# M.Sc. Physics (Semester I) (CBCS)

## COURSE: CLASSICAL MECHANICS (PH HCT 110)

Unit 1 **Newtonian mechanics** 14 hrs

Single and many particle systems-Conservation laws of linear momentum, angular momentum and energy. Application of Newtonian mechanics: Two-body central force field motion. Kepler's laws of planetary motion. Scattering in a central force field, scattering cross section, The Rutherford scattering problem

Unit 2 **Lagrangian formalism** 14 hrs

Constrains in motion, generalised co-ordinates, virtual work and D'Alembert's principle. Lagrangian equation of motion. Symmetry and cyclic co-ordinates. Hamilton variational principle; Lagrangian equation of motion from variational priniciple. Simple applications.

Unit 3 **Hamiltonian formalism**

Hamilton's equations of motion- from Legendre transformations and the variational Principle. Simple applications. Canonical transformations. Poisson brackets-Canonical equations of motion in Poisson bracket notation. Hamilton-Jocobi equations.

Unit 4 **Relativistic mechanics** 14 hrs

Relativistic mechanics: Four-dimensional formulation- four-vectors, four-velocity and four-acceleration. Lerentz co-variant form of equation of motion.

**Continuum mechanics**

Basic concepts, equations of continuity and motion; Simple applications.

**References**


1. Classical Mechanics: H Goldstein, (Addision-Wesley, 1950)
2. Introduction to Classical Mechanics: R G Takwale and P S Puranik (TMH, 1979)
3. Classical Mechanics: N C Rana and P S Joag (Tata McGraw, 1991)
4. Mechanics: Landau L D and Lifshitz E M (Addition-Wesley, 1960)

## M.Sc. Physics (Semester I) (CBCS)

## COURSE: MATHEMATICAL PHYSICS I (PH HCT 120)

Unit 1 **Differential equations** 14 hrs

Ordinary differential equations: First order homogeneous and non-homogeneous equations with variable coefficients. Second order homogeneous and non-homogeneous equations with constant and variable coefficients.

Partial differential equations: Classification, systems of surfaces and characteristics, examples of hyperbolic, parabola and elliptic equations, method of direct integration, method of separation of variables.

**Special functions**

Power series method for ordinary differential equations, Legendre's equation, Legendre polynomials and their properties, Bessel function and their properties, Laguerre's equation, its solution and properties.

Unit 2 **Fourier series** 14 hrs

Fourier's theorem. Cosine and sine series. Change of interval. Complex form of Fourier series. Fourier integral. Extension to many variables.

**Integral transforms**

Fourier transforms: Transform of impulse function. Constant unit step function and periodic function. Some physical applications.

Laplace transforms: Transform of Dirac delta function, periodic function and derivatives. Solution of linear differential equations with constant coefficients Physical applications.

Unit 3 **Matrices** 14 hrs

Orthogonal, Hermitian and unitary matrices; eigenvectors and eginvalues, digitalization of matrices, Matrix representation of linear operators, eigenvalues and eigenvectors of operators, simultaneous eigenvectors and commutativity.

**Tensors**

Coordinate transformation in linear spaces, definition and type of tensors, contravariant and covariant tensors, symmetric and antisymmetric tensors. Tensor algebra: Equality, addition and substraction, tensor multiplication, outer product; contraction of indices, inner product, quotient theorem, Kronecker delta, metric tensor, Christoffel symbols. Tensors in physics.

Unit 4 **Fortran Programming** 14 hrs

Basic concepts, constants, variables, I/O statement, formatted input and output statements, built-in functions, decision making, branching and looping statements, one and two dimensional arrays, function subprograms, subroutines, simple programming using

FORTRAN 77. Programming on numerical methods: least square curve fitting, Simpson’s 1/3 rule.

**References**

1. Mathematical Physics by P K Chattopadhyay, Wiley Eastern Lit., Mumbai
2. Introduction to Mathematical Physics by C Harper, PHI
3. Mathematical Physics by Satya Prakash, S Chand and Sons, New Delhi
4. Matrices and Tensors in Physics by A W Joshi
5. Schaum’s Outline Series, Programming with FORTRAN by Seymour Lipschutz and Arture Foe, McGraw-Hill Company, Singapore(1982)
6. Computer Based Numerical Analysis By M.Shanthkumar, Kanna Publishers, New Delhi
7. Programming eith FORTRAN 77 by Dhaliwal, Agarwal, Gupta, New Age Int. Ltd.

## M.Sc. Physics (Semester I) (CBCS)

COURSE: ELECTRONICS (PH HCT 130)

Unit 1 **Network analysis** 14 hrs

Terminal network, impedance matching, maximum power, superposition theorem, Thevenin's theorem.

**Semiconductor diode**

Semiconductor diode, reverse bias and forward bias, the current components in a P-N diode, the voltage-current characteristics, diode resistance, Capacitance of tunnel diode, F.E.T and its characteristics. Diode as rectifier; Half wave rectifier, full wave rectifier, bridge rectifier.

Unit 2 **Bipolar junction transistor** 14 hrs

Transistor operation, transistor amplification action and CB, CE, CC configuration. BJT hybrid equivalent circuits and low frequency analysis; small signal analysis for input output impedances, voltage gain, current gain and power gain. Biasing techniques for BJT and design consideration for CE and CC. Concept of feed back criteria for oscillation.

**Integrated circuits (ICs)**

Microelectronics technology; integrated circuits package relevant to BJT and MOS

Unit 3 **Analog electronics** 14 hrs

**Op-Amp**

Ideal characteristics, offset voltage, current, CMMR, Skew rate, negative feedback in Op-amp of feedback on gain and bandwidth. Current amplifier, summing amplifier, difference amplifier, integrator and differentiator.

**Active filters**

Types and specifications, filter transfer function, first order and second order filter functions, low-pass, high-pass band-pass and band-reject filters, Butterworth filter.

**Signal generators**

Basic principles. Wien bridge oscillator, phase shift oscillator, triangular wave generator.

Unit 4 14 hrs

**References**

1. Microelectronics, J Millman and Arvin Grabel.
2. Introduction to electronics, K J M. Rao.
3. Integrated electronics, Milmann and Halkias.
2. Electronic Fundamentals and Application, J D Ryder.
3. Basic Electronics, M N Farugui and S L Maskara.
4. Operational Amplifiers and Linear IC's, F Robert Coughlin and F Frederick, PHI Publications (1994).
5. Op-Amps and Linear Integrated Circuits, R Gayakwad, PHI Publications, New Delhi (2000).
6. Digital Principles and Applications, A P Malvino and D Leach, TMH Publications (1991).
7. Digital fundamentals, Thomas L Floyd, 8th edition, Pearson Education (2003).

## M.Sc. Physics (Semester I) (CBCS)

## COURSE: ELEMENTS OF SOLID STATE PHYSICS (PH SCT 140)

Unit 1 **Crystal structure** 14 hrs

Crystal systems, crystal classes, Bravais lattice. Unit cell: Wigner-Seitz cell. Notations of planes and directions. Atomic packing: packing fraction, Co-ordination number. Examples of simple crystal structures: NaCl, ZnS and diamond. Symmetry operations, point groups and space groups.

**X-ray diffraction**

X-ray diffraction, Bragg law. Laue equations, Atomic form factor and structure factor. Concept of reciprocal lattice and Ewald's construction. Experimental diffraction methods: Laue rotating crystal method and powder method.

Unit 2 **Crystal binding** 14 hrs

Types of binding. Van der Waals-London interaction, repulsive interaction. Born's theory for lattice energy in ionic crystals and comparison with experimental results. Ideas of metallic binding, Hydrogen bonded crystals.

**Lattice vibrations**

Vibrations of monoatomic lattices. First Brillouin zone. Quantization of lattice vibration-Concept of phonon, phonon momentum. Specific heat of lattice (qualitative).

Unit 3 **Energy bands in solids** 14 hrs

Formation of energy bands. Free electron model: free electron in one and three dimensional potential wells, electrical conductivity, heat capacity, paramagnetism, Fremi-Dirac distribution, density of states, concept of Fermi energy. Kroning-Penny model.

**Defects in solids**

Point defects: Schottky and Frenkel defects and their equilibrium concentrations. Line defects: Dislocations, multiplication of dislocations (Frank-Read mechanism). Plane defects: grain boundary and stacking faults.

Unit 4 **Semiconductors** 14 hrs

Intrinsic and extrinsic semiconductors, concept of majority and minority carriers. Statistics of electrons and holes, electrical conductivity, Hall effect.

