Study and Reference

Relevant chapters in

1. J. D. Jackson, *Classical Electrodynamics* (Wiley Eastern Ltd., New Delhi, 1999)
2. D. Griffiths, *Introduction to Electrodynamics* (Prentice-Hall of India, New Delhi, 1999)
3. R. P. Feynman et. al., *The Feynman Lectures on Physics: Vol. II* (Narosa Book Distributors, New Delhi, 1989)

C6 : Condensed Matter Physics

Unit 1 : Crystal Structure

Crystal classes and Symmetry – 2D, 3D, lattices – Bravais lattices – Symmetry point groups – Space groups – Reciprocal lattice – Ewald's sphere construction – Bragg's law – Systematic absences – Atomic scattering factor – Diffraction – Structure factor – Experimental techniques – Laue, Powder, and Rotation methods – Phase problem – Electron density distribution (elementary ideas only).

Bonding of common crystal structures – NaCl-CsCl & ZnS, Diamond – hcp, ccp, random stacking and polytypism.

Unit 2 : Lattice Vibrations and Thermal Properties

Vibration of monoatomic lattices – Lattices with two atoms per primitive cell – Quantization of lattice vibrations – Phonon momentum – Inelastic scattering of neutrons by phonons.

Lattice heat capacity – Einstein model – Density of mode in one-dimension and three-Dimension – Debye model of the lattice heat capacity – Thermal conductivity – Umklapp process.

Unit 3 : Free Electron Theory, Energy Bands and Semiconductor Crystals

Energy levels and density of orbitals – Fermi-Dirac distribution – 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 – Electron in a periodic potential – Semiconductors – Band gap – Effective mass – Intrinsic carrier concentration.

Unit 4 : Diamagnetism, Paramagnetism, Ferromagnetism and Antiferromagnetism

Langevin classical theory of Diamagnetism and Paramagnetism – Weiss theory – Quantum theory of Paramagnetism – Demagnetization of a paramagnetic salt – Paramagnetic susceptibility of conduction electrons – Hund's rules – Kondo effect

Ferroelectric order – Curie point and the exchange integral – Temperature dependence of saturation magnetization – Magnons – Ferromagnetic order – Antiferromagnetic order – Ferromagnetic domains – Origin of domains – Coercive force and hysteresis.

Unit 5 : Dielectrics, Ferroelectrics and Superconductivity

Macroscopic electric field – Local electric field at an atom – Dielectric constant and polarizability – Clausius-Mossotti equation – Polarizaion catastrophe – Ferroelectric domains

Occurrence of Superconductivity – Meissner effect – Thermodynamics of Superconducting transition – London equation – Coherence length – BCS theory – Flux quantization – Type-I and Type-II Superconductors – Josephson tunneling effect – DC and AC Josephson effect – SQUID – Recent developments in high Temperature Superconductivity – Application of superconductors.

Books for study and Reference

Relevant chapters in

1. C. Kittel, *Introduction to Solid State Physics,* 5^{th} *Edition* (Wiley Eastern, New Delhi, 1977)
2. N. W. Ashcrof and N. D. Mermin, *Solid State Physics* (International Edition, Philadelphia, 1976)
3. J. S. Blakemore, *Solid State Physics, Second Edition* (Cambridge University Press, Cambridge, London, 1974)
4. A. J. Dekker, *Solid State Physics* (Mac Millan, Madras, 1971)
5. M. M. Woolfson, *An Introduction to X-ray Crystallography* (Cambridge University Press, Cambridge, 1991)
6. Thomas P. Sheahen, *Introduction to High-Temperature Superconductors* (Plenum press, New York, 1994)
7. S. O. Pillai, *Solid State Physics* (New Age International (P) Ltd., New Delhi, 1995)

C7 : Nuclear and Particle Physics

Unit 1 : Basic Nuclear Properties

Nuclear size, shape, mass – Charge distribution – Spin and parity – Binding energy – Semi empirical mass formula – Nuclear stability – Mass parabola

