CLASS XII

There will be two papers in the subject.

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

Paper II: *Practical - 3 hours ... 20 marks*

Project Work ... 7 marks

Practical File ... 3 marks

PAPER I -THEORY- 70 Marks

Paper I shall be of 3 hours duration and be divided into two parts.

Part I (20 marks): *This part will consist of compulsory short answer questions, testing knowledge, application and skills relating to elementary/fundamental aspects of the entire syllabus.*

Part II (50 marks): *This part will be divided into three Sections A, B and C. There shall be* ***three*** *questions in Section A (each carrying 9 marks) and candidates are required to answer* ***two*** *questions from this Section. There shall be* ***three*** *questions in Section B (each carrying 8 marks) and candidates are required to answer* ***two*** *questions from this Section. There shall be* ***three*** *questions in Section C (each carrying 8 marks) and candidates are required to answer* ***two*** *questions from this Section. Therefore, candidates are expected to answer* ***six*** *questions in Part 2.*

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

SECTION A

1. Electrostatics

(i) Coulomb's law, S.I. unit of charge; permittivity of free space.

Review of electrostatics covered in Class X. Frictional electricity, electric charge (two types); repulsion and attraction; simple atomic structure - electrons and protons as electric charge carriers; conductors, insulators; quantisation of electric charge; conservation of charge; Coulomb's law (in free space only); vector form; (position coordinates r_1, r_2 not necessary); SI unit of charge; Superposition principle; simple numerical problems.

(ii) Concept of electric field E = F/q_o; Gauss' theorem and its applications.

Action at a distance versus field concept; examples of different fields; temperature and pressure (scalar); gravitational, electric and magnetic (vector field); definition $\vec{E} = \vec{F} / q_o$.

Electric field due to a point charge; $\vec{E}$ *for a*

group of charges (superposition); A point charge q in an electric field $\vec{E}$ *experiences an electric force* $\vec{F}_E = q\vec{E}$.

Gauss' theorem: the flux of a vector field; Q=VA for velocity vector $\vec{V} \| \vec{A}$, *the area vector, for uniform flow of a liquid. 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* $\theta = 0°, 90°$ *and* $180°$. *Examples, calculations. Gauss' law, statement:* $\phi_E = q/\epsilon_0$ *or* $\phi_E = \oint \vec{E} \cdot d\vec{A} = q/\epsilon_0$ *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: 1. Deduce Coulomb's law from the Gauss' law and certain symmetry considerations (No proof required); 2 (a). An excess charge placed on an isolated conductor resides on the outer surface; (b) $\vec{E} = 0$ *inside a cavity in an isolated conductor; (c)* $E = \sigma/\epsilon_0$ *for a point outside; 3.* $\vec{E}$ *due to an infinite line of charge, sheet of charge, spherical shell of charge (inside and outside); hollow spherical conductor. [Experimental test of coulomb's law not included].*

(iii) Electric dipole; electric field at a point on the axis and perpendicular bisector of a dipole; electric dipole moment; torque on a dipole in a uniform electric field.

Electric dipole and dipole moment; with unit; derivation of the $\vec{E}$ *at any point, (a) on the* *axis (b) on the perpendicular bisector of the dipole, for r>> 2l. [$\vec{E}$ due to continuous distribution of charge, ring of charge, disc of charge etc not included]; dipole in uniform $\vec{E}$ electric field; net force zero, torque $\vec{\tau} = \vec{p} \times \vec{E}$.*

(iv) 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 an isolated point charge (+ve and - ve); dipole, two similar charges at a small distance; uniform field between two oppositely charged parallel plates.

(v) Electric potential and potential energy; potential due to a point charge and due to a dipole; potential energy of an electric dipole in an electric field. Van de Graff generator.

Brief review of conservative forces of which gravitational force and electric forces are examples; potential, pd and potential energy are defined only in a conservative field; electric potential at a point; definition $V_P=W/q_0$; 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 $V_A = q/4\pi\varepsilon_0 . 1/r_A$; for q>0, $V_A>0$ and for q<0, $V_A < 0$. For a collection of charges V = sum of the potential due to each charge; potential due to a dipole on its axial line and equatorial line; also at any point for r>>d. 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, the electric potential energy $U_E = -\vec{p} \cdot \vec{E}$, special case for $\phi = 0, 90^0$ and 180^0.

