BPHE-101 ELEMENTARY MECHANICS 2 Credits

Kinematics of Motion: Displacement, Velocity and Acceleration; Uniform Circular Motion, Relative Motion.

Dynamics of Motion: Force, Newton's Laws of Motion, Law of Gravitation; Principle of Superposition; Applications of Newton's Laws; Equilibrium of Forces; Linear Momentum, Conservation of Linear Momentum; Impulse; Motion with Variable Mass, Rocket Motion; Gravity and its Variation, Velocity of Escape; Fundamental Forces in Nature.

Work and Energy: Work done by a Constant Force, and a Variable Force; Kinetic Energy and Work-Energy Theorem, Potential Energy and Conservative Forces, Principle of Conservation of Energy, Energy Diagrams; Elastic and Inelastic Collisions; Power.

Angular Motion: Kinematics of Angular Motion: Angular Displacement, Angular Velocity and Angular Acceleration, Use of Plane Polar Coordinates for describing Circular Motion and General Angular Motion, Relations between Linear and Angular Kinematical Variables; Dynamics of Angular Motion; Torque, Kinetic Energy of Rotation; Angular Momentum, Conservation of Angular Momentum and its Applications.

Many Particle Systems: Central Conservative Forces: Properties of Motion under Central Conservative Forces; Inverse Square Central Conservative Forces; Inverse square Gravitational Force; Motion of Two-Body Systems, Equation of Motion in Centre-of-mass and Relative Coordinates, Linear and Angular Momentum and Kinetic Energy.

Dynamics of Many-Particle Systems: Linear Momentum, Angular Momentum and Kinetic Energy of an N-particle System.

Rigid Body Dynamics: Translational, Rotational and General Motion of a Rigid Body; Moment of Inertia; Rotational Dynamics of a Rigid Body, Rotational Analogue of Newton's Second Law, Work and Energy in Rotational Motion; Gravitational Potential Energy due to Earth as a Solid Sphere; Conservation of Angular Momentum and its Applications, Precession.

Non-Inertial Frames of Reference: Motion Observed from a Non-Inertial Frame, Newton's Second Law and Inertial Forces, Weightlessness; Rotating Frame of Reference: Centrifugal Force, Coriolis Force; The Earth as a Rotating Frame of Reference, Variation of g with Latitude, Motion on the Rotating Earth, Foucault's Pendulum. (Qualitative discussion only)

Appendixes on Vector Algebra, Vectors in One, Two and Three Dimensions, Vector Addition; Calculus, Concept of Derivative and Integral; Products of Vectors; Conic Sections; Moment of Inertia.

BPHE-102 OSCILLATIONS AND WAVES 2 Credits

Simple Harmonic Motion: Oscillations of a Spring-Mass System; Equation of Motion of a Simple Harmonic Oscillator SHM and its Solution; Phase of an Oscillator Executing SHM, Velocity and Acceleration; Transformation of Energy in Oscillating Systems: Kinetic and Potential Energies; Calculation of Average Values of Quantities Associated with SHM; Examples of Physical Systems Executing SHM: Simple Pendulum, Compound Pendulum, Torsional Pendulum, *LC*-Circuit; Principle of Superposition; Superposition of Two Collinear Harmonic Oscillations of Same/Different Frequencies; Oscillations in Two Dimensions; Superposition of Two Mutually Perpendicular Harmonic Oscillations of the Same/Different Frequencies; Lissajous Figures.

Damped Oscillations and Forced Oscillations: Equation of Motion of a Damped Oscillator and its Solutions, Heavy Damping, Critical Damping, Weak Damping; Characterising Weak Damping: Logarithmic Decrement; Relaxation Time, Quality Factor; *LCR*-circuit; Differential Equation of an Undamped Forced Oscillator and its Solution; Differential Equation of a Weakly Damped Forced Oscillator and its Solutions, Steady State Solution, Resonance, Examples of Forced Oscillation and Resonance, Power Absorbed by a Forced Oscillator, Quality Factor; Resonant *LCR*-Circuit.

Coupled Oscillations: Equation of Motion of a Coupled Oscillator comprising Two Oscillators and its Solution; Normal Coordinates and Normal Modes; Modulation and Energy Exchange in Coupled Oscillator; Oscillations of Coupled Pendulums; Forced Oscillations of Coupled Oscillators; Longitudinal Oscillations of N Coupled Masses; Wave Equation.

Basic Concepts of Wave Motion: Formation of a Wave; Graphical Representation of Wave Motion, Relation between Wave Velocity, Frequency and Wavelength; Mathematical Description of Wave Motion: Phase and Phase Difference, Phase Velocity, Energy Transported by Progressive Waves, Intensity and the Inverse Square Law; One-dimensional Wave Equation: Waves on a Stretched String, Waves in Fluid, Waves in Two and Three Dimensions; The Doppler Effect: Source in Motion and Observer Stationary, Source Stationary and Observer in Motion, Source and Observer both in Motion.

