UNIVERSITY OF NORTH BENGAL

Syllabus for B. Sc. Honours under revised new course structure for Part - I, Part - II and Part - III

in

PHYSICS

University of North Bengal
Raja Rammohunpur, Darjeeling - 734430
West Bengal, India.

B.Sc. Physics (Honours)

It is resolved that one experiment "To construct a negative feed back voltage amplifier using BJT and to study its voltage gain, band-width, input and output impedances" be included in Paper – X of the existing syllabus of physics honours curriculum. It is further resolved that this change should be communicated to all the colleges without any delay.

Part – I (Honours)

Paper – I			**Full Marks – 70**
Group – A	:	Mathematical Methods of Physics	
Group – B	:	Classical Mechanics – I	
Group – C	:	General Properties of matter	
Paper – II			**Full Marks – 70**
Group – A	:	Heat	
Group – B	:	Sound (Acoustics & Waves)	
Group – C	:	Electricity – I	
		(Item 1 to 7 of the "Electricity & Magnetism" group of the existing Syllabus of Physics Honours)	
Paper – III (Practical)			**Full Marks – 60**

Part – II (Honours)

Paper – IV			**Full Marks – 70**
Group – A	:	Geometrical Optics	
Group – B	:	Physical Optics	
Group – C	:	Electronics – I	
Paper – V			**Full Marks – 70**
Group – A	:	Thermodynamics	
Group – B	:	Electricity – II	
		(Item 8 to 14 of the "Electricity and Magnetism" Group of the existing syllabus of Physics Honours)	
Paper – VI (Practical)			**Full Marks – 60**

Part – III (Honours)

Paper – VII			**Full Marks – 90**
Group – A	:	Classical Mechanics – II & Fluid Mechanics	
Group – B	:	Statistical Mechanics	
Group – C	:	Electronics - II	

Paper – VIII			**Full Marks – 90**
Group – A	:	Physical Optics – II	
Group – B	:	Electromagnetic Theory	
Group – C	:	Special Theory of Relativity	
Group – D	:	Solid State Physics	
Paper – IX			**Full Marks – 90**
Group – A	:	Atomic Physics	
Group – B	:	Quantum Mechanics	
Group – C	:	Nuclear and Elementary Particle Physics	
Group – D	:		
Paper – X (Practical)			**Full Marks – 65**
Paper – XI (Practical)			**Full Marks – 65**

General marks distribution (For Hons.)

- Compulsory Question – 10 Marks

  (4 to 5 short questions)

- Optional questions : 12 X 5 = 60

Part – I

Paper – I
Paper – II : Q. No. 1 & Any 5 questions taking at least one from each group.

Part – II

Paper – IV
Paper – V : Q. No. 1 & Any 5 questions taking at least one from each group.

Part – III

Same as that prevails in the existing Part – II Physics Honours syllabus.

Part – I (Honours)

Paper – I

Group – A : Mathematical Methods: (Approximate number of lectures – 50)

1. Vectors: Equality of vectors, unit vector, addition and subtraction of vectors, multiplication by a scalar, scalar and vector products, various triple and multiple products, applications.

   Definition of vector under transformation properties. Ordinary and partial derivatives of vectors, polar and normal components of vectors. Scalar and vector fields with examples, gradient of a scalar field, divergence and curl of a vector field and their physical significance. Solenoidal and irrotational vector fields with examples. Gauss's theorem, Stoke's theorem and Green's theorem, applications.

2. Orthogonal Curvilinear Coordinate System: Unit vectors in curvilinear coordinate systems, arc length and volume element, gradient, divergence, curl and Laplacian in Cartesian, spherical polar and cylindrical coordinates. Change of variables and the Jacobian, evaluation of surface and volume integrals.

3. Ordinary Differential Equations: Series solutions of ordinary linear second order differential equations (outlines of the methods of the series solution without going in to proof), occurrence of Legendre and Hermite differential equations in Physics, elementary properties of Legendre and Hermite polynomials (orthogonality and recurrence relation).

4. Partial Differential Equations: Solution by the method of separation of variables, Laplace's equation and its solution in Cartesian, Spherical polar and Cylindrical coordinates, the wave equation and its plane and spherical wave solutions.

5. Fourier Series: Definition of a periodic function; Fourier's theorem (proof not required); Fourier analysis of various wave forms and periodic functions and evaluation of Fourier coefficients. Introduction to Fourier transforms, the Dirac-delta function and its Fourier transform, other simple examples.

6. Matrices: Equality of matrices, transpose, conjugate and conjugate transpose of a matrix; square, null, diagonal, scalar, identity, symmetric, skew – symmetric, Hermitian and skew – Hermitian matrices.

Addition and multiplication of matrices. Commutative, associative and distributive laws, adjugate and inverse of a matrix, singular and non-singular matrices, unitary matrices, Rank of a matrix, solutions of systems of linear homogeneous and in homogeneous equations up to three unknowns by matrix method. Similarity transforms, characteristic equation of a matrix, diagonalization, eigenvalue and eigen vectors.

7. Probability and Statistics: Concept of probability, total and compound probabilities, mutually exclusive events, independent events and conditional probability. Random variables, arithmetic mean and standard deviation, Binomial, Poisson and Gaussian distributions and their elementary properties.

Tutorials on problems and discussion.(8)

Group – B : Classical Mechanics I: (Approximate number of lectures – 40)

1. Units and Dimensions: Fundamental and derived units, CGS and SI (MKS) system of units; dimensions of physical quantities, simple applications of the homogeneity of dimensions, limitations of dimensional analysis.

2. Kinetics: Velocity and acceleration of a particle in (i) Cartesian, (ii) Plane polar – tangential and normal, radial and transverse components, (iii) Cylindrical and (iv) Spherical polar coordinates. Review of elementary problems for motion with uniform velocity and uniform acceleration.

3. Kinematics: Review of Newton's laws of motion; linear momentum; force; energy – potential and kinetic; work, power, work-energy theorem; principle of conservation of linear momentum.

   Conservative forces and the concept of potential – line integral of force, principle of conservation of energy, path integral of force and impulse.

   Application of Newton's laws to motion of a particle in one dimension, in a plane (including projectiles) and in three dimensions under different types of forces; system with variable mass. Dissipative forces: definition and example – frictional force and forces linearly dependent on velocity.