Van de Graff Generator. Potential inside a charged spherical shell is uniform. A small conducting sphere of radius r and carrying charge q is located inside a large shell of radius R that carries charge Q. The potential difference between the spheres, V(R) – V(r) = $(q/4\pi\varepsilon_o)$ (1/R – 1/r) is independent of Q. If the two are connected, charge always flows from the inner sphere to the outer sphere, raising its potential. Sketch of a very simple Van de Graff Generator, its working and use.

(vi) Capacitance of a conductor C = Q/V, the farad; capacitance of a parallel-plate capacitor; $C = K\epsilon_0 A/d$ capacitors in series and parallel combinations; energy $U = {}^1/_2 CV^2$ $= \frac{1}{2}QV = \frac{1}{2}\frac{Q^2}{C}$.

Self-explanatory.

Combinations of capacitors in series and parallel; effective capacitance and charge distribution.

(vii) Dielectrics (elementary ideas only); permittivity and relative permittivity of a dielectric ($\epsilon_r = \epsilon/\epsilon_o$). Effects on pd, charge and capacitance.

Dielectric constant $K_e = C'/C$; this is also called relative permittivity $K_e = \epsilon_r = \epsilon/\epsilon_o$; 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 $Q = CV = C'\ V' = K_e\ .\ CV'$; $V' = V/K_e$; and $E' = \frac{E}{K_e}$; if the C is kept connected with the source of emf, V is kept constant V = Q/C = Q'/C' ; $Q'=C'V = K_e\ .\ CV = K_e\ .\ Q$ increases; For a parallel plate capacitor with a dielectric in between $C' = K_eC = K_e . \epsilon_o$. A/d = $\epsilon_r . \epsilon_o$ .A/d. Then, $C'' = \frac{\epsilon_0 A}{\left(d/\epsilon_r\right)}$; extending this to a partially filled capacitor $C' = \epsilon_o A/(d-t + t/\epsilon_r)$. Spherical and cylindrical capacitors (qualitative only).

2. Current Electricity

(i) Steady currents; sources of current, simple cells, secondary cells.

Sources of emf: Mention: Standard cell, solar cell, thermo-couple and battery, etc. simple cells, acid/alkali cells - qualitative description.

(ii) Potential difference as the power supplied divided by the current; Ohm's law and its limitations; Combinations of resistors in series and parallel; Electric energy and power.

Definition of pd, $V = P/I$; $P = VI$; electrical energy consumed in time t is $E=Pt= VIt$; using ohm's law $E = VIt = \frac{V^2}{R}t = I^2Rt$. Electric power consumed $P = VI = V^2/R = I^2R$; SI units; commercial units; electricity consumption and billing. Ohm's law, current density $\sigma = I/A$; experimental verification, graphs and slope, ohmic resistors; examples; deviations. Derivation of formulae for combination of resistors in series and parallel; special case of n identical resistors; $R_p = R/n$.

(iii) Mechanism of flow of current in metals, drift velocity of charges. Resistance and resistivity and their relation to drift velocity of electrons; description of resistivity and conductivity based on electron theory; effect of temperature on resistance, colour coding of resistance.

Electric current $I = Q/t$; atomic view of flow of electric current in metals; $I=v_d ena$. Electron theory of conductivity; acceleration of electrons, relaxation time τ ; derive $\sigma = ne^2\tau/m$ and $\rho = m/ne^2\tau$; effect of temperature on resistance. Resistance $R= V/I$ for ohmic substances; resistivity ρ, given by $R = \rho.l/A$; unit of ρ is $\Omega.m$; conductivity $\sigma=1/\rho$; Ohm's law as $\vec{J} = \sigma\vec{E}$; colour coding of resistance.

(iv) Electromotive force in a cell; internal resistance and back emf. Combination of cells in series and parallel.

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; $\varepsilon Idt=I^2R\,dt + I^2r dt$; $\varepsilon =I(R + r)$; $I=\varepsilon/(R + r)$; 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 formula for combination of cells in series, parallel and mixed grouping.

(v) Kirchhoff's laws and their simple applications to circuits with resistors and sources of emf; Wheatstone bridge, metre-bridge and potentiometer; use for comparison of emf and determination of internal resistance of sources of current; use of resistors (shunts and multipliers) in ammeters and voltmeters.

