Chapter - 4
Magnetic Effect of Electric Current

Biot Savart-Law :

$$dB \propto i$$
$$dB \propto \sin\theta$$
$$dB \propto 1/r^2$$
$$dB \propto dl$$

Combining above relations we have

$$dB \propto \frac{i\,dl \sin\theta}{r^2}$$

$$dB = \left(\frac{\mu_0}{4\pi}\right)\frac{i\,dl \sin\theta}{r^2}$$

where μ_0 = Permeability of free space
$= 4\pi \times 10^{-7}\ T\,m\,A^{-1}$

~~Biot Savar~~ Biot Savert Law in Vector form :

In vector form,

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

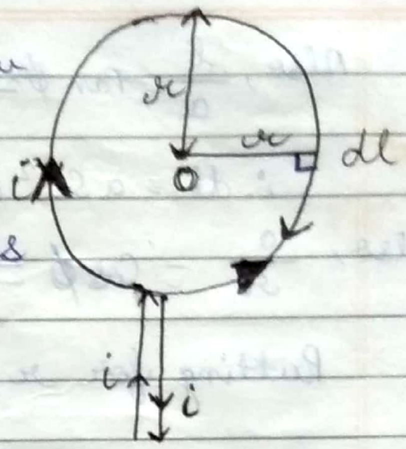
$$\frac{dl\, r \sin\theta\, \hat{r}}{r^3} = \frac{i\,dl \sin\theta\, \hat{r}}{r^2} = d\vec{B}$$

$$\boxed{|d\vec{B}| = \frac{i\,dl \sin\theta}{r^2}}$$

Applications of Biot-Savart Law :

(i) To find the magnetic field strength at the center ~~due to~~ of a current carrying circular loop :-

(1) According to Biot-Savart Law Small magnetic field at point O due to the small current carrying element can be given as



$$dB = \frac{\mu_0}{4\pi} \frac{i\,dl\,\sin 90}{r^2}$$

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

$\therefore$ Total magnetic field at point O

$$B = \oint \frac{\mu_0}{4\pi} \frac{i\,dl}{r^2} = \frac{\mu_0}{4\pi} \frac{i}{r^2} \oint dl$$

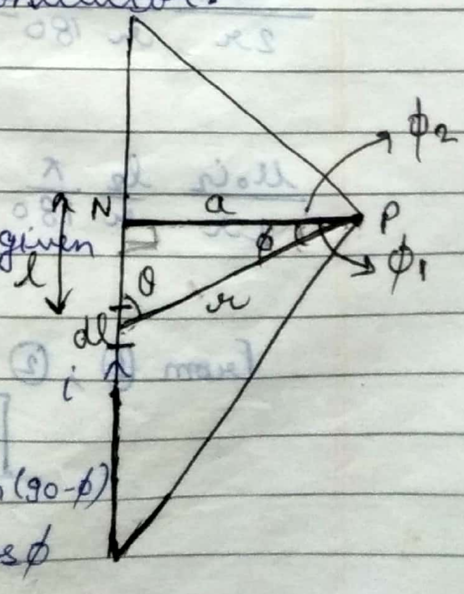
$$= \frac{\mu_0 i}{4\pi r^2} (2\pi r)$$

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

For n turns of the loop

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

(2) To find out the magnetic field strength at a point to a long straight current carrying conductor:-



Magnetic field at point P due to small carrying conductor can be given as.

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

$$\theta + \phi = 90' \Rightarrow \theta = 90 - \phi \Rightarrow \sin\theta = \sin(90-\phi)$$
$$= \cos\phi$$

Also, $\frac{l}{a} = \tan\phi \Rightarrow l = a\tan\phi$

$\therefore dl = a\sec^2\phi\, d\phi$

Also, $\frac{a}{r} = \cos\phi \Rightarrow r = \frac{a}{\cos\phi}$

Putting for r, dl & $\sin\theta$ in ① we have

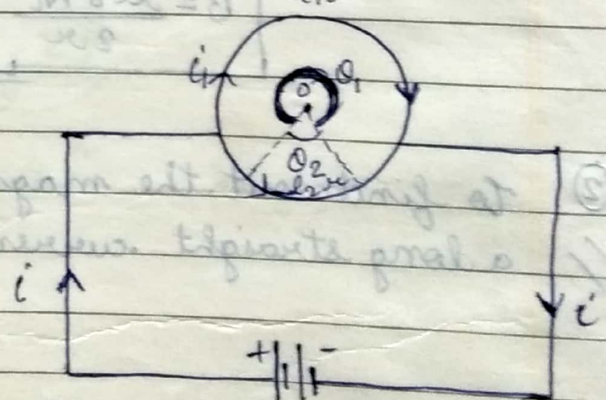
$$dB = \frac{\mu_0}{4\pi}\frac{i(a\sec^2\phi\, d\phi)\cos\phi}{(a/\cos\phi)^2} = \frac{\mu_0}{4\pi}\frac{i\cos\phi \cdot d\phi}{a}$$

$$= \frac{\mu_0 i}{4\pi a}\left[\sin\phi\right]_{\phi_1}^{\phi_2}$$

$$= \frac{\mu_0 i}{4\pi a}\left[\sin\phi_2 - \sin(-\phi)\right]$$

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

Hence Proved



$i_1 l_1 r = i_2 l_2 r$

$i_1 l_1 = i_2 l_2 \rightarrow$ ①

$\frac{\mu_0 i_1}{2r}\frac{l_1}{r}\frac{\pi}{180} = B_1 = \frac{\mu_0 i_1}{2r}\theta_1 \times \frac{\pi}{180}$

