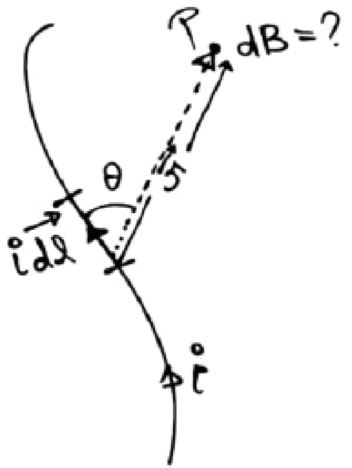
Magnetic effect of Current

Biot & Savart :-

↳ magnetic field due to small current-carrying element $i\vec{dl}$ at distance r.



$\theta \rightarrow$ angle b/w $i\vec{dl}$ & $\vec{r}$.

$$dB \propto i\,dl \quad \text{—(i)}$$

$$dB \propto \sin\theta \quad \text{—(ii)}$$

$$dB \propto \frac{1}{r^2} \quad \text{—(iii)}$$

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

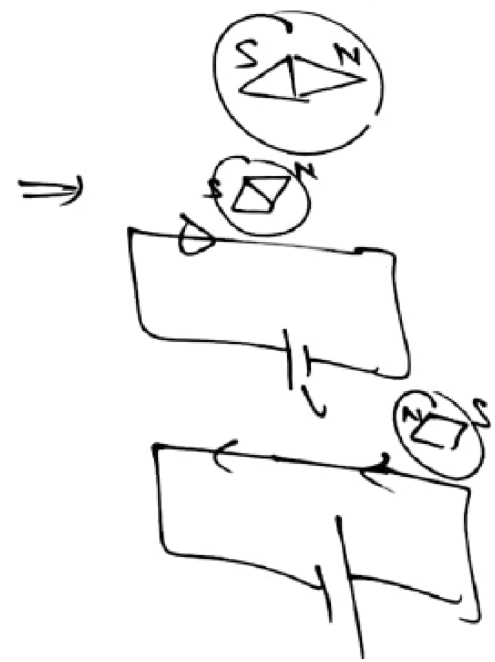
$$\boxed{dB = \frac{\mu_0}{4\pi}\frac{i\,dl\sin\theta}{r^2}}$$

Oersted experiment

1820

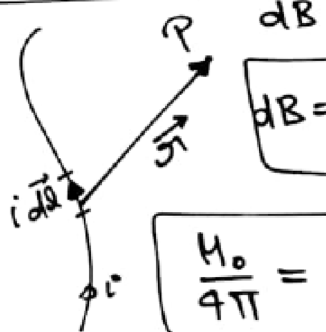
↳ Current carrying wire produce magnetic field.

Magnetic Compass :-



Magnetic effect of Current

Biot - Savart Law:-



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

$$\frac{\mu_0}{4\pi} = 10^{-7}\ \frac{T\text{-}m}{Amp}$$

SI Unit of magnetic field = Tesla = T

C.G.S Unit of magnetic field

Gauss $1G = 10^{-4}\,T$

⇒ dir^n of magnetic field due to current carrying wire:-

↳ Vector form of magnetic field due to current carrying wire.

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

↳ In form of Scalar

$$dB = \frac{\mu_0}{4\pi}\frac{i\,dl\times r\times\sin\theta}{r^3} = \frac{\mu_0 i}{4\pi}\frac{dl\sin\theta}{r^2}$$

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

$$dB = \frac{\mu_0}{4\pi}\frac{i\,dl\cdot r\sin\theta}{r^3} = \frac{\mu_0}{4\pi}\frac{i\,\vec{dl}\times\vec{r}}{r^3}$$

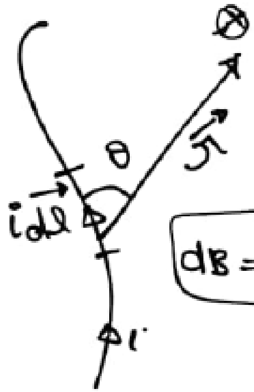
$$\vec{dB} = \frac{\mu_0 i}{4\pi}\frac{\vec{dl}\times\vec{r}}{r^3}$$

Magnetic effect of Current

magnetic field is a vector quantity

↳ magnetic field due to current-carrying wire.

