Department of Physics

B.Sc. Physics(Hons.)

Syllabus

Semester I

Paper Code: PH31011T **Marks: 100**

Module A: Mathematical Methods I

Course objective: To develop the foundations of vector calculus in three dimensions, using Cartesian coordinates. The techniques learnt in this module is a basic requirement for all learners taking up the study of physics at an advanced level. Students are exposed to the use of computers to aid in the visualization of the concepts learnt in the module. After undergoing this course, the student is expected to

(1) Be able to formulate and solve advanced problems which yield to the techniques of vector algebra.
(2) Understand how transformation laws are formulated using matrices and acquire an elementary notion of symmetries associated with the transformations.
(3) Develop facilities in application of the ideas of vector algebra and vector functions to the study of two and three dimensional curves and surfaces.
(4) Understand the notion of vector differential operators and their physical content.
(5) Learn and make use of suffix notation in the identities of vector algebra and calculus.
(6) Understanding heuristic proofs of integral theorems of vector calculus and their simple applications.

Syllabus: Brief review of the elementary notions of vector algebra including and up to the notion of cross products. Transformation of vectors: Active vs. Passive viewpoints, orthogonal transformations: Rotation, Inversion and Mirror reflection, True and Pseudo scalars and vectors, Parity, Vector Calculus: Differentiation and integration of vectors, application of vectors to the study of lines and surfaces. [10 lectures]

The use of Tensor notation for the representation of various products, the epsilon-delta rule and its use for the validation of vector identities. (Tensor notation should be used only as an aide for formal manipulation of vector identities). [4 lectures]

Representation of spatially varying physical quantities by Fields and the ideas of Gradient, Divergence and Curl, Product rules, The Integral theorems of Gauss, Green and Stokes (heuristic proof only), Evaluation of Line, Surface And Volume Integral of Fields in Cartesian Systems.

[10 lectures]

List of Books:

(1) Mathematical Methods in the Physical Sciences by Mary L. Boas.
(2) Vector Analysis by Murray R. Spiegel

(3) Advanced Engineering Mathematics by Erwin Kreyszig
(4) Mathematical Methods for Physics and Engineering by Hobson, Riley & Bence.
(5) Calculus, Concepts & Contexts (2^{nd} edition, Chapter 9) or
(6) Thomas' Calculus by Thomas, Weir, Giordano & Hass

Module B: Matter and Motion I

Course Objective: Mechanics lies at the foundation of physics and along with an appreciation of the molecular structure of matter exposes the student to the phenomenology of physics. In this course the student

(1) Acquires a thorough understanding of the principle of superposition which lies at the basis of understanding vibrations.
(2) Understands the forced oscillator and the ideas of resonance.
(3) Becomes familiar with a system of coupled oscillators and normal modes.
(4) Understands the elastic properties of matter and the limits of elastic behavior.
(5) Gains an appreciation of surface phenomena and the concept of energy involved in the creation of new surfaces.

Syllabus:

Physics of Vibrations: Free and forced oscillations of a Harmonic Oscillator, resonance, sharpness of resonance. A pair of linearly coupled oscillators – eigenfrequencies and normal modes (Matrix mode of analysis not required here). Superposition of perpendicular oscillations, Lissajous figures, Vibrational characteristics of a weakly anharmonic oscillator: generation of harmonics and phase shift. [10 Lectures]

Superficial and Bulk properties of matter:

Molecular model of matter: Surface Tension, Surface energy, the angle of contact between surfaces, capillary phenomena, excess pressure on a curved liquid membrane, dependence of surface tension on external factors. [6 lectures]

Continuum model of matter: Elastic properties, the notion of shear, description of deformation: the Stress and strain tensors, thermodynamics of deformation, Hooke's law, different moduli of elastic and their interrelations for an isotropic solid, Torsion of cylindrical wires, energy associated with strain, elastic properties of liquids and gases, Flexural rigidity: bending of beams loaded at the centre. [8 lectures]

List of Books:

(1) Advanced Acoustics by D.P. Raychaudhuri
(2) Waves by F.S. Crawford (Berkeley Physics Course, Vol. – 3)
(3) Classical Mechanics and General properties of matter by D.P. Raychaudhuri and S.N. Maiti
(4) Classical Dynamics of particles and systems by S.T. Thornton and J.B. Marion

Paper Code: PH31021T **Marks: 50**

Module A: Electrostatics-I and Electrical Networks

Course Objectives: The course aims in introducing the basic concepts in electrostatics to students and help in developing problem solving skills. Students gain in depth knowledge of the various methods of analyzing the behavior of electrical circuits with d.c. and a.c. sources. An exposure to different network theorems helps in electrical network analysis and performing/designing experiments effectively. The overall aim is to provide comprehensive knowledge and understanding in the relevant fields and enable students to pursue the subject at an advanced level later.

Syllabus: The potential and intensity in electrostatic fields due to discrete/continuous charge distributions: formulation and application of Gauss' theorem. The unique nature of inverse square fields, Electrostatic potential, Energy of continuous charge distributions, electrical image for infinite plane. [10 lectures]

Ohm's law, linear and nonlinear circuit elements, Ideal and practical current voltage sources, potential divider, analysis of series-parallel networks using KCL, KVL, nodal analysis, DC network theorems: Superposition, Reciprocity, Compensation, Thevenin, Norton, Maximum Power Transfer Theorem and MIllman Theorem and its applications, Sensitivity of Wheatstone bridge, Capacitors and Inductors as circuit elements: Transient response. A.C. circuits, A.C. bridges – Anderson bridge, Impedance, Resonance in sinusoidally driven circuits, RLC differentiators and integrators. [14 lectures]

List of Books:

(1) Electricity & Electronics by D.C. Tayal
(2) Introduction to Electrodynamics by D.J. Griffiths
(3) Electrical Technology by Theraja & Theraja (Vol. 1)
(4) Electricity, Magnetism & Electromagnetic Theory by S. Mahajan & S. Rai Choudhary
(5) Electricity & Magnetism by A. Mahajan & A. Rangawala

Module B: Lab I (Practical Exam will be conducted at the end of Semester II)

Semester II

Paper Code: PH32031T **Marks: 100**

Module A: Math Methods II

Syllabus: Cartesian, spherical polar and cylindrical polar coordinates and their interrelations, expression for vector operators in these systems (proof not required). Evaluation of Line, Surface and Volume Integral of Fields in simple symmetric cases involving spherical and cylindrical systems. [12 lectures]

The Delta function: properties and simple representations including the divergence of the inverse square field. [4 lectures]

Applications of Taylor series expansions, first and second order linear differential equations with constant co-efficients. Nonlinear first order equations, solution by the method of isoclines and Taylor series expansion. [8 lectures]

Module B: Matter and Motion II

Syllabus:

Mechanics of a single particle: Frames of reference, velocity and acceleration of a particle in plane polar, spherical polar and cylindrical polar coordinates, Newton's laws of motion, Force fields: Time and path integral of force, Work, energy, conservative force, concept of potential, dissipative force. [5 lectures]

Gravitation: Motion under central force, nature of orbits in an attractive inverse square field, Newton's laws of gravitation, Intensity and potential, Gauss' law discussion of tidal effects, Kepler's laws of planetary motion [5 lectures]

Fluid Dynamics and viscous flows: Ideal fluids: Streamlines and flowlines, equations of continuity, Euler's equation of motion, streamline flow, Bernoulli's equation and its application. Newtonian and non-Newtonian fluids, viscosity, coefficient of viscosity, critical velocity, Reynold's number, Poiseuille's equation for incompressible fluids, correction terms, Stokes' law, terminal velocity, effect of temperature on viscosity. [9 lectures]

List of Books:

(1) Classical Mechanics by John R. Taylor
(2) Classical Dynamics of particles and systems by Stephen T. Thornton and Jerry B. Marion
(3) Theoretical Mechanics by Murray R. Spiegel
(4) Introduction to Classical Mechanics by Takwale and Puranik

Paper Code: PH32041T **Marks: 50**

Module A: Thermal Physics I

Theory of probability distributions: The notion of probability, random variables: expectation values, variance, discrete and continuous probability distributions, binomial, Posisson and Gaussian distribution functions – simple examples. [8 lectures]

