PHYSICS

CLASS NOTES FOR CBSE

Chapter 17. Electric Charges and Fields

01. Introduction

Electrostatics, deals with the study of charges in rest. These stationary charges occurs due to friction of two insulting bodies, therefore it is often called frictional electricity.

Important points

(i) Gravitational force is the weakest while nuclear force is the strongest force of the nature

(ii) Nuclear force does not depend upon charge, it acts equally between proton-proton, proton neutron and neutron-neutron.

(iii) There are weak forces acting in β-degradiation in radio-activity.

(iv) A stationary charge produces electric filed while a moving charge produce electric as well as magnetic field.

(v) Moving charge produce electric field as well as magnetic field but does not radiate energy while uniform acceleration.

(vi) Accelerated charge produce electric field as well as magnetic field and radiate energy.

02. Charge

Property of a substance by virtue of which it can repel or attract another charged substance.

Charges are of two types

(a) Positive charge : Lesser number of electrons than number of protons.

(b) Negative charge : More number of electrons than number of protons

Importants Points : Only, electron is responsible for a substance to be charged and not the proton.

Properties of Charge

(i) Like charges repel while unlike charges attract each other.

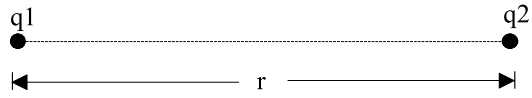
(ii) Charge is quantized in nature i.e. The magnitude of charge possessed by different objects is always and integral multiple of charge of electron (or proton) i.e. $q = \pm ne$ where $n = 1, 2, 3$ ....

(iii) The minimum possible charge that can exist in nature is the charge of electron which has a magnitude of $e = 1.60207 \times 10^{-19}$ coulomb. This is also known as quantum of charge or fundamental charge.

(iv) In an isolated system the algebraic sum of total charge remains constant. This is the law of 'Conservation of charge'.

03. Coulomb's Law

The force of attraction or repulsion between two stationary point charges is directly proportional to the product of charges and inversely proportional to the square of distance between them. This force acts along the line joining the two. If q_1 & q_2 are charges in consideration r, the distance between them and F, the force acting between them



Then, $F \propto q_1 q_2$

$$F \propto 1/r^2$$

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

$$\Rightarrow \quad F = K\frac{q_1 q_2}{r^2}, \text{ where } k = \text{constant.}$$

$$K = \frac{1}{4\pi\varepsilon_0\varepsilon_r} = \frac{9\times10^9}{\varepsilon_r} N m^2 C^{-2}$$

where,

ε_0 = Electric permittivity of vacuum or air

$= 8.85 \times 10^{-12} C^2 N^{-1} m^{-2}$ and

K or ε_r = Relative permittivity or Dielectric constant or Specific inductive capacity

$$\varepsilon_r = \frac{\varepsilon}{\varepsilon_0} \Rightarrow \varepsilon = \varepsilon_0 \varepsilon_r$$

[Newton's law for particles is analogous to coulomb's law for rest charge. The difference is that Newton's law gives attraction force while coulomb's law gives attraction as well as repulsion force]

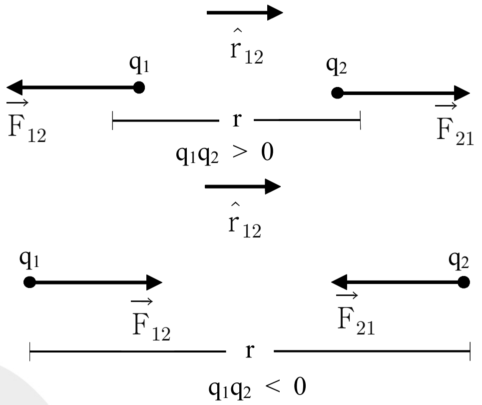
NOTE ☞ (i) Coulomb's law is applicable to point charges only. But it can be applied for distributed charges also

(ii) This law is valid only for stationary charges and cannot be applied for moving charges.

(iii) This law is valid only if the distance between two charges is not less than 10^{-15} m

Direction

Direction of the force acting between two charges depends upon their nature and it is along the line joining two charges.



$\vec{F}_{21}$ = force on q_2 due to q_1

$$\vec{F}_{21} = \frac{q_1 q_2}{4\pi\varepsilon_0\varepsilon_r r_{12}^2}\hat{r}_{12} \qquad \text{........(A)}$$

(where $\hat{r}_{12}$ is a unit vector pointing from q_1 to q_2)

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

$$\vec{F}_{12} = \frac{q_1 q_2}{4\pi\varepsilon_0\varepsilon_r r_{12}^2}\hat{r}_{21} \qquad \text{........(B)}$$

(where $\hat{r}_{21}$ is a unit vector pointing from q_2 to q_1)

⇒ Electric force between two charges not depends on neighbouring charges.

⇒ If a dielectric slab $(\in_r)$ of thickness 't' is placed between two charges (distance d), force decreases.

$$F = \frac{Q_1Q_2}{4\pi\in_0 r^2} \qquad \text{where } r = d - t + t\sqrt{\in_r}$$

04. Electric Field

A charge produces something called and electric field in the space around it and this electric field exerts a force on any charge placed in it.

NOTE ☞ The electric field does not exert force on source charge.

Electric field Intensity

Force experienced by a unit positive charge placed in and electric field at a point is called electric field intensity at that point. It is also known as electric field simply. Let q_0 be the positive test charge placed in an electric field. If $\vec{F}$ is the force experienced by this charge, then