Reflection and Refraction of Waves: Wave Motion and Impedance, Impedance Offered by Strings, Transverse Waves, Impedance Offered by Gases, Sound Waves; Reflection and Transmission; Amplitude Coefficients: Transverse Waves, Longitudinal Waves; Reflection and Transmission Energy Coefficients; Principle of Superposition of Waves; Stationary Waves: Velocity of a Particle at any Point in a Stationary Wave, Harmonics in Stationary Waves; Properties of Stationary Waves; Musical Sound and Noise; Wave Groups and Group Velocity; Beats.

BPHL-103	**PHYSICS LABORATORY-I**	**4 Credits**

Unit I	Measurement
Unit II	Error Analysis
Experiment 1	Dependence of the Period of a Pendulum on Length, Amplitude and Mass
Experiment 2	Oscillations of a Spring-Mass System and a Torsional Pendulum
Experiment 3	A Study of Energy and Momentum Conservation Principles
Experiment 4	Relation between Wavelength and Frequency of Stationary Waves
Experiment 5	Determination of Young's Modulus of a Material by Bending of Beams
Experiment 6	Measurement of Low Resistance using Carey Foster's Bridge
Experiment 7	Variation of Thermo-E.M.F. with Temperature
Experiment 8	Frequency Response of AC Series Circui
Experiment 9	Experiments using Semiconductor Diodes
Experiment 10	A Study of Transistor Characteristics
Experiment 11	Measurements with a Cathode Ray Oscilloscope

BPHE-104 MATHEMATICAL METHODS IN PHYSICS 2 Credits

Vector Algebra: Vectors and scalars, Vector Components relative to a Coordinate System (in brief), Transformation of Coordinate Systems and Vector Components, Precise Definition of Three-dimensional Vectors; Analytical Approach to Vector Algebra: Vector Addition and Subtraction, Scalar and Vector Products in Component Form (in brief); Multiple Product of Vectors, Scalar and Vector Triple Products, Quadruple Products of Vectors; Polar and Axial Vectors.

Vector Differential Calculus: Differentiation of Vectors, Vector Functions; Differentiating a Vector with respect to a Scalar, Differentiation of Scalar and Vector Products and Applications; Scalar Field: Definition, Contour Curves and Contour Surfaces, Gradient, Geometrical interpretation of the Gradient, Directional Derivative, Vector Operator ∇; Vector Field, its Divergence and Curl with Physical Meanings, Identities involving the ∇operator; Product Rules in Involving the ∇ operator and Applications, Successive applications of the ∇ operator.

Non-Cartesian Coordinate Systems: Plane Polar Coordinates, Spherical and Cylindrical Polar Coordinates; Expressing a Vector, Differential Elements of Vector Length and Area and Gradient in Non-Cartesian Coordinates; Orthogonality Condition, Unit Vectors, Vector Differential Operators, i.e., Gradient, Divergence, Curl and ∇ in Different Coordinate Systems.

Vector Integration: Integration of a Vector with respect to a Scalar: Integrals involving Scalar and Vector Products of Vectors; Multiple Integrals: Double and Triple Integrals; Line Integral of a Field: Path of Integration, Types of Line Integrals, Evaluation of Line Integrals; Surface Integral of a Field: Surface of Integration, Types of Surface Integrals; Evaluation of Surface Integrals, Volume Integral of a Field: Types of Volume Integrals, Evaluation of Volume Integral; Vector Integral Theorems: Gauss' Divergence Theorem, Stoke's Theorem, Green's Theorem (Statement only and Physical Meaning), Applications in Physics.

Probability Distributions: Random Variable, Expectation and Variance, Covariance and Correlation Coefficient, Binomial and Poisson Distributions, Normal Distribution, Continuous Probability Distributions in Physics.

Statistical Methods: Correlation Analysis; Regression Analysis: Method of Least Squares, Standard Error of Estimate; Statistical Theory of Errors: Types of Errors, Estimation of Random Errors for a Single Variable, Random Error Estimation for Indirect Measurements.

PHE-05 MATHEMATICAL METHODS IN PHYSICS-II 2 Credits

Ordinary Differential Equations: Classification, General and Particular Solution, Existence and Uniqueness of a Particular Solution, General Properties of the Solutions of Linear ODEs; First Order Ordinary Differential Equations: Equations Reducible to Separable Form: Method of Separation of Variables, Homogeneous First Order ODEs; Exact Equations, First Order Linear Differential Equations; Equations Reducible to First Order; Second Order Ordinary Differential Equations with Constant and Variable Coefficients: Basic Terminology; Homogenous and Inhomogenous Linear Equations with Constant Coefficients, The Method of Undetermined Multipliers; Method of Variation of Parameters, Complementary Functions and Particular Integral, Linear Independence, Wronskian, Power Series Solution, Frobenius Method; Applications of ODEs in Physics: Mathematical Modelling; First Order ODEs in Physics: Applications in Newtonian Mechanics, Simple Electrical Circuits; Second Order ODEs in Physics: Rotational Mechanical Systems, Planetary Orbits; Coupled Differential Equations: Coupled Oscillators, Coupled Electrical Circuits, Charged Particle Motion in Electric and Magnetic Fields.

