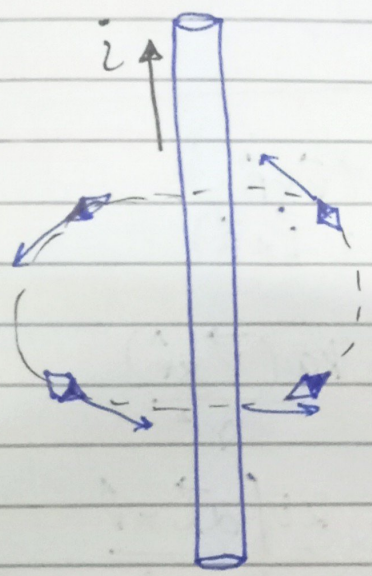
Electromagnetism

Due to moving charge.

The magnetic field and magnetic interaction established due to moving charge.

The magnetic field of current:



Right hand Rule : 2

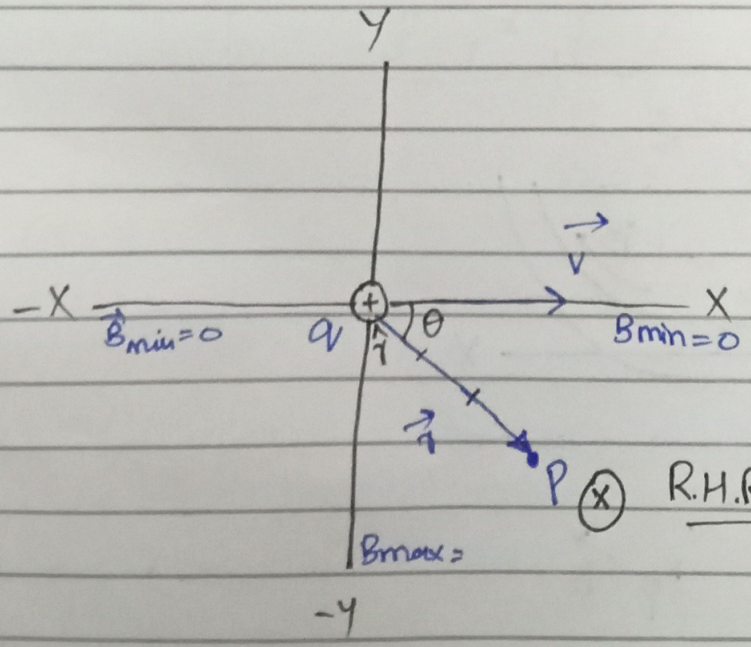
For two values

straight – ~~Finger~~, Thumb

curl → finger

$\vec{B} \rightarrow q, \vec{v}$

Moving charge produces magnetic field and moving charge detect magnetic field.



Distance from center of charge to field point is 'r'

R.H.Rule

$B \propto q$

$B \propto v$

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

$B \propto \sin\theta$

$B \propto \frac{qv\sin\theta}{r^2}$

$B = kqv\sin\theta$

$k = 10^{-7}\ Tm/A$

$K = \frac{\mu_0}{4\pi}$

$C = \frac{1}{\sqrt{\mu_0 \varepsilon_0}}$

$C = 3\times10^{8}\ ms^{-1}$

k = magnetic constant

μ_0 = magnetic Behaviour

In vector form.

$$B = \frac{kq(v\sin\theta)}{r^2}\frac{\vec{r}}{r} = \frac{kq(v\sin\theta)\vec{r}}{r^3}$$

$$B = \frac{kq}{r^2}(\vec{v}\times\hat{r})$$

$$= \frac{kq(\vec{v}\times\vec{r})}{r^3}$$

$$\vec{v}\times\hat{r} = v(1)\sin\theta = v\sin\theta$$

Magnetic field of current:

