Ch-1
Electric Charge and Field

Electric Charge is a intrinsic Property.

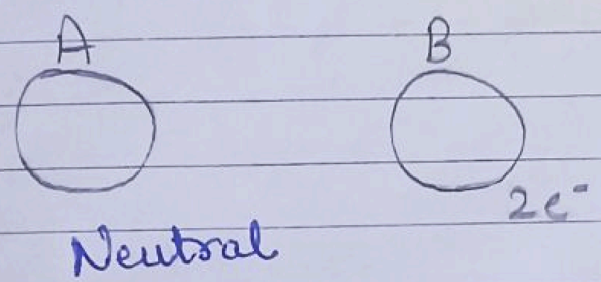
Properties :

Additive
Conservation
Quantization

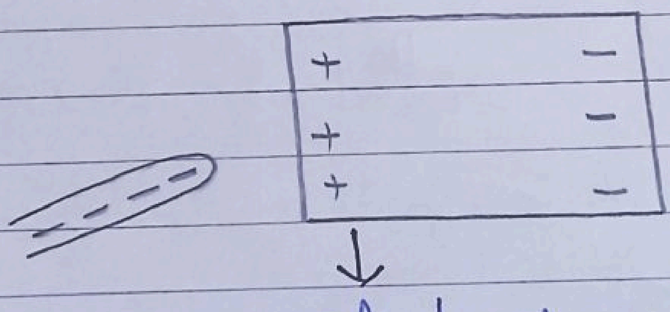
$Q = ne$

$n = 1, 2, 3 \ldots\ldots$

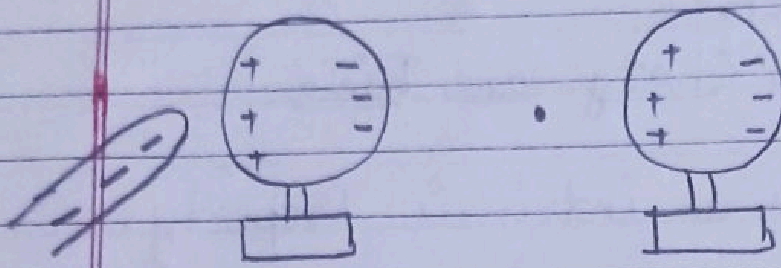
(1)

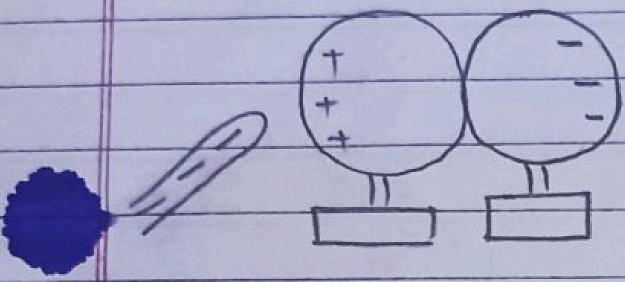


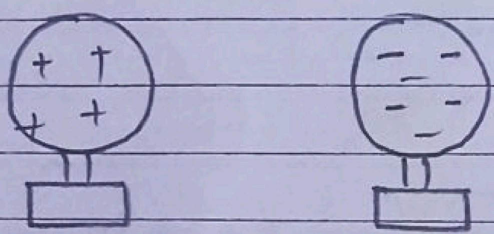
Electrostatic Induction :-



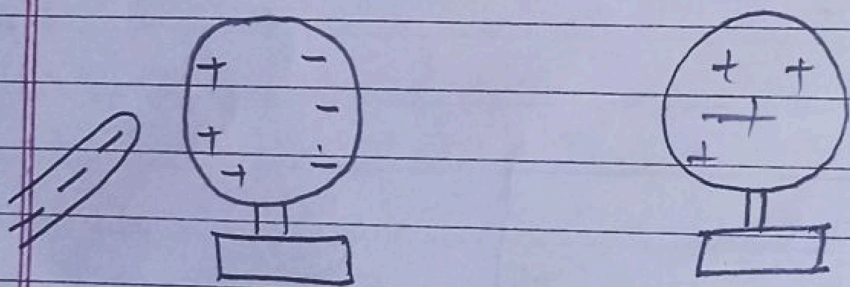
Phenomenon of produce temporary electrificatio when a charged glass rod bring near the insulated body and opposite charge appears in the nearer ~~and~~ end and like charge appear at further end.