Statement and explanation 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 $R_1/R_2 = R_3/R_4$ is simpler [Kirchhoff's law not necessary]. Metre bridge is a modified form of Wheatstone bridge. Here $R_2 = l_1p$ and $R_4 =l_2p$; $R_1/R_3 = l_1/l_2$. Potentiometer: fall in potential $\Delta V \alpha \Delta l$ - conditions; 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; comparison of emfs; determination of internal resistance of a cell. Conversion of *galvanometer to ammeter and voltmeter and their resistances.*

(vi) Heating effect of a current (Joule's law).

Flow of electric charge (current) in a conductor causes transfer of energy from the source of electricity (may be a cell or dynamo), to the conductor (resistor), as internal energy associated with the vibration of atoms and observed as increase in temperature. From the definition of pd, $V=W/q$; $W = \Delta U = qV = VIt$. The rate of energy transfer $\Delta U/t = VI$ or power $P = VI = I^2R=V^2/R$ using Ohm's law. This is Joule,s law. This energy transfer is called Joule heating. SI unit of power. Experimental verification of Joule's law.

(vii) Thermoelectricity; Seebeck effect; measurement of thermo emf; its variation with temperature. Peltier effect.

Discovery of Seebeck effect. Seebeck series; Examples with different pairs of metals (for easy recall remember - hot cofe and ABC - from copper to iron at the hot junction and from antimony to bismuth at the cold junction for current directions in thermocouple); variation of thermo emf with temperature differences, graph; neutral temperature, temperature of inversion; slope: thermoelectric power $\varepsilon = \alpha\phi + 1/2\beta\phi^2$ (no derivation), $S = d\varepsilon/d\phi = \alpha+\beta\phi$. The comparison of Peltier effect and Joule effect.

3. Magnetism

(i) Magnetic field $\vec{B}$, definition from magnetic force on a moving charge; magnetic field lines. Superposition of magnetic fields; magnetic field and magnetic flux density; the earth's magnetic field; Magnetic field of a magnetic dipole; tangent law.

Magnetic field represented by the symbol $\vec{B}$ is now defined by the equation $\vec{F} = q_o\vec{V} \times \vec{B}$ (which comes later under subunit 4.2; $\vec{B}$ 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 $\phi_B = \vec{B} . \vec{A} = BA$ for B uniform and $\vec{B} \parallel \vec{A}$; i.e. area held perpendicular to $\vec{B}$. 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, $\phi = \int d\phi=\int\vec{B} . d\vec{A}$. Earth's magnetic field $\vec{B}_E$ is uniform over a limited area like that of a lab; the component of this field in the horizontal directions B_H is the one effectively acting on a magnet suspended or pivoted horizontally. An artificial magnetic field is produced by a current carrying loop (see 4.2) $\vec{B}_c$, or a bar magnet $\vec{B}_m$ in the horizontal plane with its direction adjusted perpendicular to the magnetic meridian; this is superposed over the earth's fields $\vec{B}_H$ which is always present along the magnetic meridian. The two are then perpendicular to each other; a compass needle experiences a torque exerted by these fields and comes to an equilibrium position along the resultant field making an angle with ø with B_H. Then B_c - or $B_m = B_H \tan ø$. This is called tangent law. Deflection Magnetometer, description, setting and its working.

(ii) Properties of dia, para and ferromagnetic substances; 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 - - - - - 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 $H = (B/\mu_0) - M$; the magnetic properties, susceptibility $\chi_m = (M/H) < 0$ for dia (as M is opposite H) and >0 for para, both very small, but very large for ferro; hence relative permeability $\mu_r = 1 + \chi_m < 1$ 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.*

4. Electromagnetism

(i) Oersted's experiment; Biot-Savart law, the tesla; magnetic field near a long straight wire, at the centre of a circular loop, and at a point on the axis of a circular coil carrying current and a solenoid. Amperes circuital law and its application to obtain magnetic field due to a long straight wire; tangent galvanometer.

Only historical introduction through Oersted's experiment. [Ampere's swimming rule not included]. Biot-Savart law in vector form; application; derive the expression for B (i) near a very long wire carrying current; direction of $\vec{B}$ using right hand (clasp) rule- no other rule necessary; (ii) at the centre of a circular loop carrying current; (iii) 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. Tangent galvanometer- theory, working, use, advantages and disadvantages.

