'MAGNTISM'

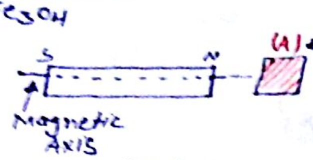
Various possible source of Magnetic Field

|1| → Bar magnet
|2| → Earth magnet
|3| → current carrying system
|4| → Moving charge.
|5| → Varying Electric field.

$K = \frac{1}{4\pi\epsilon_0} = \frac{\mu_0}{4\pi}$
↑ Electro. ↑ Mag.

|1| → BAR MAGNET →

→ Fe_3O_4



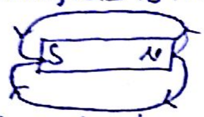
→ magnetic dipole.

* Pole strength (M) →

* It Represent the magnetic strength of Magnetic pole.
* M → −M (South pole), → +M (North pole) q → −q, → +q

जो काम 'q' करता था वही Same Work 'M' यहाँ !

* Scalar parameter
* unit = Amp × meter
* $M \propto A$ (crosssection area of magnet)
* Imp. $l_{Magnetic} = 0.91\, l_{actual}(r)$
* Magnetic field is in closed loop only & Electric field is in open loop.



* Single pole doesn't exist. [S N] [S N] ---- [S N]

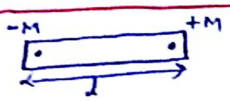
Formula for single pole

$M_1 \bullet \leftarrow r \rightarrow \bullet M_2$

* $F = \frac{\mu_0}{4\pi} \cdot \frac{M_1 M_2}{r^2}$
* $\bullet \xrightarrow{r}$ * $B = \frac{\mu_0}{4\pi} \cdot \frac{M}{r^2}$
* $F_M = MB$

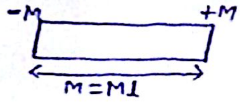
, $F = \frac{K q_1 q_2}{r^2}$
, $E = \frac{1}{4\pi\epsilon_0\epsilon_r} \cdot \frac{q}{r^2}$
, $F_e = qE$
→ Electro.

|I| → Magnetic Moment of Magnetic dipole / Bar magnet (M) : →



* $M = Ml$
  $\vec{M} = M\vec{l}$
* l = Effective length b/w mag. dipole. (S→N)
* vector (S to N) * unit → $A \times m^2$
* Imp. Bohr Magnet (μ_B) = $0.923 \times 10^{-23}\, A \times m^2$

Magnetic Moment of Magnet 'M' is-



|i| → If it is cut into 'n' equal parts // to magnetic axis then magnetic moment of each part -

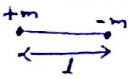
$m' = M/n$, $l' = l$

$\boxed{M' = \frac{M}{n}}$

|ii| → If cut it to 'n' equal part then magnetic moment of small part.

--- n part $\boxed{M' = m\left(\frac{l}{n}\right) = M/n}$

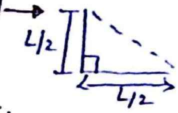
Magnetic Moment of thin magnet is 'M'.



$\boxed{M' = ml}$

|i| → When bending is done. $m' = m$, $l' < l$, $\boxed{M' < M}$

|ii| →



$l' = l/\sqrt{2}$, $M' = m$, $\boxed{M' = M/\sqrt{2}}$

|iii| →

$M' = M$
$l' = l/2$ $\boxed{M' = M/2}$ (By equilateral triangle)

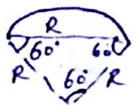
** |iv| →

$l = \pi R \Rightarrow R = l/\pi$, $l' = 2R = 2(l/\pi)$

$M' = Ml'$

$M' = m\left(\frac{2l}{\pi}\right) = \boxed{\frac{2M}{\pi}}$

NEET |v| →

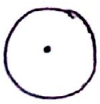


$\boxed{\text{Angle} = \frac{\text{Arc}}{\text{Radius}}}$

$R = \frac{3l}{\pi}$, $l' = R = \frac{3l}{\pi}$

$M' = m\left(\frac{3l}{\pi}\right) = \boxed{\frac{3M}{\pi}}$

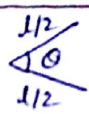
|vi| →



$m' = m$, $l' = 0$, $\boxed{M' = 0}$

NOTE →

|i| →



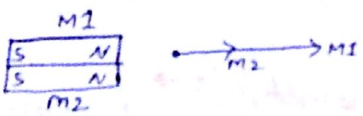
$M' = M\sin(\theta/2)$ [For Two length]

|ii| →

$M' = \frac{M\sin(\theta/2)}{\theta/2}$ [For Arc question]

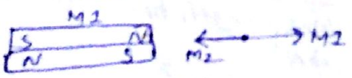
Combination of Magnet

|i| →



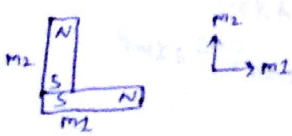
$\boxed{M_{net} = M_1 + M_2}$

|ii| →



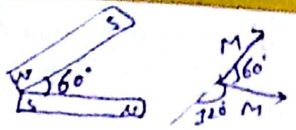
$\boxed{M_{net} = M_1 - M_2}$

|iii| →

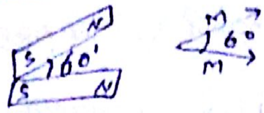


$\boxed{M_{net} = \sqrt{M_1^2 + M_2^2}}$

(iv) →

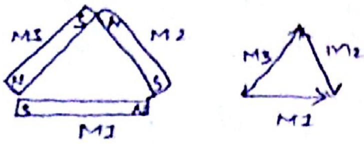


$M_{net} = M$



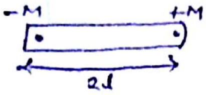
$M_{net} = \sqrt{3} M$

(v) →



$M_{net} = 0$

(2) → Magnetic field due to dipole (B) :→



$M = (m)(2l)$

case-I → Axial / End on / Longitudnal / Tan 'A' position →

$$B_{axis} = \frac{\mu_0}{4\pi} \cdot \frac{2Mr}{(r^2 - l^2)^2} = \frac{\mu_0}{4\pi} \cdot \frac{2M}{r^3} \quad (\text{along } \vec{M})$$

case-II → Equator / Broadside / Transverce / Tan 'B' position →

$$B_{eq} = \frac{\mu_0}{4\pi} \cdot \frac{M}{(r^2 + l^2)^{3/2}} = \frac{\mu_0}{4\pi} \cdot \frac{M}{r^3} \quad (\text{opposite to } \vec{M})$$

case-III → General point (r, θ) →

$$B = \frac{\mu_0}{4\pi} \cdot \frac{M}{r^3} \sqrt{1 + 3\cos^2\theta}$$

Angle b/w B & M

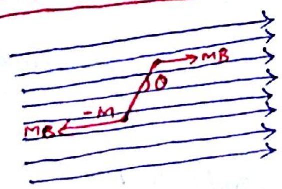
$$= \theta + \tan^{-1}\left(\frac{1}{2} \tan\theta\right)$$

(3) → Magnetic potential due to dipole :→

$$V_M = \frac{\mu_0}{4\pi} \cdot \frac{M\cos\theta}{r^2 - l^2\cos^2\theta}$$

$$= \frac{\mu_0}{4\pi} \cdot \frac{M\cos\theta}{r^2}$$

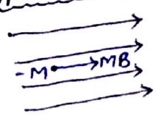
(4) → Behaviour in External magnetic field.



