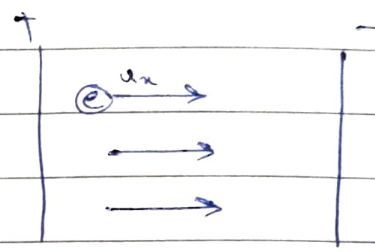
ELECTRON BALLISTICS

MOTION OF ELECTRONS

I Electric Field

Case 1) Parallel (to $\vec{v}$ of e^-)



$a_x = -\frac{qE}{m}$ $\quad (\because F = qE,\ ma = qE)$

$\therefore S_x = u_x t - \frac{1}{2}\frac{qE}{m}t^2$

$v_x = u_x - \frac{qE}{m}t$

$v_x^2 = u_x^2 - \frac{2eE}{m}S$

$\frac{1}{2}mv_x^2 = \frac{1}{2}mu_x^2 + (-eE)s$

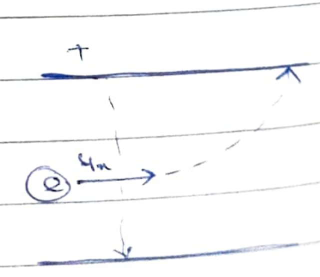
if $u_x = 0$

$KE = -eEs = eV = \frac{1}{2}mv_x^2$

$v \propto \sqrt{V}$

$$\boxed{v = 5.93 \times 10^5 \sqrt{V}}$$

Case 2) Perpendicular



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

$v_y = \frac{eE}{m}t$ $\quad (u_y = 0)$

$S_y = \frac{eE\,t^2}{2m}$

$S_x = u_x t$

$t = S_x / u_x$

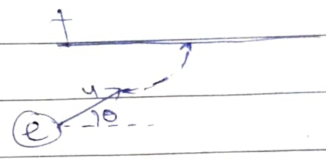
$$\left(S_y = \frac{eES_x^2}{2mu_x^2} \right)$$ if $S_y = y$ $\quad S_x = x$

$$\left[\, y = \frac{eE}{2mu_x} x^2 \,\right]$$ Parabolic

Case 3) At an angle other than $0°/90°$

$u_x = u_0 \cos\theta$

$u_y = u\sin\theta$



$x = u_x t = ut\cos\theta$

$y = u\sin\theta + \frac{1}{2}at^2$

$$\boxed{y = x\tan\theta + \frac{ax^2}{2u^2\cos^2\theta}}$$ Parabolic

$$\left[\, T = \frac{2u\sin\theta}{a} \quad H = \frac{u^2\sin^2\theta}{2g} \quad R = \frac{u^2\sin 2\theta}{g} \,\right]$$

(Time period) (max. height) (Range)

II Magnetic Field

Case 1) ~~Perpendicular (Transverse)~~ Parallel (Longitudinal)

$F = \frac{mv^2}{r} = q(\vec{v} \times \vec{B})$

$= qvB\sin\theta = qvB\sin 0°$

$\therefore F = 0$

Case 2) Perpendicular (Transverse)

$F_B = qvB\sin 90° = qvB = evB$

$F_c = \frac{mv^2}{R}$

$F_c = F_B \quad \therefore \quad \frac{mv^{\cancel{2}}}{R} = e\cancel{v}B$

$$\left[\, R = \frac{mv}{eB} \,\right] \qquad \left[\, T = \frac{2\pi R}{v} = \frac{2\pi m}{eB} \,\right]$$

$$\left[\, \nu = \frac{eB}{2\pi m} \,\right]$$

Note: i) ν is independent of $\vec{v}$ and R

ii) $R \propto v$ ∴ slower e^- move in smaller circles

$\omega = 2\pi f = 2\pi\left(\frac{eB}{2\pi m}\right) = \frac{eB}{m}$

$\boxed{\omega = \frac{eB}{m}}$

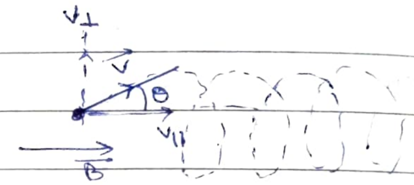
Case 3) At any angle but 0°/90°.

