Chapter-4

Moving Charges And Magnetism

Q.1 What do you meant by magnetic effect (B) of current?

Q.2 What is right hand Palm rule?

Q.3. write maxwell right hand screw rule?

Q.4 write Fleming right hand grip rule.

Q.5 Explain the Biot - savart's law.

Ans. 1) Electric current move in conductor the magnetic field is generated, the creation of magnetism due to Electric current is known as magnetic effect of current.

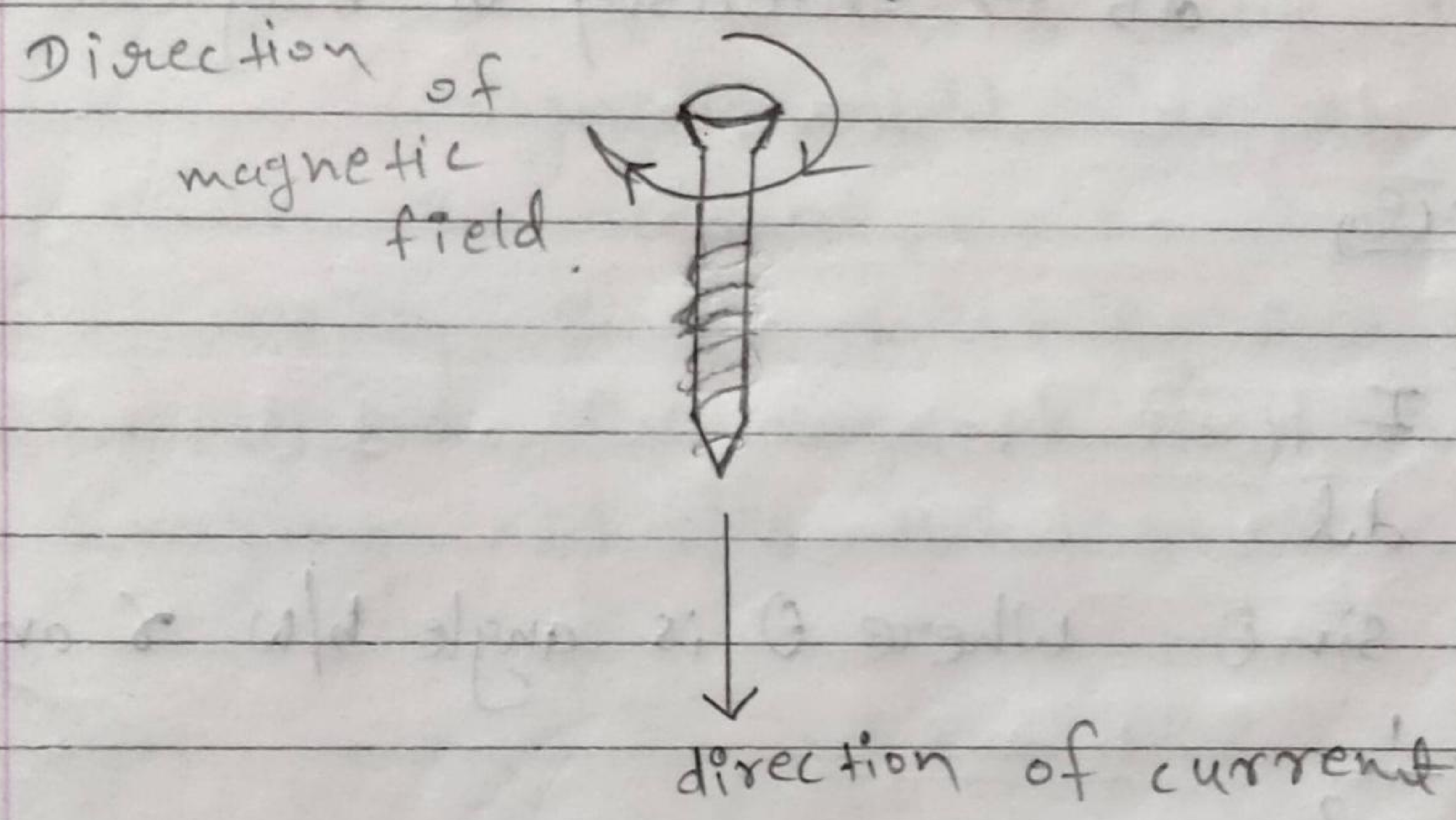
Ans. 4 **Fleming right hand Grip rule:-**

According to the fleming right hand rule, we hold a current carrying conductor then then thumb represent the direction electric current then finger show the direction of magnetic field.

Ans. 2 **Right Hand Palm Rule :-**

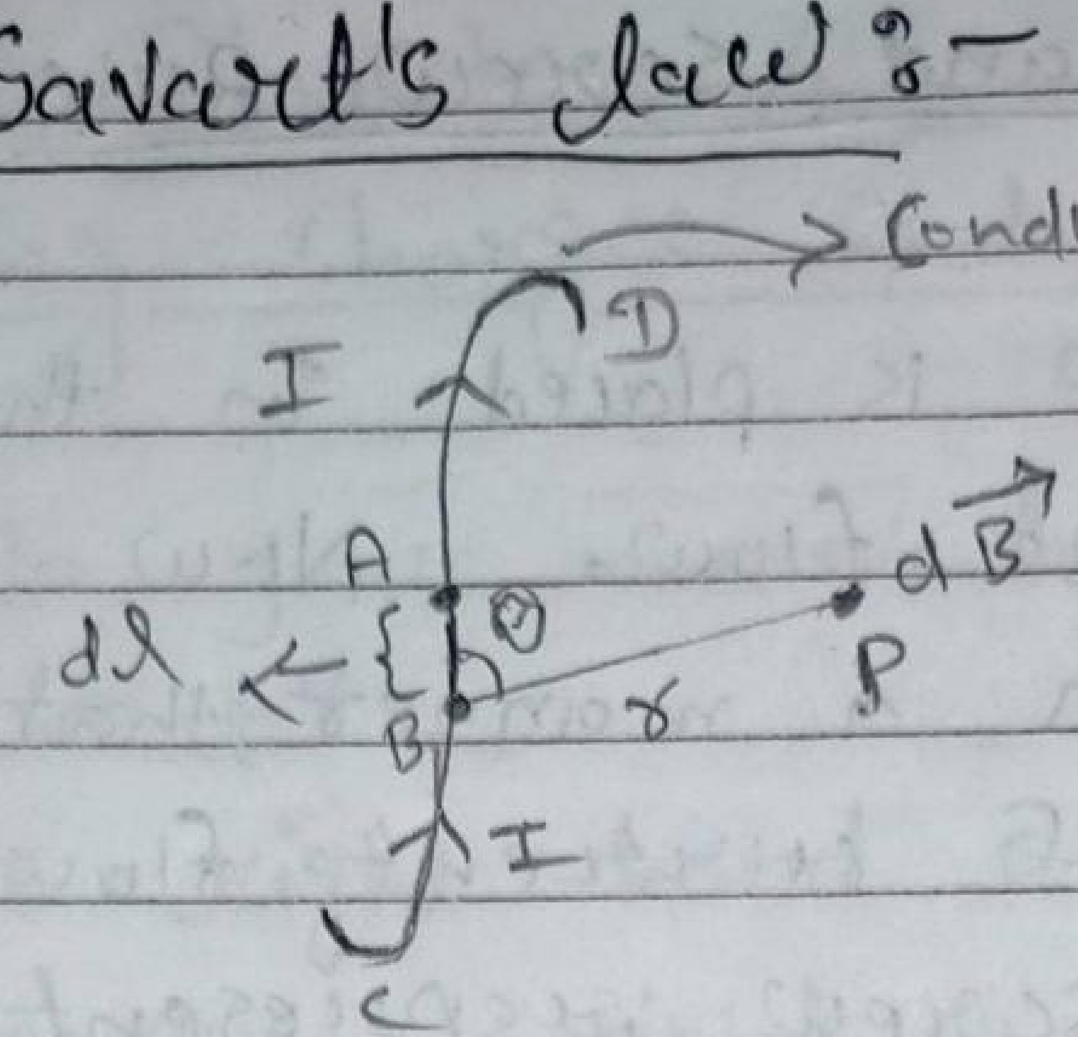
According to the right hand palm rule, ~~to~~ our thumb represent the direction of moving charge or current then our finger represent the direction of magnetism, Ans.3. Maxwell Right hand screw Rule:-

Suppose a screw is placed in the direction of conductor current flow. Now the screw is rotated in such a manner that it moves in the direction of current flowing then rotation of screw represent the direction ~~of~~ of magnetic field.



Q.6. What is lorentz force?

Ans.5 Biot - Savart's law :-



SI unit of magnetic field = Tesla (T)

CGS unit :- Gauss (G)

$\boxed{1\ T = 10^4\ G}$

It is a conductor where,

$d\vec{B} \rightarrow$ Intensity of magnetic field.

