PHYSICS (861)

CLASS XII

There will be two papers in the subject:

***Paper I**: Theory - 3 hours ... 70 marks*

***Paper II**: Practical - 3 hours ... 15 marks*
Project Work ... 10 marks
Practical File ... 5 marks

PAPER I- THEORY: 70 Marks

S. NO.	UNIT	TOTAL WEIGHTAGE
1.	Electrostatics	14 Marks
2.	Current Electricity	
3.	Magnetic Effects of Current and Magnetism	16 Marks
4.	Electromagnetic Induction and Alternating Currents	
5.	Electromagnetic Waves	2 Marks
6.	Optics	18 Marks
7.	Dual Nature of Radiation and Matter	7 Marks
8.	Atoms and Nuclei	6 Marks
9.	Electronic Devices	7 Marks
TOTAL		**70 Marks**

PAPER I -THEORY- 70 Marks

Note: *(i) Unless otherwise specified, only S. I. Units are to be used while teaching and learning, as well as for answering questions.*

(ii) All physical quantities to be defined as and when they are introduced along with their units and dimensions.

(iii) Numerical problems are included from all topics except where they are specifically excluded or where only qualitative treatment is required.

1. Electrostatics

(i) Electric Charges and Fields

Electric charges; conservation and quantisation of charge, Coulomb's law; superposition principle and continuous charge distribution.

Electric field: electric field due to a point charge, electric field lines, electric dipole, electric field due to a dipole, torque on a dipole in uniform electric field.

Electric flux, Gauss's theorem in Electrostatics and its applications to find field due to infinitely long straight wire, uniformly charged infinite plane sheet and uniformly charged thin spherical shell.

(a) Coulomb's law, S.I. unit of charge; permittivity of free space and of dielectric medium. Frictional electricity, electric charges (two types); repulsion and attraction; simple atomic structure - electrons and ions; conductors and insulators; quantization and conservation of electric charge; Coulomb's law in vector form; (position coordinates r_1, r_2 not necessary). Comparison with Newton's law of gravitation; Superposition principle $\left(\vec{F}_1 = \vec{F}_{12} + \vec{F}_{13} + \vec{F}_{14} + \cdots\right)$.

(b) Concept of electric field and its intensity; examples of different fields; gravitational, electric and magnetic; Electric field due to a point charge $\vec{E} = \vec{F} / q_o$ *(q_0 is a test charge);* $\vec{E}$ *for a group of charges (superposition principle); a point charge q in an electric field* $\vec{E}$ *experiences an electric force* $\vec{F}_E = q\vec{E}$. *Intensity due to a continuous distribution of charge i.e. linear, surface and volume.*

(c) Electric lines of force: A convenient way to visualize the electric field; properties of lines of force; examples of the lines of force due to (i) an isolated point charge (+ve and - ve); (ii) dipole, (iii) two similar charges at a small distance;(iv) uniform field between two oppositely charged parallel plates.

(d) Electric dipole and dipole moment; derivation of the $\vec{E}$ *at a point, (1) on the axis (end on position) (2) on the perpendicular bisector (equatorial i.e. broad side on position) of a dipole, also for r>> 2l (short dipole); dipole in a uniform electric field; net force zero, torque on an electric dipole:* $\vec{\tau} = \vec{p} \times \vec{E}$ *and its derivation.*

(e) Gauss' theorem: the flux of a vector field; Q=vA for velocity vector $\vec{v} \| \vec{A}$, $\vec{A}$ *is area vector. Similarly, for electric field* $\vec{E}$, *electric flux* $\phi_E = EA$ *for* $\vec{E} \| \vec{A}$ *and* $\phi_E = \vec{E} \cdot \vec{A}$ *for uniform* $\vec{E}$. *For non-uniform field* $\phi_E = \int d\phi = \int \vec{E}.d\vec{A}$. *Special cases for* $\theta = 0^0$, 90^0 *and* 180^0. *Gauss' theorem, statement:* $\phi_E = q/\epsilon_0$ *or* $\phi_E = \oint \vec{E} \cdot \vec{dA} = \frac{q}{\epsilon_0}$ *where* ϕ_E *is for a closed surface; q is the net charge enclosed,* ϵ_o *is the permittivity of free space. Essential properties of a Gaussian surface.*

Applications: Obtain expression for $\vec{E}$ *due to 1. an infinite line of charge, 2. a uniformly charged infinite plane thin sheet, 3. a thin hollow spherical shell (inside, on the surface and outside). Graphical variation of E vs r for a thin spherical shell.*

(ii) Electrostatic Potential, Potential Energy and Capacitance

Electric potential, potential difference, electric potential due to a point charge, a dipole and system of charges; equipotential surfaces, electrical potential energy of a system of two point charges and of electric dipole in an electrostatic field.

Conductors and insulators, free charges and bound charges inside a conductor. Dielectrics and electric polarisation, capacitors and capacitance, combination of capacitors in series and in parallel. Capacitance of a parallel plate capacitor, energy stored in a capacitor (No derivation, formulae only).