**References**


1. Elementary Solid State Physics: Principles and applications, M. A. Omar, Addison-Wesley.
2. Introduction to Solid State Physics, C. Kittel, Wiley Eastern.
3. Solid State Physics, A. J. Dekkar, Prentice Hall Inc.
4. Semiconductor Physics, P. S. Kireev, MIR Publishers.

## M.Sc. Physics (Semester I) (CBCS)
COURSE: ASTROPHYSICS (PH SCT 141)

Unit 1 **Basic concepts** 14 hrs

Coordinate systems, time systems, trigonometric parallaxes, parsec, apparent and absolute magnitudes, atmospheric extinction, angular radii of stars, Michelson's stellar interferometer, binary stars and their masses, radial and transverse velocities, types of optical telescopes and their characteristics, modern telescopes like Gemini, KECT etc.

Unit 2 **Properties of stars** 14 hrs

Spectra of stars, spectral sequence-temperature and luminosity classifications, H-R diagram, Saha's ionization formula and application to stellar spectra, mass luminosity relation, white dwarfs, pulsars, magnetars, neutron stars and black holes, variable stars.

Unit 3 **The solar system** 14 hrs

The surface of the sun, solar interior structure, solar rotation, sun spots, the active sun, properties of interior planets and exterior planets, satellites of planets, comets, asteroids, meteorites, Kuiper belt object and Oort cloud, theories of formation of solar system.

Unit 4 **Star clusters, galaxies and the universe** 14 hrs

Open and global clusters, the structure and contents of milky way galaxy, Hubble's classification of galaxies, Galactic structure and dark matter, galactic motions, Hubble's law, Olber's paradox, big bang theory and the origin of the early universe, nucleosynthesis, cosmic

**References**

1. Introduction to Stellar Astrophysics, E. Bohm-Vitense, 3rd Volume, CUP, 1989
2. Astrophysics and Stellar Astronomy, T.L. Swihart, Wiley 1968
3. Introduction to Cosmology, J.V. Narlikar, CUP, 1993
4. Priciples of Physical Cosmology, P.J.E. Peebles, Princeton U.P. 1993
5. Galaxies; their Structure and Evolution, R.J. Taylor, CUP, 1993
6. Solar System Astrophysics, J.C. Brandt and Hodge, McGraw-Hill, 1964
7. Introduction to Modern Astrophysics, Ostlie and Carroll, Addison Wesley, 1997
8. An Introduction to Astrophysics Baidyanath Basu, PHI
9. A Text book of Astrophysics and Cosmology, V.B.Bhatia, New Age
10. Stars and Galaxies, K.D. Abhyankar, University Press
11. Pulsar Astronomy, A.G. Lyne and G. Smith, Cambridge Univ.

## M.Sc. Physics (Semester I) (CBCS)
## COURSE: MODERN PHYSICS (PH OET 150)

Unit 1 **Electronics** 7 hrs

AC, DC, resistance, capacitance, inductance fundamentals and applications. rectifiers, power supply and amplifiers. Microphones and speakers. Mobile communication (qualitative)

Unit 2 **Basic nuclear physics** 7 hrs

Nucleus and its constitution, Basics of radioactivity, alpha, beta and gamma particles and their properties.

**Astronomy**

Solar system, evolution of stars, star birth, white dwarfs, neutron stars and holes. Newton's laws of gravitation, Kepler's laws of planetary motion. Basics of satellite.

Unit 3 **Basics of condensed matter physics** 7 hrs

Crystalline and non-crystalline solids, thin films and nano structures. X-rays production and detection, applications. conductors, semiconductors and superconductors.

**Thermodynamics**

Thermodynamic system. Laws of thermodynamics, entropy, carnot's cycles, non-reaching of 0 K.

Unit 4 **Basics of optics** 7 hrs

Electromagnetic spectrum, reflection, refraction, diffraction, interference and polarization of light. Optical fibers and its structure.

**Lasers**

Lasers, characteristics of laser, laser applications.

**References**


1. Electronic Devices and Circuit Theory, R Boylestad and L Nashelsky, VIII$^{th}$ Edi. (PHI, 2002)
2. Elements of X-ray Diffraction, B D Cullity and S R Stock, III$^{rd}$ Edi. (Prentice Hall, 2001)
3. Introduction to Solid State Physics, C Kittel, IV$^{th}$ Edi. (Wiley Eastern, 1974)
4. Thermal Physics, C Kittel and H Kroemer, II$^{nd}$ Edi. (CBS Publ., 1980)
5. Atomic and Nuclear Physics, S N Ghoshal, Vol. I and II ( S Chand and Company, 1994).
6. Text book on spherical Astronomy by Smart W.M.
7. Observational Astronomy by Binney Scott D.
7. Optics by A.Ghatak

## M.Sc. Physics (Semester I) (CBCS)

COURSE: GENERAL PHYSICS (PH OET 151)

Unit 1 **Mechanics** 7 hrs

Newton's laws of motion and their applications, energy and its conservation, rockets and satellites.

**Heat**

Definitions of heat and temperature, thermometers, different scales of temperature, specific heat, some common effects of heat.

Unit 2 **Electricity and magnetism** 7 hrs

Electrical charges, Coulomb's law, electrical current, electrical resistance, Ohm's law, magnetic field, electromagnetic induction, Faraday's law, electric generator, motors, transformers, some common applications pf electricity.

Unit 3 7 hrs

Unit 4 **Atomic and nuclear physics** 7 hrs

Atomic size and structure, Bohr's theory of hydrogen atom (qualitative), atomic spectra, nuclear size and contents, binding energy of nuclei, nuclear fission, nuclear fusion, nuclear reactors.

**References**

1. Blackwood and Kelly, General Physics, John Wiley, 1955
2. T A Ashford, The Physical Sciences, Holt, Rinehart and Winston, 1967
3. Isaac Asimov, Understanding Physics, Bracket Books, 1966
4. Albert J Read, Physics-a descriptive analysis, Addison Wesley
5. J B Marion, Physics and the Physical Universe, John Wiley, 1971
6. George Gamow, Physics, Cleaveland

## M.Sc. Physics (Semester I) CBCS

Practical I: ELECTRONICS LAB I (PH HCP 160)

LIST OF EXPERIMENTS:

1. Studies on Cathode Ray Oscilloscope
   DC/AC voltages and frequencies of sine and square signals,
   Unknown frequencies using Lissageous figures.

2. Study of RC/RL/LCR circuits
   Time constants of RC and RL circuits, resonance frequencies and quality factors of LCR series and parallel circuits.

3. Astable multivibrator using transistors
   Frequency studies

4. Full-wave bridge rectifier using diodes
   Design and study the performace of CR, L and π type filters

5. Clipping and clamping circuits
   Design circuits using diodes and resistors and study their performance

6. Operational Amplifier characteristics
   Set up a circuit and study offset voltage and currents, CNRR and slew rate

7. Op-Amp: configurations
   Voltage and current follower, Inverting and noninverting

8. Op-Amp: Mathematical operations
   Addition, subtraction, integration and fifferentiation

9. Weinbridge Oscillator using Op-Amp
   Design and study frequency response.

Note: Minimum of eight experiments must be carried. Experiments listed under S.NO.1 & 2 are compulsory.

**References**

1. Electronic devices and circuits by R.Boylstead and Nashalsky
2. Electronics principles by A.P.Malvino
3. Operational amplifiers and linear IC’s by F.Robert Coughlin and Frederick F Driscoll.
4. Any other book suggested by the course teacher

## M.Sc. Physics (Semester I) CBCS

PRACTICAL II: GENERAL AND COMPUTATIONAL LAB I (PH HCP 170)

LIST OF EXPERIMENTS:

1. Error Analysis: computations
2. Talbot bands
3. Diffraction halos (Lycopodium powder particle size determination)
4. Wavelength of sodium light using Michelson's Interferometer
5. Ultrasonic velocity studies in liquids
6. Verification of Fresnels laws
7. Blackbody radiation-Stefan's constant determination (electrical method)
8. Excitation and Ionisation potentials
9. Determination of h/e by photocell method
10. Constant Deviation spectrometer
11. Study of Beer's law
12. Production and measurement of vacuum
13. Verification of Bionomial and Gaussian distributions
    (Do experiment with identical coins for BD and lengths of nails for GD)
14. Solution of quadratic equation : Computer programming
15. Newtons forward and backward interpolations: Computer programming
16. Linear least square fitting: Computer programming
    (Provide x and y data and ask to write program for determining slope and intercept)

    With the permission of BOS, new experiments may be added to the list whenever they are developed.