(ii) Force on a moving charge in a magnetic field; force on a current carrying conductor kept in a magnetic field; force between two parallel current carrying wires; definition of the ampere based on the force between two current carrying wires. Cyclotron (simple idea).

Lorentz force equation $\vec{F}_B = q.\vec{v} \times \vec{B}$; special cases, modify this equation substituting $d\bar{l}/dt$ 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 $\vec{B}$ field. Derive the expression for force between two long parallel wires carrying current, using Biot-Savart law and $\vec{F} = I d\vec{l} \times \vec{B}$; define ampere the base unit of SI and hence, coulomb from Q = It. Simple ideas about working of a cyclotron, its principle, and limitations.

(iii) A current loop as a magnetic dipole; magnetic dipole moment; torque on a current loop; moving coil galvanometer.

Derive the expression for torque on a current carrying loop placed in a uniform $\vec{B}$, using $F = IlB$ and $\bar{\tau} = \bar{r} \times \bar{F} = NIAB \sin\phi$ for N turns $\bar{\tau} = \bar{m} \times \bar{B}$, where the dipole moment $\bar{m} = NI\bar{A}$ 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 electrons in Bohr model of H atom. Moving coil galvanometer; construction, principle, working, theory $I = k\phi$, advantages over tangent galvanometer.

(iv) Electromagnetic induction, magnetic flux and induced emf; Faraday's law and Lenz's law; transformers; eddy currents.

Magnetic flux, change in flux, rate of change of flux and induced emf; Faraday's law $\varepsilon = -d\phi/dt$, [only one law represented by this equation]. Lenz's law, conservation of energy; motional emf $\varepsilon = Blv$, and power $P = (Blv)^2/R$; eddy currents (qualitative); transformer (ideal coupling), principle, working and uses; step up and step down; energy losses.

(v) Mutual and self inductance: the henry. Growth and decay of current in LR circuit (dc) (graphical approach), time constant.

Mutual inductance, illustrations of a pair of coils, 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.*

Similar treatment for $L = \varepsilon / dI/dt$; *henry = volt. second/ampere [expressions for coefficient of self inductance L and mutual inductance M, of solenoid/coils and experiments, not included]. R-L circuit; induced emf opposes changes, back emf is set up, delays starting and closing, graphical representation of growth and decay of current in an R-L circuit [no derivation]; define and explain time constant from the graph;* $\tau = L/R$ *(result only). Unit of* τ *= unit of time = second. Hence, this name 'Time Constant'.*

(vi) Simple a.c. generators.

Principle, description, theory and use.

(v) Comparison of a.c. with d.c.

Variation in current and voltage with time for a.c. and d.c.

5. Alternating Current Circuits

(i) Change of voltage and current with time, the phase difference; peak and rms values of voltage and current; their relation in sinusoidal case.

Sinusoidal variation of V and I with time, for the output from an ac generator; time period, frequency and phase changes; rms value of V and I in sinusoidal cases only.

(ii) Variation of voltage and current in a.c. circuits consisting of only resistors, only inductors and only capacitors (phasor representation), phase lag and phase lead.

May apply Kirchhoff's law and obtain simple differential equation (SHM type), $V = V_o \sin \omega t$, *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; resistance R, inductive reactance* X_L, $X_L = \omega L$ *and capacitative reactance* X_C, $X_C = 1/\omega C$ *and their mutual relations. Graph of* X_L *and* X_C *vs f.*

(iii) The LCR series circuit: phasor diagram, expression for V or I; phase lag/lead; impedance of a series LCR circuit (arrived at by phasor diagram); Special cases for RL and RC circuits.

RLC circuit in single loop, note the pd across R, L and C; [the more able students may use Kirchhoff's law and obtain the differential equation]. Use phasor diagram method to obtain expression for I or V and the net phase lag/lead; use the results of 5(ii), 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* $V^2_m = V^2_{RM} + (V_{Lm} - V_{Cm})^2$. *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. Graph of Z vs f.*

(iv) Power P associated with LCR circuit $= {}^1/_2 V_o I_o \cos\phi = V_{rms} I_{rms} \cos\phi$; power absorbed and power dissipated; choke coil (choke and starter); electrical resonance; oscillations in an LC circuit ($\omega = 1/\sqrt{LC}$).

