M. Sc. I

Semester I

Paper I: Course I

Mathematical Physics

UNIT- I

Special Functions: Second order linear differential equations; Solution by series expansion; Legendre, Bessel, Hermite and Laguerre differential equations, their solutions and properties, Spherical Harmonics.

UNIT-II

Fourier and Laplace Transform: Dirac Delta function, Fourier Transform, Sine and Cosine transform, Laplace transform, inverse Laplace transform, Linearity, Change of Scale, Translation, Modulation, simple applications.

UNIT- III

Complex Variables I: General function of complex variable, Cauchy-Riemann differential equation and analyticity, Cauchy's integral formula, Taylor's and Laurent's series, singularity poles.

Complex Variables II: Conformal mapping (translation, rotation, inversion), Residue theorem. Evaluation of definite integrals, around (i) unit circle and (ii) infinite semi-circle using Jordan's lemma with poles lying on real axis.

UNIT- IV

Green Function: Green's function as a technique to solve linear ordinary differential equations, Homogeneous and Inhomogeneous boundary conditions, Solution of Poisson equation using Green's function technique, Symmetry property.

Reference Books:

1. Mathematical Methods for Physicists by G. Arfken, H. Weber and F.E. Harris (Elsevier)
2. Mathematics for Physicist by P. Dennery and A. Krzynicki (Dover Publication)
3. Special Functions and their Applications by N. N. Lebedev (Dover Publication)
4. Mathematical Methods for Physics and Engineering by K. F. Riley, M.P. Hobson and S. J. Bence (Cambridge University Press)
5. Mathematical Physics by B. S. Rajput (Pagati Prakashan)
6. Complex Variables and Applications by J.W. Brown and R. V. Churchill (McGraw-Hill)

Paper II: Course II

Classical Mechanics

UNIT-I

Vectors: Curvilinear Coordinates, Gradient, Divergence and Curl, Laplace equation in spherical polar and cylindrical polar coordinates and their solution, Green's theorem, Gauss and Stokes Theorems.

Tensors: Covariant and Contravariant vectors, Tensors–Addition, Multiplication, Contraction, Symmetry properties; Tensor density, Pseudo-tensors.

UNIT-II

Mechanics of a system of particles: System of particles and Constraints, Generalised coordinates, D'Alembert's principle, Lagrange's Equation. Hamilton's principle, Least action principle, Langrange's equations, symmetry properties and Noether's theorem, Lagrangian formulation for elementary mechanical systems-free particle, and simple pendulum.

UNIT-III

Two Body Problem: Reduction to one-body problem, reduced mass, Virial Theorem, planetary orbits.

Scattering: Collision between particles, disintegration of particles, elastic collisions, scattering, Rutherford's formula.

Small oscillations: Damped and Forced oscillations, coupled vibrations.

UNIT-IV

Hamiltonian Formulation: Hamilton equations, canonical transformations, Poisson's bracket, Symplectic approach to canonical transformations; Hamilton Principle function, Hamilton-Jacobi equation, Harmonic Oscillator Problem, Hamilton characteristic Function, separation of variables, Central Force problem.

Reference Books:

1. Vector Analysis and Introductory Tensor Analysis by M.R. Spiegel (Schaum Series)
2. Matrices and Tensors in Physics by A.W. Joshi (New Age)
3. Classical Mechanics by H. Goldstein (Narosa, New Delhi)
4. Classical Mechanics by K.C. Gupta (Wiley Eastern)
5. Classical Mechanics by L.D. Landau (Elsevier)
6. Classical Mechanics by N.C. Rana and P.S. Joag (Tata-McGraw-Hill)

Paper-III: Course III

Quantum Mechanics - I

UNIT-I

Wave Mechanical formulation: Schrodinger wave equation: stationary states, boundary & continuity conditions, degeneracy, orthogonality of eigenfunctions, and parity. Hermitian operators and observables, Dirac delta function, commuting observables and related algebra, Simple one-dimensional applications: potential well, barrier potential, and tunnel effect.

UNIT-II

Identical Particles and spin: Distinguishability of identical particles, exchange degeneracy and operator, construction of symmetric and antisymmetric wave functions, Pauli's exclusion principle and Slater's determinant, Electron spin hypothesis, spin matrices and eigen value equations, symmetric and antisymmetric wave functions for hydrogen molecule.

UNIT-III

Matrix formulation: Concept of Hilbert Space, Dirac's bra and ket notations, Orthonormality and completeness relations (discrete and continuous), linear and real operators, eigenvalue equations and related theorems, projection operators and measurement, Pure and mixed states, application to Harmonic Oscillator, Equivalence of wave and matrix mechanics.

UNIT-IV

Theory of Angular momentum: Orbital, spin and total angular momentum operators: eigen value equations and matrix representations. Ladder operators, commutation relations, Addition of angular momenta, Clebsch-Gordon coefficients.

Reference Books:

1. Quantum Mechanics, Vol. I & II by Albert Messiah (Dover Publication)
2. The Principles of Quantum Mechanics by P.A.M. Dirac (Oxford University Press)
3. Quantum Mechanics by L.I. Schiff (Tata-McGraw-Hill)
4. Modern Quantum Mechanics by J.J. Sakurai (Addison Wesley)
5. Introduction to Quantum Mechanics by D.J. Griffths (Pearson Education)
6. Quantum Mechanics by C. Cohen-Tannoudji, B. Diu and F. Laloe (Wiley VCH)
7. Quantum Mechanics by B. K. Agarwal and Hari Prakash (Prentice-Hall, India)
8. Introduction to Quantum Mechanics by C. J. Joachain and B. H. Bransden.

Paper-IV: Course IV

Electronics

UNIT - I

Power Electronics: Rectifier with LC Filter, Electronic regulators, SCR: Basic structure, I-V characteristics and two- transistor model of SCR, SCR controlled half and full wave rectifier circuit and their analysis. UJT. equivalent circuit, I-V characteristics, Saw tooth wave generation. Elements of SMPS.

UNIT - II

Operational Amplifier: IC-741-Block diagram, operation, Characteristics of Op-Amp; inverting and non-inverting inputs: Input offset current and Input offset voltage, differential amplifier, CMRR, Slew rate and power band width, op-amp as an amplifier. Application of Op-amp: summer, integrator and differentiator. Timer: IC-555 -Block diagram, Astable and Monostable operations, application of IC-555 - VCO.

UNIT - III

Boolean Algebra and Gates: Boolean algebra, composite function and their algebraic simplification, De-Morgan's theorem, duality in Boolean algebra, Universality of NAND and NOR gates. SOP and POS forms, Karnaugh map, design of logic circuits, X-OR gate and its applications, half adder and full adder, parallel adder, look ahead carry.

UNIT - IV

Elements of Logic Families: Transistor as a switch, FAN IN , FAN OUT, Noise Immunity, propagation delay, RTL, DTL, TTL logic, Sourcing and Sinking logic, TTL loading and Fan out, ECL logic.

Reference Books:

1. Switch Mode Power Conversion by K. Kit Sum (Marcel Dekker).
2. Power Electronics by P.C. Sen (Tata Mc Graw-Hill)
3. Pulse, Digital and Switching Wave Forms by J. Milman and H. Taub (McGraw-Hill)
4. Op-amp and Linear Integrated Circuits by R.A. Gayakwad (Prentice-Hall India)
5. Integrated Circuits by J. Millman and C.C. Halkias (Tata-McGraw-Hill)
6. Digital Principle and Application by A.P. Malvino and D.P. Leach (McGraw-Hill)
7. Modern Digital Electronics by R.P. Jain (Tata McGraw-Hill)

Semester-II

Paper-I: Course V

Computational Methods and Programming

UNIT - I

Numerical Analysis I: Interpolation: methods of interpolation, least square curve fitting, Methods of equal intervals, unequal intervals, Central Differences. Inverse interpolation: Iteration of successive approximation, exchange of dependent and independent variables and reversion of series. Numerical differentiation: method based on interpolation, finite differences, operator and undetermined coefficients.

UNIT – II

Numerical Analysis II: Numerical integration: Simpson's one-third and one-eighth rule, Euler-Maclaurin formula, Quadrature formulae, Numerical Solution to ordinary differential equation by Euler's method and Runge-Kutta (second and fourth order) method, Newton-Raphson method, Iterative methods.

UNIT - III

C++ keyword: Various data types, implicit conversions, for loop, while and do- while loop, break and continue statements, switch statements, if else, conditional operator, functions with default arguments, function overloading.
++ and – operators, Arrays, Structures, pointers, compound assignment.
Basic concept of OOP: definition of class and object, declaration of classes and objects and simple applications.

UNIT - IV

Programming in C++ for the following: Newton-Raphson Method, Matrix manipulation, Euler's method, Runge-Kutta (second and fourth order) method.

Reference Books:

1. Introductory Methods of Numerical Analysis by S.S. Sastry (Prentice-Hall India)
2. Numerical Methods by E. Balguruswamy (Tata McGraw-Hill)
3. Numerical Recipes: The art of Scientific Computing by W. H. Press, S. A. Teukolsky, W. T. Vetterling, B. P. Flannery (Cambridge University Press)
4. Object Oriented Programming with C++ by E. Balguruswamy (McGraw Hill Education).
5. The C++ Programming Language by Bjarne Stroustrup (Pearson Education India).
6. Computational Method in Physics and Engineering by Wong.