(a) Concept of potential, potential difference and potential energy. Equipotential surface and its properties. Obtain an expression for electric potential at a point due to a point charge; graphical variation of E and V vs r, $V_P=W/q_0$; hence $V_A - V_B = W_{BA}/q_0$ (taking q_0 from B to A) = $(q/4\pi\varepsilon_0)(1/r_A - 1/r_B)$; derive this equation; also $V_A = q/4\pi\varepsilon_0 \cdot 1/r_A$; for $q>0$, $V_A>0$ and for $q<0$, $V_A < 0$. For a collection of charges V = algebraic sum of the potentials due to each charge; potential due to a dipole on its axial line and equatorial line; also at any point for $r>>2l$ (short dipole). Potential energy of a point charge (q) in an electric field $\vec{E}$, placed at a point P where potential is V, is given by $U = qV$ and $\Delta U = q(V_A - V_B)$. The electrostatic potential energy of a system of two charges = work done $W_{21}=W_{12}$ in assembling the system; U_{12} or $U_{21} = (1/4\pi\varepsilon_0)\, q_1q_2/r_{12}$. For a system of 3 charges $U_{123} = U_{12} + U_{13} + U_{23}$ $= \frac{1}{4\pi\varepsilon_0}\left(\frac{q_1q_2}{r_{12}} + \frac{q_1q_3}{r_{13}} + \frac{q_2q_3}{r_{23}}\right)$. For a dipole in a uniform electric field, derive an expression of the electric potential energy $U_E = -\vec{p}\cdot\vec{E}$, special cases for $\phi = 0^0, 90^0$ and 180^0.

(b) Capacitance of a conductor C = Q/V; obtain the capacitance of a parallel-plate capacitor ($C = \epsilon_0 A/d$) and equivalent capacitance for capacitors in series and parallel combinations. Expression for energy stored ($U = \frac{1}{2}CV^2 = \frac{1}{2}QV = \frac{1}{2}\frac{Q^2}{C}$) and energy density.

(c) Dielectric constant $K = C'/C$; this is also called relative permittivity $K = \epsilon_r = \epsilon/\epsilon_o$; elementary ideas of polarization of matter in a uniform electric field qualitative discussion; induced surface charges weaken the original field; results in reduction in $\vec{E}$ and hence, in pd, (V); for charge remaining the same $Q = CV = C'V' = K.CV'$; $V' = V/K$; and $E' = E/K$; if the Capacitor is kept connected with the source of emf, V is kept constant $V = Q/C = Q'/C'$; $Q' = C'V = K.CV = K.Q$ increases; For a parallel plate capacitor with a dielectric in between, $C' = KC = K.\epsilon_o \cdot A/d = \epsilon_r \cdot \epsilon_o \cdot A/d$. Then $C' = \frac{\epsilon_0 A}{\left(d/\epsilon_r\right)}$; for a capacitor partially filled dielectric, capacitance, $C' = \epsilon_o A/(d - t + t/\epsilon_r)$.

2. Current Electricity

Mechanism of flow of current in conductors. Mobility, drift velocity and its relation with electric current; Ohm's law and its proof, resistance and resistivity and their relation to drift velocity of electrons; V-I characteristics (linear and non-linear), electrical energy and power, electrical resistivity and conductivity. Temperature dependence of resistance and resistivity.

Internal resistance of a cell, potential difference and emf of a cell, combination of cells in series and in parallel, Kirchhoff's laws and simple applications, Wheatstone bridge, metre bridge. Potentiometer - principle and its applications to measure potential difference, to compare emf of two cells; to measure internal resistance of a cell.

(a) *Free electron theory of conduction; acceleration of free electrons, relaxation time τ ; electric current I = Q/t; concept of drift velocity and electron mobility. Ohm's law, current density J = I/A; experimental verification, graphs and slope, ohmic and non-ohmic conductors; obtain the relation $I=v_d enA$. Derive $\sigma = ne^2\tau/m$ and $\rho = m/ne^2\tau$; effect of temperature on resistivity and resistance of conductors and semiconductors and graphs. Resistance R= V/I; resistivity ρ, given by $R = \rho.l/A$; conductivity and conductance; Ohm's law as $\vec{J} = \sigma \vec{E}$.*

(b) *Electrical energy consumed in time t is E=Pt= VIt; using Ohm's law* $E = \left(V^2/R\right)t = I^2Rt$. *Potential difference V = P/ I; P = V I; Electric power consumed $P = VI = V^2/R = I^2 R$; commercial units; electricity consumption and billing.*

(c) *The source of energy of a seat of emf (such as a cell) may be electrical, mechanical, thermal or radiant energy. The emf of a source is defined as the work done per unit charge to force them to go to the higher point of potential (from -ve terminal to +ve terminal inside the cell) so, $\varepsilon = dW/dq$; but $dq = Idt$; $dW = \varepsilon dq = \varepsilon Idt$. Equating total work done to the work done across the external resistor R plus the work done across the internal resistance r; $\varepsilon Idt = I^2R\,dt + I^2rdt$; $\varepsilon = I(R + r)$; $I=\varepsilon/(R + r)$; also $IR + Ir = \varepsilon$ or $V=\varepsilon - Ir$ where Ir is called the back emf as it acts against the emf ε; V is the terminal pd. Derivation of formulae for combination for identical cells in series, parallel and mixed grouping. Parallel combination of two cells of unequal emf. Series combination of n cells of unequal emf.*