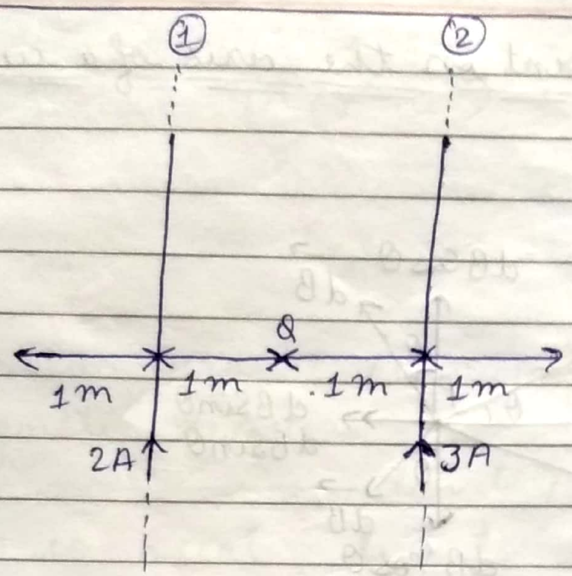
$\rightarrow$ ②

$\frac{\mu_0 i_2}{2r}\frac{l_2}{r}\frac{\pi}{180} = B_2 = \frac{\mu_0 i_2}{2r}\theta_2 \times \frac{\pi}{180}$

$\rightarrow$ ③

From ①, ② & ③, we have

$$\boxed{B_1 = B_2}$$



At P,

$$B_1 = \frac{\mu_0 i}{2\pi a} = \frac{2\times10^{-7}\times 2}{1} = 4\times10^{-7}\,T$$
upward

$$B_2 = \frac{2\times10^{-7}\times3}{3} = 2\times10^{-7}\,T$$
upward

$$B_P = B_1 + B_2 = 6\times10^{-7}\,T$$
upward

At Q

$$B_1 = \frac{2\times10^{-7}\times 2}{1} = 4\times10^{-7}\,T, \text{ downward}$$

$$B_2 = 2\times10^{-7}\times\frac{3}{1} = 6\times10^{-7}\,T, \text{ upward}$$

$\therefore$ Net Magnetic field $B_Q = B_2 - B_1 = 2\times10^{-7}\,T$ upward.

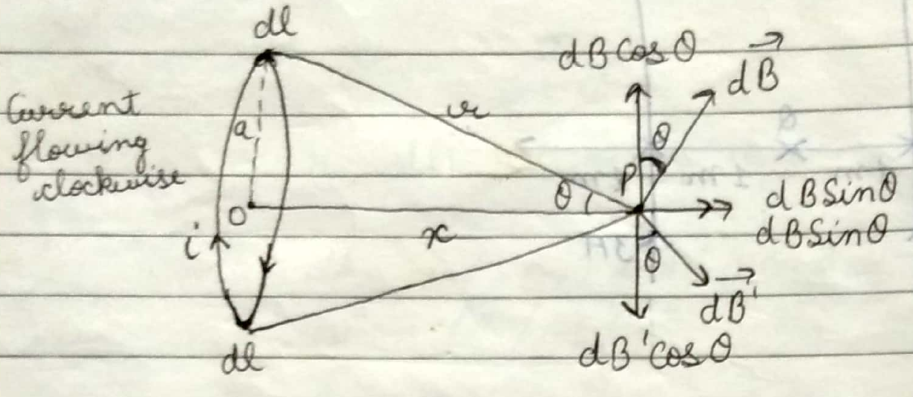
At R

$$B_1 = 2\times10^{-7}\times\frac{2}{3} = \frac{4}{3}\times10^{-7}\,T, \text{ downward}$$

$$B_2 = 2\times10^{-7}\times\frac{3}{1} = 6\times10^{-7}\,T, \text{ downward}$$

$\therefore$ Net magnetic field $B_R = \left(6+\frac{4}{3}\right)\times10^{-7}$
$= \frac{22}{3}\times10^{-7}\,T$
$=$ downward.

Magnetic field at a point on the axis of a current carrying loop:-



$$dB = \frac{\mu}{4\pi}\frac{i\,dl\,\sin 90^\circ}{r^2} = \frac{\mu}{4\pi}\frac{i\,dl}{r^2} \rightarrow (1)$$

$\therefore$ Resultant using field at point P will be $B = \oint \frac{\mu_0}{4\pi}\frac{i\,dl}{r^2}$

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

$$= \oint \frac{\mu_0}{4\pi}\frac{i\,dl}{r^2}\frac{a}{r} = \oint \frac{\mu_0}{4\pi}\frac{i\,dl \times a}{(x^2+a^2)^{3/2}}$$

$$= \frac{\mu_0\, i\, a}{4\pi(x^2+a^2)^{3/2}}\oint dl = \frac{\mu_0\, i\, a}{4\pi(x^2+a^2)^{3/2}}\, 2\pi a$$

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

For N turns of the loop

$$\boxed{B = \frac{\mu_0 N i\, a^2}{2(x^2+a^2)^{3/2}}}$$

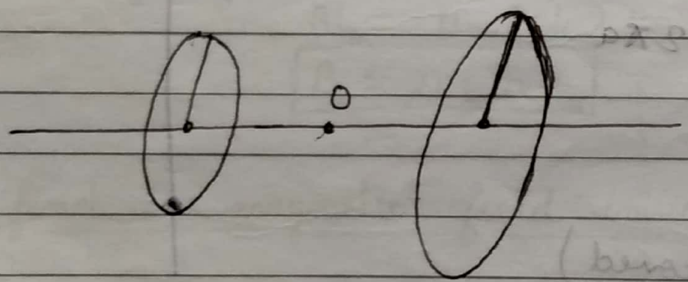
$$= \frac{\mu_0}{4\pi}\frac{2\pi N i a^2}{(x^2+a^2)^{3/2}} = \frac{\mu_0}{4\pi}\frac{2NiA}{(x^2+a^2)^{3/2}} = \frac{\mu_0}{4\pi}\frac{2NiA}{(x^2+a^2)^{3/2}}$$

$$B = \frac{\mu_0}{4\pi} \frac{2M}{(x^2+a^2)^{3/2}}$$

Circular Current carrying loop behaves like a magnetic dipole.

Q. Two co-axial circular loop L_1 & L_2 of radii 3 cm & 4 cm are placed as shown. What should be the magnitude and direction of the current in the loop L_2 so that the net magnetic field at the point O be zero?

~~Sin θ~~



Condition of loop in such a manner that

① $\vec{B}=0$.
② $B \perp$ loop.
③ $\vec{B}$ along the loop.