Partial Differential Equations: Functions of More than One Variable; Limits and Continuity, Partial Differentiation, Differentiability; Classification of Partial Differential Equations, General and Particular Solution; Partial Differential Equations in Physics: Method of Separation of Variables, Solution of Initial and Boundary Value Problems; Fourier Series: The Need for Fourier Series, Determination of Fourier Coefficients, Use of Fourier Series: as an Approximation, Even and Odd Functions, Fourier Sine and Cosine Series, Half- range Expansions, The Convergence of Fourier Series; Applications of Fourier Series to Partial Differential Equations: Diffusion Equation: Heat conduction and Diffusion of Particles; Wave Equation, The Plucked String Problem, Torsional Vibrations; Laplace's Equation, Steady State Heat Flow, the Potential Problem.

BPHE-106 THERMODYNAMICS AND STATISTICAL MECHANICS 4 Credits

Kinetic Theory of Gases: Assumptions, Pressure Exerted by a Gas, Kinetic Interpretation of Temperature, Elementary Deductions, Law of Equipartition of Energy, Classical Theory of Heat Capacities, Maxwellian Distribution, Expressions for $\bar{v}, v_p$ and v_{rms}; Mean Free Path, Distribution of Free Paths, Experimental Determination, Transport Phenomenon: Viscosity, Thermal Conductivity, Self Diffusion; Brownian Motion, Einstein's Theory, Langevin's Theory, Avogadro Number, Examples of Brownian Motion; Random Walk (No derivation), Deviations from Perfect Gas Behaviour, Regnault's, Andrews' and Amagat's Experiments, Onnes' Equations of State, Claussius and van der Waals' Equation of State, Critical Constants, Law of Corresponding States; Other Equations of State (No derivations).

Basic Concepts of Thermodynamics, Thermodynamic Processes: Reversible, Irreversible and Quasistatic; Zeroth Law of Thermodynamics, Equation of State, Deductions from the Equation of State; Principle of Measurement of Temperature, Types of Thermometers: Constant Volume Gas Thermometer (concept only), Vapour Pressure Thermometer, Platinum Resistance Thermometer, Thermistors, Thermocouples; Radiation Pyrometers; The International Temperature Scale; Nature of Heat and Work, Internal and External Work, Work done in Different Systems and Processes: Adiabatic and Isothermal Processes, Path Dependence of Work and Heat, Internal Energy, The First Law of Thermodynamics, its Differential Form, Significance and Limitations; Heat Capacities of a Gas, Equation of State for an Adiabatic Process, Adiabatic Lapse Rate: Convective Equilibrium, Adiabatic and Isothermal Elasticities; Enthalpy.

Entropy; The Second Law of Thermodynamics: Equivalence of Different Statements, Entropy Change in Natural Processes, Thermal Death of the Universe and Noise Pollution; The Carnot Cycle: Heat Engines and Refrigerators; The Thermodynamic Temperature Scale; The Thermodynamic Potentials, General Conditions for Thermodynamic Equilibrium; Maxwell's Relations in Thermodynamics; Deductions from Maxwell's Relations, TdS-Equations, Energy Equations, Heat Capacity Equations, Phase Equilibrium, Condition for Equilibrium between Phases, First Order Phase Transitions, Higher Order Phase Transitions, Gibbs' Phase Rule (statement only); Methods of Cooling: Joule-Thomson Effect, Liquefaction of Gases, Liquid Helium; Cooling by Adiabatic Demagnetization; The Third Law of Thermodynamics and its consequences.

Phase Space, Microscopic and Macroscopic States, Thermodynamic Probability, Boltzmann Relation, Classical Distribution Function, Partition Function; Partition Function for a Monatomic Gas, Gibbs Paradox, Sekur-Tetrode Equation, Heat Capacity of Hydrogen Gas, Rotational and Vibrational Partition Functions; Need for Quantum Statistics, Bose-Einstein Distribution Function, Planck's law, Radiation Pressure, Bose-Einstein Condensation, Fermi-Dirac Distribution Function, Degenerate Fermi System, Fermi Energy, Electronic Heat Capacity.

PHE-07 ELECTRIC AND MAGNETIC PHENOMENA 4 Credits

Electric Charge, Quantization and Conservation of Electric Charge, Coulomb's Law, Electric Field, Principle of Superposition, Electric Lines of Force; Electric Flux, Gauss's law, Divergence, Electric Field for Spherical, Plane and Cylindrical Distribution of Charges, Equivalence with Coulomb's law, Differential form of Gauss's Law; Electric Potential; Line Integral of the Electric Field, Potential Difference and Potential Function, Electric Field from the Potential, Electric Field and Potential of Dipole and Quadrupole; Potential for Charge Distributions: Equipotential Surfaces, Potential due to Charged Wire and Charged Disc, Energy Associated with Electric Field; Conservative Nature of Electric Force, Electrical Images.

