JADAVPUR UNIVERSITY

B.Sc. PHYSICS (HONS)
SYLLABUS

HO1 (Mechanics I)

Kinematics, Dynamics, Newton's Laws of motion: Review of elementary problems.

Motion of a particle in one dimension, time dependent force, velocity dependent damping force, conservative force – concept of potential, simple harmonic oscillator. Conservation of linear momentum and energy, Motion of falling bodies in a variable Gravitational field.

Motion of particle in two and three dimensions; Kinematics in a plane and in three dimensions; Harmonic oscillator in two and three dimensions; Motion under central force, Conservation of angular momentum, Kepler problem, Motion of charged particles in electric and magnetic fields.

Motion of a system of particles, center of mass (derivation in some simple cases – linear distribution of mass, laminar bodies, hemisphere etc.), Variable mass problem (rockets and conveyor belts): The two body problem; Collision – elastic and inelastic collisions, center of mass and laboratory coordinates, scattering cross section. Rutherford scattering.

Motion of a rigid body, rotation about an axis, Moment of inertia, Theorem of parallel and perpendicular axes, Calculation of moment of inertia for simple cases (rod, disk, sphere etc.), the simple pendulum, the compound pendulum – bar pendulum, correction for the finite amplitude of swing.

Galilean invariance, moving coordinate system, linearly accelerated frame and concept of pseudo force.

Books: Berkley Physics Course vol. I (Mechanics)
Halliday and Resnic; Physics, vol. I
Keppler and Kolenkow; Classical Mechanics
Halliday and Resnick; Physics, vol. I
Klepper and Kolenkow; Classical Mechanics

HO1 (Mathematical methods I)

Functions of more than one variable, partial derivatives, the total differential and total derivative, Exact and inexact differentials, homogeneous functions, Euler's theorem, Taylor's theorem for more than one variable, stationary values of functions of many variables, stationary values under constraints.

Matrices; addition, subtraction and multiplication of matrices; column and row matrices, associative and distributive laws; commutation and anti commutation of matrices; transpose of matrix, symmetric and antisymmetric matrices.

Vector algebra, addition and subtraction of vectors, dot and cross products, the triple scalar and vector products, reciprocal vectors; Differentiation of vectors, gradient of a scalar field, the divergence and curl of vector fields, line integrals, surface integrals and volume integrals; Stock's theorem, Gauss's divergence theorem, Green's theorem, Generalized orthogonal coordinates; gradient, divergence, curl and Laplacian in Cartesian, spherical polar and cylindrical coordinates.

Ordinary differential equations; First order linear equations, second order linear equations with constant coefficients; Examples of simple harmonic motion, damped simple harmonic motions, forced vibration.

Fourier series: Calculation of Fourier coefficients.

Books: Riley, Hobson & Bence, Mathematical Methods for Physics & Engineering

Simons, Differential equations.

HO2 (Heat I)

Concept of temperature, constant volume and constant pressuregas thermometers Platinum resistance thermometer.

Kinetic theory of gases; equation of state of a perfect gas; significance of temperature, derivation of the gas laws, mean free path, Maxwell's law for the distribution of velocities and its verification; mean speed, root mean square speed and most probable speed, degrees of freedom, equipartition of energy, application to specific heats; Transport properties viscosity and thermal conductivity of a gas; Diffusion in gases,

Brownian motion, Einstein's formula; Determination of Avogadro number.

Experimental studies of isotherms of real gases; Van der Waas equation of state, Critical constants, law of corresponding states, Virial coefficients, Boyle temperature.

Conduction of heat; conductivity and diffusivity; Fourier equation for the propagation of heat and its stedy state solution for rectilinear, radial and cylindrical flow of heat; Measurement of thermal conductivity for good and bad conductors.

Books: Saha and Srivastava; Treatise on Heat
Jeans; Kinetic Theory of gases
Loeb; Kinetic Theory of gases

HO2 (General Properties of Matter)

Gravitation: Gravitational potential and intensity: Gauss' theorem; Calculation of intensity due to a linear distribution of mass, calculation of potential and intensity due to distribution of masses with cylindrical and spherical symmetry; Self energy of a Sphere; Determination of G; Gravitational and inertial mass. The simple pendulum, the compound pendulum – bar pendulum, correction for the finite amplitude.

Elasticity; Hooke's law, relation between elastic constants; Torsion of a cylinder; Bending moment, Cantilever, Beam supported at both ends, Beams clamped at both ends, Reciprocity theorem; Elastic energy in different types of deformation.