4. System of particles: Reduction to one body problem; centre of mass, reduced mass, relative coordinates. Collision problems (in one and two dimensions) – elastic and inelastic collisions, application of conservation principles. Centre of mass and laboratory frames of reference.

5. Rotational motion: Inertial non-inertial frames, Galilean transformation, angular velocity and angular acceleration, angular momentum and torque, principle of conservation of angular momentum; rotating frames and fictitious forces centrifugal and Coriolis forces; freely falling bodies and Foucault's pendulum, direction of ocean currents and river flow.

6. Rigid Bodies: Translational and rotational motion, kinetic energy and angular momentum of rotation, moment of inertia, products of inertia and radius of gyration, parallel and perpendicular axes theorems, calculations of moment of inertia in simple cases, ellipsoid of inertia, principal axes and principal moments of inertia, setting up of principal axes in simple symmetric cases, Euler's equations and application to simple cases.

7. Central Forces: General characteristics of central forces and conserved quantities. Motion under inverse square law of force; nature of orbits. Bound state: Kepler's problem, Kepler's laws, planetary motion and artificial satellites, escape velocity.

   Scattering and scattering cross-section, Rutherford scattering.

8. Gravitation: (a) Newton's laws of gravitation, the constant G, Heyl's method of determination of G (principle only, experimental details not needed)

   (b) Compound pendulum: bar pendulum and Kater's pendulum (discussions on corrections not needed).

   (c) Calculation of gravitational potential and intensity in simple symmetric cases.

   Tutorials on problems and discussion.(5)

(Note: Proper emphasis should be given on illustrating the conservation principles and on solving problems applying the basic principles of Newtonian Mechanics.)

Group – C : General Properties of Matter: (Approximate number of lectures – 25)

1. Elasticity: Small deformations, different types of strain and stress, generalized Hooke's law, relation between different elastic constants of isotropic solid, rigidity and torsion, shear and bending moment, cantilever beams, flat spiral spring, torsional oscillation of a cylinder, energy of elastically deformed bodies, strain energy relation; dynamics of elastic waves – seismic waves.

2. Surface Tension: Molecular origin of surface energy, surface energy and surface tension, excess pressure on a curved liquid surface and capillarity, angle of contact, shape of a liquid drop, saturation vapour pressure over a curved surface, variation of surface tension with temperature.

3. Viscosity: Streamline and turbulent flow, coefficient of viscosity, viscous flow through a capillary tube – Poiseuille's equation, critical velocity and Reynold's number, Stoke's law and its applications. Rotating viscometer. Effect of temperature on viscosity.

Tutorials on problems and discussion. (5)

Paper – II

Group – A : Heat: (Approximate number of lectures – 45)

1. Kinetic Theory of Gases: Basic assumptions, deduction of perfect gas laws, significance of temperature. Maxwell's distribution law (both in terms of velocity and energy) and its experimental verification; average, root mean square and most probable speeds. Finite size of molecules; collision probability, mean free path distribution from Maxwell's law, experimental verification. Degrees of freedom , (classical) equipartition of energy (detailed derivation not required), application to specific heat, Dulong and Petit's law.

2. Transport phenomena: (a) Viscosity, thermal conduction and diffusion in gases. (b) Brownian motion: Einstein's theory, Perin's work, determination of Avogadro's number.

3. Real Gases: Experimental studies – Andrew's and Amagat's experiments; continuity of state, deviation from Boyle's law Boyle temperature, virial theorem and virial coefficient, Van der Waal's equation of state, other equations of state (mention only), critical constants, law of corresponding states, limitations of Van der Waal's equation.

4. Conduction of Heat: Thermal and thermometric conductivity, diffusivity, Fourier's equation for heat propagation – its solution for rectilinear and radial (spherical and cylindrical) flow of heat; periodic flow of heat, Angstrom's experiment. Wiedemann-Franz law.

5. Radiation: Prevost's theory of exchanges; spectra; emissive and absorptive powers, Kirchoff's law, black body radiation, energy density of radiation and radiation pressure, Stefan-Boltzmann law, Wien's displacement and distribution law, Rayleigh-Jean's law and Planck's law (no detailed derivation, discussion about black body spectrum and applicability of these laws)

6. Thermometry: Constant volume and constant pressure thermometers, resistance thermometers, thermocouples, radiation pyrometry, extreme high and extreme low temperature measurement techniques.

   Tutorials on problems and discussion.(5)

Group – B : Sound (Waves & Acoustics) (Approximate number of lectures – 30)

1. Vibrations: Linear harmonic oscillator- differential equation and its solution, potential, kinetic and total energies. Superposition principle, composition of harmonic vibrations with same frequency but different phases, Lissajous figures; combination of harmonic motions with different frequencies, generation of beats. Free and forced vibrations of a damped harmonic oscillator, amplitude and energy resonance, dependence of time period on amplitude, generation of higher harmonics, combinatorial tones. Coupled oscillations, normal modes, energy exchange. Fourier analysis of complex vibrations, electro acoustic analogy; Helmholtz resonator as an acoustic filter.

2. Waves: Equation of plane progressive wave motion and its general solution, plane waves and spherical waves. Plane progressive waves – energy transport and intensity, dispersive and non-dispersive propagation in a medium, group velocity and phase velocity; wave packets, interference of waves – stationary waves.

3. Sound Waves: Propagation characteristics in different media, velocity of sound waves in solids, liquids, gases and strings. Intensity of sound waves, standard units of intensity (Bel, Phon). Vibration of strings – equation of transverse vibration of a stretched string and its solution, kinetic energy of a vibrating string and its normal modes – eigen functions and eigen frequencies. Fourier analysis, study of plucked and struck string.

   Doppler effect. Ultrasonics – basic principles of generation and detection (no technical details), application. Elements of building acoustics.

   Tutorials on problems and discussion.(5)

Group – C : Electricity – I

Note: There is a difference of opinion among teachers whether the Gaussian system or the SI system of units is to be followed while teaching this subject. We refrain from prescribing any specific system of units to be followed for teaching this course. A teacher is free to use any system of units he/she prefers remembering the important fact that the teaching should be done in such a way so as to ensure that at the end of the course a student feels equally at home in both the Gaussian and SI systems.