① $\vec{F} = q(\vec{v}\times\vec{B})$

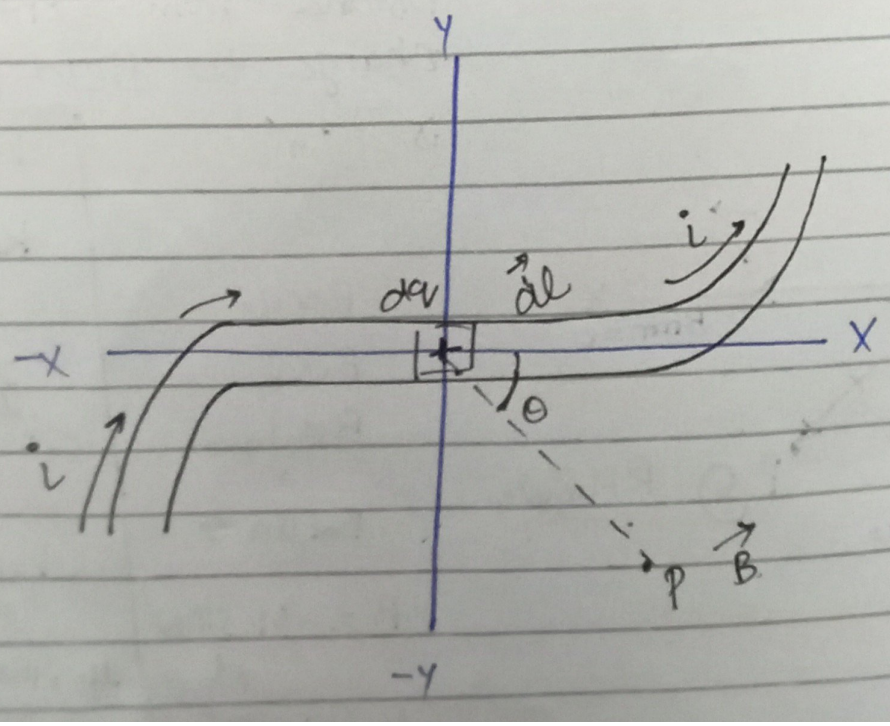
② $\vec{F} = i(\vec{l}\times\vec{B})$

③ $\vec{B} = \frac{kq(\vec{v}\times\hat{r})}{r^2}$

④ $\vec{B} = ki\int\frac{d\vec{l}\times\hat{r}}{r^2}$

$$\vec{B} = \frac{kq(\vec{v}\times\hat{r})}{r^2}$$ (single charge)

$$d\vec{B} = \frac{k\,dq(\vec{v}\times\hat{r})}{r^2}$$ (for single patch)



$$dq = i\,dt$$

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

$$d\vec{B} = \frac{kq(\vec{v} \times \hat{r})}{r^2}$$

$$d\vec{B} = k\,i\,dt\,\frac{d\vec{l} \times \hat{r}}{dt\,r^2}$$

$$\frac{d}{dt}(t) = 1$$

$$d\vec{B} = ki\int \frac{d\vec{l} \times \hat{r}}{r^2}$$

$$\boxed{\cancel{\vec{B} = ki}}$$

$$\boxed{B = ki\int \frac{d\vec{l} \times \hat{r}}{r^2}}$$

Biot-Savart Law: Single charge + current.

* only valid for moving point charges.
* Can't be applied to direct object

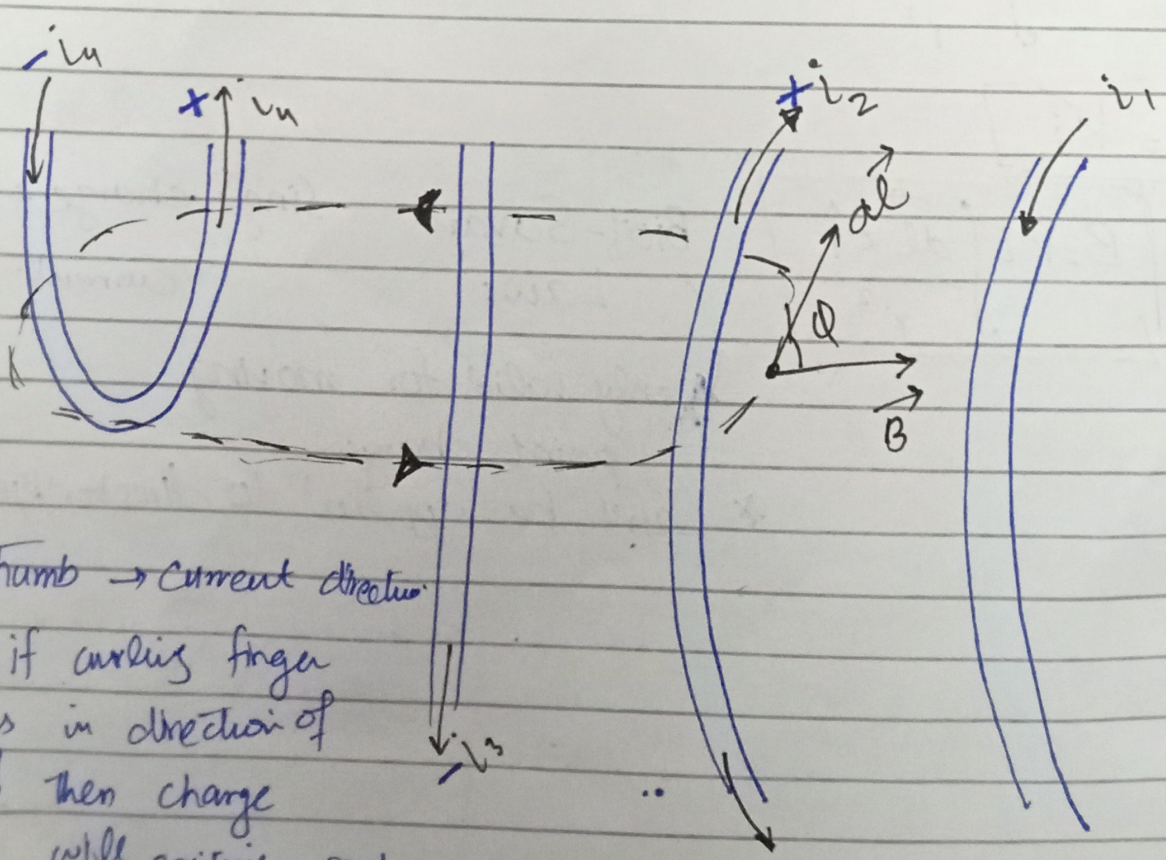
Ampere's Law:

$$\oint_{l} \vec{B}\cdot d\vec{l} = \mu_0 i_{enclosed}$$

$\vec{B}$ → magnetic field on amperian loop.

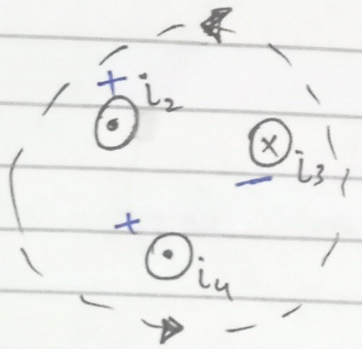
$d\vec{l}$ → length of amperian loop.

The closed line integral of dot product of magnetic field and length is equal to μ_0 times the current enclosed by amperian loop.
The direction of $d\vec{l}$ is arbitrary
it can be clockwise or anticlockwise



Thumb → current direction
if curling finger is in direction of $\vec{B}$ then charge will positive and vice versa

Right hand Rule 3



Thumb — direction of current (conventional)

If curling fingers are in direction of $\vec{B}$ Then charge is positive and vice versa.

amperian loop

For fig 1 $\oint_l B\,dl\cos\phi = \mu_0 (i_2 - i_3 + i_4 - i_4)$

For fig 2 $\oint_l B\,dl\cos\phi = \mu_0 (i_2 - i_3 + i_4)$

30-5-24

Applications

$$\oint_l \vec{B}\cdot\vec{dl} = \mu_0 i_{enclosed} \quad \text{— (A)}$$

With the help of Amperel's law we can find

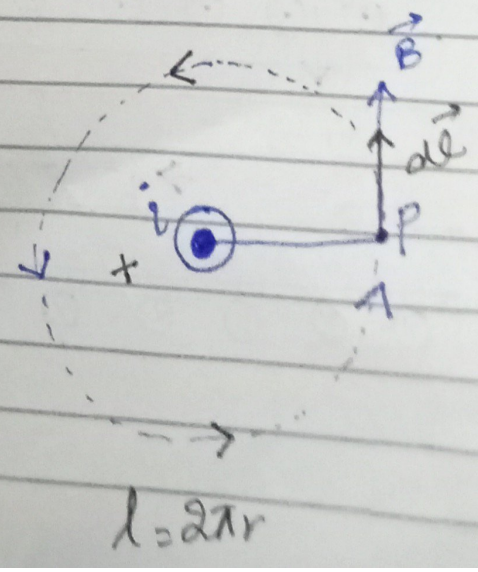
A long straight wire :-

$$\oint_l B\,dl\cos 0^\circ = \mu_0 (+i)$$

$$B\oint_l dl = \mu_0 i$$

$$B(2\pi r) = \mu_0 i$$

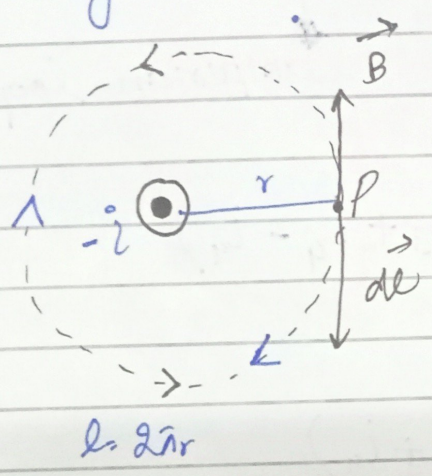
$$B = \frac{\mu_0 i}{2\pi r} \Rightarrow B \propto \frac{1}{r}$$