Now Here,

$\Rightarrow dB \propto I$

$\Rightarrow dB \propto dl$

$\Rightarrow dB \propto \sin\theta$ where θ is angle b/w r and dl.

$\Rightarrow dB \propto \frac{1}{r^2}$

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

$$\Rightarrow \boxed{dB = \frac{KI\,dl\sin\theta}{r^2}}$$

for C.G.S. system,

$\boxed{K = 1}$

$$\Rightarrow \boxed{dB = \frac{I\,dl\sin\theta}{r^2}}$$

finger

gnetism,

S.I.

for M.K.S. system,

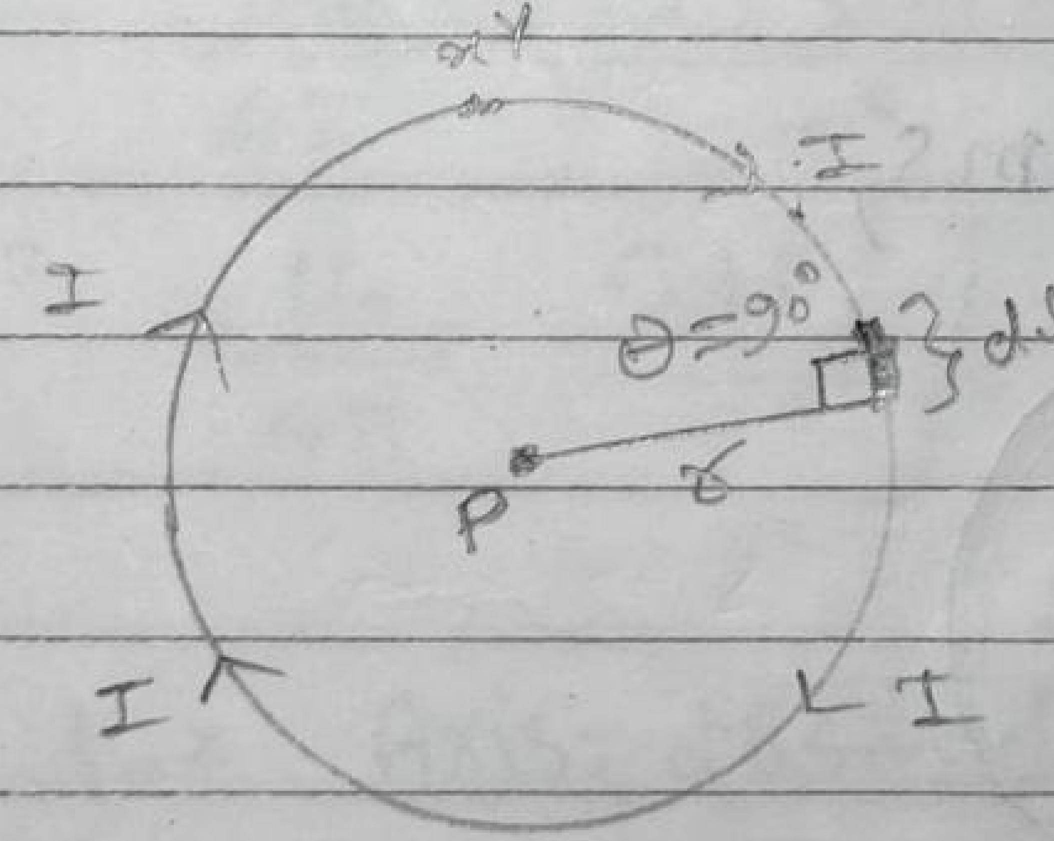
$$\boxed{K = \frac{\mu_0}{4\pi}} , \quad \frac{\mu_0}{4\pi} = 10^{-7} \ N/A^2$$

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

Q.7 By using Biot - Savart's law Derive an expression for Magnetic field due to current carrying coil in the centre.

Q.8. By using Biot - Savart's law Derive an expression for magnetic field due to current carrying coil in the axis.

Ans.7



$$\because \quad dB = \frac{\mu_0}{4\pi} \frac{I dl \sin\theta}{r^2}$$

$$\Rightarrow \quad dB = \frac{\mu_0}{4\pi} \frac{I dl \sin 90^\circ}{r^2}$$

$$\Rightarrow \boxed{dB = \frac{\mu_0}{4\pi} \frac{I dl}{r^2}}$$

Then total magnetic field,

$$\Rightarrow \int dB = \oint \frac{\mu_0}{4\pi} \frac{I\,dl}{r^2}$$

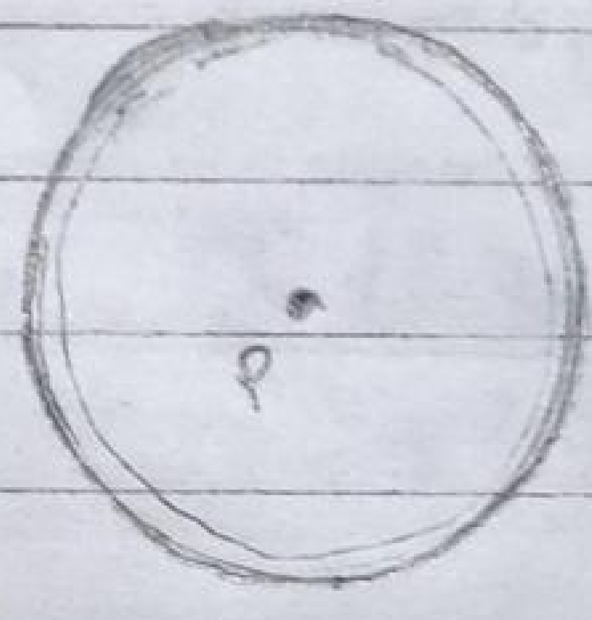
$$\Rightarrow B = \frac{\mu_0}{4\pi} \frac{I}{r^2} \int dl$$

$$\Rightarrow B = \frac{\mu_0}{4\pi} \frac{I}{r^2} (2\pi r)$$

$$\Rightarrow B = \frac{\mu_0}{\cancel{4\pi}_{2}} \cdot \frac{I}{r^{\cancel{2}}} \cdot \cancel{2\pi} \cdot \cancel{r}$$

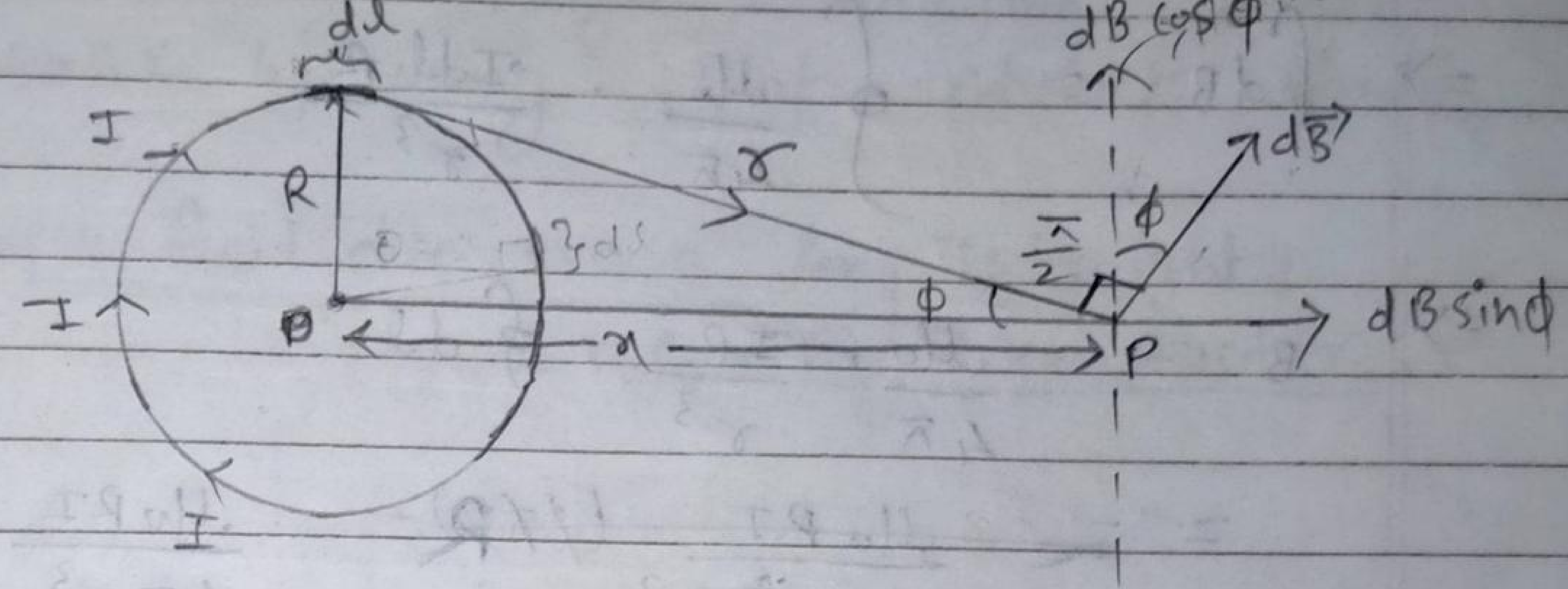
$$\Rightarrow \boxed{B = \frac{\mu_0 I}{2r}}$$ This is for 1 layered coil.