- * $F_{net} = 0$
- * $\tau = MB\sin\theta \quad (\vec{\tau} = \vec{M} \times \vec{B})$
- * $U = -MB\cos\theta$
  $U = -\vec{M} \cdot \vec{B}$
- * $W = MB(\cos\theta_1 - \cos\theta_2)$

$\tau = FE\sin\theta$

Special case



$F = 0$
$\tau = 0$
$U = -MB$

If dipole is given small angular displacement then it perform angular S.H.M, with time period.

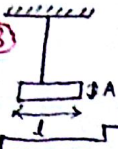
$$T = 2\pi\sqrt{\frac{I}{MB}}$$

$$I = \frac{(mass)(length)^2}{12}$$

Scanned by CamScanner

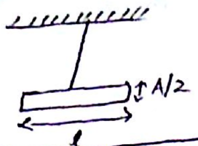
A bar magnet hanged in any field & perform assilation then time period?

(B)



$$T = 2\pi\sqrt{\frac{I}{MB}}$$

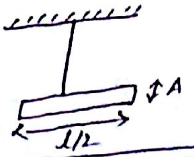
(i) →



$$T' = 2\pi\sqrt{\frac{(I/2)}{(M/2)B}} = T$$

$$T' = T$$

(ii) →

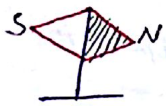


$$T' = 2\pi\sqrt{\frac{(I/8)}{(M/2)B}}$$

$$T' = T/2$$

Magnetic Needle.

It is small bar magnet used to detect direction of magnetic field.



$$\oint \vec{E}\cdot\vec{ds} = \frac{\Sigma q}{\varepsilon_0}$$ → (Electrostate)

$$\oint \vec{B}\cdot\vec{ds} = \mu_0 \Sigma M$$ → (magnate)

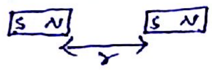
$$= \mu_0(0)$$

$$= 0$$ [So, Gauss theorum is ⊕nt in magnetism but not useful.]

[Here, single pole not exist so Gauss theorum is useless.]

Force b/w Two dipole:

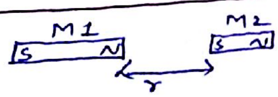
(i) → Dipole very close →



$$F = \frac{\mu_0}{4\pi}\cdot\frac{M_1 M_2}{r^2}$$

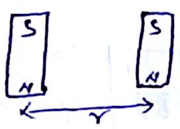
$$F \propto \frac{1}{r^2}$$

(ii) → Dipole are Far away →



*$$F_M = \frac{\mu_0}{4\pi}\cdot\frac{6M_1M_2}{r^4}$$

*$$F \propto \frac{1}{r^4}$$



*$$F_M = \frac{\mu_0}{4\pi}\cdot\frac{3M_1M_2}{r^4}$$

(2) → **Magnetic Effect of current**

Oserted Exp: → Discovered that magnetic field is produce around current carying system.

Magnetic field / Magnetic flux density / Magnetic Induction (B): →

Magnetic Field / Magnetic flux density / Magnetic Induction (B) :→ Magnetic Field / Magnetic flux density / Magnetic Induction (B): →

* It Represent strength of magnetism at particular poins
* vector quantity.
* Unit → MKS → Tesla, wb/m^2, N/A×m
  CGS → Gauss, Maxwell/m^2, Dyne/AbA×cm

$$1T = 10^4 \text{ Gauss}$$

* Dimension ⇒ $M^1L^0T^{-2}A^{-1}$

Bio-sivort Law (BSL) → Magnetic field at a point due to current small element.

$\delta B \propto I$, $\propto \delta l$, $\propto \sin\theta$, $\propto \frac{1}{r^2}$

$\delta B = \frac{I\delta l \sin\theta}{r^2}$

* $\delta B \propto \frac{\mu_0}{4\pi} \frac{I\delta l \sin\theta}{r^2}$

$\mu_0 = 4\pi \times 10^{-7}$ Henely/M

$\frac{\mu_0}{4\pi} = 10^{-7}$ (MKS)

$\frac{\mu_0}{4\pi} = 1$ (c.g.s)

NOTE → * If $\theta = 90°$ so $\sin\theta = 1$ (max)

$\therefore \delta B = max$

* If observation point is on the wire on along the wire so, $\theta = 0$, $\sin 0$, then $\delta B = 0$

Vector Form of BSL

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

$I\delta\vec{l}$ → current element vector (Always const)

$\vec{r}$ → ⊕ve vector.

θ → Angle b/w $I\delta\vec{l} \times \vec{r}$

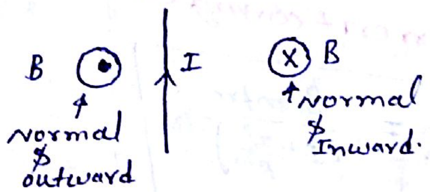
⇒ $B_{net} = \int \delta B$

⇒ $\delta B = I\delta\hat{l} \times \hat{r}$ * $\delta B \perp I\delta l$, $\delta B \perp r$

Right hand Rule for direction of magnetic field

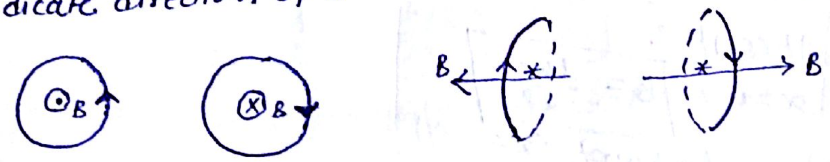
(i) → For straight current

If thumb of Right hand is along straight current & finger are streached towards observation point then $\vec{B}$ is ⊥ to Right hand palm.



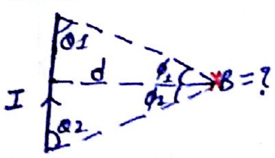
(ii) → For circular current

Finger of Right hand fold at along circular current then thumb indicate direction of 'B'.



Case - I →

(1) → Straight current carrying wire →

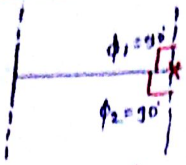


**

$B = \frac{\mu_0 I}{4\pi d}(\sin\phi_1 + \sin\phi_2)$ ϕ angle Lena Hai.

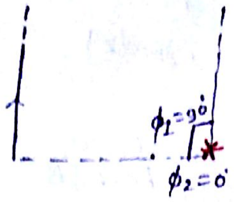
$B = \frac{\mu_0 I}{4\pi d}(\cos\theta_1 + \cos\theta_2)$ θ angle Lena hai

Case A → Infinite wire / Long wire :→



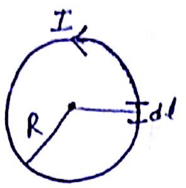
$$B = \frac{\mu_0 I}{2\pi d}$$

Case-B → Semi Infinite wire & observation point is infront of fixed.



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

Case II → Magnetic field due to current carrying coil →

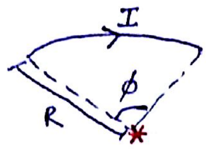


$\phi = 2\pi$

$$B_{centre} = \frac{\mu_0 I}{2R}$$

NOTE → Angle use in Radian means, $\frac{\pi}{2}, \frac{\pi}{3}$ etc.