Dielectric Material in an Electric Field, Polarisation, Gauss's Law in Dielectric Medium, Displacement Vector, Boundary Conditions on **D** and **E;** Capacitors, Dielectric Material between Capacitor Plates, Parallel Plate and Cylindrical Capacitors, Capacitors in Series and Parallel, Uniqueness Theorem; Microscopic Properties of Dielectrics, Atomic and Molecular Polarizability, Claussius-Mossotti Formula.

Electric Currents: Charge Transport and Current Density, Equation of Continuity, Microscopic View of Electrical Conductivity, Ohm's Law - Breakdown of Ohm's law; Review of Alternating Current; Magnetic Field: Definition, Divergence of Magnetic Field, Ampere's Law and its Applications to Straight Wire, Solenoid and Toroid; Force on a Charged Particle Moving in Electric and Magnetic Fields, Working Principles of an Oscilloscope, Cyclotron and Velocity Selector; Magnetic Materials: Response of Substances to Magnetic Field, Current Loop and Magnetic Dipoles, Magnetic Dipole Moment, Magnetisation Vector, Volume and Surface Distribution of Magnetization, Ampere's Law for Magnetic Materials, Magnetic Susceptibility and Permeability, B-H Curve and Hysteresis; Magnetic Circuit, Electromagnet; Electric Current in an Atom, Electron Spin and Magnetic Moment, Gyromagnetic ratio, Dia- Para and Ferro Magnetic Materials; Nuclear Magnetism.

Electromagnetic Induction: Faraday's Laws of Electromagnetic Induction, Lenz's Law, Motional E.M.F., Self and Mutual Inductance, Self Inductance for Solenoid, Mutual Inductance of Coupled Solenoids, Energy Stored in the Magnetic Field; Transformer; Maxwell's Equations and Electromagnetic Waves: Displacement Current; Generalisation of Ampere's Law; Maxwell's Equations, Poynting's Theorem, Wave Equation, Nature and Propagation of Plane Electromagnetic Waves in Vacuum and Dielectric Media; Reflection and Refraction of Plane Electromagnetic Waves at a Surface of a Dielectric (Normal Incidence); Radiation from an Oscillatory Electric Dipole (Qualitative), Antennas.

PHE-08(L)	**PHYSICS LABORATORY-II**	**4 Credits**

Experiment 1	A Study of Network Theorems
Experiment 2	Calibration of a Thermistor and Determination of its Energy Gap
Experiment 3	Construction and Characterisation of Power Supplies and Filters
Experiment 4	Study of OPAMP as Summing and Inverting Amplifier
Experiment 5	Study of OPAMP as Differentiator and Integrator
Experiment 6	Detection and Measurement of Charge using an OPAMP
Experiment 7	Study of Lens Properties and Optical instruments
Experiment 8	Spectral Analysis using a Prism Spectrometer
Experiment 9	Interference of Light – Young's Experiment
Experiment 10	Spectral Analysis using a Grating Spectrometer
Experiment 11	Production, Detection and Reflection of Polarised Light
Experiment 12	Study of Interference of Polarised Light
Experiment 13	Measurement of Cp/Cv by an Acoustic Method
Experiment 14	Measurement and Interpretation of Cooling Curves-Phase Changes

PHE-09 OPTICS 4 Credits

Electromagnetic Nature of light, Wave Equation, The Poynting Vector;, Reflection and Refraction of Electromagnetic waves, Normal and Oblique Incidence, Fresnel's Relations; Idealization of Waves as Light Rays; Fermat's Principle; Human Vision, Image Formation and Processing; Defects of Vision; Colour Vision; Colour Receptors.

Polarisation of Light, Production of Linearly Polarised Light, Polarization by Reflection, Brewster's Angle; Malus Law; Birefringence and Production of Polarized Light, Nicol Prism, Dichroism, Wave Plates.

Principle of Superposition of Waves; Young's Experiment, Fringe Width, Intensity Distribution; Interference with White Light, Fresnel's Biprism and Lloyd's Single Mirror; Interference by Division of Amplitude, Phase Change on Reflection, Interference with Multiple Reflection, Non-reflecting Films and Colour of Thin films; Fringes of Equal Thickness and Equal Inclination; Newton's Rings; Michelson Interferometer: Circular and Localised Fringes; White Light Fringes; Fabry-Perot Interferometer.

Fresnel's Diffraction: Fresnel's construction, Fresnel's Half Period Zones, Zone Plate; Diffraction Patterns of Simple Obstacles; Fraunhofer's Single Slit Diffraction Pattern, Intensity Distribution; Diffraction by a Circular Aperture and Double Slit, Intensity Distribution, Position of Maxima, Missing Orders; Diffraction by *N*-Parallel and Identical Slits: Principal and Secondary Maxima; Diffraction Grating, Formation of Spectra; Diffraction and Image Formation, Diffraction limited systems, Resolution, Resolving Power of Optical Instruments; Michelson Stellar Interferometer.