Let $\vec{v}$ have two components

$v_\perp = v\sin\theta$

$v_\parallel = v\cos\theta$

$(\because v_\parallel \times B = 0)$



$F_B = q v_\perp B \sin\phi$ $\quad \because \phi = 90°$

$\therefore e v_\perp B = \frac{m v_\perp^2}{R}$

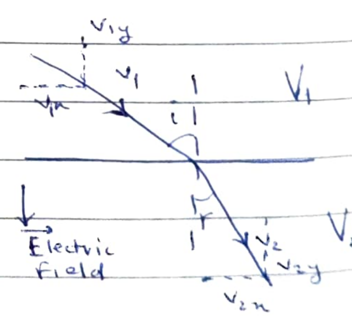
$\boxed{R = \frac{m v_\perp}{eB}}$ Radius of a loop of helix

$T = \frac{2\pi R}{v}$ $\therefore$ $\boxed{T = \frac{2\pi m}{eB}}$ Time period of one loop.

$\boxed{\text{Pitch} = v_\parallel \times T = \frac{v\cos\theta \cdot 2\pi m}{eB}}$

Bethe's law

Let there be two regions with uniform potentials V_1 & V_2. An electron from V_1 strikes the junction at i angle at velocity v_1. Get transmitted to V_2 with velocity v_2. $\because$ Field solely applys across y-direction.



$v_{1x} = v_{2x}$

$v_1 \sin i = v_2 \sin r$.

$\frac{\sin i}{\sin r} = \frac{v_2}{v_1}$ $\quad$ (v_1/v_2 = velocity of e^- in 2 regions)

$\therefore$ Kinetic Energy of e^- = Electric Potential energy

$$\frac{1}{2}mv^2 = qV \text{ i.e } eV$$

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

$$\therefore \frac{\sin i}{\sin r} = \frac{\sqrt{2eV_2/m}}{\sqrt{2eV_1/m}}$$

$$\boxed{\frac{\sin i}{\sin r} = \sqrt{\frac{V_2}{V_1}}}$$

(V_1/V_2 =: Potentials of two regions)

~~# Conditions: (For uniform electric field)~~
~~i) Value of strength is const.~~
~~ii) Dipole only experiences torque~~

Note Difference between homogeneous & non-homogeneous electric field.

	Homo EF	Non-homo EF
1)	Same magnitude & direction at every point	Magnitude & direction vary at every location
2)	Dipole only experiences torque	Dipole experiences torque and force.
3)	Eg: Field b/w two charged metal plates	Eg: Field around a charged metal ball ...

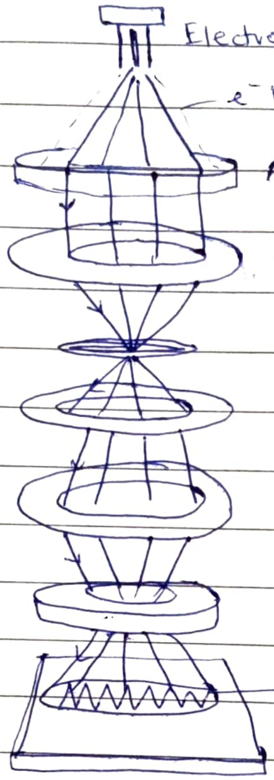
MICROSCOPES

1) FESEM - Field Emission Scanning Electron Microscope
→ Thermal emission
→ Very clear image of individual particles

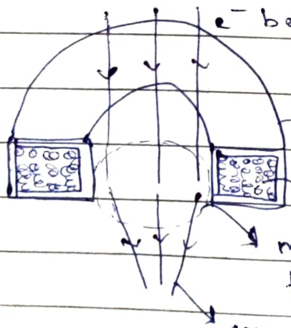
ii) TEM - Transmission Electron Microscop
→ less clear

→ Uses focused beam of high energy e^- generate a variety of signals at the surface of specimen.

TEM



Electronic lens



i) Varying focal length
ii) Bend contuniciously through successive equipotential surface
iii) Used in particle accelerators and other instuments to focus a beam of e^- on a surface.

Cathode Ray Tube (CRT)

3 components – { Electron gun, Deflection, Fluorescent sreen }

used in architecture, art, ED etc