Case-A →

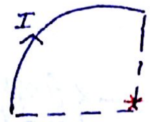


$$B = \frac{\mu_0 I \phi}{4\pi R}$$

Case-B →

$$B_C = \left[\frac{\mu_0 I}{2R}\right] \frac{\theta}{2\pi} \odot$$

Case-C →



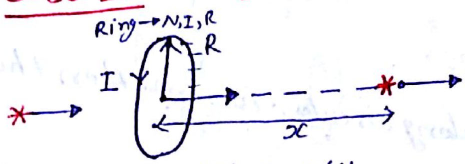
$\phi = \frac{\pi}{2}$

$$B = \frac{\mu_0 I}{8R} \otimes$$

Case-D →

$\phi = \pi$, $$B = \frac{\mu_0 I(\pi)}{4\pi R} = \frac{\mu_0 I}{4R} \otimes$$

Case-III → Magnetic field at axial point of current carrying circular Ring.



$$B = \frac{\mu_0 N I R^2}{2(R^2+x^2)^{3/2}} = \frac{B_{centre}}{\left(1+\frac{x^2}{R^2}\right)^{3/2}}$$

* If $x(\uparrow) \Rightarrow B(\downarrow)$

Situation-I → At centre

$x = 0$

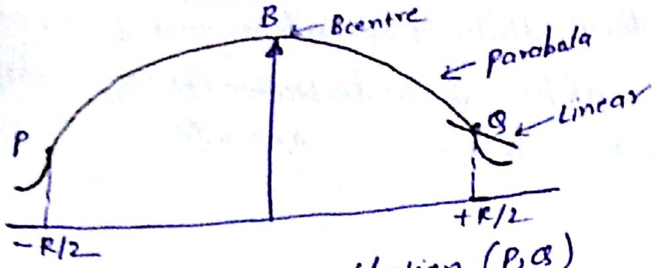
$$B = \frac{\mu_0 N I}{2R}$$

Situation-II → Near by point $(x <<< R)$

$$B = \frac{B_{centre}}{\left(1+\frac{x^2}{R^2}\right)^{3/2}}, \quad B = B_{centre}\left(1 - \frac{3x^2}{2R^2}\right)$$

Situation III → Far away point $(x >>> R)$

$$B = \frac{\mu_0 N I R^2}{2x^3} \propto \frac{1}{x^3}$$



point of Inflection (P, Q)

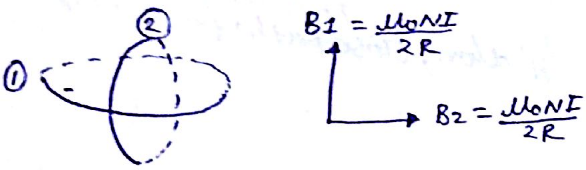
(i) → At this points curve change its direction of curvature so so curve become almost linear at this point.

$$x = \pm R/2$$

(ii) → B_{max} = Max at centre , E = 0 at centre.

$B = \frac{R}{2}$ point of Inflection , $E_{max} = R/\sqrt{2}$

TWo coils NRI are ⊥ to each other.



$$B_{centre} = \sqrt{2}\left(\frac{\mu_0 N I}{2R}\right)$$

* circular coil made of fix length wire.

$$l = N(2\pi R)$$

$$N \propto \frac{1}{R}$$

For TWo circular coil at centre B_1/B_2 = ? If -

(i) → Same Radius, same current & turns N_1 & N_2.

$B = \frac{\mu_0 N I}{2R} \propto N$ $\quad \frac{B_1}{B_2} = \frac{N_1}{N_2}$

(ii) → Same no. of turn, same current & Radius R_1 & R_2.

$B = \frac{\mu_0 N I}{2R} \propto 1/R$ $\quad \frac{B_1}{B_2} = \frac{R_2}{R_1}$

(iii) → If circular coil of N_1 turns is convert into N_2 turns & current Remain same.

$$\frac{B_1}{B_2} = \left(\frac{N_1}{N_2}\right)^2$$

(iv) → If coil of R_1 Radius is converted into R_2 Radius & current Remain same.

$N \propto \frac{1}{R}$ $\quad \frac{B_1}{B_2} = \left(\frac{R_2}{R_1}\right)^2$

Helmholtz Pair This system is use to produced Approx uniform magnetic field.

Case IV → Due to Plane sheet having current carrying Infinite Wires.

$dI = \lambda dx$, $\int_{-\infty}^{\infty} \frac{\mu_0}{2(r^2+x^2)^{1/2}} \frac{\lambda dx \cdot r}{\pi(r^2+x^2)^{1/2}}$

$$B_{net} = \frac{\mu_0 \lambda}{2}$$

Magnetic field Intensity (H) → Ratio of Magnetic flux density & Magnetic permeablity (μ)

* $H = \frac{B_{med}}{\mu} = \frac{B_{vaccume}}{\mu_0}$

* unit → MKS (Amp/meter)
→ cgs (oersted)

* Vector

[1 Amp/m = $4\pi \times 10^{-3}$ oersted
1 oersted = 80 Amp/meter.]

NOTE→ 'B' depends on medium while 'H' is independent from medium.

AIIMS 2016
[A → When a Mag. material placed inside water its mag. strength ↓.
R → Water is diamagnetic substance   Ans → (A)

Ampher's circuital law (ACL)

Line integral $\int \vec{B}\cdot d\vec{l}$ over a closed loop for any current system is equal to the times the current enclosed by the loop.

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

NOTE→ $\oint \vec{B}\cdot d\vec{l}$ is integrated along a direction of Area vector of the loop.

2nd form of ACL →
$$\oint \vec{H}\cdot d\vec{l} = \Sigma I$$
⇒ Magnetomotive force (MMF)
↑ It is line integration 'H' along close path. (unit → Amp).

$$\frac{\text{EMF unit}}{\text{MMF unit}} = \frac{\text{volt}}{\text{Amp}} = \Omega\,(\text{ohm})$$

→ By multiplying (m) both side

$W_{close\ loop} = m\mu_0 \Sigma I \neq 0$

Workdone for rotating single pole 'm' in closed loop around a current carying wire is non-zero it means magnetic field produced by current is non-conservative field.

3rd form of ACL →
$$\frac{W}{m} = \mu_0 \Sigma I$$

→ Acl represent the workdone for moving unit north pole in closed loop around the current carying wire

Application of ACL

(i) → Infinite wire / Long wire $B = \frac{\mu_0 I}{2\pi r}$

(ii) → Solid cylindrical wire

(i) → outside (r>R) $B_{outside} = \frac{\mu_0 I}{2\pi r}$

(ii) → Inside (r<R) $B = \frac{\mu_0 I}{2\pi R^2}$

(iii) → At axis (r=0)

$B_{axis} = 0$

Formula For solid cylindrical pipe

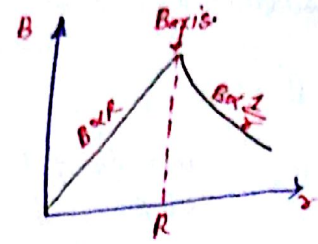
$B_{outside} = \frac{\mu_0 I}{2\pi r}$

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

$B_{inside} = \frac{\mu_0 I r}{2\pi R^2} \propto r$

$B_{axis} = 0$

Graph



Formula For Hallow cyllindrical pipe

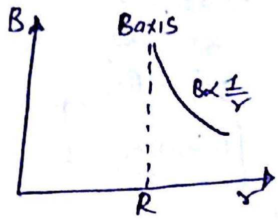
$B_{outside} = \frac{\mu_0 I}{2\pi r}$

$B_{surface} = \frac{\mu_0 I}{2\pi r}$

$B_{inside} = 0$

$B_{axis} = 0$

Graph



**

Solid cylindrical wire

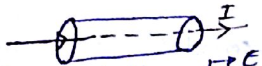
(i) → outside → $E = 0$, $B \neq 0$

(ii) → surface → $E \neq 0$, $B \neq 0$

(iii) → Inside → $B \neq 0$, $E \neq 0$

(iv) → Axis → $B = 0$, $E \neq 0$

Hollow cylindrical pipe



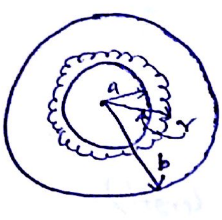
(i) → outside → $E = 0$, $B \neq 0$

(ii) → surface → $B \neq 0$, $E \neq 0$

(iii) → Inside → $E = 0$, $B = 0$

(iv) → Axis → $B = 0$, $E = 0$

**# A long cylindrical current carying pipe Radius 'a' & outer Radius 'b' then magtic field at 'r' distance from axis of wire If →