Coherence and Observable Interference of Waves, Temporal Coherence, Coherence Time and Coherence Length, Width of a Spectral Line, Spatial Coherence, Lateral Coherence Width, Angular Diameter of Stars; Visibility of Fringes.

Emission and Absorption of Light, Stimulated Emission, Einstein's Relations, Population Inversion; Optical Pumping; Intensity of Light; Different Pumping Mechanisms; Three and Four Level Pumping Schemes; Feedback Mechanism: Optical Resonant Cavity, Common Laser Systems, Solid State, Liquid and Helium-Neon Lasers, Applications of Lasers in Communication, Medicine, Industry, and Photography.

Basic Principle of Holography; Recording of a Hologram, In-Line and Off-Axis Hologram, Reconstruction of an Image; Recording and Reconstruction of Hologram; Applications of Holography: Microscopy, Information Storage, and Pattern Recognition.

Optical Fibre, Core and Cladding Materials and Their Refractive Indices; Propagation of Light Through Optical Fibre, Critical Angle; Step-Index Fibre, Gradient-Index Fibre, Refractive Index Profiles; Applications of Optical Fibres, Optical Communication Through Fibres, Pulse Dispersion and its Reduction, Material Dispersion, Power Loss.

PHE-10 ELECTRICAL CIRCUITS AND ELECTRONICS 4 Credits

Network Analysis: Circuit Elements; Kirchoff's Laws, Nodal Equations, T-and π-Networks, Network Theorems: Superposition Theorem, Thevenin Theorem, Norton's Theorem, Maximum Power Transfer Theorem; DC and AC Circuits, Attenuators, Filters (High Pass, Low Pass, Band Pass), Series and Parallel Resonant Circuits, Impedance Matching.

Devices and Instruments: Vacuum Tubes, Semiconductor Devices: Diodes (Detector, Rectifier, Voltage Reference); Zener Diodes, Transistors (Junction Transistor, FET, MOSFET); Equivalent Circuits of Transistors, Operating Point and Bias Stability, Small Signal Low Frequency Amplifiers (Gain Bandwidth), Input-Output Impedances; Large Signal Amplifiers: Power Amplifiers, (Class *A*, *B*, *C*, *AB*), Push-Pull Amplifier, Radio Frequency Amplifiers (Single-Tuned and Double Tuned); Feedback, Negative Feedback, its Effect on Amplifier Performance; Positive Feedback and Oscillators, Classification of Oscillators; *LC* Oscillators: Tuned Collector, Hartley and Colpitts Oscillators; *RC* Oscillators: Phase-Shift Oscillator, Wein Bridge Oscillator; Unregulated Power Supplies, Transformers, Rectifiers and Filters, Ripple Factor, Load Line Regulation, Regulated Power Supply.

Operational Amplifiers and their Characteristics; Op-Amp as a Comparator; Inverting and Non-Inverting Amplifier; Op-Amp as an Inverting Adder, Basic Differentiator and Integrator; Feedback in Op-Amp; Integrated Circuits: Power Amplifier ICs, Voltage Regulator ICs.

Digital Electronics: Binary Arithmetic, Decimal, Octal and Hexadecimal Number Systems and Interconversions, BCD and ASCII Codes, Boolean Algebra, Logic Gates, Adder Flip Flops (RS, D, JK); Counters, Registers, Semiconducting Memories (RAM, ROM), A/D and D/A Converters (only Functional Description); Cathode Ray Oscilloscope, Signal Generators, Electronic Voltmeter, Power Meter, Magnetic Field Meter.

PHE-11 MODERN PHYSICS 4 Credits

Special Theory of Relativity, Discovery of Constancy of Speed of Light, Postulates of Special Theory of Relativity, Lorentz Transformation, Length Contraction, Time Dilation, Examples, Lorentz Invariance; Velocity Addition Theorem, Doppler Effect, Variation of Mass with Velocity, Energy-Mass Equivalence, Relativistic Energy and Momentum and their Transforms; Newton's Laws of Motion in Relativistically Covariant Form.

Quantum Mechanics: Birth of Quantum Physics, de-Broglie Hypothesis, Wave-Particle Duality, Wave Packet, Group Velocity, the Uncertainty Principle and its Consequences, Thought Experiments, Complementarity; Postulates of Quantum Mechanics, Time Dependent and Time Independent Schrodinger Equation in One Dimension, Statistical Interpretation of Wave Function, Probability Current Density and Continuity Equation, Normalization of Wave Functions, Wave Function in Momentum Space; Observables and Operators, Linear Momentum, Orbital Angular Momentum, Commutation Relations, Expectation Values, Ehrenfest's Theorem.