Paper II: Course VI

Statistical Physics

UNIT I

A review of Gibbs ensembles, Partition function for Perfect Gas and ensemble of Harmonic Oscillators, Partition Function for Gases containing Monatomic, Diatomic and Polyatomic Molecules. Conditions for Equilibrium, Entropy of an Ideal Boltzmann gas, Gibb's paradox, Sackur -Tetrode equation.

UNIT II

Grand partition function, Grand potential, FD and BE distribution in Grand Canonical ensemble, Bose - Einstein Condensation, Ideal Fermi - Dirac gas, Fermi temperature, applications of degeneracy to free electrons in metals, Magnetic susceptibility, White dwarfs and Chandrasekhar limit.

UNIT III

Fluctuations: Mean square deviation, Fluctuation in ensembles, Concentration Fluctuation in quantum statistics, one dimensional Random walk: random walk and Brownian motion

UNIT IV

Random processes, Markoff process, Langevin Equation, Correlation functions, Dissipation Theorem, Weiner-Khintchine theorem, Nyquist theorem, Conditional probability, Fokker-Plank Equation.

Reference Books:

1. Fundamentals of Statistical and Thermal Physics by F. Reif (McGraw-Hill)
2. Statistical Mechanics by K. Huang (John Wiley & Sons)
3. Statistical Mechanics by R.K. Pathria (Elsevier)
4. Statistical Mechanics and Properties of Matter by E.S.R. Gopal (Macmillan Ltd., Delhi)
5. Statistical Mechanics by B. K. Agarwal and M. Eisner (Wiley Eastern)

Paper III: Course VII

Electromagnetic Theory and Plasma Physics

UNIT - I

Maxwell Equations: Microscopic and Macroscopic fields, Macroscopic Maxwell equations, Fields **D** and **H**, Dielectric tensor, Principal dielectric axes.

Potential and Gauges: Scalar and vector potentials, Gauge transformation, Lorentz guage and Transverse gauge, Maxwell equations in terms of electromagnetic potentials.

UNIT - II

Propagation of Electromagnetic Waves: Propagation of electromagnetic waves in free space, conducting and non-conducting medium, skin depth, Boundary conditions on EM Fields, Reflection and refraction at a plane interface between dielectrics.

Polarisation of EM Waves: Fresnel's Formula Normal- and anomalous- Dispersion, metallic reflection. EM Wave in bound media: rectangular and circular wave guides, TE, TM and TEM Modes, Cut-off frequency and Wavelength.

UNIT – III

Plasma State: Plasma state of matter, Motion of charge particles in uniform E & B fields, non-uniform fields, drifting motion. electrostatic and magneto static drift ; Time varying E & B fields, Adiabatic invariants, Plasma confinements (Pinch effect, Mirror confinement, Van Allen Belts), Elementary idea of fusion technology. Sun Spots.

UNIT – IV

Hydrodynamics of Plasma: Hydrodynamical description, Equation of magneto hydrodynamics, High frequency plasma oscillations, Short wavelength limit and Debye-screening distance.

Reference Books:

1. Introduction to Electrodynamics by D. J. Griffiths (Prentice - Hall, New Delhi)
2. The Classical theory of Fields by L. D. Landau and E.M. Lifshitz (Elsevier)
3. Classical Electrodynamics by J. D. Jackson (Wiley Eastern)
4. Introduction to Plasma Physics by F.F. Chen (Plenum Press, New York)
5. Plasma Physics by S.N. Sen (Pragati Prakashan)
6. Plasma Physics by A. Bitten Court.

Paper-IV: Course VIII

Atomic and Molecular Physics

UNIT- I

Quantum states of an electron in an atom. Spectrum of Hydrogen and Helium atom, fine structure, Spectra of Alkali atoms: energy level diagrams. Sharp, Principal, Diffuse and fundamental series.

UNIT-II

Hyperfine structure. Width of spectral lines. Spectroscopic terms; LS & JJ couplings. Zeeman, Paschen Back & Stark effect. X-ray spectroscopy. Electron spin resonance, Nuclear magnetic resonance, chemical shift, Spectra of Diatomic Molecules.

UNIT-III

Rotational Spectra (rigid rotator and non rigid rotator model), Vibrational Spectra (harmonic and anharmonic model), Molecular Symmetric Top, Vibrating rotator, Isotopic shift.

UNIT-IV

Raman Spectra (Quantum mechanical and classical approach). Electronic Spectra-vibrational structure of band system, fine structure of the band systems. Intensity distribution in band systems: Frank Condon principle.

Reference Books:

1. Molecular Spectra and Molecular Structure by G. Herzberg (Dover Publication).
2. Fundamentals of Spectroscopy by C.N. Banwell and E.M. McCash (Tata-McGraw-Hill)
3. Introduction to Molecular Spectroscopy by G.M. Barrow (McGraw-Hill)
4. Modern Spectroscopy by M.J. Hollas (Wiley Inter Science)

PRACTICAL

Students will be required to perform at least four experiments from each semester. They will have to maintain record books of experiments done for each course separately.

LIST OF EXPERIMENTS

SEMESTER I: Electronics Laboratory

1. Study of regulator circuits
2. Study of switch mode power supply (SMPS)
3. Study of characteristic of SCR and controlled rectification by SCR.
4. Study of RC coupled amplifier
5. Study of emitter follower
6. Study of phase shift oscillator
7. Study of multivibrator: Use of 555
8. Study of saw tooth wave generation by UJT
9. Study of characteristics of operational amplifier
10. Study of TTL gates
11. Study of combinational logic circuits
12. Study of super heterodyne receiver
13. Study of linear and square wave detector
14. Microwave measurement: Mode analysis and standing wave ratio

SEMESTER II: Optical and General Laboratory

1. Use of constant deviation spectrograph
2. Use of Fabry-Perot interferometer
3. Use of concave grating
4. He-Ne Laser
5. e/m by Zeeman effect
6. EPR of free radicals
7. Programming on PC
8. Velocity of ultrasonic wave
9. Hall effect
10. Magnetic Susceptibility
11. Measurement of dipole moment
12. Use of scintillation counter
13. Determination of Dielectric Constant
14. Double slit/Triple slit/ Four slit Wedge shape

Semester-III

Paper I: Course IX
Quantum Mechanics-II

UNIT- I

Application of three-dimensional Schrodinger equations: Particle in box, spherically symmetric systems: hydrogen atom, harmonic oscillator. Their solutions for quantum numbers, energy levels & degeneracy, and eigen functions

UNIT-II

Approximate methods: Time independent perturbation theory and anharmonic oscillator, Variational method and Helium atom, Time dependant perturbation theory and transition probability (Fermi-Golden Rule), WKB method and alpha decay.

UNIT-III

Relativistic quantum mechanics: Klein-Gordon equation, Plane wave solution and Physical interpretation, Inadequacy of Klein-Gordon equation; Dirac equation, α and β matrices and related algebra, Representation and arbitrariness of α and β, Probabilistic interpretation.

UNIT- IV

Covariance of Dirac equation: Covariant form of Dirac equation, Dirac(γ) matrices, Representation and algebra, Linearly independent set of composite γ- matrices; Infinitesimal and Finite proper Lorentz transformation, Proof of covariance, Plane wave solution and negative energy states; Two component Pauli spin theory, Non relativistic correspondence.

Reference Books:

1. Quantum Mechanics by L.I. Schiff (Tata-McGraw-Hill)
2. Introduction to Quantum Mechanics by D. J. Griffths (Pearson Education)
3. Quantum Mechanics by C. Cohen-Tannoudji, B. Diu and F. Laloe (Wiley VCH)
4. Quantum Chemistry by Ira N. Levine (Pearson Education)
5. Relativistic Quantum Mechanics by James D. Bjorken and Sidney D. Drell (McGraw-Hill)
6. An Introduction to Relativistic Quantum Field Theory by S.S. Schweber (Harper & Row)

Paper II: Course X

Solid State Physics

UNIT- I

Crystal Structure: Ionic, covalent, metallic and hydrogen bonding, space lattice and basis ; Types of lattice, Miller indices, crystal structures of NaCl, CsCl, ZnS, graphite and diamond; Reciprocal lattice and Brillouin Zones; Basic idea of crystal defects and dislocations.

UNIT-II

Band Theory of Solids: Sommerfield model, Density of states, Fermi and mean energies at zero and finite temperatures; Origin of energy bands; Bloch Theorem; Kronig Penny model, Electron dynamics in crystalline lattice; Light binding approximation.

UNIT- III

Thermal Properties: Lattice vibrations of mono and diatomic chains, Quantization of lattice vibration, Phonon; Infrared absorption: Einstein and Debye theories of specific heat; Thermal conductivity; Anharmonicity and Thermal expansion.

UNIT- IV

Optical Properties: Optical reflectance, Kramers-Kronig relations; Conductivity and dielectric function of electron gas; Basic theory of luminescence, phosphorescence, thermoluminescence, electroluminescence and photo-conductivity; Excitons in ionic and molecular crystals, Electron-hole drops (EHD) and colour centres.