1. Electrostatics in Vacuum: Coulomb's law, Cavendish's experiment; electric field, Gauss' flux theorem and its application to simple symmetrical charge distribution, divergence of the field, line integral around a closed path, irrotational nature of the electric field, potential, Poisson's and Laplace's equations, Uniqueness theorem, superposition theorem (statement only), calculation of electric field and potential for continuous charge distribution with simple geometry, solution of Laplace's and Poisson's equations in simple cases of spherical charge distribution.

2. Electric Dipoles: Multipole expansion of the scalar potential- monopole, dipole and quadrupole terms; field and potential due to a dipole, energy of and torque on a dipole placed in a uniform external field, force on a dipole in a non-uniform field; interaction between two dipoles- mutual potential energy and torque.

3. Dielectrics: Dielectrics and conductors, polarization, polarizability, electric displacement vector (D), Gauss' and Coulomb's laws in dielectrics, boundary conditions.

4. Capacitance: Capacity and capacitors, Capacitances of capacitors having various geometries (without and with dielectrics)

5. Electrostatic energy: Energy of a charge distribution, electrostatic field energy, energy stored in a capacitor, self energy

6. Standard Potential Problems:

   (a) Method of images: a point charge in front of an infinite conducting plane, a point charge in front of a spherical conductor, conducting sphere in a uniform electric field.

   (b) Boundary value problems: point charge in front of a dielectric sphere, conducting sphere in a uniform electric field, dielectric sphere in a uniform electric field.

7. Stationary Currents and D C Circuits: Drift velocity and electric current, conductivity and resistivity; equation of continuity, Ohm's law in the microscopic form, Kirchoff's

laws and application, Wheatstone's bridge and its sensitivity, Kelvin's double bridge, Callendar and Griffith's bridge, potentiometers.

Practical

Paper – III

A student has to perform at least 80% of the experiments in each group in the practical classes and record the experimental data preferably in two separate notebooks for the two groups. These Laboratory Note Books (LNB) duly signed by the class teachers is to be presented at the time of final Practical Examination in Paper III.

During the B.Sc. Part-I Practical Examination in Paper III *one experiment* is to be performed from Gr.B only. No question (experiment) will be set from Gr.A in the Practical Examination, however the candidates will be assessed for Gr.A on the basis of oral questions and the relevant LNB presented by him.

Distribution of marks: Gr.A : LNB - 5, Viva – 5, Expt.- nil.

Gr.B : LNB - 5, Viva – 15, Expt. - 35

Group – A

1. Determination of moment of inertia of a metallic cylinder/rectangular bar about an axis pasing through its centre of mass.
2. Determination of acceleration due to gravity with Kater's pendulum.
3. Determination of the rigidity modulus of the material of a wire by static method.
4. Determination of the rigidity modulus of the material of a wire by dynamic method.
5. Determination of the surface tension of a liquid by capillary rise method.
6. Determination of the coefficient of viscosity of water by Poiseuille's method.
7. Verification of the laws of vibrating string with a sonometer.
8. Determination of the coefficient linear expansion of a solid by optical lever method.
9. Measurement of pressure coefficient of air with a constant volume gas thermometer.

Group – B

1. Determination of the Young's modulus of the material of a metallic beam by the method of flexure. (At least three lengths of the beam to be taken)
2. Determination of the surface tension by Jaeger's method and study of its variation with temperature.
3. Determination of the coefficient of viscosity of a highly viscous liquid by Stoke's method. (Density of the material of the spherical body and the liquid to be determined).
4. Determination of the thermal conductivity of a bad conductor in the shape of a disc by Lee and Chorlton's method.
5. Determination of the thermal conductivity of glas in the form of tube.
6. Determination of the boiling point of a liquid with a platinum resistance thermometer.
7. Determination of the melting point of a solid by thermocouple.
8. Measurement of J by Callendar and Barnes method.
9. Determination of the ECE of silver using potentiometer.

Part – II (Honours)

Paper – IV

Group – A : Geometrical Optics (Approximate number of lectures – 25)

1. Fundamentals: Wave normals and rays, short wavelength limit and geometrical optics.

2. Fermat's principle: application of Fermat's principle to reflection and refraction at plane and curved boundaries.

3. Optical Systems: Cardinal points of an optical system, thick lens, two thin lenses separated by a distance, equivalent lens. Different types of magnification, Helmholtz-Lagrange equation; paraxial approximation; (matrix methods may be used in paraxial optics).

4. Optical Instruments: Field of view of optical instruments; construction of eyepieces Ramsden and Huygens, Construction of high power immersion objectives, telescope and microscope, phase contrast microscopy.

5. Dispersion: Dispersive power of optical instruments; dispersive power of a prism; chromatic aberration- methods of reduction, achromatic lens combination.

6. Seidel Aberrations: (Only qualitative discussions are to be undertaken with reference to specific optical instruments) Nature and cause of different Seidel aberrations, methods of reducing these.

   Tutorials on problems and discussion.(5)

Group – B : Physical Optics – I (Approximate number of lectures – 40)

1. Wave Nature of Light: The electromagnetic spectrum; plane, spherical and cylindrical waves. Huygen's principle- derivation of laws of reflection and refraction. Basic properties of waves: superposition principle. Huygens-Fresnel principle. Vibration curve.

2. Interference: Young's experiment, coherent and incoherent superposition, conditions of interference; temporal and spatial coherence. Methods of division of wave front and division of amplitude, Fresnel's biprism, Lloyd's mirror- phase change on

reflection, multiple beam interferometry fringes of equal inclination and equal thickness, Newton's rings, thin films: colour of thin films.

3. Diffraction: Fresnel's half period zones and explanation of rectilinear propagation of light; zone plate. Types of diffraction- Fraunhoefer and Fresnel type. Fraunhoefer diffraction- single slit, double slit, rectangular aperture, circular aperture (qualitative discussion), plane diffraction grating- its dispersive power. Concave grating- mounting. Fresnel's diffraction- single slit, straight edge, circular and rectangular apertures, Fresnel's integrals and Cornu's spirals.

4. Resolving Power of Optical Instruments: Rayleigh criterion; resolving power of eye, prism, telescope, microscope and grating.

5. Interferometers: Michelson's Interferometer- description, principle of operation and uses, resolving power. Fabry-Perot Interferometer- description, principle of operation and uses, resolving power. Lummer-Gehrcke plate- description, principle of operation and uses, resolving power. Etalons, Michelson's stellar interferometer.