Kinetic theory of gases: Towards a microscopic theory of matter, basic assumptions, ideal gas approximation, the perfect gas equation of state. The random nature of molecular collisions, Maxwell's distribution, finite size effects: Mean free time and paths, degrees of freedom of molecular configurations and the law of equipartition of energy. Intermolecular interaction in real gases: The Virial EOS (Equation of state): virial coefficients and Van der Waal's equation of state: Critical constants, law of corresponding states, Boyle temperature, Limitations of the Van der Waal's EOS. Transport phenomena: Molecular explanation of viscosity thermal conduction and diffusion in gases, the phenomenon of Brownian motion and its significance.

[16 lectures]

Module B: Lab II (Practical Exam will be conducted at the end of Semester II)

Semester III

Paper Code : PH33051T **Marks: 100**

Module A: Math Methods III

Syllabus: Partial Differential Equations: Formulation of problems that lead up to the wave, diffusion and Laplace's equation in Cartesian coordinates. The solution of Boundary Value Problems belonging to the above class using the method of separation of variables. Formulation and solution of axisymmetric problems in spherical and infinite cylinder problems in cylindrical polar coordinate systems. Solution of equations with non-constant coefficients using the Frobenius Method. Orthogonal Functions: Solution of Legendre and Hermite equations about x = 0. [14 Lectures]

Fourier Series and Fourier Integrals: Piecewise continuous functions, Periodic functions and the Dirichlet conditions for expanding them in a harmonic series of sines, cosines and complex exponentials. Fourier integrals and Transforms: Transforms of simple pulses like the delta peak or triangular peak. Wave packets and the bandwidth theorem. [10 Lectures]

List of Books:

(1) Advanced Engineering Mathematics by Erwin Kreyszig
(2) Mathematical Methods in the Physical Sciences by Mary L. Boas
(3) Mathematical Methods for Physicists by Arfken and Weber
(4) Fourier analysis by M.R. Spiegel

Module B: Electronics I

Course Objective: In this course the student will learn

(1) Concepts of semiconductor materials.
(2) Calculation of carrier concentration in the intrinsic and extrinsic semiconductor.
(3) P-n junction formation and behavior of the junction in different external bias condition.
(4) Normal diodes and their uses in electronic circuits.
(5) Heavily doped diodes and zener and avalanche breakdown in electronic circuits.
(6) Concept of bipolar junction transistor and its characteristics in different mode of operation.
(7) Concepts of Q point and load line.
(8) Concept of digital electronics.
(9) Boolean algebra, implementation of basic gates using diode and transistors, EX-OR gate, Half adder and Full adder.

Syllabus: Diodes: Intrinsic and extrinsic semiconductors, current carriers, current conduction, (mobility, conductivity, diffusion). P-N junction, space charge and electric field distribution at an unbiased junction, junction capacitance. Forward and reverse characteristics, Schottky relation, diode resistance. Avalanche and Zener breakdown. Zener diode as a voltage regulator. C and L-section filters, Bridge rectifier with C and L filter.

BJT: Current components, generalized transistor equation, dependent and independent variables in CB and CE connections, characteristic curves, α and β of a transistor and their relations. CE output characteristics, load line and Q-point.

Digital Electronics: Boolean algebra, Implementation of basic gates using diode and transistors, EX-OR gate, Half adder and Full adder. [24 Lectures]

List of Books:

(1) Semiconductor Physics and Devices by Donald A. Neamen (Tata McGraw-Hill)
(2) Solid State Electronic Devices by G. Streetman and S. Banerjee (PHI)
(3) Electronic Devices and Circuit Theory by R.L. Bollestad and L. Nashelsky (PHI)

Paper Code: PH33061T **Marks: 50**

Module A: EM Field I

Syllabus: Conductors: Basic properties, force on a surface charge, capacitors, Electrostatic Fields in Matter: Dielectric Polarization, the electric displacement D, Linear dielectrics.