(i) → $r > b$: $B = \frac{\mu_0 I}{2\pi r}$

(ii) → $r = b$: $B = \frac{\mu_0 I}{2\pi b}$

(iii) → $a < r < b$: $B = \frac{\mu_0 I}{2\pi r}\left(\frac{r^2 - a^2}{b^2 - a^2}\right)$

(iv) → $r = a^+ \Rightarrow B \neq 0$

$r = a^- \Rightarrow B = 0$

$r = a$ (boundry condition)

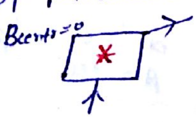
(v) → $r = a$

$\Sigma I = 0 \Rightarrow B = 0$

***

NOTE → For any symmetrical closed loop made of uniform wire If there are two parallel path of current then on Geometrical centre ($B=0$) in Respective of length of parallel path.

EX → (i) →

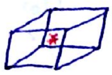


(ii) →

(iii) →

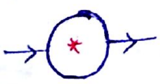
Bcentre = 0

(iv) →



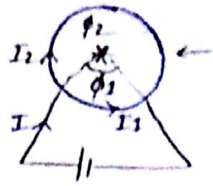
Bcentre = 0

(v) →



Bcentre = 0

A circular ~~coil~~ path of uniform wire & current enters & lives the circuit as shown then B_{centre} = ?



← This is not a circle b/c current is in opposite direction.

$$\vec{B_1} = \frac{\mu_0 I_1 \phi_1}{4\pi R} \odot$$

$$B_2 = \frac{\mu_0 I_2 \phi_2}{4\pi R} \otimes$$

For two Arc

$\text{Angle} = \frac{\text{Arc}}{\text{Radius}}$ ↑same

$\therefore$ Angle $\propto$ Arc $\propto$ Resistance $\propto \frac{1}{\text{current}}$.

$\boxed{R = \frac{\rho l}{A}}$ $\boxed{I \propto \frac{1}{R}}$

$\therefore$ (Angle) (current) = const.

$I_1 \phi_1 = I_2 \phi_2$

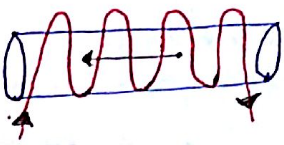
$B_1 = B_2$

$\vec{B_1} = -\vec{B_2}$

$\boxed{B_{centre} = 0}$

Solenoid / Electromagnet

It is coil having some length.



* conducting wire is wound on cyclindrical insulating frame in such a way that all turns are electrically insulated with each other, when current is passed then almosed uniform uniform magnetic field is produced along axis inside the frame b/c this system is equivalent to a group of Helmontz pair.

$B_{inside} \neq 0$ (uniform)

$B_{outside} = 0$ (Ideally)

Solenoid
- → Infinite / Long ($R << L$)
- → Finite ($R \not<< L$)

Finite solenoid →

$$B = \frac{\mu_0 n I}{2} (\cos\alpha - \cos\beta)$$

n → Turn density (turn per unit length)

$\boxed{n = \frac{N}{L}}$

* α, β → angle measured in same sense or direction.

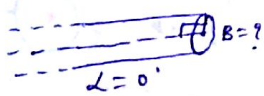
Infinite solenoid →

(a) → At axis →

$\alpha = 0$
$\beta = 180°$

$\boxed{B_{axis} = \mu_0 n I}$

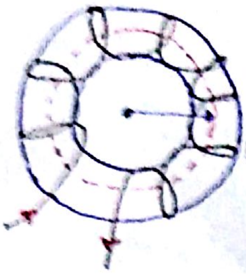
(b) → At End →



$\alpha = 0°$
$\beta = 90°$

$\boxed{B_{net} = \frac{\mu_0 n I}{2}}$

Toroid / Endless solenoid :



$B_{inside\ frame} = \mu_0 n I$
$B_{outside\ frame} = 0$
] → Means वहाँ जहाँ जाती है एक. 'B' बराबर है (Tire में)

$n = \frac{N}{l} = \frac{N}{2\pi r}$

$r = \frac{r_1 + r_2}{2}$

**
Force acting on moving charge in external magnetic field. [FM]

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

If $q \neq 0$, $v \neq 0$, $\theta \neq 0°, or, 180°$] $F \neq 0$

Magnitude of force $F = qvB\sin\theta$

$\theta \rightarrow$ angle b/w $\vec{v}$ & $\vec{B}$

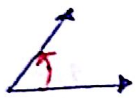
NOTE →

|i| → In the vector form → 'q' will be used along with sign.

|ii| → Direction of force

$\vec{F} \Rightarrow \odot$ For ⊕ve

$\vec{F} \Rightarrow \otimes$ For ⊖ve



Righthand palm Rule
* Applicable only if $\vec{v} \perp \vec{B}$
Finger ⇒ In the direction of magnetic field.
Thum ⇒ In the direction of velocity.
Palm ⇒ Show direction of ⊕ve charge.

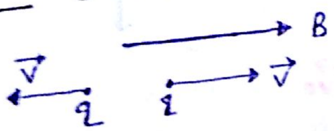
|iii| → Force acting on charge is always ⊥ to its velocity hence it can only change its direction not the magnitude.

|iv| → Work done by magnetic force on a charge is always zero, b/w any two point of path hence it can't change K.E of particle.

***
PMP sir SMS } → Teacher is like magnetic field, can change your direction only. They can't change your kinetic energy. Text book are like electric field More you come in their influence more kinetic energy Aquire from them.

Different cases of Motion of charge

case-|1| → 'q' is projected along or, opposite to $\vec{B}$

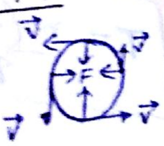


$\vec{v}$ & $\vec{B}$ = $\theta = 0° = 180°$

$F = 0$

Path straight line.

case-|2| → If $\vec{v} \perp \vec{B}$ (In uniform Transverce field)



$F = qvB\sin 90° = qvB = \frac{mv^2}{R}$

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

$$r = \frac{mv}{qB} = \frac{p}{qB} = \frac{\sqrt{2m(K.E)}}{qB} = \frac{\sqrt{2m(qV_{acc})}}{qB}$$

** Time period of Revolution

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

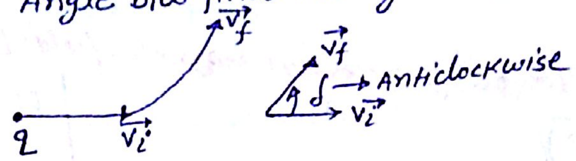
$$\text{Frequency} = \frac{1}{T} = \frac{qB}{2\pi m} = f$$

* 'T' is Independent of $\vec{v}$.

