Honours Core Papers

PHY-HC-2016
Electricity & Magnetism
Total Lectures: 60 Credits: 6 (Theory: 04, Lab: 02)

Course Outcome: *After successful completion of this course, students will be able to Understand electric and magnetic fields in matter, Dilectric properties of matter magnetic properties of matter, electromagnetic induction, applications of Kirchhofff's law in different circuits, applications of network theorem in circuits.*

Theory

Unit I: Electric Field and Electric Potential (Lectures 26)

Electric field: Electric field lines. Electric flux. Gauss' Law with applications to charge distributions with spherical, cylindrical and planar symmetry. Conservative nature of Electrostatic Field. Electrostatic Potential. Laplace's and Poisson equations. The Unique- ness Theorem. Potential and Electric Field of a dipole. Force and Torque on a dipole. Electrostatic energy of system of charges. Electrostatic energy of a charged sphere. Conductors in an electrostatic Field. Surface charge and force on a conductor. Capacitance of a system of charged conductors. Parallel-plate capacitor. Capacitance of an isolated conductor. Method of Images and its application to: (1) Plane Infinite Sheet and (2) Sphere.

Unit II: Dielectric Properties of Matter (Lectures 08)

Electric Field in matter. Polarization, Polarization Charges. Electrical Susceptibility and Dielectric Constant. Capacitor (parallel plate, spherical, cylindrical) filled with dielectric. Displacement vector $\vec{D}$. Relations between $\vec{E}$, $\vec{P}$ and $\vec{D}$ Gauss' Law in dielectrics.

Unit III: Magnetic Field (Lectures 09)

Magnetic Force on a point charge, definition and properties of magnetic field $\vec{B}$. Curl and Divergence. Vector potential $\vec{A}$. Magnetic Force on (1) a current carrying wire (2) between current elements. Torque on a current loop in a uniform magnetic field. Biot-Savart's law and its simple application : straight wire and circular loop. Current loop as a magnetic dipole and its dipole moment (analogy with electric dipole) Ampere's circuital law and its application to (1) Solenoid (2) Torus.

Unit IV: Magnetic Properties of Matter (Lectures 04)

Magnetization vector ($\vec{M}$). Magnetic Intensity ($\vec{H}$). Magnetic Susceptibility and permeability. Relation between $\vec{B}$, $\vec{H}$, $\vec{M}$. Ferromagnetism. B-H curve and hysteresis.

Unit V: Electromagnetic Induction (Lectures 06)

Faraday's Law. Lenz's Law. Self Inductance and Mutual Inductance. Reciprocity Theorem. Energy stored in a Magnetic Field. Introduction to Maxwell's Equations. Charge Conservation and Displacement current.

Unit VI: Electrical Circuits (Lectures 04)

AC Circuits: Kirchhoff's laws for AC circuits. Complex Reactance and Impedance. Series LCR Circuit: (1) Resonance, (2) Power Dissipation and (3) 13 Quality Factor, and (4) Band Width. Parallel LCR Circuit.

Unit VII: Network Theorems (Lectures 03)

Ideal Constant-voltage and Constant-current Sources. Network Theorems: Thevenin theorem, Norton theorem, Superposition theorem, Reciprocity theorem, Maximum Power Transfer theorem. Applications to dc circuits.

Unit VIII: Ballistic Galvanometer (Lectures 03)

Torque on a current Loop. Ballistic Galvanometer: Current and Charge Sensitivity. Electromagnetic damping. Logarithmic damping. CDR.

PHY-HC-2026
Waves & Optics
Total Lectures: 60 Credits: 6 (Theory: 04, Lab: 02)

Course Outcome: *After successful completion of this course, students will be able to Understand superposition of harmonic oscillations, different types of wave motions, superposition of harmonic waves, interference and interferometer, diffraction, holography.*

Theory

Unit I: Superposition of Collinear Harmonic Oscillations (Lectures 05)

Linearity and Superposition Principle. Superposition of two collinear oscillations having (1) equal frequencies and (2) different frequencies (Beats). Superposition of N collinear Harmonic Oscillations with (1) equal phase differences and (2) equal frequency differences.

Unit II: Superposition of Two Perpendicular Harmonic Oscillations (Lectures 02)

Graphical and Analytical Methods. Lissajous Figures with equal an unequal frequency and their uses.

Unit III: Wave Motion (Lectures 04)

Plane and Spherical Waves. Longitudinal and Transverse Waves. Plane Progressive (Travelling) Waves. Wave Equation. Particle and Wave Velocities. Differential Equation. Pressure of a Longitudinal Wave. Energy Transport. Intensity of Wave. Water Waves: Ripple and Gravity Waves.