Average power consumed averaged over a full cycle $\overline{P} = (1/2)\, \varepsilon_m . I_m \cos\phi$. *Power factor* $\cos\phi = R/Z$. *Special case for pure R , L, C; choke coil:-* X_L *controls current but* $\cos\phi = 0$, *hence* $\overline{P} = 0$; *LC circuit; at resonance with* $X_L = X_c$, $Z = Z_{min} = R$, *power delivered to circuit by the source, is maximum;* $\omega^2 = 1/LC$; $f = \frac{\omega}{2\pi}$.

SECTION B

6. Wave Optics

(i) Complete electromagnetic spectrum from radio waves to gamma rays; transverse nature of electromagnetic waves, Huygen's principle; laws of reflection and refraction from Huygen's principle. Speed of light.

Qualitative descriptions only, but some wave length range values may be noted; common features of all regions of em 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 spectrum, IR, microwaves, radio and TV waves) in their production (source), propagation, modulation and demodulation (qualitative only) – AM and FM, interaction with matter, detection and other properties; uses; approximate range of λ or f or at least proper order of increasing f or λ. Huygen's principle: wavefronts - different types/shapes, rays: Huygen's construction and Huygen's principle; proof of laws of reflection and refraction using this. [Refraction through a prism and lens on the basis of Huygen's theory: Not required]. Michelson's method to determine the speed of light.

(ii) Conditions for interference of light, interference of monochromatic light by double slit; measurement of wave length. Fresnel's biprism.

Phase of wave motion; superposition of identical waves at a point, path difference and phase difference; coherent and incoherent light waves; 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 to be done]. Young's double slit experiment, set up, diagram, geometrical deduction of path difference $\Delta = d \sin Ø$, between waves (rays) from the two slits; using $\Delta = n\lambda$ for bright fringe and $(n+½)\lambda$ for dark fringe and $\sin Ø = \tan Ø = y_n/D$ as y and Ø are small, obtain $y_n=(D/d)n\lambda$ and fringe width $\beta=(D/d)\lambda$ etc. Experiment of Fresnel biprism (qualitative only). Measurement of β using a telescope; determination of λ, using $\lambda = \frac{\beta d}{D}$.

(iii) Single slit Fraunhoffer diffraction (elementary explanation).

Diffraction at a single slit experimental setup, diagram, diffraction pattern, position of secondary maxima, conditions for secondary maxima, a $\sin\theta_n = (2n+1)\lambda/2$, for secondary minima a $\sin\theta_n = n\lambda$, where n = 1,2,3 ...; distribution of intensity with angular distance; angular width of central bright fringe. Mention diffraction by a grating and its use in determining wave length of light (Details not required).

(iv) Plane polarised electromagnetic wave (elementary idea), polarisation of light by reflection. Brewster's law; polaroids.

Review description of an electromagnetic wave as transmission of energy by periodic changes in $\vec{E}$ and $\vec{B}$ along the path; transverse nature as $\vec{E}$ and $\vec{B}$ are perpendicular to $\vec{C}$ (velocity). These three vectors form a right handed system, so that $\vec{E}$ x $\vec{B}$ is along $\vec{C}$, they are mutually perpendicular to each other. For ordinary light, $\vec{E}$ and $\vec{B}$ are in all directions in a plane perpendicular to the $\vec{C}$ vector-unpolarised waves. If $\vec{E}$ and (hence $\vec{B}$ also) is confined to a single line only ($\perp \vec{C}$, we have linearly polarized light. The plane containing $\vec{E}$ (or $\vec{B}$) and $\vec{C}$ remains fixed. Hence, a linearly polarised light is also called plane polarised light. Plane of polarisation; polarisation by reflection; Brewster's law: $\tan i_p=n$; refracted ray is perpendicular to reflected ray for $i = i_p$; $i_p+r_p = 90°$; polaroids; use in production and detection/analysis of polarised light., other uses.

7. Ray Optics and Optical Instruments for

(i) Refraction of light at a plane interface (Snell's law); total internal reflection and critical angle; total reflecting prisms and optical fibres.