Nuclear Forces : Nature of nuclear forces – Ground state of deuteron – Magnetic dipole moment of deuteron – Proton-neutron scattering at low energies – Scattering length, phase shift – Proton-proton scattering at low energies – Properties of nuclear forces – Spin dependence – Charge symmetry – Charge independence – Repulsion at short distances – Exchange forces – Meson theory

Unit 2 : Radioactive Decays

Alpha emission – Geiger – Nuttal law – Gamow theory – Neutrino hypothesis – Femi theory of beta-decay – Selection rules – Nonconservation of parity – Gamma emission – Selection rules – Transition probability – Internal conversion – Nuclear isomerism

Detection of Nuclear Radiations : Interaction of charged particles and X-rays with matter – Basic principles of particle detectors – Ionization chamber – Proportional counter and G.M counters – Solid state detectors – Scintillation and semiconductor detectors

Unit 3 : Nuclear Reactions

Q-values and kinematics of nuclear cross sections – Energy and angular dependence – Reciprocity theorem – Breit-Wigner formula – Compound nucleus – Resonance theory – Optical model

Nuclear Models : Shell model – Liquid drop model – Collective model

Unit 4 : Accelerators

Cyclotron – Synchrocyclotron – Betaron – Synchrotron – Linear accelerators

Nuclear Fission and Fusion : Characteristics of fission – Mass distribution of fragments – Radioactive decay processes – Fission cross section – Energy in fission – Bohr-Wheeler's theory of nuclear fission – Fission reactors – Thermal reactors – Homogeneous reactors – Heterogeneous reactors – Basic fusion processes – Characteristics of fusion – Solar fusion – Controlled fusion reactors – Cold fusion

Unit 5 : Elementary Particles

Building blocks of nucleus – Nucleons, leptons, mesons, baryons, hyperons, hadrons, strange particles – Classification of fundamental forces and elementary particals – Basic conservation laws – Additional conservation laws : Baryonic, leptonic, strangeness and isospin charges/quantum numbers – Gell-Mann – Nishijima formula – Multiplets – Invariance under time reversal (T), charge conjugation (C) and parity (P) – TCP theorem – Parity nonconservation in weak interactions – CP violation – Eight fold way and supermultiples –

SU(3) symmetry and quark model – Basic ideas on the theories of weak and strong interactions.

Books for Study and Reference

Relevant chapters in

1. K. S. Krane, *Introductory Nuclear Physics* (John-Wiley, New York, 1987)
2. S. B. Patel, *Nuclear Physics : An Introduction* (Wiley-Eastern Limited, New Delhi, 1991)
3. B. L. Cohen, *Concepts of Nuclear Physics* (Tata Me-Graw Hill, New Delhi, 1988)
4. H. S. Hans, *Nuclear Physics : Experimental and Theoretical* (New Age International Publishers, New Delhi, 2001)
5. D. C. Cheng and G. K. O'Neill, *Elementary Particle Physics : An Introduction* (Addison – Wesley, New York, 1979)
6. D. Griffiths, *Introduction to Elementary Particles*, (Wiley International Edition, New York, 1987)

C8T : Experimental Techniques and Instrumentation – Theory

Unit 1 : Error Analysis

Types of errors – Systematic and random errors – Accuracy and Precision – Significant figures and round-off – Uncertainties and probable error – Random variable – Mean, variance and standard deviation, Standard Deviation of Standard Deviation – Normal distribution – Sampling technique – Propagation of errors – Estimates of mean and errors: Instrumental uncertainties – Statistical fluctuations – Chi square test – Goodness of fit

Unit 2 : Basic Principles of some important instruments

Cathode ray oscilloscope – Its operation – Sweep, signal and function generators – Ideal and real voltage sources – Local current – Load voltage – Thevinin's theorem – Norton's theorem – troubleshooting – shorts and opens in a circuit – Impedance and capacitance – Frequency analysis of reactive circuits – Measurement of magnetic field – Hall probe – SQUID