III Stimes

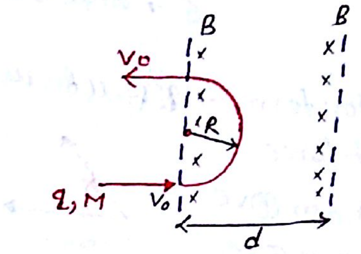
Angle of Deviation (δ)

Angle b/w final velocity vector & Initial velocity vector.



Situation (I) → $\vec{B}$ confined in a Region horizontal width (d)

$$R = \frac{mv_0}{qB}$$



(i) → $d > R$
(Halfcircle) $\delta = 180°$ or, π

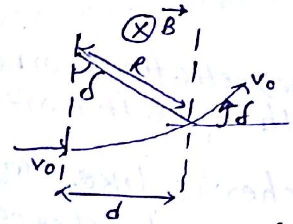
(ii) → $d = R^+$ $\delta = 180°$ or π (Half circle) (Grazing the final boundriees)

(iii) → $d \approx R^-$ (1/4 circle) $\delta = 90°$ or, $\pi/2$

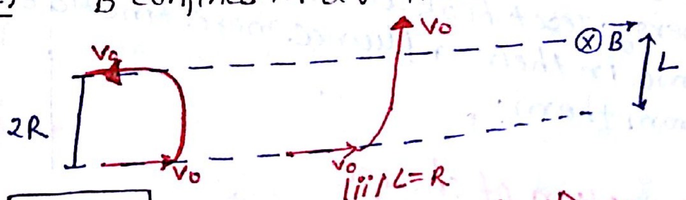
(iv) → $d < R$

$\sin\delta = d/R$

$$\delta = \sin^{-1}(d/R)$$



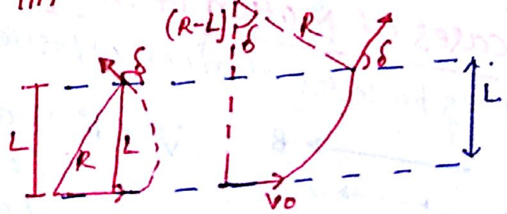
Situation (II) → $\vec{B}$ confined in a vertical width (L)



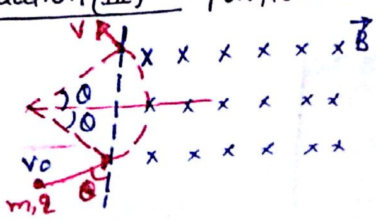
(i) → $L \geq 2R$ $\delta = 180°$

(ii) → $L = R$ $\delta = 90°$

(iii) → $L < R$ $\delta = \cos^{-1}\left(\frac{R-L}{R}\right)$



Situation (III) → Particle enters at an angle with Boundry



Time spend by particle in $\vec{B}$

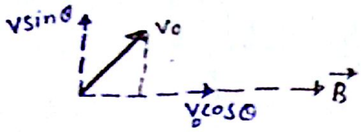
$$T = \frac{2\pi m}{qB}, \quad \frac{T}{2\pi} = \frac{m}{qB}$$

$$t = \frac{T}{2\pi} \times 2\theta = \frac{2m\theta}{qB}$$

* $$T = \frac{m(2\pi - 2\theta)}{qB}$$

NOTE → If particle come out from same Initial boundries then Entery angle is equal to exit angle.

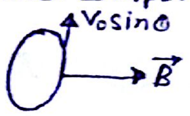
Case III → velocity ($\vec{v}$) & $\vec{B}$ makes an angle 'θ' with each other ($0 < \theta < 90°$)



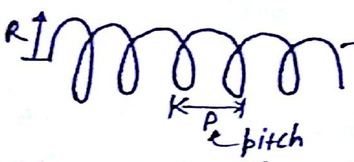
* Horizontal component ⇒ $\boxed{V_0 \cos\theta}$ (straight line)

⊕ ⟶ $V_0\cos\theta$ - - - - - → $V_0\cos\theta$

* vertical component ⇒ $\boxed{V_0 \sin\theta}$ (circular path)

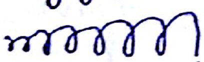


$$\boxed{R = \frac{m v_0 \sin\theta}{qB}}$$ *



$$\boxed{p = \left(\frac{2\pi M}{qB}\right) V_0\cos\theta}$$ *

↳ Horizontal distance covered by particle in Time period.

NOTE →
* If 'B' constant then, $\begin{bmatrix} P = const \\ r = const \end{bmatrix}$ → 
* If 'B' (↑) then $\begin{bmatrix} P = \downarrow \\ r = \downarrow \end{bmatrix}$ → 
* If 'B' (↓) then, $\begin{bmatrix} r \uparrow \\ P \uparrow \end{bmatrix}$ → 
* If there is Ext Electric field in the direction of mag. field.
  * helix width (→)
  * ↑ pitch.
* Horizontal motion

  $\overrightarrow{V_0\cos\theta}$ $\quad \overrightarrow{a_x = \frac{qE}{M}}$ ⟶ V_x

  $V_x = V_0\cos\theta + \left(\frac{qE}{M}\right)t$

* Net speed $= V_{net}^2 = V_x^2 + V_\perp^2$

Most imp.

A proton

$r_p : r_d : r_\alpha = ?$ If

(i) → same velocity *
$\boxed{r_p : r_d : r_\alpha = 1 : 2 : 2}$

(ii) → Momentum same. *
$\boxed{r_p : r_d : r_\alpha = 2 : 1 : 1}$

(iii) → same Kinetic Energy. *
$\boxed{1 : \sqrt{2} : 1}$

(iv) → If all particle Accelerate with same P.D. *
$\boxed{1 : \sqrt{2} : \sqrt{2}}$

Radius of curvature = Radius

curvature $\propto \frac{1}{\text{Radius}}$

Deviation $\propto \frac{1}{\text{Radius}}$

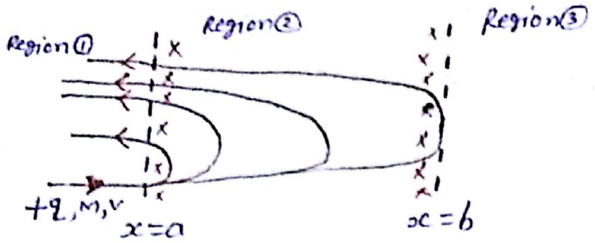
Two proton performing circular motion in UTF If $v_1 > v_2$

⇒ $r \propto v$ ⇒ $r_1 > r_2$

& $T \propto v^0$ ⇒ $T_1 = T_2$

* Work done by Fm ($F_m \perp v$)
  $\boxed{W = 0}$
* K.E = const.
* $|P| = const.$
* Power(P) = $P = \vec{F_m} \cdot \vec{v} = 0$.

#



|i|→ calculate velocity of particle for which it moves in Region ③

$$V > \frac{qB(b-a)}{M}$$

|ii|→ Find max. velocity of particle so that comes back in Region ① by graving the final boundry?