Ampere's Circuital Law :-

Convention : in $-ve$. out $+ve$.

$$\oint \vec{B}\cdot\vec{dl} = \mu_0 \text{ (Total Current threading the closed path or loop)}$$

$$\boxed{\oint \vec{B}\cdot\vec{dl} = \mu_0 i}$$

Proof:- Taking LHS.

$= \oint \vec{B}\cdot dl$

$= \oint B\, dl \cos\theta$

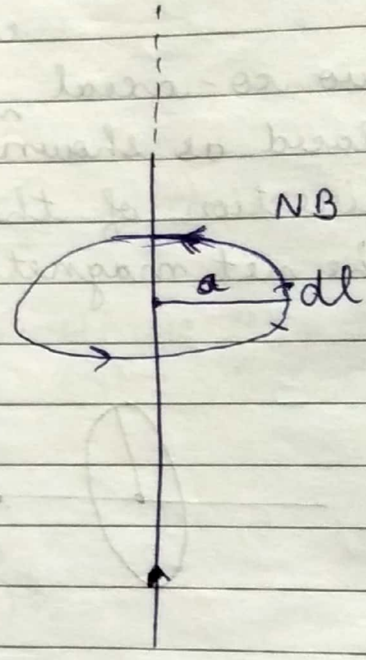
$= B \oint dl$

$= \dfrac{\mu_0 i}{2\pi a} \times 2\pi a$

$= \mu_0 i$

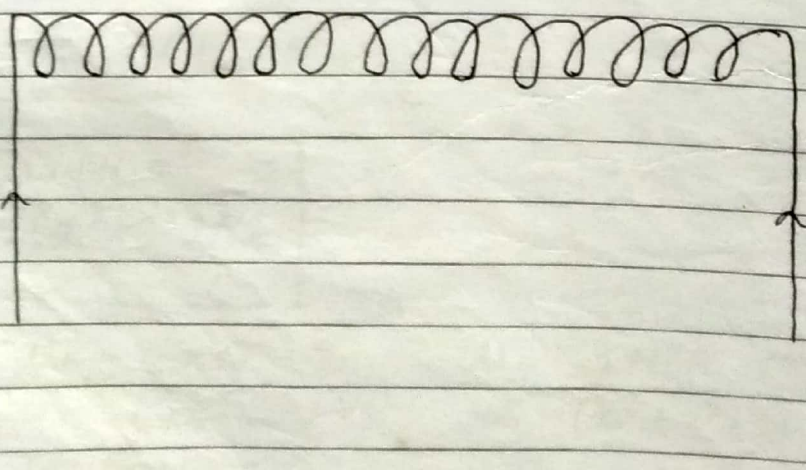
$=$ RHS.

(Proved)



Applications of Ampere's Circuital Law :-

(i) To find out the magnetic field inside a long straight solenoid :-



Line integral of magnetic field along the closed path PQRS can be given as

$$\oint \vec{B}\cdot\vec{dl} = \int_{PQ} \vec{B}\cdot\vec{dl} + \int_{QR} \vec{B}\cdot\vec{dl} + \int_{RS} \vec{B}\cdot\vec{dl} + \int_{SP} \vec{B}\cdot\vec{dl}$$

$$= \int_{PQ} B\,dl \cos 0 + \int_{QR} B\,dl \cos 90 + 0 + \int_{SP} B\,dl \cos 90$$

$$= B\int_{PQ} dl + 0 + 0 + 0 = B(L) = BL \rightarrow (1)$$

Applying Ampere's Circuital Law we have,

$$BL = \mu_0 (Ni) \Rightarrow BL = \mu_0 n L i$$

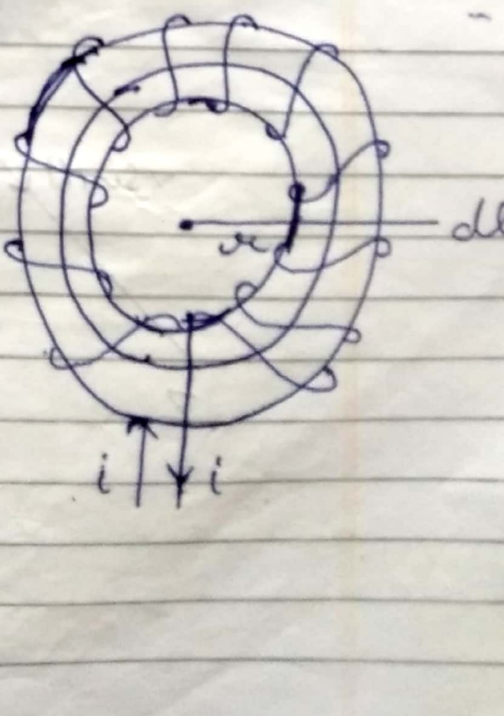
$$\boxed{B = \mu_0 n i}$$

To find the magnetic field inside a torroidal solenoid:-

~~After~~ Applying Ampere's Circuital law along the axis of the torroidal solenoid.

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

$$\oint B\,dl \cos 0 = \mu_0 (n 2\pi r) i$$



$$B\oint dl = \mu_0 n 2\pi r i$$

$$B(\cancel{2}\cancel{\pi}\cancel{r}) = \mu_0 n \cancel{2}\cancel{\pi}\cancel{r} i$$

$$B = \mu_0 n i$$

$\frac{\mu_0 N i}{2r}$

Force on a moving charge in a moving magnetic field :

$$\text{Fleming}\begin{cases} F \propto v \sin\theta \\ F \propto B \\ F \propto q \end{cases}$$

