

### Coulomb's law

According to this law, the force of attraction or repulsion between two charged body is directly proportional to product of magnitude of their charges and inversely proportional to square of distance between them.

If  $Q_1$  and  $Q_2$  are two charges placed at distance 'r' from each other, then magnitude of force will be given as,

$$F \propto Q_1 \cdot Q_2 \dots\dots\dots (i) \text{ and}$$

$$F \propto 1/r^2 \dots\dots\dots(ii)$$

After combining these two we get

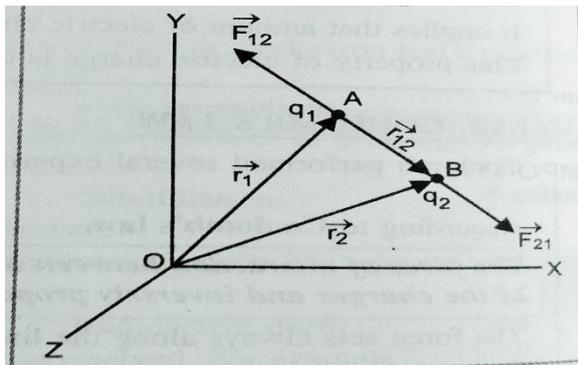
$$F \propto Q_1 \cdot Q_2 / r^2$$

Or  $F = K Q_1 \cdot Q_2 / r^2$  where K is a constant given as

$$K = 1/4\pi\epsilon_0 = 9 \times 10^9 \text{ here } \epsilon_0 \text{ is called permittivity in}$$

vacuum or air.  $\epsilon_0 = 8.85 \times 10^{-12} \text{ C}^2 \cdot \text{N}^{-1} \cdot \text{m}^{-2}$

Coulomb's law in vector form –



As shown in figure  $\vec{r}_1 = \vec{OA}$  and  $\vec{r}_2 = \vec{OB}$

Again  $\vec{r}_{12} = \vec{AB} = \vec{r}_2 - \vec{r}_1$

And,  $\vec{r}_{21} = \vec{BA} = \vec{r}_1 - \vec{r}_2$

And,  $r_{12} = r_{21} = r$

also we can write  $\hat{r}_{12} = \vec{r}_{12} / r_{12}$

Similarly  $\hat{r}_{21} = \vec{r}_{21} / r_{21}$

If, force acting on  $q_1$  due to  $q_2$  is  $F_{12}$  and force acting on  $q_2$  due to  $q_1$  is  $F_{21}$

Therefore,  $\vec{F}_{21} = k q_1 q_2 / (AB)^2$  along AB

Or,  $\vec{F}_{21} = (k q_1 q_2 / r^3) \hat{r}_{12}$

Similarly  $\vec{F}_{12} = (k q_1 q_2 / r^3) \hat{r}_{21} = -(k q_1 q_2 / r^3) \hat{r}_{12} = -\vec{F}_{21}$  ;

**Dielectric constant or relative permittivity** - Dielectric constant of a given medium is the ratio of permittivity of the medium to the permittivity of free space (vacuum /air )

Or

Dielectric constant of a given medium is the ratio of force of interaction between two charges separated by a certain distance in vacuum/air to the force of interaction between two given charges at the same distance in that medium .

Dielectric constant  $K (\epsilon_r) = \epsilon_m / \epsilon_0 = F_0 / F_m$  where ;

$F_0$  = force of interaction between two charges separated by a certain distance in vacuum/air

$F_m$  = force of interaction between two charges separated by a certain distance in the given medium

\*Dielectric constant is unitless .