Tutorials on problems and discussion.(5)

Group – C : Electronics – I (Approximate number of lectures – 25)

1. Basic Concepts: Basic concepts regarding energy sources (voltage source and current source), active element, passive element.

2. Networks: Definition, mesh and nodal methods, two port networks, characteristic impedance of two port network, prototype filter- low pass, high pass, band pass, band stop, superposition theorem, Thevenin's theorem, Norton's theorem, maximum power transfer theorem.

3. Semiconductor devices:

   (a) Semiconductors: Intrinsic and extrinsic semiconductors, p-type and n-type semiconductors, electron and hole densities, generation and recombination of carriers, drift and diffusion of carriers, equation of continuity, diffusion length and lifetime of minority carriers.

   (b) p-n junction: space charge and electric field distributions at junctions, contact potential and depletion layer, depletion layer and diffusion capacitance, forward and reverse biased junctions, diode equation, diode characteristics, breakdown- avalanche and zener effects, zener diode, diode as a rectifier, zener diode as a voltage regulator, clipping circuit, clamping circuit, basic ideas of light emitting diode, silicon controlled rectifier.

(c) BJT transistors: p-n-p and n-p-n transistors, majority and minority carriers, two port network analysis, biasing of transistors, common collector, common base and common emitter configurations, α and β parameters, hybrid model and h-parameters, equivalent circuits, transistors characteristics, load line and Q-point, basic ideas about application of transistor as amplifier, switch, emitter follower, current source.

4. Digital and Logic circuits: Binary, decimal and hexadecimal number systems and conversion from one system to another, 1's complement and 2's complement of a binary number, binary addition and subtraction, Boolean algebra- fundamental postulates, basic theorems, simplification theorems and De Morgan's theorem, simplification of Boolean expression. Logic Systems, AND, OR, NOT and NAND gates, truth tables, basic construction of these gates using diodes and transistors, combination of these gates for obtaining different Boolean functions.

Tutorials on problems and discussion. (8)

Paper – V

Group – A : Thermodynamics (Approximate number of lectures – 50)

1. Basic concepts: Microscopic and macroscopic points of view; thermodynamic variables of a system; thermodynamic state and state function; exact and inexact differentials.

2. First law of thermodynamics: Thermal equilibrium, zeroth law and concept of temperature; internal energy, external work, thermodynamic equilibrium, quasi-static processes, first law of thermodynamics and applications including magnetic systems, specific heats and their ratio, isothermal and adiabatic changes in perfect and real gases.

3. Second law of thermodynamics: Reversible and irreversible processes; indicator diagram. Carnot's cycle and Carnot's theorem, efficiency of Carnot's engine. Second law of thermodynamics- different formulations and their equivalence, entropy, Clausius theorem, Clausius inequality, change of entropy in simple reversible and irreversible processes, probabilistic interpretation, entropy and disorder; Kelvin's scale of temperature- relation to perfect gas scale.

4. Thermodynamic functions: Enthalpy, Helmholtz free energy, Gibb's free energy, Legendre transformation and its use in thermodynamics, Jacobian determinants, Maxwell's relations and simple deductions using these, thermodynamic equilibrium.

5. (a) Heat engines: Steam engine and Rankine cycle. Internal combustion engines- Otto and Diesel cycles. (b) Refrigerators: Compression and absorption types of machines.

6. Change of state: Equilibrium between phases, triple point; Gibb's phase rule and simple applications. First order phase transitions; Clausius-Clapeyron's equations. Joule-Thomson effect, inversion temperature, regenerative cooling, liquefaction of air, hydrogen and helium. Cooling by adiabatic demagnetization, approach to absolute zero. Le-Chatelier's principle. Nernst heat theorem and third law of thermodynamics.

7. Chemical thermodynamics: Thermodynamic functions for mixture of ideal inert gases, change of entropy in diffusion, chemical potential, conditions of chemical equilibrium.

Tutorials on problems and discussion.(8)

Group – B : Electricity – II

1. Electromagnetism:

   (a) Source of magnetic fields, magnetic induction vector $\vec{B}$ and magnetic flux; Biot-Savart's law and calculation $\vec{B}$ for standard current distributions, Ampere's circuital law and applications.

   (b) Lorentz force; force on a current in a magnetic field, force between current carrying conductors, torque on a closed current loop in a magnetic field, equivalence between current loops and magnetic dipoles, multipole expansion of a magnetic field due to a current distribution.

   (c) Magnetic scalar and vector potentials, calculation of vector potential in simple cases; conservative and non-conservative field, $\nabla.\vec{B}$ and $\nabla \times \vec{B}$ relations.

   (d) Solenoid, Helmholtz coil, moving coil galvanometer.

2. Electromagnetic Induction: Faraday's laws and Lenz's law, calculation of induced emf in simple cases, rotating coil in a magnetic field, moving conductor in a magnetic field. Self and mutual inductances, calculations for standard geometries, reciprocity theorem, inductors in series and parallel, energy stored in an inductor, eddy current. Ballistic galvanometer and dead beat galvanometer- sensitivity and applications, Grassot flux meter.

3. Magnetic Field in Material Media:

   (a) Magnetic moment of an orbiting electron, dia-, para- and ferromagnetic materials (brief and qualitative discussion)

   (b) Magnetic current, free current and bound currents, surface and volume densities of current distribution, examples; the vectors $\vec{M}$ and $\vec{H}$, Ampere's law in terms of free current density, line integral of $\vec{H}$ in terms of free currents, magnetic susceptibility and permeability.

   (c) Magnetic scalar potential, boundary conditions for $\vec{B}$ and $\vec{H}$, solution of magnetic problems with simple geometry, magnetic sphere in a magnetic field.

(d) Magnetic circuit, energy stored in a magnetic field, magnetization cycles and hysteresis loss.

4. Transients in DC circuits: Growth and decay of currents in L-R, C-R and L-C-R circuits. Charging and discharging of capacitors, oscillatory discharge, oscillation in L-C circuits, measurement of high resistance by leakage, induction coil.