Note: Minimum of six experiments and three computations must be carried out.

**References**


1. Advanced practical physics by Worsnop anf Flint, 9th Edition
2. Experiments in modern Physics by A.C.Melissons
3. Taylor manual of advanced laboratory experiments in Physics by Ed.T.Brown
4. Optics by A.K.Ghatak
5. Instrumental methods of analysis by HH Willard, LL Merrit, FA Settle, JK Jain
6. Any other book suggested by the course teacher.

## M.Sc. Physics (Semester II) (CBCS)

COURSE: ELECTRODYNAMICS AND PLASMA PHYSICS (PH HCT 210)

Unit 1 **Electrostatics and magnetostatics** 14 hrs

Gauss's law and applications, electric potential, Poisson's equations, work, energy in electrostatics, Laplace and Laplace's equation in one, two and three dimension Cartesian co-ordinates, boundary conditions and uniqueness theorem, method of images with applications, Ampere's law and applications, magnetic vector potential, multipole expansion of the vector potential, magnetic field inside matter.

Unit 2 **Electrodynamics and electromagnetic waves** 14 hrs

Review of Maxwell's equations, scalar and vector potentials, gauge transformations, Coulomb and Lorentz gauges, energy and momentum of electromagnetic waves, propagation through linear media, reflection and transmission of electromagnetic waves, plane waves.

Unit 3 **Electromagnetic radiation** 14 hrs

Retarded potentials, electric and magnetic dipole radiation, Lienard-Wiechert potentials, fields of a point charge in motion, power radiated by a point charge, review of Larentz transformations, magnetism as a relativistic phenomenon, transformation of eclectic and magnetic fields, the tensor, electrodynamics in tensor notation, potential formulation of relativistic electrodynamics.

Unit 4 **Plasma physics** 14 hrs

Definition of plasma, Debye shielding, charge particle motion in electric and magnetic fields at right angles, time varying E and B field, adiabatic invariants, dielectric constant of a plasma, the equations of motion of a plasma fluid, drift velocities, plasma oscillations, plasma waves, propagation of electromagnetic waves in plasma.

**References**

1. Introduction to Electrodynamics, D.J. Griffths, PHI, 3rd Ed.
2. Electromagnetics, B.B. Laud, New Age International PVT. LTD (1987).
3. Electromagnetism, I.S. Grant and W.R. Phillips, John Wiley and Sons Ltd (1975).
4. Plasma Physics, R.A.Cairns, Blackie (1985).
5. Principles of Plasma Physics, N.A.Krall and A.W.Trivelpiece, McGraw Hill (1973).
6. The Theory of Plasma Wave, T.H.Stix, McGraw Hill (1962).
7. Magnetohydrodynamics, T.G.Cowling, Interscience (1957).
8. Basic Space Plasma Physics: W. Baumjohann and R.A. Treumann, Imperial College Press, 1997

## M.Sc. Physics (Semester II) (CBCS)

## COURSE: STATISTICAL MECHANICS (PH HCT 220)

Unit 1 **Basic thermodynamic and statistical concepts** 14 hrs

The laws of thermodynamics and their implications. Thermodynamic potentials, Maxwell's relations and their applications. phase space, ensembles, Ergodic hypothesis and Liouville's theorem. Probability, probability distribution and the most probable distribution. The probability distribution and partition function, ensembles, thermodynamic potentials and the partition function.

Unit 2 **Classical statistics** 14 hrs

Partition function of a system of particles. The translation partition function, Gibbs paradox and Boltzmann equipartition theorem. Rotational and vibrational partition function. Einstein relation and electronic partition function. Various other partition functions and the corresponding thermodynamic potentials. Maxwell-Boltzmann distribution and its physical applications.

Unit 3 **Quantum statistics** 14 hrs

The symmetry and anti symmetry of the wave functions, Bosons and Fermions, Bose-Einstein and Fermi-Dirac distributions. Ideal Bose and Fermi gases-their properties at high and low temperatures and densities.

Unit 4 **Fluctuations** 14 hrs

Fluctuations in canonical, grand canonical and microcanonical ensembles. The Brownian motion and Langevin equation. Random walk, diffusion and the Einstein relation for mobility. Fockker-Plank equation. Johnson noise and shot noise.

**thermodynamics**

Onsager reciprocity relations. Thermoelectric phenomena. Non-equilibrium phenomenon in liquid helium-fountain effect. Gibbs entropy for non-equilibrium states. The entropy and information.

**References**

1. Statistical Mechanics: K Huang (Wiley Eastern)
2. Statistical Mechanics and Properties of matter: E S R Gopal (Macmillan)
3. Elementary Statistical Physics: C Kittel (John Wiley)
4. Fundamentals of Statistical and Thermal Physics: F Reif (McGraw Hill)
6. Thermodynamics of irreversible Processes: S R de Groot
7. Statistical Physics: L D Landau and E M Lifshitz (Pergamon)

## M.Sc. Physics (Semester II) (CBCS)

## COURSE: QUANTUM MECHANICS I (PH HCT 230)

Unit 1 **Physical basis of Quantum mechanics** 14 hrs

Experimental background, inadequacy of classical physics, summary of principal experiments and inferences, uncertainty and complementarity. Wave packets in space and time and their physical significance.

**Schrodinger wave equation**

Development of wave equation: One-dimensional and extension to three dimensions inclusive of forces. Interpretation of wave function: Statistical interpretation, normalization, expectation value and Ehrenfest's theorem. Energy eigen functions: separation of wave equation, boundary and continuity conditions.

Unit 2 **Some exactly soluble eigenvalue problems** 14 hrs

One dimensional: Square well and rectangular step potentials, Rectangular barrier, Harmonic oscillator.

Three dimensional: Particle in a box. Particle in a spherically symmetric potential, rigid rotator, Hydrogen atom.

Unit 3 **General formalism of Quantum mechanics** 14 hrs

Hilbert space. Operators-definition and properties, eigen values and eigen vectors of an operator; Hermitian, unitary and projection operatore, commuting operators, Bra and Ket notation for vectors. Representation theory: matrix representation of an operator, change of basis. Co-ordinate and momentum representations.

The basic formalism: The fundamental postulates, expectation values and probabilities; uncertainty principle. Matrix method, solution of linear harmonic oscillator.

Unit 4 **Approximation methods for stationery states** 14 hrs

Time-independent perturbation theory; non-degenerate and degenerate cases, perturbed harmonic oscillator.

The variation method. Application to ground state of Helium. WKB method, application to barrier penetration.

**Theory of scattering**

Scattering cross-section, wave mechanical picture of scattering, scattering amplitude. Born approximation. Partial wave analysis: phase shifts, scattering amplitude in terms of phase shifts, optical theorem; exactly soluble problem-scattering by square well potential.

**References**

1. Quantum Mechanics by L. I. Schiff (McGraw-Hill, 1968)
2. Quantum Mechanics by F. Schwabl (Narosa, 1995)
3. A Text Book of Quantum Mechanics by P.M. Mathews and K Venkateshan.
4. Quantum Mechanics by V.K. Thankappan (Wiley Eastern, 1980)
5. Quantum Mechanics by B.K. Agarwal and Hari Prakash.

## M.Sc. Physics (Semester II) (CBCS)
## COURSE: ELEMENTS OF NUCLEAR PHYSICS (PH SCT 240)

Unit 1 **Basic properties of nucleus** 14 hrs

Nuclear constitution. The notion of nuclear radius and its estimation from Rutherford's scattering experiment; the coulomb potential inside the nucleus and the mirror nuclei. The nomenclature of nuclei and nucleon quantum numbers. Nuclear spin and magnetic dipole moment. Nuclear electric moments and shape of the nucleus.

**Nuclear forces**

General features of nuclear forces. Bound state of deuteron with square well potential, binding energy and size of deuteron. Deuteron electric and magnetic moments-evidence for non-central nature of nuclear forces. Yukawa's meson theory of nuclear forces.

Unit 2 **Nuclear reactions** 14 hrs

Reaction scheme, types of reactions and conservation laws. Reaction kinematics, threshold energy and Q-value of nuclear reaction. Energetics of exoergic and endoergic reactions.

**Nuclear models**

The shell model; Evidence for magic numbers, energy level, scheme for nuclei with infinite square well potential and the ground state spins. The liquid drop model: Nuclear binding energy, Bethe-Weizsacker's semi empirical mass formula.

