B.Sc. III year
Physics - II
Electrodynamics, Electromagnetic Waves & Relativity

Books:

Introduction to Electrodynamics – D. J. Griffiths (Prentice Hall of India)

Introduction to Electrodynamics – Reitz and Milford (Addison-Wesley)

The Feynman Lectures in Physics Vol. II – Feynman, Leighton, Sands (B. I Publications)

More books → See syllabus circulated

UNIT – I

Motion of charged particles in E and B fields

Motion of charged particles – motion of particles such as electrons, protons, ions etc

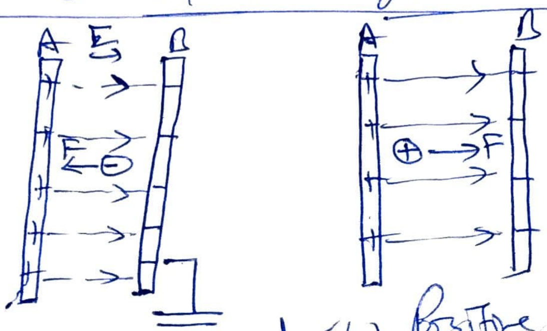
↓

Can be considered as point mass

↳ so energy is limited to kinetic and potential energy.

Gravitational or mutual repulsive forces are negligible in comparison to forces due to electric and magnetic fields.

Electron motion in a longitudinal Uniform Electric field



(a) Negative charged particle (b) Positive charged particle

Two metal plates of same area are placed apart a small distance 'd'. ②

On connecting to a dc source (Battery) the plates are charged and Electric field E is established.

If an electron of mass (m) and charge (e) is placed between the plates, It feels force $\vec{F_e}$ and force

$$\vec{F_e} = -e\vec{E} \quad \text{---(1)}$$

the electron moves from negative plate to positive plate under influence of this force.

The direction of force $\vec{F_e}$ is opposite to electric field $\vec{E}$.

The acceleration produced in electron's

direction of $\vec{a}$ is opposite to $\vec{E}$

$$\vec{a} = \frac{\vec{F_e}}{m} = (-)\frac{e\vec{E}}{m} \quad \text{---(2)}$$

for positive particle the direction of $\vec{a}$ is along $\vec{E}$.

Let $e, \vec{E}, m$ dont change with time.

The eqn of motion can be obtained for such uniformly accelerated particle

Let electron is at rest at $x_0 = 0$

and its initial velocity is $v_0 = 0$

after time interval 't'

$$v = v_0 + at$$

$$\text{or} \quad \vec{v} = \vec{a}t = -\frac{e\vec{E}}{m}t \quad \text{---(3)}$$

Position of electron after time interval '(t)'

$$\vec{x} = \frac{1}{2} a t^2 = \frac{1}{2} (-) \frac{e\vec{E}}{m} t^2 \quad \text{---(4)}$$

Velocity of particle in this point

$$|V| = \sqrt{2ax} = \sqrt{2\left[\frac{eE}{m} x\right]} \quad \text{---(5)}$$

Kinetic energy of moving particle

$$K = \frac{1}{2} m v^2$$

$$= \frac{1}{2} m \left[\frac{2eE}{m} x\right]$$

$$= eEx \quad \text{---(6)}$$

The kinetic energy depends on position of the electron in electric field.

Energy of electron in electric field

When electron moves in electric field kinetic energy is produced due to its velocity change, due to change in configuration potential energy also changes.

If V is potential difference between plates A and B, force on electron on any moment

$$\vec{F} = (-)e\vec{E}$$

or

$$F = e\frac{dV}{dx} \qquad \because E = (-)\frac{dV}{dx} \quad \text{---(7)}$$

Work done due to movement of electron by distance 'dx' from plate B to A

$$dW = F dx$$

from eqn 5

$\Rightarrow dW = e\,dV$

$$W_{12} = \int_1^2 dW = \int_1^2 e\,dV = e(V_2 - V_1) \quad \text{--- (8)}$$

if positively charge particle is

$$W_{12} = q(V_2 - V_1) \quad \text{--- (8a)}$$

electron moves in the in the direction of increasing potential

From work-energy theorem → The work done by electric field on electron express increase in kinetic energy of electron

$$W_{12} = \frac{1}{2}m\left[v_2^2 - v_1^2\right]$$

from eqn (8)

$$e\left[V_2 - V_1\right] = \frac{1}{2}m\left[v_2^2 - v_1^2\right] \quad \text{--- (9)}$$

v_2, v_1 velocity of electron at position 1 and 2.

If $v_1 = 0$

then $\quad eV = \frac{1}{2}mv^2 \quad \text{--- (10)}$

$\boxed{1\,eV = 1.6 \times 10^{-19}\ \text{Joule}}$

V → potential difference

v → final velocity of electron

The velocity of electrons moving between plates of potential difference V is

$$v = \sqrt{\frac{2eV}{m}} = \sqrt{\frac{2qV}{m}} \quad \text{--- (11)}$$

The energy of moving charged particle in electric field is given in eV → electron volts