5. Alternating Currents: Mean and rms values, L-R, C-R and L-C-R circuits with sinusoidal emf, use of complex variables, reactance and impedance, phase diagrams, power and power factor, losses in AC circuits, series and parallel resonance, Q-factor, selectivity, coupled circuits, impedance matching, transformers. Three phase systems-star and delta connections; rotating magnetic fields, three phase and single-phase induction motors; outlines of principles of AC and DC generators and motors. Generalized Wheatstone's bridge, common types of AC bridges for the measurement of L and C, Anderson's bridge for the measurement of L. AC meters: moving iron and hot wire instruments, induction type instrument, watt meters and energy meters.

6. Thermoelectricity: Seebeck, Peltier and Thomson effects, laws of thermoelectricity, thermoelectric series, thermoelectric diagram, thermoelectric power, application of thermodynamics, thermocouples and their uses.

7. Units and Dimensions: CGS, Gaussian and SI (MKS) units, conversion between Gaussian and SI units, dimensions of various quantities in Gaussian and SI units.

Tutorials on problems and discussion.(10)

Practical

Paper – VI

A student has to perform at least 80% of the experiments in each group in the practical classes and record the experimental data preferably in two separate notebooks for the two groups. These Laboratory Note Books (LNB) duly signed by the class teachers is to be presented at the time of final Practical Examination in Paper VI.

During the B.Sc. Part-I Practical Examination in Paper VI *one experiment* is to be performed from Gr.B only. No question (experiment) will be set from Gr.A in the Practical Examination, however the candidates will be assessed for Gr.A on the basis of oral questions and the relevant LNB presented by him.

Distribution of marks: Gr.A : LNB - 5, Viva – 5, Expt.- nil.
Gr.B : LNB - 5, Viva – 15, Expt. - 35

Group – A

1. Measurement of focal length of a convex lens by displacement method and hence to determine the focal length of a concave lens by combination method.
2. Determination of the refractive index of the material of a lens and that of a liquid using a convex lens and a plane mirror. (Radii of curvature of lens surfaces to be measured with the help of a spherometer).
3. Verification of the inverse cube law of magnetic dipoles. Comparison of moments of two magnetic dipoles and measurement of the earth's magnetic field with deflection and oscillation magnetometers.
4. Determination of end corrections of a metre bridge and to measure the specific resistance of a material in the form of a wire.
5. Determination of the resistance per unit length of the wire of a Carey-Foster's bridge and to measure an unknown resistance.
6. Determination of the temperature coefficient of the material of a coil using metre bridge.

7. Use of potentiometer- (a) comparison of two emfs, (b) measurement of low resistance.

8. Determination of the resistance of a mirror galvanometer by half deflection method and determination of its figure of merit.

9. Calibration of a suspended coil ballistic galvanometer by (a) direct method, (b) standard capacitance method and (c) standard solenoid method.

Group – B

1. To study the L-R circuit: to draw the phase diagrams, to study the current-voltage relationship across L and to study the variation of reactance of L with frequency and hence to find its value.

2. To study the C-R circuit: to draw the phase diagrams, to study the current-voltage relationship across C and to study the variation of reactance of C with frequency and hence to find its loss factor.

3. To study a series/parallel L-C-R ac circuit: to draw its response curve, to find its resonance frequency and to study the variation of Q with C (and L if possible).

4. Determination of the constant of a ballistic galvanometer and to measure the value of the capacitance by discharge and a high resistance by leakage.

5. To measure the flux of a magnetic field with a search coil and a ballistic galvanometer.

6. To measure the mutual inductance of two coaxial coils at various relative orientations using ballistic galvanometer.

7. Tracing the B-H loop of a ferromagnetic specimen in the form of an anchor ring using ballistic galvanometer and to determine the area under the hysteresis loop and finding the energy loss.

8. To measure the capacitance of a capacitor by an AC bridge (Wien Bridge).

To measure the self-inductance of two coils separately by Anderson's bridge and the total inductance of the above two coils when they are connected in series and hence estimate the coefficient of coupling between the two coils.

Part – III

Paper – VII

A) **Classical Mechanics – II & Fluid Mechanics (Approximate number of lectures – 35)**

i) Classical Mechanics:

1. Degrees of freedom, constraints – holonomic and nonholonomic with examples, generalized coordinates.

2. Virtual displacement and virtual work, principle of virtual work, D'Alembert's principle, simple applications, generalized force and generalized moments, the Lagrangian.

3. Lagrange's equations of motion from D'Alembert's principle, application to simple systems, canonically conjugate momenta, cyclic coordinates.

4. Hamilton's variational principle, Lagrange's equations from the variational principle, principle of least action.

5. The Hamiltonian and its physical significance, Hamilton's equations of motion and application to simple systems. Poisson brackets.

6. Integrals of motion, symmetry and conservation principles in classical mechanics.

7. Small oscillations and coupled pendulums.

ii) Fluid Mechanics:

Equation of continuity, rotational and irrotational motion, velocity potential, streamline flow; Euler's equation of motion for an ideal fluid; Navier Stoke's equation for a viscous liquid (deduction not required); Bernoulli's theorem and applications, Torricelli's theorem.

Tutorials on problems and discussion.(8)

B) **Statistical Mechanics (Approximate number of lectures – 35)**

1. Basic concepts: Phase space, macrostates and microstates, hypothesis of equal a priori probability for microstates, statistical weight; System in equilibrium

with its environment- isolated, closed and open systems, statistical definitions of temperature, pressure, entropy and chemical potential.

2. Classical statistics: Maxwell-Boltzmann distribution law, law of equipartition of energy and applications, calculation of thermodynamic quantities for ideal monatomic gases.

3. Quantum statistics: Gibb's paradox, identical particles and symmetry requirements, derivation of MB, FD and BE statistics as the most probable distributions (micro-canonical ensemble), classical limit of quantum statistics.

4. Bose – Einstein statistics: Application to radiation – Planck's law, phonons and lattice specific heat of solids, Einstein and Debye's theory, Bose – Einstein condensation.

5. Fermi – Dirac statistics: Fermi distribution at zero and non-zero temperatures, Fermi energy and its expression in terms of particle density, degenerte and non-degenerate Fermi gas, electron specific heat of metals at low temperature, Thermionic emission- Richardson Dushman equation.