(d) *Statement and explanation of Kirchhoff's laws with simple examples. The first is a conservation law for charge and the 2nd is law of conservation of energy. Note change in potential across a resistor $\Delta V=IR<0$ when we go 'down' with the current (compare with flow of water down a river), and $\Delta V=IR>0$ if we go up against the current across the resistor. When we go through a cell, the -ve terminal is at a lower level and the +ve terminal at a higher level, so going from -ve to +ve through the cell, we are going up and $\Delta V=+\varepsilon$ and going from +ve to -ve terminal through the cell, we are going down, so $\Delta V = -\varepsilon$. Application to simple circuits. Wheatstone bridge; right in the beginning take $I_g=0$ as we consider a balanced bridge, derivation of $R_1/R_2 = R_3/R_4$ [Kirchhoff's law not necessary]. Metre bridge is a modified form of Wheatstone bridge, its use to measure unknown resistance. Here $R_3 = l_1\rho$ and $R_4=l_2\rho$; $R_3/R_4=l_1/l_2$. Principle of Potentiometer: fall in potential $\Delta V \propto \Delta l$; auxiliary emf ε_1 is balanced against the fall in potential V_1 across length l_1. $\varepsilon_1 = V_1 = Kl_1$; $\varepsilon_1/\varepsilon_2 = l_1/l_2$; potentiometer as a voltmeter. Potential gradient and sensitivity of potentiometer. Use of potentiometer: to compare emfs of two cells, to determine internal resistance of a cell.*

3. Magnetic Effects of Current and Magnetism

(i) Moving charges and magnetism

Concept of magnetic field, Oersted's experiment. Biot - Savart law and its application. Ampere's Circuital law and its applications to infinitely long straight wire, straight solenoids (only qualitative treatment). Force on a moving charge in uniform magnetic and electric fields. Force on a current-carrying conductor in a uniform magnetic field, force between two parallel current-carrying conductors-definition of ampere, torque experienced by a current loop in uniform magnetic field; moving coil galvanometer - its sensitivity. Conversion of galvanometer into an ammeter and a voltmeter.

(ii) Magnetism and Matter

A current loop as a magnetic dipole, its magnetic dipole moment, magnetic dipole moment of a revolving electron, magnetic field intensity due to a magnetic dipole (bar magnet) on the axial line and equatorial line (Qualitative only) torque on a magnetic dipole (bar magnet) in a uniform magnetic field; bar magnet as an equivalent solenoid. Diamagnetic, paramagnetic, and

ferromagnetic substances, with examples. Electromagnets and factors affecting their strengths, permanent magnets.

(a) Only historical introduction through Oersted's experiment. [Ampere's swimming rule not included]. Biot-Savart law and its vector form; application; derive the expression for B (i) at the centre of a circular loop carrying current; (ii) at any point on its axis. Current carrying loop as a magnetic dipole. Ampere's Circuital law: statement and brief explanation. Apply it to obtain $\vec{B}$ near a long wire carrying current and for a solenoid. Only formula of $\vec{B}$ due to a finitely long conductor.

(b) Force on a moving charged particle in magnetic field $\vec{F}_B = q\left(\vec{v} \times \vec{B}\right)$; special cases, modify this equation substituting $d\vec{l}/dt$ for v and I for q/dt to yield $\vec{F} = I\,d\vec{l} \times \vec{B}$ for the force acting on a current carrying conductor placed in a magnetic field. Derive the expression for force between two long and parallel wires carrying current, hence, define ampere (the base SI unit of current) and hence, coulomb; from Q = It. Lorentz force.

(c) Derive the expression for torque on a current carrying loop placed in a uniform $\vec{B}$, using $\vec{F} = I\vec{l} \times \vec{B}$ and $\vec{\tau} = \vec{r} \times \vec{F}$; $\tau = NIAB \sin\phi$ for N turns $\vec{\tau} = \vec{m} \times \vec{B}$, where the dipole moment $\vec{m} = NI\vec{A}$, unit: $A.m^2$. A current carrying loop is a magnetic dipole; directions of current and $\vec{B}$ and $\vec{m}$ using right hand rule only; no other rule necessary. Mention orbital magnetic moment of an electron in Bohr model of H atom. Concept of radial magnetic field. Moving coil galvanometer; construction, principle, working, theory $I = k\phi$, current and voltage sensitivity. Shunt. Conversion of galvanometer into ammeter and voltmeter of given range.