Unit IV: Velocity of Waves (Lectures 06)

Velocity of Transverse Vibrations of Stretched Strings. Velocity of Longitudinal Waves in a Fluid in a Pipe. Newton's Formula for Velocity of Sound. Laplace's Correction.

Unit V: Superposition of Two Harmonic Waves (Lectures 07)

Standing (Stationary) Waves in a String: Fixed and Free Ends. Analytical Treatment. Phase and Group Velocities. Changes with respect to Position and Time. Energy of Vibrating String. Transfer of Energy. Normal Modes of Stretched Strings. Plucked and Struck Strings. Melde's Experiment. Longitudinal Standing Waves and Normal Modes. Open and Closed Pipes. Superposition of N Harmonic Waves.

Unit VI: Wave Optics (Lectures 03)

Electromagnetic nature of light. Definition and properties of wave front. Huygens Principle. Temporal and Spatial Coherence.

Unit VII: Interference (Lectures 09)

Division of amplitude and wavefront. Young's double slit experiment. Lloyd's Mirror and Fresnel's Biprism. Phase change on reflection: Stokes' treatment. Interference in Thin Films: parallel and wedge-shaped films. Fringes of equal inclination (Haidinger Fringes); Fringes of equal thickness (Fizeau Fringes). Newton's Rings: Measurement of wavelength and refractive index.

Unit VIII: Interferometer (Lectures 04)

Michelson Interferometer-(1) Idea of form of fringes (No theory required), (2) Determination of Wavelength, (3) Wavelength Difference, (4) Refractive Index, (5) Visibility of fringes. Fabry-Perot interferometer.

Unit IX: Diffraction (Lectures 09)

Fresnel and Fraunhofer diffraction. Fresnel's Half-Period Zones for Plane Wave. Explanation of Rectilinear Propagation of Light. Theory of a Zone Plate: Multiple Foci of a Zone Plate. Fresnel diffraction pattern of a straight edge and at a circular aperture . Resolving Power of a telescope.

Unit X: Fraunhofer Diffraction (Lectures 08)

Single slit. Double slit. Multiple slits. Diffraction grating . Resolving power of grating.

Unit XI: Holography (Lectures 03)

Principle of Holography. Recording and Reconstruction Method. Theory of Holography as Interference between two Plane Waves. Point source holograms.

PHY-HC-3026
Thermal Physics
Total Lectures: 60 Credits: 6 (Theory: 04, Lab: 02)

Course Outcome: *Upon successful completion, students will have the knowledge and skills to identify and describe the statistical nature of concepts and laws in thermodynamics, in particular: entropy, temperature, Thermodynamics potentials, Free energies, Maxwell's relations in thermodynamics, behaviour of real gases.*

Theory

Introduction to Thermodynamics

Unit I: ***Zeroth and First Law of Thermodynamics*** **(Lectures 08)**

Extensive and intensive Thermodynamic Variables, Thermodynamic Equilibrium, Zeroth Law of Thermodynamics & Concept of Temperature, Concept of Work & Heat, State Functions, First Law of Thermodynamics and its differential form, Internal Energy, First Law & various processes, Applications of First Law: General Relation between C_P and C_V, Work Done during Isothermal and Adiabatic Processes, Compressibility and Expansion Coefficient.

Unit II: ***Second Law of Thermodynamics*** **(Lectures 10)**

Reversible and Irreversible process with examples. Conversion of Work into Heat and Heat into Work. Heat Engines. Carnot's Cycle, Carnot engine & effciency. Refrigerator & coeffcient of performance, 2nd Law of Thermodynamics: Kelvin-Planck and Clausius Statements and their Equivalence. Carnot's Theorem. Applications of Second Law of Thermodynamics: Thermodynamic Scale of Temperature and its Equivalence to Perfect Gas Scale.

Unit III: ***Entropy*** **(Lectures 07)**

Concept of Entropy, Clausius Theorem. Clausius Inequality, Second Law of Thermodynamics in terms of Entropy. Entropy of a perfect gas. Principle of Increase of Entropy. Entropy Changes in Reversible and Irreversible processes with examples. Entropy of the Universe. Entropy Changes in Reversible and Irreversible Processes. Principle of Increase of Entropy. Temperature–Entropy diagrams for Carnot's Cycle. Third Law of Thermodynamics. Unattainability of Absolute Zero.