↳ How to find dirn of magnetic field due to current carrying wire



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

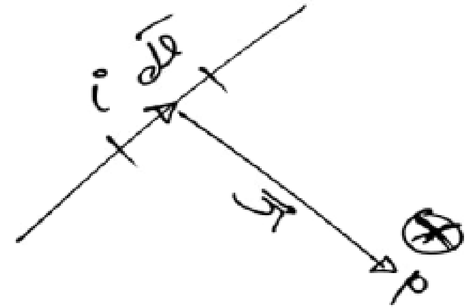
$$dB = \frac{\mu_0}{4\pi}\frac{i\,dl\sin\theta}{r^2}$$

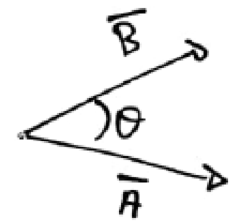
$$\vec{dB} \perp \vec{r}$$

$$\vec{dB} \perp \vec{dl}$$

(i) Use Right hand rule.

$$\hat{dB} = \hat{dl} \times \hat{r}$$



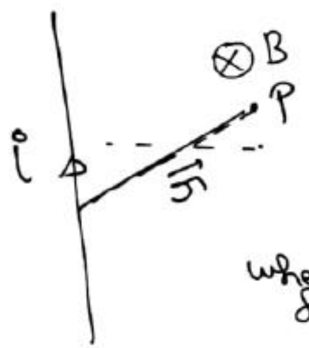


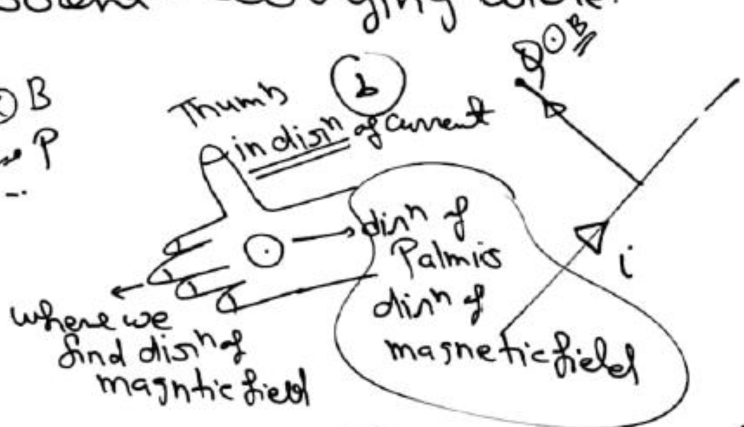
$$\vec{C} = \vec{A} \times \vec{B}$$

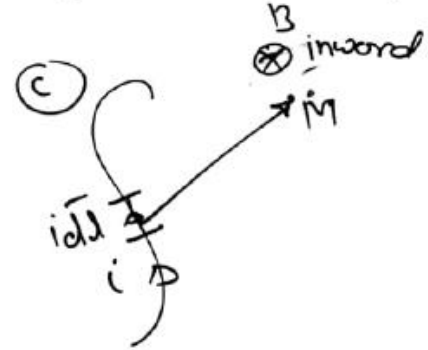
Magnetic effect of Current

⇒ **Right-hand palm rule-:** to find dirn of magnetic field due to current-carrying wire.

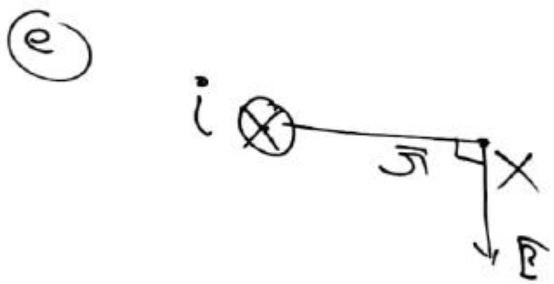
(a)

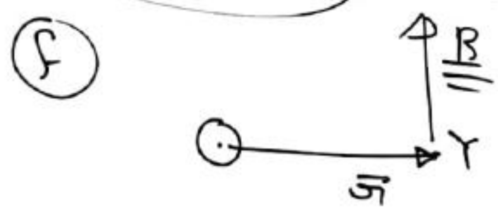






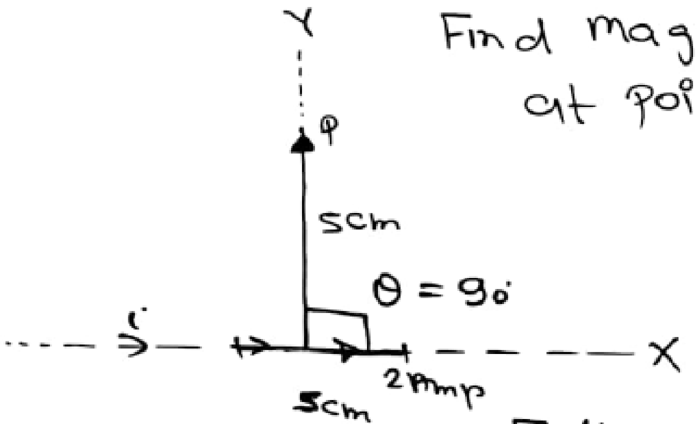
⇒ Right Rand Palm rule.





Magnetic effect of Current

Q2) Find magnetic field due to wire element (5 cm) at point P is.