(d) Magnetic field represented by the symbol $\vec{B}$ is now defined by the equation $\vec{F} = q_o\,(\vec{v} \times \vec{B})$; $\vec{B}$ is not to be defined in terms of force acting on a unit pole, etc.; note the distinction of $\vec{B}$ from $\vec{E}$ is that $\vec{B}$ forms closed loops as there are no magnetic monopoles, whereas $\vec{E}$ lines start from +ve charge and end on -ve charge. Magnetic field lines due to a magnetic dipole (bar magnet). Magnetic field in end-on and broadside-on positions (No derivations). Magnetic flux $\phi = \vec{B} \cdot \vec{A} = BA$ for B uniform and $\vec{B} \parallel \vec{A}$; i.e. area held perpendicular to For $\phi = BA(\vec{B} \parallel \vec{A})$, $B = \phi/A$ is the flux density [SI unit of flux is weber (Wb)]; but note that this is not correct as a defining equation as $\vec{B}$ is vector and ϕ and ϕ/A are scalars, unit of B is tesla (T) equal to 10^{-4} gauss. For non-uniform $\vec{B}$ field, $\phi = \int d\phi = \int \vec{B} \cdot d\vec{A}$.

(e) Properties of diamagnetic, paramagnetic and ferromagnetic substances; their susceptibility and relative permeability.

It is better to explain the main distinction, the cause of magnetization (M) is due to magnetic dipole moment (m) of atoms, ions or molecules being 0 for dia, >0 but very small for para and > 0 and large for ferromagnetic materials; few examples; placed in external $\vec{B}$, very small (induced) magnetization in a direction opposite to $\vec{B}$ in dia, small magnetization parallel to $\vec{B}$ for para, and large magnetization parallel to $\vec{B}$ for ferromagnetic materials; this leads to lines of $\vec{B}$ becoming less dense, more dense and much more dense in dia, para and ferro, respectively; hence, a weak repulsion for dia, weak attraction for para and strong attraction for ferro magnetic material. Also, a small bar suspended in the horizontal plane becomes perpendicular to the $\vec{B}$ field for dia and parallel to $\vec{B}$

for para and ferro. Defining equation H = (B/μ_0)-M; the magnetic properties, susceptibility χ_m = (M/H) < 0 for dia (as M is opposite H) and >0 for para, both very small, but very large for ferro; hence relative permeability μ_r =(1+ χ_m) < 1 for dia, > 1 for para and >>1 (very large) for ferro; further, $\chi_m \propto 1/T$ (Curie's law) for para, independent of temperature (T) for dia and depends on T in a complicated manner for ferro; on heating ferro becomes para at Curie temperature. Electromagnet: its definition, properties and factors affecting the strength of electromagnet; selection of magnetic material for temporary and permanent magnets and core of the transformer on the basis of retentivity and coercive force [B-H loop and its significance, retentivity and coercive force (Qualitative only)].

4. Electromagnetic Induction and Alternating Currents

(i) Electromagnetic Induction

Faraday's laws, induced emf and current; Lenz's Law, eddy currents. Self-induction and mutual induction. Transformer.

(ii) Alternating Current

Peak value, mean value and RMS value of alternating current/voltage; their relation in sinusoidal case; reactance and impedance; LC oscillations (qualitative treatment only), LCR series circuit, resonance; power in AC circuits, wattless current. AC generator.

(a) Electromagnetic induction, Magnetic flux, change in flux, rate of change of flux and induced emf; Faraday's laws. Lenz's law, conservation of energy; motional emf $\varepsilon = Blv$, and power $P = (Blv)^2/R$; eddy currents (qualitative);

(b) Self-Induction, coefficient of self-inductance, $\phi = LI$ and $L = \varepsilon / (dI/dt)$; henry = volt. Second/ampere, expression for coefficient of self-inductance of a solenoid $L = \frac{\mu_0 N^2 A}{l} = \mu_0 n^2 A \times l$.

Mutual induction and mutual inductance (M), flux linked $\phi_2 = MI_1$; induced emf $\varepsilon_2 = \frac{d\phi_2}{dt} = M\frac{dI_1}{dt}$. Definition of M as $M = \varepsilon_2 \Big/ \frac{dI_1}{dt}$ or $\mathrm{M} = \phi_2 / I_1$. SI unit henry. Expression for coefficient of mutual inductance of two coaxial solenoids.

$M = \frac{\mu_0 N_1 N_2 A}{l} = \mu_0 n_1 N_2 A$ *Induced emf opposes changes, back emf is set up, eddy currents.*

Transformer (ideal coupling): principle, working and uses; step up and step down; efficiency and applications including transmission of power, energy losses and their minimisation.

(c) Sinusoidal variation of V and I with time, for the output from an ac generator; time period, frequency and phase changes; obtain mean values of current and voltage, obtain relation between RMS value of V and I with peak values in sinusoidal cases only.

(d) Variation of voltage and current in a.c. circuits consisting of only a resistor, only an inductor and only a capacitor (phasor representation), phase lag and phase lead. May apply Kirchhoff's law and obtain simple differential equation (SHM type), V = Vo sin ωt, solution $I = I_0 \sin \omega t$, $I_0 \sin(\omega t + \pi/2)$ and $I_0 \sin(\omega t - \pi/2)$ for pure R, C and L circuits respectively. Draw phase (or phasor) diagrams showing voltage and current and phase lag or lead, also showing resistance R, inductive reactance X_L; ($X_L = \omega L$) and capacitive reactance X_C, ($X_C = 1/\omega C$). Graph of X_L and X_C vs f.

