INTRODUCTION

The branch of physics which deals with electric effect of static charge is called electrostatics.

ELECTRIC CHARGE

Charge of a material body or particle is the property (acquired or natural) due to which it produces and experiences electrical and magnetic effects. Some of naturally occurring charged particles are electrons, protons, -particles etc.

Charge is a derived physical quantity & is measured in Coulomb in S.. unit. In practice we use mC(10^{-3}C), C (10^{-6}C), nC(10^{-9}C) etc.
C.G.S. unit of charge = electrostatic unit = esu. 1 coulomb = 3 × 109 esu of charge
Dimensional formula of charge = [$M^0L^0T^1I^1$]

Properties of Charge

- **Charge is a scalar quantity :** It adds algebraically and represents excess or deficiency of electrons.

- **Charge is of two types :** (i) Positive charge and (ii) Negative charge Charging a body implies transfer of charge (electrons) from one body to another. Positively charged body means loss of electrons i.e. deficiency of electrons. Negatively charged body means excess of electrons. This also shows that mass of a negatively charged body > mass of a positively charged identical body.

- **Charge is conserved :** In an isolated system, total charge (sum of positive and negative) remains constant whatever change takes place in that system.

- **Charge is quantized :** Charge on any body always exists in integral multiples of a fundamental unit of electric charge. This unit is equal to the magnitude of charge on electron (1e = 1.6 × 10^{-19} coulomb). So charge on anybody is Q = ±ne, where n is an integer and e is the charge of the electron. Millikan's oil drop experiment proved the quantization of charge or atomicity of charge

- Like point charges repel each other while unlike point charges attract each other.

- Charge is always associated with mass, i.e., charge can not exist without mass though mass can exist without charge. The particle such as photon or neutrino which have no (rest) mass can never have a charge.

- **Charge is relativistically invariant :** This means that charge is independent of frame of reference i.e. charge on a body does not change whatever be its speed. This property is worth mentioning as in contrast to charge, the mass of a body depends on its speed and increases with increase in speed. (viii) A charge at rest produces only electric field around itself, a charge having uniform motion produces electric as well as magnetic field around itself while a charge having accelerated motion emits electromagnetic radiations.

Conductor :

Conductors are the material in which the outer most electrons are very loosely bound, so they are free to move (flow). So in a conductor, there are large number of free electrons. Ex. Metals like Cu, Ag, Fe, Al.....

Insulator or Dielectric or Nonconductor :

Non-conductors are the materials in which outer most electrons are very tightly bound, so that they cannot move (flow). Hence in a non-conductor there are no free electrons. Ex. plastic, rubber, wood etc.

Semi conductor :

Semiconductors are the materials which have free electrons but very less in number. Now lets see how the charging is done by conduction. In this method, we take a charged conductor 'A' and an uncharged conductor 'B'. When both are connected, some charge will flow from the charged body to the uncharged body. If both the conductors are identical & kept at large distance and connected to each other, then charge will be divided equally in both the conductors otherwise they will flow till their electric potential becomes same. Its detailed study will be done in last section of this chapter.

COULOMB'S LAW (INVERSE SQUARE LAW) :

On the basis of experiments Coulomb established the following law known as Coulomb's law : The magnitude of electrostatic force between two point charges is directly proportional to the product of charges and inversely proportional to the square of the distance between them.

$$\text{i.e. } F \propto q_1 q_2 \text{ and } F \propto \frac{1}{r^2} \Rightarrow F \propto \frac{q_1 q_2}{r^2} \Rightarrow F = \frac{K q_1 q_2}{r^2}$$

Important points regarding Coulomb's law :

- It is applicable only for point charges. $q_1\ r^2$
- The constant of proportionality K in SI units in vacuum is expressed as $\frac{1}{4\pi\varepsilon_0}$ and in any other medium expressed as $\frac{1}{4\pi\varepsilon}$. If charges are dipped in a medium then electrostatic force on one charge is $\frac{1}{4\pi\varepsilon_0\varepsilon_r}\frac{q_1q_2}{r^2}$ where ε_0 and ε_r are called permittivity of vacuum and absolute permittivity of the medium respectively. The ratio $\varepsilon/\varepsilon_r = \varepsilon_0$ is called relative permittivity of the medium, which is a dimensionless quantity.
- The value of relative permittivity r is constant for a medium and can have values between 1 to ∞ . For vacuum, by definition it is equal to 1. For air it is nearly equal to 1 and may be taken to be equal to 1 for calculations. For metals, the value of r is and for water is 81. The material in which more charge can induce r will be higher.
- The value of $\frac{1}{4\pi\varepsilon_0}$ = 9 × 109 $Nm^2\ C^{-2}$ & ε_0 = 8.855 × $10^{-12}\ C^2/Nm^2$. Dimensional formula ε of is $[M^{-1}\ L^{-3}\ T^4\ A^2]$.
- The force acting on one point charge due to the other point charge is always along the line joining these two charges. It is equal in magnitude and opposite in direction on two charges, irrespective of the medium in which they lie.
- The force is conservative in nature i.e., work done by electrostatic force in moving a point charge along a closed loop of any shape is zero.
- Since the force is a central force, in the absence of any other external force, angular momentum of one particle w.r.t. the other particle (in two particle system) is conserved.
- In vector form formula can be given as below. $|\vec{r}|^3$

  F = $\frac{1}{4\pi\varepsilon_0\varepsilon_r}\frac{q_1q_2}{|\vec{r}|^3}\vec{r} = \frac{1}{4\pi\varepsilon_0\varepsilon_r}\frac{q_1q_2}{|\vec{r}|^2}\hat{r}$; (q1 & q2 are to be substituted with sign.)

  Here, r is position vector of the test charge (on which force is to be calculated) with respect to the source charge (due to which force is to be calculated).