Applications of Quantum Mechanics: One Dimensional Rectangular Potential Barrier, Tunneling, Parity Operator and its Eigenvalues; One Dimensional Potential Well, Particle in a Box, Free Particle, Simple Harmonic Oscillator (Energy Eigenvalues only); Spherically Symmetric Systems: Hydrogen Atom, Separation of Schrodinger Equation in Spherical Polar Coordinates, Eigenvalues of L^2, Spherical Harmonics (mention only), the Solution of Radial Equations (Qualitative), Energy Levels, Stationary State Wave Function, Discussion of Bound and Continuum States, Quantum Numbers and Constants of Motion; Spin Angular Momentum: the Magnetic Moment of Electron, Stern-Gerlach Experiment, the Total Angular Momentum Vector, Space Quantization; Optical Spectra of Hydrogenic Atoms, Spectral Notation, Pauli's Exclusion Principle and Electronic Configurations, Selection Rules, Allowed and Forbidden Transitions, Half Life of Excited States, Finite Width of Spectral Lines; *X*-ray Spectra, Characteristic *X*-ray Spectra, Moseley's Law, *X*-ray Terms and Selection Rules, Applications of *X*-rays.

Nuclear Physics; Radioactive Decay Law, Radioactive Equilibria, Naturally Radioactive Series, Nature of α, β and γ Spectra and Qualitative Explanation Thereof; General Properties of Nuclei: Mass, Spin, Neutron Number, Magnetic Moment, Size etc.; Stability of Nuclei: Binding Energy Curve, Magic Numbers, Semi-empirical Mass Formula, Liquid Drop Model, Nuclear Fission, Nuclear Fusion; Nuclear Reactors, Nuclear Power Generation (Indian Programme, Existing Facilities), Radio-Tracer Studies, Biological Effects of Nuclear Radiation, Radiation Dosimetry (mention only); Applications of Nuclear Radiation in Science and Industry; Particle Accelerators and Detectors; Elementary Particles; Modern Notion of Constituents of Matter, Quarks.

PHE-12 (L) PHYSICS LABORATORY-III **4 Credits**

Experiment 1	Some Investigations on the Rotation of Plane of Polarisation
Experiment 2	Some Investigations on Interference of Light
Experiment 3	To Study the Diffraction Pattern of a Thin Wire
Experiment 4	Resolving Power of a Telescope
Experiment 5	To Investigate the Temperature Dependence of Radiation from a Hot Filament
Experiment 6	Study of Magnetisation Intensity in a Magnetic Material
Experiment 7	Measurement of Inductance: Anderson's Bridge
Experiment 8	To study an Off-balance Wheatstone Bridge and to Investigate its use in the Measurement of Strain
Experiment 9	Study of an Audio Frequency Amplifier using Bipolar Junction Transistor
Experiment 10	Some Experiments with Logic Gates
Experiment 11	Study of Hall Effect in a Metal

Table Top Experiment 1 Fourier Analysis of Periodic Waveforms

Table Top Experiment 2 Kepler's Third Law of Planetary Motion

PHE-13 PHYSICS OF SOLIDS 4 Credits

Symmetries Observed in Nature, Inanimate and Animate World, Symmetries in Atoms and Molecules, Commonly Observed Symmetries, Translational Symmetry and Periodicity; Geometrical Arrangement of Atoms and Molecules, Symmetry Operations; Two and Three Dimensional Crystals, Cubic Crystals, Crystal Directions and Crystal Planes, Miller Indices; Quasi Crystals, Polycrystalline and Amorphous Solids; Crystal Systems and Elements of Symmetry, Bravais Lattices; Concept and Properties of Lattice Types, Reciprocal Lattice; and Brillouin zone; X-ray diffraction, Bragg's Conditions; Laue Treatment of X-ray Diffraction, Atomic and Structural Scattering Factors; Neutron Diffraction and Electron Microscopy.

Different Types of Crystal Bonding: Ionic, Covalent, Metallic, Hydrogen Bonding and van der Waals Bonding; Cohesive Energy for Ionic and van der Waals Crystals; Elastic Stress and Strain and their Analysis for Cubic Crystals, Elastic Constants for a Cubic Crystal; Elastic Energy Density, Propagation of Elastic Waves in a Cubic Crystal, Wave Velocity along Typical Crystal Directions; Elastic Properties of Non-Cubic Crystals; Atoms in Solids as a Microscopic Spring-Mass System; Dynamics of a Chain of One and Two Types of Atoms; Quantisation of Lattice Vibrations, Acoustic and Optical Phonons; Classical Theory of Specific Heat; Quantum Theories of Einstein and Debye; Concept of Normal Modes; Thermal Conductivity and Thermal Expansion.

Classical Free Electron Theory of Metals, Drude–Lorentz Theory, Electrical Conductivity, Relaxation Time, Limitations of the Classical Theory; Sommerfeld Theory, Temperature Dependence of Resistivity; Electronic Specific Heat and Electronic Thermal Conductivity, Lorentz Number; Energy Levels, Energy States, Fermi-Dirac Statistics, Distribution of Free Electrons, Fermi Energy; Limitation of Sommerfeld Model; Origin of Energy Bands in Solids; Bloch Model and Motion of Electrons in Periodic Potential, Kronig–Penney Model; Brillouin Zone and Effective Mass; Classification of Solids into Metals, Insulators and Semiconductors.