Magnetostatics: Lorentz force, Biot-Savart Law, The Divergence and Curl of B, Ampere's law, Magnetic vector potential, Comparison of Electrostatics and Magnetostatics, Magnetostatic Fields in matter, Magnetization, Field of a magnetized object, The Auxiliary field H, Linear and Nonlinear Media, Ferromagnetism, Hysterisis, Boundary conditions for B and H. Current Electricity: Ohm's law, EMF, Motional EMF and Faraday-Lenz's laws: Inductors, Calculation of self and mutual inductances in simple cases. [24 Lectures]

List of Books:

(1) Introduction to Electrodynamics by David J. Griffiths
(2) Electricity and Magnetism by Chattopadhyay and Rakshit

Module B: Lab III (Practical Examination will be conducted at the end of Semester IV)

Semester IV

Paper Code: PH34071T **Marks: 100**

Module A: Classical Mechanics I

Motivation for studying the canonical formalism: constraints of motion, examples of constrained dynamical systems: calculation of their degrees of freedom and the notion of generalized coordinates. Virtual displacements and the D'alembert's Principle, Illustrations of the Lagrange's equation. [10 Lectures]

Mechanics of system of particles: Expressions of linear and angular momentum, descriptions of the centre of mass motion, motion of particles in force fields, conservation of laws of momentum and energy. [5 Lectures]

Variational calculus: Idea of a functional and its extrema, illustrative examples: brachistochrone problem and the shortest distance between two points in a plane. The principle of least action: Euler Lagrange equation of particle dynamics. [9 Lectures]

Module B: Waves and Geometrical Optics

Physics of wave propagation:

Study of plane wave progressive waves in 1 dimension. Waves in 2-3 dimensions, characteristic features of a spherical wave, Intensity of a plane wave field. Superposition of waves: Huygens' Principle: Deduction of the laws of reflection and refraction. Stationary waves and Interference phenomena. Oscillations of a stretched string, Wave propagation in isotropic fluids and solids. Doppler effect, Propagation of waves in a medium with speeds exceeding the speed of light/sound in that media: Cerenkov radiation and ultrasonics. Dispersion in wave propagation, wave packets, group and phase velocity. [15 Lectures]

Ray optics:

Fermat's principle, Matrix method in paraxial optics, lens systems, Dispersion: Dispersive power of prisms, Chromatic aberration. Theory behind the construction of optical systems: methods of reductions of chromatic and Seidel aberrations (including a qualitative discussion of their nature and causes). Microscopes, Telescopes and Eyepieces – Ramsden and Huygens. [9 Lectures]

Paper Code: PH34081T **Marks: 100**

Module A: EM field II

Electrostatic and magnetostatic boundary condition, Multipole expansions of the vector potential, Formulation of Maxwell's equations and of EM waves. Maxwell's correction to Ampere's law, displacement current, Electrodynamic boundary conditions, Maxwell's Field equations, Poynting theorem, Poynting vector. Wave equation for the EM fields in vacuum: transverse nature, Energy and momentum carried by EM waves, Propagation through linear media: reflection and transmission coefficients, Fresnel formula.

EM waves in conductors: attenuation and skin depth, reflection and transmission. Dispersion in Nonconductors: The damped driven radiator, normal and anomalous dispersion, Cauchy's formula, Rayleigh scattering. [24 Lectures]

Module B: Physical Optics

Interference of light waves: Intensity distribution in Young's experiment, concept of spatial and temporal coherence, coherence time and coherence length. Examples of interference by division of amplitude: interference in thin films and wedges, Newton's rings, interference by division of wavefront: Fresnel's biprism.

Diffraction of light waves: Bending of light near obstacles and spreading out from small apertures.

Fresnel Diffraction: Theory of half period zones for plane waves, explanation of rectilinear propagation of light, zone plates.

Fraunhofer Diffraction: Diffraction pattern due to a single slit, double slit, circular aperture (qualitative) and plane transmission grating. Rayleigh criterion of resolution, resolving power of prism and transmission grating. Resolving power of telescopes and microscopes.

Polarization: Different states of polarization, double refraction, Huygens' construction for uniaxial crystals, polaroids and their uses. Production and analysis of plane, circularly and elliptically polarized light by retardation plates and rotary polarization and optical activity, Fresnel's explanation of optical activity: Biquartz and half shade polarimeter.

