PHYSICS CLASS-XII
REVISION CHEAT SHEET

ELECTROSTATICS

- Coulomb's Law : $\vec{F}_{21}$ = force on q_2 due to $q_1 = \dfrac{k\,(q_1 q_2)}{r_{21}^2}\hat{r}_{21}$

  where $k = \dfrac{1}{4\pi\varepsilon_0} = 9\times10^9\ \text{Nm}^2\,\text{C}^{-2}$

- Electric field due to a point charge q has a magnitude $|q|/4\pi\varepsilon_0 r^2$

- Field of an electric dipole in its equatorial plane

  $$\vec{E} = \frac{-\vec{p}}{4\pi\varepsilon_0}\frac{1}{(a^2+r^2)^{3/2}} \cong \frac{-\vec{p}}{4\pi\varepsilon_0 r^3},\quad \text{for } r >> a$$

  Dipole electric field on the axis at a distance r from the centre:

  $$\vec{E} = \frac{2\vec{p}r}{4\pi\varepsilon_0 (r^2-a^2)^2} \cong \frac{2\vec{p}}{4\pi\varepsilon_0 r^3}\quad \text{for } r >> a$$

  Dipole moment $\vec{p} = q2\vec{a}$

- In a uniform electric field $\vec{E}$, a dipole experiences a torque $\vec{\tau}$ given by $\vec{\tau} = \vec{p}\times\vec{E}$ but experiences no net force.

  The flux $\Delta\phi$ of electric field $\vec{E}$ through a small area element $\Delta\vec{S}$ is given by $\Delta\phi = \vec{E}.\Delta\vec{S}$

- Gauss's law: The flux of electric field through any closed surface S is $1/\varepsilon_0$ times the total charge enclosed i.e., Q

- Thin infinitely long straight wire of uniform linear charge density λ : $\vec{E} = \dfrac{\lambda}{2\pi\varepsilon_0 r}\hat{n}$

- Infinite thin plane sheet of uniform surface charge density σ

  $$\vec{E} = \frac{\sigma}{2\varepsilon_0}\hat{n}$$

- Thin spherical shell of uniform surface charge density σ :

  $$\vec{E} = \frac{\sigma}{4\pi\varepsilon_0 r^2}\hat{r}\qquad (r \ge R)\ ;\ \vec{E} = 0\quad (r < R)$$

- Electric Potential : $V(\vec{r}) = \dfrac{1}{4\pi\varepsilon_0}\dfrac{Q}{r}$.

- An equipotential surface is a surface over which potential has a constant value.

- Potential energy of two charges q_1, q_2 at $\vec{r}_1, \vec{r}_2$ is given by

  $U = \dfrac{1}{4\pi\varepsilon_0}\dfrac{q_1 q_2}{r_{12}}$, where r_{12} is distance between q_1 and q_2.

- Capacitance C = Q/V, where Q = charge and V = potential difference

- For a parallel plate capacitor (with vacuum between the plates), $C = \varepsilon_0\dfrac{A}{d}$.

- The energy U stored in a capacitor of capacitance C, with charge Q and voltage V is $U = \dfrac{1}{2}QV = \dfrac{1}{2}CV^2 = \dfrac{1}{2}\dfrac{Q^2}{C}$

- For capacitors in the series combination,

  $$\frac{1}{C_{eq}} = \frac{1}{C_1}+\frac{1}{C_2}+\frac{1}{C_3}+\ldots\ldots\ldots$$

  In the parallel combination, $C_{eq} = C_1 + C_2 + C_3 + \ldots$ where $C_1, C_2, C_3 \ldots$ are individual capacitances.

CURRENT ELECTRICITY

- Electric current, $I = \dfrac{q}{t}$

- Current density j gives the amount of charge flowing per second per unit area normal to the flow, $\vec{J} = nqv_d$
- Mobility, $\mu = \frac{V_d}{E}$ and $V_d = \frac{I}{Ane}$
- Resistance $R = \rho\frac{\ell}{A}$, ρ = resistivity of the material
- Equation $\vec{E} = \rho\vec{J}$ another statement of Ohm's law, ρ= resistivity of the material.
- Ohm's law $I \propto V$ or $V = RI$
- (a) Total resistance R of n resistors connected in series $R = R_1 + R_2 + ... + R_n$
  (b) Total resistance R of n resistors connected in parallel $\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + ... + \frac{1}{R_n}$.
- Kirchhoff's Rules – (a) Junction rule: At any junction of circuit elements, the sum of currents entering the junction must equal the sum of currents leaving it.
  (b) Loop rule: The algebraic sum of changes in potential around any closed loop must be zero.
- The Wheatstone bridge is an arrangement of four resistances R_1, R_2, R_3, R_4. The null-point condition is given by $\frac{R_1}{R_2} = \frac{R_3}{R_4}$
- According 'to Joule's Heating law, $H = I^2Rt$