Surface tension; Molecular forces, surface tension and surface energy; Angle of contact; Excess pressure over a curved liquid surface, Capillarity; Shape of liquid drops. Ripples.

Viscosity of liquids ; Streamline and turbulent motion; Reynold's number; Poiseuille's equation. Stoke's law, Rotating cylinder and rotating disc methods for determining the coefficient of viscosity.

Equation of continuity; Euler's equation for liquid flow; Bernoulli's theorem and its applications.

Books: Newman and Searle; General properties of Matter
C. J. Smith: Properties of Matter
D. P. Roychaudhuri; Padarther Dharma (in Bengali)

HO3 (Heat II ; Thermodynamics)

Basic concepts; macroscopic and microscopic points of view ; temperature; Thermodynamic systems and thermodynamic equilibrium; Quasistatic process; Work:
The first law of thermodynamics; isothermal and adiabatic changes in perfect and real gases.

Reversible and irreversible processes; The second law of thermodynamics; Carnot cycle and the Kelvin temperature scale; Clausius theorem; Entropy and its physical interpretation; entropy change in simple processes; Thermodynamic functions – Helmholtz free energy, Gibb's free energy and enthalpy functions; **Condition of equilibrium;** Maxwell's relations and their applications; The Joule-Thomson effect; Temperature of inversion.

Equilibrium between two phases; General equilibrium conditions; The Clausis-Clapeyron equation.

Chemical thermodynamics; Thermodynamic functions for as mixture of ideal mert gases; Chemical potential, conditions of chemical equilibrium.

Radiation: Detection of thermal radiation, emissive and absorptive power of different bodies, Prevost's theory, black body radiation, Kirchoft's law, pressure of radiation, the Stefen-Boltzmann law and its experimental verification.

Nernst heat theorem and the third law of thermodynamics;

Books: Zemansky; Heat and Thermodynamics
Fermi; Thermodynamics
Callen; Thermodynamics

HO3 (Vibrations, Waves and Acoustics)

Linear harmonic oscillator; Composition of S. H. M.'s in parallel and perpendicular directions; Lissajous figures.

Differential equation for wave propagation in solid, liquid and gases and its solution; Energy and intensity of plane waves; Velocity; The Doppler effect.

Forced vibrations and resonance, sharpness of resonance: coupled vibrations, normal modes.

Intensity of sound. Measurement of intensity; stationary waves; Interference of waves, beats, combination tones; Application of Fourier's series to the vibration of strings-struck and plucked strings; Energy of a vibration string; The Helmholtz resonator; The Kundt's tube.

Waves generated by high speed projectiles, Shock waves.

Reverberation and acoustics of buildings; Sabine's law; Ultrasonics-generation and propagation through liquids and crystals;

Books: A. B. Wood; Textbook of sound
French; Waves and Oscillations
D. P. Roycahudhuri; Advanced Acoustics

HO4 (Optics I)

Geometrical Optics:

Fermat's principle and its application to reflection and refraction at plane and spherical surfaces: Dispersive power of prisms; angular magnification; Cardinal points of optical systems; Paraxial optics and matrix method of evaluation of cardinal points and lens equations; Helmholtz-Lagrange Law; Combination of lenses and equivalent lens;

Qualitative discussions of aberrations; Chromatic aberration and achromatic combination of lenses.

Physical Optics:

Huygen's principle, derivation of the laws of reflection and refraction.

Interference of light ; Fresnel and Fraunhoffer diffraction; Fraunhoffer diffraction due to a (i) single slit, (ii) double slit and (iii) plane transmission grating.

Polarisation; Polarisation of light by reflection – Brewster's – law; Double refraction – ordinary and extraordinary ray; Optic axis; Huygen's construction for uniaxial crystals; Nicol prism, polaroids; Production and analysis of (i) plane polarized, (ii) circularly polarized and (iii) elliptically polarized light; Babinet's compensator.

Books: Jenkins and White ; Fundamentals of Optics
Longhurst; Geometrical and Physical Optics
Klein: Optics
Ghatak: Optics

HO4 (Electricity and Magnetism I) :

Electrostatics:

Coulomb's law, electrostatic intensity and potential, Gauss' law and its application to the calculation of fields. Laplace's and Poisson's equations, energy of a system of charges, force on a charged surface, the method of images and its application to (i) point charge near a conducting plane, (ii) point charge near a conducting sphere, field around conductors, capacitor and capacitance for plane parallel plates, concentric spheres and coaxial cylinders, energy stored in a capacitor.