Unit 3 **Nuclear decays**

Alpha decay: Quantum mechanical barrier penetration, Gammow's theory of alpha, half-life systematics. Beta decay: Continuous beta spectrum, neutrino hypothesis and Fermi's theory of beta decay, beta comparative half-life systematics. Gamma decay: Qualitative consideration of multipole character of gamma radiation and systematics of mean lives for gamma multipole transitions.

**Interaction of radiation with matter**

Interaction of charged particles with matter, ionization energy loss, stopping power and range energy relations for charged particles. Interaction of gamma rays; photoelectric Compton and pair production processes. Nuclear radiation detectors-G M counter and scintillation detector.

Unit 4 **Nuclear energy**

Fission process, fission chain reaction, four factor formula and controlled fission chain reactions, energitics of fission reactions, fission reactor. Fusion process, energitics of fusion reactions; Controlled thermonuclear reactions; Fusion reactor. Stellar nucleo synthesis.

**References**

1. The Atomic Nucleus: R D Evans (TMH)
2. Nuclear and Particle Physics: W.E. Burcham and M. Jobes (Addison Wesley, 1998, ISE)
3. Nuclear Physics: R R Roy and B P Nigam (Wiley Eastern)
4. Physics of Nuclei and Particles: P Mermier and E Sheldon (Academic Press)
5. Subatomic Physics-Nuclei and Particles: L Valantin
6. Nuclei and Particles: E Serge (Benjamin)
7. Nuclear Physics: D C Tayal (Himalaya)
8. Nuclear Physics: R C Sharma (Khanna)
9. Introduction to Nuclear Physics: S B Patel (Wiley Eastern)
10. Introductory Nuclear Physics: Kenneth S Krane (Wiley)
11. Atomic and Nuclear Physics: S N Ghoshal (S. Chand)

## M.Sc. Physics (Semester II) (CBCS)

COURSE: ATMOSPHERIC AND SPACE SCIENCE (PH SCT 241)

Unit 1 **Physical Meteorology and atmospheric pollution** 14 hrs

Scope of atmospheric science terminology and definitions: weather and climate, composition of the atmosphere: fixed and variable gases, VMR, mechanism of production and destruction of atmospheric constituents, structure of atmosphere, temperature variation in the boundary layer and free atmosphere, Chapman cycle, laws of thermodynamics of the atmosphere: Equation of state for dry air and moist air, virtual temperature. Role of meteorology on atmospheric pollution, atmospheric boundary layer-solar radiation, terrestrial radiation, soil temperature; Air stability, Local wind structure, aerosols.

Unit 2 **Optics of the atmosphere and atmospheric instrumentation systems** 14 hrs

Scattering – role of scattering, elements of radiometry and photometry-geometric considerations, radiometric quantities, response of eye, photometric quantities, Characteristic of scattering – types and nature of scattering processes, scattering in the atmosphere – angular scattering and polarization, total scattering and attenuation, transmittance and optical thickness, ground based instruments for the measurement of temperature – mechanical thermometers,

Unit 3 **Orbital motion and space dynamics** 14 hrs

Coordinate and time systems, elements of orbits in space, motion, elements of reduction of observational data, review of two body problem: Kepler's law of orbital motion, Newton's laws of motion and gravitation, solution to two body problem: Elliptical, parabolic and hyperbolic orbits, orbit in space: f and g series, many body problem: Equations of motion, Lagrange's solutions, Lagrange's planetary equations (qualitative), weightlessness and artificial gravity. Forces acting on artificial satellites, atmospheric drag. Rocket motion: Motion of a rocket in a gravitational field and in atmosphere.

Unit 4 **Remote sensing** 14 hrs

Concepts of remote sensing, electromagnetic spectrum, source of electromagnetic radiation for remote sensing, fundamentals of radiometry and radiometric measurements, energy interaction with earth's surface, signatures of vegetation, soil and water bodies of the earth's surface (general discussion), classification of remote sensors, spectral, spatial and temporal resolution, IR and microwave sensors (qualitative), data reception and products (qualitative), application of remote sensing for earth's resource management (general discussion). Indian remote sensing programme.

**References**

1. Fundamentals of Atmospheric Modeling: Mark Z Jacobson,

Cambridge University, 1999/2000
2. Optics of the Atomosphere: Earl J McCartney, John Wiley and Sons, 1976
3. Radar Meteorology by S Raghavan, Kulwer Academic Publishers, 2003
4. Dynamic Meteorology by Holton, J.R., 3rd edition, Academic Press N.Y. 1992
5. Meteorology for Scientists and Engineers: Roland B. Stull, Brookes/Cole (Thomson Learning), 2000
6. Atomospheric Physics: J.V. Iribrine and H.R. Cho, D. Reidel Publishing Co. 1980
7. The Physics of Atmosphere: John Hougton Cambridge University Press, 1976
8. Orbital Motion: A.E. Roy, Adam Hinglar Ltd. 2002
9. Fundamentals of Remote Sensing: George Joseph, University Press Pvt. Ltd. Hyderabad, 2002
10. Introduction to Remote Sensing: Singh and Sharma, Rawath Publications, New Delhi, 2004.
11. Basic Space Plasma Physics: W. Baumjohann and R.A. Treumann, Imperial College Press, 1997
12. Introduction to Ionosheric Physics: H. Rishberth and O.K. Garriot, Academic Press, 1969
13. Physics of Space Plasma, 2nd Edn.: G.K. Parks, Addison-Wesley, 1991

## M.Sc. Physics (Semester II) (CBCS)

COURSE: ENERGY SCIENCE (PH OET 250)

Unit 1 **Energy and thermodynamics** 7 hrs

Laws of thermodynamics, forms of energy, conservation of energy, heat capacity, thermodynamic cycles, Carnot diesel, Otto and Rankin cycle.

Unit 2 **Renewable energy resources** 7 hrs

Fossil fuels, time scale of fossil fuels and solar energy as an option. Solar energy for clean environment sun as the source of energy and its energy transport to the earth, extraterrestrial and terrestrial solar radiations, solar spectral irradiance, measurement techniques of solar radiations, estimation of average solar radiation.

Unit 3 **Biomass energy** 7 hrs

Nature of biomass as a fuel, biomass energy conversion processes, direct combustion: heat of combustion, combustion with improved Chulha and cyclone furnace.

Unit 4 **Biogas technology** 7 hrs

Dry chemical conversion processes: pyrolysis, gasification, types of gasification importance of biogas technology, anaerobic decomposition of biodegradable materials, factors affecting bio-digestion, types of biogas plants, applications of biogas.

**References**


1. Advances in energy systems and technology: A. Peter, Academic Press, USA, 1986
2. Solar energy conversion: C.R. Neville, Elsevier North-Holland, 1986
3. Solar energy conversion: A.E. Dixon and J.D. Leslie, Pergamon Press, New York, 1978
4. Biomass, energy and environment: N.H. Ravindranath, Oxford University Press, 1995

## M.Sc. Physics (Semester II) (CBCS)

COURSE: RADIATION PHYSICS (PH OET 251)

Unit 1 **Nuclear radiation** 7 hrs

Natural radioactivity, half life, alpha, beta and gamma radiations, induced nuclear transformations; Interaction of gamma rays and x-rays with matter.

Unit 2 **Biological effect of radiation** 7 hrs

Basic human physiology, cell biology, interaction of radiation with cells, somatic effects of radiation, hereditary effect of radiation.

Unit 3 **Radiation protection in medicine** 7 hrs

Protection against sealed sources, diagnostic radiography, diagnostic fluoroscopy radiotherapy. Protection against unsealed sources, control and disposal of radioactive materials.

Unit 4 **Lasers** 7 hrs

Definition, principle of lasing action, pumping techniques, different lasers and their characteristics, applications: defense, medical and industry.