MAGNETISM

- The total force on a charge q moving with velocity v i.e., Lorentz force. $\vec{F} = q(\vec{v} \times \vec{B} + \vec{E})$.
- A straight conductor of length ℓ and carrying a steady current I experiences a force $\vec{F}$ in a uniform external magnetic field $\vec{B}$, $\vec{F} = I\vec{\ell} \times \vec{B}$, the direction of ℓ is given by the direction of the current.
- Biot-Savart law $d\vec{B} = \frac{\mu_0}{4\pi} I \frac{d\vec{\ell} \times \vec{r}}{r^3}$.
- The magnitude of the magnetic field due to a circular coil of radius R carrying a current I at an axial distance x from the centre is $B = \frac{\mu_0 IR^2}{2(x^2 + R^2)^{3/2}}$.
- The magnitude of the field B inside a long solenoid carrying a current I is : $B = \mu_0 nI$. For a toroid one obtains, $B = \frac{\mu_0 NI}{2\pi r}$.
- Ampere's Circuital Law : $\oint_C \vec{B}.d\vec{\ell} = \mu_0 I$, where I refers to the current passing through S.
- Force between two long parallel wires $F = \frac{\mu_0 I_1 I_2}{2\pi a} Nm^{-1}$.
  The force is attractive if currents are in the same direction and repulsive currents are in the opposite direction.
- For current carrying coil $\vec{M} = NI\vec{A}$; torque = $\vec{\tau} = \vec{M} \times \vec{B}$
- Conversion of (i) galvanometer into ammeter, $S = \left(\frac{I_g}{I - I_g}\right)G$
  (ii) galvanometer into voltmeter, $S = \frac{V}{I_g} - G$
- The magnetic intensity, $\vec{H} = \frac{\vec{B}_0}{\mu_0}$.
- The magnetisation $\vec{M}$ of the material is its dipole moment per unit volume. The magnetic field B in the material is, $\vec{B} = \mu_0(\vec{H} + \vec{M})$
- For a linear material $\vec{M} = \chi\vec{H}$. So that $\vec{B} = \mu\vec{H}$ and χ is called the magnetic susceptibility of the material.
  $\mu = \mu_0\mu_r$; $\mu_r = 1 + \chi$.

ELECTROMAGNETIC INDUCTION

- The magnetic flux
  $\phi_B = \vec{B}.\vec{A} = BA\cos\theta$, where θ is the angle between $\vec{B}$ & $\vec{A}$.

- Faraday's laws of induction : $\varepsilon = -N\frac{d\phi_B}{dt}$
- Lenz's law states that the polarity of the induced emf is such that it tends to produce a current which opposes the change in magnetic flux that produces it.
- The induced emf (motional emf) across ends of a rod $\varepsilon = B\ell v$
- The self-induced emf is given by, $\varepsilon = -L\frac{dI}{dt}$

  L is the self-inductance of the coil.

  $L = \frac{\mu_0 N^2 A}{\ell}$
- A changing current in a coil (coil 2) can induce an emf in a nearby coil (coil 1).

  $\varepsilon_1 = -M_{12}\frac{dI_2}{dt}$, M_{12} = mutual inductance of coil 1 w.r.t coil 2.

  $M = \frac{\mu_0 N_1 N_2 A}{\ell}$

ALTERNATING CURRENT

- For an alternating current $i = i_m \sin \omega t$ passing through a resistor R, the average power loss P (averaged over a cycle) due to joule heating is $(1/2)i^2_m R$.

  E.m.f, $E = E_0 \sin \omega t$
- Root mean square (rms) current $I = \frac{i_m}{\sqrt{2}} = 0.707\, i_m$.

  $E_{rms} = \frac{E_0}{\sqrt{2}}$
- The average power loss over a complete cycle

  $P = VI\cos\phi$. The term $\cos\phi$ is called the power factor.
- An ac voltage $v = v_m \sin\omega t$ applied to a pure inductor L, drives a current in the inductor $i = i_m \sin(\omega t - \pi/2)$, where $i_m = v_m/X_L$. $X_L = \omega L$ is called inductive reactance.
- An ac voltage $v = v_m \sin\omega t$ applied to a capacitor drives a current in the capacitor: $i = i_m \sin(\omega t + \pi/2)$. Here,

  $i_m = \frac{v_m}{X_C}$, $X_C = \frac{1}{\omega C}$ is called capacitive reactance.
- Impedance $z = \sqrt{R^2 + (x_L - x_C)^2}$
- Transformation ratio, $K = \frac{N_S}{N_P} = \frac{E_S}{E_P} = \frac{I_P}{I_S}$
- Step up transformer : $N_S > N_P$; $E_S > E_P$; $I_P > I_S$
- Step down transformer $N_P > N_S$; $E_P > E_S$ and $I_P < I_S$

RAY OPTICS

- Reflection is governed by the equation $\angle i = \angle r$ and refraction by the Snell's law, sini/sinr = n, where the incident ray, reflected ray, refracted ray and normal lie in the same plane.
- Mirror equation: $\frac{1}{v} + \frac{1}{u} = \frac{1}{f}$
- Magnification $M = \frac{V}{u} = \frac{I}{O}$
- Prism Formula $n_{21} = \frac{n_2}{n_1} = \frac{\sin[(A + D_m)/2)]}{\sin(A/2)}$, where D_m is the angle of minimum deviation.
- Dispersion is the splitting of light into its constituent colours. The deviation is maximum for violet and minimum for red.
- For refraction through a spherical interface (from medium 1 to 2 of refractive index n_1 and n_2, respectively)