Reference Books:

1. Solid state Physics by A. J. Dekkar (McMillan Publishers)
2. Introduction to Solid State Physics by C. Kittel (Wiley Eastern)
3. Elementary Solid State Physics by M. Ali Omar (Pearson Education)
4. Solid State Physics, N. W. Ashcroft and N. D. Mermin, (Harcourt Asia Limited)
5. Principles of the Theory of Solids by J. M. Ziman (Cambridge University Press)
6. Solid State Physics by S. O. Pillai (New Age Publishers)

Paper III: Course XI
Nuclear and Particle Physics

UNIT- I

Nuclear Models: Evidence of Nuclear shell Structure; Nuclear Potential and sequence of energy levels of nucleons, spin orbit potential and explanation of magic numbers, Collective model.

UNIT-II

Nuclear Reactions: Cross section; partial wave analysis, optical theorem and shadow scattering, Compound nucleus hypothesis, Breit-Wigner one level formula, Direct Reactions; pickup and stripping reactions.

UNIT-III

Beta Decay: Pauli's neutrino hypothesis, Fermi theory of (β)-decay, Fermi-Kurie Plot and comparative half lives, selection rules and classification of transitions, Parity non-conservation and Wu's experiment.

Nuclear forces: Deuteron problem, low energy (n-p) and (p-p) scattering, scattering length, effective range theory, Spin-dependence of (n-p) interaction

UNIT-IV

Elementary Particles: Fundamental interactions, Classification of elementary particles, symmetry and conservation laws, Elementary idea of CP and CPT invariance, Classification of Hadrons, Quantum numbers in strong interaction, Gell-Mann Nishijima formula, Lie algebra, SU(2)-SU(3) multiplets, Quark model of Hadrons.

Reference Books:

1. Nuclear Physics by Irvin Kaplan (Addison-Wesley)
2. Concepts of Nuclear Physics by B.L. Choen (Tata McGraw Hill)
3. Atomic and Nuclear Physics Vol II by S.N.Ghoshal (S. Chand and Co. Ltd.)
4. Nuclear Physics (Theory and Experiment) by R.R. Roy and B.P. Nigam (Wiley Eastern)
5. Nuclear Physics Vol I by Y M Shirikov and N P Yudin, (Mir Publisher, Moscow 1982).
6. Nuclear and Particle Physics by E.B. Paul (North Holland Publishing)
7. Facts and Mysteries in Elementary Particle Physics by M. Veltman (World Scientific)

Paper - IV: Course XII

Special-I

Course XII (a): Electronics-I

UNIT- I

Analog and Combinational Logic Circuits: Analog computation, time and amplitude scaling, Analog to digital and digital to analog converter. Comparator, parity generator and checking, code conversion. Binary to gray and gray to binary. Logic design with MSI coder and decoder, multiplexer and demultiplexer circuits.

UNIT-II

Sequential Circuits: Basic definition, finite state model SR, JK, T, D, Edge triggered flip flop, race condition and master slave flip flop, characteristic table and characteristic equation, sequential logic design state table, state diagram, state equation.

UNIT-III

Registers and Counters: Register, shift register, universal shift register, Ring counter, twisted or Johnson counter, synchronous and asynchronours counters, UP/DOWN and scale of 2n counter

UNIT-IV

Microprocessor: Basic idea of magnetic memory, Ferrite core memory, semiconductor memory viz. RAM, ROM, PROM, EPROM, EEPROM. Introduction to intel 8085 microprocessor architecture, instruction and timings assembly language programming, stack and subroutine, code conversion.

Reference Books:

1. Digital Systems by J. Ronald Tocci
2. Digital Principles and applications by Malvino and Leach
3. Microprocessor by Goenkar

Paper IV: Course XII (b)

Condensed Matter Physics

UNIT- I

Magnetic Properties: Magnetic ions, ground and excited states and multiplet separation; Paramagnetism of non-interacting magnetism ions and its application to transition and rare-earth ions.

Ferromagnetism: Molecular field theory, Heisenberg explanation of internal magnetic field, Landau theory of domain, Spin-wave theory, Magnon excitation and Bloch $T^{3/2}$ law, Antiferromagnetism, ferrimagnetism: Neel's two sub-lattice model.

UNIT-II

Ferroelectricity: Basic features of piezo-, Pyro- and ferrro electric materials; Order-disorder and displacive type ferro electric materials; Occurance of ferroelectricity due to polerisation catastrophe and lattice modes; Devonshire theory of ferroelectric phase transition.

UNIT- III

Transport Properties: Linearised Boltzmann transport equation, Electrical conductivity, Relaxation time, Impurity scattering, Ideal resistance, Carrier mobility, General transport coefficient; Thermal conductivity, Thermoelectric effects, Lattice conduction, Phonon drag, Hall effect and magnetoresistance.

UNIT-IV

Liquid crystals: Definition, Classification, Characteristic features; Thermotropic and Lyotropic Liquid Crystals, FLCs, Basic principle of LCDs.

Polymers: Structure, properties and methods of Polymerization, Degradation of Polymers, Viscoelastic state, Glass transition temperature.

Nano-materials: Definition, Types and characteristic features; Quantum size effect; density of states, Synthesis and characterization; Nanocomposites, Application in devices.

Reference Books:

1. Principle of theory of solid by J.M. Ziman (Cambridge University Press, London)
2. Theoretical Solid State Physics Vol.1 and Vol.11 by W. Jones and N.H. March (John Wiley and Sons, London)
3. Quantum Theory of Solid by C. Kittel (John Wiley and Sons, London)
4. Quantum Theory of Solids by R.E. Peirls (Oxfbrd University Press, London)
5. Nanotechnology: Principles and Practices, S.K. Kulkarni, Capital Pub. Co., New Delhi, 2006
6. Liquid Crystals by S. Chandrashekhar, (Cambridge Univ. Press, London)
7. An Introduction to Polymer Physics by I. I. Perepechko (Mir Publishers)

Paper IV:
Course XII (c)
Nuclear and Particle Physics-I

UNIT-I

Fission Reactor: Neutron multiplication factor, Fermi's four factor formula, resonance escape probability and thermal utilization factor, Basic reactor theory and reactor materials, Basic idea of breeding and fast neutron reactors.

Fusion Reactor: Fusion reaction, reaction rate and critical temperature, Lawson's criteria; magnetic confinement techniques, Tokamak and magnetic mirror devices.

UNIT-II

Nuclear Shell Model: Common potential V(r) in spherical shell model, wave function, quantum numbers. Two-particle outside a closed core, residual interaction and configuration mixing, effective interaction and operators. Transformation to center-of mass and relative coordinates, Moshinsky transformation brackets, energy level calculations.

UNIT-III

Spectra of closed shell nuclei, lp-lh excitations, three or more particles outside a closed core, coefficient of fractional percentage. Shell model Monte Carlo methods. Collective models: Nuclear vibrations, isoscalar vibrations, sum rule in vibration model, Giant resonances. Collective model of Bohr and Mottelson, back bending, high spin states, superdeformed and hyperdeformed shapes.

UNIT-IV

Particle states in nonspherical nuclei-Nilsson's model, coupling of particle states and collective motion in unified model.

Mean Field models: Nuclear mean field, Hartree-Fock theory, Hartree-fock Bogolieubov, Pairing plus quadrupole interactions.

Reference Books:

1. *Atomic and Nuclear Physics Vol II* by S. N. Ghoshal (S. Chand and Co. Ltd., New Delhi).
2. *Theory of Nuclear structure* by M. K. Pal (East West Press, New Delhi).
3. *Nuclear Physics (Theory and Experiment)* by R. R. Roy and B. P. Nigam (Wiley Eastern Ltd., New Delhi).
4. *Nuclear Physics Vol I* by Y. M. Shirikov and N. P. Yudin, (Mir Publisher, Moscow).
5. *Nuclear and Particle Physics* by F. B. Paul (North Holland Pub. Co., Amsterdam).
6. *Quams and Leptons* by F. Halzen and A. D. Martin (John Wiley and sons).

Paper IV:
Course XII (d)
Spectroscopy-I

UNIT-I

Vector model for two and three valence electrons, Lande interval rule, Inverted terms and Hund's rule, Lande 'g' factor, spectral terms by magnetic quantum numbers.
Breadth of spectral lines, Intensity of spectral lines, Nuclear spin, Isotope effect and Hyperfine structure, Lamb shift.

UNIT-II

Normal coordinate analysis: classical and quantum mechanical treatment of normal modes of vibration, vibrational selection rules, Fermi resonance, Vibrational and electronic spectra of benzene.

UNIT-III

Rotational spectra of linear molecules like CO_2 and HCN, Rotational Raman spectra, Microwave spectra of ammonia.
Rotational structure of vibrational bands, Parallel and perpendicular bands of linear molecules like CO_2 and HCN and symmetric top molecules like NH_3, Coriolis interaction.

UNIT-IV

Classification of electronic states, interaction of vibration and electronic motion, Renner-Teller effect, Coupling of rotation with vibration and electronic motion for linear molecules.
Allowed and forbidden electronic transitions, Isotope effect, Teller and Redlich product rule.

Reference Books:

1. *Atomic spectra* by H. E. White
2. *Molecular spectra and Molecular structure Vol. I, II & III* by G. Herzberg.
3. *Atomic and Molecular Spectra: Laser* by Rajkumar.