**References**


1. Nuclear radiation Physics, R E Lapp, Prentice hall, 1963
2. Principles of Nuclear Science and Reactors, Jacobs, Kline, Remik, Van Nostrand, 1966
3. Radiation- What it is and how it affects you, J Schubert and R E Lapp, Viking, 1957
4. An introduction to radiation protection, A.Martin, S.A.Harbison, Chapman and Hall, 1982
5. Introduction to High energy Physics, Hughes
6. Lasers and Non-linear Optics, B.B.Laud
7. Optics, Ajay Ghatak

## M.Sc. Physics (Semester II) CBCS

## PRACTICAL III: ELECTRONICS LAB II (PH HCP 260)

LIST OF EXPERIMENTS:

1. Study of Transistor cascade amplifier
2. Timer circuit using IC 555
3. Fixed voltage regulator using IC 7812/7912
4. Variable voltage regultor using IC 723/8085
5. Logic gates using diodes and transistors
6. Flip Flops: RS, clocked RS, JK and clocked JK
7. Half and Full adders and sub tractors using NAND gates
8. Shift registers: 4-bit left shift and right shift registers
9. Counters: 4-bit ripple counter
10. Decoders: Truth table verification of 3-to-8 decoder IC74LS138
11. Multiplexer and demultiplexer: Truth table verification of 74151 and 74154

With the permission of BOS, new experiments may be added to the list whenever they are developed.

Note: Minimum of eight experiments must be carried.

**References**


1. Electronic devices and circuits by R.Boylstead and Nashalsky
2. Electronics principles by A.P.Malvino
3. Microelectronics circuits by Adel S.Sedra and Kenneth C Smith
4. Digital principles and applications by A.P.Malvino and D.Leach
5. Any other book suggested by the course teacher

## M.Sc. Physics (Semester II) CBCS

## PRACTICAL IV: GENERAL AND COMPUTATIONAL LAB II (PH HCP 270)

LIST OF EXPERIMENTS:

1. Modes of vibration of a fixed bar
2. Material constant of a semiconductor
3. Determination of doublet separation by using Michelson's Interferometer
4. Wavelength of Laser light by single slit diffraction method.
5. Wavelength of Laser light by double slit interference method.
6. Verification of Hartman's formula
7. Cornu's method for elastic constants
8. Thermionic emission
9. Calibration of thermocouple

10 Refractive Index and thickness of reflecting surface using Laser source

11. Velocity of light by Kerr cell method
12. Study of Zeeman effect: determination of (e/m) of electron
13. Euler's method of interpolation: Computer programming
14. Numerical integration by Simpson's 1/3 and 3/8 rules: Computer programming.
15. Numerical integration by Trapezoidal rule: Computer programming.

With the permission of BOS, new experiments may be added to the list whenever they are developed.

Note: Minimum of six experiments and three computations must be carried out.

**References**


1. Advanced practical physics by Worsnop anf Flint, 9$^{th}$ Edition
2. Experiments in modern Physics by A.C.Melissons
3. Taylor manual of advanced laboratory experiments in Physics by Ed.T.Brown
4. Optics by A.K.Ghatak
5. Instrumental methods of analysis by HH Willard, LL Merrit, FA Settle, J Jain
6. Any other book suggested by the course teacher.

## M.Sc. Physics (Semester III) (CBCS)
## COURSE: MATHEMATICAL PHYSICS II (PH HCT 310)

Unit 1 **Complex analysis** 14 hrs

Properties of analytic functions, Cauchy's integral theorem, singularities, Cauchy's residue theorem, evaluation of definite integrals.

**Vector analysis**

Cartesian and curvilinear coordinate systems; Review of vector algebra; Vector differentiation and integration; Line, surface and volume integrations, some examples; Gauss and Stock theorems, some physical applications.

Unit 2 **Group theory** 14 hrs

Groups, subgroups, classes. Homomorphism and isomorphism. Group representation. Reducible and irreducible representations. Character of a representation, character tables. Construction of representations. Representations of groups and quantum mechanics. Lie groups. The three dimensional rotation group SO(3). The special unitary groups SU(2) and SU(3). The irreducible representations of SU(2). Representations of SO(3) from those of SU(2). Some applications of group theory in physics.

Unit 3 **Numerical techniques** 14 hrs

Numerical methods. Solutions of algebraic and transcendental equations: Bisection, iterative and Newton-Raphson methods. Interpolation: Newton's and Lagrange's methods. Curve fitting: Method of least squares. Differentiation: Newton's formula. Integration: Trapezodal rule, Solutions of ordinary differential equations: Euler's modified method and Runge-Kutta methods.
Numerical computing. Computer programming for above numerical methods using C Language.

Unit 4 **Computational Physics** 14 hrs

Programming in C for solution of problems in physics-examples from atomic and molecular physics, nuclear physics, mechanics, electrodynamics, quantum mechanics, solid state physics.

**PC based instrumentation**

PC interface for instrumentation, Programming for PC-interface-Languages for standard GPIB, Programming GPIB in basics, visual basic. PC based analytical instruments.

**References**

1. Mathematical Physics by P K Chattopadhyay, Wiley Eastern Ltd., Mumbai.
2. Introduction to Mathematical Physics by C Harper, PHI.
3. Mathematical Physics by Satya Prakash, S Chand and Sons, New Delhi
4. Introductory Methods of Numerical Analyes: S. S. Sastry, PHI, 1995
5. Fundamentals of Computers by V. Rajaraman, PHI
6. Programming in Basic by balagurswamy TMH
7. Programming with C by Venugopal and Prasad, TMH
8. Numerical Methods: E. Balagurswamy (TMH, 2001)
9. Instrumentation measurement analysis, Nakra and Chaudhury

## M.Sc. Physics (Semester III) (CBCS)

## COURSE: ATOMIC, MOLECULAR AND OPTICAL PHYSICS (PH HCT 320)

Unit 1 **Atomic physics** 14 hrs

Brief review of early atomic models of Bhor and Sommerfeld. One electron atom: Quantum states, atomic orbitals, spectrum of hydrogen, Rydberg atoms (brief treatment), relativistic corrections to spectra of alkali atoms: Spin-orbit interaction and fine structure in alkali spectra. Two electron atom: Ortho and para states and role of Pauli principle, level schemes of two electron atoms. Perturbations in the spectra of one and two electron atoms: Zeeman effect, Paschen-Back effect, Stark effect in hydrogen spectra. Hyperfine interactions. Many electron atom: Central field approximation.

Unit 2 **Molecular physics A** 14 hrs

Brief treatment of chemical bond: Covalent, ionic, Van der Waal's interactions. The Bron-Oppenheimer approximation (qualitative treatment), diatomic molecule as a rigid rotator, rotational spectra of rigid and non-rigid rotator, microwave spectroscopy-principle and technique. Types of rotors: Eigen values of linear, symmetric top, asymmetric top and spherical top molecules. Raman spectroscopy: Theory of Raman effect, experimental technique, rotational Raman spectra of diatomic and linear polyatomic molecules.

Unit 3 **Molecular physics B** 14 hrs

Diatomic molecule as a simple harmonic oscillator, anharmonicity, Morse potential curves, vibrating rotator: energy levels and vibration spectra, PQR branches in rovibronic spectra, experimental technique and IR spectrometer. Applications of IR spectroscopy for material characterization, comparision of vibration and Raman spectra. Electrical spectra of diatomic molecules: Vibrational coarse structure, Deslandrer table, rotational fine structure in electronic spectra, Fortrat parabola, intensity of vibrational lines in electronic spectra-Frank-Condon principle, dissociation and pre-dissociation, fluorescence and phosphorescence-Jablonski diagram. Selection rules.

Unit 4 **Optical physics** 14 hrs

Coherence of light, spatial and temporal coherence, Einstein's coefficients: spontaneous and stimulated emission, idea of light amplification, characteristics of a laser beam, threshold condition for laser oscillation, role of resonant cavity, He-Ne lasers, Brief treatment of application of lasers. Holography: Fundamentals of 3D-mapping of images, recording and reconstruction, applications in microscopy and interferometry. Fiber optics: Mechanism of light propagation in a fiber wave guide, numerical aperture, types of optical fibers, transmission characteristics of optical fibers-attenuation and dispersion, optical fiber communication system (qualitative).

**References**


1. Physics of Atoms and Molecules, Bransden and Joachain, (2nd Edition) Pearson Education, 2004
2. Fundamentals of Molecular Spectroscopy, Banwell and McCash, Tata McGrawHill, 1998
3. Modern Spectroscopy, J.M. Hollas, John Wiley, 1998
4. Molecular Quantum Mechanics, P.W. Atkins and R.S. Friedman, Third Edition, Oxford Press (India Edition), 2004
5. Lasers, silfvast, Cambridge Press, 1998
6. Lasers, Nambiar, New Age International, 2004
7. Optical Electronics, Ghatak and Tyagarajan, Cambridge Press, 2004
8. Laser and Nonlinear Optics, B.B. Laud, Wiley-Eastern Ltd. 1991

## M.Sc. Physics (Semester III) (CBCS)
## COURSE: SOLID STATE PHYSICS I (PH SCT 330)

Unit 1 **Periodic structures** 14 hrs

Reciprocal lattice and its properties. Periodic potential and Bloch theorem, reduction to Brillourin zone, Born-von Karman boundary conditions. Counting of states.