Self-explanatory. Simple applications; numerical problems included.

(ii) 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 prism; application to triangular prisms with angle of the prism 30^0, 45^0, 60^0 and 90^0 respectively; ray diagrams.

(iii) Refraction at a single spherical surface (relation between n_1, n_2, u, v and R); refraction through thin lens (lens maker's formula and formula relating u, v, f, n, R_1 and R_2); combined focal length of two thin lenses in contact. Combination of lenses [Silvering of lens excluded].

Self-explanatory.

Limit detailed discussion to one case only- convex towards rarer medium, for spherical surface and real image. For lens, derivation only for biconvex lens with $R_1= R_2$; extend the results to biconcave lens, plano convex lens and lens immersed in a liquid; do also power of a lens P=1/f with SI unit dioptre. For lenses in contact $1/F= 1/f_1+1/f_2$ and $P=P_1+P_2$. Formation of image and determination of focal length with combination of thin lenses.

(iv) Dispersion; dispersive power; production of pure spectrum; spectrometer and its setting (experimental uses and procedures included); absorption and emission spectra; spherical and chromatic aberration; derivation of condition for achromatic combination of two thin lenses in contact and not of prism.

Angular dispersion; dispersive power, conditions for pure spectrum; spectrometer with experiments for A and δ. Hence, δ_m and n; rainbow - ray diagram (no derivation). Simple explanation. Spectra: emission spectra; line; band and continuous spectra- their source and qualitative explanation; absorption spectra - condition; solar spectrum and Fraunhoffer lines, spherical aberration in a convex lens (qualitative only), how to reduce linear or axial chromatic aberration, derivations, condition for achromatic combination of two lenses in contact.

(v) Simple microscope; Compound microscope and their magnifying power.

For microscope - magnifying power for image at least distance of distinct vision and at infinity; ray diagrams, numerical problems included.

(vi) Simple astronomical telescope (refracting and reflecting), magnifying power and resolving power of a simple astronomical telescope.

Ray diagrams of reflecting as well as refracting telescope with image at infinity only; simple explanation; magnifying power; resolving power, advantages, disadvantages and uses.

SECTION C

8. Electrons and Photons

(i) Cathode rays: measurement of e/m for electrons. Millikan's oil drop experiment.

Production of cathode rays – only brief and qualitative [historical details not included]. Thomson's experiment to measure e/m of electrons: $e/m=(½V)(E/B)^2$.

Thermionic emission, deflection of charged particle by $\vec{E}$ and $\vec{B}$, and fluorescence produced by electron. Millikan's oil drop experiment - quantization of charge.

(ii) Photo electric effect, quantization of radiation; Einstein's equation; threshold frequency; work function; energy and momentum of photon. Determination of Planck's Constant.

Experimental facts; do topics as given; note 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. Theory and experiment for determination of Planck's constant (from the graph of stopping potential V versus frequency f of the incident light). Momentum of photon $p=E/c=hf/c=h/\lambda$.

(iii) Wave particle duality, De Broglie equation, phenomenon of electron diffraction (informative only).

Dual nature of radiation already discussed; wave nature in interference, diffraction and polarization; particle nature in photoelectric effect and Compton effect. Dual nature of matter: particle nature common in that it possess momentum p=mv and kinetic energy $K=\frac{1}{2}mv^2$. The wave nature of matter was proposed by Louis de Broglie $\lambda=h/p= h/mv$. Davisson and Germer experiment; qualitative description and discussion of the experiment, polar graph. No numerical problem.

9. Atoms

(i) Charge and size of nuclei (α-particle scattering); atomic structure; Bohr's postulates, Bohr's quantization condition; radii of Bohr orbits for hydrogen atom; energy of the hydrogen atom in the nth state; line spectra of hydrogen and calculation of E and f for different lines.

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 $\Delta K=\frac{1}{2}\ mv^2$ of the α particle to the change in electrostatic potential energy ΔU of the system $[(1/4\pi\varepsilon_0(2e)(Ze)/r_0]$; $r_0\sim10^{-15}m$ =1 fm or 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 spectra; empirical formula for Lyman, Balmer and Paschen series. 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 for n=1,2,3… 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) Production of X-rays; maximum frequency for a given tube potential. Characteristic and continuous X -rays. Mosley's law.