Unit 3 : Crystal Growth Techniques

Nucleation – Concept of formation of the critical nucleus – Spherical and cylindrical shapes of nucleus – Melt-growth – Bridgman method – Czochralski method – Growth by vapour – Basis of vapour growth – Chemical vapour transport method – Low temperature solution growth – Solubility diagram – Slow cooling method – Slow evaporation method – Gel growth method – Structure and property of gel – Different methods

Unit 4 : Nonlinear Optics

Wave propagation in an anisotropic crystal – polarization response of materials to light – Second order nonlinear processes – Sum and difference frequency generation – Optical parametric oscillations – Third order nonlinear optical process – Third harmonic generation – Intensity dependent refractive index – Selffousing – Phase matching – optical bistability – Two photon absorption – Stimulated Raman scattering

Unit 5 : Resonance Spectroscopy

Nuclear magnetic resonance – Principle and theory – Chemical shift – Spin-spin and spin – Lattice relaxation – Simple applications – Nuclear quardrupole resonance – Principle and application to study of crystals – Electron spin resonance – Theory – Hyperfine splitting in some simple systems – Moessbauer spectroscopy – Theory and application

Books for study and Reference

Relevant chapters in

1. B. C. Nakra and K. K. Chaudry, *Instrumenation, Measurement and Analysis* (Tata McGraw Hill, New Delhi, 1985)
2. Austin E. Fribance, *Industrial Instrumentation Fundamentals* (Tata McGraw Hill, New Delhi, 1982)
3. A. D. Helfrickand W. D. Cooper, *Modern Electronic Instrumentation and Measurement Techniques* (Prentice Hall, New Delhi, 1995)
4. A. Carrington and A. D. Mc Lachlan, *Introduction to Magnetic Resonance* (Chapman and Hall, New York, 1980)
5. J. C. Brice, *Crystal Growth Processes* (John Wiley and Sons, New York, 1986)

6. H. K. Henisch, *Crystals in Gels and Liesegang Rings* (Cambridge University Press, Cambridge, 1986)
7. Banwell, *Fundamentals of Molecular Spectroscopy* (TMH Edition, New Delhi, 1979)
8. Drago, *Physical Methods in Inorganice Chemistry* (East West Press, New Delhi, 1965)
9. Bevington, *Data Reduction and Error Analysis for the Physical sciences* (McGraw-Hill Book Company, New York, 1969)
10. William T. Silfvast *Laser Fundamentals* (Cambridge University Press, Cambridge 1998)
11. D. L. Mills, *Nonlinear Optics – Basic Concepts* (Springer, Berlin, 1998)

C8P : Experimental Techniques and Instrumentation – Practice

List of experiments

A. Condensed Matter Physics

1. Determination of Planck's Constant
2. Crystal Growth
3. Determination of Wavelength of He-Ne Laser
4. Determination of Melting Point
5. Refractive Index using He-Ne laser
6. Forbidden Energy gap in Pn junction
7. Determination of Circular aperture Diameter
8. Density Measurement
9. Identification of Functional Groups using FTIR spectroscopy
10. X-Ray Powder diffraction
11. Particle size determination using He-Ne Laser
12. Determination of wavelength of He-Ne Laser using Michelson interferometer
13. Determination of width of single slit

B. Biophysics

1. pH titration of an amino acid
2. Preparation of caesin from milk
3. Separation of leaf pigments on calcium carbonate
4. Conductivity measurements of a given solution
5. Viscosity measurements of a given solution
6. Ultrasonic interferometry of a given solution
7. Polarimetry study of sugar solutions

III. Elective

E1 : Nonlinear Dynamics

Unit 1 : Introduction to Nonlinear Dynamics

The notion of nonlinearity – Superposition principle and its validity – Linear and nonlinear oscillators – Autonomous and nonautonomous systems – Equilibrium points – Phase space – Classification of equilibrium points – Limit cycle motion – Lorenz equations