Unit IV: ***Thermodynamic Potentials*** **(Lectures 07)**

Thermodynamic Potentials: Internal Energy, Enthalpy, Helmholtz Free Energy, Gibb's Free Energy. Their Definitions, Properties and Applications. Surface Films and Variation of Surface Tension with Temperature. Magnetic Work, Cooling due to adiabatic demagnetization, First and second order Phase Transitions with examples, Clausius Clapeyron Equation and Ehrenfest equations.

Unit V: ***Maxwell's Thermodynamic Relations*** **(Lectures 07)**

Derivations and applications of Maxwell's Relations, Maxwell's Relations:(1) Clausius Clapeyron equation, (2) Values of C_p-C_v, (3) TdS Equations, (4) Joule-Kelvin coefficient for Ideal and Van der Waal Gases, (5) Energy equations, (6) Change of Temperature during Adiabatic Process.

Kinetic Theory of Gases

Unit VI: ***Distribution of Velocities*** **(Lectures 07)**

Maxwell-Boltzmann Law of Distribution of Velocities in an Ideal Gas and its Experimental Verification. Doppler Broadening of Spectral Lines and Stern's Experiment. Mean, RMS and Most Probable Speeds. Degrees of Freedom. Law of Equipartition of Energy (No proof required). Specific heats of Gases.

Unit VII: ***Molecular Collisions*** **(Lectures 04)**

PHY-HC-3036
Digital Systems & Applications
Total Lectures: 60 Credits: 6 (Theory: 04, Lab: 02)

Course Outcome: *After successful completion of the course student will be able to understand the working principle of CRO, develop a digital logic and apply it to solve real life problems, Analyze, design and implement combinational logic circuits, Classify different semiconductor memories, Analyze, design and implement sequential logic circuits, Analyze digital system design using PLD, Simulate and implement combinational and sequential circuits.*

Theory

Unit I: Introduction to CRO (Lectures 03)

Block Diagram of CRO. Electron Gun, Deflection System and Time Base. Deflection Sensitivity. Applications of CRO: (1) Study of Waveform, (2) Measurement of Voltage, Current, Frequency, and Phase Difference.

Unit II: Integrated Circuits (qualitative treatment only) (Lectures 03)

Active & Passive components. Discrete components. Wafer. Chip. Advantages and drawbacks of ICs. Scale of integration: SSI, MSI, LSI and VLSI (basic idea and definitions only). Classification of ICs. Examples of Linear and Digital lCs.

Unit III: Digital Circuits (Lectures 06)

Difference between Analog and Digital Circuits. Binary Numbers. Decimal to Binary and Binary to Decimal Conversion. BCD, Octal and Hexadecimal numbers. AND, OR and NOT Gates (realization using Diodes and Transistor). NAND and NOR Gates as Universal Gates. XOR and XNOR Gates.

Unit IV: Boolean Algebra (Lectures 06)

De Morgan’s Theorems. Boolean Laws. Simplification of Logic Circuit using Boolean Algebra. Fundamental Products. Idea of Minterms and Maxterms. Conversion of a Truth table into Equivalent Logic Circuit by (1) Sum of Products Method and (2) Karnaugh Map.

Unit V: Data Processing Circuits (Lectures 04)

Basic idea of Multiplexers, De-multiplexers, Decoders, Encoders.

Unit VI: Arithmetic Circuits (Lectures 05)

Binary Addition. Binary Subtraction using 2’s Complement. Half and Full Adders. Half & Full Subtractors, 4-bit binary Adder/Subtractor.

Unit VII: Sequential Circuits (Lectures 06)

SR, D, and JK Flip-Flops. Clocked (Level and Edge Triggered) Flip-Flops. Preset and Clear operations. Race- around conditions in JK Flip-Flop. M/S JK Flip-Flop.

Unit VIII: Timers: IC 555 (Lectures 03)

Block diagram and applications: Astable multivibrator and Monostable multivibrator.

Unit IX: Shift Registers (Lectures 02)

Serial-in-Serial-out, Serial-in-Parallel-out, Parallel-in-Serial-out and Parallel-in-Parallel-out Shift Registers (only up to 4 bits).

PHY-HC-4026
Elements of Modern Physics
Total Lectures: 60 Credits: 6 (Theory: 04, Lab: 02)

Course Outcome: *On completion of the course students will be able to understand modern development in Physics, Starting from Planck's law, it development of the idea of probability interpretation and the formulation of Schrodinger equation. Students will also get preliminary idea of structure of nucleus, radioactivity Fission and Fusion and Laser*

Theory

Unit I: Quantum Theory and Blackbody Radiation (Lecture 12)

Quantum theory of light; photo-electric effect and Compton scattering. De Broglie wavelength and matter waves; Davisson-Germer experiment. Wave description of particles by wave packets. group and phase velocities and relation between them. Two-slit experiment with electrons. Probability. wave amplitude and wave functions.

