

CH 4: MOVING CHARGES AND MAGNETISM

* Motion of charge particle: -



$$F = q[v \times B]$$

$$F = qvB \sin \theta$$

$$\theta = 90^\circ$$

$$F = qvB$$

Circular motion

$$qvB = \frac{mv^2}{r}$$

$$B = \frac{F}{qv}$$

$$r = \frac{mv}{qB}$$

$$K = \frac{p^2}{2m}$$

$$v = r\omega$$

$$r = \frac{m}{qB} \omega$$

$$\omega = \frac{qB}{m}$$

$\omega \rightarrow$ Angular velocity

$$2\pi f = \frac{qB}{m}$$

$$f = \frac{qB}{2\pi m}$$

$$T = \frac{2\pi m}{qB}$$

work done $F \perp v$

$$\therefore W = 0$$

$$\Delta K = 0$$

$$K_f - K_i = 0$$

$$K_f = K_i = \text{constant}$$

If charge is not moving

$$F = 0$$

$$\theta = 0^\circ$$

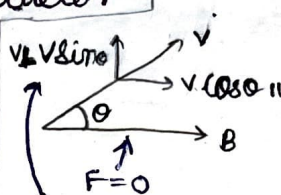
$$F = 0$$

$$\theta = 180^\circ$$

$$F = 0$$

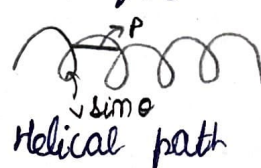
$$m \propto 4m_p$$

$$q \propto 2q_p$$



$$F = qv \sin \theta$$

$$F = qvB$$



$$r = \frac{mv \sin \theta}{qB}$$

$$\text{Pitch (p)} = v \cos \theta T$$

$$p = \frac{v \cos \theta 2\pi m}{qB}$$

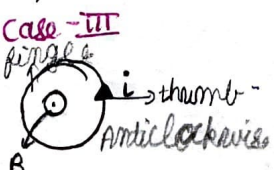
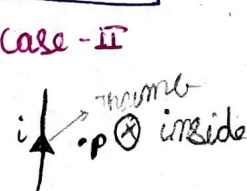
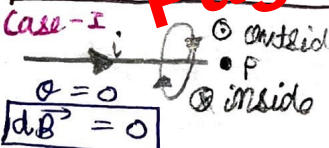
* Biot-Savart's law: -

$$dB = \frac{\mu_0 i dl \times \hat{r}}{4\pi r^2}$$

$$dB = \frac{\mu_0 i dl \sin \theta}{4\pi r^2}$$

$$\mu_0 \rightarrow \text{Permeability of free space}$$

$$\mu_0 = 4\pi \times 10^{-7} \text{ Tm/A}$$

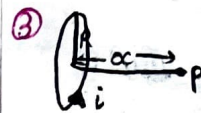


* Magnetic field due to ∞ length of wire:

$$B = \frac{\mu_0 i}{2\pi r}$$



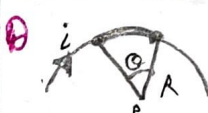
$$B = \frac{\mu_0 i}{4\pi r} [\sin \theta_1 + \sin \theta_2]$$



$$B = \frac{\mu_0 i R^2}{2(a^2 + R^2)^{3/2}}$$

$$B_{\text{center}} = \frac{\mu_0 i R^2}{2R^3}$$

$$B_{\text{center}} = \frac{\mu_0 i}{2R}$$



$$B = \frac{\mu_0 i}{4\pi r}$$

* Ampere's Circuital law: -

$$\oint \vec{B} \cdot d\vec{l} = \mu_0 i$$

$\Rightarrow$ Solenoid:



$$B = \frac{\mu_0 N i}{l}$$

$$B = \frac{\mu_0 N i}{2\pi r}$$

$\Rightarrow$ Toroid:



$$B = \frac{\mu_0 N i}{2\pi r}$$

$$B = \frac{\mu_0 N i}{2\pi R}$$

* Torque on Rectangular coil: -

$$T = NiAB \sin \theta$$

$$T = mB \sin \theta$$

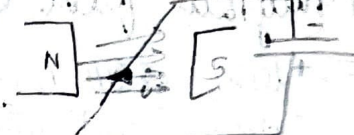
$$T = \vec{m} \times \vec{B}$$

* Magnetic force due to n wires: -



$$F = \frac{\mu_0 i_1 i_2 L}{2\pi r}$$

SAME = Attractive
OPP = Repulsive



$$F = ILB \sin \theta$$

$$\theta = 90^\circ$$

$$F = ILB$$

* Moving coil galvanometer:

$$T = NiAB \sin \theta$$

$$T = NiAB = K\theta$$

$$F \propto \theta$$

$$T \propto \theta$$

$$T = K\theta$$

$$NiAB = K\theta$$

$$\frac{\theta}{i} = \frac{NAB}{K}$$

* Current sensitivity

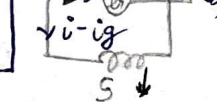
$$\frac{\theta}{i} = \frac{NAB}{K\theta}$$

* Voltage sensitivity

$$\frac{\theta}{V} = \frac{NAB}{K\theta}$$

* Galvanometer $\rightarrow$ ammeter

$$i = \frac{V}{G + R}$$



$$i_g \cdot G = (i - i_g) S$$

$$S = \frac{i_g \cdot G}{i - i_g}$$

* Galvanometer $\rightarrow$ voltmeter



$$V = i_g [R + G]$$

$$R = \frac{V}{i_g} - G$$

$$I = q \times f$$

frequency

$$R \propto \sqrt{m}$$

$$\text{Mobility}$$

$$\mu_0 = \frac{m^2}{sV}$$

$$R = \sqrt{2mK}$$

$$K \propto \frac{q^2}{m}$$