Unit 2 : Bifurcation and Chaos in Dissipative Systems

Some simple bifurcations – The Logistic map: Period doubling phenomenon – Onset of chaos – Bifurcation scenario in Duffing oscillator – Nonlinear electronic circuits : chaos in Chua and MLC circuits

Unit 3 : Chaos in Conservative Systems

Poincare cross section – Possible orbits in conservative systems – Henon-Heiles system – Characterization of regular and chaotic motions : Lyapunov exponents – Numerical computation – Power spectrum and dynamical motion

Unit 4 : Finite Dimensional Integrable Nonlinear Dynamical Systems

The notion of integrability – complete integrability – How to detect integrability : Painleve analysis – Examples – Symmetries and integrability – Integrals of motion – Integrable discrete systems

Unit 5 : Soliton and Complete Integrability

Nonlinear dispersive systems – Cnoidal and solitary waves – The Scott Russel phenomenon and K-dV equation – Fermi – Pasta – Ulam numerical experiment – Numerical experiment of Zabusky and Kruskal – Birth of soliton – Lax pair – Inverse scattering transform method for K-dV equation – Explicit soliton solutions – Bilinearisation method – Applications

Books for Study and Reference

Relevant chapters in

1. M. Lakshmanan and S. Rajasekar, *Nonlinear Dynamics : Integrability Chaos and Patterns* (Springer-Verlag, Berlin, 2003)

2. M. Lakshmanan and K. Murali, *Chaos in Nonlinear Oscillators* (World Scientific, Singapore, 1996)
3. *P. G. Drazin, Nonlinear Systems* (Cambridge University Press, Cambridge, 1992)
4. A. J. Lichtenberg and M. A. Lieberman, *Regular and Stochastic Motion* (Springer−Verlag, Heidelberg, 1992)
5. *P. G. Drazin and R. S. Johnson, Solitons: An Introduction* (Cambridge University Press, Cambridge, 1989)
6. M. J. Ablowitz and P. A. Clarkson, *Solitons, Nonlinear Evolution Equations and Inverse Scattering* (Cambridge University Press, Cambridge, 1991)

E2 : Molecular Biophysics

Unit 1 : Cellular Basis of Life

Structure and constitution of animal cell − Plant cell and bacterial cell − Molecular constituents of cell (elementary ideas)

Stereochemistry and conformation : Asymmetric carbon − Isomerism − Types − Constitution, Configuration and Conformation − Chirality − Fisher convention − L and D system R-S system − Torision angles − Conformation of ethane and n butane − Barrier to rotation

Unit 2 : Structure and Function of Proteins

Amino acids − Peptide bond − Rigid planar peptide − cis and trans configuration − Allowed conformation of a pair of linked peptide units − Torsion angles − Phi and Psi − Steric hindrance − Hardsphere approximation − Contact criteria − Ramachandran diagram − Map for glycine and alanine residues − Conformational energy − Non covalent forces − Description of various interactions by potential functions − Energy map − Minimisation of energy − Functions of Proteins − Classification of proteins into globular and fibrous − Levels of structural organisation − Types of secondary structures − Helix − b sheet − Turns − Super secondary and domain structure − Structure of collagen and silk − Bioinformatics − Biomolecular data bases − applications

Unit 3 : Structure and Function of Carbohydrates

Classification − Nomenclature − L and D sugars − Monosaccharides − Stereoisomerism of sugars − Confirmation of pyranoid rings − Disaccharides − Types of linkages in poly saccharides − Structure of maltose, celloboise, lactose and laminarabiose − Ramachandran map for disacharies − Conformational energy map − polysaccharides − Carbohydrate peptide linkages − Functions glycoproteins − Muco polysaccharides − Functions − Bacterial cell wall − Structure of peptidoglycan − Mode of penicillin action

