Date

Expt. No. Page No.

CHAPTER 01

ELECTRIC CHARGE AND FIELD

Electric charge :- Electric charge is a fundamental property of matter that causes it to experience and produce electric and magnetic effects. It is typically represented by the Symbol q.

$$q = ne$$

Where

n = No. of e^- in the Substance
e = charge on an electron (1.6×10^{-19} Coulomb)

- **Unit :-** The S.I. unit of electric charge is the **Coulomb**, represanted by the symbol C.

Teacher's Signature

Date

Expt. No. Page No.

Quantity :- Electric charge is a Scalar quantity.

Type :- There are two types of electric charges:-
(i) Positive charge :- (deficiency of e^-)
(ii) Negative charge :- (excess of e^-)

Dimension :- Unit of charge = Coulomb

charge :- ne

Charge = [A] [T]

Dimension formula :- [A][T] = [AT]

Law of conservation of Electric charge :- "Electric charge can neither be created nor destroyed ; it can only be transferred from one form to another."

Note :- The total charge of an isolated electric System always remains conserved.

Teacher's Signature

Date

Expt. No. Page No.

Basic properties of Electric charge :- There are three main properties of electric charge :-

* **Additivity of charges** :- The total charge of a System is obtained by adding the individual charges algebraically

* **Conservation of charge** :- The total charge always remains Constant.

* **Quantization of charge** :- The total charge (q) of any System is always an integral multiple of the basic unit of charge (e).

Fundamental Charge (Elementary charge) :-

The minimum amount of charge that can exist on any charged particle is called the fundamental charge. It is denoted by 'e'

$$e = \pm 1.6 \times 10^{-19} \, C$$

Teacher's Signature

Date ____________

Expt. No. ____________ Page No. ____________

Coulomb's law :- The electric force acting between two Stationary point charges is directly proportional to the product of the magnitudes of the charges and inversely proportional to the square of the distance between them.

Suppose two point charges q_1 and q_2 are placed at a distance r from each other. Then the electric force acting between these two point charges is :-

$$F \propto q_1 q_2 \text{ —— (1) equation.}$$

$$F \propto \frac{1}{r^2} \text{ —— (2) equation.}$$

from eq. (1) and (2)

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

Teacher's Signature

Date

Expt. No.   Page No.

$$F = K \frac{q_1 q_2}{r^2} \quad \text{—— (3) equation}$$

for air / vacuum air :-

$$K = \frac{1}{4\pi\varepsilon_0} \quad \text{—— (4) equation.}$$

Where,

ε_0 = permittivity of vacuum / air

And

$$K = \frac{1}{4\pi\varepsilon_0} = 9 \times 10^9 \ \frac{N\text{-}m^2}{C^2} \quad \text{—— (5) equation.}$$

putting the value of equation (4) in eq (3) :-

$$F = \frac{1}{4\pi\varepsilon_0} \frac{q_1 q_2}{r^2} \quad \text{—— (6) equation}$$

putting the value from eq (5) in eq (3) :-

$$F = 9 \times 10^9 \ \frac{q_1 q_2}{r^2}$$

Teacher's Signature

Date

Expt. No. Page No.

If two point charges are situated in an insulating medium (paper, glass), then :-

$$F_m = \frac{1}{4\pi\varepsilon_0 K} \cdot \frac{q_1 q_2}{r^2} \quad \text{— (7) equation.}$$

Where ; K = Dielectric constant of the dielectric medium.

from eq. (6) and (7) :-

$$\frac{F}{F_m} = \frac{1/4\pi\varepsilon_0 \cdot q_1q_2/r^2}{1/4\pi\varepsilon_0 K \cdot q_1q_2/r^2}$$

$$\frac{F}{F_m} = \frac{1}{\cancel{4\pi\varepsilon_0}} \cdot \frac{\cancel{q_1q_2}}{\cancel{r^2}} \times \frac{\cancel{4\pi\varepsilon_0} K}{1} \cdot \frac{\cancel{r^2}}{\cancel{q_1q_2}}$$

$$\frac{F}{F_m} = K$$

$$F = K F_m$$

Value, unit, and dimensional formula of ε_0 :-

from coulomb's law:- $K = \frac{1}{4\pi\varepsilon_0} = 9 \times 10^9 \, N.m^2/C^2$