Paper IV:
Course XII (e):
Quantum and Non Linear Optics-I

UNIT I

Nonlinear Interaction of Light with Mater: Nonlinear Polarization, Classical Model of an Anharmonic Oscillator, Nonlinear Susceptibilities and Miller's Rule. Simple explanation of Kerr Effect: elementary explanation.

UNIT II

Harmonic Generation: Elementary Discussion of Harmonic Generation in Dielectric and Phase Matching. Elementary discussion of Self-Focussing and Self-Steepening. Self Induced Transparency.

UNIT III

Optical quantum fields: Quantization of a single-mode field, quantum fluctuations of a single-mode field, quadrature operators for a single-mode field, multimode fields, thermal fields, vacuum fluctuations and the zero-point energy, Coherent States of Radiation. Coherent State as wave packet, Expansion of States and Operators in Terms of Coherent States. The quantum phase and its limitation.

UNIT IV

Optical quantum states in phase space: Density Operator of Radiation and phase-space probability distributions (Sudarshan-Glauber Representation, Wigner- and Q-function), characteristic functions, Density Operators of Coherent and Chaotic Radiation. Polarization, Annihilation and Creation Operators for Modes with General Polarization, and quantum Stokes parameters.

Reference Books:

1. *Nonlinear Optics* by R. W. Boyd.
2. *Nonlinear Fiber Optics* by Govind P. Agarwal(Elesevier)
3. *Optical Coherence and Quantum Optics* by L. Mandel and E. Wolf.
4. *Quantum Optics* by Girish S Agarwal
5. *Measuring the quantum state of light* by U. Leonhardt.
6. *Introductory Quantum Optics* by C. C. Gerry and P. L. Knight.

Semester-IV
Paper-I: Course XIII
Electrodynamics

UNIT-I

Four Dimensional Formulation: Postulates of special theory of relativity, Minkowski Space, Lorentz transformation, Intervals, Light cone, Proper time, Four Vectors, Doppler Effect (Transverse and Longitudinal) and Aberration.

UNIT- II

Relativistic Mechanics: Langrangian formulation, Principle of least action, Four-momentum vector of a free particle, Hamiltonian, Equation of motion.
Electromagnetic Field Equations: Four Potential Four dimensional formulation: Action of a charged particle, Generalised Momentum and Hamiltonian, Equation of motion, Electromagnetic field tensor, Transformation properties of electric and magnetic fields.

UNIT-III

Invariants of Electromagnetic field, Four dimensional formulation of first and second pair of Maxwell equations, Equation of continuity.
The Field of Moving Charges: Retarded potentials, Lienard-Wiechert potentials, Field due to system of charges at large distances,

UNIT-IV

Dipole radiation, Quadrupole and magnetic dipole radiation; Field at near distances, Radiation from a rapidly moving charge, Synchrotron radiation (magnetic bremsstrahlung), Radiation damping.

Reference Books:

1. *The Classical theory of Fields* by L.D. Landau and E.M. Lifshitz (Elsevier)
2. *Classical Electrodynamics* by J.D. Jackson (Wiley Eastern)
3. *Classical Electricity and Magnetism* by W. Panofsky and M. Phillips (Dover Publication)
4. *Quantum Electrodynamics* by F. Mandl & G. Shaw (John Wiley and Sons)
5. *A First Book of Quantum Field Theory* by A. Lahiri & P. B. Pal (Narosa, New Delhi)

Paper II: Course XIV
Modern Optics

UNIT-I

Nonlinear Optics: Non-linear polarizability tensors. Coupled amplitude equation; Manely-Rowe relationship; Parametric amplification and oscillation, Phase matching, Second harmonic generation.

UNIT-II

Quantum Optics: Spatial and temporal coherence, classical and quantum coherence function; Glauber's theory of optical coherence, Over completeness of coherent states and its properties; Quasi phase distribution function.

UNIT-III

Fibre Optics: Types of fibres, Single mode and multi-mode fibres; dispersion and loss in fibre; Principles of optical communication, Optical elements.

UNIT-IV

Holography: Basic principle of holography, Method of hologram Recording and Reconstruction; Basic theory of plane hologram; practical consideration of holography and its application.

Reference Books:

1. *Optical Coherence and Quantum Optics* by L. Mandel and E. Wolf (Cambridge University Press, Cambridge)
2. *Quantum Optics* by M. O. Scully and M. Suhail Zubairy (Cambridge University Press, Cambridge)
3. *Physics of Non-Linear Optics* by Guang S. He and Song H. Liu (World Scientific Press, Singapore)
4. *Laser and holographic Data processing* by N. G. Bosov (Mir Publisher, Moscow)
5. *Nonlinear Optics* by R. W. Boyd.
6. *Nonlinear Fiber Optics* by Govind P. Agarwal (Elesevier)
7. *Quantum Optics* by Girish S. Agarwal

Paper III: Elective Papers: Course XV (1/2/3/4/5/6)

Paper-3

Course XV-1

Nano Science and Sensor Technology

UNIT-I

Nanomaterials Science: Nanomaterials -Definition, Properties of Nanomaterials, Nanomaterials Scale, Nanoscale in One Dimension: Thin Films, Layer and Surfaces, Nanoscale in Two Dimension: Carbon Nanotubes Inorganic Nanotubes, Nano wires, Biopolymers, Nanoscale in Three Dimensions: Nanoparticles, Fullerenes (C-60), Quantum Dots, Application of Nanomaterials

.UNIT-II

Graphene: Discovery, Synthesis and Structural Characterization through TEM, Elementary Concept of its applications.

Quantum Wells, Wires and Dots: Preparation of Quantum Nanostructures, Size Effects, Conduction Electrons and Dimensionality, Properties dependent on Density of States

UNIT-III

Nanoparticles-Synthesis and Properties: Method of Synthesis: RF Plasma Chemical Methods, RF spurting method, Sol-gel Method, Physical Vapor Deposition, Chemical Vapor Deposition and Pulsed Laser Method

UNIT-IV

Physics of Sensor-Technology: Physical sensor, Chemical sensor, MOS gas sensor, MOS capacitor; C-V characteristics, Thin/thick films Sensor; sensing mechanism of gas sensors, Fabrication of MOS, Thick/Thin film gas sensors

Reference Books:

1. Introduction to Nanotechnology: Poole and Owners
2. Quantum Dots: Jacak, Hawrylak and Wojs
3. Handbook of Nanostructured Materials and Nanotechnology: Nalva (editor)
4. Nano Technology/ Principles and Practices: S.K. Kulkarni
5. Carbon Nanotubes: Silvana Fiorito
6. Nanotechlongy: Richard Booker and Earl Boysen.
7. Functional Thin Films and Nanostructures for Sensors by Anis, Zribi, Jeffrey.
8. Gas Sensors by Xiao, Tun, Qiu.

Paper-3

Course XV-2
Atmospheric Physics

UNIT-I

Lower Atmosphere:

Its Composition, constituent, dynamics; Diurnal and seasonal variations of temperature, pressure and humidity; Cloud methodology, cloud microphysics.

UNIT-II

Aerosols:

Aerosol Optical Depth, Effects of Aerosols in Indo-Gangetic basin.

Synoptic systems in different seasons:

Winter, western disturbances, Fog, cold wave; Summer; thunderstorm, dust storm, heat wave, cyclones; Monsoon: onset, withdrwal.

UNIT-III

Ozone:

Temporal & spatial variation of ozone, Ozone hole and its impact on climate.

Ionosphere:

Its structure & formation: Ionospheric irregularities: Sporadic E and Spread-F irregularities and their distribution; Ionospheric Scintillations, Aurora Borealis: morphology of auroral region, distribution of auroral emissions.

UNIT-IV

Magnetosphere:

Its structure, Bow shock, Magnetopause, Magnetopause current, Stand-off distance of stagnation point, Microstructure of magnetopause; Shape of magnetospheric cavity, Magnetotail; Planetary magnetospheres. VLF waves, Whistlers & its applications.

Reference Books:

1. Atmospheric Physics: J. V. Iribrne & H. R. Cho, D. Reidel, Pub. Company, Holland.
2. The Physics of Atmosphere: John Houghton, Cambridge University Press, U.K.

Paper 3
Course XV-3
Satellite Communication and Remote Sensing

UNIT-I

Principle of Satellite Communication: General and Technical characteristics, Active and Passive satellites, Modem and Codec.

Communication Satellite Link Design: General link design equation, Atmospheric and Ionospheric effect on link design, Earth station parameters.

UNIT-II

Satellite Analog Communication: Baseband analog signal, FDM techniques, S/N and C/N ratio in FM in satellite link.

Digital Satellite Transmission: Advantages, Elements of digital satellite communication, Digital base band signal, Digital modulation Techniques, Digital link Design, TDM, TDMA, some applications of satellite communications.

UNIT-III

Concept and Foundations of Remote Sensing: Electromagnetic Radiation (EMR), interaction of EMR with atmosphere and earth surface, Application area of Remote Sensing.

Characteristics of Remote Sensing Platform & Sensors: Ground, Air & Space platforms, Return Beam Vidicon, Multi-spectral Scanner, Brief idea of Digital Image Processing.