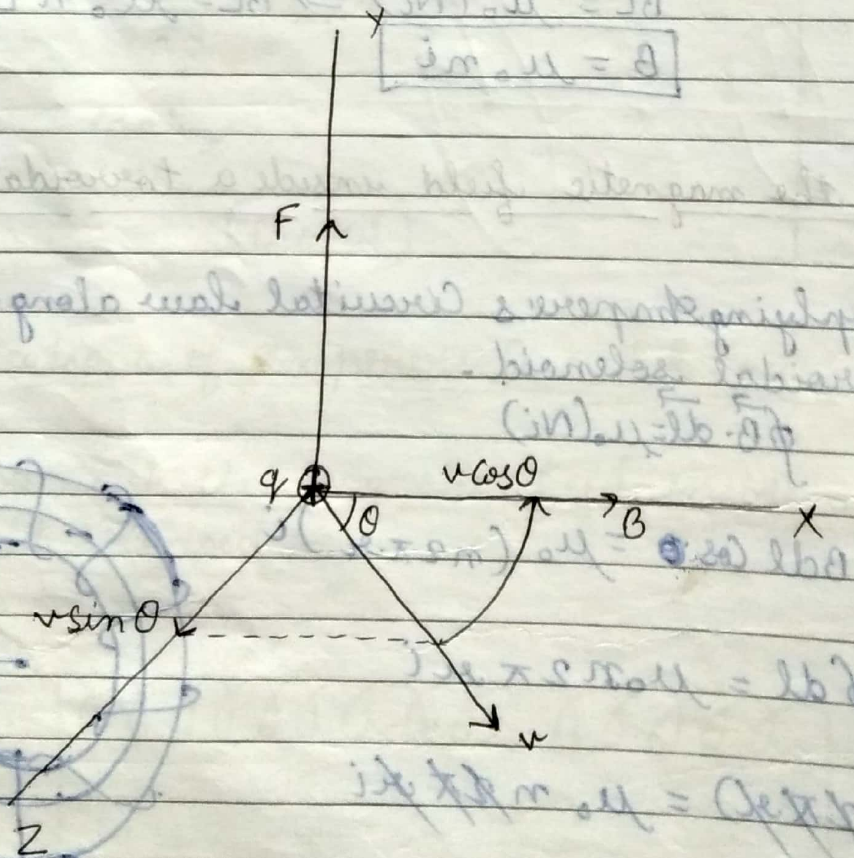
joining the above 3 relations

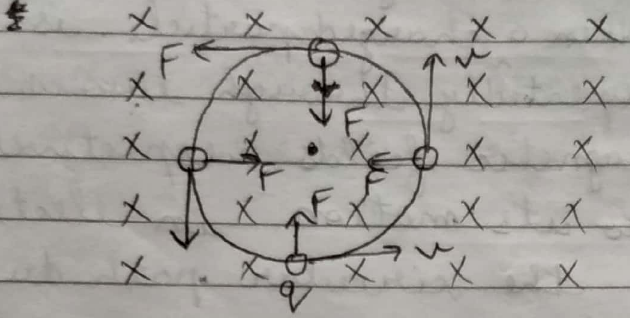
$$F \propto q v B \cdot \sin\theta$$

$$\boxed{F = q v B \sin\theta}$$ In SI system

In vector form

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





Magnetic Lorentz Force

$$F = qvB = \frac{mv^2}{r} \Rightarrow r = \frac{mv}{qB}$$

$$T = \frac{2\pi r}{v} \Rightarrow T = \frac{2\pi m}{qB}$$

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

$$K = \frac{1}{2}mv^2 = \frac{1}{2}m\frac{r^2q^2B^2}{m^2} \Rightarrow \frac{r^2q^2B^2}{2m}$$

Power delived by the magnetic field.

$$P = \frac{W}{F}$$

$$= \frac{\vec{F}\cdot\vec{v}}{t}$$

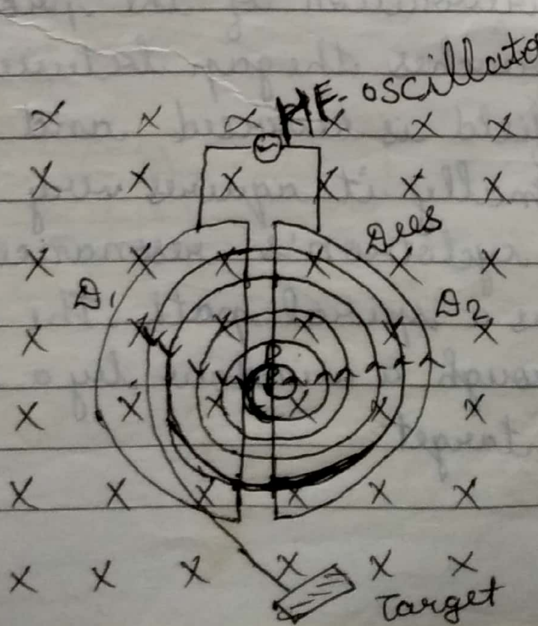
$$P = \frac{Fv\cos 90^\circ}{t} = 0.$$

$$F = qvB = \frac{mv^2}{r}, \quad r = \frac{mv}{qB}.$$

$$T = \frac{2\pi r}{v}, \quad T = \frac{2\pi m}{qB}.$$

$$f =$$

Cyclotron :



(+)vely
Principle:- When a charged particle is allowed to pass or move repeatedly through two mutually ⊥ar electric & magnetic feilds respectively it is acclerated to its motion in electric field & moves along the circular path due to its motion in a magnetic field.

$$t = \frac{\pi m}{qB} = \frac{\pi}{qB} \times \left[\frac{m}{\sqrt{1-\frac{v^2}{c^2}}} \right].$$

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

$$t = \frac{\pi r\uparrow}{v\uparrow}$$

Working:- Suppose a position ion says a proton, enters the gap b/w two dees and find dee D_1. ~~As it~~ to be negative. It gets acclerated towards dee D_1. As it enters the dee D_1, it does not experience any electric field due to shielding effect of the metallic dee. The ⊥ar magnetic field throws it into a circular path. At the instant the proton comes out of dee D_1, It finds D_1 positive and D_2 negative. It now gets acclerated towards dee D_2, It moves faster through D_2 describing a larger semicircle than before. Thus the frequency of the applied voltage is kept exactly the same as the frequency of revolution of the proton, then everytime the proton reaches the gap between the two dees, the electric field is reversed and proton recieves a push, and fitnally it aquires very high energy. This is called the cyclotron's resonance condition. The proton follows a spiral path. The acclerated proton is ejected through a window by a deflecting voltage and hits the target.