   Tutorials on problems and discussion.(5)

C) Electronics – II (Approximate number of lectures – 50)

1. Field Effect Transistor (FET) :

   (a) Junction FET (JFET) – structure (source, drain, gate, channel), JFET operation, static characteristics, drain and transfer characteristics, pinch off.

   (b) MOSFET: principle of operation, drain and transfer characteristics, small signal low frequency equivalent circuit, common source FET amplification-expression for voltage gains.

2. BJT amplifiers: Basic principle of operation: current, voltage and power gains, input and output impedances, effect of source resistance, frequency response, bandwidth; phase shift on amplification, operating point- class A, B, AB and C amplifiers. Small signal low frequency single stage amplifiers- comparison of CB, CE and CC configurations, wide band and tuned amplifiers, emitter

followers. Multistage amplifiers- basic principles, two-stage RC coupled amplifier- gain and bandwidth. Requirements of a power amplifier- push pull amplifier. Decibel units. Bode's plots

3. Feed back in Amplifier: principle of feedback: negative and positive feedback, voltage and current feedback, advantage of negative feedback

4. Oscillators: Barkhausen criterion for sustained oscillation, sinusoidal oscillators: Hartley, Colpitts; Wien bridge oscillators, crystal oscillator and negative resistance oscillator. Square wave generator, 555timer for astable operation

5. Power supply: Half wave, full wave and bridge rectifiers, voltage doubler, ripple factor and different types of filters-capacitor, inductor and pi types. Voltage regulation – with a zener diode and feedback circuit- basic principles.

6. Operational Amplifiers: ideal operational amplifier- structure and characteristics, practical OPAMPs, concept of virtual ground, operational feedback. Applications of OPAMPs- adder, subtractor, inverting and non-inverting amplifier, integrator and differentiator, unity gain follower, phase shifter, voltage to current converter, current to voltage converter, function generator.

7. Combinational Logic: Half adder, full adder, digital comparator, decoder, encoder, Read Only Memory (ROM), digital to analog conversion, analog to digital conversion, multiplexer.

8. Sequential Logic: Flip-flops- RS, D, JK, JKMS; edge triggering and clocked operations, shift registers, binary ripple counter, decade ripple counter.

9. Communication Principles: Propagation of electromagnetic waves in atmosphere, ground wave and sky wave, microwave transmission and communication.

   Modulation and demodulation- theory of AM, FM, PM, detection of AM wave (diode detector), detection of FM wave (slope detector)

10. Instruments: Electrostatic voltmeters, multimeters, high impedance meters. Cathode Ray Oscilloscope: cathode ray tube, deflection sensitivity, simple time base circuits; use of CRO in frequency and phase measurements.

11. Microprocessor: Architecture, register structure, interrupts, bus structure. Interfacing concepts, memory interfacing, basic concepts of programming a microprocessor, addressing data movement, arithmetic and logic instructions. (Topics to be discussed with reference to 8085 microprocessor).

Tutorials on problems and discussion.(10)

Paper – VIII

A. Physical Optics – II (Approximate number of lectures – 30)

1. Polarisation: Different types of polarization- plane, elliptically and circularly polarized light, production of polarized light- reflection, refraction, scattering; double refraction in anisotropic crystals- optical axis, principal section and principal plane, dichoric crystals. Huygen's construction of wave surfaces in uniaxial crystals; Nicol prism, Polaroids, retardation plates and Babinet's compensator. Production, detection and analysis of different types of polarization by Nicol prism, retardation plates and Babinet's compensator, Rotatory polarization and optical activity, Fresnel explanation of optical activity; polarimeters.

2. Coherent Optics: Temporal and spatial coherence, absorption and spontaneous and induced emissions of radiation in atoms and molecules, Einstein A and B coefficients (qualitative discussion only), population inversion, optical resonators, quality factor, principles of LASER and MASER, Ruby laser, He-Ne laser; basic principles of holography.

3. Fibre Optics: Optical fibre- core and cladding, step index and graded index fibre, communication through optical fibre, energy loss, bandwidth and channel capacity- a typical system, attenuation and dispersion, splicing and couplers. Fibre sensor.

Tutorials on problems and discussion.(5)

B. Electromagnetic Theory (Approximate number of lectures – 35)

1. Generalisation of ampere's law, displacement current, Maxwell's field equations, wave equation for electromagnetic field and its solution- plane wave and spherical wave solutions, gauge invariance; transverse nature of field, relation between $\vec{E}$ and $\vec{B}$; energy density of field, Poynting vector and Poynting's theorem. Boundary conditions.

2. Electromagnetic waves in isotropic dielectric medium: wave equation, relation between $\vec{E}$ and $\vec{B}$, energy density and energy flow; reflection and refraction at plane boundary, reflection and transmission coefficients, Fresnel's formulae; change of phase on reflection, polarization on reflection and Brewster's law. Total internal reflection.

3. Electromagnetic waves in conducting medium: Maxwell's equations in homogeneous conducting media, general wave equation, plane wave equations- harmonic wave solution, phase lag between electric and magnetic fields, exponential damping, skin depth, electrical and magnetic energy densities, their ratio; reflecting power of a metallic surface, wave guides (qualitative discussion only).

4. Dispersion: Equation of motion of an electron in a radiation field, Lorentz theory of dispersion- normal and anomalous. Sellmeier's and Cauchy's formulae.

5. Scattering: Scattering of radiation by a bound charge, Rayleigh scattering, blue of the sky; absorption.

   Tutorials on problems and discussion.(5)

C. Special Theory of Relativity (Approximate number of lectures – 20)

1. Velocity of light: Outline of important methods of measurement.

2. Perspectives of Special theory: inertial frames, Galilean transformation and the Galilean principle of relativity in mechanics, failure of the principle in electrodynamics; aberration of light, Fizeau's experiment, ether drag hypothesis, Michelson-Morley experiment, Lorentz contraction hypothesis.

3. Special Theory: Postulates of special theory of relativity, Lorentz transformation, length contraction, time dilation and simultaneity; velocity addition theorem, explanation of stellar aberration, Fizeau's experiment and Michelson-Morley experiment. Relativistic Doppler effect. Requirement of momentum conservation, variation of mass with velocity, form of the relativistic momentum, force, kinetic energy; transformation relations for momentum, energy and force.