  $\frac{n_2}{v} - \frac{n_1}{v} = \frac{n_2 - n_1}{R}$
- Refractive index of a medium $\mu = \frac{C}{V}$ $(C = 3 \times 10^8$ m/s)

  $r = \frac{1}{\sin C}$ (C = Critical angle)

- Condition for TIR : 1. Ray of light must travel from denser to rarer medium 2. Angle of incidence in denser medium > critical angle.
- Lens formula $\frac{1}{v}-\frac{1}{u}=\frac{1}{f}$
- Lens maker's formula : $\frac{1}{f}=\frac{(n_2-n_1)}{n_1}\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$
- The power of a lens P = 1/f. The SI unit for power of a lens is dioptre (D): 1 D = 1 m^{-1}.
- If several thin lenses of focal length f_1, f_2, f_3,.. are in contact, the effective focal $\frac{1}{f}=\frac{1}{f_1}+\frac{1}{f_2}+\frac{1}{f_3}+.....$
- The total power of a combination of several lenses $P = P_1 + P_2 + P_3 + ...$
- For compound microscope $M=\frac{V_0}{u_0}\left(1+\frac{D}{f_e}\right)$

  when final image at D

  $M=\frac{V_0}{u_0}.\frac{D}{f_e}$ when final image at infinity.

WAVE OPTICS

- Wavefront : It is the locus of all the particles vibrating in the same phase.
- The resultant intensity of two waves of intensity $I_0/4$ of phase difference ϕ at any points $I = I_0\cos^2\left[\frac{\phi}{2}\right]$,

  where I_0 is the maximum density.
- Intensity $I \propto (\text{amplitude})^2$
- Condition for dark band : $\delta=(2n-1)\frac{\lambda}{2}$, for bright band : $\delta = m\lambda$
- Fringe width $\beta=\frac{D\lambda}{d}$
- A thin film of thickness t and refractive index μ appears dark by reflection when viewed at an angle of refraction *r* if $2\mu t\cos r = n\lambda$ (n = 1, 2, 3, etc.)
- A single slit of width a gives a diffraction pattern with a central maximum. The intensity falls to zero at angles of $\pm\frac{\lambda}{a},\pm\frac{2\lambda}{a}$, etc.
- Amplitude of resultant wave $R=\sqrt{a^2+b^2+2ab\cos\phi}$
- Intensity of wave $I = I_1 + I_2 + 2\sqrt{I_1 I_2}\cos\phi$
- Brewster law : $\mu = \tan i_p$

MODERN PHYSICS

- Energy of a photon $E = h\nu = \frac{hc}{\lambda}$
- Momentum of a photon $P=\frac{h}{\lambda}$
- Einstein's photoelectric equation

  $\frac{1}{2}mv^2_{max} = V_0e = h\nu - \phi_0 = h(\nu-\nu_0)$
- Mass defect,

  $\Delta M = (Zm_p + (A-Z)m_n) - M$; $\Delta E_b = \Delta M c^2$.

  1 amu = 931 MeV
- $E_n = -\frac{Z^2}{n^2}\times 13.6eV$ (For hydrogen like atom)
- According to Bohr's atomic model, angular momentum for the electron revolving in stationary orbit, $mvr = nh/2\pi$
- Radius of the orbit of electron $r=\frac{n^2h^2}{4\pi^2mkze^2}$
- Radius of the nucleus $R = R_oA^{1/3}$
- Pure semiconductors are called 'intrinsic semiconductors'. The presence of charge carriers (electrons and holes) number of electrons (n_e) is equal to the number of holes (n_h).

- The number of charge carriers can be changed by 'doping' of a suitable impurity in pure semiconductors known as extrinsic semiconductors (n-type and p-type).
- In n-type semiconductors, $n_e >> n_h$ while in p-type semiconductors $n_h >> n_e$.
- n-type semiconducting Si or Ge is obtained by doping with pentavalent atoms (donors) like As, Sb, P, etc., while p-type Si or Ge can be obtained by doping with trivalent atom (acceptors) like B, Al, In etc.
- In forward bias (n-side is connected to negative terminal of the battery and p-side is connected to the positive), the barrier is decreased while the barrier increases in reverse bias.
- Diodes can be used for rectifying an ac voltage (restricting the ac voltage to one direction).
- Zener diode is one such special purpose diode. In reverse bias, after a certain voltage, the current suddenly increases (breakdown voltage) in a Zener diode. This property has been used to obtain voltage regulation.
- The important digital circuits performing special logic operations are called logic gates. These are: OR, AND, NOT, NAND, and NOR gates. NAND gate is the combination of NOT and AND gate. NOR gate is the combination of NOT and OR gate.