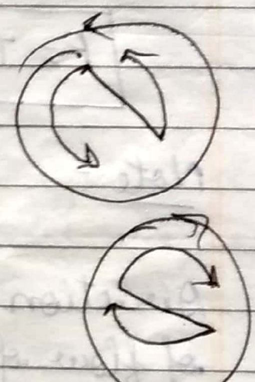
The ions will attain maximum velocity near the periphery of the dees. If v_0 is the max. velocity acquired by the ions and

---

$$t = \frac{\pi m}{qB} = \frac{\pi}{qB}\left[\frac{m}{\sqrt{1-\frac{v^2}{c^2}}}\right]$$

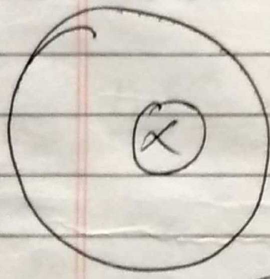
$$r = \frac{mv}{qB}, \therefore t = \frac{\pi r \uparrow}{v \uparrow}$$

$$B \times AB = \mu_0 \frac{N}{L} \times AB \times i$$



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

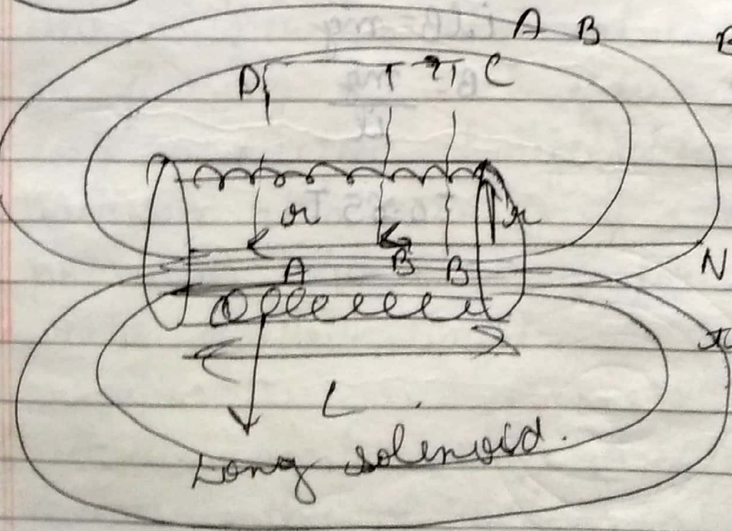
$$\boxed{B = \mu_0 n i}$$



at CD, $B = 0$. $[L >> r]$

BC, AD $B = 0$ or $B \perp$ length

AB B is along the length



N turns

total current $= \frac{N}{L} AB\, i$

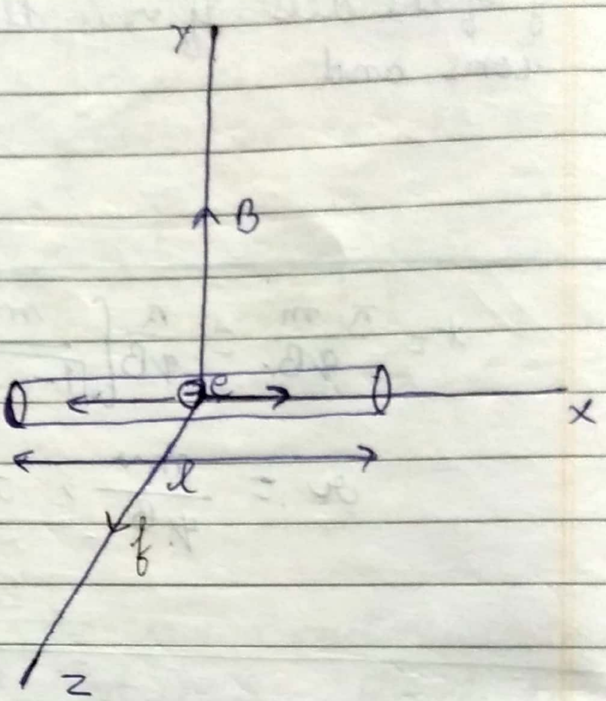
$\boxed{L >> r}$

Force on a Current Carrying Conductor placed in a uniform magnetic field :-

$f = e v_d B \sin 90°$
$= e v_d B$
$F = Nf$
$= nAl (e v_d B)$
$= (neAv_d) lB$
$F = IlB$

If θ be the angle between $\vec{Il}$ & $\vec{B}$ then
$\vec{F} = I(\vec{l} \times \vec{B})$

In magnitude



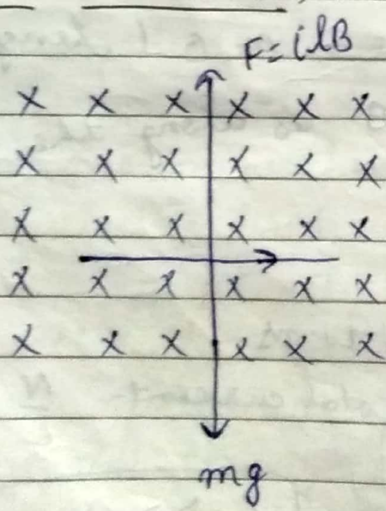
$$\boxed{F = IlB \sin\theta}$$

Note :-

Direction of Il vector is always ~~given~~ taken in the direction of flow of current.

Q. Ex 59. (SL Arora)

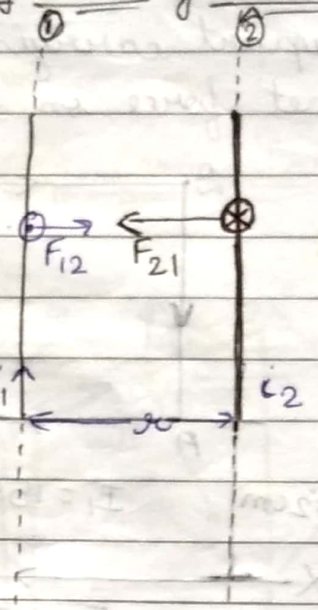
Ans.