UNIT-IV

Microwave Remote Sensing Tools: Radar Remote Sensing, Microwave Sensing, LIDAR (Single and double ended system), (Radar & Lidar): Data Characteristics.

Earth Resource Satellites: Brief description of Landsat and Indian remote sensing satellites (IRS) Satellites.

Reference Books:

1. Satellite Communication: D.C. Agrawal and A. K. Maini.
2. Satellite Communication: T. Pratt and C. W. Bostiern.
3. Satellite Communication System: M. Richharia.
4. Introduction of Remote Sensing: J. B. Campbell.
5. Manual of Remote Sensing Vol I & II: (Ed. R.N. Colwell).

Paper 3
Course XV-4
Physics of Electronic Materials and Devices

UNIT-I

Physical Mechanisms-I: Crystal structures of Electronic materials (Elemental, III-IV and VI semiconductors), Energy Band consideration in solids in relation to semiconductors, Direct and Indirect bands in semiconductor, Electron/Hole concentration and Fermi energy in intrinsic/Extrinsic semiconductor continuity equation

UNIT-II

Physical Mechanisms-II: Carrier mobility in semiconductors, Electron and Hole conductivity in semiconductors, Shallow impurities in semiconductors (Ionization Energies), Deep Impurity states in semiconductors, Carrier Trapping and recombination/generation in semiconductors, Schokley Read theory of recombination, Switching in Electronic Devices.

UNIT-III

Devices-I: Metal/Semiconductor Junction or (Abrupt P-N Junction). Current-voltage characteristics, C-V measurements, Estimation of Barrier Height and carrier concentration from C-V characteristics. Surface/Interface States, Role of interface States in Junction Diodes.Field Effect devices, C-V characteristic of MIS diodes (Frequency dependence), Estimation of Interface Trapped charges by capacitance conductance, method CCD (Charge Coupled Devices), MESFET, MOSFET.

UNIT-IV

Devices-II: (i) Microwave Devices: Tunnel Diode, MIS Tunnel Diode, MIS Switch Diode, MIM Tunnel diode, IMPATT Diode, QWITT Diode, TRAPATT Diode.

(ii) Photonic Devices: LED and LASER, Photo detectors, Solar-cells.

Reference Books:

1. Physics of Semiconductor Devices: S. M. Sze.
2. Semiconductor Devices Basic Principles: Jaspreet Singh.
3. Physics and Technology of Semiconductor Devices: A. S. Grove.
4. Metal/Semiconductor Schottky Barrier Junction and their Applications: B. L. Sharma.
5. Metal/Semiconductor Contact: Rhoderick.

Paper-3
Course XV-5.
Science and Technology of Solar, Hydrogen and other Renewable Energies

UNIT-I

Solar Energy: Fundamental and Material Aspects:
Fundamentals of photovoltaic Energy Conversion Physics and Material Properties, Basic to Photovoltaic
Energy Conversion: Optical properties of Solids. Direct and indirect transition semiconductors, interrelationship between absorption coefficients and band gap recombination of carriers.

UNIT-II

Solar Energy: Different Types of Solar Cells:
Types of Solar Cells, p-n junction solar cell, Transport Equation, Current Density, Open circuit voltage and short circuit current, Brief description of single crystal silicon and organic and Polymer Solar Cells, Elementary Ideas of Advanced Solar Cells e.g. Tandem Solar cells, Solid Liquid Junction Solar Cells, Nature of Semiconductor, Principles of Photo-electrochemical Solar Cells.

UNIT-III

Hydrogen Energy: Fundamentals, Production and Storage:
Relevance in relation to depletion of fossil fuels and environmental considerations. Solar Hydrogen through Photoelectrolysis, Physics of material characteristics for production of Solar Hydrogen. Brief discussion of various storage processes, special features of solid hydrogen storage materials, Structural and electronic characteristics of storage materials. New Storage Modes.

UNIT-IV

Hydrogen Energy: Safety and Utilization:
Various factors relevant to safety, use of Hydrogen as Fuel, Use in Vehicular transport, Hydrogen for Electricity Generation, Energy storage devices, rechargeable batteries, Li Ion Batteries, Fuel Cells, Various type of Fuel Cells, Applications of Fuel Cell, Elementary concepts of other Hydrogen- Based devices such as Hydride Batteries.

Reference Books:
1. Solar Cell Devices-Physics: Fonash
2. Fundamentals of Solar Cells Photovoltaic Solar Energy: Fahrenbruch & Bube
3. Phoptoelectrochemical Solar Cells: Chandra
4. Hydrogen as an Energy Carrier Technologies Systems Economy: Winter & Nitch (Eds.)
5. Hydrogen as a Future Engery Carrier: Andreas Zuttel, Andreas Borgschulte and Louis Schlapbach

Paper-3
Course XV-6
Quantum Information

UNIT I

Basic tools for quantum information: Hilbert space, linear and Hermitian operators, eigenvalue equations (bra-ket notation), tensor products, partial trace, commutator and anti-commutator, polar and singular value decomposition.

Quantum bits, Bloch sphere, Pauli matrices, density operators: pure and mixed states, reduced density operator.

Entangled states, Schmidt decomposition, and dynamics of density operator (elementary).

UNIT II

Entropy and Quantum Information-I: Shannon entropy. Basic properties of entropy: binary entropy, relative entropy, and conditional entropy. Mutual information. Entropic quantum uncertainty relation.

UNIT III

Entropy and Quantum Information-II: von Neumann entropy: relative entropy and Klein's inequality, Continuity of the entropy and Fannes' inequality, basic properties of entropy: concept of subadditivity and concavity, measurements and entropy.

UNIT IV

Elementary theorems of quantum information and applications: Projective and generalised measurements, Quantum dynamics: Super operators, completely positive maps, and Kraus representations. No-cloning theorem, quantum copying. Open quantum systems: Lindblad's equation. Physical realisations of qubits. Quantum key distribution and teleportation (elementary discussion).

Reference Books:

1. *Quantum computation and quantum information* by M. A. Nielsen and I. L. Chuang (Cambridge University Press, Cambridge).
2. *Quantum information* by S. M. Barnett (Oxford University Press, Oxford).
3. *Elements of information theory* by T. M. Cover and J. A. Thomas (Wiley, New York).
4. *Quantum theory: concepts and methods* by A. Peres (Academic, Dordrecht).
5. *Introduction to quantum information science* by V. Vedral (Oxford University Press, Oxford).

Paper 4:

Special Papers

Course XVI (a): Electronics-II

UNIT-I

Communication Theory: Types of Noise and its Spectrum, S/N ratio in analog communication systems, information content of message, rate of information-transmission in discrete communication channels, channel capacity, Shanon- Hartly Theorem and its applications.

UNIT-II

Analog Modulaion: Sampling of analog signals, sampling theorem, Types of modulation and generation: PAM, PPM, and PWM; Quantization of Analog signals: Uniform and Non-uniform.

UNIT-III

Digital Modulation: Pule code modulation, Binary coding and PCM bandwidth DPCM, DM and ADM, Base Band data transmission, inter-symbol interference, RRC filters. Passband data transmission. ASK, PSK and FSK system, transmission and detection of binary system.

UNIT-IV

Microwaves and Antenna: Microwave generation, Reflex Klystron Oscillator, Transfer Electron Effect :Gun Diode, Tunnel diode, IMPATT. Current and voltage distribution in antenna, Short electric dipole, linear and ground antenna, field -distribution around vertical antenna, antenna arrays.

Reference Books:

1. Communication Systems by B. P. Lathi (Oxford University Press)
2. Principles of CommunicationSystem by Taub& Schilling (Mc Graw Hill)
3.Microwave by K. C. Gupta (Wiley Eastern Limited)
4. Antennas and Wave Propagation by J.D. Kraus (Tata Mc Graw Hill Publishing Company Limited -2010
5. Communication System by Haykin

Paper 4:

Special Papers

Course XVI (b): Condensed Matter Physics-II

UNIT- I

Superconductivity-I: Basic features (Zero resistance, Meissner effect, Penetration depth, Critical field, Heat capacity and isotopic shift) of superconductors, Soft and hard superconductors; Thermodynamics of superconducting transitions, London equation, Coherent length; Elements of BCS theory. Applications of superconductors: Particle tunneling and Josephson effect.

UNIT- II

Superconductivity-II: Electron-electron interaction and screening, electron-phonon-electron interaction and Cooper pairs, Salient features of BCS theory, Superconducting ground state, Quasi particle and energy gap, High T_c superconductors; Charge transfer model of Cuprates, Defect ordering.

UNIT- III

Magnetic Resonance: General theory of magnetic resonance and Bloch equations, Electron paramagnetic resonance (EPR): Method of observation, Structure of resonance lines and their uses; Nuclear magnetic resonance (NMR): Salient theory and method of observation, Structure of resonance lines and their uses.

UNIT-IV

Mossbauer Effect: Difficulties in observing resonance flourescence of nuclear system, Recoil energy, Natural and dipole broadenings, Classical and quantum theories of Mossbauer effect, experimental method and principal uses of Mossbauer effect.