A simple modern X-ray tube – main parts: hot cathode, heavy element target kept cool and anode, all enclosed in a vacuum tube; elementary theory of X-ray production; effect of increasing filament current- temperature increases rate of emission of electrons (from the cathode), rate of production of X rays and hence, intensity of X rays increases (not its frequency); increase in anode potential increases energy of each electron, each X-ray photon and hence, X-ray frequency (E=hf); maximum frequency $hf_{max}=eV$; continuous spectrum of X rays has minimum wavelength $\lambda_{min}= c/f_{max}$. Mosley's law. Characteristic and continuous X-rays; origin.

10. Nuclei

(i) Atomic masses; unified atomic mass unit u and its value in MeV; the neutron; composition and size of nucleus; mass defect and binding energy.

Atomic masses; unified atomic mass unit, symbol u, 1u=1/12 of the mass of C^{12} atom = $1.66x10^{-27}$kg). Composition of nucleus; mass defect and binding energy $BE=(\Delta m)c^2$. Graph of BE/nucleon versus mass number A, special features - low for light as well as heavy elements. Middle order more stable [see fission and fusion in 11.(ii), 11.(iii)].

(ii) Radioactivity: nature and radioactive decay law, half-life, mean life and decay constant. Nuclear reactions.

Discovery; spontaneous disintegration of an atomic nucleus with the emission of α or β particles and γ radiation, unaffected by ordinary chemical changes. Radioactive decay law; derivation of $N = N_oe^{-\lambda t}$; half life period T; graph of N versus t, with T marked on the X axis. Relation between T and λ; mean life τ and λ. Value of T of some common radioactive elements. Examples of few nuclear reactions with conservation of nucleon number and charge. (neutrino to be included.

[Mathematical theory of α and β decay not included]. Changes taking place within the nucleus included.

11. Nuclear Energy

(i) Energy - mass equivalence.

Einstein's equation $E=mc^2$. Some calculations. (already done under 10.(i)); mass defect/binding energy, mutual annihilation and pair production as examples.

(ii) Nuclear fission; chain reaction; principle of operation of a nuclear reactor.

(iii) Nuclear fusion; thermonuclear fusion as the source of the sun's 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) nucleus, 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. Discovery of fission. Any one equation of fission reaction. Chain reaction- controlled and uncontrolled; nuclear reactor and nuclear bomb. Main parts of a nuclear reactor including a simple diagram and their functions - fuel elements, moderator, control rods, coolant, casing; criticality; utilization of energy output - all qualitative only. Fusion, simple example of $4\ {}^1H \rightarrow {}^4He$ 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].

12. Semiconductor Devices

(i) 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. [No numerical problems from this topic].

(ii) Junction diode; depletion region; forward and reverse biasing current - voltage characteristics; pn diode as a half wave and a full wave rectifier; solar cell, LED and photodiode. Zener diode and voltage regulation.

Junction diode; symbol, simple qualitative description only [details of different types of formation not included]. The topics are self explanatory. [Bridge rectifier of 4 diodes not included]. Simple circuit diagram and graphs, function of each component - in the electric circuits, qualitative only. Elementary ideas on solar cell, photodiode and light emitting diode (LED) as semi conducting diodes. Self explanatory.

(iii) The junction transistor; npn and pnp transistors; current gain in a transistor; transistor (common emitter) amplifier (only circuit diagram and qualitative treatment) and oscillator.

Simple qualitative description of construction - emitter, base and collector; npn and pnp type; symbol showing directions of current in emitter-base region (one arrow only)- base is narrow; current gain in transistor; common emitter configuration only, characteristics; I_B vs V_{BE} and I_C vs V_{CE} with circuit *diagram; no numerical problem; common emitter transistor amplifier - correct diagram; qualitative explanation including amplification, wave form and phase reversal. [relation between α, β not included, no numerical problems]. Circuit diagram and qualitative explanation of a simple oscillator.*

(iv) Elementary idea of discreet and integrated circuits, analogue and digital circuits. Logic gates (symbols; working with truth tables; applications and uses) - NOT, OR, AND, NOR, NAND.

Self explanatory. Advantages of IC.

Introduction to elementary digital electronics. Logic gates as given; symbols, input and output, Boolean equations (Y=A+B etc), truth table, qualitative explanation. [No numerical problems. Realisation not included].

