UNIVERSITY OF CALCUTTA

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THREE-YEAR HONOURS AND GENERAL
DEGREE COURSES OF STUDIES

PHYSICS

2010

B.Sc. (Physics) General Syllabus

PART-I (1st Year)

Paper IA: (50 Marks): Classical Mechanics and Gravitation, Heat and Thermodynamics
Paper IB: (50 Marks): General Properties of Matter, Waves and Vibrations, Geometrical Optics

PART-II (2nd Year)

Paper IIA:(50 Marks): Laboratory
Paper IIB:(50 Marks): Electricity and Magnetism
Paper IIIA:(50 Marks): Physical Optics, Electronics, Modern Physics
Paper IIIB:(50 Marks): Laboratory

PART-III (3rd Year)

Paper IVA:(50 Marks): Application of Thermodynamics, Energy Sources, Electronics, Communications
Paper IVB:(50 Marks): Laboratory, Computer Laboratory

(*Only SI Units to be used*)

Paper IA
Unit I: Classical Mechanics and Gravitation (25)

1. Dimensions of Physical Quantities : Principle of dimensional homogeneity

2. Vectors : Axial and polar vectors, dot product and cross product, scalar triple product and vector triple product. Scalar and vector fields --- gradient, divergence and curl, statement of divergence theorem, statement of Stokes' theorem.

3. Mechanics of a Particle : (a) Newton's laws of motion, principle of conservation of linear momentum, time and path integral of force, conservative force field, concept of potential, conservation of total energy, equation of motion of a system with variable mass.
(b) Rotational motion, angular velocity, angular acceleration, angular momentum, torque, fundamental equation of rotational motion, principle of conservation of angular momentum, radial and cross-radial acceleration.

4. Dynamics of Rigid Bodies : Moment of inertia and radius of gyration - their physical significance, theorems of parallel and perpendicular axes, rotational kinetic energy, calculation of moment of inertia for some simple symmetric systems. Physical significance of MI.

5. Gravitation : Gravitational potential and intensity due to thin uniform spherical shell and solid sphere of uniform density, escape velocity.

Unit II : Heat and Thermodynamics (25)

1. Kinetic Theory of Gases : Perfect gas, pressure exerted by it, Maxwell's law of distribution of molecular velocities (statement only) - rms, mean and most probable velocities, degrees of freedom, principle of equipartition of energy - application in simple cases. Equation of state - defects of ideal gas equation, van der Waals equation (qualitative study), critical constants.

2. Thermal Conductivity : Steady state and variable state, thermal and thermometric conductivity, Fourier equation for one-dimensional heat flow and its solution, Ingen Hausz's experiment, cylindrical flow of heat.

3. Thermodynamics : Basic concepts (equilibrium state, state function, exact and inexact differential), internal energy as state function. First law of thermodynamics and its application. Isothermal and adiabatic changes - relations, indicator diagrams. Reversible and irreversible processes, second law of thermodynamics, Carnot cycle and its efficiency, entropy and its physical interpretation.

4. Radiation : Nature of radiant heat, emissive and absorptive power, Kirchhoff's law, black body radiation, Stefan's law, Newton's law of cooling, Planck's distribution law (only statement), Wien's displacement law, pyrometer - principle.

Paper IB

Unit I : General Properties of Matter (20)

1. Elasticity : Elastic moduli and their interrelations, torsion of a cylinder, bending moment, cantilever, simply supported beam with concentrated load at the centre, strain energy.

2. Viscosity : Streamline and turbulent motion, Poiseuille's formula, critical velocity, Reynolds number, Bernoulli's theorem, Stokes' law (statement only).

3. Surface Tension : Surface tension and surface energy, molecular theory, angle of contact, elevation and depression of liquid columns in a capillary tube, excess pressure in a spherical bubble and spherical drop.

Unit II : Waves and Vibrations (15)

1. Simple Harmonic Motion : Differential equation and its solution.

2. Superposition of Simple Harmonic Motion : Analytical treatment, Lissajous figures, natural, damped and forced vibration, resonance, sharpness of resonance.

