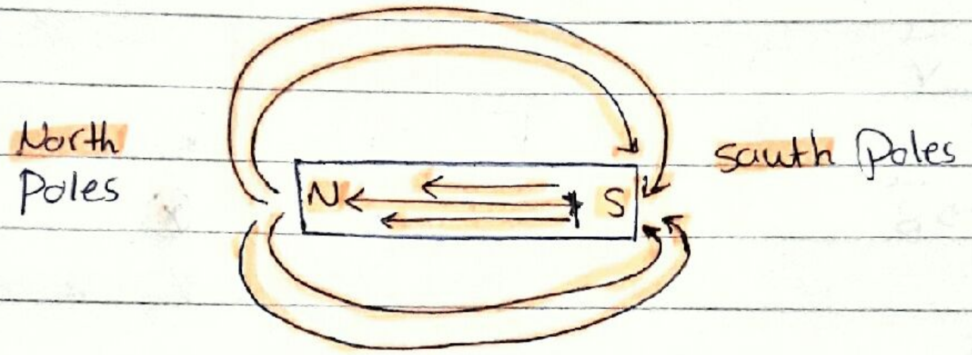
28- Magnetic fields

• Introduction:-

* Magnetic field ($\vec{B}$) produced from:-

① permanet magnet.
② electric magnet.
③ electric current.

* Eeach magnet has 2 Poles:-



* Mggnetic field lines are closed Loops

* There is NO magnatic monpole.

* Magnatic dipoles Cann't be separated.

* Similar Poles repel each Other, Opposite Poles attract each other.

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

* Magnetic Force :-

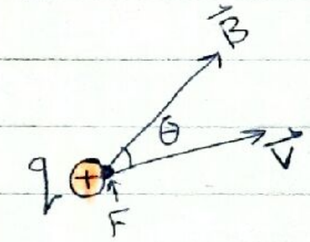
$$\vec{F} = q\,\vec{V} \times \vec{B}$$

N, C, m/s, Tesla

$\Rightarrow$ Tesla $= \dfrac{N.S}{C.m}$

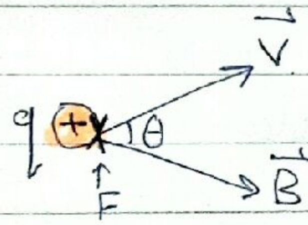
- Find The Magnetic force In each Cases :-

[1]



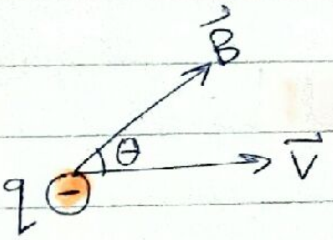
$\vec{F} = qVB\sin\theta\,\hat{k}$
(Out ward). ⊙

[2]



$\vec{F} = qVB\sin\theta\,(-\hat{k})$
(in ward) ⊗

[3]



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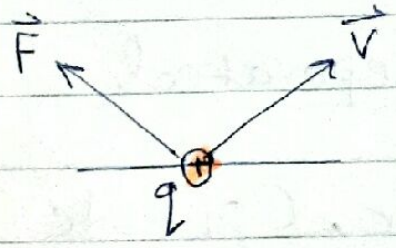
(inward) ⊗

[4]

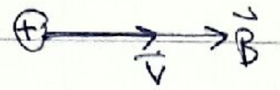


- It is already given put what the direction of $(\vec{B})$?
$\vec{F} = qBV\sin\theta$ in the direction shown, Through The right hand rule The Magnattic filed is in ward ⊗.

5

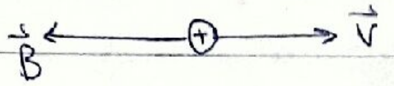
$\vec{F} = qvB\sin\theta\ \hat{j}$

6



$\vec{F} = qvB\sin 0 = \text{zero}$

7



$\vec{F} = qvB\sin 180 = \text{zero}.$

$$\boxed{\vec{F} = q\vec{v}\times\vec{B}}$$

- Consider the following notes:-

(1) $\vec{F}_B \perp \vec{v}\ \&\ \vec{B}$

(2) $\vec{F}_B$ Changes the direction of $\vec{v}$ Only.

(3) $\Delta k = \text{zero}$ during the motion under the influence of $\vec{F}_B$ $\Rightarrow W_B = \text{zero}.$

(4) $\vec{F}_B$ cannot accelerate q from rest.