**Electron states**

Nearly free electron model, discontinuity at zone boundary, energy gap and Bragg reflection. Tight binding model, band width and effective mass in linear lattice and cubic lattices. APW and k.p.methods of band structure calculations.

Unit 2 **Quantization of lattice vibrations** 14 hrs

Potential and kinetic energies in terms of generalized coordinates and momenta, Hamiltons equations of motion, quantization of normal modes.

**Lattice waves**

Lattice dynamics, properties of lattice waves using mono and diatomic lattices, lattice spectrum and Van Hove singularity, diffraction by crystal with and without lattice vibrations, phonons and Debye-Waller factor.

Unit 3 **Thermal properties** 14 hrs

Density of states, thermal energy of harmonic oscillator. Lattice heat capacity: Dulong-Petit's classical theory, Einstein and Debye's theories, comparison of theory with experimental results. Anharmonicity and thermal expansion, phonon-phonon interaction.

**Elastic properties of solids**

Stress and strain tensors, elastic constants and Hooke's law, strain energy, reduction of elastic constants from symmetry, isotropy for cubic crystals, technical moduli and elastic constants. Propagation of long wavelength vibrations. Experimental determination of elastic constants by ultrasonic interference method.

Unit 4 14 hrs

**References**

1. Principle of the theory of solids: J.M. Ziman (Cambridge University Press)
2. Introduction to Solid State Physics: C. Kittel (Wiley Eastern)
3. Solid State Physics: A.J. Dekkar (Prentice Hall Inc)
4. Solid State Physics: N.W. Ashcroft and N.D. Mermin (Saunders College Publishing)
5. Elementary Solid State Physics: Principles and applications, M.A. Omar (Addison-Wesley)
6. Physics of Solids: F.C. Brown (Benjamin Inc. Amsterdam)
7. Introduction to Theory of Solid State Physics: J.D. Patterson (Addison-Wesley)

**M.Sc. Physics (Semester III) (CBCS)**

COURSE: NUCLEAR PHYSICS I (PH SCT 331)

Unit 1 **Two nucleon systems and nuclear forces** 14 hrs

**Deuteron**

The deuteron ground state and its radius. Excited state of deuteron. Magnetic dipole and electric quadrupole moments-deuteron as admixture of S and D states. Range of nuclear force.

**Nucleon-nucleon scattering**

The partial wave analysis of neutron-proton scattering at low energy, Scattering length and effective range formalism. Scattering from ortho- and para-hydrogen and spin dependence of nuclear force.

Proton-proton scattering at low energy, Coulomb effects, scattering length and effective range theory, Neutron-neutron system at low energy and the scattering parameters. Qualitative features of nucleon-nucleon scattering at high energies.

Unit 2 **Nuclear structure models** 14 hrs

**Shell model**

Single particle model: Energy level scheme for infinite harmonic oscillator and intermediate potentials, spin orbit interaction. Shell model predictions, nuclear spin and moments, Nordheim's rules. Nuclear isomerism and isobaric levels. Independent particle model and coupling schemes.

**Collective model**

Nuclear deformations and collective motions of nucleons. Nuclear rotational motion and rotational energy spectra for even-even nuclei. Vibrational excitation and vibrational energy levels for even-even nuclei. Nuclear moments.

**Fermi model**

Fermi gas model, Fermi energy of nucleons, Fermi momentum and level density; nuclear matter.

Unit 3 **Particle Physics**

**Conservation laws and symmetry principles**

Fundamental interactions and their basic features. Elementary particles and their classification based on fundamental interactions. Conservation laws in elementary particle decays; Strangeness and Gellmann-Nishijima relation; Isospin conservation in strong interactions. The conservation laws, invariance and symmetry principles; Space-time symmetries, internal and gauge symmetries; the parity and its non-conservation in weak interaction; Tau theta puzzle. Charge conjugation invariance; isotopic parity; C P invariance; C P violation and its analysis. Time reversal symmetry; C P T invariance and its consequences.

Unit 4 **Unification of basic interactions** 14 hrs

Quark model of hadrons. The eight fold way; meson and baryon multiplets; Gellmann-Okubo mass formula. Broken symmetry. Qualitative discussions on unification of basic interactions; Standard model, GUTs and proton decay; Super symmetry.

**References**


1. Physics of Nuclei and Particles: P Mermier and E Sheldon (Academic Press)
2. Nuclear Physics: R R Roy and B P Nigam (Wiley Eastern)
3. Subatomic Physics-Nuclei and Particles: L Valantin
4. The Structure of Nucleus: M A. Preston and R K Bahaduri
5. Nuclei and Particles: E Serge (Benjamin)
6. Nuclear and Particle Physics: W.E. Burcham and M. Jobes (Addison Wesley, 1998, ISE)
7. Nuclear Physics: D C Tayal (Himalaya)
8. Atomic and Nuclear Physics: S N Ghoshal (S. Chand)
9. Fundamentals of Elemetary Physics: M.J. Longo
10. Elementary Particle Physics: D C Cheng and G.K.O. Neill
11. Introduction to High Energy Physics: Houghs
12. Intruduction to High Energy Physics: D.H. Perkins

## M.Sc. Physics (Semester III) (CBCS)

COURSE: MATERIALS SCIENCE I (PH SCT 332)

Unit 1 **Engineering Materials** 14 hrs

Materials science and engineering, classification, level of structure, structure-property relationship in materials.

**Structure of solids**

The crystalline and non-crystalline states, covalent solids, metals and alloys, ionic solids, the structure of silica and silicates.

Unit 2 **Crystal growth** 14 hrs

Crystal growth from melt: Bridmann technique, crystal pulling by Czochralski's method, growth from solutions, hydrothermal method, gel method, zone refining method of purification.

**Crystal imperfections**

Point imperfections, dislocation-Edge and Screw dislocation, concept of Burger vector and Burger circuit, surface imperfections, colour centres in ionic solids.

Unit 3 **Solid phase and phase diagrams** 14 hrs

Single and multiphase solids, solid solutions and Hume-Rothery rules, intermediate phase, the intermetallic and interstitial compounds, properties of alloys: solid solutions and two component alloy systems; phase diagram, Gibbs phase rule, lever rule; first, second and third order phase transitions with example; some typical phase diagrams: Pb-Sn and Fe-$Fe_2O_3$, eutectic, eutectoid, peritectic and peritectoid systems.

Unit 4 **The phase transformation**

Time scale for phase changes; nucleation and growth, nucleation kinetics; the growth and overall transformation kinetics, applications: transformation in steel; precipitation processes, solidification and crystallization; glass transition, recovery, recrystallization and grain growth.

Theory of diffusion, self-diffusion, Fick's law of diffusion, Krikindal effect, activation energy for diffusion, applications of diffusion.

**References**


1. Elements of Material Science and Engineering, L.H. van Vleck, Addison Wesley (1989, 6th edition)
2. Material Science and Engineering, V. Raghvan, Printice Hall of India, 3rd edition
3. Material Science and Processes, S.K. Hazra Chaudary, Indian Distr Co. (1977)
4. Introduction to Solids, L.V. Azaroff, Tata McGraw Hill
5. Crystal Growth, B. R. Pamplin, Pergamon Press

## M.Sc. Physics (Semester III) (CBCS)

COURSE: SOLID STATE PHYSICS II (PH SCT 340)

Unit 1 **Transport properties of metals** 14 hrs

Boltzman equation, electrical conductivity, calculation of relaxation time. Impurity scattering, ideal resistance. General transport coefficients, thermal conductivity, thermoelectric effects, lattice conduction, phonon drag.

**Transport properties of semiconductors**

Thermal conductivity. Thermoelectric and magnetic effects. Hot electron and energy relaxation times. High frequency conductivity. Acoustic (deformation and piezoelectric) and optical (polar and non polar) scattering by electrons.

Unit 2 **Dielectric properties** 14 hrs

Macroscopic description of static dielectric constant, electronic, ionic and orientational polarization, Lorentz field, dielectric constant of solids, complex dielectric constant and dielectric losses. Theory of electronic polarization and optical absorption.

**Ferroelectricity**

General properties, classification, dipole theory and its drawbacks, thermodynamics of ferroelectric transitions, ferroelectric domains.