[24 Lectures]

Paper Code : PH34091T **Marks: 50**

Module A: Quantum Physics

The limitations of existing theories of blackbody radiation: Planck's hypothesis and its successes, Einstein's explanation of the photoelectric effect – validation of the quantum nature of radiation (photon). Existence of discrete energy states within atoms: Franck and Hertz experiments, De Broglie's explanation. Electron waves from Davissson-Germer and G.P. Thomson's experiments. Basic statement of the Heisenberg uncertainty principle: Order of magnitude of α, β energies within the nucleus. Basic statement of the energy-time uncertainty relation: relation with the lifetime of excited states, Gamma ray microscope (thought experiment), Classical vs. Quantum Particles. [24 Lectures]

Module B: Lab IV (Practical Examination will be conducted at the end of Semester IV)

Paper Code: PH34101T **Marks: 100**

Laser Physics and Fiber Optics

Module A: Spontaneous and stimulated emission. Einstein's A and B coefficients. Basic components of a laser: active medium, optical resonator, pumping source. Threshold condition for oscillation. Laser cavity modes, Curved mirror cavities. Cavity stability criteria – statement, Properties of Gaussian beams. Beam waist. Laser rate equations for three-level and four-level systems. Examples: He-Ne laser, Ruby laser, CO_2 laser. Line broadening mechanisms. Laser pumping techniques. Modes of a rectangular cavity and the open planar resonator. The quality factor. Mode selection. Q-switching. Mode-locking in lasers. Semiconductor Lasers, tunable lasers, Optically induced band-band transitions in semiconductors. Diode lasers.

[36 Lectures]

Module B: Fiber Optics. Advantages of glass fibres. The coherent bundle. Numerical aperture. Ray propagation in step-index and graded-index fibers. Effect of material dispersion. Multimode fibers and single mode fibers. Block diagram of a fiber optic communication system. Fiber fabrication methods. Fiber splices and fiber optic connectors. Losses in fibers, Link Budget calculation. [12 Lectures]

PH34112T

Theoretical Physics (Non Linear dynamics)

Module A: Introduction: Essential nonlinearity of physical phenomena. Examples of physical systems exhibiting nonlinearity. The damped driven pendulum: Expected features, approach to chaos through the period doubling route. [12 Lectures]

Module B: Discrete time problems: The logistic map, Bifurcation, State space methods: orbits , tests for stability, Poincare sections, Chaos and sensitivity to initial conditions: Liapumov exponents. [12 Lectures]

PH34112P

Module C: Computer/Hands on Experiments related to the theory: Twelve computer sessions, with two periods for each session. [24 Lectures]

Semester V

Paper Code: PH35111T **Marks: 100**

Module A: Thermal Physics II

The Macroscopic and microscopic viewpoints, Unchanging states and thermodynamic variables, Thermal equilibrium: Zeroth Law and the concept of temperature. Thermodynamic equilibrium: Quasitatic processes, Internal Energy and the First law, application to hydrostatic systems, ideal gas, magnetic and other two parameter systems. Real vs. Reversible processes, Kelvin-Planck and the Clausius statements of the Second law, Carnot's cycle and Carnot's theorem, The absolute temperature scale, Clausius Inequality, Definition of entropy, calculation of entropy changes and the Entropy version of the second law, Unavailable energy. [14 Lectures]

The approach to thermal equilibrium via different processes and the introduction of thermodynamic potentials, Free energies. Maxwell relations: Simple deductions using these relations. The theory of phase transitions: Multi-component systems , Phase diagrams: Phase equilibrium curves and the triple point. Gibbs' phase rule and simple applications. Ehrenfest criteria and classification of phase transitions. First order phase transitions, Latent Heat, Clausius-Clapeyron's Equation. The Joule-Thomson effect and its application to cooling: inversion temperature. [10 Lectures]

Module B: Classical Mechanics II

Hamiltonian formulation of classical mechanics, Hamilton's equation of motion and its applications. Basic canonical transformation theory, Examples. Poisson brackets: identities, fundamental Poisson bracket under canonical transformation and its application.