Reference Books:

1. Principle of theory of solid by J. M. Ziman (Cambridge University Press, London)
2. Theoretical Solid State Physics Vol. I and Vol. II by W. Jones and N. H. March (John Wiley and Sons, London)
3. Quantum Theory of Solid by C. Kittel (John Wiley and Sons, London)
4. Quantum Theory of Solids by R. E. Peirls (Oxford University Press, London)
5. Mossbauer Effect and its Application by V. G. Bhinde
6. Principles of Magnetic Resonance by C. P. Slichter (Horper and Row, NewYork)

Paper 4:
Special Papers
Course XVI (c): Nuclear and Particle Physics-II

UNIT-I

Symmetries and conservation laws, Noether theorem, Parity, Charge Conjugation and Time Reversal, CPT theorem, G-Parity, SU (2) of isospin, SU (3) and the quark model, meson and baryon spectra.

UNIT-II

Elementary particles as fields, Recapitulation of the quantization of free, scalar and electromagnetic fields. Dirac equation, helicity and chirality, quantization of Dirac fields.

UNIT-III

Interaction Hamoltonian in normal form, chronological products, Wicks theorem, S-matix formulation, Feyman digrams, propagators, Feynman rules, Compton scattering

UNIT-IV

Particle accelerators, fixed targets and colliding beam experiments, basic ideas of particle detection, discovery of J/Ψ.

Reference Books:

1. *Atomic and Nuclear Physics Vol II* by S. N. Ghoshal (S. Chand and Co. Ltd., New Delhi).
2. *Theory of Nuclear structure* by M. K. Pal (East West Press, New Delhi).
3. *Nuclear Physics (Theory and Experiment)* by R. R. Roy and B. P. Nigam (Wiley – Eastern Ltd., New Delhi).
4. *Nuclear Physics Vol I* by Y. M. Shirikov and N. P. Yudin, (Mir Publisher, Moscow).
5. *Nuclear and Particle Physics* by E. B. Paul (North Holland Pub. Co., Amsterdam).
6. *Quans and Leptons* by F. Halzen and A. D. Martin (John Wiley and sons).

Paper 4:

Special Papers
Course XVI (d): Spectroscopy-II

UNIT - I

Laser Physics: Rate equations for three and four level systems. Resonant modes of optical cavities, Mode size and cavity stability. Q factor and resonance line width, Q switching, Techniques of Q switching. Pockel's effect and mode locking.

UNIT - II

Laser Systems: Pulsed crystal lasers. Rare earth ion lasers, Actinide ions and Transition metal ion lasers, Effects of crystal imperfections on laser behaviour, Ga-As injection laser, Tunable dye lasers and colour centre lasers.

UNIT - III

.Laser Spectoscopy: Resonance Raman Spectorscopy. Laser investigations in atmospheric pollution monitoring and Picosecond spectroscopy.

UNIT - IV

Holography: Description of holography. Recording of plane and volume holograms, Holographic interferometry. Applications of holography.
Raman and Brillouin Scattering

Reference Books:

1. Atomic and Laser spectroscopy: Alan Corney
2. Lasers vol I and vol II: Edited by A. K. Levine
3. Principles of Holography: Howard M. Smith
4. Laser Applications: Monte Ross
5. Laser Spectroscopy: Edited by J. L. Hall
6. Lasers and Non-linear optics: B. B. Laud

Paper 4:
Special Papers
Course XVI (e): Quantum and Non-Linear Optics-II

UNIT I

Resonant Interaction of Atoms with Radiation-I: Homogeneous and Inhomogeneous Broadenings. Semi-classical Theory of Interactions of Two-Level Atoms with Radiation: Rotating Wave Approximation and Description by a Pseudo-spin Vector. Optical Bloch Equations: Comparison of Classical and Semi-classical Descriptions.

UNIT II

Resonant Interaction of Atoms with Radiation-II: Two-Level Atomic systems, Atomic Spin Operators and States: their properties. Rotations in Atomic Spin Space and Elementary Ideas about Berry's Phase. Dicke's Collective Atom Operators and States, Degeneracy of Dicke States of an Assembly of Atoms.

UNIT III

Hanbury-Brown and Twiss Experiment, Photon counting distribution, Photon: bunching and antibunching (antibunching in Fock state), Schwartz inequalities and nonclassicality in optical fields: squeezed states.

UNIT IV

Quantum theory of beam splitters (linear and nonlinear), Mach-Zehnder interferometer and its use in phase estimation, quantum interferometry with a single photon, and with coherent states of light.

Reference Books:

1. *Optical Resonance and Two-Level Atom* by L. Allen and J. H. Eberly.
2. *Optical Coherence and Quantum Optics* by L. Mandel and E. Wolf (Cambridge University Press, Cambridge).
3. *Quantum Optics* by Girish S Agarwal
4. *Measuring the quantum state of light* by U. Leonhardt.
5. *Introductory Quantum Optics* by C. C. Gerry and P. L. Knight.

PRACTICALS

Candidates will be required to perform at least four experiments in each semester from special paper.

List of Experiments

(a) ELECTRONICS-I

Analog Electronics:

1. Linear characteristics of Operational amplifier
2. Non-linear characteristics of Operational amplifier
3. Active filters using Operational amplifier
4. IC 555 Timer in different modes
5. Phase Locked Loops using IC 565 PLL
6. Sample and Hold circuit
7. Pulse amplitude modulation and demodulation
8. PAM, PPM, PWM modulation and demodulation

(a) ELECTRONICS-II

Digital Electronics:

1. Combinational circuits
2. Sequential circuits
3. Characteristics of TTL logic
4. Multiplexer and Demultiplexer circuits
5. Semiconductor memory using IC 7489 RAM
6. D / A and A / D converters
7. Encoder and Decoder
8. Microprocessor 8085 - I
9. Microprocessor 8085 – II

(b) CONDENSED MATTER PHYSICS-I

1. X-ray powder diffraction
2. X-Rays: Lauve photograph
3. X-Rays: rotation photograph
3. Experiment on lattice dynamics
4. Energy band gap by four probe technique
5. Dielectric constant of BaTiO3 and Curie temperature
6. Ionic conductivity.

(b) CONDENSED MATTER PHYSICS-II

1. Thermoelectric power
2. E. P. R.
3. Magnetic susceptibility
4. Electro-Luminescence
5. B.H. curve (Hysteresis loss) by C.R.O
6. Hall effect
7. Magnetoresistance coefficient measurement
8. Superconducting transition and critical current density measurement.

(c) NUCLEAR & PARTICLE PHYSICS-I

1. Gamma - Ray Spectroscopy Using NaI (Tl) detector
2. Alpha Sepctroscopy with Surface Barrier Detector
3. Determination of the range and energy of alpha particles using spark counter
4. Study of gamma ray absorption process
5. X-Ray Fluorescence
6. Neutron Activation Analysis Measurement of the Thermal Neutron Flux
7. To Study the Solid State Nuclear Track Detector

(c) NUCLEAR & PARTICLE PHYSICS –II

1. Fission Fragment Energy Loss Measurements from Cf252
2. Gamma - Gamma Coicidence studies
3. Compton Scattering: Energy Determination
4. Compton Scattering: Cross-Section Determination
5. Determination of energy of mu-mesons in pi-decay using Nuclear Emulsion Technique
6. Identification of particles by visual range in Nuclear Emulsion
7. Study of Rutherford Scattering

(d) SPECTROSCOPY and LASERS-I

Spectroscopy:

1. Verification of Cauchy's and Hartmann dispersion formula
2. Determination of the wavelength of Zn triplets
3. Dissociation energy of Iodine by absorption spectra in visible region
4. Rotational and Vibrational analysis of 3883 Å band system of CN molecule
5. Analysis of 2600 Å vibronic system of benzene
6. Study of the great Ca triads

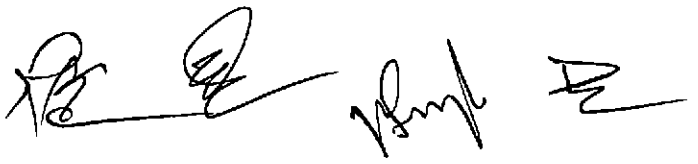
(d) SPECTROSCOPY and LASERS-II

Lasers:

1. Determination of wavelength of laser by grating (transmission/reflection)
2. Power distribution within the laser beam
3. Spatial coherence with Young's double slits
4. Spot size and divergence of a laser beam
5. Raman spectrum of CCl4
6. Study of speckle phenomenon

(e) QUANTUM & NONLINEAR OPTICS-II

1. **Pockel's Effect**
2. **Faraday Rotation**
3. **Fiber Optics**



4. **Solid State Laser**
5. **Thermal expansion**
6. **Michelson Interferometer- Wavelength and separation of wavelengths**
7. **Michelson Interferometer-Thickness of mica sheet**

(e) QUANTUM & NONLINEAR OPTICS-II

1. **Magnetostriction**
2. **Spatial Filtering**
3. **Fiber Optics**
4. **Solid State Laser**
5. **NdYAG Laser: Second Harmonic Generation, phase matching**
6. **Raman-Nath Scattering**
7. **Diffraction by glass tube: refractive index**
8. **Michelson Interferometer-Thickness of sheet**
9. **F. P. Etalon-using Michelson set up**

B. Sc. I

PAPER I - MECHANICS AND WAVE MOTION

UNIT-I

Inertial reference frame, Newton's laws of motion, Conservative and Non -conservative forces, Conservation of energy, linear momentum and angular momentum, Collision in one and two dimensions, cross section.