Current Electricity:

Electrical conductivity and Ohm's law, Electrical networks and Kirchoff's laws, the Wheatstone bridge and its sensitivity, the potentiometer.

Electromagnetism:

Magnetic force on a moving charge and current carrying conductors. Motion of charged particles in electric and magnetic fields.

The magnetic effect of steady currents, definition of the magnetic field due to a current, Bio-Savart's law, magnetic field due to straight current carrying conductors, magnetic field on the axis of a circular coil and solenoid, Ampere's law and its applications.

Electromagnetic Induction:

Faraday's law, Lenz's law, the calculation of self and mutual inductance in simple cases.

Units and Dimensions:
C. G. S. , M. K. S and rationalized M. K. S units, dimensional equations.

Books: Halliday and Resnick; Physics, vol. 2
David J. Griffiths; Introduction to Electrodynamics
Purcell; Electricity and magnetism (Berkley Physics Course, vol. III)

HO5 (Mathematical methods II):

Tensors: Introduction to Cartesian tensors; tensors of rank 2 ; contraction of tensors, Contravariant and convariant vectors and tensors.

Series solution of linear homogeneous second order differential equations, Special functions- Legendre and Bessel functions. Laplace's equation in spherical polar and cylindrical coordinates.

Linear equations, solubility of homogeneous and inhomogeneous systems of linear equations, inverse of a square matrix, eigenvalues and eigenvectors of matrices, orthogonal sets of eigenvectors, orthogonal transformations, Hermitian and unitary matrices, diagonalisation of matrices.

Linear vector spaces, the dual space and the scalar product, linear operators, hermitian operators, the unitary operators, the eigenvalue problem, projection operators, the completeness relation, representation of vectors and operators by matrices.

Books: Riley, Hobson and Bence; Mathematical Methods for Physics and Engineering
Arfken and Weber; Mathematical Methods for Physicists.

HO5 (Electricity and Magnetism II)

Electrostatics: Solution of boundary value problems for rectangular and spherical symmetrics; problems with azimuthal symmetry, two dimensional problems with circular symmetry, conducting sphere in a uniform field.

Potential and field due to a dipole, force and torque on a dipole in external fields, dipole dipole interaction in a plane, the multipole expansion of charge distribution.

Dielectrics, polarization, displacement, boundary conditions. Gauss' law in a dielectric, atomic and molecular dipoles, induced dipole moments, the polarizability tensor, capacitor filled with dielectric, point charge in front of semi-infinite dielectric slab dielectric sphere in a uniform field.

Magnetostatics:

Calculation of divergence and curl of B in a general case, Gauss, law in magnetostatics, boundary conditions, vector potential- calculation of the vector potentials for straight current carrying conductors and solenoid, Forces and

torques on magnetic dipoles, magnetic field of magnetized objects and bound currents, magnetic field due to a uniformly magnetized sphere, Ampere's law in magnetized materials and the auxiliary field H. Magnetic properties of materials, susceptibility, para, dia and ferromagnetic media, Magnetic hysteresis.

Books: Halliday and Resnick; Physics, vol. 2
David J. Griffiths; Introduction to Electrodynamics
Purcell; Electricity and magnetism (Berkley Physics Course, vol. III)

HO6 (Modern Physics I)
Discharge of electricity through gases, measurement of e/m for cathode rays, determination of electric charge.

Positive rays, isotopes, the Bainbridge mass spectrograph.

The atomic view of radiation, Planck's law, the photoelectric effect, Einstein's equation and its verification by Millikan.

The Rutherford nuclear atom. Bohr's theory of hydrogen spectra, ionization and resonance potentials, the Frank and Hertz experiment.

X ray: production and properties of x-ray, continuous and characteristic x-ray spectra. Moseley's law, absorption and scattering of x-rays, diffraction of x-rays, the Laue equation, reflection from crystal planes, Bragg's law, the Bragg spectrometer, determination of crystal structure, the Compton effect. Thomson scattering (qualitative discussion), determination of lattice constants of cubic crystals.

Natural radioactivity: radioactive decay, half-life and mean life, successive disintegration, secular and transient equilibrium, radioactive series, dating from radioactivity.

Properties of alpha, beat and gamma rays.

Books: Beiser; Concepts in Modern Physics
Ghosal; Atomic and Nuclear Physics

HO6 (Mechanics II):
Constraints, generalized coordinates, D'Alembert's principle and Lagranges's equation. Hamilton's principle, Lagrange's equation from Hamilton's principle, application of Lagrange's equation to the two-body central force problem. The

equations of motion and first integrals, the equivalent one dimensional problem. Virial theorem.