for n no. of terms,



$$\boxed{B = \frac{\mu_0}{4\pi} nI}$$ $$\boxed{B = \frac{\mu_0 nI}{2r}}$$

Ans. 8. Along the axis,



$\sin\phi = \frac{P}{H}$

$\sin\phi = \frac{R}{r}$

Biot - savart's law,

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

$$= \frac{\mu_0}{4\pi} \frac{I dl \sin 90^\circ}{r^2}$$

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

Along the Axis = $dB \sin\phi$

$$\Rightarrow dB = \frac{\mu_0}{4\pi} \cdot \frac{I dl}{r^2} \cdot \sin\phi$$

$$= \frac{\mu_0}{4\pi} \frac{I dl}{r^2} \cdot \frac{R}{r}$$

$$= \frac{\mu_0}{4\pi} \frac{I dl R}{r^3}$$

Total magnetic field,

$$\Rightarrow \int dB = \oint \frac{\mu_0}{4\pi} \cdot \frac{I\,dl\,R}{r^3}$$

$$\Rightarrow B = \frac{\mu_0}{4\pi} \cdot \frac{IR}{r^3} \oint dl$$

$$= \cancel{\frac{\mu_0 RI}{2\,4\pi\,r^3}\,(2\pi R)} \quad \frac{\mu_0 RI}{4\pi r^3} \cdot 2\pi r$$

$$\Rightarrow B = \frac{\mu_0 R^2 I}{2r^3}$$

$$\Rightarrow \because \quad r^2 = R^2 + x^2$$

$$r = (R^2 + x^2)^{1/2}$$

$$\Rightarrow B = \frac{\mu_0 R^2 I}{2\{(R^2+x^2)^{1/2}\}^3}$$

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

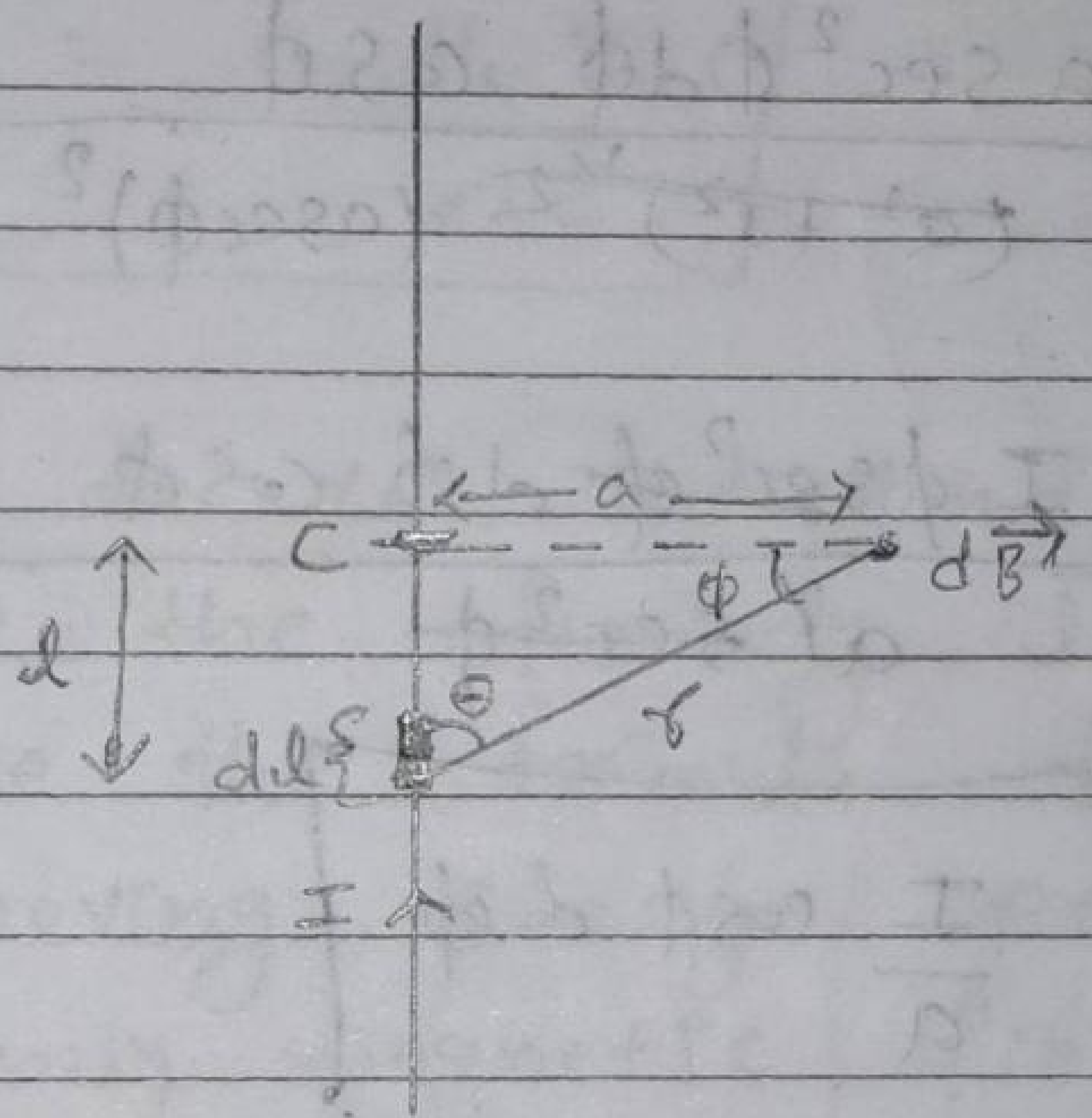
for n terms,

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

Q. 9 Derive an expression for magnetic field due to a long straight carrying current conductor by using Biot - savarts law.

Ans.

Magnetic field due to a long straight carrying conductor :-



$r^2 = a^2 + l^2$

$r = \sqrt{a^2 + l^2}$

$r = (a^2 + l^2)^{1/2}$

In ΔACP,

$\Rightarrow \cos\phi = \dfrac{a}{r}$ and, $r = \dfrac{a}{\cos\phi} \Rightarrow a\sec\phi$

$\Rightarrow \tan\phi = \dfrac{l}{a}$

$\Rightarrow l = a\tan\phi$

D. w. r. to "ϕ"

$\Rightarrow \dfrac{dl}{d\phi} = \dfrac{d}{d\phi}\{a\tan\phi\}$

$\Rightarrow \dfrac{dl}{d\phi} = a\sec^2\phi$

$\Rightarrow \boxed{dl = a\sec^2\phi \cdot d\phi}$

$\because \Rightarrow 90^\circ + \phi + \theta = 180^\circ$

$\boxed{\theta = 90^\circ - \phi}$

Now,

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

$$dB = \frac{\mu_0}{4\pi} \cdot \frac{I \cdot a\sec^2\phi \, d\phi \, \sin(90^\circ - \phi)}{(a^2+l^2)^{1/2}}$$

$$dB = \frac{\mu_0}{4\pi} \frac{I a \sec^2\phi \, d\phi \, \cos\phi}{\cancel{(a^2+l^2)^{1/2}} \, (a\sec\phi)^2}$$

$$= \frac{\mu_0}{4\pi} \frac{I \cancel{a} \cancel{\sec^2\phi} \, d\phi \, \cos\phi}{a^{\cancel{2}} \cancel{\sec^2\phi}}$$

$$\boxed{dB = \frac{\mu_0}{4\pi} \frac{I}{a} \cos\phi \, d\phi}$$

Total magnetic field,

$$\Rightarrow \int dB = \int_{-\phi_1}^{\phi_2} \frac{\mu_0}{4\pi} \frac{I}{a} \cos\phi \, d\phi$$

$$\Rightarrow B = \frac{\mu_0}{4\pi} \frac{I}{a} \int_{-\phi_1}^{\phi_2} \cos\phi \, d\phi$$

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

$$= \frac{\mu_0 I}{4\pi a} \left[\sin\phi_2 - \sin(-\phi_1)\right]$$

$$\boxed{B = \frac{\mu_0 I}{4\pi a} \left[\sin\phi_2 + \sin\phi_1\right]}$$

case :- If $\phi_1 = \phi_2 = \frac{\pi}{2}$.