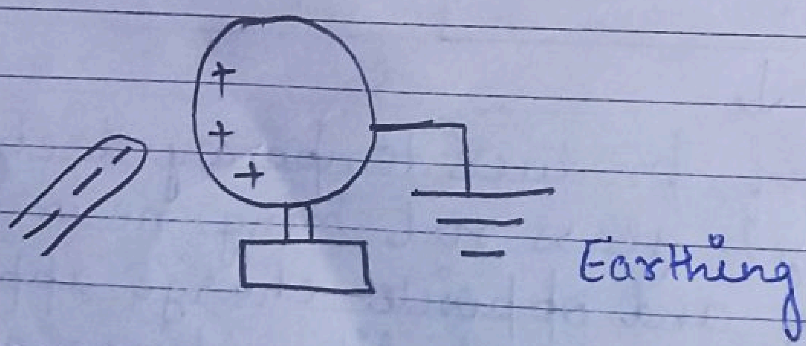






If we have single insulated —





RAJAT SIR PHYSICS NOTES

Difference between charge and mass.

Charge	Mass
① +ve, -ve, zero	① Positive
② Charges are conserved.	② Conservation of mass is not discovered yet.
③ Charge is not depend on speed.	③ Depend on speed.
④ Charges are quantized	④ Mass is not quantized.
⑤ Charges acquired mass.	⑤ It is not ~~acquired~~ compulsary for mass to acquired.

Coulomb's Law

$F \propto q_1 q_2$

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

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

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

$\frac{1}{4\pi\varepsilon_0} = 9 \times 10^9 \, Nm^2/C^2$

$\varepsilon_0 =$ Permitivity of free space
$8.85 \times 10^{-12} \, C^2/Nm^2$

In vector form,

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

$$\vec{F}_{12} = \frac{1}{4\pi\varepsilon_0} \frac{q_1 q_2}{r^2} \cdot \hat{r}_{21} \quad \text{--- (1)}$$

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

$$\vec{F}_{21} = \frac{1}{4\pi\varepsilon_0} \frac{q_1 q_2}{r^2} \cdot \hat{r}_{12} \quad \text{--- (2)}$$

$$\hat{r}_{12} = -\hat{r}_{21}$$

$$\boxed{\vec{F}_{12} = -\vec{F}_{21}}$$ → Action / Reaction Newton's III Law

Electrostatic Force & Gravitational Force

$$F_E = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r^2} \qquad F_G = G\frac{m_1 m_2}{r^2}$$

1. Both follows inverse square law.
2. Forces directly proportional to the product of charges and masses.
3. Both are central forces.
4. Both are conservatives

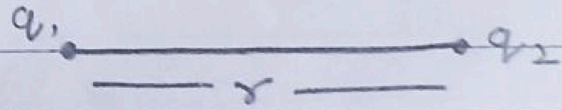
Differences

1. Gravitational forces does not depend on medium but electrostatic force depends.

2. Gravitational forces is always attractive but electro-static force can be attractive or repulsive.

Relative Permitivity (Dielectric constant.)

$$F_{vac} = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r^2}$$



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

$$\frac{F_{vac}}{F_{med}} = \frac{\frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r^2}}{\frac{1}{4\pi\varepsilon}\frac{q_1 q_2}{r^2}} = \frac{\varepsilon_0}{\varepsilon}$$

DATE: / /

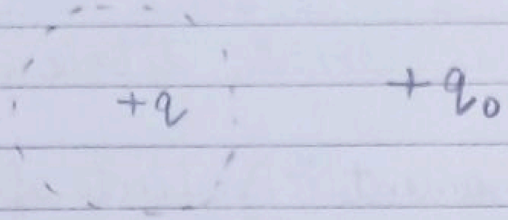
$$F_{med} = \frac{F_{vac}}{k} = \frac{\varepsilon}{\varepsilon_0} = k \text{ or } \varepsilon_r$$

$$\boxed{\varepsilon = k\varepsilon_0}$$

Principle of Superposition :- When the number of charges are interacting the total force on a given charge is vector sum of the forces exerted on it due to all other charges. The force b/w two charges is not affected by the presence of other charge.

Ch-1 Part-II

Electric field :-



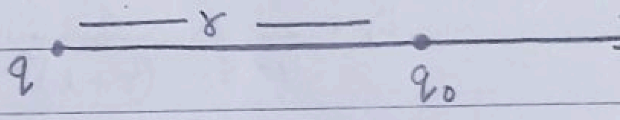
The force experience per unit charge is called electric field.

$$E = \frac{f}{q_0}$$

Unit = N/C or V/m

Dim. $= \frac{[MLT^{-2}]}{[AT]}$
$= [MLT^{-3}A^{-1}]$

Electric field due to point charge :-



$$f = \frac{1}{4\pi\varepsilon_0}\frac{q q_0}{r^2}$$

$$E = \frac{f}{q_0}$$

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

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

RAJAT SIR PHYSICS NOTES

Electric dipole :- Two equal but opposite charge place at a small distance is known as electric dipole.