3. Differential Equation of Wave Motion : Plane progressive wave - energy and intensity. Bel, decibel and phon. Superposition of waves, beats. Velocity of longitudinal wave in solid and in gas, velocity of transverse wave in string, Doppler effect.

Unit III : Geometrical Optics (15)

1. Reflection and refraction : Fermat's Principle, laws of reflection and refraction at a plane surface, refraction at a spherical surface, lens formula. Combination of thin lenses - equivalent focal length.

2. Optical instruments : Dispersion and dispersive power, chromatic aberration and its remedy, different types of Siedel aberration (qualitative) and their remedy. Eye-piece : Ramsden and Huygen's type. Astronomical telescope and compound microscope - their magnifying power.

Paper IIB
Electricity and Magnetism (50)

1. Electrostatics : Quantisation of charge and Millikan's oil-drop experiment, Coulomb's law, intensity and potential --- example of point charge, Gauss' theorem --- simple applications, potential and field due to an electric dipole, mechanical force on the surface of a charged conductor. Dielectric medium, polarization, electric displacement.

2. Capacitor : Parallel-plates and cylindrical, energy stored in parallel plate capacitor.

3. Steady Current : Network analysis --- Kirchoff's laws, Thevnin and Norton's theorem, Wheatstone bridge, potentiometer.

4. Thermoelectricity : Seebeck, Peltier, and Thomson effects, laws of thermoelectricity, thermoelectric curve --- neutral and inversion temperature, thermoelectric power.

5. Magnetic effect of current : Biot and Savart's law, ampere's circuital law (statement only), magnetic field due to a straight conductor, circular coil, solenoid, endless solenoid, Magnetic field due to a small current loop --- concept of magnetic dipole, Ampere's equivalence theorem.

6. Lorentz force : Force on a moving charge in simultaneous electric and magnetic fields, force on a current carrying conductor in a magnetic field.

7. Magnetic materials : Intensity of magnetization, relation between **B**, **H**, and **M** --- illustration in the case of bar magnet, magnetic susceptibility --- dia, para and ferromagnetic materials, statement of Curie's law. Hysteresis in a ferromagnetic material, hysteresis loss.

8. Electromagnetic induction : Self and mutual inductances in simple cases, energy stored in inductance.

9. Varying currents : growth and decay of currents in L-R circuit; charging and discharging of capacitor in C-R circuit.

10. Alternating current : Mean and r.m.s. values of current and emf with sinusoidal wave form; LR, CR and series LCR circuits, reactance, impedance, phase-angle, power dissipation in AC circuit --- power factor, vector diagram, resonance in a series LCR circuit, Q-factor, principle of ideal transformer.

Paper IIIA

Unit I: Physical Optics (15)

1. Light as an electromagnetic wave : Full electromagnetic spectrum, properties of electromagnetic waves, Huygens' principle --- explanation of the laws of reflection and refraction.

2. Interference of light : Young's experiment, intensity distribution, conditions of interference, interference in thin films, Newton's ring.

3. Diffraction : Fresnel and Fraunhofer class, Fresnel's half-period zones, zone plate. Fraunhofer diffraction due to a single slit and plane transmission grating (elementary theory), resolving power.

4. Polarisation : Different states of polarisation, Brewster's law, double refraction, retardation plate, polaroid, optical activity.

Unit II: Electronics (15)

1. Diodes and Transistors : P-N junction diode, bridge rectifier, capacitance input filter, Zener diode, voltage regulator, Transistors --- α and β and their interrelations; output characteristics in CE mode, single stage CE amplifier --- approximate expressions of current and voltage gain with the help of 'Load Line'.

2. Digital circuits : binary systems, binary numbers. Decimal to binary and reverse conversions; binary addition and subtraction.

3. Logic gates : OR, AND, NOT gates --- truth tables. Statement of de Morgan's theorem, NOR and NAND universal gates.

Unit III: Modern Physics (20)

1. Special Theory of Relativity : Postulates of STR, formulae of (i) Length contraction; (ii) Time dilation; (iii) Velocity addition; (iv) Mass variation, and (v) Mass-energy equivalence.