4. Proper time and light cone: Minkowaski space; space like and time like four vectors, causality.

Tutorials on problems and discussion (5)

D. Solid State Physics (Approximate number of lectures – 35)

1. Crystal structure: Crystalline and amorphous solids, translational symmetry; elementary ideas about crystal structure, lattice and basis, unit cell, reciprocal lattice, fundamental types of lattices, Miller indices, simple cubic, fcc and bcc lattices; Laue and Bragg equations, Ewald's construction. Determination of crystal structure by X-ray diffraction – studies of NaCl and KCl structures; powder photograph method.

2. Structure of solids: Different types of binding- ionic, covalent, metallic and van der Waals. Band theory of solids (qualitative), energy band structure from symmetry arguments, electrons and holes, conductors, semiconductors and insulators; free electron theory of metals, effective mass, drift current, mobility and conductivity (electrical and thermal), Wiedemann and Franz law, Hall effect, thermoelectricity-Seebeck, Peltier and Thomson effect, thermoelectric engines, heat pumps. Thermionic emission, Richardson equation; elementary idea of photoelectric effect, secondary emission, field emission.

3. Dielectric properties of materials: Electronic, ionic and dipolar polarisability, local fields, induced and orientational polarization, molecular field in a dielectric, Clausius – Mosotti relation. Electrets, ferroelectricity, piezoelectricity.

4. Magnetic properties of materials: dia, para and ferromagnetic properties of materials, magnetic moment of an atom due to spin and orbital motion, Langevin's theory of diamagnetism, theory of paramagnetism, Curie's law; spontaneous magnetization and

domain structure; magnetization and its temperature dependence, Curie-Weiss law, explanation of hysteresis; ferri and antiferromagnetism.

Tutorials on problems and discussion.(5)

Paper – IX

A. Atomic Physics (Approximate number of lectures – 30)

1. Structure of the atom: Discovery of the electron, Millikan's oil drop experiment and Thomson's experiment, discovery of the proton, implications of Rutherford's experiment on the internal structure of the atom isobars, isotopes and isotones; mass spectrometers – Aston & Bainbridge and their uses.

2. Atomic spectra: predictions of classical theory, characteristics of atomic spectra, Ritz principle, Balmer's formula, different spectral series and Rydberg constant. Bohr – Sommerfeld atomic model and quantum conditions, hydrogen spectrum; excitation and ionization of atoms- Franck and Hertz experiment, Stern-Gerlach experiment and the intrinsic spin of the electron; fine structure; magnetic moment of the electron; Lande g-factor, gyromagnetic ratio. Vector atom model- space quantisation; alkali atom spectra- existence of four series; screening, selection rules. Pauli exclusion principle; shell structure of the atoms, the periodic table. X-rays- continuous and characteristic X-rays; Moseley's law and its explanation from Bohr's theory. Zeeman effect – normal and anomalous, explanation from vector atom model. Faraday effect; qualitative discussions of Stark effect and Kerr effect.

   Tutorials on problems and discussion. (5)

B. Quantum Mechanics (Approximate number of lectures – 55)

1. Failure of classical Physics and evolution of old quantum theory:

   (a) Black body radiation – shortcomings of Rayleigh-Jeans and Wien's laws; Planck's law – quantisation of energy of harmonic oscillators.

   (b) Photo electric effect

   (c) Thomson scattering and Compton scattering- dual nature of radiation

(d) Electron diffraction- Davisson Germer and G.P. Thomson's experiments.

2. Basic Quantum Mechanics:

(a) de Broglie hypothesis; group velocity and phase velocity; group velocity of waves and particle velocity.

(b) Principle of superposition; Schroedinger's wave equation; equation of continuity; probabilistic interpretation of the wave function.

(c) Dynamical variables and linear hermitian operators; properties of eigen functions and eigen values of hermitian operators; momentum, energy and angular momentum operators.

(d) Momentum, angular momentum operators and Schroedinger equation in rectangular Cartesian, spherical polar and cylindrical coordinates.

(e) Result of measurement of dynamical observables, expectation values, Bohr's correspondence and complementarity principles; Ehrenfest's theorem; stationary and non-stationary states.

(f) Commutation relation between operators, simultaneous measurements; Heisenberg's uncertainty principle with illustrations.

3. Simple applications of Quantum Mechanics:

(a) One dimensional potential well and barrier: boundary conditions, bound and unbound states, reflection and transmission coefficients. (Similarities and differences with classical systems to be emphasized at each step).

(b) Free particle in one dimensional box- box normalization of free particles, momentum eigen functions of a free particle.

(c) Linear harmonic oscillator- wave function and energy eigen values, parity of wave functions. [Detailed solution of the wave function for at least the ground state].

(d) Hydrogen problem: solution of the wave function for the ground state, discrete eigen values as a consequence of boundary conditions, comparison with the Bohr – Sommerfeld model.

(e) Diatomic molecules: rotational and vibrational energy levels, basic ideas about molecular spectra, Raman effect and its application to molecular spectroscopy.

Tutorials on problems and discussion. (8)

C. **Nuclear and Elementary Particle Physics (Approximate number of lectures – 55)**

1. Gross properties of Nuclei: Nuclear constituents, discovery of the neutron; nuclear mass, charge, size, binding energy, isospin; nuclear spin and magnetic moment;

2. Nuclear Structure: Nature of forces between nucleons; nuclear stability and nuclear binding, the static liquid drop model (descriptive) and Bethe – Weizsacker mass formula, application of mass formula to stability considerations; nuclear shell model (qualitative discussions with emphasis on phenomenology with examples)

3. Unstable Nuclei:

   (a) Radioactivity: discovery, identification of alpha, beta and gamma rays, radioactive decay laws, disintegration constant, half life and mean life, successive disintegrations- transient and secular equilibriums; units of radioactivity; dating from radioactivity and other applications.

   (b) Alpha decay: alpha particle spectra- velocity and energy of alpha particles; Geiger-Nuttal law, fine structure in alpha spectra; outlines of theory of alpha decay based on rectangular barrier penetration.

   (c) Beta decay: nature of beta ray spectra; the neutrino; energy levels and decay schemes; positron emission and electron capture; selection rules; beta absorption and range of beta particles.

