BIOT-SAVART'S LAW

$$\boxed{d\vec{B} = \frac{\mu_0}{4\pi}\frac{I(d\vec{l}\times\vec{r})}{r^3}}$$

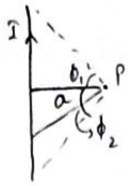
$$\boxed{|dB| = \frac{\mu_0}{4\pi}\frac{I\,dl\sin\theta}{r^2}}$$

$\frac{\mu_0}{4\pi} = 10^{-7}\ \frac{N}{A^2}$

Note: $\vec{B} \perp d\vec{l}$, $\vec{B} \perp d\vec{r}$

direction of $\vec{B}$: $d\vec{l}\times\vec{r}$ screw Rule

Magnetic field due to Finite current carrying wire



$$\boxed{B = \frac{\mu_0}{4\pi}\frac{I}{a}(\sin\phi_1 + \sin\phi_2)}$$

Note ① a $\perp^{r}$ distance
② ϕ_1, ϕ_2 measured in opp direction from $\perp^{r}$ line

Along wire ... P $\boxed{B_P = 0}$

B due to circular loop

$$\boxed{B = \frac{\mu_0}{4\pi}\frac{I}{a}(\theta)}$$ $a \to$ radius

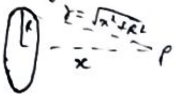
for complete circular, $\theta = 2\pi$

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

for semi-circular, $\theta = \pi$

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

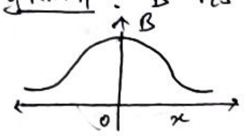
$\vec{B}$ on axis of circular current carrying wire



$r = \sqrt{x^2+R^2}$

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

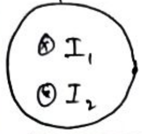
GRAPH: B v/s x



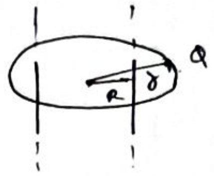
At centre, $x = 0$

$$\boxed{B = \frac{\mu_0 I}{2R}}$$ max

Ampere's circuital law



$$\boxed{\oint \vec{B}\cdot d\vec{l} = \mu_0 I_{inside}}$$



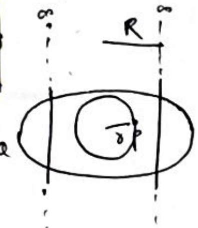
$\oint B\cdot dl = \mu_0 I_{in}$

$B\,2\pi r = \mu_0 I$

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

$B \propto \frac{1}{r}$

$\vec{B}$ inside & outside of cylindrical wire carrying current on its surface

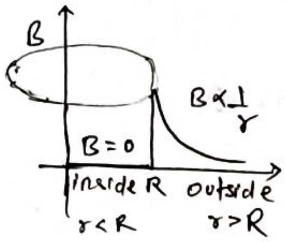


Inside ($r<R$)

$\oint B\cdot dl = \mu_0 I_{in}$

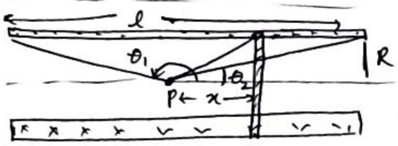
$\because I_{in} = 0$

$\boxed{\therefore B = 0}$



$B \propto \frac{1}{r}$, $B=0$, inside R $r<R$, outside $r>R$

Magnetic field due to solenoid → Inside the solenoid on its axis



$$\boxed{B = \frac{\mu_0 n I}{2}[\cos\theta_1 - \cos\theta_2]}$$

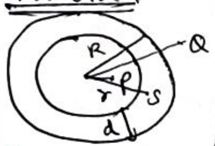
Force on a (moving charge) placed in a Magnetic field

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

$$\boxed{F_m = qvB\sin\theta}$$

$\theta \to$ angle between $\vec{B}$ & $\vec{v}$

Toroid:



$\boxed{B_P = 0}$

$\boxed{B_Q = 0}$

for point S,

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

for ideal toroid ($d \ll R$)

$$\boxed{B = \mu_0 n I}$$

Path of charged Particle in a magnetic field

Case I: $\theta = 0°$ or $\theta = 180°$
$v \parallel B$, $v \parallel -B$

$F_m = qvB\sin 0$

$\boxed{F_m = 0}$

Trajectory → Straight line

Case II: $B \perp V \Rightarrow \theta = 90°$

ie $\boxed{F_m = qvB}$

$F_m = F_{centripetal}$

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

$$\boxed{R = \frac{mv}{qB}}$$

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

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

$$\boxed{R = \frac{mv}{qB}}$$

$$\boxed{R = \frac{P}{qB}}$$

$$\boxed{P = \sqrt{2mK}}$$

if 'q' is accelerated through P.D V then

$W = qV$

$\boxed{K.E = qV}$

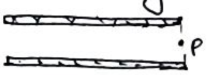
$$\boxed{R = \frac{\sqrt{2mK}}{qB}}$$

$$\boxed{R = \sqrt{\frac{2mV}{qB^2}}}$$ $V \to$ P.D

for Ideal solenoid ($l \gg R$)

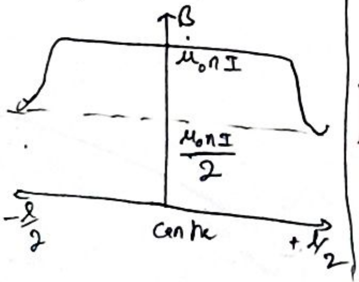
$$\boxed{|B| = \mu_0 n I}$$

for at edge (end)



$$\boxed{B = \frac{\mu_0 n I}{2}}$$

Graph B v/s l



Note:- force on the closed is zero in uniform magnetic field

$\boxed{f = 0}$

Force on a current carrying wire placed in B

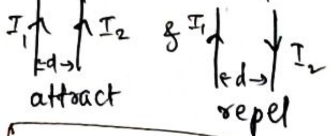
$$\boxed{f = IBl\sin\theta}$$

or

$$\boxed{\vec{f} = I(\vec{l}\times\vec{B})}$$

$\theta \to$ angle between $\vec{l}$ & $\vec{B}$

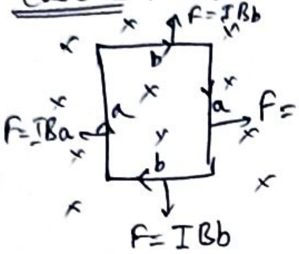
Force Btw 2 $\parallel$ wires



$$\boxed{\frac{f}{l} = \frac{2\mu_0}{4\pi}\frac{I_1 I_2}{d}}$$

Torque ~~on~~ a current loop (Magnetic Dipole) in $\vec{B}$

Case I : θ btw $\vec{m}$ & $\vec{B}$ is $0°$



m → dipole moment
B → magnetic field

$\boxed{F_{net} = 0}$

$\tau_{net} = F \times d_{\perp}$

$\boxed{\tau_{net} = 0}$

Case II : Angle btw $\vec{m}$ & $\vec{B}$ is θ

$\boxed{F_{net} = 0}$

$\tau_{net} = IBab\sin\theta$

$= IBA\sin\theta$

$= IAB\sin\theta$

$\tau_{net} = MB\sin\theta$

$\boxed{\tau_{net} = M \times B}$

M → magnetic moment, B → magnetic field

$\boxed{\tau_{net} = NIBA\sin\theta}$

τ_{max}: $\theta = 90°$, $\boxed{\tau_{max} = NIBA}$, ie $\vec{M} \perp \vec{B}$

τ_{min}: $\theta = 0°$, $\boxed{\tau_{min} = 0}$, $M \parallel B$ or $M \parallel -B$

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flux density = Magnetic field.

If a current carrying circular loop $(n=1)$ is turned into a coil having n identical turns then magnetic field at the centre of the coil becomes n^2 times the previous field

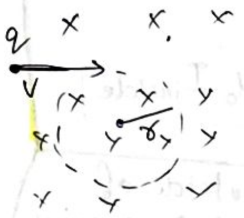
i.e $B_{n\,turns} = n^2 B_{(single\ turn)}$

Charge of Proton: ${}^1_1H$, $q = 1$

Charge of α-particle: ${}^4_2He$, $q = 2$

In hydrogen atom, the electron has magnetic moment of range 10^{-24} to 10^{-23}

Radius of circular path in a cyclotron:



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

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

$$\frac{1}{r} = \frac{qB}{mv}$$

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