Chapter 1st ⇒ Electric charges and Field

Electric charge ⇒ Electric charge is an intrinsic property of elementary particle which it automatically accompanies.

* SI unit of electric charge → coulomb (c)
* It is scalar quantity

Dimension of charge

$$\text{current} = \frac{\text{charge}}{\text{Time}}$$

$$q = \frac{Q}{t}$$

$$Q = qt$$

$$\text{Dim.} \Rightarrow [AT]$$

$$= [M^0L^0T^1A^1]$$

Production of charge :-

① Frictional electricity ⇒ electricity produced by friction.

Ex When a glass rod is rubbed by silk cloth. In this rubbed substance became electrified. It is bcz of friction that the substance get charged on rubbing.

Electrostatic ... study of charges at rest

(ii) Induction method ⇒ In this method neutral body is charged by bringing a charged body nearby to it.

Properties of Electric charge

(i) Additive nature of electric charge ⇒ Since the charge is scalar quantity it fallow simple alzebric sum.
It means that if a system contain charges $q_1, q_2 - - - q_n$ then it's total charge will be

$$\boxed{q = q_1 + q_2 + - - - q_n}$$

(ii) Conservation of charge ⇒ Charge can neither be created nor be destroyed it can only transformed from one system to another. Net charge will always remain same.

(iii) Quantisation of charge ⇒ This law states that quantity of a charge on a particle is always an integeral multiple of least amount of charge.
e is the basic unit of charge.

$$q = \pm ne.$$

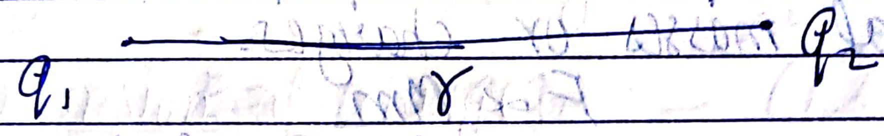
When a glass rod is rubbed with silk cloth then glass rod acquire (+)ve charge and silk acquire equal (-)ve charge.

Scanned with CamScanner

Coulomb's law

This law states that the force acting b/w two charges get seperated by a distance r is directly proportional to the product of the charges and inversely proportional to the square of distance b/w them.

$\Rightarrow$



If two point charges q_1 and q_2 are seperated by distance r then Force of attraction or repulsion b/w them is such that

$$F \propto q_1 q_2 \quad \text{--- (I)}$$

$$F \propto \frac{1}{r^2} \quad \text{--- (II)}$$

Combining (I) and (II)

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

$$F = \frac{k q_1 q_2}{r^2}$$

$k \rightarrow$ electrostatic force constant

$$\boxed{F = \frac{1}{4\pi\varepsilon_0} \frac{q_1 q_2}{r^2}}$$

$\varepsilon_0 \rightarrow$ permitivity of free space or vaccum.

$K = 9 \times 10^9$

Comparing electrostatic and Gravitational Forces

Simmilarities :-

(I) Both forces obey inverse square law.

$$F \propto \frac{1}{r^2}$$

(II) Both forces are proportional to product of masses or charges.

$$F \propto Mm$$

$$F \propto q_1 q_2$$

(III) Both are central forces i.e they act along the line joining the centres of the two ~~bodies~~ bodies.

(IV) Both are conservative forces

(V) Both can operate in vaccum.

Dissimilarities :-

(I) Gravitational forces is attractive while electrostatic force may be attractive or repulsive.

(II) Gravitational force does not depend on nature of substance while electrostatic force depends on nature of substance.

(III) Electrostatic force are much stronger than gravitational forces.

Date
Page No.

Numerical → If two charges system is kept in vaccum then immersed as it is in liquid then what will be the effect on force.