Dipole moment :- Product of any charge and distance b/w them is known as dipole moment.

$$P = q \times 2a$$

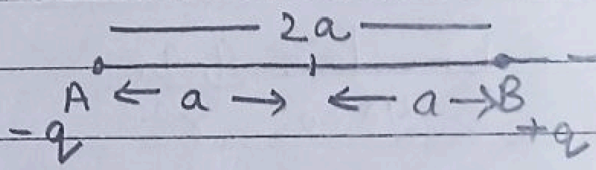
Unit : C-m

Dimension: [AT][L]

[LTA]

Direction : Negative to +ve.

Electric field due to electric dipole at an axial position



$$E_1 = \frac{1}{4\pi\varepsilon_0} \frac{q}{(r+l)^2}$$

$$E_2 = \frac{1}{4\pi\varepsilon_0} \frac{q}{(r-l)^2}$$

Net → $E_1 - E_2$

$$= \frac{1}{4\pi\varepsilon_0} \frac{q}{(r+l)^2} - \frac{1}{4\pi\varepsilon_0} \frac{q}{(r-l)^2}$$

$$= \frac{1}{4\pi\varepsilon_0} q \left[\frac{1}{(r+l)^2} - \frac{1}{(r-l)^2} \right]$$

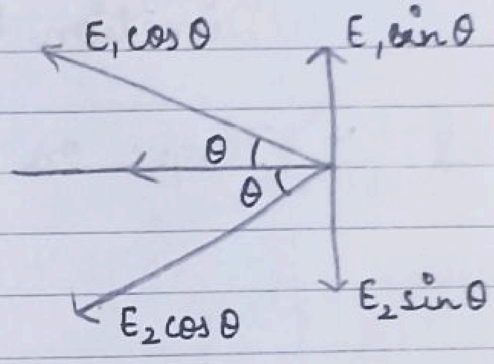
$$= \frac{1}{4\pi\varepsilon_0} q \left[\frac{(r-l)^2 - (r+l)^2}{(r-l)^2 (r+l)^2} \right]$$

$$= \frac{1}{4\pi\varepsilon_0} q \left[\frac{r^2 + l^2 + 2rl + r^2 + l^2 - 2rl}{(r^2 - l^2)^2} \right]$$

$$= \frac{1}{4\pi\varepsilon_0} q \frac{2l\,2r}{(r^2 - l^2)^2}$$

$$= \frac{1}{4\pi\varepsilon_0} \cdot \frac{2rP}{(r^2)^2}$$

$$\boxed{= \frac{1}{4\pi\varepsilon_0} \frac{2P}{r^3}}$$



$$E_1 = \frac{1}{4\pi\varepsilon_0} \frac{q}{(\sqrt{r^2 + l^2})^2}$$

$$E_2 = \frac{1}{4\pi\varepsilon_0} \frac{q}{(\sqrt{r^2 + l^2})^2}$$

$$= E_1 \cos\theta + E_2 \cos\theta$$

$$= 2E_1 \cos\theta$$

$$= \cos\theta = \frac{l}{(\sqrt{r^2 + a^2})} = \frac{l}{(r^2 + a^2)^{1/2}}$$

$$= 2 \times \frac{1}{4\pi\varepsilon_0} \frac{q}{(r^2 + a^2)} \cdot \frac{l}{(r^2 + a^2)^{1/2}}$$

$$= \frac{1}{4\pi\varepsilon_0} \frac{P}{(r^2 + a^2)^{(1/2 + 3/2)}}$$

$$\boxed{= \frac{1}{4\pi\varepsilon_0} \frac{P}{r^3}}$$

$r >>>> a$

then l = negative.

* Relation

$$E = \frac{1}{4\pi\varepsilon_0} \frac{P}{r^3}$$

$$E_{axial} = \frac{1}{4\pi\varepsilon_0} \frac{2P}{r^3}$$

$$E_{equa} = \frac{1}{4\pi\varepsilon_0} \frac{P}{r^3}$$

$$\boxed{E_{axial} = 2E_{equatorial}}$$

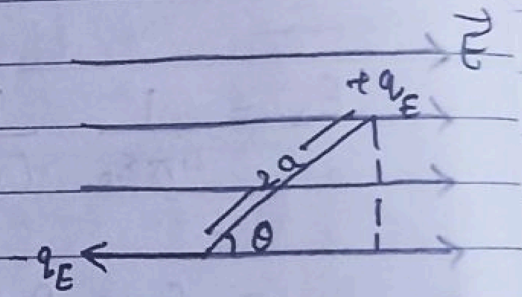
$E = \frac{f}{q}$

+ - Perpen-dicular

Torque on a dipole in an uniform electric field

Net translating force

$$f = -qE + qE = 0$$



τ = force × ⊥ distance

$\tau = qE \times 2a \sin\theta$

$\tau = 2aq\ E \sin\theta$

$\tau = PE \sin\theta$

$$\boxed{\tau = \vec{P} \times \vec{E}}$$

RAJAT SIR PHYSICS NOTES