ELECTROSTATICS

CHARGE

* There are two types of charges ① Positive ② Negative
* There are three ways to transfer charges
① Friction - when both the bodies are rubbed together, both of them get oppositely charged
② Conduction - when a charge body is placed in contact with uncharged body, then same charge is developed into other
③ Induction - In this process, a charged object induces charge in an uncharged conductor placed near it, without touching

* Properties of charges.
① Conservation of charge - charge can neither be produced nor destroyed, it can only be transfered from one body to other. For an isolated system of bodies $\Sigma q = 0$
② Additive property :- Total charge on an isolated system is equal to the algebraic sum of charges. If a system contains, $q_1, -q_2, q_3$ charges, then total charge $Q = q_1 - q_2 + q_3$.
③ Quantisation of charge
The total charge on a body is integral multiple of fundamental charge e
$q = \pm ne$. n is an integer.
$n = 1, 2, 3, \ldots$
④ Charge is invariant
charge remains unaffected of its motion.
⑤ Attractive and Repulsive property -
like charges repel.
unlike ,, attracts.

* S.I. unit of charge is coulomb
1 coulomb = 1 ampere - second
Electron has 1.6×10^{-19} coulomb.

COULOMB'S LAW

"The force of attraction or repulsion between two point charges is directly proportional to the product of magnitude of charges and inversely proportional to the square of distance between them. The direction of the force is along the line joining the two charges"

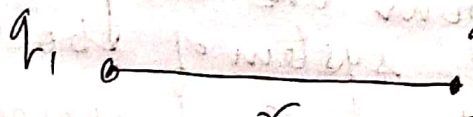
$$F = \frac{k\, q_1 q_2}{4\pi \epsilon_0 r^2} \qquad k = \frac{1}{4\pi\epsilon_0}$$

ϵ_0 = Permittivity of free space

If the charge is taken into the medium

$$F = \frac{1}{4\pi\epsilon} \frac{q_1 q_2}{r^2}$$

r = distance between the charges



ϵ = permittivity of the medium

$\epsilon = \epsilon_0 \epsilon_r$

ϵ_r = Relative permittivity or dielectric constant (K)

$$F = \frac{1}{4\pi \epsilon_0 \epsilon_r} \frac{q_1 q_2}{r^2}$$

dielectric constant (K)

It is defined as the ratio of permittivity of medium to the free space.

ie. ϵ_r or $K = \frac{\epsilon}{\epsilon_0}$

$K > 1$ for all dielectric medium
$K = \infty$ for metals
$K = 1$ for air or vacuum.
$K = 81$ for water.

permittivity of free space is $8.85 \times 10^{-12} C^2 N^{-1} m^{-2}$

$$\epsilon_0 = \frac{[A^2 T^2]}{[MLT^{-2}][L^2]} = [M^{-1} L^{-3} T^4 A^2]$$

In M.K.S. system unit of ϵ_0 is $kg^{-1} m^{-3} s^4 A^2$

Coulomb's law in Vector form

$$\vec{F} = \frac{1}{4\pi\epsilon_0} \frac{q_1 q_2}{r^2} \hat{r}$$

$$\hat{r} = \frac{\vec{r}}{|\vec{r}|} = \frac{\vec{r}}{r}$$

$$\vec{F} = \frac{1}{4\pi\epsilon_0} \frac{q_1 q_2}{r^3} \vec{r}$$

ϵ is termed as epsilon.

Important points

* Law holds for point charges.
* Both charges exert equal and opposite forces on each other.
* The force is central.
* The force between two charges depends upon the medium present.

Ques. If the distance between the two equal point charges is halved and their individual charges are doubled, what would happen to the force between them?

Sol^n $F = \frac{1}{4\pi\epsilon_0} \frac{q_1 q_2}{r^2} = \frac{1}{4\pi\epsilon_0} \frac{q^2}{r^2}$ $(q_1 = q_2 = q)$

New force $F' = \frac{1}{4\pi\epsilon_0} \frac{(2q)^2}{(r/2)^2} = 16 \times \frac{1}{4\pi\epsilon_0} \frac{q^2}{r^2}$

$F' = 16F$.