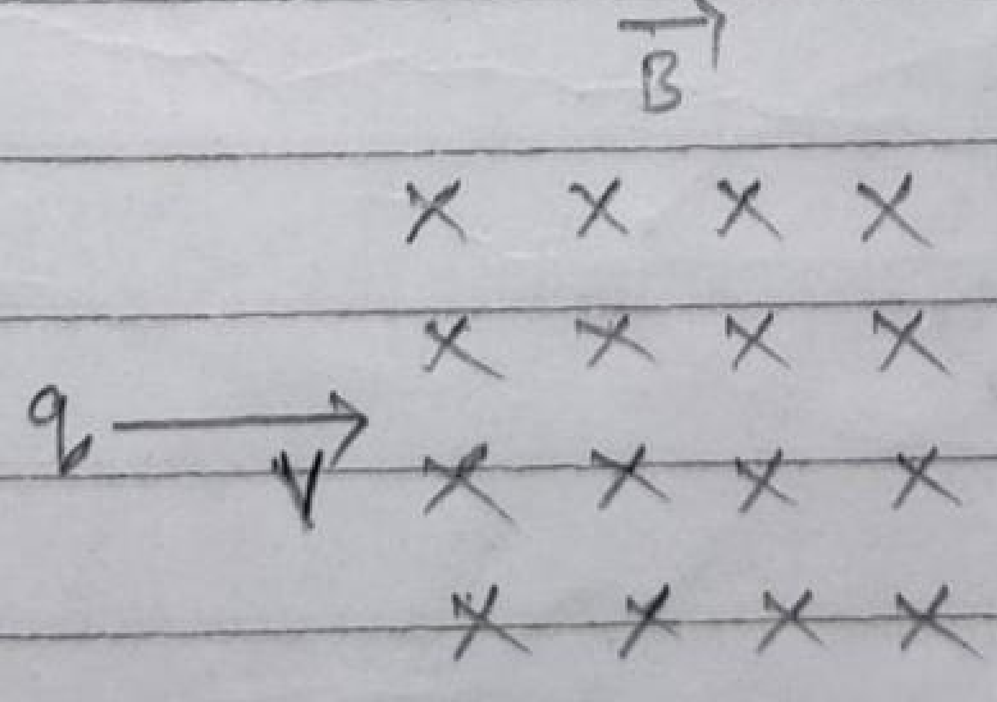
$$B = \frac{\mu_0}{4\pi} \frac{I}{a} \left[\sin\frac{\pi}{2} + \sin\frac{\pi}{2} \right]$$

$$\Rightarrow \quad B = \frac{2\mu_0 I}{4\pi a}$$

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

Q.10 What do you understand by lorentz force?
Q.11 Write the fleming left hand rule.
Q.12 Derive the formula for radius of the path of moving charge perpendicular enter in uniformly magnetic field

Ans. 10) / Ans. 9.) Any moving charge particle is placed in a external magnetic field then the moving charge experience a force that force is called lorentz force.



I represent lorentz force as F,

$F \propto q$	$F \propto \sin\theta$
$F \propto V$	where, $\theta \rightarrow$ Angle b/w.
$F \propto B$	V and B.

$\Rightarrow \quad F \propto qBV\sin\theta$

$\Rightarrow \quad F = KqBV\sin\theta$

According to lorent force in SI system,

$$K = 1,$$

$\Rightarrow \quad F = 1(qBV\sin\theta)$

$\Rightarrow \quad \boxed{F = qBV\sin\theta}$

or

$\Rightarrow F = q(VB\sin\theta)$

$\Rightarrow \boxed{F = q(\vec{V} \times \vec{B})}$

By using Fleming left hand rule we can find the direction of lorentz force.

for maximum lorentz force,

$$\boxed{\theta = 90^\circ}$$

$\Rightarrow \quad F_{max} = qVB\sin 90^\circ$

$\Rightarrow \quad \boxed{F_{max.} = qVB}$

When charged particle enter perpendicularly in external magnetic field then it moves in circular path.

for radius when particle enter external magnetic field perpendicularly :-

centripetal force, $F_c = \frac{mv^2}{r}$.

lorentz force, $F = qvB$.

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

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

Now,

$$\boxed{r \propto v}$$

Q. 13 Explain Ampere circpital law ?

Ans. 13. Ampere Circpital law :- The linear integral of magnetic field in closed surface is equal to product of absolute permiability and flowing current.

Use :- To determine the magnetic field due to current.

Application :-

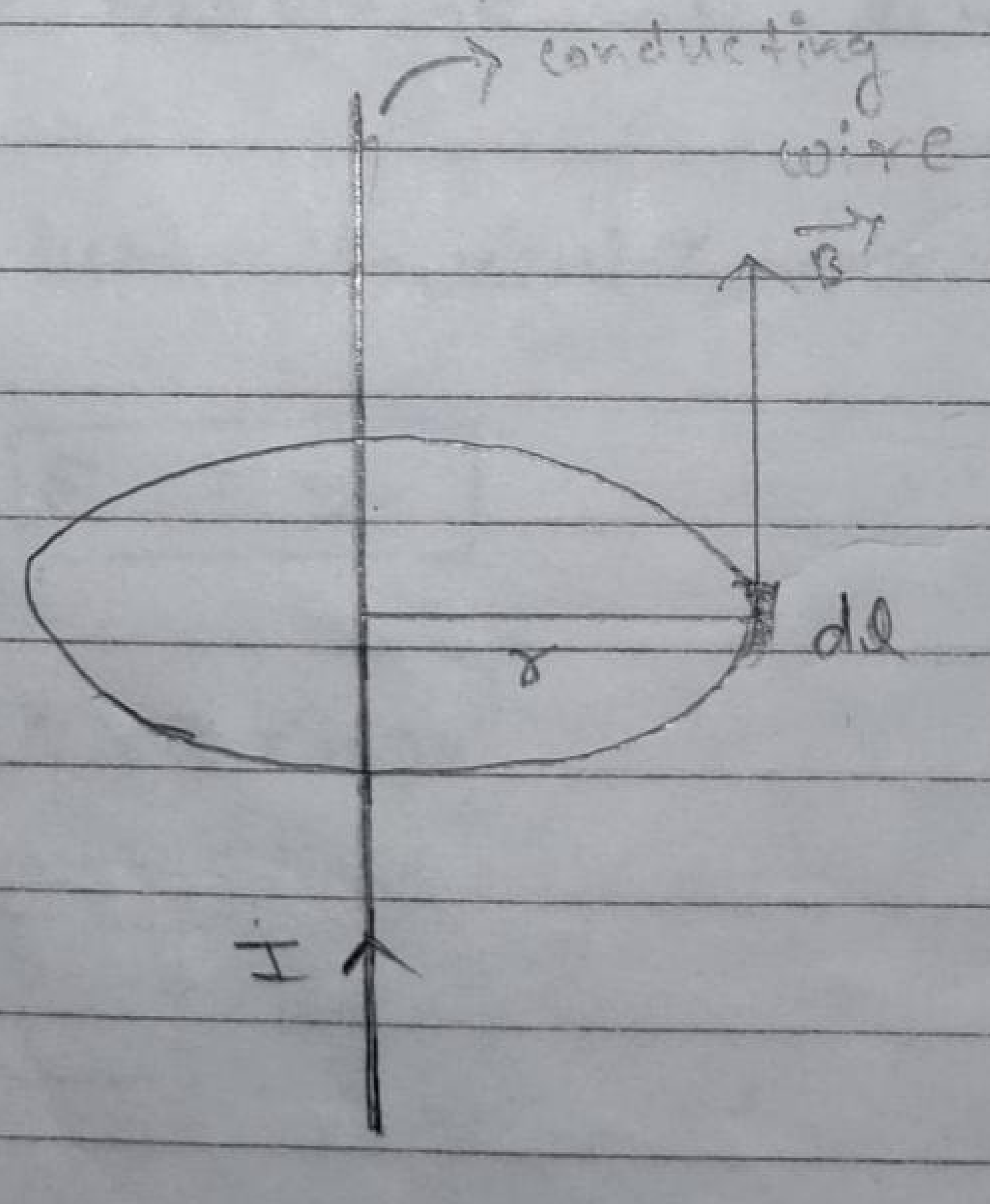
Magnetic field due to -

i) long straight carrying conducting wire

ii) current carrying Solenoid

iii) current carrying Toroid

i) Magnetic field due to long straight carrying conducting wire :-



$$\Rightarrow \oint \vec{B} \cdot \vec{dl} = \mu_0 I$$

$$\Rightarrow \oint B dl \cos\theta = \mu_0 I$$

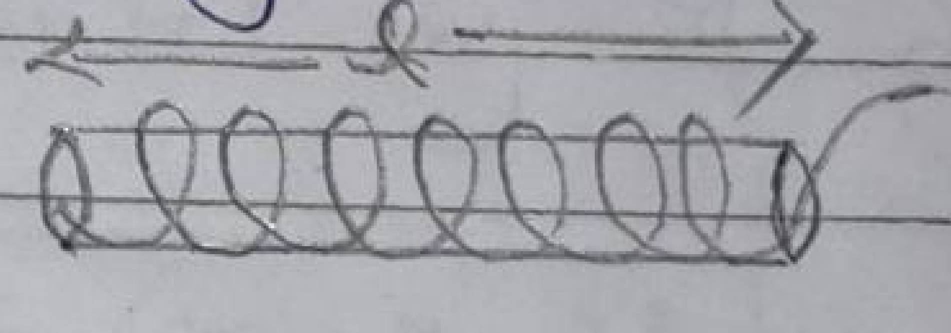
$$\Rightarrow B \oint dl \cos 0^\circ = \mu_0 I$$