2. Quantum theory of radiation : Planck's concept --- radiation formula (statement only) --- qualitative discussion of photo-electric effect and Compton effect in support of quantum theory; Raman effect.

3. Basic Quantum Mechanics : Wave nature of material particles, wave-particle duality, wavelength of de Broglie waves, Heisenberg uncertainty principle, Schroedinger equation, particle in a one-dimensional infinite well --- energy eigenvalues, wavefunction and its probabilistic interpretation. Bohr's theory of hydrogen spectra --- concept of quantum number, Pauli exclusion principle.

4. Solid State Physics : Crystalline nature of solid, diffraction of X-ray, Bragg's law; Moseley's law --- explanation from Bohr's theory.

5. Nuclear Physics : Binding energy of nucleus, binding energy curve and stability; Radioactivity, successive disintegration, radioactive equilibrium, radioactive dating, radioisotopes and their uses, nuclear transmutation, fission and fusion, nuclear reactor.

Paper IVA

Unit I: Pumps, gauges and engine (10)

1. Production and measurement of high vacuum : Rotary and diffusion pump, Mcleod, Pirani, and Penning gauges.

2. Engines : Heat engines, thermal efficiency, indicated Horse-power and brake Horse-power, Otto

cycle and Diesel cycle, four-stroke petrol and diesel engines, calculation of efficiency and comparison.

Unit II: Energy Sources (15)

1. Conventional energy sources : thermal power plant, relevance of Rankine cycle (qualitative discussion), steam turbine, hydro-electric power plant --- basic principle.

2. Non-conventional energy sources : solar, wind, tidal, geothermal, and biogas sources, elementary idea of production and uses.

Unit III: Electronics (15)

1. Feedback : Basic principle, positive and negative feedback, Barkhausen criterion, oscillator, OPAMP : characteristics, uses of OPAMP as amplifier, oscillator, and filter; light-emitting diodes, 7-segment display, SCR, diac and triac.

2. Digital electronics : combinational circuits --- adder and subtractor, multiplexer, demultiplexer, encoder, decoder, sequential circuits --- flip-flop, D and J-K, registers and counters.

3. Instruments : cathode-ray oscilloscope, digital multimeter, L and C measurements.

Unit IV: Communications (10)

1. Propagation of electromagnetic waves in atmosphere, various layers of atmosphere, ground and sky waves.

2. Transmission of electromagnetic waves : Amplitude and frequency modulation, calculation of power in amplitude modulation, sideband generation in frequency modulated wave; demodulation, linear diode detector, detection of FM waves, signal-to-noise ratio.

3. Transmission through media : coaxial cables, optical fibre --- cladding, energy loss, band width and channel capacity, information carrying capacity of lightwaves (qualitative); satellite communication, microwave link --- modem and internet.

Practical Papers

In practical classes all data should be recorded directly in the Laboratory Note Book and signed regularly by the attending teachers. This Note Book should be submitted at the time of final practical examination. No separate fair L.N.B. need be maintained. The evaluation of the L.N.B. will be done by the external examiner.

Paper IIA

Full Marks: 50 Time: 4Hours
(L.N.B. -10, Viva Voce- 10, Experiment-30)

1. Determination of modulus of rigidity of the material of a wire by dynamical method
2. Determination of moment of inertia of a metallic cylinder / rectangular bar about an axis passing through its c.g.
3. Determination of the coefficient of linear expansion of a metallic rod using an optical lever.
4. Determination of the pressure coefficient of air.
5. Determination of the refractive index of the material of a lens and that of a liquid using a convex lens and a plane mirror.
6. Determination of the focal length of a concave lens by auxiliary lens method or by combination method.
7. Determination of the frequency of a tuning fork with the help of a sonometer (Either by using the relevant formula or by using the n-l curve).
8. Determination of the horizontal component of earth's magnetic field using a deflection and an oscillation magnetometer.
9. Determination of the resistance of a suspended coil galvanometer by the method of half deflection and to calculate the figure of merit of the galvanometer (using the same data)
10. To draw the I-V characteristic of i) resistor and ii) a P-N junction diode in forward bias condition. (Plot both the characteristic curves on the same graph paper.) Estimate from the graphs i) the resistance of the resistor and ii) the dynamic resistance of the diode for three different currents. One current should correspond to the intersecting point of the two curves.
11. Determination of (i) an unknown resistance and (ii) resistance per unit length of an wire by Carey Foster method.
12. Determination of the reduction factor of a tangent galvanometer using a copper voltameter.
13. Measurement of current flowing through a resistor by using a potentiometer. Verify the result with the help of a milliammeter.