UNIT -II

Rotational energy and rotational inertia for simple bodies, the combined translation and rotational and motion of a rigid body on horizontal and inclined planes, Simple treatment of the motions of a top. Relations between elastic constants, bending of beams and torsion of cylinder.

UNIT - III

Central forces, Two particle central force problem, reduced mass, relative and centre of mass motion, Law of gravitation. Kepler's laws, motions of planets and satellites, geo-stationary satellites.

UNIT IV

Simple harmonic motion, differential equation of S. H. M. and its solution, uses of complex notation, damped and forced vibrations, composition of simple harmonic motion.

Differential equation of wave motion, plane progressive waves in fluid media, reflection of waves, phase change on reflection, superposition, stationary waves, pressure and energy distribution, phase and group velocity.

Text and Reference Books

1. EM Purcell, Ed: "Berkeley Physics Course, Vol. 1, Mechanics" (McGraw-Hill).
2. "The Feymman Lectures in Physics", Vol. I (BI Publications, Bombay, Delhi, Calcutta, Madras).
3. J.C. Upadhyay: 'Mechanics'.
4. D.S, Mathur "Mechanics".

PAPER II- KINETIC THEORY AND THERMODYNAMICS

UNIT-I

Ideal Gas: Kinetic model. Deduction of Boyle's law, interpretation of temperature, Gas law and Avagadaro hypothesis, estimation of r.m.s. speeds of molecules. Equipartition of energy, specific heat of monatomic gas. extension to di-and triatomic gases, Behaviour at low temperatures. Adiabatic expansion of an ideal gas.

Real Gas: Vander Waals gas. equation of state, nature of Vander Waals forces, comparison with experimental P-V curves. The critical constants, gas and vapour. Joule expansion of ideal gas, and of a Vander Waals gas. Joule coefficient, estimates of J-T cooling.

UNIT -II

Liquefaction of gases: Boyle temperature and inversion temperature. Liquefaction of hydrogen and helium gas. Refrigeration cycles, coefficient of performance.

Transport phenomena in gases: Molecular collisions, mean free path and collision cross sections. Estimates of molecular diameter and mean free path. Transport of mass, momentum and energy and interrelationship.

UNIT - III

The laws of thermodynamics: The Zeroth law. various indicator diagrams. work done by and on the system, first law of thermodynamics, internal energy as a state function and other applications. Reversible and irreversible changes, Carnot cycle and its efficiency. Carnot theorem and the second law of thermodynamics. Different versions of the second law. Entropy, principle of increase of entropy. The thermodynamic scale of temperature; its identity with the perfect gas scale.

Impossibility of attaining the absolute zero. third law of thermodynamics. Thermodynamic relationships: Thermodynamic variables, Maxwell's general relationships, application to Joule-Thomson cooling and adiabatic cooling in a general system, Clausius-Clapeyron heat equation. First and second Clausius-Clapeyron latent heat equation. Thermodynamic potentials and equilibrium of thermodynamical systems, relation with thermodynamical variables.

UNIT -IV

Blackbody radiation: Pure temperature dependence, Stefan-Boltzmann law, pressure of radiation, spectral distribution of Black body radiation, Wien's displacement law, Rayleigh-Jean's law, The ultraviolet catastrophy, Plank's Law, Kirchaff's Law: absorption and emission.

Text and Reference Books

1. F. Rief, "Fundamentals of Statistical and Thermal Physics"
2. E. Fermi, "Thermodynamics"
3. C. Kittel and H. Kroemer, "Thermal Physics"
4. Brij Lal, N. Subrahmayam, P. S. Hemne "Heat, Thermodynamics and Statistical Physics.
5. G. G. Agarwal and H. P. Sinha "Thermal Physics"
6. S. K. Agarwal and B. K. Agarwal "Thermal Physics"

PAPER III - CIRCUIT FUNDAMENTALS AND BASIC ELECTRONICS

UNIT-I

Growth and decay of currents through inductive resistances, charging and Discharging in R.C. and R.L.C. circuits, Time constant, Measurement of high resistance.
A.C. Bridges, Maxwell's and Schering's Bridges, Wien Bridge. THEVENIN, NORTON and Superposition theorems and their applications.

UNIT -II

Semiconductors, intrinsic and extrinsic semiconductors, n-type and p-type semiconductors, unbiased diode, forward bias and reverse bias diodes, diode as a rectifier, diode characteristics, zener diode, avalanche and zener breakdown, power supplies, rectifier, bridge rectifier, capacitor input filter, voltage regulation, zener regulator. Bipolar transistors, three doped regions, forward and reverse bias, DC alpha, DC beta transistor curves.

UNIT - III

Transistor biasing. DC load line. Basic AC equivalent circuits, low frequency model, small signal amplifiers. Common emitter amplifier, common collector amplifiers, and common base amplifiers, current and voltage gain, R.C. coupled amplifier, gain, frequency response, equivalent circuit at low, medium and high frequencies, feedback principles.

UNIT-IV

Input and output impedance, transistor as an oscillator, general discussion and theory of Hartley oscillator only, cathode ray oscillograph and its simple applications. Lissajous figure and its application.

Text and Reference Books

1. B. G. Streetman; "Solid State Electronic Devices" (Prentice Hall of India, New Delhi, 1986).
2. W. D. Stanley: "Electronic Devices, Circuits and Applications" (Prentice-Hall, New Delhi).
3. J. D. Ryder, "Electronics Fundamentals and Applications" (Prentice-Hall of India, New Delhi, 1986)
4. J. Millman & C. Halkias, "Electronic Devices and Circuits" (Mc Graw Hill, New York)
5. Vinod Prakash, "Electrical Circuits and Introductory Electronics" (Lok Bharti Prakashan, Allahabad)

PRACTICALS

Every institution may add any experiment of the same standard in the subject.

Mechanics

1. Study of laws of parallel and perpendicular axes for moment of inertia.
2. Study of conservation of momentum in two dimensional oscillations.

Oscillations

1. Study of a compound pendulum.
2. Study of damping of a bar pendulum under various mechanics.
3. Study of oscillations under a bifilar suspension.
4. Potential energy curves of a 1-Dimensional system and oscillations in it for various amplitudes.
5. Study of oscillations of a mass under different combinations of springs.

Properties of matter

1. Study of bending of a cantilever or a beam.
2. Study of torsion of a wire (static and dynamic methods)

Kinetic theory of matter

1. Study of Brownian motion.
2. Study of adiabatic expansion of a gas.
3. Study of conversion of mechanical energy into heat.
4. Heating efficiency of electrical kettle with varying voltages.

Thermodynamics

1. Study of temperature dependence of total radiation.
2. Study of temperature dependence of spectral density of radiation.
3. Resistance thermometry.
4. Thermo-emf thermometry
5. Conduction of heat through poor conductors of different geometries.

Circuit fundamentals

1. Charging and discharging in R.C. and R.C.L. circuits.
2. High resistance by leakage.
3. A.C. Bridges.
4. Half wave and full wave rectifiers.
5. Characteristics of a transistor in CE,CB and CC configurations
6. Frequency response of R.C. coupled amplifier.

Waves

I. Speed of waves on a stretched string.

2. Studies on torsional waves in a lumped system.
3. Study of interference with two coherent sources of sound.

Text and reference books

1. D. P. Khandelwal, "A laboratory manual for undergraduate classes" (Vani Publishing House, New Delhi).
2. S. P. Singh, "Advanced Practical Physics" (Pragati Prakashan, Meerut).
3. B. L. Worsnop and H. T. Flint, "Advanced Practical physics for students".
4. S. K. Kor, "Practical Physics"

B. Sc. II

MAX. MARKS		**50**
PAPER I	PHYSICAL OPTICS AND LASERS	**50**
PAPER II	ELECTROMAGNETICS	**50**
PAPER III	ELEMENTS OF QUANTUM MECHANICS, ATOMIC SPECTRA	**50**
PRACTICALS	TWO PRACTICALS (30 MARKS) + VIVA (10 MARKS) + RECORD (10 MARKS)	**50**
TOTAL		**200**

PAPER I - PHYSICAL OPTICS AND LASERS

UNIT-I

Interference of a light: The principle of superposition, two-slit interference, coherence requirement for the sources, optical path retardations, lateral shift of fringes, Rayleigh refractometer and other applications. Localised & unlocalised fringes, Thin Films Newton's Ring, determination of wavelength of sodium light by Newton's ring.
Haidinger fringes: Fringes of equal inclination. Michelson interferometer, its application for precision determination of wavelength, wavelength difference and the width of spectral lines. Antireflection Coating. Optical filters. Intensity distribution in multiple beam interference, Fabry-Perrot interferometer and etalon.

UNIT -II

Fresnel diffraction: Fresnel half-period zones, straight edge, rectilinear propagation.
Fraunhoffer diffraction: Diffraction due to single slit, diffraction at a circular aperture and double slit, missing orders spectrum. Distinction between interference and diffraction. Rayleigh criterion of resolution, resolving power of telescope and microscope and prism.
Diffraction gratings: Diffraction at N parallel slits, intensity distribution, plane diffraction grating, determination of wavelength by grating. Reflection grating, blazed gratings, concave grating and different mountings (Qualitative). Resolving power of a grating .