PAPER II

PRACTICAL WORK- 20 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. Take care of polarity of cells and meters, their range, zero error, least count, etc. A graph is a convenient and effective way of representing results of measurement. Therefore, it is an important part of the experiment. Usually, there are two graphs in all question papers. Students should learn to draw graphs correctly noting all important steps such as title, selection of origin, labelling of axes (not x and y), proper scale and the units given along each axis. Use maximum area of graph paper, plot points with great care, mark the points plotted with □ or ⊗ and draw the best fit straight line (not necessarily passing through all the plotted points), keeping all experimental points symmetrically placed (on the line and on the left and right side of the line) with respect to the best fit thin straight line. Read intercepts carefully. Y intercept i.e. y_0 is that value of y when x = 0. Slope 'm' of the best fit line should be found out using two distant points, one of which should be unplotted point, using $m = \dfrac{y_2 - y_1}{x_2 - x_1}$.

NOTE:

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

The list of experiments given below is only a general recommendation. Teachers may add, alter or modify this list, keeping in mind the general pattern of questions asked in the annual examinations.

1. Draw the following set of graphs using data from lens experiments -
   i) ν against u. It will be a curve.
   ii) Magnification $\left(m = \dfrac{\text{v}}{\text{u}}\right)$ against ν and to find focal length by intercept.
   iii) y = 100/v against x = 100/u and to find f by intercepts.
2. To find f of a convex lens by using u-v method.
3. To find f of a convex lens by displacement method.
4. Coaxial combination of two convex lenses not in contact.
5. Using a convex lens, optical bench and two pins, obtain the positions of the images for various positions of the object; f<u<2f, u~2f, and u>2f. Plot a graph of y=100/v versus x=100/u. Obtain the focal length of the lens from the intercepts, read from the graph.
6. Determine the focal length of a concave lens, using an auxiliary convex lens, not in contact and plotting appropriate graph.
7. Refractive index of material of lens by Boys' method.
8. Refractive index of a liquid by using convex lens and plane mirror.
9. Using a spectrometer, measure the angle of the given prism and the angle of minimum deviation. Calculate the refractive index of the material. [A dark room is not necessary].

10. Set up a deflection magnetometer in Tan-A position, and use it to compare the dipole moments of the given bar magnets, using (a) deflection method, neglecting the length of the magnets and (b) null method.
11. Set up a vibration magnetometer and use it to compare the magnetic moments of the given bar magnets of equal size, but different strengths.
12. Determine the galvanometer constant of a tangent galvanometer measuring the current (using an ammeter) and galvanometer deflection, varying the current using a rheostat. Also, determine the magnetic field at the centre of the galvanometer coil for different values of current and for different number of turns of the coil.
13. 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.
14. Verify Ohm's law for the given unknown resistance (a 60 cm constantan wire), plotting a graph of potential difference versus current. From the slope of the graph and the length of the wire, calculate the resistance per cm of the wire.
15. From a potentiometer set up, measure the fall in potential 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. 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?
16. Compare the emf of two cells using a potentiometer.
17. To study the variation in potential drop with length of slide wire for constant current, hence to determine specific resistance.
18. To determine the internal resistance of a cell by potentiometer device.
19. Given the figure of merit and resistance of a galvanometer, convert it to (a) an ammeter of range, say 2A and (b) a voltmeter of range 4V. Also calculate the resistance of the new ammeter and voltmeter.
20. To draw I-V characteristics of a semi-conductor diode in forward and reverse bias.
21. To draw characteristics of a Zener diode and to determine its reverse breakdown voltage.
22. To study the characteristics of pnp/npn transistor in common emitter configuration.

PROJECT WORK AND PRACTICAL FILE – 10 Marks

Project Work – 7 Marks

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

All candidates will do project work involving some physics related topics, under the guidance and regular supervision of the Physics teacher.

Candidates are to prepare a technical report formally written including an abstract, some theoretical discussion, experimental setup, observations with tables of data collected, analysis and discussion of results, deductions, conclusion, etc. (after the draft has been approved by the teacher). The report should be kept simple, but neat and elegant. No extra credit shall be given for typewritten material/decorative cover, etc. Teachers may assign or students may choose any one project of their choice.

Practical File – 3 Marks

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