$$\Rightarrow B(2\pi r) = \mu_0 I$$

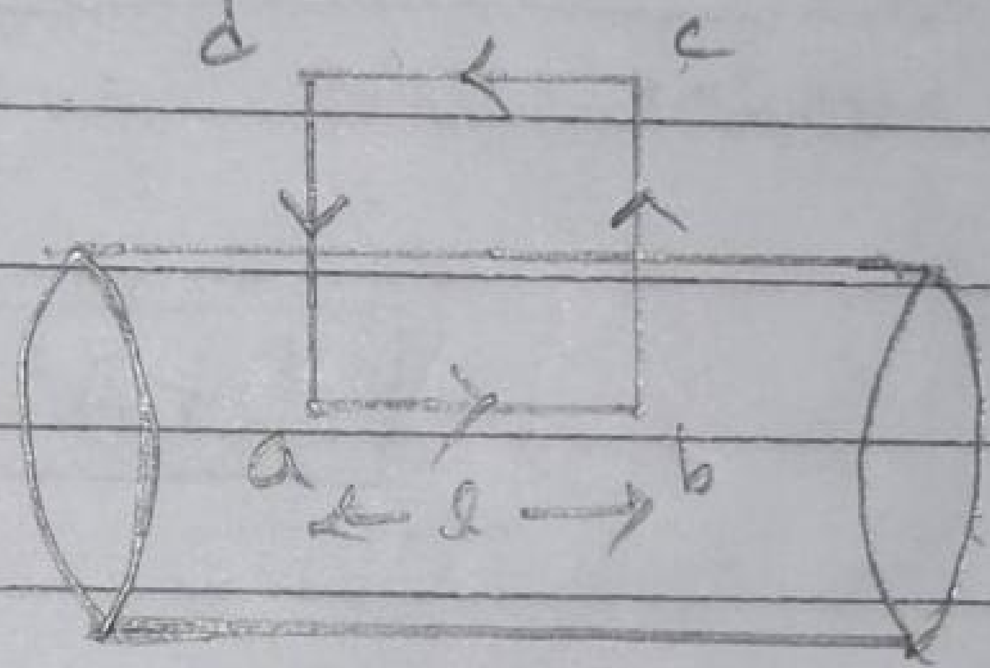
$$\Rightarrow B = \frac{\mu_0 I}{2\pi r}.$$

$$\Rightarrow \boxed{B = \frac{\mu_0}{4\pi}\,\frac{2I}{r}}$$

ii) $\vec{B}$ due to <u>current carrying solenoid</u> :-

<u>Solenoid</u> → 

where $r << l$



$$\Rightarrow \oint \vec{B}\cdot\vec{dl} = \mu_0 I$$

$$\Rightarrow \int_a^b B\,dl\cos 0^\circ + \int_b^c \cancel{B\,dl\cos 90^\circ}^{\,0} + \int_c^d \cancel{B\,dl\cos 180^\circ}^{\,\text{outside}=0} + \int_d^a \cancel{B\,dl\cos 90^\circ}^{\,0} = \mu_0 I$$

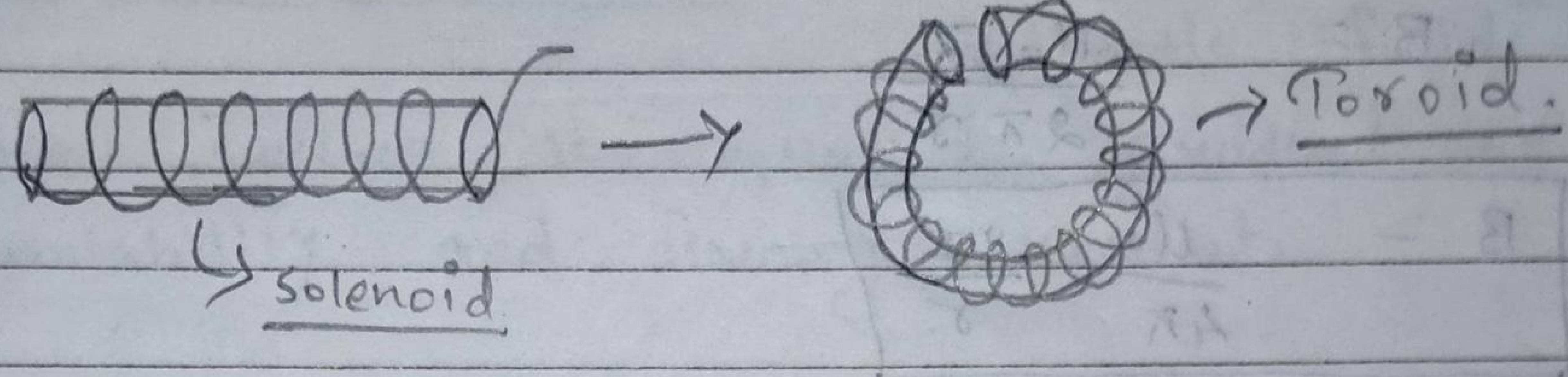
$$\Rightarrow B\int_a^b dl = \mu_0 I$$

$$\Rightarrow \cancel{B(2\pi r)} = Bl = \mu_0 I$$

$$\Rightarrow Bl = \mu_0\{(nl)I\}$$

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

iii) **Magnetic field due to current carrying Toroid :-**



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

Q 14 A current carrying coil placed a external magnetical field coil experienced a torque, derive an expression for this torque.

Q.15 Define magnetic dipole and magnetic moment.

Ans. 15) a simple magnet is known as magnetic dipole.

Magnetic Moment :- ~~It~~ This is the product of pole strengths and effective lenghth, represented by "M" and also "μ"

$$\boxed{M = m \times 2l}$$

where, $M \rightarrow$ Magnetic moment
$m \rightarrow$ magnetic dipole.

