Chapter 21
Coulomb's Law

→ Elective Charge :

2 kinds of Charges → Possitive Charge
2 kinds of Charges → Negative Charge

1 Quantization of Charge:-

* $q = ne$, $n = \pm 1, \pm 2, \pm 3, \ldots\ldots$
* electroncharge = $e = -1.6 * 10^{-19}$ C

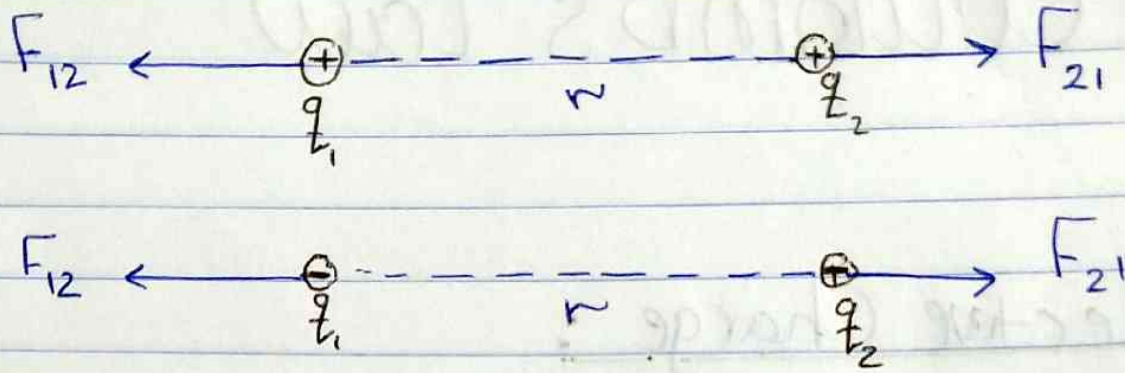
2 Conservation of Charge:-

$$q_{\text{before reaction}} = q_{\text{after reaction}}$$

* pair production: $\gamma + \gamma \longrightarrow e^- + e^+$ (electron, positron)

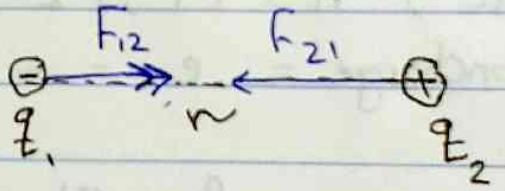
* Annihilation: $e^- + e^+ \longrightarrow \gamma + \gamma$

→ Electric force :



* The electric force between similar charges are electric repulsive force.

* The electric force between opposite Charges are electric attractive force



* $F_{12} = -F_{21}$ « depend On F as a vector »
* $F_{12} = F_{21}$ « depend On F as a magnitude »

→ Coulomb's law :-

$$F \propto \frac{q_1 q_2}{r^2}$$

* Electric force directly proportional with q_1, q_2
* Electric force inversaly proportional with r^2.

$$F = \frac{K\, q_1 q_2}{r^2}$$

- K : Constant depend On a- Units
  b- medium between q_1 & q_2.

- ϵ : permitivity of the medium.
- In air : $\epsilon_0 = 8.85 \times 10^{-12}\ C^2/N.m^2$
- $K = \frac{1}{4\pi\epsilon_0} = 9 \times 10^9\ N.m^2/C^2$.

Example:

$q_1 = q_2 = 50\ \mu c$

$q_3 = -50\ \mu c$

$L_{12} = L_{23} = L_{13} = 50\ cm$

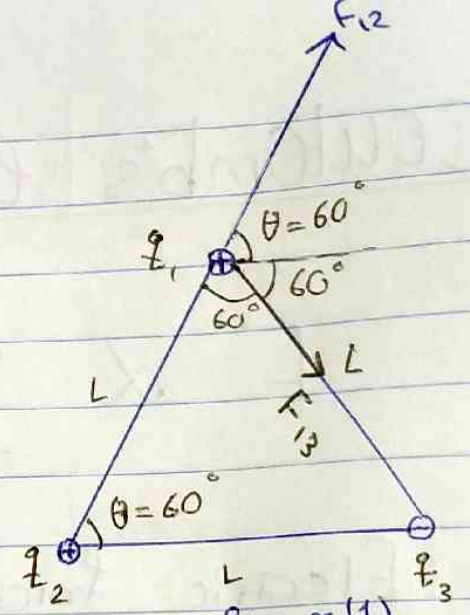


figure (1)

* find the net force (or resultant force) on q_1 ?!

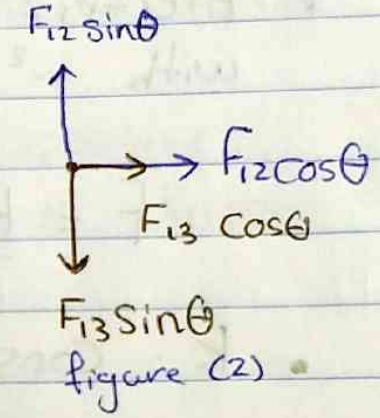


figure (2)

$$F = \frac{9\times10^9 \times q_1 \times q_2}{r^2}$$

$$F_{12} = \frac{9\times10^9 \times 50\times10^{-6} \times 50\times10^{-6}}{(0.5)^2}$$

$= 90\ N$ in the direction shown in figure (1)

$$F_{13} = \frac{9\times10^9 \times 50\times10^{-6} \times 50\times10^{-6}}{(0.5)^2}$$

$= 90\ N$ in the direction show in figure (2)

- $F_y = F_{12}\sin60 - F_{13}\sin60 = 0$
- $F_x = F_{12}\cos60 + F_{13}\cos60 = 90\cos60 + 90\cos60$

$= 90\ N$ in $(+x)$ direction

$= \text{or}\sim\ 90\ N\ \hat{i}$

Example:

- let $q_3 = +50\ \mu c$

⇒ Find the resultant (electrostatic) force on q_1 ?!

