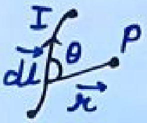
Moving Charges and Magnetism Mindmap...

Magnetic Field :-

→ A moving charge produced varying E.F. which in turn produces constant M.F.

→ **Biot-Savart's Law :-**



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

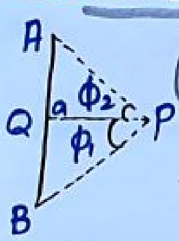
$\mu_0 = 4\pi \times 10^{-7}\ T m A^{-1}$

or

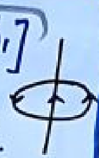
$$\vec{dB} = \frac{\mu_0}{4\pi}\frac{I(\vec{dl} \times \vec{r})}{r^3}$$

SI Unit = T
CGS Unit = G
1 Tesla = 10^4 G

$\vec{B}$ due to a Finite Wire :-



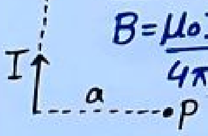
$$B = \frac{\mu_0 I}{4\pi a}[\sin\phi_2 + \sin\phi_1]$$



→ Right hand grib rule.

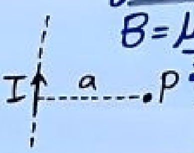
$\vec{B}$ due to a Semi-infinite wire.

(a) Semi-infinite wire



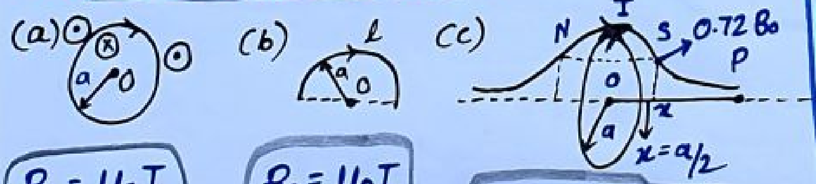
$$B = \frac{\mu_0 I}{4\pi a}$$

(b) Infinite Wire



$$B = \frac{\mu_0 I}{2\pi a}$$

$\vec{B}$ due to a Circular Coil :-



(a) $B_0 = \frac{\mu_0 I}{2a}$

(b) $B_0 = \frac{\mu_0 I}{4a}$

(c) $B_P = \frac{\mu_0 I a^2}{2(a^2 + x^2)^{3/2}}$

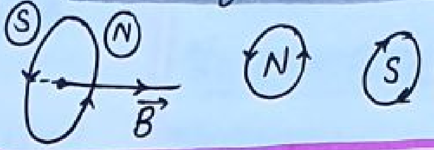
$$\frac{B_0}{B_P} = \left[1 + \frac{x^2}{a^2}\right]^{\frac{3}{2}}$$

$$B_{x = \frac{a}{2}} = 0.72\ B_{centre}$$

$\vec{B}$ due to an Arc →

$$B = \frac{\mu_0 I}{4\pi a}(\alpha)$$

Direction of $\vec{B}$ due to Coil :-



{ ⊙ Outside
{ ⊗ Inside

Ampere's Circuital Law :-

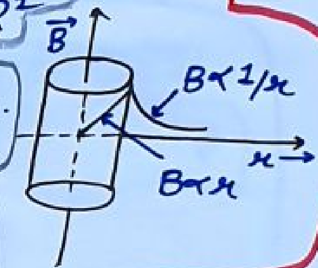
$$\oint \vec{B}\cdot\vec{dl} = \mu_0(I_{enclosed})$$

$\vec{B}$ due to a Solid Cylinder →

(a) $B_{inside} = \frac{\mu_m I r}{2\pi R^2}$

(b) $B_{surface} = \frac{\mu_0 I}{2\pi R}$

(c) $B_{outside} = \frac{\mu_0 I}{2\pi r}$



$\vec{B}$ due to a Hollow Cylinder →

(a) When $r < a$:- $B = 0$

(b) When $a < r < b$:-

$$B = \frac{\mu_m I(r^2 - a^2)}{2\pi r(b^2 - a^2)}$$

(c) When $r > b$:-

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

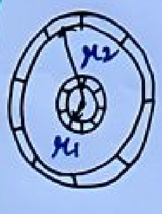
$\vec{B}$ due to Solenoid and Toroid →

→ Long Solenoid:

$B_{solenoid} = \mu_0 n i$ (inside)

$B_{solenoid} = \frac{\mu_0 n i}{2}$ (at edge)

→ Toroid



(a) $r < r_1$ $B = 0$

(b) $r_1 < r < r_2$ = $B = \frac{\mu_0 N I}{2\pi r}$

(c) $r > r_2$ $B = 0$

Magnetic Force on a Charged Particle →

$\vec{F} = q(\vec{v} \times \vec{B})$

→ Force is perpendicular to both v and B.

→ Direction of force can be find using Fleming's Left Hand Rule

Motion of Charged Particle in $\vec{B}$

$r = \frac{mv}{qB}$, $T = \frac{2\pi m}{qB}$, $f = \frac{1}{T} = \frac{qB}{2\pi m}$.

- Lorentz Force $\vec{F} = q\vec{E} + q(\vec{v} \times \vec{B})$
- Force on Wire in $\vec{B}$ $\vec{F} = i(\vec{l} \times \vec{B})$
- Force b/w 2 Wires $\frac{F}{l} = \frac{\mu_0 i_1 i_2}{2\pi r}$

If, $r = 1m$, $i_1 = i_2 = 1A$

$\frac{F}{l} = 2 \times 10^{-7} N/m$

- Force on a loop in $\vec{B}$ $\vec{F} = 0$
- Magnetic Moment of loop in $\vec{B}$

$\vec{M} = NIA\hat{n}$

- Torque on a loop in $\vec{B}$

$\vec{\tau} = \vec{M} \times \vec{B}$

$= MB \sin\theta \, \hat{n}$

Moving Coil Galvanometer

→ For Galvanometer :- $i = \frac{K}{nAB}\theta$

→ Sensitivity $= \frac{nAB}{K}$

→ To convert into ammeter:-

$I_g R_g = (I - I_g) \times R_s$

→ To convert in voltmeter:-

$V = I_g (R_s + R_g)$