$\boxed{\text{SI Unit :- } Am^2}$

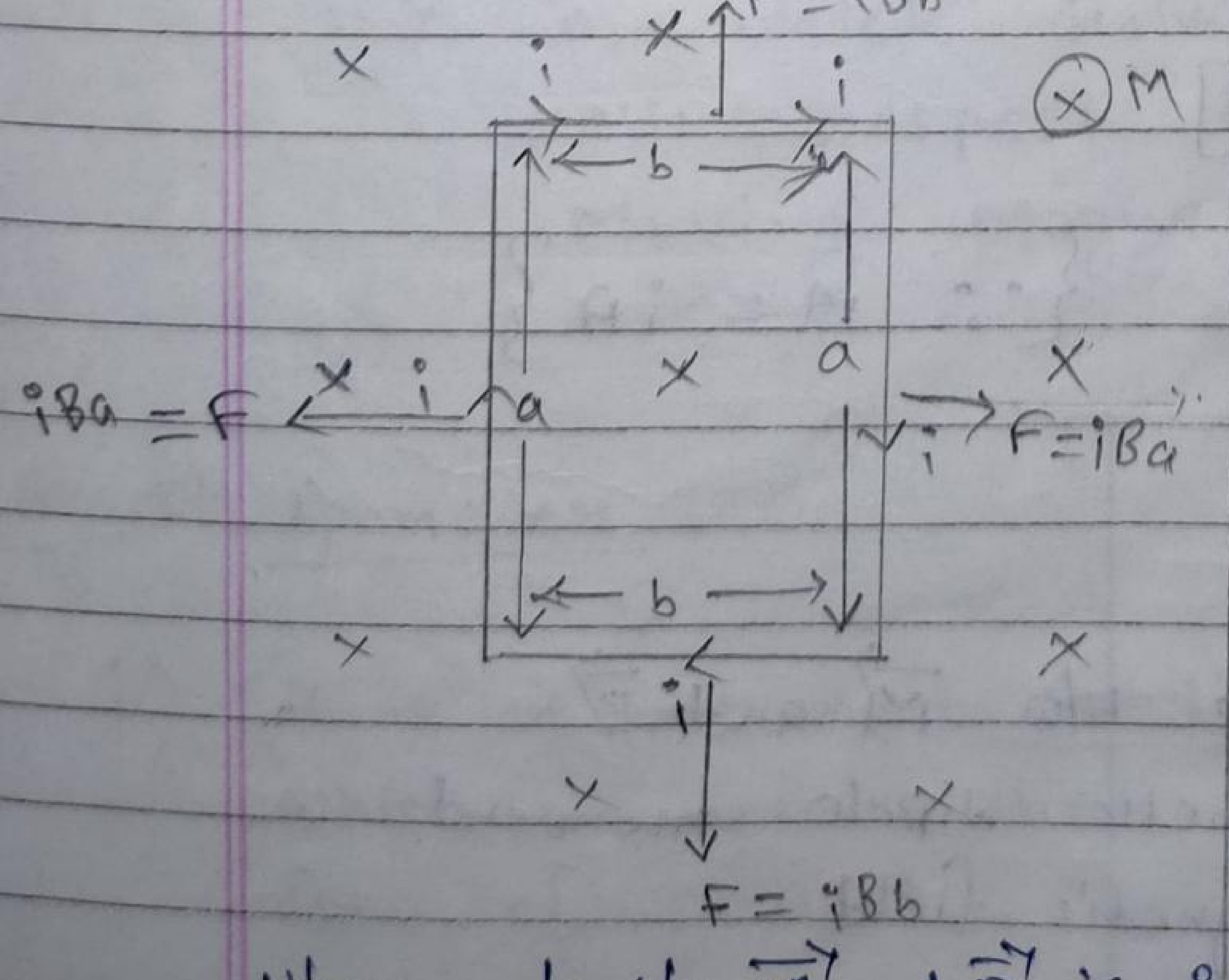
And also,

$$\boxed{M = IA}$$

and $\vec{M} = I\vec{A}$

where, $A \rightarrow$ Area.
$I \rightarrow$ current.

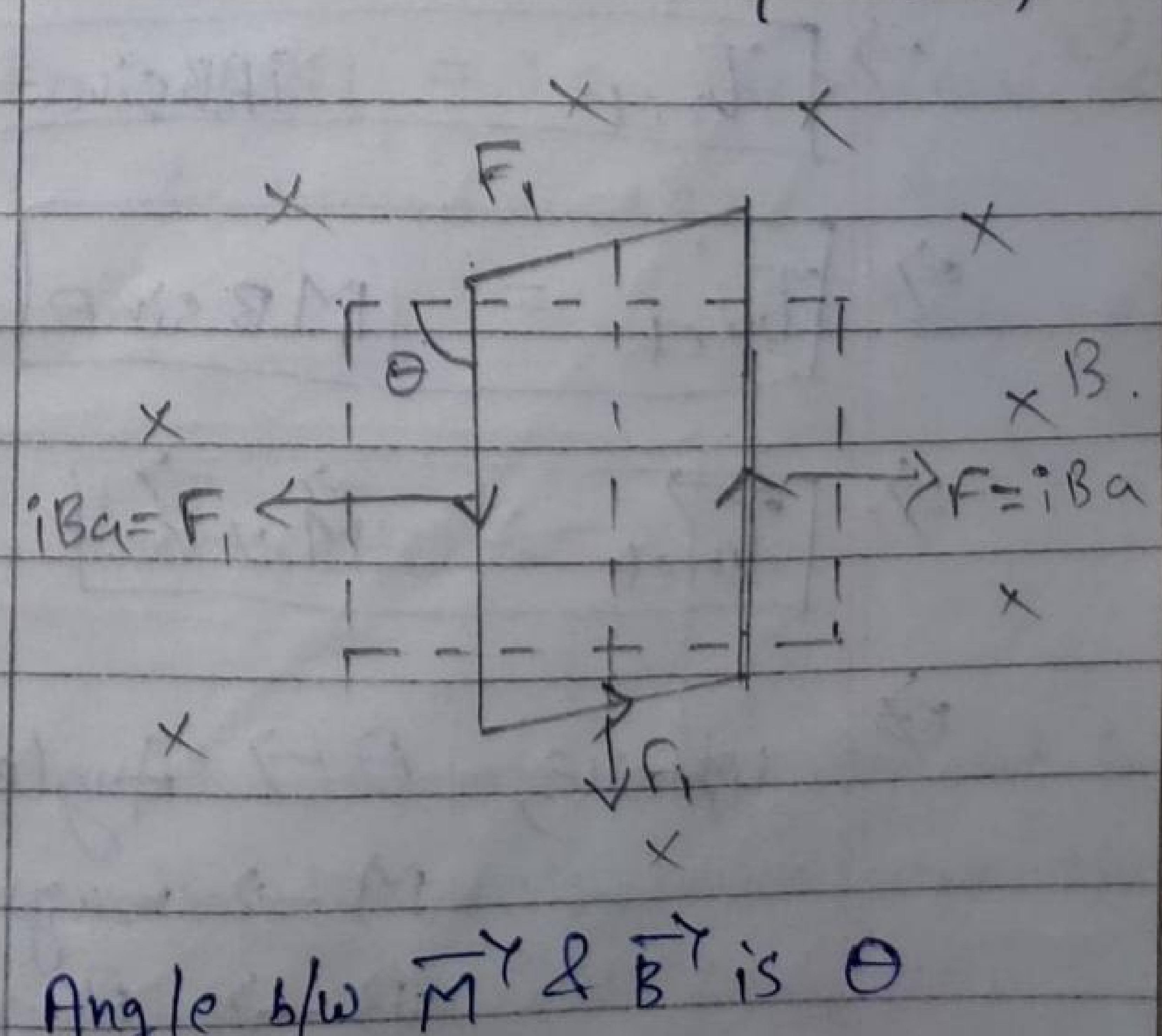
loop at initial position :-



when angle b/w $\vec{M}$ and $\vec{B}$ is $0°$

$F_{net} = 0$, $\tau_{net} = 0$.

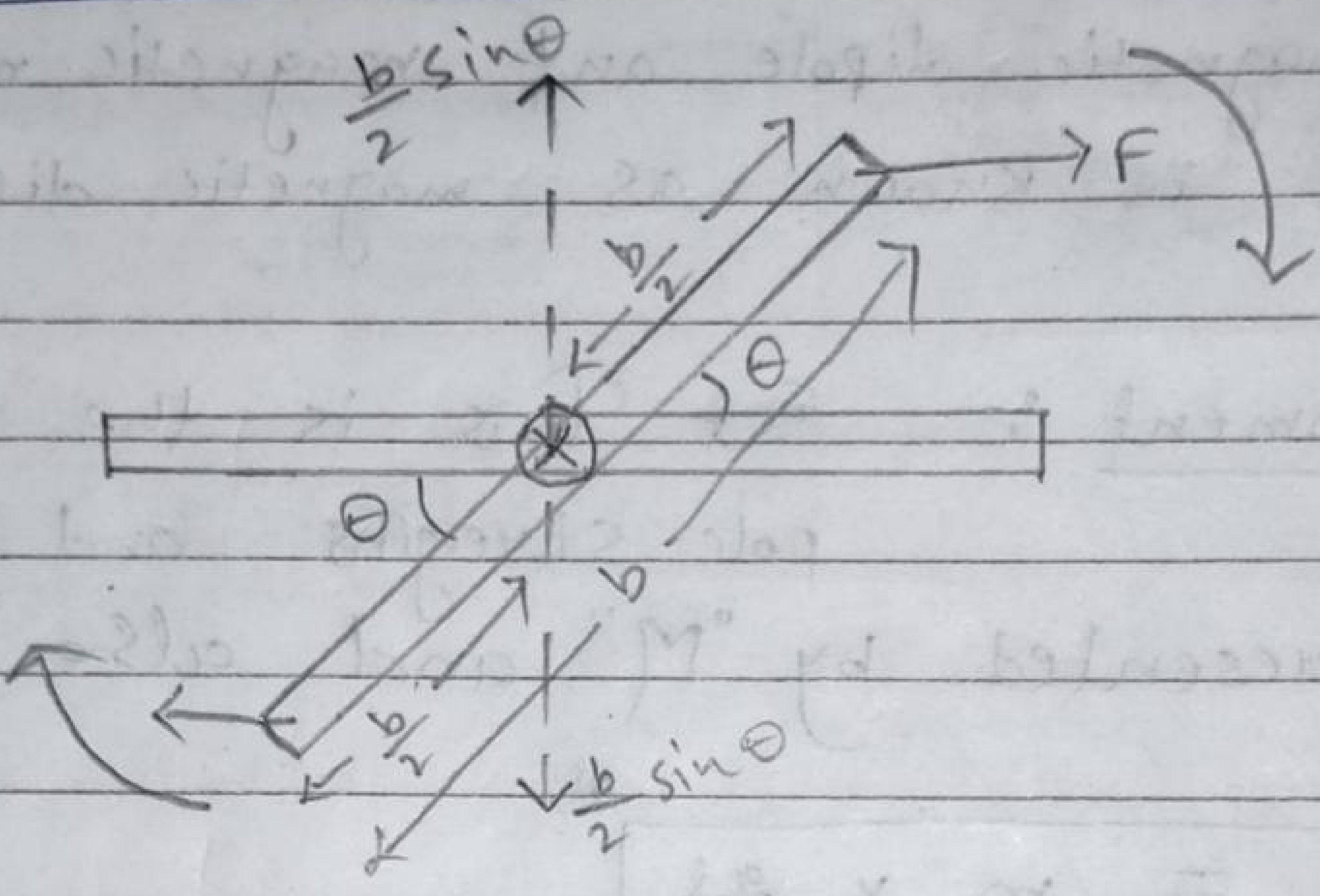
loof ~~at~~ when rotated by θ :-



Angle b/w $\vec{M}$ & $\vec{B}$ is θ

$$\boxed{\tau = F \times \perp d}$$

Let us consider top view of loop :-



$\tau = \vec{r} \times \vec{F}$

$\Rightarrow \tau = F \times \perp d$

$\Rightarrow \tau_{net} = F \times \perp d + F \times \perp d$

$\Rightarrow \tau_{net} = F \cdot \frac{b}{2} \sin\theta + F \cdot \frac{b}{2} \sin\theta$