Lagendre transformation and the Hamilton's equations of motion, conservation theorems and the physical significance of the Hamiltonian, application of Hamilton's equations to simple problems.

Rotating coordinate system, centrifugal and coriolis forces, the spherical pendulum, the Foucault pendulum.

The kinematics of rigid body motion, Eulerian angles, angular momentum and kinetic energy of rotation, the inertia tensor, the eigenvalues of the inertia tensor and the principal axis transformation, Euler's equations of motion of a rigid body, force free motion of a rigid body.

Small oscillations, normal modes, frequency of small oscillations about equilibrium orbits.

Books: Goldstein; Classical Mechanics
Symon; Mechanics
Marion; Mechanics

HO7 (Optics II)

Interference: Interference with multiple beams, colour of thin films, the Michelson Interferometer, the Fabry – Perot Interferometer, uses of Michelson and Fabry-Perot Interferometer.

Diffraction:
Fresnel diffraction: half – period zones, Fresnel's explanation of the rectilinear propagation of light, zone plates, fresnel's integrals, Cornu's spiral. Diffraction at a straight edge, single slit, circular disc, circular apertures.

Fraunhoffer Diffraction: The concave grating, Diffraction througha rectangular aperture, resolving power of instruments, the Rayleigh's criterion, the Taylor's criterion, resolving power of prism, grating, Fabry-Perot Interferometer, telescope, microscope, Michelson's stellar Interferometer.

Polarization: Optical activity, Fresnel's explanation, polarimeter.

Absorption and scattering of light, Rayleigh scattering, anomalous dispersion.

Books: Jenkins and White; Fundamentals of Optics
Longhurst; Geometrical and Physical Optics
Klein: Optics
Ghatak: Optics

HO7 (Electricity and Magnetism III) :

Thermoelectricity: Seebeck, Peltier and Thomson effects, thermoelectric power and thermoelectric diagrams, application of thermodynamics, thermocouples.

Response of circuits containing L, C and R to step input and pulses, transients.

A.C. Theory: Alternating currents, basic ideas of generation, mean and r.m.s. values, use of complex numbers, R, L, C, RL, RC, circuits, voltage, phase diagrams, power factor, LCR circuit, series and parallel resonance, band width and Q-value, losses in A. C. circuits, the skin effect, coupled circuits and coefficient of coupling, leakage inductance, impedance matching, the transformer, reflected impedance transformation, equivalent circuit of a transformer.

Networks: Loop and mode analysis. Thevenin's theorem, Norton's theorem, superposition theorem, maximum power transfer theorem, four-terminal network, network matrices.

Networks: Loop and mode analysis, Thevenin's theorem, Norton's theorem, superposition theorem, maximum power transfer theorem, four-terminal network, network matrices.

Books: Cotton; Electrical Technology
C. J. Smith; Electricity and Magnetism
David J. Griffiths; Introduction to Electrodynamics
Purcell; Electricity and magnetism (Berkley Physics Course, vol. III)

HO8 (The Special Theory of Relativity):

Outline of important experimental methods of measurement of velocity of light, aberration, Fizeau's experiment, the Michelson-Morley experiment and its implications.

Postulates of the special theory of relativity, Lorentz transformations, length contraction, time dilations, simultaneity, velocity addition theorem, aberration, the Doppler effect, mass energy relation.

Proper time and the light cone, Lorentz transformations as orthogonal transformations in 4 dimensions, 4-vectors and tensors, covariance of the equations of physics, variation of mass with velocity.

Relativistic particle kinematics, kinematics of decay products of an unstable particle, centre of momentum transformation and reaction thresholds, transformation of scattering cross section, momenta and energies from CM to laboratory systems.

Books: Resnick; Special Theory of Realtivity
French; Special Theory of Realtivity
Wheeler and Taylor; Space-time Physics
Kittel et. Al; Mechanics (Berkley Physics Course, vol. I)

HO8 (Quantum Mechanics I):

Origin of the quantum theory; Difficulties with the classical theory; Rayleigh-Jean's law and Wien's law for black body radiation and their difficulties, Planck's law for black body radiation, short review of the line spectra, the Rutherford and Bohr atom, Franck-Hertz experiment.

Photons as particles, particle diffraction, the de Broglie hypothesis and electron diffraction experiments; wave packets, the wave function for a free particle, the correspondence principle, the Schrodinger equation, physical interpretation of the wave function, expectation values of a dynamical variable.