Teacher's Signature

Expt. No. ______ Date ______ Page No. ______

$$9 \times 10^{9} \frac{N \cdot m^2}{C^2} = \frac{1}{4\pi\varepsilon_0}$$

$$\varepsilon_0 = \frac{1}{4\pi \times 9 \times 10^{9}} \times \frac{C^2}{N\text{-}m^2}$$

$$\varepsilon_0 = \frac{1}{4 \times 3.14 \times 9 \times 10^{9}} \frac{C^2}{N\text{-}m^2}$$

$$\varepsilon_0 = \frac{1}{113.1 \times 10^{9}} \frac{C^2}{N\text{-}m^2}$$

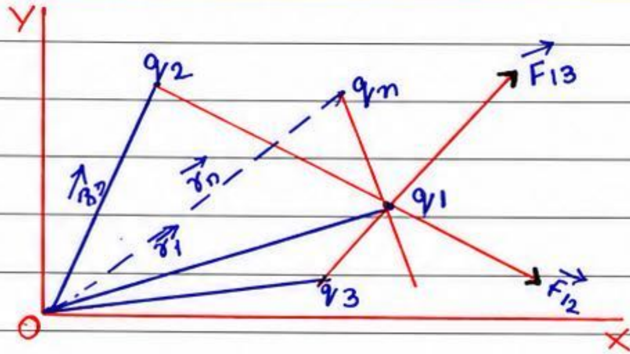
$$\varepsilon_0 \approx 8.85 \times 10^{-12} \frac{C^2}{N\text{-}m^2}$$

dimension = $M^{-1} L^{-3} T^{4} A^{2}$

Principle of Superposition of forces :- "The resultant force on any point charges due to all other charge, is the vector sum of all the forces exerted on the point charge by each individual charge."

There fore :- $F_1 = F_{12} + F_{13} + \text{-------} + F_n$

Teacher's Signature ______



Suppose the total number of charges in a System is n $(q_1, q_2 \ldots q_n)$ and the position vectors on q_1 relative to $q_2, q_3, \ldots q_n$ are $\vec{r}_{12}, \vec{r}_{13}, \ldots, \vec{r}_{1n}$. Then the electrostatic force exerted on q_1 by all other charges is:-

$$\vec{F}_{12} = 1/4\pi\varepsilon_0 \cdot \frac{q_1 q_2}{r_{12}^2} \hat{r}_{12}$$

$$\vec{F}_{13} = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q_1 q_3}{r_{13}^2} \hat{r}_{13}$$

Similarly :-

$$\vec{F}_{1n} = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q_1 q_n}{r_{1n}^2} \hat{r}_{1n}$$

According to the principle of Superposition :-

$$\vec{F}_1 = \vec{F}_{12} + \vec{F}_{13} + \ldots \vec{F}_{1n}$$

$$\vec{F_1} = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q_1 q_2}{r_{12}^2} \hat{r}_{12} + \frac{1}{4\pi\varepsilon_0} \cdot \frac{q_1 q_3}{r_{13}^2} \hat{r}_{13} + \text{-----}$$

$$\text{-------} + \frac{1}{4\pi\varepsilon_0} \frac{q_1 q_n}{r_{1n}^2} \cdot \hat{r}_{1n}$$

$$\vec{F_1} = \frac{q_1}{4\pi\varepsilon_0} \left[\frac{q_2}{r_{12}^2} \hat{r}_{12} + \frac{q_3}{r_{13}^2} \cdot \hat{r}_{13} + \text{-----} \frac{q_n}{r_{1n}^2} \hat{r}_{1n} \right]$$

Electric field :- The region surrounding a charge or a group of charges, in which an attraction or repulsion force acts upon the arrival of any other charge, is called an electric field. The electric field is represented by E.

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

Electric field lines or Electric force Lines :- Electric field lines are imaginary and smooth curves drawn in an electric field that continuously repersent the electric field at that location.