Non-Inertial frames of reference, Rotating frames, Coriolis and centrifugal forces, simple examples.

Kinematics of rigid body motion, angular momentum & kinetic energy of rotation, Moment of Inertia Tensor, Perpendicular and Parallel axis transformations, Force free motion of rigid bodies: Euler's equations [24 Lectures]

Paper Code: PH35121T **Marks: 100**

Module A: Special Relativity

Special Relativity: Historical Perspective: Limitation of Galilean Transformation, significance of Michelson-Morley and Fizeau's experiments, Einstein's Postulates, Heuristic deduction of the Lorentz transformation equations, Clock synchronization, Length contraction and time dilation, the relativity of simultaneity, velocity addition rule.

The Geometry of Space-time, Coordinates of an event, 4-vectors, Invariance of the interval, Space-time Diagrams – World Lines, regions of spacetime, the Lorentz transformation and the velocity parameter, momentum and energy in units of mass/energy, the momentum energy 4 vector, equivalence of energy and rest mass. Relativistic dynamics: applications to particle interactions. [24 Lectures]

Module B: Quantum Mechanics I

Free Particle – Plane wave Correspondence, Dispersion relation for matter waves, Spatially confined matter and wave packets, Equation satisfied by massive particles – Schrödinger's equation. Bandwidth theorem and the Heisenberg uncertainty principle, evolution of wave packets, collapse of the wave function.

Stationary states: The infinite Square well, Free particle and the Delta-Function Potential, Finite square well and potential barriers – transmission and tunneling through barriers. The Harmonic oscillator: Formulation of the problem using Creation and Annihilation Operators. Solution using Hermite polynomials. [24 Lectures]

Paper Code: PH35131T **Marks: 100**

Module A: Atomic and Molecular Physics

Atoms and light in a magnetic field, orbital magnetic moments, the Stern-Gerlach experiment, the Vector atom model, properties of electron spin, magnetic resonance, addition of orbital and spin angular momenta, the spin-orbit interaction, the Zeeman effect: Normal and Anomalous, the Pauli exclusion principle, the ground states of atoms and the periodic table, electron antisymmetry, the helium atom, alkali atoms. Molecules: Rigid diatomic molecule, Rotation, Vibration and Electronic Spectra. [24 Lecture]

Module B: Electronics II

[Analog Electronics]

Amplifier: h-parameter analysis of the CE amplifier: current , voltage and power gains, input and output impedances, effect of source resistance, comparison of CB,CE and CC amplifiers, Emitter follower and other transistor circuits.

Feedback amplifiers: Voltage and current gain, principle of feedback, positive and negative feedback, advantages of negative feedback, multistage amplifier, frequency response of a two-stage R-C coupled amplifier, gain and bandwidth and their product.

Oscillators: Barkhausen criterion for sustained oscillation, L-C and Wien bridge oscillators.

Operational amplifiers: Properties of an ideal OPAMP, differential amplifiers, CMRR, inverting and non-inverting amplifiers, mathematical operations. [24 Lectures]

Paper : Lab V (Practical Examinations will be conducted at the end of Semester VI)

Semester VI

Paper Code: PH36141T **Marks: 100**

Module A: Quantum Mechanics II

Linear algebra: Function Spaces, Inner product, Operators as linear transformations, Hermiticity, Hermitian Eigensystems. Formalism of Quantum Mechanics: Hilbert space, States and Observables. Bra-Ket algebra, Axiomatic foundation of Quantum Mechanics: Continuous basis states: Coordinate and Momentum space wave function, the uncertainty principle and the minimum uncertainty wave packet.

Quantum Dynamics – Schrödinger and Heisenberg picture. Theory of angular momentum: Formulation using Ladder operators, Form of angular momentum wave functions for spherical symmetry in terms of associated Legendre polynomials.

The Central force problem and the Hydrogen atom. [24 Lectures]

Module B: Solid State Physics

Crystallography: Crystalline and amorphous solids, Translational and rotational symmetry, Lattice and Basis, fundamental types of lattice in two and three dimensions, lattice systems, unit cell, primitive lattice vectors, packing fraction, Miller indices, Crystal planes and directions, Reciprocal lattice vectors, Crystal diffraction by X rays, Laue and Bragg equations, Electron Diffraction by Crystals.