   (d) Gamma decay: gamma ray spectra and nuclear energy levels; isometric state; multipolarity of transitions and selection rules (no derivation); internal conversion and bremsstrahlung (descriptive); gamma absorption in matter- photo electric process; Compton scattering and pair production (no derivation of formulae- qualitative discussions only)

4. Nuclear Reactions:

   (a) Conservation principles in nuclear reactions; Q-values and thresholds, exoergic and endoergic reactions, nuclear reaction cross-sections; examples of different types of reactions; characteristics and examples of compound nuclear and direct interactions; Bohr's hypothesis on compound nuclear reactions- Ghosal's experiment.

(b) Artificial radioactivity, its discovery, growth and decay of artificial radioactivity.

(c) Nuclear fission: discovery, characteristics- fission products and energy release, spontaneous and induced fission, transuranic elements, chain-reaction and basic principle of nuclear reactors.

(d) Nuclear fusion, energy release in stars.

5. Elementary Particles:

(a) Discovery of particles- positron, muon, pion, K-meson and hyperons; stable and semi stable particles – lifetime and decay widths; measurement of lifetime of the neutron..

(b) Four basic interactions in nature and their relative strengths, examples of different types of interactions; quantum numbers – mass, spin, isotopic spin, intrinsic parity, hypercharge and charge conjugation; conservation laws.

(c) Classification of elementary particles – hadrons and leptons; baryons and mesons, elementary ideas about quark structure of hadrons – octet and decuplet families.

(d) Cosmic rays: nature and origin, primary and secondary rays; showers; Van Allen belt.

6. Experimental Techniques:

(a) Accelerators: Electrostatic machines, Van de Graaf Cockroft-Walton machines, Cyclic accelerators- cyclotron: focusing condition and phase stability; synchrocyclotron, synchrotron, betatron. Linear accelerators; modern accelerators with colliding beams.

(b) Detectors: Passage of charged particles through matter- Bohr's ionization formula; types of interaction of charged particles with matter (qualitative- no derivation of any formulae). Charged particle detectors: Gas counters- ionization chamber, proportional counter and G.M counter, Spark chambers and wire counters; cloud chamber and bubble chamber. Gamma ray detector, scintillation counters. Semi conductor detectors for charged particles and Gamma rays.

Tutorials on problems and discussion.(8)

The duration of each laboratory class for practical should be of three periods (at least 45 minutes each). A student should have at least four laboratory classes in a week.

Paper - X

During the B.Sc. Part-II Practical Examination in Paper X one experiment is to be performed in Optics. Laboratory Note Books for both Computer and Optics is to be submitted at the time of Practical Examination. No formal examination on computer will be held during Practical Examination.

Each student has to write five computer programs and execute them. The programs and the results should be recorded in a laboratory notebook, which is to be presented at the time of Practical Examination in Paper X. The Examiners will check the Computer Note Book (CNB) and ask questions on the basis of the report presented by the student.

(Distribution of Marks:	Optics	-	LNB-5; Viva-15; Experiment- 30
	Computer	-	CNB-5; Viva-10).

Experiments in Optics:

1. Adjustment of a Spectrometer by Schuster's method and to calibrate the spectrometer (D - λ curve) and hence to determine an unknown wavelength.
2. To draw the μ-λ curve for the material of a prism using a spectrometer and to find the dispersive power.
3. To determine the wavelength of a monochromatic light by Fresnel's bi-prism.
4. To determine the wavelength of a monochromatic light by Newton's ring method.
5. Measurement of the slit width and the separation between the slits of a double slit by observing the diffraction and interference fringes using spectrometer.
6. To find the number of lines per centimeter of a plane transmission grating and hence to measure the wavelength of an unknown spectral line and to determine the resolving power of the grating.

7. To calibrate a polarimeter and hence to determine the concentration of a given sugar solution.

8. To verify the Brewster's law and Fresnel formulae for reflection of electromagnetic waves with help of a spectrometer, a prism and two Polaroid sheets.

9. To study the diffraction pattern of a crossed grating with the help of a laser source.

(At least two laboratory classes should be devoted to explain the functions and use of spectrometer and polarimeter at the beginning).

Computer Training and Experiments.

Few laboratory classes to be allotted for Computer fundamentals and Programming in C.

Computer Fundamentals: Block diagram, CPU, Memory, I-O devices, software-hardware, concepts of operating system (OS)- DOS, WINDOWS/LYNUX.

Programming in C: Variables type, operators and expressions, if-else, else-if, switch, loops-while, for and do, break and continue, go to and labels; array- one and two-dimensional.

Student will write five programs in C and execute them on a computer.

Paper – XI

One experiment to be performed during the B.Sc. Part-II Practical Examination in Paper XI. (Distribution of Marks: LNB-5; Viva-20; Experiment- 40).

1. To verify Thevenin's theorem, Norton's theorem and maximum power transfer theorem using a resistive Wheatstone's bridge with a DC source.

2. (a) To draw the I-V characteristics of a p-n junction diode.

   (b) To draw the forward and reverse bias characteristics of a zener diode and to study its voltage regulation characteristics relating to the variation of load current, variation of line voltage and ripple.

3. To draw the characteristics of a bipolar junction transistor (BJT) in CE and CB modes and to find its parameters α and β.

4. To measure the hybrid parameters and leakage current of a transistor using an AC source.

5. To construct a single stage voltage amplifier using a transistor in CE mode on a breadboard and to measure its voltage gain, bandwidth, input and output impedances form the study of frequency response curve.

6. To construct an emitter follower on a breadboard using a BJT and to study its voltage gain, bandwidth, input and output impedances.

7. To construct a regulated power supply on a breadboard using feedback and a zener diode for voltage regulation and to study its characteristics.

8. To study the input offset voltage, input bias current, input offset current of an OPAMP and use it as an (a) inverting and no inverting amplifier, (b) differential amplifier (c) integrator and (d) differentiator.

9. To construct a Wien bridge oscillator using OPAMP and to study the waveform of the oscillator and calibrate it using a CRO.

10. (a) To construct the OR, AND and NOT gates using discrete components and verify the truth tables using them.

    (b) To verify the truth tables of NOR, NAND and Ex-OR gates using IC gates.

    (c) To verify that the NOR and NAND gates are universal gates

    (d) To Verify De Morgan's theorem using IC gates.

11. To study the Fourier spectrum of (a) a square wave, (b) a saw tooth wave and (c) a half sinusoidal wave with the help of CRO.

12. To study the 8085 microprocessor