Date ______________

Expt. No. ______________ Page No. ______________

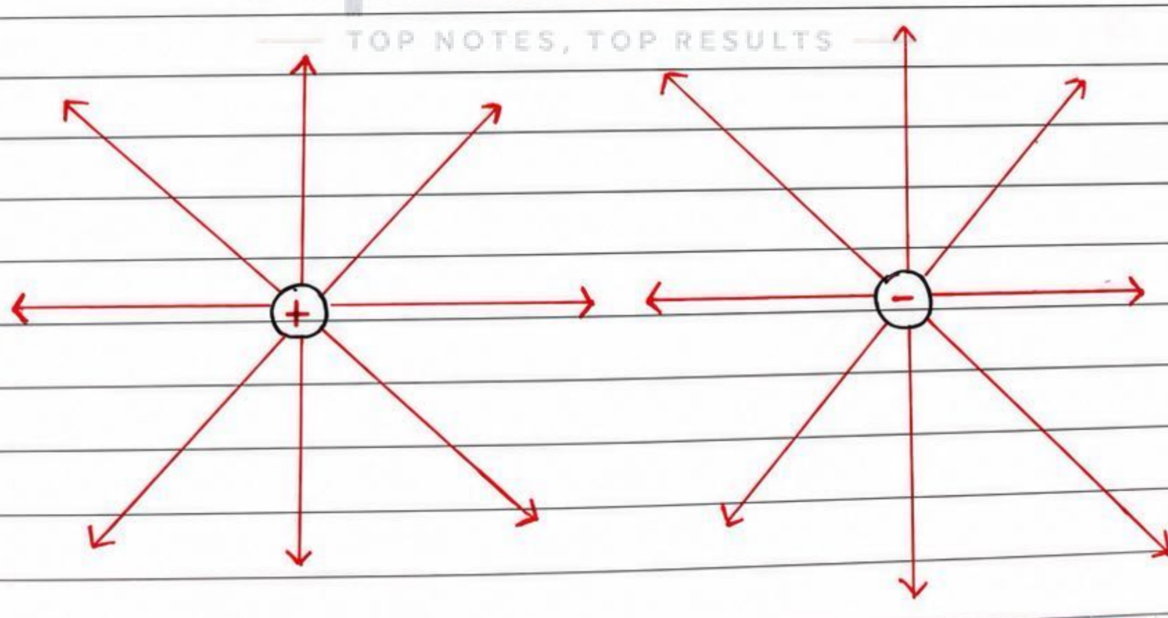
Important properties of Electric force lines:-

* Electric force lines start from a positive charge and end a negative charge.

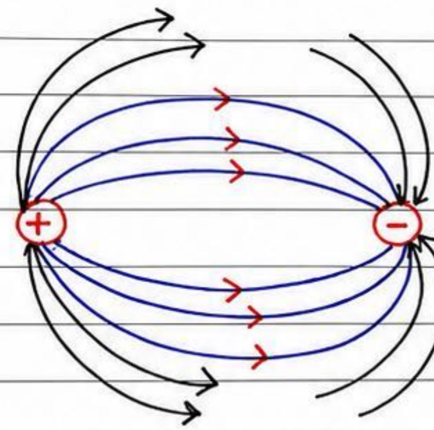
* Electric field lines never intersect each other. This is because if they did, there would be two tangents at the point of intersection, implying two different directions of the electric field at a single point, which is impossible.

* A tangent drawn at any point on an electric field line indicates the direction of the electric field at that point.

* Electric field lines form continous curves.



Teacher's Signature ______________

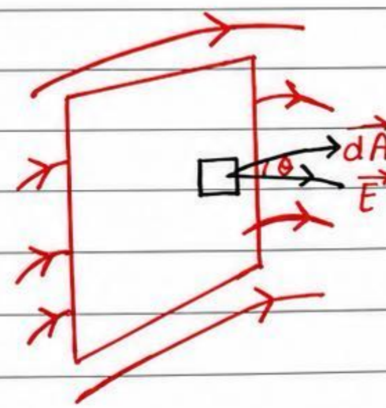


(Combined electric field Lines of a positive and negative charge)

Electric flux :- The measure of the number of electric field lines passing throught an imaginary Surface dA in an electric feild E is called electric flux. It is represented by ϕ_E

Suppose there is a small area element $d\vec{A}$ in an electric field $\vec{E}$. The scalar product of $\vec{E}$ and $d\vec{A}$ is defined as the electric flux passing through that area element.

$$d\phi_E = \vec{E} \cdot \vec{dA}$$



$$\phi_E = \int_A \vec{E} \cdot \vec{dA}$$

$$\phi_E = \int_A E\,dA\cos\theta$$

$$\phi_E = E\cos\theta \int_A dA$$

Date

Expt. No.   Page No.

$E \because \int_A dA = A]$

$\phi_E = EA\cos\theta$

Units of Electric flux = $\frac{N-m^2}{C}$

Dimensions :-

$$\frac{[MLT^{-2}][L^2]}{[AT]} = [ML^3T^{-3}A^{-1}]$$

- Electric flux is a Scalar quantity.

Electric Dipole :- if two unlike point charges of equal magnitude (+q and −q) are placed at a very small distance from each other, then this arrangement is called an electric dipole.

Example :- HCL, H_2O

Teacher's Signature