$ilB = mg$
$B = \frac{mg}{il}$
$= 0.65\,T$

parallel

Force between two infinitely long straight current carrying conductor :-



$$B_1 = \frac{\mu_0 i_1}{2\pi r}$$

F_{21} = Force experienced by ② due to 1 (over l length of 2)

$= i_2 B_1 l \sin 90^\circ$

$= i_2 \times \frac{\mu_0 i_1}{2\pi r} l$

$$F_{21} = \frac{\mu_0}{2\pi} \frac{2 i_1 i_2}{r} l \rightarrow ①$$

Towards ①

Similarly, $F_{12} = \frac{\mu_0}{2\pi} \frac{2 i_1 i_2}{r} l \rightarrow ②$

Towards ②

$$\boxed{F_{12} = i B_2 \, l \sin 90^\circ}$$

If currents in both the conductors flow in opposite direction then force will be repulsive in nature.

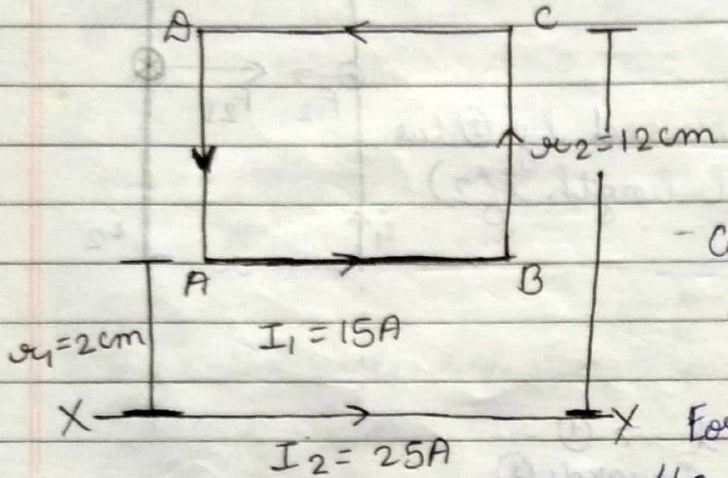
Def^n of 1 ampere :- $i_2 = i_2 = 1A$ & $r = 1m$

then $\frac{F_{12}}{l} = 2 \times 10^{-7} N \, 10^{-1}$ N/m

One ampere is that value of steady current, which on flowing in each of two parallel infinitely long conductors of negligible cross-section placed in vacuum at a distance of 1 m from each other, produces b/w them a force of 2×10^{-7} Newton per meter of their length.

Ex 68. A rectangular loop of sides 25 cm & 10 cm carrying a conductor of 15A is placed with its longer side parallel to a long straight conductor 2.0 cm apart carrying a current of 25A. What is the net force on the loop?

<u>Ans</u>



Current through the rectangular loop, $I_1 = 15A$

Current through the long wire XX, $I = 25A$

Force on AB,

$$F_1 = \frac{\mu_0}{4\pi} \cdot \frac{2I_1I_2}{r_1} \times \text{length of AB}$$

$$= \frac{10^{-7} \times 2 \times 15 \times 25}{2.0 \times 10^{-2}} \times 25 \times 10^{-2}$$

$$= 9.375 \times 10^{-4} N \quad \text{(Attractive)}$$

Force on CD,

$$F_2 = \frac{\mu_0}{4\pi} \cdot \frac{2I_1I_2}{r_2} \times \text{length of CD}$$

$$= \frac{10^{-7} \times 2 \times 15 \times 25}{12 \times 10^{-2}} \times 25 \times 10^{-2}$$

$$= 1.5625 \times 10^{-4} \quad \text{(Repulsive)}$$

∴ Net force on the loop

$$F = F_1 - F_2 = 9.375 \times 10^{-4} - 1.5625 \times 10^{-4}$$

$$= 7.8125 \times 10^{-4} N \simeq 7.8 \times 10^{-4} N.$$

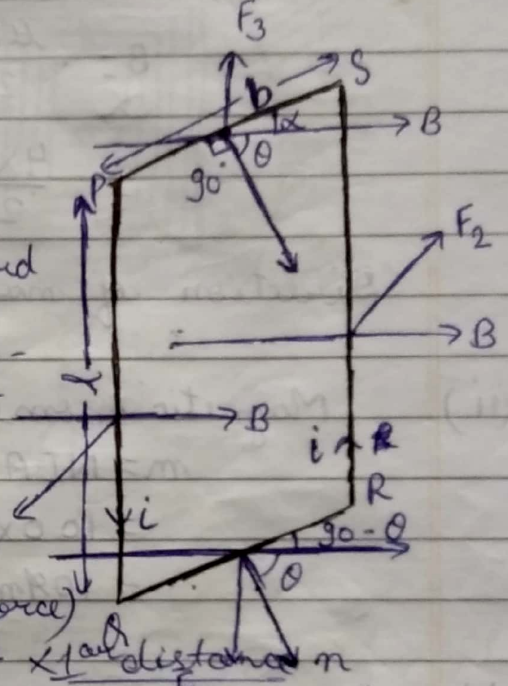
(Attractive).

Thus the force on the loop will act towards the long conductor (attractive) if the current in its closer side is in the same direction as the

θ = Angle b/w the normal to the plane of the coil and magnetic field **B**.

current in the long conductor, otherwise it will be repulsive.

Torque acting over a current carrying loop placed in a uniform magnetic field :-



$F_1 = ilB \sin 90° = ilB$ $\perp^r$ outward

$F_2 = ilB$ .... $\perp^r$ inward

$F_3 = ibB \sin(90+\theta) = ibB \cos\theta$ ... upward

$F_4 = ibB \sin(90-\theta) = ibB \cos\theta$ ... downward

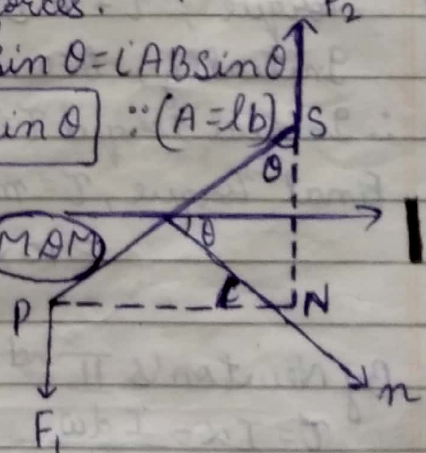
F_3 & F_4 cancel out the effect of each other

$\therefore$ Torque τ = either force $\times$ $\perp^r$ distance b/w the line of action of forces.

