lecture -2-

Gravitational Force (F_g)

Gravitational Force : The Force between two masses bodies (m_1, m_2) is direct proportional to the product of their individual masses ($m_1 \times m_2$) and inversely proportional to the squar of their separation (r^2).

$$F_g \propto \frac{m_1 m_2}{r^2} \Longrightarrow F_g = G \frac{m_1 m_2}{r^2}$$

G (gravitational constant) $G = 6.67 \times 10^{-11} \frac{Nt \cdot m^2}{kg\, m^2}$

① $F_g \propto m_1 m_2$ ∴ The force (F_g) is direct proportional to the product of their indiviual masses $F_g \propto m_1 m_2$

② Force (F_g) is inversely proportional to the squar of their separation

$$F_g \propto \frac{1}{r^2}$$

Example (3): In Hydrogen atom calculate

(a) The electrostatic force (F_e).

(b) Gravitational force (F_g) between electron electron and protons

(c) Compare between two forces (F_e, F_g) $\frac{F_e}{F_g}$ = ? if the average separation of the electeron and proton ($r = 5.3 \times 10^{-11}$ m)

Solution:

(a) $F_e = K \frac{q_1 q_2}{r^2}$

$F_e = 9 \times 10^9 \frac{(1.6 \times 10^{-19})(1.6 \times 10^{-19})}{(5.3 \times 10^{-11})^2}$

$F_e = 8.2 \times 10^{-8}$ Nt

(b) $F_g = G \frac{m_1 m_2}{r^2}$

$= 6.67 \times 10 \frac{(9.11 \times 10^{-31})(1.67 \times 10^{-27})}{(5.3 \times 10^{-11})^2}$

$F_g = 3.6 \times 10^{-37}$ Nt

(c) $\frac{F_e}{F_g} = \frac{8.2 \times 10^{-8}}{3.6 \times 10^{-37}} = 2 \times 10^{39}$

$F_e = 2 \times 10^{-37} F_g$

Example (4) : Calculate the electro static force (F_e) between two protons and gravitational force (F_g) and compare between F_e and F_g ($\frac{F_e}{F_g}$) = ? if the separation between (p, p) ($r = 2 \times 10^{-10}$ m)

① $F_e = K \frac{q_p q_p}{r^2} = 9 \times 10^9 \frac{2(1.6 \times 10^{-19})^2}{(2 \times 10^{-10})^2}$

$F_e = 5.76 \times 10^{-9}$ Nt

② $F_g = G \frac{m_p m_p}{r^2} = 6.67 \times 10^{-11} \frac{2 \times (1.67 \times 10^{-27})^2}{(2 \times 10^{-10})^2}$

$F_g = 4.56 \times 10^{-45}$ Nt

③ $\frac{F_e}{F_g} = \frac{5.76 \times 10^{-9}}{4.56 \times 10^{-45}} = 1.24 \times 10^{36}$

$F_e = 1.2 \times 10^{36} F_g$

Electric Field (E)

Is defined as the force exerted an acting positive test charge at that point divided by the magnitude of the test charge.

$$E = \frac{Fe}{q}$$

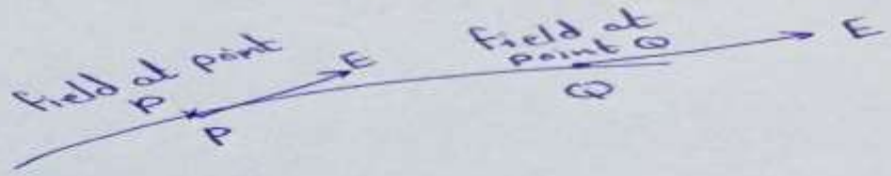
E : is the electric strength

Fe : is the electric force

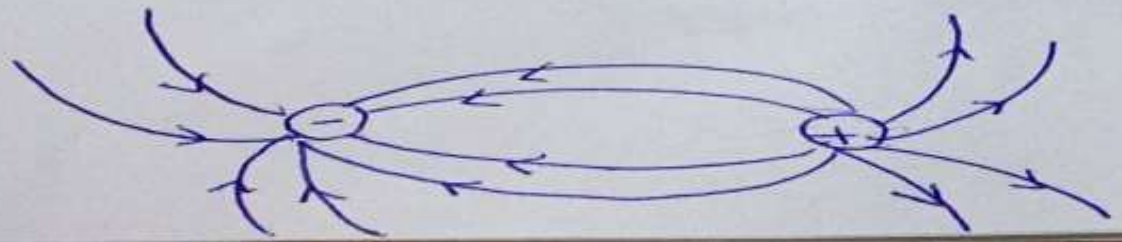
q : is the charge in coulombs.

Line of Force

The line of force is an imaginary line draw in such away that its direction at any point is the same as the direction of the direction of the field at that point



Electric field with aid of lines of force



$$\vec{E} = \frac{\vec{F}}{q}$$

$$E = \frac{+1}{q}(F) \quad [q \text{ is positive}]$$

$$E = \frac{-1}{q}(F) \quad [q \text{ is negative}]$$

E same direction or opposite direction of $\vec{F}$

$\vec{E}$ $\vec{F}$

$\vec{E}$ $\vec{F}$

$\vec{A} = -\vec{B}$

$\vec{B} = -\vec{A}$

unit of $E = \frac{F}{q}$ $\frac{Nt}{coul.}$

Example (5) : Electric field Intensity between two parallel plates equal $E = 10^4$ Nt/coul. separation by r = 1cm electron moved in this field calculate the ① Acting force on one electron in this field ?

② V_{final} after 1cm

③ Kinetic Energy ?

Solution : ① $E = 10^4$ Nt/coul

$q_e = 1.6 \times 10^{-19}$ coul.

$F = qE = 1.6 \times 10^{-19} \times 10^4$

$= 1.6 \times 10^{-15}$ Nt

② $V_f = ?$

$V_o = 0$, $x = 1cm = 1 \times 10^{-2}$ m

$$F = ma \Longrightarrow a = \frac{F}{m} = \frac{qE}{me} = \frac{1.6 \times 10^{-19} \times 10^4}{9.11 \times 10^{-31}}$$

$a = 1.8 \times 10^{15}$ m/sec^2

$$V_f^2 = V_0^2 + 2ax$$

$$V_F^2 = 0^2 + 2 \times 1.8 \times 10^{15} \times 1 \times 10^{-2} = 3.6 \times 10^{-13}$$

$$V_f = \sqrt{3.6 \times 10^{-13}} = 6 \times 10^6 \text{ m/sec}$$

(3) $$K.E = \frac{1}{2} mcV^2$$

$$= \frac{1}{2} \times 9.11 \times 10^{-31} \times (6 \times 10^6)^2$$

$$K.E = 1.8 \times 10^{-17} \text{ Joul.}$$