Unit II: Uncertainty and Wave-Particle Duality (Lecture 05)

Position measurement : gamma ray microscope thought experiment; wave-particle duality, Heisenberg uncertainty principle (Uncertainty relations involving Canonical pair of variables): Derivation from wave packets, impossibility of a particle following a trajectory; estimating minimum energy of a confined particle using uncertainty principle; energy-time uncertainty principle- application to virtual particles and range of an interaction.

Unit III: Schrödinger Equation (Lecture 8)

Two slit interference experiment with photons, atoms and particles; linear superposition principle as a consequence; Matter waves and wave amplitude; Schrödinger equation for non- relativistic particles; expectation value, momentum and energy operators; stationary states; physical interpretation of a wave function, probabilities and normalization; probability and probability current densities in one dimension.

Unit IV: One-dimensional Box and Step Barrier (Lecture 9)

One dimensional infinitely rigid box- energy eigenvalues and eigenfunctions, normalization; quantum dot as example; quantum mechanical scattering and tunnelling in one dimension-across a step potential and rectangular potential barrier.

Unit V: Structure of the Atomic Nucleus (Lecture 06)

Size and structure of atomic nucleus and its relation with atomic weight; impossibility of an electron being in the nucleus as a consequence of the uncertainty principle. Atomic Mass Unit. Nature of nuclear force, $N - Z$ graph, liquid drop model: semi-empirical mass formula and binding energy, nuclear shell model (qualitative discussions) and magic numbers.

Unit VI: Radioactivity (Lecture 08)

Stability curve and stability of nuclei, Law of radioactive decay, disintegration constant, half life and mean life. Activity unit. Alpha decay – Range energy relation, Fine structure of alpha energy spectrum. Beta decay energy released, continuous beta spectrum and Pauli's prediction of neutrino. Gamma ray emission, energy-momentum conservation: electron-positron pair creation by gamma photons in the vicinity of a nucleus.

Unit VII : Detection of nuclear radiation (Lecture 04)

Method of energy loss by charged particles and gamma photons. Photoelectric, Compton and Pair-production processes Gas filled detectors – principle and construction of a gas filled detector, Ionization, proportional, GM and spark region.

PHY-HE-5056
Nuclear and Particle Physics
Total Lectures: 75 Credits: 6 (Theory: 05, Tutorial: 01)

Course Outcome: *Upon completion of this course, students will have the understanding of the sub atomic particles and their properties. They will gain knowledge about the different nuclear techniques and their applications in different branches of Physics and societal application. The course will develop problem based skills and the acquire knowledge can be applied in the areas of nuclear, medical, archeology, geology and other interdisciplinary fields of Physics and Chemistry.*

Theory

Unit I: General Properties of Nuclei (Lectures 10)

Constituents of nucleus and their Intrinsic properties, quantitative facts about mass, radii, charge density (matter density), binding energy, average binding energy and its variation with mass number, main features of binding energy versus mass number curve, N/A plot, angular momentum, parity, magnetic moment, electric moments, nuclear excites states.

Unit II: Nuclear Models (Lectures 12)

Liquid drop model approach, semi empirical mass formula and significance of its various terms, condition of nuclear stability, two nucleon separation energies, Fermi gas model (degenerate fermion gas, nuclear symmetry potential in Fermi gas), evidence for nuclear shell structure, nuclear magic numbers, basic assumption of shell model, concept of mean field, residual interaction, concept of nuclear force.

Unit III: Radioactivity decay (Lectures 10)

(a) Alpha decay: basics of α-decay processes, theory of α- emission, Gamow factor, Geiger Nuttall law, α-decay spectroscopy. (b) -decay: energy kinematics for -decay, positron emission, electron capture, neutrino hypothesis. (c) Gamma decay: Gamma rays emission & kinematics, internal conversion.

Unit IV: Nuclear Reactions (Lectures 8)

Types of Reactions, Conservation Laws, kinematics of reactions, Q-value, reaction rate, reaction cross section, Concept of compound and direct Reaction, resonance reaction, Coulomb scattering (Rutherford scattering).

Unit V: Interaction of Nuclear Radiation with matter (Lectures 8)

Energy loss due to ionization (Bethe- Block formula), energy loss of electrons, Cerenkov radiation. Gamma ray interaction through matter, photoelectric effect, Compton scattering, pair production, neutron interaction with matter.

