Electrostatics

Deals with the study of electric charges at rest.

Electric charges - S.I unit is Coulomb (C)

Properties of electric charges

1. Like charges repels and unlike charges attract each other.

2. Quantisation of charge

Any charge in nature is an integral multiple of a fundamental charge 'e' where 'e' is the charge of an electron. i.e. $\boxed{q = \pm ne}$ where $n = 1, 2, 3, \ldots$

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

3. Conservation of charge

Charge can neither be created nor be destroyed. For any system, total charge must be conserved. But charge can be transferred from one body to another.

4. Additive property

Electric charges are additive in nature. When we add charges, we must take care of their sign also.

Different Methods of Charging

1. Charging by Conduction: A body can be charged by bringing a charged body in contact with it. Same type of charge is transferred by contact.

2. Charging by Induction: A body can be charged when a charged body brought near it. Opposite type of charge is induced by induction.

3. Charging by friction : A body can be charged by rubbing it with special materials.
Consider a series of materials : Glass, Flannel, Wool, Silk, metal, Rubber, Wax, etc. When two substances in the series rubbed together acquire electric charges in such a way that, the former gets +ve charge and the later gets -ve charge.

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Problem 1

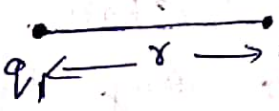
1) How many electronic charges form 1 C of charge?

2) A comb drawn through person's hair causes 10^{22} electrons to leave the person's hair and stick to the comb. Calculate the charge carried by the comb?

Coulomb's Law : Force between two point charges or repulsion

The force of attraction between two point charges is directly proportional to the product of charges and inversely proportional to the square of distance between them.

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



$$F = \frac{1}{4\pi\epsilon} \frac{q_1 q_2}{r^2}$$ where ϵ is called permittivity of the medium between the charges.

If the charges are in free space 'ϵ' changes to 'ϵ_0' which is known as permittivity of free space.

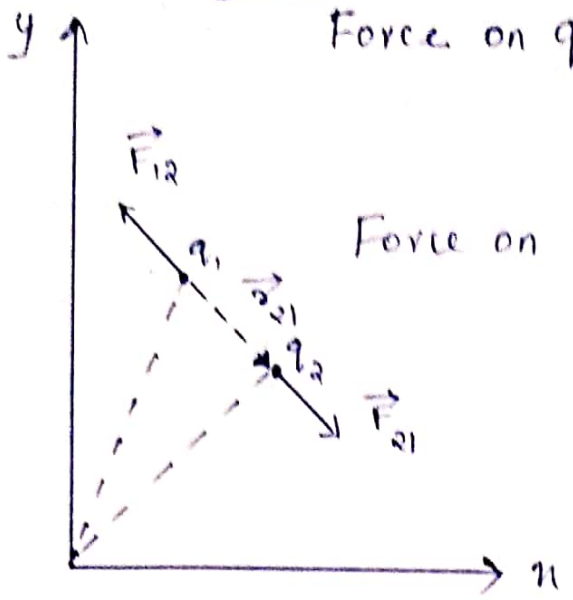
Relative permittivity (Dielectric Constant) ϵ_r

The ratio of permittivity 'ϵ' of a medium to permittivity of free space 'ϵ_0'.

$$\boxed{\epsilon_r = \frac{\epsilon}{\epsilon_0}}$$

$\frac{1}{4\pi\epsilon_0} = 9 \times 10^9 \ N m^2 C^{-2}$ and $\epsilon_0 = 8.85 \times 10^{-12} \ C^2 N^{-1} m^{-2}$.

Coulomb's law in vector form



Force on q_2 due to q_1 is

$$\vec{F}_{21} = \frac{1}{4\pi\epsilon_0} \frac{q_1 q_2 (\hat{r}_{21})}{|\vec{r}_{21}|^2}$$

Force on q_1 due to q_2 is

$$\vec{F}_{12} = \frac{1}{4\pi\epsilon_0} \frac{q_1 q_2 (-\hat{r}_{21})}{|\vec{r}_{21}|^2}$$

$$\vec{F}_{21} = -\vec{F}_{12}$$

Electro Static Force

* Long Range central force that obeys inverse square law
* Obeys Newton's 3rd law
* It is a Conservative force

If the medium is not vacuum, $\epsilon = \epsilon_0 \epsilon_r$

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

$$F_{air} = \frac{1}{4\pi\epsilon_0} \frac{q_1 q_2}{r^2}$$

$$\therefore \epsilon_r = \frac{F_{air (vacuum)}}{F_{med}}$$

Super Position Principle

The net force acting on a charge due to more than 1 charge will be the vector sum of forces due to individual charges

$$\vec{F} = \vec{F}_1 + \vec{F}_2 + \vec{F}_3 + \cdots \vec{F}_n$$