(e) The LCR series circuit: Use phasor diagram method to obtain expression for I and V, the pd across R, L and C; and the net phase lag/lead; use the results of 4(e), V lags I by $\pi/2$ in a capacitor, V leads I by $\pi/2$ in an inductor, V and I are

in phase in a resistor, I is the same in all three; hence draw phase diagram, combine V_L and Vc (in opposite phase; phasors add like vectors) to give $V=V_R+V_L+V_C$ (phasor addition) and the max. values are related by $V^2_m=V^2_{Rm}+(V_{Lm}-V_{Cm})^2$ when $V_L>V_C$ Substituting pd=current x resistance or reactance, we get $Z^2=R^2+(X_L-X_c)^2$ and $\tan\phi = (V_{L\ m} - V_{Cm})/V_{Rm} = (X_L-X_c)/R$ giving $I = I_m \sin(wt-\phi)$ where $I_m = V_m/Z$ etc. Special cases for RL and RC circuits. [May use Kirchoff's law and obtain the differential equation] Graph of Z vs f and I vs f.

(f) Power P associated with LCR circuit = $^1/_2 V_o I_o \cos\phi = V_{rms} I_{rms} \cos\phi = I_{rms}^2 R$; power absorbed and power dissipated; electrical resonance; bandwidth of signals and Q factor (no derivation); oscillations in an LC circuit ($\omega_0 = 1/\sqrt{LC}$). Average power consumed averaged over a full cycle $\overline{P} = (1/2)\ V_o I_o \cos\phi$, Power factor $\cos\phi = R/Z$. Special case for pure R, L and C; choke coil (analytical only), X_L controls current but $\cos\phi = 0$, hence $\overline{P}=0$, wattless current; LC circuit; at resonance with $X_L=X_c$, $Z=Z_{min}= R$, power delivered to circuit by the source is maximum, resonant frequency $f_0 = \dfrac{1}{2\pi\sqrt{LC}}$.

(g) Simple a.c. generators: Principle, description, theory, working and use. Variation in current and voltage with time for a.c. and d.c. Basic differences between a.c. and d.c.

5. Electromagnetic Waves

Basic idea of displacement current. Electromagnetic waves, their characteristics, their transverse nature (qualitative ideas only). Complete electromagnetic spectrum starting from radio waves to gamma rays: elementary facts of electromagnetic waves and their uses.

Concept of displacement current, qualitative descriptions only of electromagnetic spectrum; common features of all regions of electromagnetic spectrum including transverse nature ($\vec{E}$ and $\vec{B}$ perpendicular to $\vec{c}$); special features of the common classification (gamma rays, X rays, UV rays, visible light, IR, microwaves, radio and TV waves) in their production (source), detection and other properties; uses; approximate range of λ or f or at least proper order of increasing f or λ.

6. Optics

(i) Ray Optics and Optical Instruments

Ray Optics**:** Reflection of light by spherical mirrors, mirror formula, refraction of light at plane surfaces, total internal reflection and its applications, optical fibres, refraction at spherical surfaces, lenses, thin lens formula, lens maker's formula, magnification, power of a lens, combination of thin lenses in contact, combination of a lens and a mirror, refraction and dispersion of light through a prism.

Optical instruments: Microscopes and astronomical telescopes (reflecting and refracting) and their magnifying powers.

(a) Reflection of light by spherical mirrors. Mirror formula: its derivation; R=2f for spherical mirrors. Magnification.

(b) Refraction of light at a plane interface, Snell's law; total internal reflection and critical angle; total reflecting prisms and optical fibers. Total reflecting prisms: application to triangular prisms with angle of the prism 30^0, 45^0, 60^0 and 90^0 respectively; ray diagrams for Refraction through a combination of media, ${}_1n_2 \times {}_2n_3 \times {}_3n_1 = 1$, real depth and apparent depth. Simple applications.

(c) Refraction through a prism, minimum deviation and derivation of relation between n, A and δ_{min}. Include explanation of i-δ graph, $i_1 = i_2 = i$ (say) for δ_m; from symmetry $r_1 = r_2$; refracted ray inside the prism is parallel to the base of the equilateral prism. Thin prism.

Dispersion; Angular dispersion; dispersive power, rainbow - ray diagram (no derivation). Simple explanation.

(d) *Refraction at a single spherical surface; detailed discussion of one case only - convex towards rarer medium, for spherical surface and real image. Derive the relation between n_1, n_2, u, v and R. Refraction through thin lenses: derive lens maker's formula and lens formula; derivation of combined focal length of two thin lenses in contact. Combination of lenses and mirrors (silvering of lens excluded) and magnification for lens, derivation for biconvex lens only; extend the results to biconcave lens, plano convex lens and lens immersed in a liquid; power of a lens P=1/f with SI unit dioptre. For lenses in contact $1/F= 1/f_1+1/f_2$ and $P=P_1+P_2$. Lens formula, formation of image with combination of thin lenses and mirrors.*

[Any one sign convention may be used in solving numericals].