Solid Materials: Types of Semiconductors; Physics of Semiconductors – Electronic, Optical and Thermal Properties; PN Junction; Polycrystalline and Amorphous Semiconductors; Determination of Different Parameters; Hall Effect; Perfect Conductor and Superconductor, Meisner Effect, Critical Temperature and Critical Field Characteristic Parameters of Superconductors, Type–I and Type–II Superconductors; High T_c Superconductors (a brief outline); Different Types of Magnetic Materials; Pauli's Theory of Paramagentism; Curie-Weiss Law; Crystal Growth and Purification; Strength of Materials; Alloying; Crystal Defects; Properties and Some Important Applications of Piezoelectrics; Pyroelectrics; Ferrites; Ferroelectrics; Polymers; Liquid Crystals; Ceramics; Glasses; Principles of Operation and Fabrication of Transducers, Solar Cells, Thin Film Devices.

PHE-14 MATHEMATICAL METHODS IN PHYSICS-III 4 Credits

The Eigenvalue Problem for Matrices: Definitions; Characteristic Equation; Determination of Eigenvectors; General Results Regarding Eigenvalues and Eigenvectors; Cayley – Hamilton Theorem; Minimal Equation and its Uses; Real, Symmetric and Orthogonal Matrices; Hermitian and Unitary Matrices and their Relevance in Physics; Properties of Eigenvalues and Eigenvectors of Hermitian and Unitary Matrices; Diagonalization of Matrices, Similarity Transformations; Diagonalisable Matrices; Applications to Reduction of Quadratic Forms etc.

Tensors: Coordinate Transformations and Effect on Physical Quantities; Scalars; Covariant and Contravariant Vectors; Higher Rank Tensors (Definition and Examples); Symmetry and Anti-symmetry.

Basic Notions of Group Theory: Symmetry in Physical Problems; Usefulness of Symmetry (Selection Rules etc.); Definition of a Group; Examples (Square or Equilateral Triangle with Centre Fixed) and Counter Examples; Abstract Group and Realisations; Sub-Groups, Conjugate Elements, Class; Examples; Applications of Group Theory: Symmetry in Molecules; Crystals and Symmetry (Two-dimensions); Some Crystallographic Point Groups, Translation Group, Space Groups; Symmetry and Conservation Laws in Quantum Mechanics, Symmetry under Spatial Translations and Conservation of Linear Momentum, Time Translations and Conservation of Energy.

Complex Analysis: Complex Variables, Function of a Complex Variable; Limit, Continuity and Analytic Continuation; Derivative in the Complex Plane; Different Complex Functions (Exponential, Trigonometric, Logarithmic, Hyperbolic); Analyticity and the Cauchy-Riemann Conditions; Singularities (Essential, Removable); Complex Integration: Line Integrals; Cauchy's Integral Theorem and Integral Formulae; Taylor and Laurent Series; Order of Poles; Concept of Residue; Residue Theorem; Evaluation of Residues; Application to Evaluation of Definite Integrals involving Rational Functions and Trigonometric Functions.

Fourier Transforms: Definition, Fourier Integral Theorem; Evaluation of Fourier Transform of Simple Functions; Fourier Sine and Cosine Transforms; Fourier Transform of Derivatives and Integrals; Solving Differential Equations through Fourier Transforms; Heat Conduction Equation in One-Dimension and Other Examples; Laplace Transforms: Definition; Evaluation of Laplace Transforms of Various Functions; Inverse Laplace Transforms (only Simple Methods); Laplace Transforms of Derivatives and Integrals; Application to Solution of Ordinary Differential Equations with Constant Coefficients; Applications to Physical Systems.

Special Functions: Legendre Equation, Legendre Polynomials, Properties, Rodrigue's Formula, Recurrence Relations, Orthogonality Relations, Generating Function for Legendre Polynomials, Legendre Polynomials as Solutions of Physical Importance; Bessel Equation, Bessel Function $J_n(x)$ for Integral n, Recurrence Relations, Generating Function, Integral Representation of $J_n(x)$, Orthogonality Relations, Bessel Functions in Physical Problems with Cylindrical Symmetry; Hermite Equation, Recurrence Relations, Generating Functions, Orthogonality Relations, Laguerre Equation; Recurrence Relations, Generating Functions.

PHE–15 ASTRONOMY AND ASTROPHYSICS 4 Credits

Astronomical Distance, Mass and Time Scales; Brightness, Radiant Flux and Luminosity, Measurement of Astronomical Quantities (distance, mass, stellar radii and temperatures); Basic Concepts of Positional Astronomy: Celestial Sphere; Astronomical Coordinate Systems (horizon and equatorial); Measurement of Time (mean solar time, sidereal time, equation of time); Calendar; Astronomical Techniques: Basic Optical Definitions (magnification, light gathering power, resolving power, diffraction limit); Atmospheric Windows; Optical Telescopes, Detectors, Detectability Limits of Telescopes; Physical Principles: Virial Theorem; Newtonian Theory vs. General Relativity; Systems in Thermodynamic Equilibrium; Maxwellian Velocity Distribution; Black-Body Radiation; Boltzmann & Saha Equations; Radiative Transfer Equation and Optical Depth; Local Thermodynamic Equilibrium.