(5) $\vec{F}_B = 0$ in two Cases:
- $\vec{v} = \text{zero}$
- $\vec{v} \parallel \vec{B} \rightarrow \theta = 180/0.$

28-63 :-

- electron moves at

$\vec{V} = -5\times10^6\ \hat{i} + 3\times10^6\ \hat{j}$ m/s

$\vec{B}$ acts on ⓔ

$\vec{B} = 0.03\ \hat{i} - 0.15\ \hat{j}$ Tesla

- Find the force on the electron ?

$\vec{F} = q\vec{V}\times\vec{B}$

$\vec{F} = -1.6\times10^{-19}\left[(-5\hat{i}+3\hat{j})\times(0.03\hat{i}-0.15\hat{j})\right]\times10^6$

$= -1.6\times10^{-19}\left[0.75\ \hat{k} + 0.09\ (-\hat{k})\right]$

$\vec{F}_{on\ electron} = -1.6\times10^{-13}\times 0.66\ \hat{k}$

$= -1.1\times10^{-13}\ \hat{k}$ N

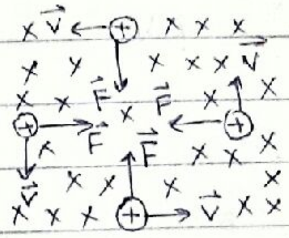
Applications on $q\vec{V}\times\vec{B}$

[1] q moves in a Uniform circular motion:-

- $\vec{B}$ act on $\vec{V}$, $\theta = 90^\circ$

$$\vec{F} = q\,\vec{V}\times\vec{B}$$

$$F = qVB = ma = \frac{mV^2}{R}$$



$\Rightarrow R = \frac{mV}{qB}$

$\Rightarrow$ Periodic time $= \frac{2\pi r}{V}$

$$= \frac{2\pi}{V}\left(\frac{mV}{qB}\right) = \frac{2\pi m}{qB}$$

$\Rightarrow$ frequancy $f = \frac{1}{T} = \frac{qB}{2\pi m}$

[2] Cyclotron: To accelerate Charges

$K_{max} = 2Nq V_0$

الطاقة الحركية

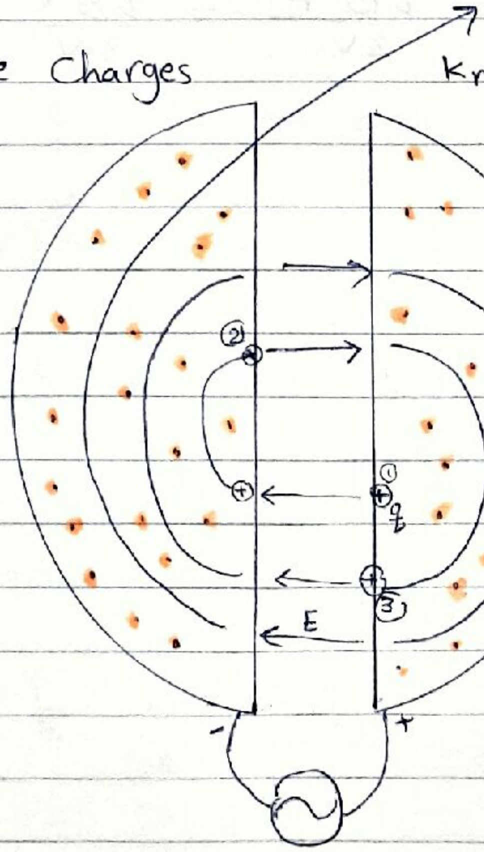
N: number of circeles.

- $V = V_0 \sin \omega t$

- Potential difference between the 2 Dees accelerate q :-

- $f_{cyclotron} = f_{\substack{circular\\motion}} = \frac{qB}{2\pi m}$

- $\vec{B} \perp \vec{V}$ to produce circular motion.



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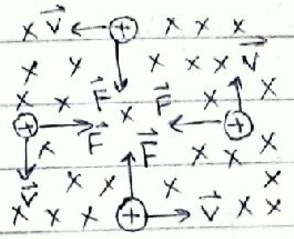