(e) *Ray diagram and derivation of magnifying power of a simple microscope with image at D (least distance of distinct vision) and infinity; Ray diagram and derivation of magnifying power of a compound microscope with image at D. Only expression for magnifying power of compound microscope for final image at infinity.*

Ray diagrams of refracting telescope with image at infinity as well as at D; simple explanation; derivation of magnifying power; Ray diagram of reflecting telescope with image at infinity. Advantages, disadvantages and uses. Resolving power of compound microscope.

(ii) Wave Optics

Wave front and Huygen's principle. Proof of laws of reflection and refraction using Huygen's principle. Interference, Young's double slit experiment and expression for fringe width(β), coherent sources and sustained interference of light, Fraunhofer diffraction due to a single slit, width of central maximum.

(a) *Huygen's principle: wavefronts - different types/shapes of wavefronts; proof of laws of reflection and refraction using Huygen's theory. [Refraction through a prism and lens on the basis of Huygen's theory not required].*

(b) *Interference of light, interference of monochromatic light by double slit. Phase of wave motion; superposition of identical waves at a point, path difference and phase difference; coherent and incoherent sources; interference: constructive and destructive, conditions for sustained interference of light waves [mathematical deduction of interference from the equations of two progressive waves with a phase difference is not required]. Young's double slit experiment: set up, diagram, geometrical deduction of path difference $\Delta x = d\sin\theta$, between waves from the two slits; using $\Delta x=n\lambda$ for bright fringe and $\Delta x= (n+½)\lambda$ for dark fringe and $\sin\theta = \tan\theta = y_n/D$ as y and θ are small, obtain $y_n=(D/d)n\lambda$ and fringe width $\beta=(D/d)\lambda$. Graph of distribution of intensity with angular distance.*

(c) *Single slit Fraunhofer diffraction (elementary explanation, qualitative treatment only). Diffraction at a single slit: experimental setup, diagram, diffraction pattern, obtain expression for position of minima, $a\sin\theta_n = n\lambda$, where n = 1,2,3… and conditions for secondary maxima, $a\sin\theta_n = (n+½)\lambda$.; distribution of intensity with angular distance; angular width of central bright fringe.*

7. Dual Nature of Radiation and Matter

Wave particle duality; photoelectric effect, Hertz and Lenard's observations; Einstein's photoelectric equation - particle nature of light. Matter waves - wave nature of particles, de-Broglie relation; conclusion from Davisson-Germer experiment (Qualitative only).

(a) *Photo electric effect, quantization of radiation; Einstein's equation*

$E_{max} = h\upsilon - W_0$; threshold frequency; work function; experimental *facts of Hertz and Lenard and their conclusions; Einstein used Planck's ideas and extended it to apply for radiation (light); photoelectric effect can be explained only assuming quantum (particle) nature of radiation. Determination of Planck's constant (from the graph of stopping potential V_s versus frequency f of the incident light). Momentum of photon $p=E/c=h\nu/c=h/\lambda$.*

(b) De Broglie hypothesis, phenomenon of electron diffraction (qualitative only). Wave nature of radiation is exhibited in interference, diffraction and polarisation; particle nature is exhibited in photoelectric effect. Dual nature of matter: particle nature common in that it possesses momentum p and kinetic energy KE. The wave nature of matter was proposed by Louis de Broglie, $\lambda=h/p= h/mv$. Davisson and Germer experiment; qualitative description of the experiment and conclusion.

8. Atoms and Nuclei

(i) Atoms

Alpha-particle scattering experiment; Rutherford's atomic model; Bohr's atomic model, energy levels, hydrogen spectrum.

Rutherford's nuclear model of atom (mathematical theory of scattering excluded), based on Geiger - Marsden experiment on α-scattering; nuclear radius r in terms of closest approach of α particle to the nucleus, obtained by equating $\Delta K=½\ mv^2$ of the α particle to the change in electrostatic potential energy ΔU of the system [$U = \frac{2e \times Ze}{4\pi\varepsilon_0 r_0}$ $r_0 \sim 10^{-15}$m = 1 fermi; atomic structure; only general qualitative ideas, including atomic number Z, Neutron number N and mass number A. A brief account of historical background leading to Bohr's theory of hydrogen spectrum; formulae for wavelength in Lyman, Balmer, Paschen, Brackett and Pfund series. Rydberg constant. Bohr's model of H atom, postulates (Z=1); expressions for orbital velocity, kinetic energy, potential energy, radius of orbit and total energy of electron. Energy level diagram, calculation of ΔE, frequency and wavelength of different lines of emission spectra; agreement with experimentally observed values. [Use nm and not Å for unit of λ].

(ii) Nuclei

Composition and size of nucleus. Mass-energy relation, mass defect; binding energy per nucleon and its variation with mass number; Nuclear reactions, nuclear fission and nuclear fusion.

(a) Atomic masses and nuclear density; Isotopes, Isobars and Isotones – definitions with examples of each. Unified atomic mass unit, symbol u, 1u=1/12 of the mass of ^{12}C atom = 1.66×10^{-27}kg). Composition of nucleus; mass defect and binding energy, BE= $(\Delta m)\ c^2$. Graph of BE/nucleon versus mass number A, special features - less BE/nucleon for light as well as heavy elements. Middle order more stable [see fission and fusion] Einstein's equation $E=mc^2$. Calculations related to this equation; mass defect/binding energy, mutual annihilation and pair production as examples.