The Sun; Solar Parameters, Photosphere, Solar Atmosphere, Chromosphere; Corona, Solar Activity (solar wind, solar flares, sun spots); Introduction to Magneto-hydrodynamics, Seismology of the Sun (brief mention only); The Solar Family; Facts and Figures; Origin of the Solar System (Nebular model); Tidal Forces and Planetary Rings; Extra-solar Planets; Stellar Spectra and Classification; Atomic Spectra, Stellar Spectra, Spectral Types and Temperature Dependence, Luminosity Classification, H-R Diagram; Stellar Structure; Hydrostatic Equilibrium; Virial Theorem; Sources of Stellar Energy, Models of Energy Transport; Polytropic Stellar Models; Star Formation: Composition of Interstellar Medium, Jean's Instability Criterion, Collapse and Fragmentation of Molecular Clouds (mass function); Evolution towards Main Sequence; Nucleosynthesis and Stellar Evolution; Cosmic Abundances; Stellar Nucleosynthesis; Main Sequence and Post-main Sequence Evolution of Stars; End stages; Supernovae; Compact Stars; Equation of State and Degenerate Gas of Fermions; White Dwarfs (Chandrasekhar limit), Neutron Stars (pulsars); Limiting Mass; Black Holes.

The Milky Way; Structure and Properties; Rotation (Differential Rotation and Oort's constants), Rotation Curve; Galactic Center; Inter-stellar Matter (21 cm line); Star Clusters; Galaxies: Morphology, Hubble Classification; Spirals, Ellipticals and Irregulars; Gas and Dust; Active Galaxies: Nature, Classification, (Radio Galaxies and quasars; Seyferts and star burst galaxies); Behaviour, Central Engine (accretion disks and jets), Unified Model; Large-Scale Structure and the Expanding Universe; Cosmic Distance Ladder; Hubble's Law; Cluster of Galaxies (Virial Theorem and Dark Matter); Friedmann Equations and Solutions; Early Universe and Nucleosynthesis, Cosmic Microwave Background Radiation; Evolving vs. Steady State Universe.

PHE–16 COMMUNICATION PHYSICS 4 Credits

Elements of Communication: Everyday Communication System; Large Distance Communication Systems (Block Diagram); Communication System Model: Source - Media - Sink; Types of Media and Characteristics (Wires, Ionosphere, Microwave, Space); Classification of Signals (Periodic, Pulses, Serial, Parallel Communication Modes etc.); Basic Tools for Handling Deterministic Signals; Signal to Noise Ratio, Wide and Narrow Band Noise; Channel Bandwidth and Capacity; Signal Representation: Energy and Power Limited Signals; Spectrum and Density Function; Frequency Spectrum of Source and Response of Detector.

Signal Propagation: Review of Maxwell's Equation and Concept of Boundary Conditions; Plane Wave Solution in Dielectrics and Conductors; Poynting Theorem, Total Internal Reflection, Surface Waves; Review of Antennae (No Derivation), Elements of Antenna, Radiation Pattern (Interference in Multielement Antennae); Transmission Line Equation (Recap); Characteristic Impedance of Transmission Line and Impedance Matching (Reflection Coefficient, Scattering); Distributed Components versus Lumped Components; Resonance; Types of Transmission Lines - Microstriplines, Striplines, Dielectric Transmission Line, Co-axial, 2-wire Line.

Modulation Techniques: Modulation Theorem; Linear Modulation Systems; AM, FM, PM and Their Modulation and Demodulation Techniques; Pulse Modulation Systems - PAM, PDM, PPM; Sampling Theorem, Quantization; Discrete Modulation Techniques, PCM.

Telephony and Switching: Point to Point, Point to Multipoint Communication; Concepts of Telephone System, Central Switching, Routing and Call Processing; Wireless and Cellular Communication; Simplex, Half Duplex, Full Duplex Communication, Multiplexing in Time, Space, Frequency and Wavelength.

Audio and Video Communication: AM, FM Broadcasting; Transmission and Reception; TV Transmission and Reception, Colour and Monochrome Signal; Vestigial Band Transmission; Camera and Display Tubes; TV Standards.

Microwaves: Waveguide Components; Microwave Generators and Detectors; Line of Sight, Satellite Communication, RADAR.

Optical Fibre Communication: Fibre Optics Principles; Channel Capacity; Attenuation and Losses; Optical Sources and Detectors; Modulation Techniques.

Computer Based Communication: Computer as Tool of Communication; Hardware Architecture and Software Aspects; Personal, Desktop, Multi-media Systems; LAN, WAN Computer Network; INTERNET; WWW; e-mail.

Futuristic Look of Communication Systems: Wireless Technology, Blue Tooth, WAP and any other new emerging topics.