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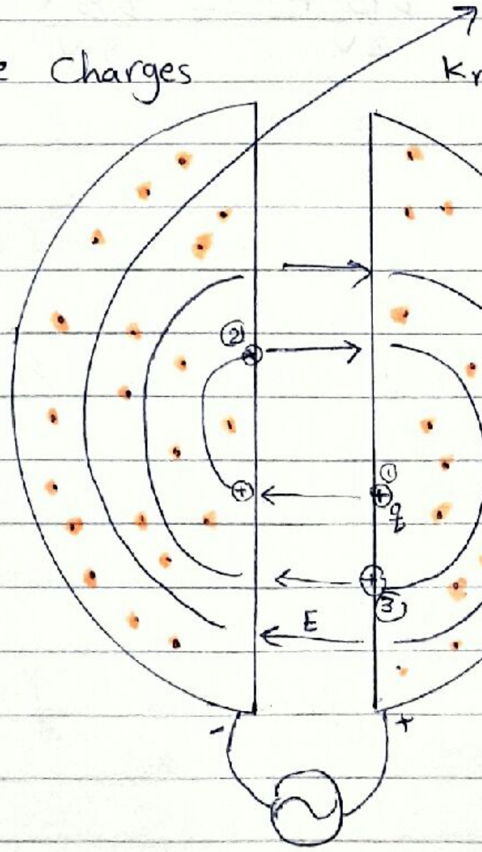
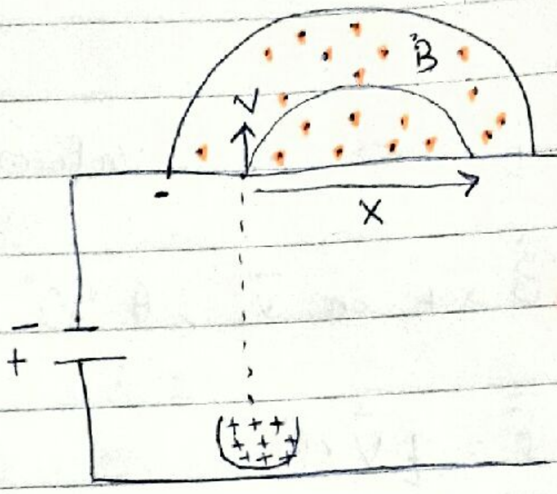


3 Mass spectrmeter:- To measure the mass of Ions.



① Potential difference

V accelerate q to $K = qV$

$$\frac{1}{2}mv^2 = qV$$

$$v = \sqrt{\frac{2qV}{m}}$$

$$\boxed{r = \frac{x}{2}}$$

② apply $\vec{B} \perp \vec{V}$

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

$$\frac{m}{r}\sqrt{\frac{2qV}{m}} = qB$$

$$\frac{m^2}{r^2}\frac{2qV}{m} = q^2B^2$$

$$m = \frac{qB^2r^2}{2V} = \frac{qB^2x^2}{8V}$$

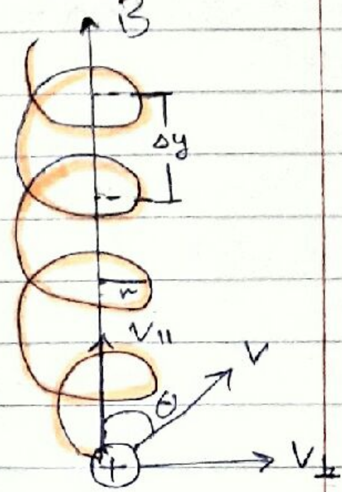
4 Helical Motion (spiral Motion):

θ between $\vec{V}$ + $\vec{B}$ not $90°$

$\theta \neq 90$, q will move in a helix

q, V, B, θ find r? T? Δy?

$V_\perp = V\sin\theta$ (case circular motion)
$V_\parallel = V\cos\theta$ (case linear motion)
→ helical motion



$\Rightarrow q V_\perp B = \frac{m V_\perp^2}{r}$

$r = \frac{m V_\perp}{qB} = \frac{m V \sin\theta}{qB}$

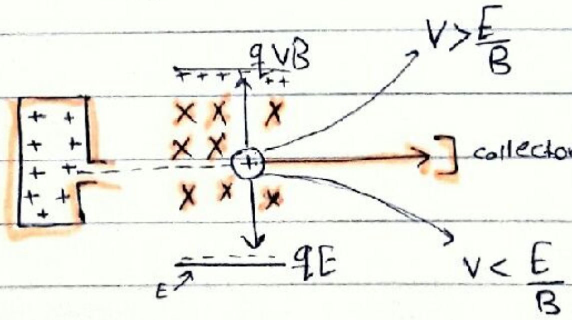
$\Rightarrow T = \frac{2\pi r}{V_\perp} = \frac{2\pi m}{qB}$

$\Delta y = V_\parallel T$
pitch $= V_\parallel T$

5 Lorentz' force: $\vec{E}$ + $\vec{B}$ are acting on q

$$\vec{F} = q\vec{E} + q\vec{V}\times\vec{B}$$

6 Velocity selector: to select charges with certain v.



(1) Apply $\vec{E} \perp \vec{V}$
(2) Apply $\vec{B} \perp \vec{V}$
$\vec{B} \perp \vec{E}$