(b) Nuclear Energy

Theoretical (qualitative) prediction of exothermic (with release of energy) nuclear reaction, in fusing together two light nuclei to form a heavier nucleus and in splitting heavy nucleus to form middle order (lower mass number) nuclei, is evident from the shape of BE per nucleon versus mass number graph. Also calculate the disintegration energy Q for a heavy nucleus (A=240) with BE/A ~ 7.6 MeV per nucleon split into two equal halves with A=120 each and BE/A ~ 8.5 MeV/nucleon; Q ~ 200 MeV. Nuclear fission: Any one equation of fission reaction. Chain reaction-controlled and uncontrolled; nuclear reactor and nuclear bomb. Main parts of a nuclear reactor including their functions - fuel elements, moderator,

control rods, coolant, casing; criticality; utilization of energy output - all qualitative only. Fusion, simple example of 4 $^{1}H \rightarrow {}^{4}He$ and its nuclear reaction equation; requires very high temperature ~ 10^{6} degrees; difficult to achieve; hydrogen bomb; thermonuclear energy production in the sun and stars. [Details of chain reaction not required].

9. Electronic Devices

(i) Semiconductor Electronics: Materials, Devices and Simple Circuits. Energy bands in conductors, semiconductors and insulators (qualitative ideas only). Intrinsic and extrinsic semiconductors. P and n type, p-n junction.

(ii) Semiconductor diode: I-V characteristics in forward and reverse bias, diode as a rectifier; Special types of junction diodes: LED, photodiode and solar cell and Zener diode and its characteristics, Zener diode as a voltage regular.

(a) Energy bands in solids; energy band diagrams for distinction between conductors, insulators and semi-conductors - intrinsic and extrinsic; electrons and holes in semiconductors.

Elementary ideas about electrical conduction in metals [crystal structure not included]. Energy levels (as for hydrogen atom), 1s, 2s, 2p, 3s, etc. of an isolated atom such as that of copper; these split, eventually forming 'bands' of energy levels, as we consider solid copper made up of a large number of isolated atoms, brought together to form a lattice; definition of energy bands - groups of closely spaced energy levels separated by band gaps called forbidden bands. An idealized representation of the energy bands for a conductor, insulator and semiconductor; characteristics, differences; distinction between conductors, insulators and semiconductors on the basis of energy bands, with examples; qualitative discussion only; energy gaps (eV) in typical substances (carbon, Ge, Si); some electrical properties of semiconductors. Majority and minority charge carriers - electrons and holes; intrinsic and extrinsic, doping, p-type, n-type; donor and acceptor impurities.

(b) Junction diode and its symbol; depletion region and potential barrier; forward and reverse biasing, V-I characteristics and numericals; half wave and a full wave rectifier. Simple circuit diagrams and graphs, function of each component in the electric circuits, qualitative only. [Bridge rectifier of 4 diodes not included]; elementary ideas on solar cell, photodiode and light emitting diode (LED) as semi conducting diodes. Importance of LED's as they save energy without causing atmospheric pollution and global warming. Zener diode, V-I characteristics, circuit diagram and working of Zener diode as a voltage regulator.

PAPER II

PRACTICAL WORK- 15 Marks

The experiments for laboratory work and practical examinations are mostly from two groups: (i) experiments based on ray optics and (ii) experiments based on current electricity.

The main skill required in group (i) is to remove parallax between a needle and the real image of another needle.

In group (ii), understanding circuit diagram and making connections strictly following the given diagram is very important. Polarity of cells and meters, their range, zero error, least count, etc. should be taken care of.

A graph is a convenient and effective way of representing results of measurement. It is an important part of the experiment.

There will be one graph in the Practical question paper.

Candidates are advised to read the question paper carefully and do the work according to the instructions given in the question paper. Generally they are not expected to write the procedure of the experiment, formulae, precautions, or draw the figures, circuit diagrams, etc.

Observations should be recorded in a tabular form.

Record of observations

- All observations recorded should be consistent with the least count of the instrument used (e.g.

focal length of the lens is 10.0 cm or 15.1cm but **10 cm is a wrong record.)**

- All observations should be recorded with correct units.

Graph work

Students should learn to draw graphs correctly noting all important steps such as:

(i) Title

(ii) Selection of origin (should be marked by two coordinates, example 0,0 or 5,0, or 0,10 or 30,5; **Kink is not accepted).**

(i) The axes should be labelled according to the question

(ii) Uniform and convenient scale should be taken and the units given along each axis (one small division = 0.33, 0.67, 0.66, etc. should not to be taken)

(iii) Maximum area of graph paper (**at least 60% of the graph paper along both the axes**) should be used.

(iv) Points should be plotted with great care, marking the points plotted with (should be a circle with a dot) ⊙ or ⊗. A blob ( ) is a misplot.

(v) The best fit straight line should be drawn. The best fit line does not necessarily have to pass through all the plotted points and the origin. While drawing the best fit line, **all experimental points must be kept on the line or symmetrically placed on the left and right side of the line.** The line should be continuous, thin, uniform and extended beyond the extreme plots.

