Coulomb's Law :

If two stationary point charge q_1 and q_2 are kept at a distance r, then it is found that force of attraction or repulsion between them is -

$F \propto q_1$

$F \propto q_2$

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

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

$\boxed{F = K \frac{q_1 q_2}{r^2}}$, K = Proportionality constant.

$K = \frac{1}{4\pi\epsilon_0} = 9 \times 10^9 \ N\text{-}m^2/c^2$

or, $\boxed{F = \frac{1}{4\pi\epsilon_0} \cdot \frac{q_1 q_2}{r^2}}$, ϵ_0 = permittivity of free space

$\epsilon_0 = 8.85 \times 10^{-12} \ c^2/n\text{-}m^2$

↳ dimensional formula: $[M^{-1}L^{-3}T^4A^2]$

~~For free space~~

For Medium

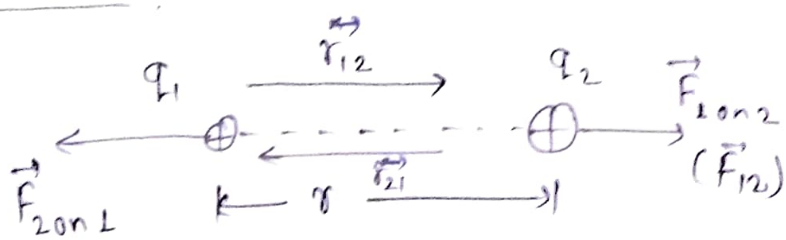
$\boxed{F_m = \frac{1}{4\pi\epsilon_0 K} \cdot \frac{q_1 q_2}{r^2}}$, ϵ = permittivity of medium

K = dielectric constant / Relative permittivity

ie $\epsilon_0 K = \epsilon \Rightarrow \boxed{K = \frac{\epsilon}{\epsilon_0}}$ ↳ dielectric constant or relative permittivity.

For free space K = 1

Vector form of Coulomb's law:



Vector form of coulomb's law is -

$$\boxed{\vec{F}_{12} = k\frac{q_1 q_2}{r_{12}^2}\hat{r}_{12}}$$

$$\vec{F}_{12} = k\frac{q_1 q_2}{r_{12}^3}\vec{r}_{12} \quad \text{——} (1)$$

Where. $\vec{F}_{12}$ = Force on charge q_2 due to charge q_1.

r_{12} = vector position of q_2 from q_1

$\hat{r}_{12}$ = unit vector $\Rightarrow \hat{r}_{12} = \frac{\vec{r}_{12}}{|\vec{r}_{12}|} = \frac{\vec{r}_{12}}{r_{12}}$

Similarly,

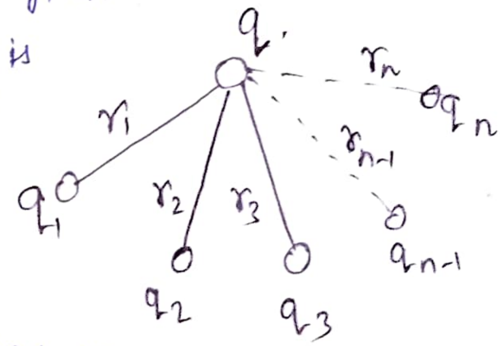
$$\vec{F}_{21} = k\frac{q_1 q_2}{r_{21}^2}\hat{r}_{21} = k\frac{q_1 q_2}{r_{21}^3}\vec{r}_{21} \quad \text{——} (2)$$

From eqn. (1) & (2), $\vec{r}_{12}$ & $\vec{r}_{21}$ are equal but in opposite direction

Hence, $\boxed{\vec{F}_{12} = -\vec{F}_{21}}$

ie the forces exerted by the two charges on each other are equal and opposite (Newton's third law is obeyed).

Principle of superposition:- According to the principle of superposition, total forces acting on a given charge due to number of charges is the vector sum of the individual forces acting on that charge due to all the charges.



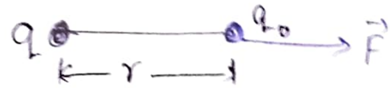
consider n number of charges $q_1, q_2, q_3, \ldots\ldots q_n$ applying on a charge q. Then Net force on q will be.

$$\boxed{\vec{F}_{net} = \vec{F}_1 + \vec{F}_2 + \cdots + \vec{F}_n = k\sum_{i=1}^{n}\frac{q q_i}{r_i^2}\hat{r}_i}$$

Electric field:- A positive charge or a negative charge is said to create its field around itself. Thus the space around a charge in which another charged particle experiences a force is said to have electric field in it.