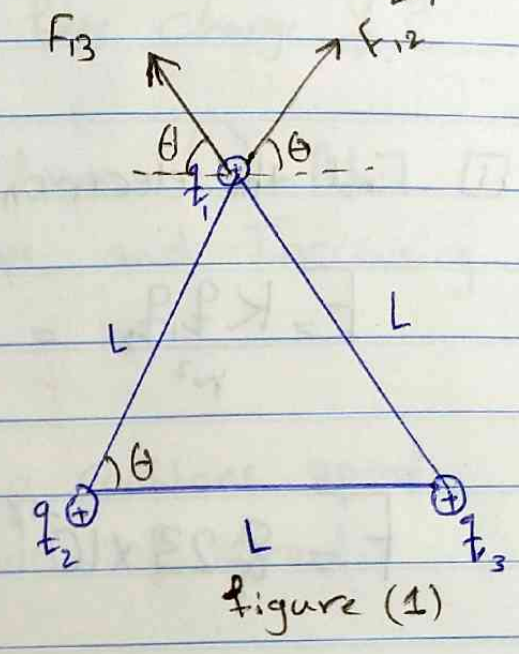
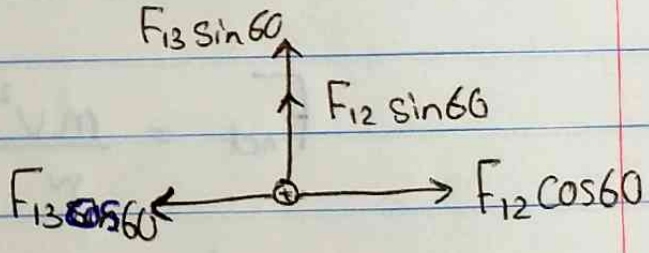


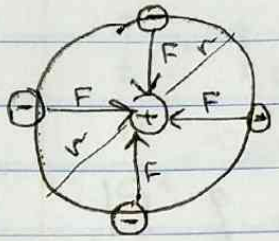
figure (1)

$$F_y = F_{12}\sin 60 + F_{13}\sin 60$$
$$= 90\frac{\sqrt{3}}{2} + 90\frac{\sqrt{3}}{2}$$
$$= 156\ N \text{ in } (+y) \text{ direction}$$
$$= \text{or } 156\hat{j}\ N$$

$$F_x = F_{12}\cos 60 - F_{13}\cos 60$$
$$= \text{zero}.$$



problem: H_ atomic In Bohrs model electron moves in a circular motion arounel the nucleus (proton).



The Radius = 5.29×10^{-11} m

$e = 1.6 \times 10^{-19}$ C

$m_e = 9.11 \times 10^{-31}$ kg

[1] Find the electron Static force on the electron?

$$F = \frac{K q_1 q_2}{r^2} = \frac{K q_e q_p}{r^2} = \frac{9 \times 10^9 \times 1.6 \times 10^{-19} \times 1.6 \times 10^{-19}}{(5.29 \times 10^{-11})^2}$$

$F = 8.23 \times 10^{-18}$, toward the Center.

[2] Find the electron Speed ?

$$F_{net} = \frac{mv^2}{r} \Rightarrow 8.23 \times 10^{-18} = \frac{9.11 \times 10^{-31} V^2}{5.29 \times 10^{-11}}$$

$V = 2.187 \times 10^6$ m/s

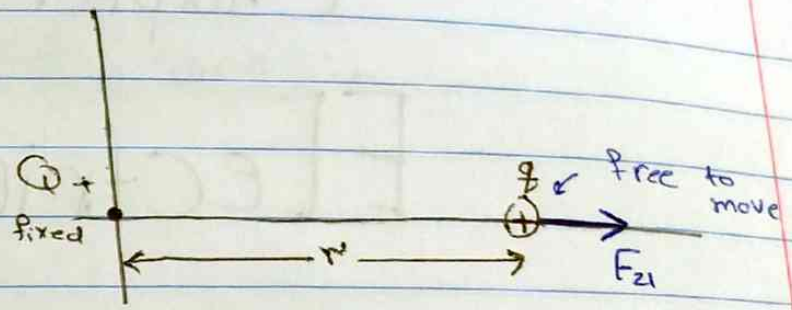
[3] Find the electron kinatic energy?

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

$$= \frac{1}{2} \times 9.11 \times 10^{-31} \times (2.187 \times 10^6)^2$$

$$= 2.18 \times 10^{-8} \text{ J}$$

problem ⟹



1) Describe the motion of free charge q ?

- It will move away from Q At decreasing acceleration and Increasing speed.

- In ∞ it will move in a constant speed with maximum magnitude of speed