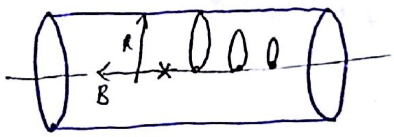
$$V_{Max} = \frac{qB(b-a)}{M}$$

|iii|→ calculate time in wich particle come back in Region ①. (Half circle)

$$t = \frac{T}{2} = \frac{1}{2}\left(\frac{2\pi m}{qB}\right)$$

$$t = \frac{\pi m}{qB}$$

A long solenoid (N, R, L, I), A particle (+q, M, v) is projected ⊥ to axis of Solenoid ~~from axis of~~ from axis of solenoid. calculate minimum current of Solenoid so particle complete circular path.



$$I \geq \frac{2MVL}{q\mu_0 NR}$$

$$I_{min} = \frac{2MVL}{q\mu_0 NR}$$

A charge particle enters in UTF at 45° then Relation b/w pitch & Radius of Helical path?

$$r = \frac{P}{2\pi}$$

Lorentz Force (F_L)→ It is net force on charge due to Electric force & Magnetic force.

$$\vec{F_L} = \vec{F_e} + \vec{F_m}$$
$$= q\vec{E} + q(\vec{v} \times \vec{B})$$
$$= q = [\vec{E} + (\vec{v} \times \vec{B})]$$

A charge particle in Region $\vec{E}, \vec{B}$ & $\vec{v}$ are mutually perpendicular, If velocity of particle Remain uncharge then velocity of particle.

|i|→ V=?

velo=const
accln = 0
Fnet = 0

$$V = \frac{E}{B}$$

|ii|→ $\vec{V}$=?

$\vec{F}_{net} = 0$

$\vec{F_e} + \vec{F_m} = 0$

$\vec{E} = \vec{B} \times \vec{v}$ $\left(\frac{\vec{E}}{\vec{B}} = \vec{v}\right.$ not possible in vector)

$$\vec{V} = \frac{\vec{E} \times \vec{B}}{B^2}$$

Imp

$$\{(\vec{A} \times \vec{B}) \times \vec{C} = (\vec{A} \cdot \vec{C})\vec{B} - (\vec{A} \cdot \vec{B})\vec{C}\}$$

**# A (+ve) charge enters in a Region then find various possibilities.

(1) → If velocity Remain const. (v = const)

$F_{net} = 0$.

(a) → $E = 0 \Rightarrow F_e = 0$, $B = 0 \Rightarrow F_m = 0$] $F_{net} = 0$ ✓

(b) → $E = 0 \Rightarrow F_e = 0$, $B \neq 0 \Rightarrow F_m = 0$ (If $v \parallel B$)] $F_{net} = 0$ ✓

(c) → $E \neq 0 \Rightarrow F_e \neq 0$, $B = 0 \Rightarrow F_m = 0$] $F_{net} \neq 0$ ✗

(d) → $E \neq 0 \Rightarrow F_e \neq 0$, $B \neq 0$ $F_m \neq 0$] $F_{net} = 0$ ✓

If $\vec{F_e} = -\vec{F_m}$ ($\vec{F}$: $(\vec{B} \times \vec{v})$)

✓ When ($\vec{E}, \vec{B}, \vec{v}$ are mutually ⊥)

(ii) → Particle moves in straight line path.

$F_{net} = 0$

$F_{net} \neq 0$ [But should be $F_{net} \parallel v$]

(i) → $E = 0 \Rightarrow F_e = 0$, $B = 0 \Rightarrow F_m = 0$] $F_{net} = 0$

(ii) → $E = 0 \Rightarrow F_e = 0$, $B \neq 0 \Rightarrow F_m = 0$ [If $B \parallel v$]] $F_{net} = 0$

(iii) → $\vec{E} \neq 0 \Rightarrow F_e \neq 0$, $B = 0 \Rightarrow F_m = 0$] $F_{net} \neq 0$ ($F_e \parallel F_{net} \parallel v$)

(iv) → $E \neq 0 \Rightarrow F_e \neq 0$, $B \neq 0 \Rightarrow F_m \neq 0$] All E, B, v ⊥

$F_e = -\vec{F_m}$

$\Rightarrow F_{net} = 0$

(v) → $E \neq 0$, $B \neq 0$] All are ∥

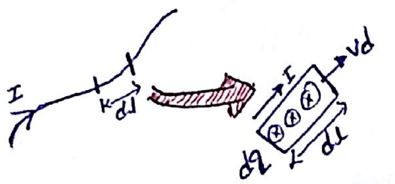
$F_m = 0$

$F_e \neq 0$

But, $F_e \parallel F_m \parallel v$

$\Rightarrow$ straight line.

**# Force Acting on a current carrying conductor/wire.



$\vec{v_d} = \frac{d\vec{l}}{dt}$

* $$d\vec{F} = I(d\vec{l} \times \vec{B})$$

(Here, $\vec{l}$ effective length vector) ↑ min distance b/w ends of wire from Initial to final end.

$dl \rightarrow d\vec{l}$

↓

Direction of $d\vec{l}$ is along current 'I'

NOTE → Right hand palm Rule.

When $d\vec{l}$ & $\vec{B}$ are perpendicular.

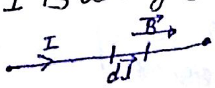
Fingers ⇒ $\vec{B}$

Thumb ⇒ $d\vec{l}$

Palm ⇒ Force.

Case-I → Straight conductor

(a) → 'I' is along $\vec{B}$.

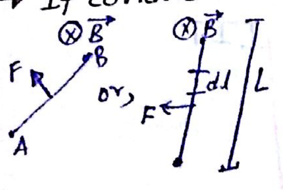


$\theta = 0°$

$dF = 0$

$F_{net} = 0$

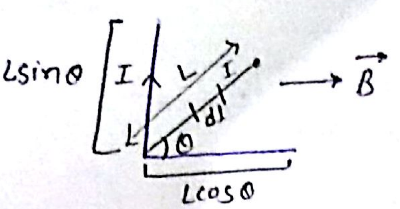
(b) → If conductor is kept perpendicular to $\vec{B}$.

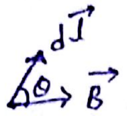


$|d\vec{F}| = I(dl) B \sin 90°$

$F = BIL$

|c|→ If conductor is kept at angle 'θ' with 'B'.

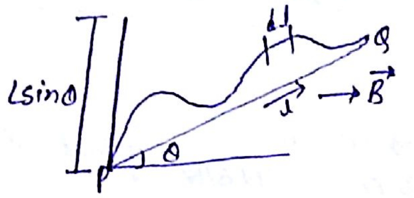




$$\int dF = \int I(dl)B\sin\theta$$

$$F = BI\sin\theta L$$
$$= BI(L\sin\theta)$$

Case-II → conductor having Arbitrary shape



$$\vec{F} = I\left(\int d\vec{l} \times \vec{B}\right)$$

$$\vec{F} = I(\vec{L} \times \vec{B})$$

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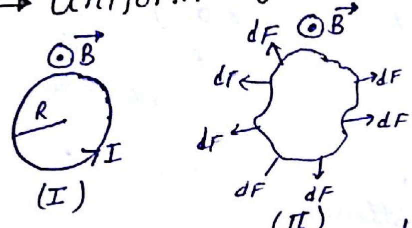
Case-III → Force acting on current carrying loop.

*|a|→ Uniform magnetic field-

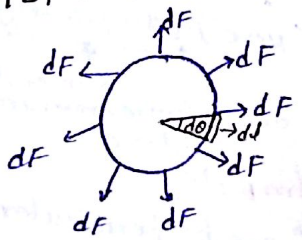


*Total force acting on loop is zero.

NOTE→ *If loop is made up of flexible material. It will streached & become circular having centre at centre of mass (C.M).

* If direction of current or, magnetic field is Reversed it will contract & will come to its center of mass.

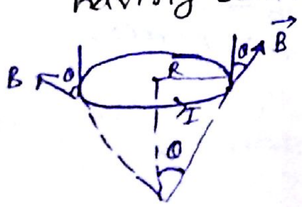
*** |b|→ Tension in loop in uniform $\vec{B}$ext.