Torque τ = either force (other force) $\times$ $\perp^{ar}$ distance

$= ilB \times PN = ilB \times SP \sin\theta = ilB\, b \sin\theta = iAB \sin\theta$

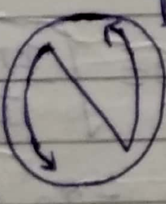
N turns of the coil, $\boxed{\tau = NiAB \sin\theta}$ $\because (A = lb)$



$\boxed{\tau = MB \sin\theta}$ $\because M = NiA = $ MDM

$\tau = MB \sin\theta$

$\boxed{\vec{\tau} = \vec{m} \times \vec{B}}$



$\theta + \alpha = 90°$
$\theta = 90 - \alpha$
$90 - \alpha - \alpha = 90°$
$90 - 2\alpha = 90°$
$2\alpha = 0°$
$\alpha = 0°$

$\theta + \alpha = 90°$

$\theta = 90 - \alpha \Rightarrow 90 + \alpha + \alpha = 90°$

$90 + \alpha + \alpha = 90°$

$90 + 2\alpha = 90°$

$2\alpha =$

Magnetic dipole moment of coil is always directed South to North pole.

$\tau = NiAB = \sin(90 - \alpha) = NiAB \cos\alpha$

where α = Angle b/w plane of coil and magnetic field.

$$\boxed{\therefore \text{In vector form } \vec{\tau} = \vec{M} \times \vec{B}}$$

Example II :-

Ans

$N = 100$

$I = 3.2A$, $r = 10cm = 0.1m$

$$B = \frac{\mu_0 NI}{2r} = \frac{4\pi \times 10^{-7} \times 100 \times 3.2}{2 \times 0.1}$$

$$= \frac{4 \times 10^{-5} \times 10}{2 \times 0.1} = 2 \times 10^{-3} T$$

(Right Hand Thumb)

Direction of magnetic field is given by RHT rule.

(ii) Magnetic moment associated with the coil

$m = NIA \times \pi r^2$

$= 100 \times 3.2 \times 3.14 \times (0.1)^2$

$= 10 Am^2$

(iii) Torque, $\tau = mB \sin\theta$

Initially, $\theta = 0$

$\therefore$ Initial torque $\tau = mB \sin 0$

Final Torque, $\tau = mB \sin 90°$

$= 10 \times 2 \times 1 = 20 Nm$

(iv) By Newton's IInd Law

$$\tau = I\alpha = \frac{I d\omega}{dt} = I \frac{d\omega}{d\theta} \cdot \frac{d\theta}{dt}$$

$$= I \cdot \frac{d\omega}{d\theta} \cdot \omega$$

$\tau = mB \sin\theta$

$\therefore I \cdot \frac{d\omega}{d\theta} \cdot \omega = mB \sin\theta$ or

$I \omega d\omega = mB \sin\theta d\theta$

When θ changes from 0 to $\pi/2$, Integrating eq^n within these limits of θ & ω,

$$I \int_0^{\omega} \omega d\omega = mB \int_0^{\pi/2} \sin\theta d\theta$$

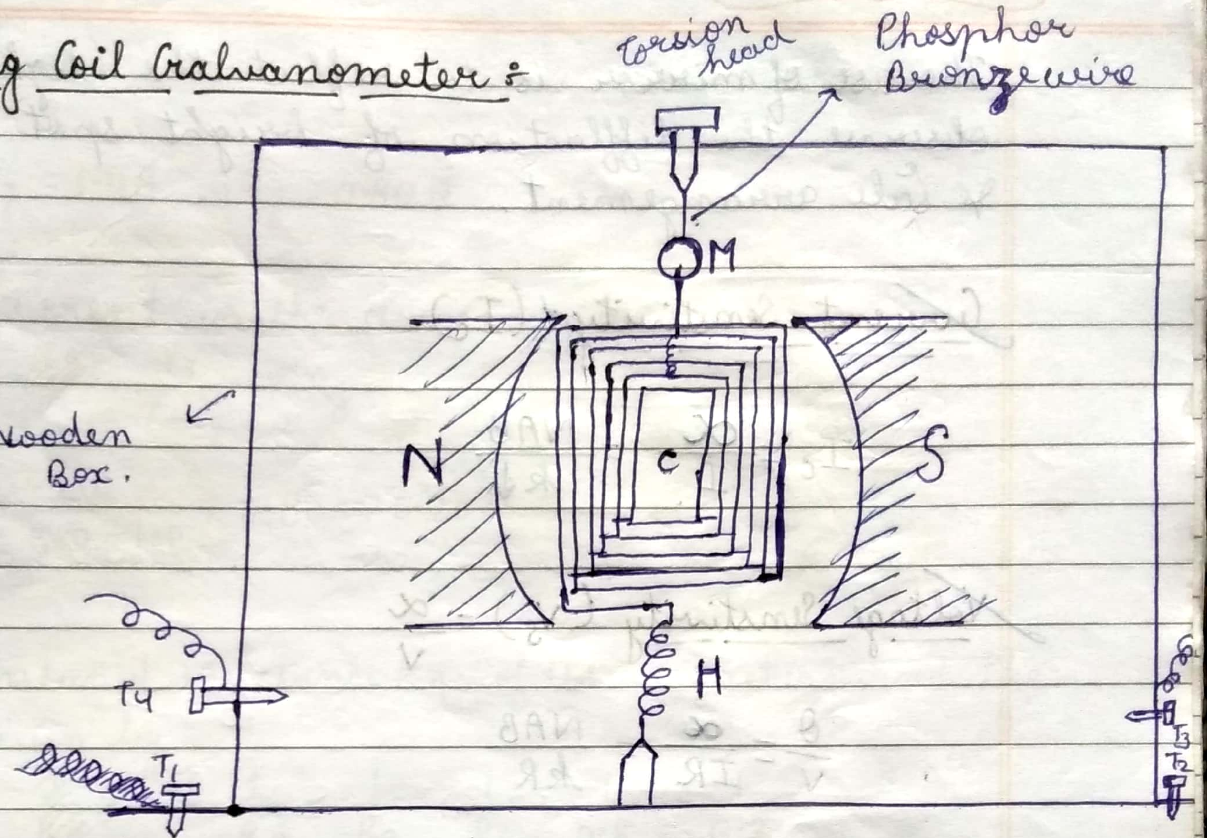
$$I \left[\frac{\omega^2}{2}\right]_0^{\omega} = mB \left[-\cos\theta\right]_0^{\pi/2}$$

$$\frac{1}{2} I\omega^2 = -mB \left[\cos\frac{\pi}{2} - \cos 0\right] = m$$

$$\omega = \sqrt{\frac{2mB}{I}} = \sqrt{\frac{2 \times 10 \times 2}{0.1}}$$

$= 20$ rad s^{-1}

Moving Coil Galvanometer :



Deflecting torque : $\tau = NiAB\cos\alpha$

where α = Angle b/w plane of coil and magnetic field.