UNIT - III

Polarization, Double refraction in uniaxial crystals, Nicol prism, polaroids and retardation plates, Babinet's compensator. Analysis of polarised light. Optical activity and Fresnel's explanation, Half shade and Biquartz polarirneters.

UNIT-IV

Laser system: Purity of a special line, coherence length and coherence time, spatial coherence of a source, Einstein's A and B coefficients, spontaneous and induced emissions, conditions for laser action, population inversion. Three and four level laser with Example Ruby & (He-Ne). Application of Lasers, spatial and temporal coherence and spectral energy density.

PAPER II- ELECTROMAGNETICS

UNIT-I

Electrostatics :Coulomb's law, Electric Field and potentials, Field due to a uniform charged sphere, Derivations of Poisson and Laplace Equations, Gauss Law and its application: The Field of a conductor. Electric dipole, Field and potential due to an electric dipole, Dipole approximation for an arbitrary charge distribution. Electric quadruple, Field due to a quadrupole , Electrostatic Energy of a charged uniform sphere, Energy of a condenser.

UNIT-II

Magnetostatics: Magnetic field, Magnetic force of a current, Magnetic Induction and Biot-Savart Law, Lorentz Force, Vector and Scalar Magnetic potentials, Magnetic Dipole, Magnetomotive force and Ampere's Circuital theorem and its applications to calculate magnetic field due to wire carrying current and solenoid.

UNIT-III

Electromagnetic Induction :Laws of Induction, Faraday's laws and Lanz's Law. Mutual and Self Induction, Vector potential in varying Magnetic field, Induction of current in continuous media, Skin effect, Motion of electron in changing magnetic field , Betatron, Magnetic energy in field, Induced magnetic field (Time varying electric field), Displacement current, Maxwell's equations, Theory and working of moving coil ballistic galvanometer.

UNIT-IV

Electromagnetic Waves : The wave equation satisfied by E and B, plane electromagnetic waves in vacuum, Poynting's vector, reflection at, a plane boundary of dielectrics, polarization by reflection and total internal reflection, Faraday effect: waves in a conducting medium, reflection and refraction by the ionosphere.

PAPER III – ELEMENTS OF QUANTUM MECHANICS, ATOMIC SPECTRA

UNIT-I

Matter Waves: Inadequacies of classical mechanics, Photoelectric phenomenon, Compton effect, wave particle duality, de- Broglie matter waves and their experimental verification, Heisenberg's Uncertainty principle, Complementarity principle. Principle of superposition, Phase and Group Velocity .

UNIT -II

Schrodinger Equation and its Applications : Schrodinger wave equation Interpretation of wave function, Expectation values of dynamical variables, Ehrenfest theorem, Orthonormal and Orthogonal properties of wave functions, One dimensional motion in step potential, Rectangular barrier, Square well potential, Particle in a box.

UNIT– III

Hermitian operator: Properties of Hermitian operator, Commutator algebra, commutation relation between position and momentum, Hamiltonion and momentum, angular momentum and its component, total angular momentum and its components. Linear Harmonic oscillator (qualitative).Spherically symmetric system, Hydrogen atom, normal state of hydrogen atom.

UNIT-IV

Atomic spectra: Spectra of hydrogen, deuteron and alkali atoms, spectral terms, doublet fine structure, screening constants for alkali spectra for s, p. d, and f states, selection rules. Singlet and triplet fine structure in alkaline earth spectra, L-S and J-J couplings. Weak spectra: continuous X-ray spectrum and its dependence on voltage, Duane and Haunt's law. Characteristics X-rays, Moseley's law, doublet structure and screening parameters in X-ray spectra, X-ray absorption spectra.

B. Sc.-III

PAPER I - RELATIVITY AND STATISTICAL PHYSICS

UNIT-I

Relativity: Reference systems, inertial frames, Galilean invariance and conservation laws, propagation of light, Michelson-Morley experiment; search for ether. Postulates for the special theory of relativity. Lorentz transformations, length contraction, time dilation, velocity addition theorem, variation of mass with velocity, mass-energy equivalence, particle with a zero rest mass.

UNIT-II

Statistical physics :

The statistical basis of thermodynamics: Probability and thermodynamic probability, principle of equal a prior probabilities, probability distribution and its narrowing with increase in number of particles. . The expressions for average properties. Constraints; accessible and inaccessible states, distribution of particles with a given total energy into a discrete set of energy states.

UNIT- III

Some universal laws: The μ (mu)- space representation, division of μ (mu)-space into energy sheets and into phase cells of arbitrary size, applications to one-dimensional harmonic oscillator and free particles. Equilibrium before two systems in thermal contact, bridge with macroscopic physics. Probability and entropy, Boltzmann entropy relation. Statistical interpretation of second law of thermodynamics. Boltzmann canonical distribution law and its applications: rigorous form of equipartition of energy.

UNIT -IV

Maxwellian distribution of speeds in an ideal gas: Distribution of speeds and of velocities, experimental verification, distinction between mean, r.m.s. and most probable speed values. Doppler broadening of spectral lines. Bose-Einstein, and Fermi-Dirac distributions, photons in black body chamber, free electrons in a metal, Fermi level and Fermi energy.

PAPER II- SOLID STATE AND NUCLEAR PHYSICS

UNIT-I

Crystal Structure:
Lattice translation vectors and lattice, Symmetry operations, Basis and Crystal structure, Primitive Lattice cell, Two-dimensional lattice types, systems, Number of lattices, Three dimensional lattice types, Systems, Number of Lattices. Index system for crystal planes Miller indices, Simple crystal structures, NaCl, hcp, diamond, Cubic ZnS and hexagonal.

Crystal Diffraction and Reciprocal Lattice
Bragg's law, Experimental diffraction method, Laue method, Rotating crystal method, Powder method, Derivation of scattered 'wave amplitude, Atomic term factor, Reciprocal lattice vectors, Diffraction conditions, Ewald's method, Reciprocal lattice to sc, bcc and fcc lattices.

UNIT -II

Crystal Bondings: Crystal of inert gases, Van der Walls-London interaction, repulsive interaction, Equilibrium lattice constants, Cohesive energy, compressibility and bulk modulus, ionic crystal, Madelung energy, evaluation of Madelung constant, Covalent crystals, Hydrogen-bonded crystals, Atomic radii.

UNIT-III

Lattice Vibrations: Lattice Heat capacity, Einstein model, Vibrations of monatomic lattice, derivation of dispersion relation, First brillouin zone, group velocity, continuum limit, Force constants, Lattice with two atoms per primitive cell, derivation of dispersion relation, Acoustic and optical modes, Phonon momentum. Hall effect in metals. Qualitative idea of Bloch theorem and Kronig-Penney model. Effective mass and Concept of holes.

UNIT - IV

Nuclear Physics
General Properties of Nucleus: Brief survey of general Properties of the Nucleus, Mass defect and binding energy, charges, Size, Spin and Magnetic moment.
Nuclear Forces: Saturation phenomena and Exchange forces, Deutron ground state properties. Nuclear Models: Liquid drop model and Bethe Weiszacker mass formula.
Nuclear Reactions: Nuclear reactions and their conservation laws, Cross section of nuclear reactions, Theory of fission (Qualitative), Nuclear reactors and Nuclear fusion.
Elementary Particles: Basic classification based on rest mass, Spin and half life, particle interactions (gravitational, Electromagnetic, week and strong Interactions).

PAPER III - SOLID STATE ELECTRONICS

UNIT-I

Diffusion of minority carriers in semiconductor, work function in metals and semiconductors Junctions between metal and semiconductors, Semiconductor and semiconductor, p.n. Junction, Depletion layer, Junction Potential Width of depletion layer, Field and Capacitance of depletion layer, Forward A.C. and D.C. resistance of junction, Reverse Breakdown, Zener and Avalanche diodes, Tunnel diodes, Point contact diode, their importance at High frequencies, LED photodiodes, Effect of temperature on Junction diode Thermistors.

UNIT -II

Transistor parameters, base width modulation, transit time and life-time of minority carriers, Base- Emitter resistance Collector conductance, Base spreading resistance, Diffusion capacitance, Reverse feedback ratio, Equivalent circuit for transistors, Basic model, hybrid model and Y parameter equivalent circuit, Input and output impedances.

UNIT-III

Current and Voltage gain, Biasing formulae for transistors, Base bias, emitter bias and mixed type bias and mixed type biasing for small and large signal operation. Transistor circuit application at law frequencies, their AC and DC equivalent for three different modes of operation. Cascading of stages, Frequency response, Negative and positive feedback in transistor amplifiers.

UNIT –IV

Digital Electronics: Binary numbers, addition and substraction. Conversion from decimal to binary and vice-versa. Hexadecimal number system. Boolean theorem , Boolean identities. OR, AND, NOT, NAND, NOR gates, X-OR and X-NOR universal gates, de-Morgans theorem, SOP and POS, Karnaugh Map. Basic linear integrated circuits, phototransistors, Silicon Controlled rectifiers.