Uncertainty of position and momentum, uncertainty principle, uncertainty principle for wave packets, examples of uncertainty principle.

Interaction amongst particles and the Schrodinger equation, analogy with optics and mechanics, the principle of superposition of states, Probability current, motion of wave packets.

Separation of variables in one dimension and stationary states, time evolution and expectation values of stationary and non-stationary states, Qualitative idea of transitions in presence of time dependent interactions.

Problems in one dimension: the potential step, the potential barrier, rectangular potential well, the linear harmonic oscillator. Hermite polynomials, oscillator wave function, party. An elementary introduction to the S-matrix and its symmetries in relation to I-D problems.

Books: Berkley Physics Course (vol. 5)
Crawford; Quantum Mechanics
Gasiorowickz; Quantum Mechanics

HO9 (Mathematical methods III):

Functions of a complex variable: Limit, continuity and complex differentiation, analytical functions, the Cauchy Riemann equations, multivalued functions, complex, integration, Cauchy's theorem, Taylor's series, Laurent series, singularities of complex functions, Cauchy residue theorem, Principle value of integral, evaluation of certain definite integrals by contour integration.

The Fourier integral theorem and the Fourier transforms, the Dirac delta function, properties and representation of delta functions, Laplace transforms and solution of differential equations with constant coefficients.

Solution of Lapace equation in cylindrical coordinates, Bessel functions;

Books: Riley, Hobson and Bence; Mathematical Methods for Physics and Engineering
Arfken and Weber; Mathematical Methods for Physicists.

HO9 (Statistical Mechanics I):

Elementary statistical concepts and examples, the simple random walk problem in one dimension, calculation of mean values, other examples of binomial distribution, continuous probability distribution, the Gaussian probability distribution.

Statistical descriptions of system of particles, specification of the state of the system, statistical ensemble, basic postulates and probability calculations, the density of states, thermal and mechanical interaction between macroscopic systems, constraints, equilibrium and irreversibility.

Distribution of energy between macroscopic systems, the approach to thermal equilibrium, temperature, mean energy and mean pressure of an ideal gas, the entropy, thermodynamic laws and basic statistical relations.

Isolated systems and systems in contact with a heat reservoir, the canonical distribution, simple applications of the canonical distribution, the Maxwell distribution and the equipartition theorem, simple applications of the equipartition theorem, the grand canonical distribution, the chemical potential.

Books: Reif; Statistical Physics (Berkley Physics Course, vol. – iv)
Reif; Statistical and Thermal Physics
Mandl; Statistical Physics

H10 (Instrumentsand Measurements) :

Low Temprature Physics and Vacuum Techniques:

Production of low temperature, thermodynamics of liquefaction, Joule-Thompson liquefier, cryogenic system design, cryostat design, heat transfer, temperature control, Adiabatic demagnetization.
Cryogenic thermometry: gas and vapour pressure thermometers, resistance, semiconductor and diode capacitance thermometers, thermocouples, magnetic thermometry.
Different types of pump: rotary pump, diffusion pump, ion pump, pumping speed, conductance and molecular flow; vacuum gauges; Macleod, Pirani and ionization gauges.

Electrical measurements:

A. C. meters, dynamometer type moving coil ammeter and voltmeter, moving iron and hot wire instruments, induction type instruments, wattmeters and energy meters.

Use of ballistic galvanometer in the measurements of (i) magnetic flux, (ii) self inductance, (iii) mutual inductance , (iv) high resistance by leakage.

Absolute determination of the ohm and the ampere, standard of resistance, voltage, inductance and capacitance, absolute and secondary measurements.

Generalized Wheatstone bridges for the measurement of R. I. and C common AC bridges.

Three phase systems, star and delta connections, rotating magnetic field, three phase and single phase induction motors.

Books:

H10 (Electronics Devices and Circuit I):

Thevenin's and Norton's Theorems. Transients in circuits with I . C . and R .

Intrinsic semiconductors, p-type and n-type semiconductors, the unbiased diode, forward and reverse bias, breakdown, Half-wave and full-wave rectifiers, the triple voltage, Bridge rectifier, choke-input filter, capacitor-input filter, Clippers and limiters, voltage multipliers.

Zener diode, loaded zener regulator, second approximation of a Zener diode, load-lines.

The bipolar transistor, n-p-n and p-n-p type transistors, transistor characteristics, current gain, load-line, operating point, saturation, emitter bias, voltage divider bias (VDB), accurate VDB analysis, VDB load-line and Q-point, two supply emitter bias.