Paper IIB

Full Marks: 50 Time: 4Hours
(L.N.B. -10, Viva Voce- 10, Experiment-30)

1. Determination of Young's modulus of the material of a beam by the method of flexure (single length only).
2. Determination of the coefficient of viscosity of water by Poiseuille's method (The diameter of the capillary tube to be measured by travelling vernier microscope).
3. Determination of the surface tension of water by capillary rise method.
4. Determination of the refractive index of the material of a prism by drawing the i-δ curve using spectrometer.

5. To determine the wavelength of a monochromatic light by Newton's ring method.
6. To calibrate a polarimeter and hence to determine the concentration of sugar solution.
7. Determination of the temperature coefficient of the material of a coil using a Carey-Foster bridge (3 sets of readings for both temperatures to be taken, also the resistance per unit length of the wire to be measured).
8. To draw the I-V characteristics of a bridge rectifier (4-diode) (i) without using any filter and (ii) using a capacitive filter. (Percentage voltage regulation to be calculated for each case at a specified load current.)
9. To draw the reverse characteristics of a Zener diode & to study its voltage regulation characteristics using a variable load. (Breakdown region to be identified on the graph and Percentage voltage regulation to be calculated for two load currents.)
10. To draw the output characteristics of a transistor in C-E configuration (for at least 5 base currents) and hence to determine the A.C. current gain from the active region of the characteristics.
11. To verify the truth tables of OR and AND logic gates using diodes and construction of AND, OR and NOT gates using NOR / NAND IC gates on breadboard.
12. To draw the resonance curve of a series LCR circuit and hence to determine the Quality-factor of the circuit.

Paper IV

Module I (Computer lab)

Full Marks: 25
(Experiment - 15, Project Report - 5, Viva -5) Time: 3 hours

1. To familiarise with the hardware and the operating system and to solve simple problems by programming in C or Fortran as per the syllabus.

(i) Computer hardware: basic building blocks, central processing units, memory, hard disc, RAM. ROM, CD-ROM, DVD, pen drive, memory units: bits and bytes, input-output devices,
(ii) Computer software: Operating system, Windows, Unix/Linux

(iii) Programmingin C: basic structure, character set, keywords, identifiers, constants, variables, type declaration, operators --- arithmetic, rational, logical, assignment, increment, increment
and decrement, operator precedence and associativity, arithmetic expression, evaluation and type conversion character I/O, escape sequence and formatted I/O, branching and looping, if, if-else, while, do-while, for, arrays (one and two dimensional).

OR

(iii) Programming in Fortran : constants, variables, arrays, dimension-type statements, arithmetic expressions, input and output statements, control statements -- jumping, branching, and looping.

Problems

(i) Sorting: arranging in ascending/descending order
(ii) Read N numbers ,find their mean, median, mode
(iii) Sum of a G.P. series term by term
(iv) Solution of a quadratic equation with real / complex roots
(v) Simple matrix operations (addition, subtraction, multiplication)

2. To use database package and word processor.

Module II

(All experiments are of project type)

Full Marks: 25 Time: 3Hours
(Experiment – 15, Project report – 5, Viva – 5)

1. To convert a given ammeter into a voltmeter and a given voltmeter into an ammeter. To calibrate the instrument and to measure the internal resistance of it in each case.
2. To construct an adjustable voltage power supply using appropriate IC and to study its regulation.
3. To measure the internal resistance of an analog voltmeter and to increase its internal resistance by using an OP AMP.
4. To use OP AMP as inverting, non-inverting, differential amplifier and as an adder.
5. To calibrate a given temperature sensor and to use the sensor to control the temperature of a heat bath.
6. To develop a photo-sensor using a phototransistor followed by an amplifier and to use the same to control the switching of a bulb.