$\Rightarrow \tau_{net} = F b \sin\theta$

$\Rightarrow \tau_{net} = iBab\sin\theta \qquad \{\because F = iBa\}$

$\Rightarrow \tau_{net} = iBA\sin\theta \qquad \{\because A = \text{area} = ab\}$

$\Rightarrow \boxed{\tau_{net} = iAB\sin\theta}$

$\Rightarrow \boxed{\tau_{net} = MB\sin\theta} \qquad \{\because M = iA\}$

$\Rightarrow \boxed{\vec{\tau}_{net} = \vec{M} \times \vec{B}.}$

$\Rightarrow$ where, $\theta \rightarrow$ Angle b/w $\vec{M}$ and $\vec{B}$

$M \rightarrow$ magnetic dipole moment

$B \rightarrow$ Magnetic field

Q.16 What is Galvanometer. ~~wri~~ How many types of Galvanometer.

Q.17 Write the difference b/w Ammeter and Voltemeter,

Q.18 How a Galvanometer converted into ammeter.

Q.19 How a Galvanometer converted into voltemeter.

Ans.16. Galvanometer is a electrical device which is used to detect the flowing current in any circuit and to find the direction of current.

Two types of Galvanometer :-

i) Moving coil Galvanometer
ii) Moving magnet Galvanometer (pivot Galvanometer)

i) in which Galvanometer coil is moving with respect to magnet is known as Moving coil Galvanometer.

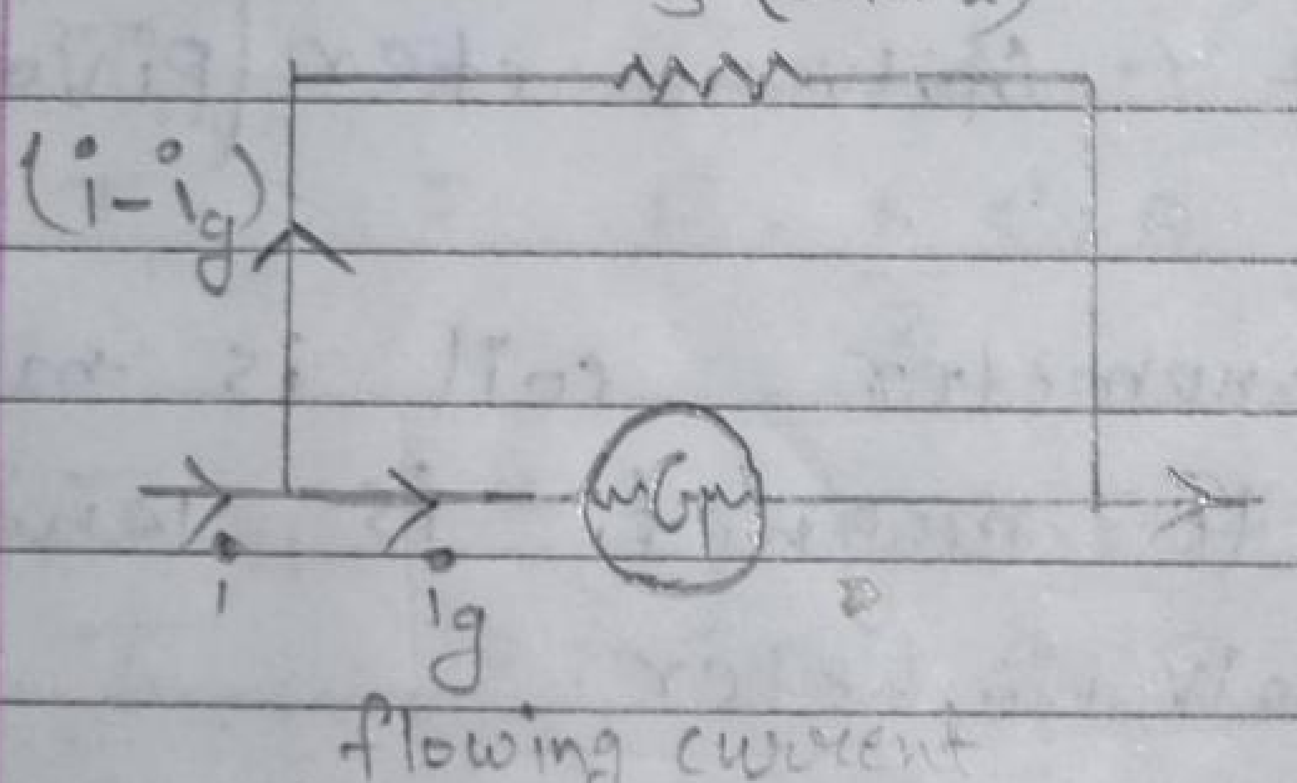
ii) in which Galvanometer ~~coil~~ Magnet is moving with respect to coil is known as Moving Magnet Galvanometer.

Ans 17

Ammeter :-	Voltemeter :-
i) it is an instrument in which we measure the flow of current	i) it is an instrument in which we measure the potential difference.

ii) Ammeter is ~~used~~ connected in series combination.	ii) Voltemeter is connected in parrallel combination.
iii) The resistance of ammeter is zero.	iii) The resistance of voltemeter is infinite (∞).
iv) Denoted by "A"	iv) Denoted by "V"

Ans. 18. To convert Galvanometer into ammeter we use Shont (low value resistance) in the parrallel of the Galvanometer.



In Parrallel combination, current is variable but Potential diff. is constant so $V_G = V_s$.

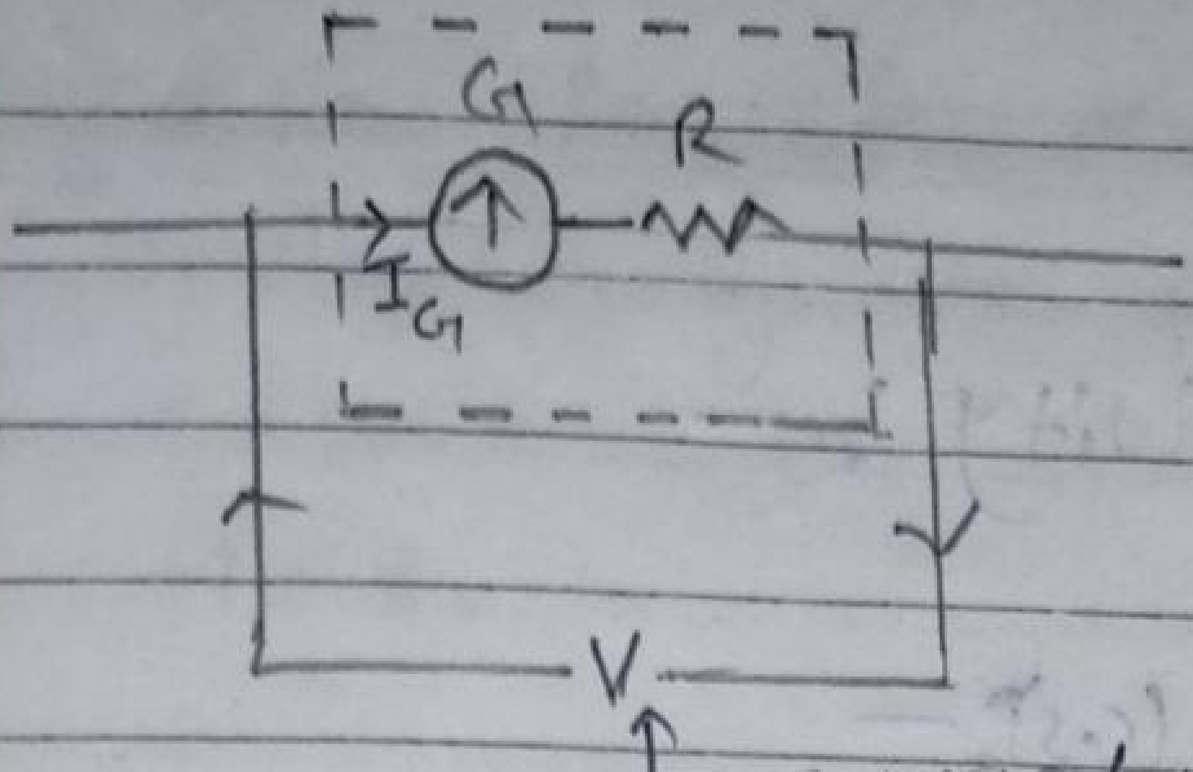
$\therefore V_G = V_S$

$$\Rightarrow \underbrace{V_G}_{\text{Potential difference of Galvanometer}} = \underbrace{V_s}_{\text{Potential diff. of shunt}}$$