Binding forces in solids: Van der Waal’s, ionic, covalent and metallic bonding, Band Theory of Solids, Kronig-Penney model, energy band structure – idea of conductors, insulators and semiconductors, effective mass, Free electron theory of metals, drift current, mobility and conductivity, Widemann Franz Law, Hall effect in metals and semiconductors.

Magnetic materials: Classification of magnetic materials, Dia, Para and Ferro-magnetic properties of materials, Larmor precession, Langevin’s theory of diamagnetism, Classical and Quantum theory of paramagnetism – Curie’s law, spin and spontaneous magnetization and ferromagnetism, Curie Weiss law, Exchange interaction (qualitative), Domain structure and Hysterisis. [24 Lectures]

Paper Code: PH36151T **Marks: 100**

Module A: Nuclear Physics

Nuclear Structure, Properties and reactions and masses, ground state properties of nuclei, Models: Liquid drop and shell model (simple features). Nuclear radioactivity: Alpha, Beta and Gamma emissions. Alpha decay and spontaneous fission, nuclear reactions.

Nuclear Instrumentation: Basic theory of cyclotron, synchrotron, electron storage ring and linear accelerator, GM counter, semiconductor detectors for charged particles and gamma rays.

Elementary Particles: Fundamental forces and Particle interactions: Elementary particles: Leptons, Quarks and Mediators. Hadrons: Baryons and Mesons. Antiparticles, Neutrinos, Symmetries and Conservation Laws, Quantum numbers: Parity, Charge Conjugation, Time reversal. Exact vs. Approximate conservation Laws. Strange Particles. The Quark structure of hadrons. [24 Lectures]

Module B: Thermal Physics III

Unique features of Macroscopic Systems: Thermodynamic vs. Statistical Approach. Phase Space. Calculation of phase volumes. Microstates and macrostates, statistical weight of a macrostate, ensembles: PEAPP (Postulate of equal a priori probability). Equilibrium of an isolated system (microcanonical ensemble) – The entropy connection. Equilibrium of a system in a Heat Bath (The canonical ensemble), the partition function, averages of thermodynamic quantities, fluctuations, general definition of entropy.

Bose-Einstein and Fermi-Dirac Statistics (using state counting), the classical limit and its region of validity, reduction to Maxwell distribution, comparison between photon, phonon, electron and the ideal gas, Entropy of mixing, Gibbs' paradox. Applications: Paramagnetic solid in a heat bath, Heat capacity of solids, Equipartition theorem. Blackbody radiation, Electronic heat capacity of metals. [24 Lectures]

Paper : Lab VI

Paper : Project

Syllabus for Practical Papers

Sem I: Module B: Lab I

LP1a. Principles of laboratory practice: Effective ways to record and present data and analysis, Theory of Errors, Concept of absolute and relative errors, estimation of errors contributed by various factors in any specific experiment. Plotting functions and plotting best-fit curve out of a dataset using GNUPLOT. [6 Lectures]

LP1b. Initiation to different methods of laboratory measurements: Demonstrations and handling instructions of basic measuring instruments. Practice of simple experiments like:

1. Measurements with slide calipers/ screw gauge/ travelling microscope/ spherometer.
2. To draw the current-voltage characteristics of a resistor and a p-n diode/ Measurements with a breadboard including electronic components)/ Analog and Digital meters/ Use of rheostat for constructing potential divider arrangement.
3. Determination of the moment of inertia of a regular solid body.
4. To measure the focal length of a convex lens by displacement method.
5. Spectrometer: To measure angle of prism and determine refractive index of the material.

Sem II: Module B: Lab II

LP2. Methods of laboratory measurements:

1. Determination of Young's modulus by flexure method.
2. Determination of thermal conductivity.
3. To verify Thevenin and Norton's theorem theorem and the maximum power transfer theorem using Wheatsone's Bridge.
4. To draw the resonance curve of a series/parallel LCR circuit and hence to determine the Q factors.
5. Verification of Stefan's law.
6. To draw the (μ - λ) curve of a prism and to verify Cauchy's dispersion relation.