Restoring torque = $k\alpha$ $\xrightarrow{}$ Torsion constant

In equillibrium

$NiAB\cos\alpha = k\alpha$. $\qquad NiAB\cos\alpha = k\alpha$

$i = \frac{k}{NAB}\frac{\alpha}{\cos\alpha}$ $\qquad i = \frac{k}{NAB}\frac{\alpha}{\cos\alpha}$

$i = \left(\frac{k}{NAB}\right)\alpha$ For radial magnetic field 'α' is very small $\therefore \cos \approx 1$

$i = \left(\frac{k}{NAB}\right)\alpha$ $\therefore i = \left(\frac{k}{NAB}\right)\alpha \Rightarrow i \propto \alpha$

shows that the scale of galvanometer is linear.

Whenever a current carrying coil is suspended in a magnetic field it experiences a torque

The use of mirror is to reflect the light and observe the difflaction of bright spot on lamp & scale arrangement.

Current Senstivity (I_c)

$$I_c = \frac{\alpha}{I} = \frac{NAB}{k}$$

Voltage Senstivity (V_s) $= \frac{\alpha}{V}$

$$\frac{\theta}{V} = \frac{\alpha}{IR} = \frac{NAB}{kR}$$

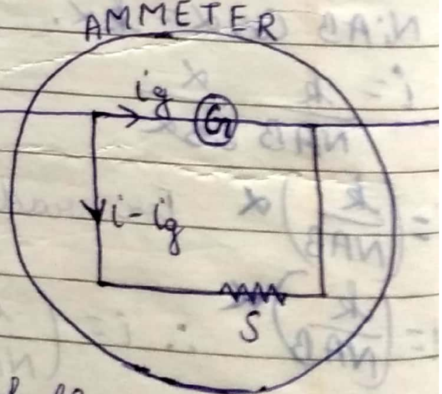
~~Ex-11~~ ~~Ans.~~ (~~.....~~) Conversion of Galvanometer into Ammeter:

Galvanometer can be converted in Ammeter by connecting a low value resistance (shunt) parallel to it.

to be done

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

G → Res. of coil of galvanometer



$$\boxed{S = \left[\frac{i_g}{i - i_g}\right] G} \Rightarrow \boxed{R_S = \frac{I_g}{i - i_g} \times R_g}$$

where i_g = current that produces full scale deflection in the galvanometer

i = current in the ammeter

$$\frac{1}{R} = \frac{1}{G} + \frac{1}{S}$$

$$\boxed{R = \frac{G \cdot S}{G + H}}$$

Ex 89 (SL Arora)

Ans. ∴ $I_g = 1.0A$, $R_g = 0.80\Omega$

(i) Total current in the circuit, $I = 5.0A$

$$R_s = \cancel{I_g}\ \frac{i_g}{i - i_g} \times R_g$$

$$= \frac{1.0}{5.0 - 1.0} \times 0.80 \Rightarrow 0.20\Omega$$

(ii) The combined resistance R_A of the ammeter and the shunt given by

$$\frac{1}{R_A} = \frac{1}{R_g} + \frac{1}{R_s} = \frac{1}{0.8} + \frac{1}{0.2}$$

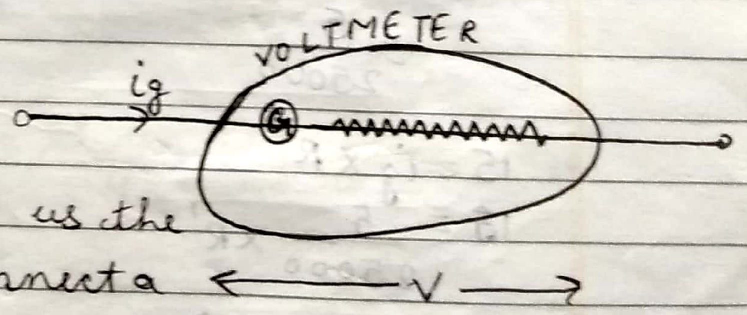
$$= \frac{1+4}{0.8} = \frac{25}{4}$$

$$R_A = 4/25 = 0.16\Omega$$

Conversion of ~~Galvolt~~ Gravanometer into Voltmeter:-

$$V = i_g (G + R)$$

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



This formula gives us the resistance required to connect a galvanometer into a voltmeter of required range.

Ex 87 (Page no. 4.64)
SL Arora.

P.T.O

Ans 1. (i) $G = 12\,\Omega$

$i_g = 25\ mA$

$S = ?$

$$S = \frac{i_g \times G}{i - i_g} = \frac{2.5 \times 10^{-3} \times 12}{75 - 25 \times 10^{-3}}$$

$$= \frac{30 \times 10^{-2}}{7.5 - 0.0025} = 4 \times 10^{-3}\,\Omega$$

(ii) $R_g = 12\,\Omega$, $i_g = 2.5 \times 10^{-3} A$, $V = 10V$

$$R = \frac{V}{i_g} - R_g \Rightarrow \frac{10}{2.5 \times 10^{-3}} - 12$$

$$= 4000 - 12 = 3988\,\Omega$$

Ex 98. Page no. (4.67)
SL. Arora.

Ans. $1V = 5000\,\Omega$

$5V = 25000\,\Omega$

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

$$= \frac{5}{25000}$$

$15 = i_g \times R'$

$$15 = \frac{5}{25000} \times R'$$

$$R' = \frac{15 \times 25000}{5} = 75000\,\Omega$$