Unit 3 **Magnetic properties** 14 hrs

Classification, Langevin theory of diamagnetism, quantum theory of paramagnetism.

Ferromagnetism: concept of domains, thermodynamics, thickness of Bloch wall, molecular field concept, Weiss theory, Heisenberg exchange interaction, Ising model, spin waves dispersion relation (one dimensional case), quantization of spin waves, concept of

Unit 4 **Superconductivity** 14 hrs

Review of basic properties, classification into type I and type II. Energy gap and its temperature dependence. Super current and critical currents.

London's phenomenological equations, penetration depth. Cooper pairs, coherence length. Instability of Fermi surface and cooper pairs. BCS theory and comparison with experimental results. Ground state energy of superconductor. Quantization of magnetic flux. Josephson effects (AC and DC) and applications

High $T_c$ materials: Structure and properties, some applications

**References**

1. Principle of the theory of solids: J.M. Ziman (Cambridge University Press)
2. Introduction to Solid State Physics: C. Kittel (Wiley Eastern)
3. Solid State Physics: A.J. Dekkar (Prentice Hall Inc)
4. The physical principles of solids: A.H. Morish
5. Introduction to Superconductivity: M. Tinkham (McGraw-Hill, International Edition)
6. Semiconductor Physics: P.S. Kireev (MIR Publishers)
7. Solid State Science: K. Seeger (Springer Verlag)

**M.Sc. Physics (Semester III) (CBCS)**
COURSE: NUCLEAR PHYSICS II (PH SCT 341)

Unit 1 **Formal theory of nuclear reactions** 14 hrs

Nuclear reactions, general formalism and cross sections. Principle of detailed balance. Resonance reactions, Breit-Wigner formula for $l = 0$, level width and strength functions.

**Statistical model**

Statistical theory of nuclear reactions, evaporation probability and cross sections for specific reactions. Experimental results.

**Optical model**

Optical potentials and optical model parameters. Optical model at low energy, Kapur-Pierls dispersion formula for potential scattering and experimental results.

Unit 2 **Direct reaction** 14 hrs

Transfer reactions. Theory of stripping and pickup reaction. Plane wave Born approximation and qualitative consideration of distorted wave Born approximation.

**Heavy ion physics**

Special features of heavy ion reactions. Qualitative treatment of remote electromagnetic interaction Coulomb excitations; close encounters, grazing collisions and particle transfer. Direct and head on collision, compound nucleus and quasi molecule formation.

Unit 3 **Particle detectors and accelerators** 14 hrs

Gas filled ionization detectors: Current mode and pulse mode operation; proportional counter, position sensitive ionization chamber and multi-wire proportional counter. Semiconductor detectors: Semiconductor P-N junction as a detector. Types of semiconductor detectors; surface barrier, Si(Li), Ge(Li) and high purity germanium detectors. Pelletron accelerator.

**Radiation protection**

Dose units, estimation and measurement of dose from beta, gamma and neutron sources. Dosimeters. Biological effects of ionizing radiation. Radiation protection, tolerance limits of exposure to radiation and late effect of radiation. Radiation shielding.

Unit 4 **Neutron diffraction** 14 hrs

Classification of neutrons in terms of energy. Bound and free atom cross section, coherent and incoherent cross sections. Neutron diffraction from single crystals and powders, advantages of neutron diffraction over X-ray diffraction. Refractive index of neutrons and mirror reflection of cold neutrons. Neutron interferometer and its application.

**Nuclear techniques**

Basic principles, instrumentation and application of positron annihilation spectroscopy, X-ray fluorescence (XRF), proton induced X-ray emission (PIXE), Rutherford back scattering (RBS).

**References**


1. Nuclear Radiation Detectors: Kapoor and Ramamurthy
2. Radiation Detection and Measurement: G F Knoll
3. Measurement and detection of Radiation: Nicholas Tsonlfanidis
4. Physics of Nuclei and Particles: P Mermier and E Sheldon (Academic Press)
5. Introduction to Experimental Nuclear Physics: Sigru
6. Nuclear Physics: R R Roy and B P Nigam (Wiley Eastern)
7. Nuclear Physics: D C Tayal (Himalaya)
8. Atomic and Nuclear Physics: S N Ghoshal (S. Chand)
9. Neutron Diffraction: G F Bacon

**M.Sc. Physics (Semester III) (CBCS)**
COURSE: MATERIALS SCIENCE II (PH SCT 342)

Unit 1 **Elastic behaviour of materials** 14 hrs
Elastic, anelastic and viscoelastic behaviours; Fracture of materials: ductile and brittle fracture, fatigue fracture, fracture toughness, ductile-brittle transition, methods of protection against fracture; Plastic deformation: tensile stress-strain curve, plastic deformation by slip, shear strength of perfect and real crystals, mechanism of creep.

Unit 2 **Ceramics** 14 hrs
Classification and their structures, polymorphism; Mechanical and thermal properties; Application of ceramics.

**Glasses**
Glass forming constituents, structure of glasses, glass transition, types of glasses: soda lime glass, lead glass, borosilicate glasses, fiber glasses. Optical and high temperature electrical properties of glasses.

**Polymers**
Polymers, basic concepts, mechanisms of polymerization, structure and properties of polymers, polymer melting and glass transition, electrical and optical properties.

Unit 3 **Dielectric materials** 14 hrs
Ideas of static dielectric constant, loss, polarization, electric susceptibility, types of polarization; electronic, ionic, orientational and space charge lorentz field, Clausius-Mosotti relation, dielectric break down-types and characterisitics. Complex dielectric constants, ferroelectrics. Applications of dielectrics.
**Magnetic materials**
Classification of magnetic materials; dia, para, ferro, antiferro and ferri, examples. Weiss theory of ferromagnetism, domains, hysteresis, hard and soft materials, applications of magnetic materials.

Unit 4 **Nanomaterials** 14 hrs
Introduction, types of nano materials, preparation, structure, properties of nanomaterials, carbon nanotubes, types and their properties. Nano films: Preparation and properties. Applications of nanomaterials: nanosensors, drug delivery.

Liquid crystals: Classification, structure, optical and dielectric properties, applications

**References**

1. Elements of Material Science and Engineering, L.H. van Vleck, Addison Wesley (1989, 6th edition)
2. Material Science and Engineering, V. Raghvan, Printice Hall of India, 3rd edition
3. Material Science and Processes, S.K. Hazra Chaudary, Indian Distr Co. (1977)
4. Introduction to Ceramics, W.D. Kinnery, John Wiley
5. Polymer Science, V.R. Gowarikar, N.V. Vishwanathan, Jayadev Sridhar, Wiley Eastern (1986)
6. An advances in Ferrites, V.R.K. Murthy and B. Vishwanath, Narosa Publishing House.
7. Liquid crystals, S. Chandrasekhar, Cambridge Univ Press, 2nd edition
8. Principles of Polymer Science, P. Bahadur and N.V. Sastry, Narosa, 2002
9. An Introduction to nanoscience and Technology, C.N.R.Rao, JNCASR, Bangalore (2010)
10. Material Science, M.Arunugam, Anuradha agencies, Kumbakonam (2002)
11. An Introduction to nanoscience, G.L.Hornyak, J.Dutta, H.F.Tibbals and A.K.Rao, CRC Press (2008)

## M.Sc. Physics (Semester III) CBCS

PRACTICAL V: SOLID STATE AND MATERIALS SCIENCE LAB I (PH HCP 350)

LIST OF EXPERIMENTS:

1. Determination of interplanar spacing using X-ray powder pattern
2. Magnetic Susceptibility of liquid by Quinke's method
3. Measurement of resistivity of a semiconductor by four probe method (fixed temperature)
4. Determination of Debye's temperature of Lead or Tin
5. Structure factor determination: Computations
6. Specific heat of metals
7. Ultrasonic velocity in solids
8. Activation energy of point defects in metals: Experiment/Computation
9. Fermi energy of metals: Experiment/Computation
10. Thermal expansion coefficient in solids
11. Thermoelectric power of Ferrites
12. Energy gap of a pn-junction diode/LED
13. Thermistor characteristics

    With the permission of BOS, new experiments may be added to the list whenever they are developed.

Note: Minimum of eight experiments must be carried.