$\rightarrow q\vec{E} + q\vec{V}\times\vec{B} = 0$

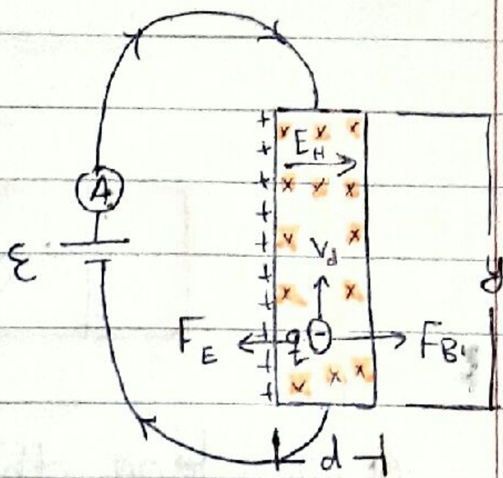
$\rightarrow V = \frac{\vec{E}}{\vec{B}}$ collected.

7 Hall Effect: Aim to find $\left\langle \begin{matrix} V_d \\ n \end{matrix} \right.$

$i = neA\vec{V}_d$ —— (1)

$\vec{J} = ne\vec{V}_d$

metalic strip
- → length = y
- → width = d
- → thickness = l
- → n = ?



(1) Apply $B \perp$ strip

B in ward

$F_{B\,\text{on electron}} = eV_dB$

$\Rightarrow$ creat E_H

At equilibrium $\sum\vec{F} = \text{zero.}$

$$eE = eV_dB$$

$$\boxed{V_H = Ed}$$

1 $V_d = \dfrac{V_H}{Bd}$

$V_d = \dfrac{i}{enA} \Rightarrow \dfrac{i}{neld}$

$\dfrac{V_H}{Bd} = \dfrac{i}{neld}$

2 $n = \dfrac{iB}{elV_H}$ —— (1)

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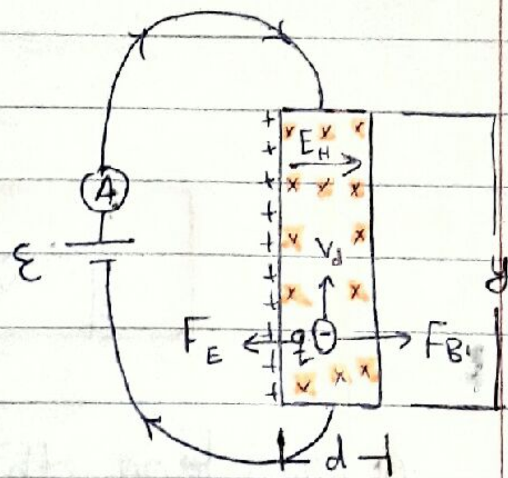
$i = neA\vec{V}_d$ —— (1)

$J = ne\vec{v}_d$

metalic strip
- $\rightarrow$ length $= y$
- $\rightarrow$ width $= d$
- $\rightarrow$ thickness $= l$
- $\rightarrow$ $n = ?$



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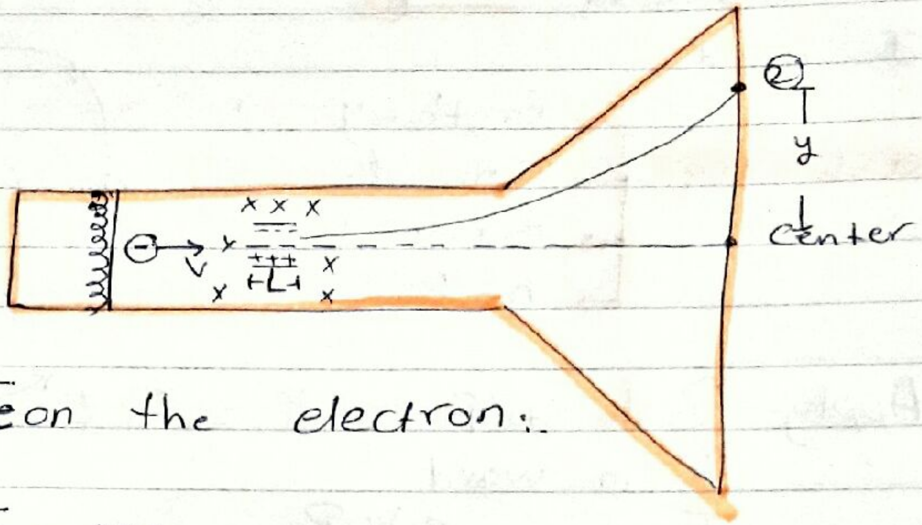
8 **Thomson's exp**: aim to find $\frac{q}{m}$ of the electron.