Electric field intensity ($\vec{E}$): The electric field intensity at any point is defined as the force experienced by a unit positive charge placed at that point.

ie
$$\vec{E} = \frac{\vec{F}}{q_0}$$



$$\because \vec{F} = k\frac{q q_0}{r^2}$$

$$\vec{E} = \frac{k q q_0}{r^2} = k\frac{q}{r^2}$$

$$\boxed{\vec{E} = k\frac{q}{r^2}}$$

Where $q_0 \to 0$, so that presence of this charge may not affect the source charge q. and its field is not changed, therefore expression for electric field intensity can be better written as—

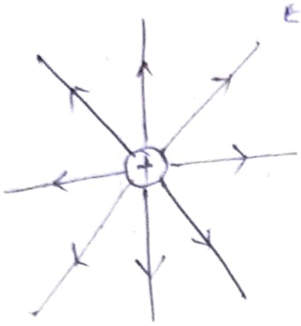
$$\boxed{\vec{E} = \lim_{q_0 \to 0} \frac{\vec{F}}{q_0}}$$

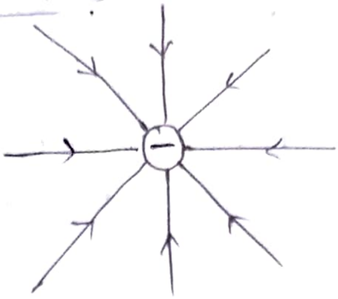
unit = S.I. unit = $\frac{\text{newton}}{\text{Coulomb}} = \frac{\text{volt}}{\text{meter}} = \frac{\text{Joule}}{\text{Coulomb} \times \text{meter}}$

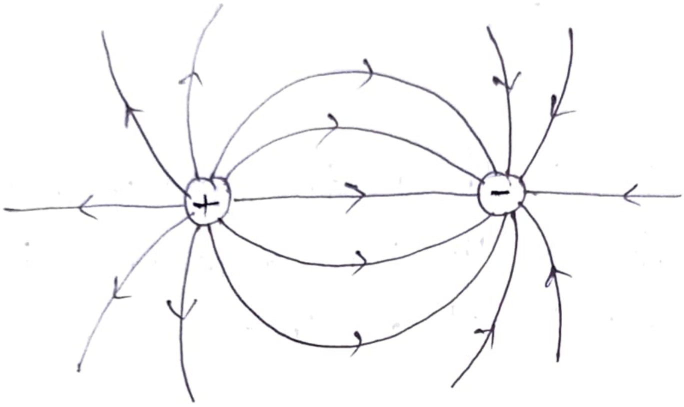
Dimension = $[MLT^{-3}A^{-1}]$

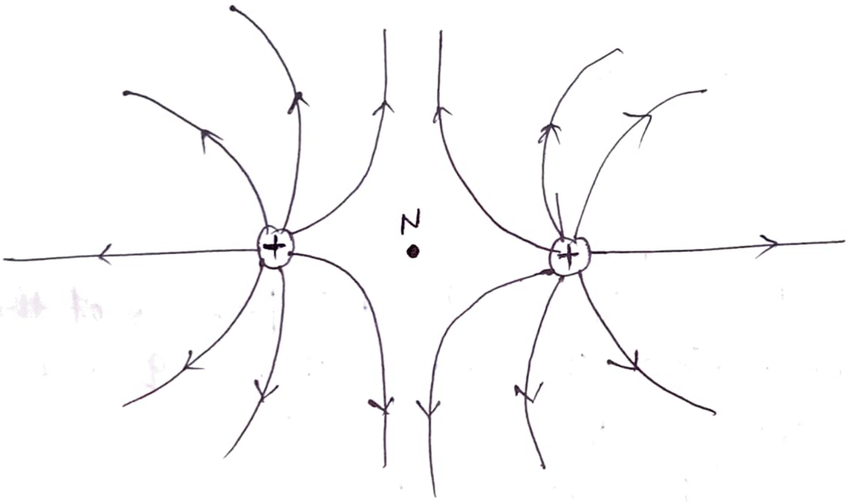
Direction:- ~~Direction~~ Electric field intensity ($\vec{E}$) is a vector quantity. Electric field due to a positive charge is always away from the charge and that due to negative charge is always towards the charge.

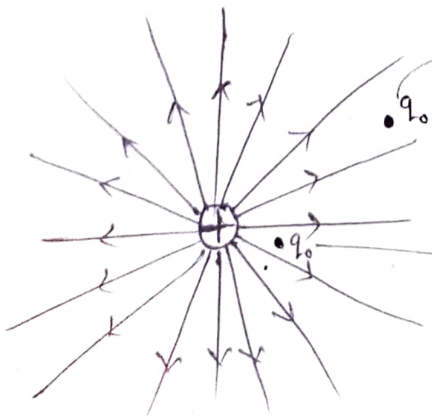
Electric field lines











Electric field strength is less

Electric field strength is higher.