Unit VI: Detector for Nuclear Radiations (Lectures 8)

Gas detectors: estimation of electric field, mobility of particle, for ionization chamber and GM Counter. Basic principle of Scintillation Detectors and construction of photo-multiplier tube (PMT). Semiconductor Detectors (Si and Ge) for charge particle and photon detection (concept of charge carrier and mobility), neutron detector.

Unit VII: Particle Accelerators (Lectures 5)

Accelerator facility available in India: Van-de Graaff generator (Tandem accelerator), Linear accelerator, Cyclotron, Synchrotrons.

Unit VIII: Particle physics (Lectures 14)

Particle interactions; basic features, types of particles and its families. Symmetries and Conservation Laws: energy and momentum, angular momentum, parity, baryon number, Lepton number, Isospin, Strangeness and charm, concept of quark model, color quantum number and gluons.

Subject: Physics
Semester: Two
Course Name: Mathematical Physics & Electricity and Magnetism
Existing Base Syllabus: HS Maths and Physics
Course Level: PHY151
Syllabus showing each unit against class number and marks

Unit no.	Unit content	No. of classes	Marks/Credit
Theory			
Part A: Mathematical Physics (Theory)			
Unit 1- Differential equations	First and second order ordinary differential equations (ODE). Homogeneous and inhomogeneous differential equations. Solutions of first order ODE – integrating factors (physical examples – radioactive decay, Newton's law of cooling, particle falling under gravity through a resistive medium). Concept of initial/boundary conditions. Solutions of second order ODE with constant coefficients - complementary function and particular integral (physical examples- simple harmonic oscillation, forced vibration). Wronskian- definition and its use to check linear independence of 2nd order homogeneous linear differential equation. Partial differential equations (PDE) (physical examples – wave equation, diffusion equation, Laplace and Poisson equation – introduction only). Exact and inexact differentials. Concept of variable separation in a PDE.	10	Credit - 1
Unit– II: Matrices	Properties of matrices. Determinant and rank. Transpose and complex conjugate of matrices. Hermitian and anti-Hermitian matrices. Unitary and orthogonal matrices. Representation of linear homogeneous and inhomogeneous equations through matrix equation. Inverse of a matrix. Eigen values and eigen-vectors. Cayley-Hamilton Theorem (statement only), Diagonalization of simple matrices.	5	
Part B – Electricity and Magnetism (Theory)			
Unit I: Electric field	Electrostatic field, electric flux. Gauss's law. Application of Gauss's law to charge distributions with planar, spherical and	13	Credit - 2

and electric potential	cylindrical symmetries. Conservative nature of electrostatic field. Electrostatic potential. Electrostatic energy of a system of charges. Electrostatic boundary conditions. Laplace's and Poisson's equations. Uniqueness theorem. Application of Laplace's equation involving planar, spherical and cylindrical symmetries. Potential and electric field of a dipole. Force and torque on a dipole. Capacitance of a system of charged conductors. Parallel plate capacitor. Capacitance on an isolated conductor.		
Unit –II: Dielectric properties of matter	Electric field in matter. Polarisation, polarisation charges. Electrical susceptibility and dielectric constant. Capacitor (parallel plate, spherical and cylindrical) filled with dielectric. Displacement vector, $\vec{D}$. Relation between $\vec{E}$, $\vec{P}$ and $\vec{D}$. Gauss's law in dielectrics.	4	
Unit –III: Magnetic field	Magnetic force on a point charge, definition and properties of magnetic field $\vec{B}$. Curl and divergence. Vector potential, $\vec{A}$. Magnetic scaler potential. Magnetic force on (i) a current carrying wire and (ii) between two elements. Torque on a current loop in a uniform magnetic field. Biot-Savart's law and its simple application: straight wire and circular loop. Current loop as a magnetic dipole and its dipole moment (analogy with electric dipole). Ampere's circuital law and its application to (i) solenoid and (ii) torus.	6	
Unit–IV: Magnetic properties of matter	Magnetization vector, $\vec{M}$. Magnetic intensity, $\vec{H}$. Magnetic susceptibility and permeability. Relation between $\vec{B}$, $\vec{H}$ and $\vec{M}$. Ferromagnetism. B-H curve and hysteresis.	2	
Unit–V: Electrical circuits	AC circuits: Kirchhoff's laws for AC circuits. Complex reactance and inductance. Series LCR circuits and parallel LCR circuits: (i) phasor diagram, (ii) resonance, (iii) power dissipation, (iv) quality factor, and (v) band width. Ideal constant-voltage and constant-current sources. Thevenin theorem and Norton theorem (only statements and solving of related problems).	5	
Laboratory			
	<u>At least four from the following:</u>		Credit-1