AC models of transistors, base-biased amplifier, emitter biased amplifier, small signal operation, AC Beta, AC resistance of emitter diode, the T and Pi transistor models, reading the AC-parameters of a transistor on the data sheet.

Voltage amplifiers, voltage gain, loading effect of the input impedance, Multistage amplifiers, swamped amplifiers.
Digital systems, binary numbers, Boolean Algebra, AND, OR and NOT gates. De Morgan's theorem, NAND and NOR gates, XOR and XNOR gates.

Universality of NAND and NOR gates, Implementation of sum of products and products of sum, Karnaugh maps and Karnaugh simplification. Half adder and full adder. Multiplexers and demultiplexers.

Operational amplifiers: virtual ground, inverting amplifier, differentiator and integrator.

Books: Malvino; Electronic Circuits
Malvino ct. al; Digital computer Electronics

H11 (Electromagnetic Theory):

The generalization of Ampere's law, displacement current, Maxwell's equations and their empirical basis, the wave equation in vacuum, the Poynting vector and the Poynting theorem.

The wave equation in isotropic dielectrics, reflection and refraction of plane waves at the boundary of two dielectrics, the wave equation in anisotropic dielectrics.

Plane monochromatic waves in conducting media, reflection from a conducting plane. Skin effect.

Radiation from a oscillating dipole, Hertzian oscillator, absorption and scattering, anomalous dispersion.

Books: Reitz and Milford, Electromagnetic Theory
David J. Griffiths; Introduction to Electrodynamics
Marion, Electromagnetic Theory
Joos, Theoretical Physics

H11 (Modern Physics II):

Atomic spectra, Sommerfield's elliptic orbits, relativistic corrections (qualitative), space quantization, magnetic moments of atoms, the Stern-Gerlach experiment, electron spin and fine spectra, the exclusion principle and its use in understanding the periodic table, the vector atom model and the coupling between orbital and spin angular momenta, alkali doublet spectra, the Zeeman effect, the Pashchen-Back effect, selection rules for transitions.

Molecular spectra: Classification of molecular spectra, (qualitative) rotation spectra of diatomic molecules, vibration spectra, the Raman effect.

Nuclei: Rutherford scattering of alpha particles – theory and experiment, determination of nuclear charge and size.
Elementary study of nuclear structure, nuclear mass and binding energy, packing fraction, the atomic mass unit, isotopes.

H12 (Quantum Mechanics II):

The Schrodinger equation in two and three dimensions. The Schrodinger equation for spherically symmetric potentials, spherical harmonics, orbital angular momentum, eigenvalues and eigenfunctions, the hydrogen atom, quantum numbers and eigenfunctions.

Linear operators, eigenfunctions eigenvalues and the operator formalism in quantum mechanics, the bra-ket notation, the momentum operator, hermitian operators, simultaneous eigenfunctions, commutators, the party operator, the fundamental commutation relation in quantum mechanics, the Heisenberg equation of motion, commutation relation and the uncertainty principle.

The one dimensional harmonic oscillators in matrix mechanics, angular momentum commutation relation.

System of many identical particles and symmetry of the wave function under particle exchange.

Electron spin and Paul matrices, Eigenfunctions and eigenvalues of the total angular momentum operator for (a) two spin-1/2 system and (b) a spin -1/2 and the orbital angular momentum operator, Spin magnetic resonance and its application.

Motion of a particle in a magnetic field, Flux quantization, The Bohm-Ahranov effect.

Books: Gasiorowicz, Quantum Mechanics

H12 (Statistical Mechanics II):

The partition function and its properties, calculation of thermodynamic quantities for an ideal monatomic gas, the Gibb's paradox, validity of the classical approximation, paramagnetism and the calculation of magnetization.

Quantum statistics, identical particles and symmetry requirements, quantum states of a single particle, Maxwell-Boltzmann, Bose-Einstein and Fermi-Dirac statistics, quantum statistics in the classical limit, equation of states for Bose and Fermi gases, PV = (2/3) E the ideal gas in the classical limit, evaluation of the partition function, partition function of ideal monatomic Boltzmann gas.

Non – ideal classical gas, calculation of partition function for a gas of law density and second virial coefficients.

Simple ideas ofr Bose- Einstein condensation and recent observations.

Books: Reif; Statistical Physics (Berkley Physics Course. Vol – iv)
Reif; Statistical and Thermal Physics
Mandl; Statistical Physics

H13 (Nuclear Physics):

Alpha decay, measurement of velocity and energy of alpha particles, Geiger-Nuttal law, alpha particle spectra, nuclear energy levels, qualitative theory of alpha decay.