$\vec{B} = 4\times10^{-6}\,T\,(\hat{k})$

$r = 5\,cm$

$r = 5\times10^{-2}\,m$

$|d\vec{l}| = 5\,cm$

$|dl| = 5\times10^{-2}\,m$

$\odot\ (+\hat{k})$

$\otimes\ (-\hat{k})$

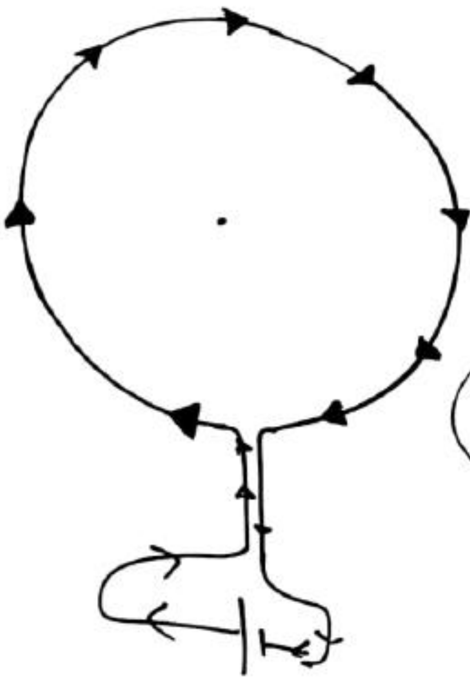
$$dB = \frac{\mu_0}{4\pi}\frac{i\,dl\sin\theta}{r^2} \qquad \left[\frac{\mu_0}{4\pi} = 10^{-7}\,\frac{T\text{-}m}{A}\right]$$

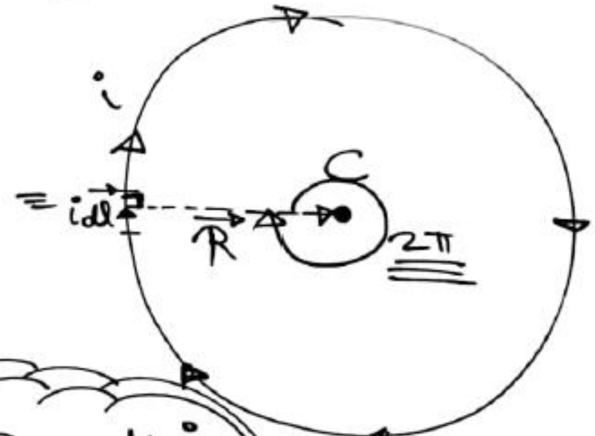
$$= 10^{-7}\,\frac{2\times5\times10^{-2}\times\sin 90}{(5\times10^{-2})^2}$$

$$= \frac{2\times10^{-7}}{5\times10^{-2}} = \frac{2\times10^{-7}\times10^{+2}}{5} = \frac{2\times10^{-5}}{5} = \frac{20\times10^{-6}}{5} = 4\times10^{-6}\,T$$

Magnetic effect of current

Magnetic field due to circular current carrying loop :- at its centre :-





$$B_C = \frac{\mu_0 i}{2R}$$

Magnetic field due to small element idl at its centre.

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

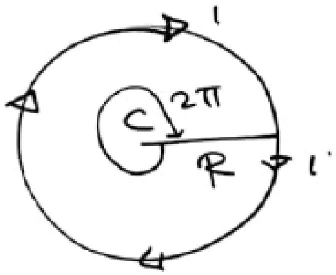
$$\int dB = \frac{\mu_0}{4\pi}\int \frac{i\,dl}{R^2}$$

$$B = \frac{\mu_0 i}{4\pi R^2}\int dl$$

$$= \frac{\mu_0 i}{4\pi R^2} \times 2\pi R = \boxed{\frac{\mu_0 i}{2R}}$$

Magnetic effect of current

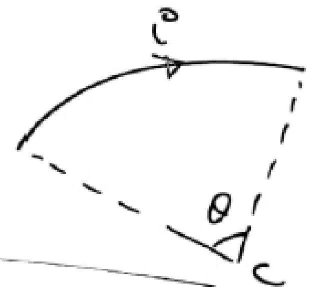
Magnetic field due to circular current carrying wire at its centre.



$$B_c = \frac{\mu_0 i}{2R}$$

$$B_c = \frac{\mu_0 i}{4\pi R}(2\pi)$$

⇒ Magnetic field due to circular current carrying arc at its centre

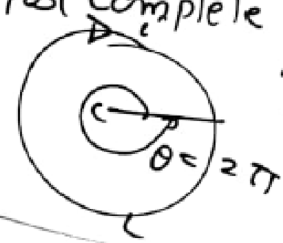


$$B_c = \frac{\mu_0 i}{4\pi R}(\theta)$$

θ → ~~Magh~~ Angle made by arc at centre

$$B_C = \frac{\mu_0 i}{4\pi R}(\theta)$$

(1) For complete circle



$$B_c = \frac{\mu_0 i}{4\pi R}(2\pi) = \frac{\mu_0 i}{2R}$$