Practical Paper Code: PH32511P (Exam at the end of Semester II) **Marks: 100**

Sem III: Module B: Lab III

LP2 Methods of laboratory measurements:

Demonstration of CRO

1. To study the reverse characteristics of a zener diode and to study the line and load regulation.
2. To study transistor characteristics in CE and CB mode.
3. To determine Fourier spectrum of (i) square, (ii) triangular and (iii) half rectified sinusoidal waveform.
4. To study the performance of a bridge rectifier and its regulation characteristics with and without filter.
5. To draw the calibration curves (sin θ-λ) of optical sources using a plane transmission grating.
6. Measurement of Thermal Relaxation time constant of a serial light bulb.

Sem IV: Module B: Lab IV

LP4. Methods of laboratory measurements:

1. To determine the mutual inductance between a pair of coils using a ballistic galvanometer/ a lock-in amplifier.
2. Principle of different types of a.c. bridges.
3. To calibrate a polarimeter and hence to determine the concentration of an unknown solution.

4. To find the number of lines/cm of a plane transmission grating and hence to measure an unknown wavelength. To measure the separation between the D1-D2 lines of sodium.
5. To study the diffraction and interference patterns of a double slit using a laser.
6. To study the resistivity of a semiconductor using the four-probe method.

Paper Code: PH34521P (Exam at the end of Sem IV) **Marks: 100**

Sem V:

Practical Paper Code: PH36551P (Exam at the end of Sem VI) **Marks: 100**

Module A: Physics Lab V

LP5a. Methods of laboratory measurements:

1. To investigate the magnetic field between the pole pieces of an electromagnet using a ballistic galvanometer and calibration of a Hall probe.
2. Determination of band-gap in semiconductors.
3. To determine an unknown wavelength using a Fresnel's biprism
4. To verify Fresnel's equation.
5. Determination of viscosity of water by Poiseulli's method.
6. To draw the B-H loop of a ferromagnetic material in the form of anchor ring and to study the energy loss.

Sem V: Module B: Computer Lab I

PC5b. Numerical Computation – I:

The Fortran-90 Language Subset: syntax and semantics, programming styles, F90 specific working style, declaratives, assignments, array handling, I/O, Arithmetic and Logical Operators, logical variables, looping (iteration) and branching (decision) operations, reading, writing, redirection to and from data files, Practice of writing simple and effective codes: ordering, sorting and searching methods, implementation of matrix operations. [15 Lectures]

Sem VI:

Practical Paper Code: PH36541P (Exam at the end of Sem VI) **Marks: 100**

Module A: Physics Lab VII

LP6a. Methods of laboratory measurements:

1. To design a series regulated power supply and to study its performance characteristics.
2. To measure the offset parameters of an OPAMP. To study the use of an OPAMP as (i) an inverting (ii) a non-inverting amplifier, (iii) an adder and (iv) a differential amplifier. To study the performance of an OPAMP (i) integrator, (ii) differentiator and (iii) Schmitt trigger.
3. To determine mid-band gain in the mid-frequency region of a CE amplifier and to find its band-width.

4. To design a Wien-bridge oscillator of a given frequency of oscillation and to study the stability of the amplitude of oscillation and the performance of the lead-lag network.
5. Verification of truth tables for basic logic gates using discrete components and also with ICs. Verification of De Morgan's theorems. NAND/NOR as universal gate. Verification of some logic identities. Implementation of SR Flip Flop.
6. Verification of Curie-Weiss law of a ferroelectric material and temperature dependence of a Ceramic capacitor.

Sem VI: Module B: Computer Lab II

PC6b. Numerical Computation – II:

Application of the Fortran-90 Language Subset to some portion of numerical analysis module that is covered in SEM-III under compulsory anciliary paper (Mathematics): Numerical errors, Univariate interpolation (Newton's forward and backward interpolation, Lagrange's interpolation), Series sums and numerical integration (Trapezoidal method and Simpson's 1/3 rule) [15 Lectures]

Sem VI: Paper Code: PH36533P Project Marks: 100