Beta decay: velocity and energy of beta particles, beta spectra, internal conversion, position emission and orbital electron capture, the neutrino.

Gamma rays: measurement of gamma energies, absorption by matter anspair production, nuclear levels and gamma spectra, internal conversion.
Discovery of the neutron, mass and life time of the neutron.

Accelerators: Vande Graff, Cyclotron, Betatron, Linear accelerator.

Nuclear reactions: Artificial radioactivity, Q-value of reactions, exo and eddo-energic reactions, reactions induced by neutrons, protons, alphas and photons. Nuclear fission, general characteristics, simple explanation from liquid drop model, energy release, reactors, nuclear fusion and energy release in stars.

Radiation detectors, ionization chambers, proportional counter, scintillation counter, emulsions, the cloud and bubble chamber, Cerenkov detectors, spark chamber, solid state Detectors, Cosmic rays – nature, origin, properties, methods of studies.

Books: Semat and Albright, Atomic and Nuclear Physics
Ghosal, Atomic and Nuclear Physics
Kaplan, Nuclear Physics
Enge, Nuclear Physics

H13 (Solid State Physics) :

Crystalline and amorphous solids, Idea of bravais lattice and reciprocal lattice.

Ionic, covalent, molecular and metallic binding in crystalline solids, Cohesive energies of ionic and metallic crystals.

Anisotropy of physical properties of a single crystal.

Simple theories of electrical and thermal conductivity, the Wiedemann-Franz law, Hall effect.

Band theory of solids, Bloch theorem, Kronig-Penny model, idea of Brillouin zone, conductors, semiconductors and insulators.

Specific heats of solids, normal mode of frequencies coupled vibrations of atoms, linear chain frequency distribution function, quantization of harmonic vibrations, phonons, Einstein and Debye theories of specific heats of solids.

Application of the Fermi-Dirac distribution, specific heat due to conduction electron.

Dia, para and ferromagnetism, Curie's law, explanation of Dia, para and ferromagnetism in terms of electronic moments, spontaneous magnetization, the Curie-Wress law and the critical temperature, domain structure and hysteresis. The general properties of magnetic resonance, NMR and ESR.

Books: Kittel, Introduction to Solid State Physics
Asheroft and Mermin, Solid State Physics

H14 (Electronics Devices and Circuit II):

Power amplifiers, Class A . B . C . operators.
Emitter follower, CC amplifier, output impedence, maximum peak – peak output, Darlington connection, voltage regulation.

Junction field effect transistors, drain curves, the transconductance curve, biasing in the active region transconductance, JFET amplifiers.

MOSFETs, the deplation mode and the enhancement mode, the ohmic region, CMOS.

Thyristros, the four layer diode, Silicon controlled rectifier.

Frequency response of an amplifier, cut-off frequencies and midband, decibel power gain, decibel voltage gain, impedance matching, The Miller effect, frequency analysis of bipolar stages.

Differential amplifiers, DC analysis, AC analysis, Input characteristics of an OP – amp, common mode gain, Integrated circuit.

Negative feedback, four types of negative feedback, VCVS voltage gain, ICVS amplifier, VCIS amplifier, ICIS amplifier, bandwidth.

Oscillators, theory of sinusoidal oscillations, Wein-bridge oscillator, other RC oscillators, Colpits oscillator, other LC oscillators, Quartz oscillator.

Regulated power supply, supply characteristics, shunt regulators, series regulators, Monolithic linear regulators.

Books: Malvino; Electronic Circuits
Malvino et. Al; Digital computer Electronics

H14 (Modern Physics III) :

The nuclear two-body problem and simple theory of the deuteron.

Elementary particles: Baryons, Mesons and Leptons, Additively conserved quantum numbers, antiparticles, isospin, analogy with angular momentum, charge independence of nuclear forces.
Proliferation of particles: The discovery of resonance particles, uncertainty principle and the lifetime of resonance particles.
The quark model, the basic building blocks of matter (quark and leptons) and their interactions, uncertainty principle and the meson theory of nuclear forces, The virtual particles as carriers of fundamental forces in nature.

Simple application of relativistic kinematics:
Two-body and three-body decays, kinematic variables in the lab-frame and CM-frame. Fixed target vs colliding beam experiment, a few important discoveries at positron-electron and hardon colliders.

A brief history of the universe and its future, Dark matter.

Quantum mechanics of two –level systems, the ammonia maser, Ko-Ko oscillations, neutrino oscillations, and lepton flavour violation.