Biot-Savart law

$$\vec{B} = \frac{\mu_0 i}{4\pi} \int \frac{d\vec{l} \times \hat{r}}{r^2}$$

Q. Prove that the direction of Amperean loop is arbitrary.



$$\oint_l B\,dl\cos 180^\circ = \mu_0(-i)$$

$$\cancel{-}B\oint_l dl = \cancel{-}\mu_0 i$$

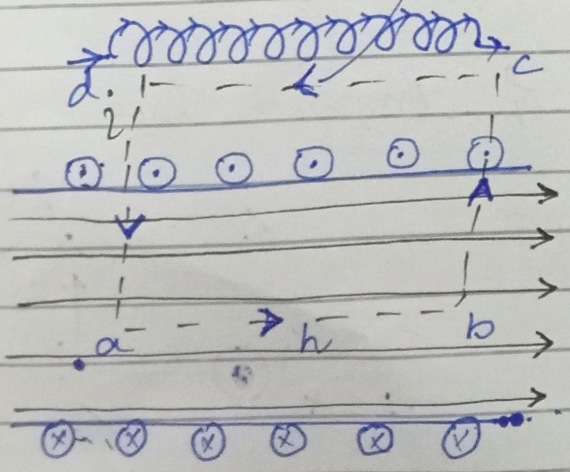
$$B(2\pi r) = \mu_0 i$$

$$B = \frac{\mu_0 i}{2\pi r} \Rightarrow B \propto \frac{1}{r}$$

Solenoid: (internal points)

$\vec{B}_{ext} \cong$ Negligible

No angle, No field.



$$\oint_l \vec{B}\cdot d\vec{l} = \mu_0 i_{enc}$$

$$\vec{B} = \int_a^b B\,dl_1\cos 0^\circ + \int_b^c B\,dl_2\cos 90^\circ + \int_c^d B_{ext}\cdot dl_3\cos\theta + \int_d^a B\,dl_4\cos 90^\circ = \mu_0 i_{enc}$$

$$B\int_a^b dl_1 \cos 0^\circ = \mu_0 i_{enc}$$

$$B\int_a^b dl_1 = \mu_0 i_{enc}$$

$$B\cancel{h} = \mu_0 (i n \cancel{h}) \Rightarrow \boxed{B = \mu_0 n i}$$

No. of Turns enclosed by Amperian loop $= N = nh$

No density $: \frac{N}{h} = n$

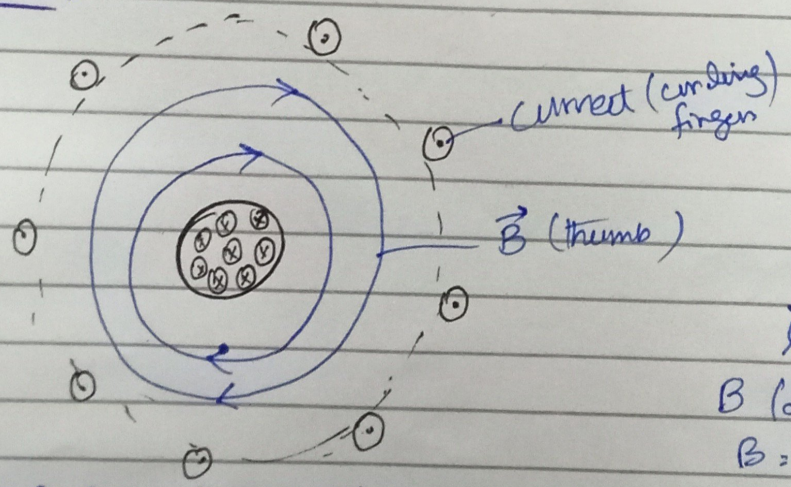
$N = nh$

Current enclosed $= iN$

$= inh$

Non-uniform field not present in solenoid.

Toroid:



$\theta = 0^\circ$ for all patches.

$$\oint_l B\,dl \cos 0^\circ = \mu_0 (Ni)$$

$$B(2\pi r) = \mu_0 N i$$

$$B = \mu_0 i \left(\frac{N}{2\pi r}\right)$$

$$B = \mu_0 i n.$$