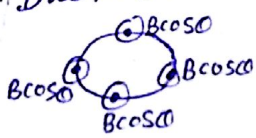
$$2T\sin\left(\frac{d\theta}{2}\right) = dF = IdlB$$

$$T = IBR$$

*** |c|→ Force Acting on a circular loop If $\vec{B}$ext is Radially outward having centre on its Axis.

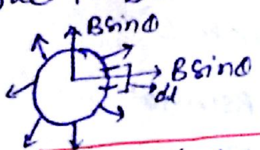


*Due to Bcosθ



$$F = 0$$

*Due to Bsinθ



$$dF = I(dl)B\sin\theta$$
$$F = I(2\pi R)B\sin\theta$$

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$$T = \frac{IBL}{2\pi}$$

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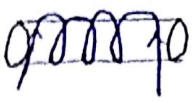
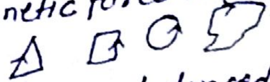
(i) → When current is passed b/w spring then attraction b/w consecutive turns spring contract.

(ii) → When current is passed in spring then it contract but its circular turns have tendency to Expand.

In solenoid When current is passed then contract.



*** # In Uniform Magnetic field net Magnetic force on current carrying loop of any shape is always zero.



$l_{eff} = 0, \; F_m = 0$

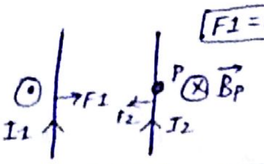
current in wire so that wire is just balanced on Incline plane.

$$I = \frac{Mg}{lB} \tan\theta$$

* In uniform field force is zero.
* In non-uniform field force may be zero or, non zero.

Force of attraction/Repulsion b/w two parallel current carrying wire

$F_1 = F_2$



Magnetic field at 'P' due to wire (i)

$$\vec{B}_P = \frac{\mu_0 I_1}{2\pi d} \otimes$$

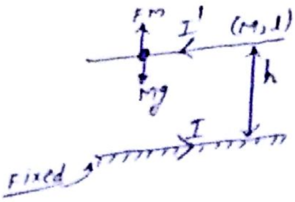
$F_1 = I_2 B_P L$

$$\frac{F_1}{L} = \frac{\mu_0 I_1 I_2}{2\pi d}$$ ← Force per unit length of Each wire.

If $d = 1\,m$, $I_1 = I_2 = 1\,Amp$, $\frac{F_1}{L} = 2 \times 10^{-7} N$

NOTE →
* Same direction current attraction.
* opposite direction current Repulsion.
* Two ∥ long wire connected in ckt one in series then Repulsion & once in parallel grafting then attraction occur.

(i) → Find (I') so that wire Remain stationary at height (h)?



At Balance $F_m = Mg$

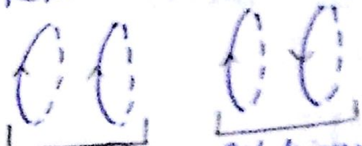
$$\left(\frac{\mu_0 I I_2}{2\pi h}\right) = Mg$$

$$I' = Mg\left(\frac{2\pi h}{\mu_0 I_2 l}\right) = \frac{2\pi Mgh}{\mu_0 I_2 l}$$

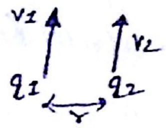
(ii) → Find this is stable or, unstable equilibrium.
When upper upper wire displaced then its comes back at its eqm position it means it is stable eqm.

NOTE →
* If 'h' is less than (h), Mg = same → Fm (+) b/c distance (↓) so move upward.
* If 'h' is More than (h), Mg = ↑ ⇒ Fm same so wire move downward.

* Due to attraction or, Repulsion b/w two ∥ wire there is attractive or, Repulsive.



Force b/w charge particle moving on || path.



Electric force

$F_e = \frac{1}{4\pi\epsilon_0} \cdot \frac{q_1 q_2}{r^2}$ (attraction/Repulsion)

Magnetic force

$F_M = \frac{\mu_0}{4\pi} \frac{q_1 q_2}{r^2}$ (attraction/Repulsion)

$M = qv = I\delta l$

↓ Magnetic Pole ↓ current carrying mag. force.

$$F_m = \frac{\mu_0}{4\pi} \cdot \frac{M_1 M_2}{r^2} = \frac{\mu_0}{4\pi} \cdot \frac{q_1 q_2}{r^2}$$

$\Rightarrow \frac{F_e}{F_m} = \frac{1}{\mu_0\epsilon_0} \cdot \frac{1}{v_1 v_2} = \frac{c^2}{v_1 v_2}$

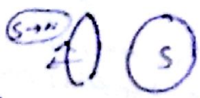
$$c = \frac{1}{\sqrt{\mu_0\epsilon_0}}$$

$F_e >>> F_m$

* Two proton moving on || path in same direction →
  * $F_e \neq 0$ (Repulsion)
  * $F_m \neq 0$ (attraction)
  * $F_{net} \neq 0$ (Repulsion) → b/c $F_e >> F_m$

Magnetic behavior of current carrying coil.

→ current carrying coil is like magnetic dipole so magnetic pole are developed at its faces.



→ If current is clockwise ⇒ 'S' pole

→ If current is Anticlockwise ⇒ 'N' pole

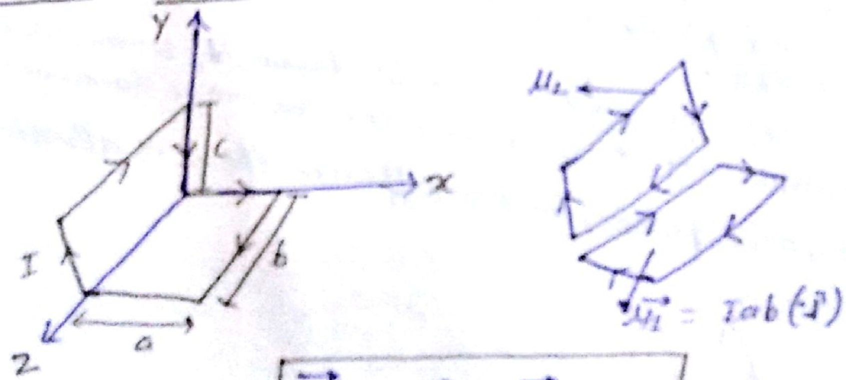
Magnetic Moment (μ/M)

$M = NIA$, $\vec{M} = NI\vec{A}$ ($\vec{A}$ = Area enclosed by coil) (direction $\parallel \vec{B}$)

vector ($\vec{B} \parallel \vec{A} \parallel \vec{M}$)

* unit → $A \times m^2$

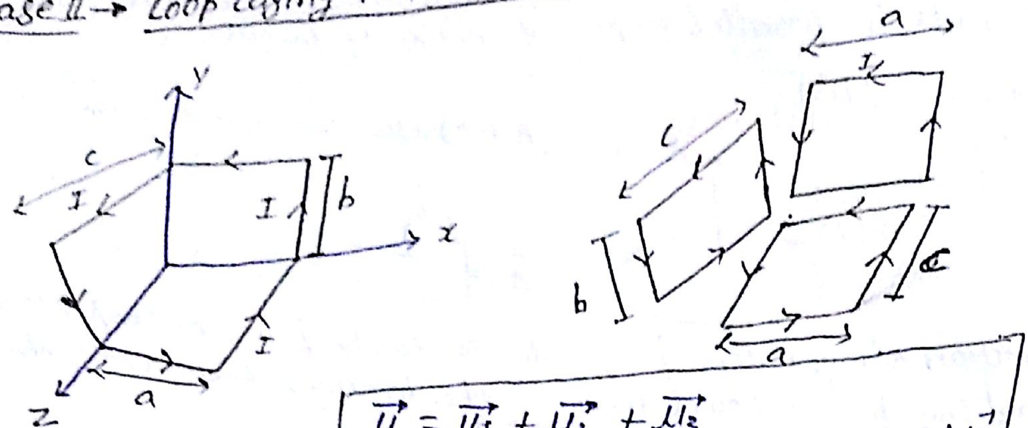
Case I → Loop laying in two perpendicular planes.