History of superconductivity, the Meissner effect, perfect conductivity and perfect diamagnetism of superconductors, the London equation, the Jesephson junction.

Superfluidity, the fountain effect, the superfluidity of He4, the two-fluid model, thermodynamics of superfluids.

Statistical mechanics of a dimensional spin chain, qualitative ideas of modern theories of phase transitions.

Books:

H15 (Comprehensive viva: Full Marks – 100):

Phys. Lab. HO1

Preliminary Experiments:

1 To weigh a body by method of oscillation.

2 Determination of moment of Inertia of a body.

3 Determination of density of a solid soluble in water by specific gravity bottle.

4 Young's modulus by stretching.

5 Coefficient of expansion of air at constant pressure.

6 Specific Heat by method of mixture (applying radiation correction).

7 Refractive Index of a liquid by plane mirror & convex lens.

8 Frequency of a tuning fork by a Sonometer.

9 Specific Resistance of the material of a wire by a Meter Bridge.

10 Measurement of current / e.m.f. by a potentiometer.

11 Resistance of a galvanometer by a P. O. Box (Thomson's method).

12 Refractive Index of material of a prism by a spectrometer (I-D curve).

13 Refractive Index of a liquid by microscope.

14 Determination of earth's horizontal intensity (H) by employing magnetometers.

15 Resistance per unit length of a Meter Bridge by Cazy Foster's method

16 Galvanometer resistance by half – deflection method.

Phys. Lab. H 02 .

1 Determination of `g' by Kater's Pendulam.

2 Determination of coefficient of expansion of a liquid by Wet Bulb thermometer.

3 Determination of expansion of water solidification.

4 Determination of vapour density of a liquid by Victor Meyer's method.

5 Determination of thermal conductivity of a metal by Scarle's apparatus.

6 Determination of thermal conductivity of a bad conductor by Lee's apparatus.

7 Determination of coefficient of linear expansion of a solid by optical ever method.

8 Determination of boiling point of a liquid by platinum resistance thermometer.

9 Determination of the melting point of a substance by a thermocouple.

10 Determination of `J' by Callender & Barne's method.

Phys. Lab. H 03

General Physics :

1 Determination of Young's modulus of the material of a beam by bending.

2 Determination of surface tension of a liquid by capillary tube method.

3 Determination of surface tension of a liquid by Jaeger's method.

4 To determine the viscosity of a liquid by capillary flow method.

5 To verify Stokes' Law.

6 To determine the velocity of sound by Kundt's apparatus.

Phys. Lab. H 04

Electricity :

1 Determination of Mutual Inductance of a coil by Ballistic Galvanometer.

2 Determination of the strength of a given magnetic by Ballistic Galvanometer.

3 Determination of high resistance by the method of leakage.

4 To draw the BH curve of a material in the form of anchor ring.

5 Determination of frequency by a stroboscope.

6 To determine the electrical conductivity of a liquid by Kohlrausch method.

7 To calibrate an ammeter by copper deposition method.

8 Determination of low resistance by Kelvin's Double Bridge.

9 Construction of one ohm coil.

Phys. Lab. H 05

1 Determination of cardinal points of a lens combination by the method of nodal slides.

2 To find the radius of curvature of the curved surface of a plano-convex lens from the study of Newton's rings.

3 To measure the wavelength of monochromatic radiation by the biprism.

4 To measure the width of a single slit from the study of its Fraunhofer diffraction pattern.

5 Calibration of spectrometer (u – y) curve.

6 To measure the wavelengths of light by plane diffraction grating.

7 Determination of wavelengths of light by Lloyd's mirror.

8 Determination of concentration of a given sugar solution by a Polarimeter.

9 Determination of Refractive Index by measurement of critical angles.

10 Luminous and spectral characteristics of light source by photometric arrangements.

Phys. Lab. H 06.

General :

1 Determination of capacity of a condenser by Anderson's method.

2 Determination of self Inductance by Anderson Bridge.

1 . Determination of c/m by Cathode Ray Oscilloscope.

2 . To find the plateau of a G. M. counter.

3 . To find the Range of particles with the help of Electroscope and Ionization Chamber.

4 . To study the series and parallel resonance circuits with an AC source and to draw the current frequency curves.

5 . To assemble a Power Supply Unit and study its performance.

6 . Determination of the parameters from the static characteristics of (a) Diode (b) Triode (c) Pentode (d) BJT (e) FET .

7 . To study Amplifiers using :

(a) Triode (b) Pentode (c) FET (d) BJT.