Sol ⇒

q_1 —— r —— q_2

In vaccum

By coulomb's law, $F = \frac{k q_1 q_2}{r^2}$

$$F_0 = \frac{1}{4\pi\varepsilon_0} \frac{q_1 q_2}{r^2} \quad \text{—— (I)}$$

In liquid

$$F = \frac{1}{4\pi\varepsilon} \frac{q_1 q_2}{r^2} \quad \text{—— (II)}$$

(I) / (II)

$$\frac{F_0}{F} = \frac{1}{4\pi\varepsilon_0} \frac{q_1 q_2}{r^2} \times \frac{4\pi\varepsilon r^2}{q_1 q_2}$$

$$\frac{F_0}{F} = \frac{\varepsilon}{\varepsilon_0}$$

$$\frac{F}{F_0} = \frac{\varepsilon_0}{\varepsilon}$$

$$\frac{F}{F_0} = \frac{\varepsilon_0}{k\varepsilon_0} \quad [\varepsilon = k\varepsilon_0]$$

k → dielectric constant

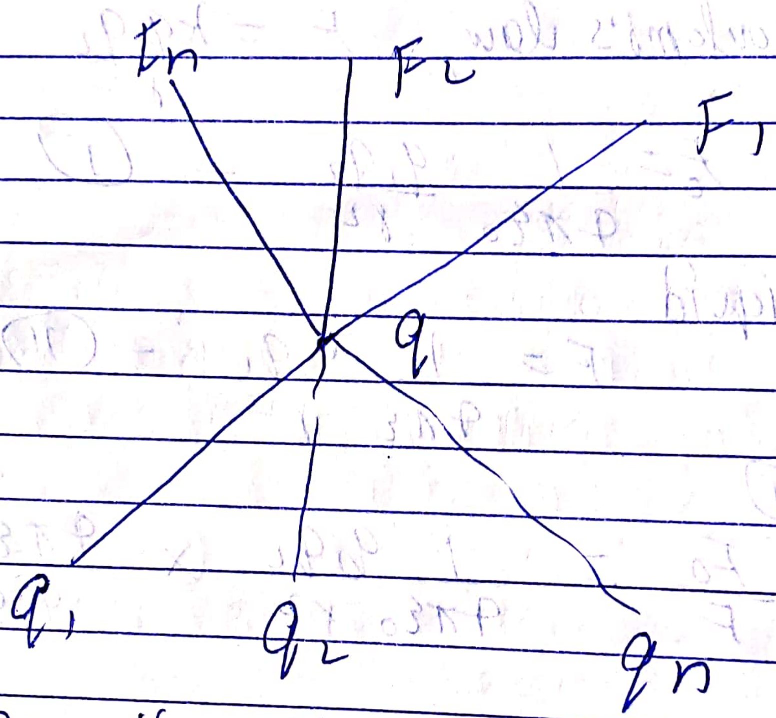
$$\frac{F}{F_0} = \frac{1}{k} \qquad F = \frac{F_0}{k}$$

For liquid $k > 1$ and for vaccum $k = 1$.

$$\boxed{F < F_0}$$

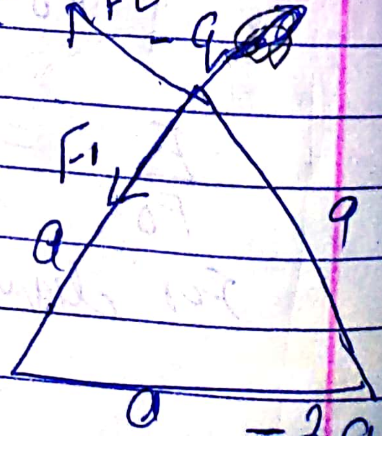
Forces b/w multiple charges or Principle of Superposition

⇒ It states that when a number of charges are interacting then the total force on a given charge is the vector sum of all forces exerted on it due to all other charges.