$\vec{\mu_1} = Iab(-\hat{j})$

$$\vec{\mu}_{res} = \vec{\mu}_1 + \vec{\mu}_2 = Ib(-c\hat{i} - a\hat{j})$$

case II → Loop laying in three different planes



$\vec{\mu} = \vec{\mu_1} + \vec{\mu_2} + \vec{\mu_3}$
$= I(bc)\vec{i} + I(ac)\vec{j} + I(ab)\vec{k}$

NOTE → * By using a fix length of wire diffrent shape coil are made & current in them, then max Moment for circle. (Area = max).

* For two circular coil M1/M2 is if.
 (i) → Same current & same Radius & turns are N1 & N2.

$\frac{M_1}{M_2} = \frac{N_1}{N_2}$

 (ii) → If circular coil of N1 turn to N2 turns & current Remain same.

$N \propto \frac{1}{R}$ $\frac{M_1}{M_2} = \frac{N_2}{N_1}$

 (iii) → If coil of R1 Radius converted into R2 Radius & current same.

$\frac{M_1}{M_2} = \frac{R_1}{R_2}$

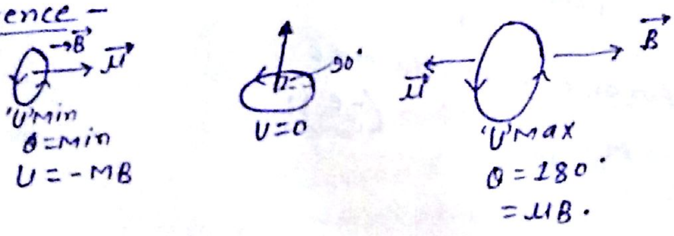
 (iv) → $\frac{M_1}{M_2} = \left(\frac{R_1}{R_2}\right)^2$

Torque acting on current carrying loop in uniform $\vec{B}_{ext}$.

*
$\tau = IAB\sin\theta$
$\vec{\tau} = \vec{\mu} \times \vec{B}$

NOTE → * Above expression of torque is applicable for all kinds of loop of any shape or size.
* Magnetic field should be uniform.
* If loop is made up of 'n' turns then
 * $\tau_{net} = nIA\sin\theta$
* Potential energy (PE) → $PE = -\vec{\mu}\cdot\vec{B}$ (μ is taken at $\theta = 90°$)

Reference –

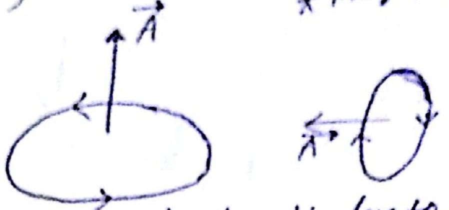


* The loop will rotate about an axis, falling through its center of mass & the axis will be parallel to the direction of torque.

* Magnetic Moment ($\vec{\mu}$)

$$\boxed{\vec{\mu} = I\vec{A}}$$

* Magnetic Moment ∝ quantum no.



$\vec{A}$ ⇒ direction Along a line perpendicular to the plane of loop A/c to Right hand Thumb Rule (curl finger in the direction of current & thumb will give direction of Area ($\vec{A}$) or, $\vec{\mu}$.)

* current carrying close loop placed in Ext. uniform mag. field then force = 0 ($F_{net} = 0$)

* $W_{\theta_1 - \theta_2} = MB(\cos\theta_1 - \cos\theta_2)$
$= NIAB[\cos\theta_1 - \cos\theta_2]$

Magnetic behavior of circulating charge

(i) → current (I)

$$\boxed{I = \frac{dq}{dt} = \frac{q}{T} = qf = \frac{q\omega}{2\pi} = \frac{qv}{2\pi r}}$$

Ex → In Ist H-atom find current.

$I = \frac{ev}{2\pi r} = \frac{1.6\times10^{-19} \times 2.18\times10^{6}}{2\pi \times 0.529\times10^{-10}} = I = 0.96\ mA = 1\ mA$

(ii) → Bcentre

$$\boxed{B_{centre} = \frac{\mu_0 I}{2r} = \frac{\mu_0 qf}{2r} = \frac{\mu_0 q\omega}{4\pi r}}$$

Ex – In Ist orbit of H-atom

$B_{centre} = \frac{\mu_0 ev}{4\pi r^2} = 12.5\,T$

(iii) → Magnetic Moment (M)

$$\boxed{M = I(\pi r^2) \quad \frac{q\omega r^2}{2} = \frac{qvr}{2}}$$

Ex → In Ist orbit of H-atom

$M = \frac{evr}{2} = 0.923\times10^{-23}$ $\boxed{= 1\,\mu_B}$

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(iv) → Relation b/w Magnetic Moment (M) & Angular Momentum (L)

$$\boxed{M = \left(\frac{q}{2M}\right)L \qquad \vec{M} = \left(\frac{q}{2m}\right)\vec{L}}$$ *

(3e) Ex → For an e^- Ration b/w M & L

$M = \frac{eL}{2M}$, $\vec{M} = \left(\frac{-e}{2M}\right)L$

Moving coil Galvenometer

* Based on magnetic effect of current.
If deflection is ϕ for I current.

$\tau_{deflecting} = \tau_{restoring}$ $[NIAB = K\phi]$

$\boxed{\phi = \left[\frac{NAB}{K}\right] I}$

K ⇒ Restoring torque for unit deflection (It depend on material of suspension wire).

* $\boxed{\phi \propto I}$ (Linear Relation)

* $\boxed{C_S = \frac{\phi}{I} = \frac{NAB}{K}}$

For (↑) cs k should be Reduced.

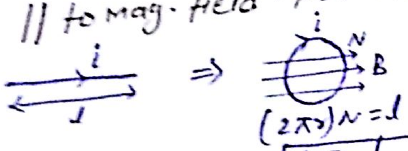
*Phosphate Bronze
*Fibre wire] → Best low 'K' so it is used.

* concave magnet produced radial magnetic field so $\vec{A}\cdot\vec{B}_{ext}$ is always ⊥ so $\phi \propto I$.

Properties of Magnetic field Lines

* unlike electric field lines, they always exist in the form of close loop.
* Tangent at any point gives direction of Magnetic field.
* Their relative density gives quantitatives idea about Magnitude of magnetic field.
* Magnetic flux through a close surface will always be zero.

A wire of length (l) carrying current (i) bent into circular form having 'N' turns & kept || to mag. field. For What value of 'N' torque on the loop is max.



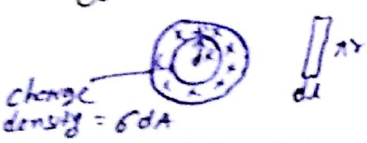
$(2\pi r)N = l$

$\boxed{r = \frac{l}{2\pi N}}$

$\boxed{\tau_{max} \propto \frac{1}{N_{min}}}$

$\boxed{\text{For } \tau_{max},\ N = 1}$

A disck of Radius (R) uniface charge density (σ) is Rotating ω angular velocity 'ω' about its own axis. Find its Mag. moment.



$\boxed{B = \frac{\mu_0 \sigma \omega R}{2}}$ *