**References**


1. Introduction to Solid State Physics by C.Kittel
2. X.Ray diffraction by B.D.Cullity
3. Physics of Solids by F.C.Brown
4. Interpretation of X-ray powder diffraction pattern by H.P.Lipson and H.Steeple
5. Any book suggested by the course teacher

**M.Sc. Physics (Semester III) CBCS**

PRACTICAL V: NUCLEAR LAB I (PH HCP 351)

LIST OF EXPERIMENTS:

1. Nuclear counting statistics: Verification of Poisson Distribution
2. GM counter characteristics: Operation voltage determination
3. Determination of dead time of GM counter – single source
4. Verification of inverse square law for nuclear radiation
5. Attenuation of β-rays in aluminium
6. Attenuation of γ-rays
7. Half life of K-40
8. Coincidence circuit
9. Analysis of stopping power and energy loss
10. Nuclear radius calculation
11. Semiempirical mass formula and binding energy analysis
12. Analysis of β-spectrum and half life systematics

With the permission of BOS, new experiments may be added to the list whenever they are developed.

Note: Minimum of eight experiments must be carried.

**References**


1. Experiments in Nuclear Science, ORTEC Applications Note. ORTEC (1971)
2. Practical Nucleaonics by F.J.Pearson and R.r.Dsborne
3. Experimental Nucleaonics by E.Bleuler and G.J.Goldsmith, Rinehart
4. The Atomic Nucleus by R.d.Evans
5. Any other book suggested by the course teacher

## M.Sc. Physics (Semester III) CBCS

PRACTICAL VI: SOLID STATE AND MATERIALS SCIENCE LAB II (PH HCP 360)

LIST OF EXPERIMENTS:

1. Magnetic susceptibility by Gouy's method
2. Temperature variation of resistivity of a semiconductor: four probe method
3. Curie temperature of a ferromagnetic material
4. Hall effect in semiconductors
5. Electron spin resonance: g factor determination
6. Dielectric studies in some solids
7. Ionic conductivity of an alkali halide crystal
8. Temperature variation of conductivity in a glass
9. Study of creep
10. Determination of yield point and yield strength
11. Determination of elastic constants
12. Intensity calculations of X-ray powder pattern

Note: Minimum of eight experiments must be carried.

**References**


1. Introduction to Solid State Physics by C.Kittel
2. X.Ray diffraction by B.D.Cullity
3. Physics of Solids by F.C.Brown
4. Interpretation of X-ray powder diffraction pattern by H.P.Lipson and H.Steeple
5. Any book suggested by the course teacher

**M.Sc. Physics (Semester III) CBCS**

PRACTICAL V: NUCLEAR LAB II (PH HCP 361)

LIST OF EXPERIMENTS:

1. Dead time of GM counter by double source method

2. Nuclear electronics: linear amplifier, single channel analyzer, coincidence circuits

3. Study of scintillation detector (NaI)

4. Γ-ray spectrum using scintillation detector: multi channel analysis

5. Β-ray spectrum using scintillation detector

6. Half life of Indium-116

7. Study of Bremsstrahlung radiation

8. Positron annihilation

9. Study of solar cells

10. Study of solar panels

11. Energy transfer efficiency in liquid scintillators

12. Nuclear models and nuclear structure analysis

With the permission of BOS, new experiments may be added to the list whenever they are developed.

Note: Minimum of eight experiments must be carried.

**References**

1. Experiments in Nuclear Science, ORTEC Applications Note. ORTEC (1971)
2. Practical Nucleaonics by F.J.Pearson and R.r.Dsborne
3. Experimental Nucleaonics by E.Bleuler and G.J.Goldsmith, Rinehart
4. The Atomic Nucleus by R.d.Evans
5. Any other book suggested by the course teacher

## M.Sc. Physics (Semester IV) (CBCS)

COURSE: QUANTUM MECHANICS II (PH HCT 410)

Unit 1 **Time-dependent phenomena** 14 hrs

Perturbation theory for time evolution, first and second order transition amplitudes and their physical significance. Application of first order theory: constant perturbation, wide and closely spaced level-Fermi's golden rule, scattering by a potential. Harmonic perturbation: interactions of an atom with electromagnetic radiation, dipole transitions and selection rules; spontaneous and induced emission, Einstein A and B coefficients. Sudden approximation.

Unit 2 **Identical particles and spin** 14 hrs

Indistiguishability of identical paricles. Symmetry of wave function and spin, Bosons and Fermions. Pauli exclusion principle. Siglet and triplet state of He atom and exchange integral spin angular momentum, Pauli matrices.

**Angular momentum**

Definition, eigenvalues and eigenvectors, matrix representation, orbital angular momentum. Addition of angular momenta, Clebsch-Gordon coefficients for simple cases.–$j_1$= ½, $j_2$ =½ and $j_1$= 1, $j_2$ = ½.

**Symmetry principles**

Symmetry and conservation laws, symmetry and degeneracy. Space-time symmetries.

Unit 3 **Relativistic wave equations** 14 hrs

Schrodinger's relativistic equation: free particle, electromagnetic potentials, separation of equations, energy level in a coulomb field.

Dirac's relativistic equation: free particle equation, Dirac matrices, free particle solutions, charge and current densities. Electromagnetic potentials. Dirac's equation for central field: spin angular momentum, approximate reduction, spin orbit energy. Separation of the equation. The Hydrogen atom, classification of energy levels and negative energy states.

Unit 4 **Quantization of wave fields** 14 hrs

Classical and quantum field equations; coordinates of the field, classical Lagrangian equation, functional derivative; Hamilton's equations, quantum equations for the field; Quantization of non-relativistic Schrodinger wave equation: classical Lagrangian and Hamiltonian equations. Second quantization.

**References**

1. Quantum Mechanics: L. I. Schiff (McGraw-Hill, 1968)
2. Quantum Mechanics: F. Schwabl (Narosa, 1995)
3. A Text Book of Quantum Mechanics: Mathews and K Venkateshan.
4. Quantum Mechanics: V.K. Thankappan (Wiley Eastern, 1980)
5. Quantum Mechanics:B.K.Agarwal and Hariprakash (P-H, 1997)

## M.Sc. Physics (Semester IV) (CBCS)

COURSE: ANALYTICAL TECHNIQUES AND INSTRUMENTATION
(PH HCT 420)

Unit 1 **Spectrophotometry** 14 hrs

Ultra-violet, visible, infrared, raman, fluorescence and atomic absorption spectrophotometry.

**Thermal analyses**

Differential Thermal Analysis (DTA); Differential Scanning Calorimetry (DSC); Thermo Gravimetric Analyses (TGA).

**X-ray spectrometry**

X-ray Diffraction (XRD) techniques and associated instrumentation.

Unit 2 **Electron and ion spectroscopy** 14 hrs

Auger Electron Spectroscopy (AES), Scanning Electron Microscopy (SEM); Transmission Electron Microscopy (TEM). Scanning Tunnelling Electron Microscopy (STEM). Ion Spectroscopy, Secondary Ion Mass Spectroscopy (SIMS), Ion Scattering Spectroscopy (ISS).

Unit 3 **Optical techniques** 14 hrs

Refractometry, palarimetry.

**Electric and dielectric techniques**

Impedance, dielectric constant and dielectric loss measurements using impedance analyzers.

**Magnetic resonance spectroscopy**

Nuclear Magnetic Resonance (NMR), Electron Paramagnetic Resonance (EPR), Electron Spin Resonance (ESR).

Unit 4 **Nuclear techniques** 14 hrs

Nuclear activation analysis, isotope tracer methods, Mossbauer spectroscopy, neutron diffraction, positron annihilation.

**Low temperature techniques**

Production and measurement of low temperatures: liquification of gases ($H_2$, $N_2$ and $O_2$), cryostats, refrigerators.

**Vacuum techniques**

Production and measurement of vacuum.

**References**


1. Handbook of Analytical Instruments, R.S.Khandpur, Tata McGraw-Hill.
2. Istrumental method of analysis, Willard, Merritt, Dean and Settle, CBS Publishers and Distributors, Delhi.
3. Instruments methods of Chemical analysis, Chatwal and Anand, Himalaya Publishing House.
4. Methods of Experimental Physics Vol. 14 A and B, edited by Dudley.
5. Experimental Spectroscopy by Sawyer.

## M.Sc. Physics (Semester IV) (CBCS)

COURSE: Project (PH HCT 430)

1. Project work must be carried out at the rate of 8 hours per week under the guidance of a course teacher. Through project work, students are expected to acquire some skills in research (theory or experiment). At the end of the study every student shall have to submit a written project report which would be assessed for 200 marks (project report for 150 marks plus viva-voce examination for 50 marks).

   Both project report and viva-voce examinations must be assessed by two examiners drawn from the panel of examiners prepared by the BOS.