(vi) The intercepts must be read carefully. Y intercept i.e. y_0 is that value of y when x = 0. Similarly, X intercept i.e. x_0 is that value of x when y=0. **When x_0 and y_0 are to be read, origin should be at (0, 0).**

Deductions

(i) The slope 'S' of the best fit line must be found taking two distant points **(using more than 50% of the line drawn), which are not the plotted points**, using $S = \frac{y_2 - y_1}{x_2 - x_1} = \frac{\Delta y}{\Delta x}$. Slope S must be calculated upto proper decimal place or significant figures as specified in the question paper.

(ii) All calculations should be rounded off upto proper decimal place or significant figures, as specified in the question papers.

NOTE:

Short answer type questions may be set from each experiment to test understanding of theory and logic of steps involved.

Given below is a list of required experiments. Teachers may add to this list, keeping in mind the general pattern of questions asked in the annual examinations.

Students are required to have completed all experiments from the given list (excluding demonstration experiments):

1. To find focal length of a convex lens by using u-v method (no parallax method)

   Using a convex lens, optical bench/metre scales and two pins, obtain the positions of the images for various positions of the object; f<u<2f, u~2f, and u>2f.

   Draw the following set of graphs using data from the experiments -

   (i) ν against u. It will be a curve.

   (ii) Magnification $\left(m = \frac{\nu}{u}\right)$ against ν which is a straight line and to find focal length by intercept.

   (iii) y = (100/v) against x = (100/u) which is a straight line and find f by intercepts.

2. To find f of a convex lens by displacement method.
3. To determine the focal length of a given convex lens with the help of an auxiliary convex lens.
4. To determine the focal length of a concave lens, using an auxiliary convex lens, not in contact and plotting appropriate graph.
5. To determine focal length of concave mirror by using two pins (by u-v method).
6. To determine the refractive index of a liquid by using a convex lens and a plane mirror.

7. To determine the focal length of a convex mirror using convex lens.
8. Using a metre bridge, determine the resistance of about 100 cm of (constantan) wire. Measure its length and radius and hence, calculate the specific resistance of the material.Verify Ohm's law for the given unknown resistance (a 60 cm constantan wire), plotting a graph of potential difference versus current. Also calculate the resistance per cm of the wire from the slope of the graph and the length of the wire.
9. To determine the internal resistance of a cell by a potentiometer.
10. From a potentiometer set up, measure the fall in potential (i.e. pd) for increasing lengths of a constantan wire, through which a steady current is flowing; plot a graph of pd (V) versus length (l). Calculate the potential gradient of the wire and specific resistance of its material. Q (i) Why is the current kept constant in this experiment? Q (ii) How can you increase the sensitivity of the potentiometer? Q (iii) How can you use the above results and measure the emf of a cell?
11. To verify the laws of combination of resistances (series and parallel) using metre bridge.

Demonstration Experiments *(The following experiments are to be demonstrated by the teacher)*:

1. To convert a given galvanometer into (a) an ammeter of range, say 2A and (b) a voltmeter of range 4V.
2. To study I-V characteristics of a semi-conductor diode in forward and reverse bias.
3. To determine refractive index of a glass slab using a traveling microscope.
4. Identification of diode, LED, transistor, IC, resistor, capacitor from mixed collection of such items.
5. Use of multimeter to (i) identify base of transistor, (ii) distinguish between npn and pnp type transistors, (iii) see the unidirectional flow of current in case of diode and an LED, (iv) check whether a given electronic component (e.g. diode, transistors, IC) is in working order.
6. Charging and discharging of a capacitor.

PROJECT WORK AND PRACTICAL FILE – 15 marks

Project Work – 10 marks

The Project work is to be assessed by a Visiting Examiner appointed locally and approved by the Council.

All candidates will be required to do **one** project involving some physics related topic/s under the guidance and regular supervision of the Physics teacher.

Candidates should undertake any **one** of the following types of projects:

- Theoretical project
- Working Model
- Investigatory project (by performing an experiment under supervision of a teacher)

Candidates are to prepare a technical report including title, abstract, some theoretical discussion, experimental setup, observations with tables of data collected, graph/chart (if any), analysis and discussion of results, deductions, conclusion, etc. The teacher should approve the draft, before it is finalised. The report should be kept simple, but neat and elegant. Teachers may assign or students may choose **any one** project of their choice.

Suggested Evaluation Criteria for Theory Based Projects:

▪ Title of the Project
▪ Introduction
▪ Contents
▪ Analysis/ material aid (graph, data, structure, pie charts, histograms, diagrams, etc.)
▪ Originality of work (the work should be the candidates' original work,)
▪ Conclusion/comments

Suggested Evaluation Criteria for Model Based Projects:

▪ Title of the Project
▪ Model construction
▪ Concise Project report

Suggested Evaluation Criteria for Investigative Projects:

▪ Title of the Project
▪ Theory/principle involved
▪ Experimental setup
▪ Observations calculations/deduction and graph work
▪ Result/ Conclusions

Practical File – 5 marks

The Visiting Examiner is required to assess the candidates on the basis of the Physics practical file maintained by them during the academic year.