① Apply E on the electron:

$$F_e = qE = ma$$

$$a_y = \frac{qE}{m}$$

$$y = V_{oy}\, t + \frac{1}{2} a_y t^2$$

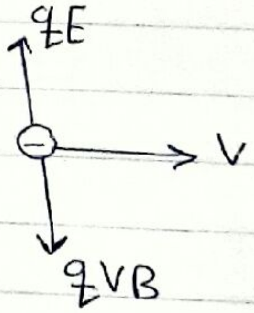
$$y = \frac{1}{2}\frac{qE}{m} t^2 \Rightarrow y = \frac{qEt^2}{2m}$$

$$y = \frac{qE}{2m}\left(\frac{L}{V}\right)^2$$

② Apply $\vec{B} \perp \vec{V}$

$\vec{B} \perp \vec{E}$

At equilibrium

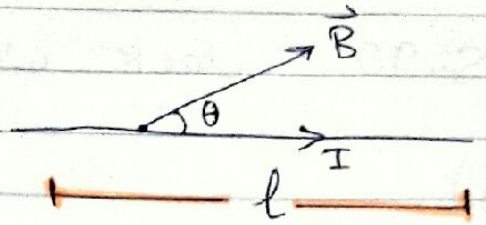


$$qE = qVB \Rightarrow V = \frac{E}{B}$$

$$y = \frac{qE\,L^2 B^2}{2mE^2}$$

$$\frac{m}{q} = \frac{E\,L^2 B^2}{2yE}$$

* Magnetic force on a wire Carying Current:-



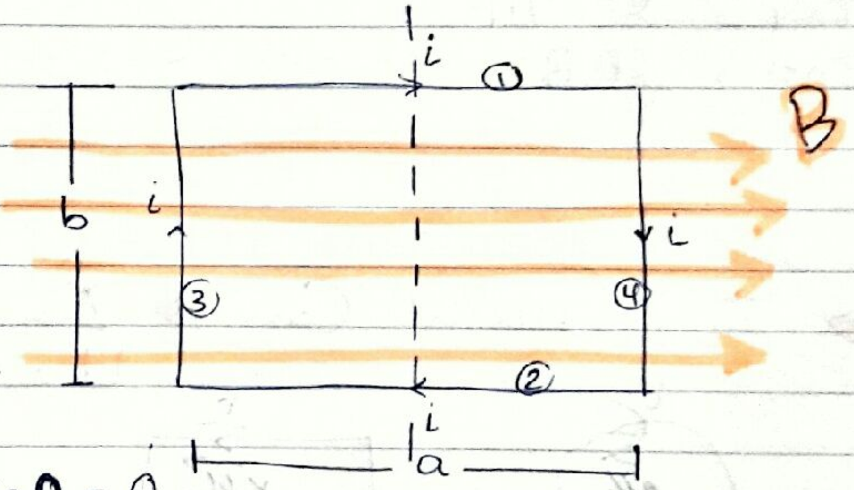
$$\vec{F} = i\vec{\ell} \times \vec{B}$$

$$F = i\ell B \sin\theta \quad ; \quad \vec{F} \perp \vec{\ell}$$

$$\vec{F} \perp \vec{B}$$

* Torque on a current loop:-

$\boxed{\text{Case 1}}$



$\Rightarrow$ $F_1 = i a B \sin 0 = 0$

$F_2 = i a B \sin 180 = 0$

$F_3 = i b B \sin 90 (-\hat{k})$ N

$F_4 = i b B \sin 90 (\hat{k})$ N

$F_{net} = \text{zero}$

The loop will rotate $\rightarrow$ ④ $\rightarrow$ out ward.

③ $\rightarrow$ in ward.

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

$\tau_3 = \left(\frac{a}{2}\right)(ibB) \sin 90$ clock wise

$\vec{\tau}_3 = \frac{iabB}{2} (-\hat{j})$

$\tau_4 = \frac{a}{2} (ibB) \sin 90$ clock wise

$\vec{\tau}_4 = \frac{iabB}{2} (-\hat{j})$

$\tau_{net} = iabB$ clock wise

$\tau_{net} = N i AB$

$\tau_{net} = \mu B$

$A = ab$

μ: magnatic dipole moment.

⇒ In General Case ⇒ $\vec{\tau} = \vec{\mu} \times \vec{B}$ N.m

$U = -\vec{\mu} \cdot \vec{B}$ J