$\Rightarrow i_g \times G = (i - i_g) \times S$ $\quad \{\because V = IR\}$

$$\Rightarrow \boxed{S = \frac{i_g \times G}{(i - i_g)}}$$

Ans. 19. To convert a Galvanometer into voltemeter we use a high value resistance and attach in series to Galvanometer.



source (to produce potential diff.)

In Series combination, current is constant but the Potential diff. is not.

$$\because \quad V = IR$$
$$\Rightarrow \quad V = I_g (G+R)$$
$$\Rightarrow \quad \frac{V}{I_g} = G + R$$

$$\Rightarrow \quad \boxed{R = \frac{V}{I_g} - G}$$

And,

$$\Rightarrow \quad \boxed{R = \frac{V - G I_g}{I_g}}$$

Q.20 Explain the principal of Moving coil Galvanometer

Q.21 Why are the magnetic pole in a Galvanometer concave?

Q.22 What is the meant sensitivity of a Galvanometer?

Q.23 Which material wire used in Galvanometer to suspend the coil? → Fasforbranz material.

Ans.23 Fasforbranz material wire is used in Galvanometer to suspend the coil.

~~Ans. 20~~

~~Q.24~~

Ans. 22 Sensitivity of Galvanometer:-

The deflection ~~.~~ produce due to the per unit Ampere current is known as the

Sensitivity.

Two types of Sensitivity :-

i) <u>current sensitivity (c.s)</u> :-

Deflection produced in the galvanometer per unit current is called current sensitivity.

$\Rightarrow$ current sensitivity (c.s.) $= \frac{\phi}{I}$

$$C.S = \frac{1}{I} \cdot \phi$$

$$C.S = \frac{1}{I} \cdot \frac{NABI}{K}$$

$$\Rightarrow \boxed{C.S = \frac{NAB}{K}}$$

To reduce the torsional constant (K) we use FosForbranz wire.

ii) <u>Voltage Sensitivity</u> :- Deflection produced in the Galvanometer per unit volt.

$$\Rightarrow \boxed{\frac{\phi}{V} = \frac{NAB}{KR}}$$

Ans. 21) Principle of Moving coil Galvanometer:-

The magnetic pole in a Galvanometer is concave to produce radial (चमकीला) magnetic field.

Ans. 20) current carrying coil is placed in external magnetic field then coil experience magnetic torque and coil rotate at some angle (ϕ) due to the effect of magnetic torque, The deflection in galvanometer is directly proportional to the current (I)

$$\boxed{\phi \propto I}$$

where,

$\phi \rightarrow$ deflection in galvanometer,

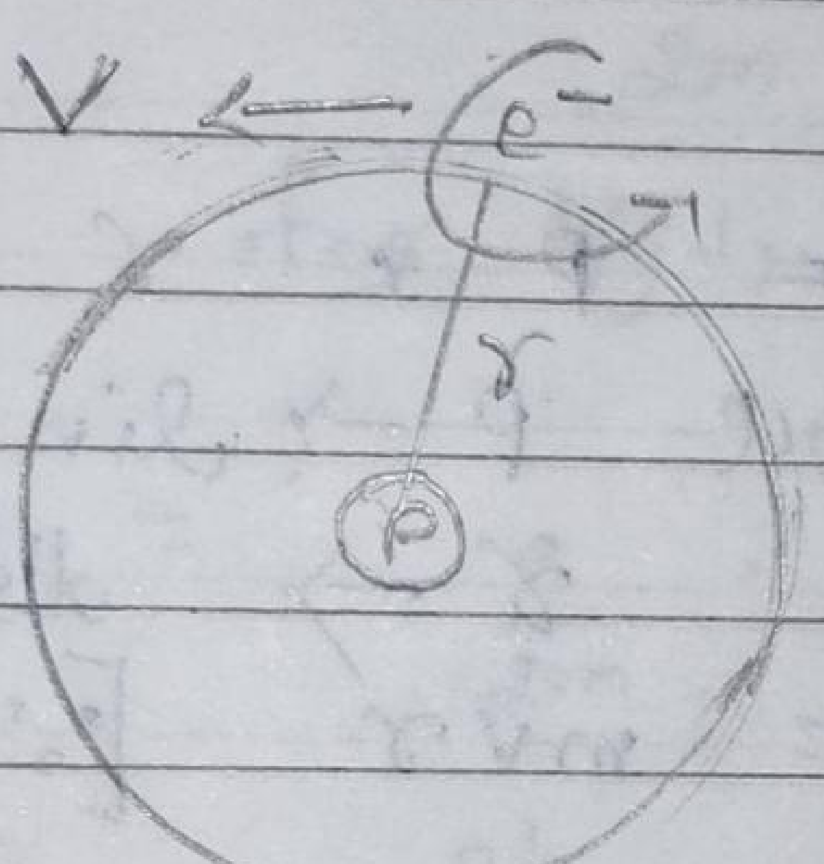
$I \rightarrow$ current.

Q.24 Derive an expression for magnetic dipole moment due to a revolving electron in our orbit.

Q.25 What is bohr magneton ?

Q.26 What is Gyromagnetic ~~rotation~~ ratio ?

Ans 24.



$\Rightarrow$ Magnetic dipole moment (M) = IA , where A → area.

$\Rightarrow$ $M = \frac{q}{t} \cdot A$ $\left[\because I = \frac{q}{t}\right]$

$\Rightarrow$ $M = \frac{e}{T} \cdot \pi r^2$ $\left[\because q = \text{electron}(e), A = \pi r^2 \quad T = \text{Time Period for 1 revolution}\right]$

$\because$ $V = \frac{\text{displacement (d)}}{\text{Time (T)}}$

$V = \frac{2\pi r}{T}$

$$\boxed{T = \frac{2\pi r}{V}}$$

$\Rightarrow$ $M = \frac{e}{T} \cdot \pi r^2$

$$\Rightarrow M = \frac{e}{\frac{2\cancel{\pi}\cancel{r}}{v}} \cdot \cancel{\pi} r^2$$

$$\Rightarrow M = \frac{evr}{2}$$

$$\Rightarrow \boxed{M = \frac{1}{2} evr}$$

Ans. 26 The ratio of Magnetic dipole moment (M) and Angular momentum (l) is known as Gyromagnetic ratio.

Angular momentum (l) = $P \times r$

where $P \rightarrow$ linear momentum

$r \rightarrow$ distance

Now, $l = mvr$ [$\because P = mv$]

$$\Rightarrow M = \frac{1}{2} evr$$

$$\Rightarrow M = \frac{1}{2m} emvr$$

$$\Rightarrow M = \frac{1}{2m} el$$

$$\Rightarrow \boxed{\frac{M}{l} = \frac{e}{2m}}$$

where $M \rightarrow$ magnetic dipole moment

$l \rightarrow$ Angular momentum.

$e \rightarrow$ electron.

$m \rightarrow$ mass of electron.

$$\Rightarrow \boxed{\frac{M}{l} = 8.8 \times 10^{10}\ C/kg}$$

$$\because \frac{e}{2m} = 8.8 \times 10^{10}.$$ Ans.

Ans. 25 According to bohr atomic model, the angular momentum of electron is integral multiple of $\frac{h}{2\pi}$.

$$\boxed{l = n . \frac{h}{2\pi}}$$

where $l \rightarrow$ Angular momentum
$2\pi \rightarrow 6.28$
$h \rightarrow$ plank constant
$h = 6.62 \times 10^{-34}$ Js.

$\because M = \frac{el}{2m}$

$\Rightarrow M = \frac{e}{2m} . n . \frac{h}{2\pi}$

for hydrogen atom, $n = 1$

$\Rightarrow M = \frac{e}{2m} . \frac{h}{2\pi}$

$\Rightarrow M = \frac{eh}{4\pi m_e}$

$\Rightarrow M = 9.27 \times 10^{-24}$ Ans.