Unit 4 : Structure and Function of Nucleic Acids

Conformations of monomer nucleosides and nucleotides − Structure of oligon nucleotides − Base pairing and base stacking − Structure of DNA − Watson and Crick model − Variations in DNA structure − Polymonphism − A, B and Z DNA − Structure of RNA and t RNA − Usual DNA structures − High order DNA structures − Genetic code − Protein biosynthesis − Origin of life − Reverse Principles of Macromolecular assembly: Structure of viruses − Types − packing of protein subunits − Structure of TMV − HIV viruses

Unit 5 : Crystallography

X-rays − Generation − Detecion of X-rays − Crystal diffraction − Data collection − Weissenberg, Precession and diffractometer methods of recording and measurement of X-ray intensity − Data reduction p Wilson plot − Scale factor and temperature factor − Crystal Structure determination − Space group determination − Systematic absences − Phase problem − Methods of solution − Patterson and heavy atom method − Isomorphous and anomalous scattering methods − Direct methods − Sayre's relation − Tangent formula − Structure solution and structure refinement − Fourier and least squares methods − R-factor − Interpretation of results − Bond length − Bond-angle, torison-angle − Conformation

Elementary theory of the diffraction − Protein modelling and drug design

Books for Study and Reference

1. A. I. Lehninger, D. I. Nelson and M. M. Cox, *Principles of Biochemsitry* (CBS Publishers, New Delhi, 1993)

2. I. Stryer, *Biochemsitry* (W. H. Freeman and Co., New York, 1995)
3. G. E. Schulz and R. H. Schirmer, *Principles of Protein Structure* (Springer-Verlag, Berlin, 1984)
4. C. R. Cantor and P. R. Schimmel, *Biophysical Chemistry: Part I, II and III* (W. H. Freeman and Co. New York, 1980)
5. C. Branden and J. Tooze, *Introduction to Protein Structure* (Garland Publishing, 1991)
6. Thomas E. Creighton, *Protein Structure and Molecular Properties* (W. H. Freeman and Company, New York, 1993)
7. V. S. R. Rao, P. K. Qasba, P. V. Balaji and R. Chandrasekaran, *Conformation of Carbohydrates* (Harwood Academic Publishers, Amsteerdam, 1998)
8. M. M. Woolfson, *An Introduction to X-ray Crystallography* (Cambridge University Press, Cambridge, 1980)
9. M. F. C. Ladd and R. A. Palmar, *Structure Determination by X-ray Crystallography* (Plenum Press, New York, 1977)
10. T. L. Blundell and L. N. Johnson, *Protein Crystallography* (Academic Press, New York, 1976)

IV. Extra Disciplanary

ED1 : Electronic and Electrical Home Appliances

Unit 1 : Heater

Room Heater, Electric Stove(heater), Making heater element, method of making element, Testing, Fault finding, precautions, general faults of immersion heater.

Unit 2 : Electric Iron

Common electric press or nonautomatic electric press, Main parts of common electric press, method of opening the press, re-assembling the electric press, Testing the electric press, Fault finding of common electric press, automatic press, Thermostat, circuit diagram of automatic press, Working procedure of thermostat, Steam press.

Unit 3 : Exhaust Fan

Different parts of exhaust fan, opening the exhaust fan, assembling exhaust fan, precautions motor of exhaust fan, Fault finding of exhaust fan.

Unit 4 : Room Cooler

Cooler pump, motor of cooler pump, capacity of cooler pump, open the cooler pump, rewinding cooler pump motor, Coil connections of cooler pump, checking of induced of magnetic field in the motor, working procedure of cooler fan motor.

Unit 5 : Electric mixy

Different part of mixy, motor of mixy, changing the direction of mixy motor, sparking on the commutator, testing the armature, rewinding the armature, checking armature after removing defective winding, Fault finding of mixy.

Unit 6 : Electric Geyser

Types of electric geyser, testing and repairing of geyser, Fault finding of Geyser.