According to superposition principle Total force on charge q_1 is given by, $\vec{F_0} = \vec{F_1} + \vec{F_2} + \ldots \vec{F_n}$

Q. Find resultant force acting on (-q).



⇒ Force acting on charge (-q) due to q

$F_1 = \frac{Kq^2}{a^2}$

Force acting on charge (-q) due to (-2q)

$$F_2 = \frac{2Kq^2}{a^2}$$

$$F_2 = 2F_1$$

Resultant force acting on $(-q)$

$$F = \sqrt{F_1^2 + F_2^2 + 2F_1F_2\cos 120^\circ}$$

$$F = \sqrt{F_1^2 + (2F_1)^2 + 2F_1(2F_1)\left(-\frac{1}{2}\right)}$$

$$F = \sqrt{F_1^2 + 4F_1^2 + 4F_1^2\left(-\frac{1}{2}\right)}$$

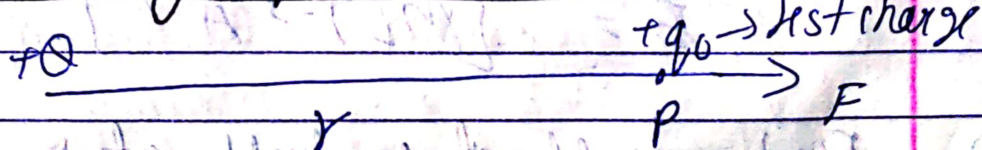
$$F = \sqrt{5F_1^2 - 2F_1^2}$$

$$F = \sqrt{3}\,F_1$$

$$F = \sqrt{3}\,\frac{Kq^2}{a^2}$$

- **Electric field** ⇒ The space surrounding a charge in which another charge experience an electric force is called electric field.

Electric field due to point charge or Intensity of electric field



$$E = \frac{F}{q_0} \quad - \quad \frac{\text{Force}}{\text{test charge}} \quad (1)$$

By coulomb's law $F = \frac{1}{4\pi\varepsilon_0} \cdot \frac{Q q_0}{r^2}$

Date
Page No.

Substituting F in 1

$$E = \frac{1}{4\pi\varepsilon_0} \frac{Q}{\frac{q_0}{\frac{r^2}{q_0}}}$$

$$\boxed{E = \frac{1}{4\pi\varepsilon_0}\frac{Q}{r^2}} \text{ or } \boxed{E = \frac{kQ}{r^2}}$$

* unit of e-field → N/C
* It is vector quantity
* The test charge (q_0) must be very small so that it doesn't change value of E.

Dimension of e-field

$$E = \frac{F}{q}$$

$$\text{Dim. } E = \frac{\text{Dim. } F}{\text{Dim. } q}$$

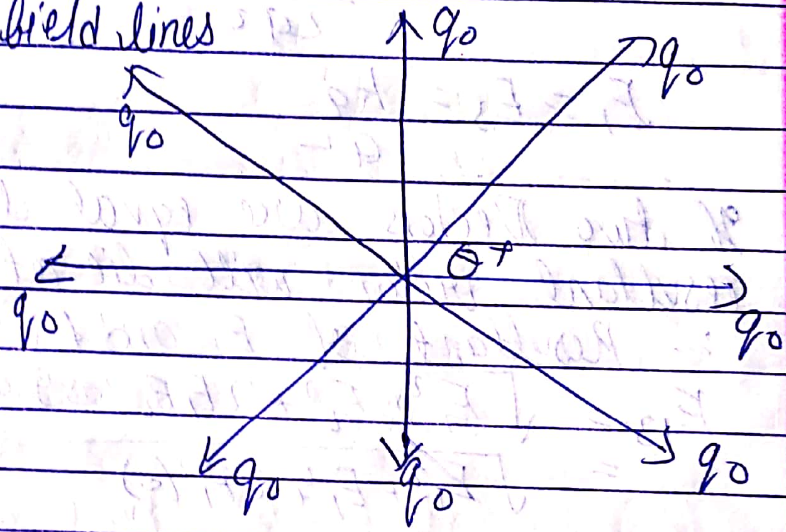
$$E = \frac{[MLT^{-2}]}{[AT]}$$

$$E = [MLT^{-3}A^{-1}]$$

Electric field lines ⇒ Electric field lines are imaginary lines which are used to represent an e- field.

Dipole field ⇒ e- field produced by an e- dipole.

e- field lines



Electric Dipole ⇒ It is an arrangement in which two equal and opposite charges are kept at short distance.

e- dipole movement ⇒ electric dipole movement is defined as product of either of the charge and separation b/w them.

μ $+q$ ———— $-q$

2a

$$p = q \times \underbrace{2a}_{\text{distance of separation}}$$