

PHYSICS

CLASS - X

MODULE-1

- ELECTRICITY
- SOURCES OF ENERGY

- MAGNETIC EFFECTS OF ELECTRIC CURRENT



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2. MAGNETIC EFFECTS OF ELECTRIC CURRENT

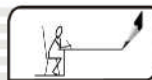
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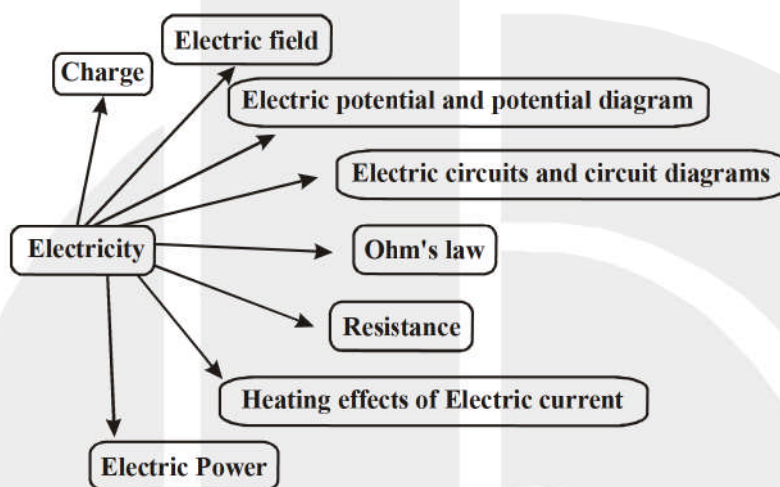
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ELECTRICITY



THEORY

CONCEPT TREE :



1.1 INTRODUCTION :

Electricity has great importance in the modern society. The modern devices in our day to day life require electricity for their operation. The most clean and convenient form of energy in our day to day life is electricity.

1.2 CHARGE :

Charge is defined as the property of matter. When a charge is at rest, it produces electric field only, but when in motion, it also produces magnetic field. Charge can be positive or negative. The smallest [stable](#) possible charge is the charge on an electron.

Properties of Electric Charge :

1. Electric charge is of two types viz., positive and negative charge. Proton is said to be charged positively and electron is said to be charged negatively. The magnitude of elementary positive or negative charge is same and is equal to $1.6 \times 10^{-19} \text{ C}$.
2. Like charges repel and unlike charges attract each other. Thus a proton repels a proton and attracts an electron.
3. The force of attraction or repulsion between two charges is given by Coulomb's law.

4. **Charge is conserved :** Charge can neither be created nor destroyed. The charge from one body can be transferred to another body but the total charge of a system remains constant. This is called the law of conservation of charge.
5. **Charge is quantized :** Protons and electrons are elementary charged particles. Though the charge on them is opposite in nature, the magnitude of charge possessed by them is same i.e., 1.6×10^{-19} C. Charge on a body is always an integral multiple of this value. This is called quantization of charge.

The charge exists in fixed packets i.e. when a body is charged the charge on it is an integral multiple of the charge on an electron.

$$q = \pm ne$$

Reason for quantisation :

Since, electrons are indivisible, thus, only integral number of electrons can be transferred from one body to another, on rubbing. Hence, the charged bodies will have charges which are integral multiples of the charge on electron.

6. When a body gains electrons, it becomes negatively charged. When it loses electrons it becomes positively charged. The positive charge being bound firmly in the nucleus does not participate in charging.
7. Charge is invariant
8. Charge resides on the outer surface of the conductor. In insulators it remains where it is placed.
9. The electric charge is additive in nature.
10. Charge cannot exist without mass but mass can exist without charge.
11. Charge is scalar quantity and the SI unit of charge is coulomb, denoted by (C).

Note : The smallest possible charge is the charge on a quark i.e. $\frac{2e}{3}$ and $-\frac{e}{3}$, but it is unstable in nature.



Mass of an electron = 9.1×10^{-31} Kg.

A body having a charge of +1C has an electron deficit of 6.25×10^{18} electrons.

The study of electricity is classified into two parts.

1. **Static electricity :** It deals with electric charges at rest and their effects.
2. **Current electricity :** It deals with charges in motion and their effects.

S.No.	Positive Charge	Negative Charge
1.	Glass Rod	Silk
2.	Woolen cloth or fur	Ebonite, Amber, Rubber
3.	Woolen cloth	Plastic
4.	Dry hair	Plastic Comb

This chapter deals with charges in motion i.e., current electricity.

1.3 ELECTRIC FIELD

The region of influence around a charge is called the region of electric field.

Interaction of electric field between two charged particles :

Two charged particles always interact with each other due to their electric field. There may be force of repulsion or attraction between two charged particles.

This force of attraction exists between unlike charges and force of repulsion exist between like charges. The force between two point charges q_1 and q_2 separated by distance 'r' is given by Coulomb's law.

Coulomb's law :

In 1785, Coulomb gave two laws for the force of attraction or repulsion between two electrically charged bodies separated from each other by a definite distance. The laws are stated as follows

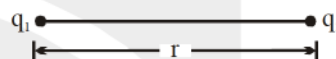
- (i) "The force of attraction or repulsion between two electric charges is directly proportional to the product of two charges."
- (ii) "The force of attraction or repulsion between two electric charges is inversely proportional to the square of the distance between them. This is known as inverse square law."

$$F \propto q_1 q_2$$

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

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

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



where K is proportionality constant (or Electrostatic Force constant or Coulomb's constant). Its value depends upon the medium between charges and units used for charge, distance and force.

The value of $K = \frac{1}{4\pi\epsilon_0} = 9 \times 10^9 \frac{Nm^2}{C^2}$

The constant ϵ_0 is called the **permittivity of free space**. Its value is $8.9 \times 10^{-12} C^2/N\cdot m^2$.

⇒

$$F = \frac{1}{4\pi\epsilon_0} \cdot \frac{q_1 q_2}{r^2}$$

Force is a vector quantity.

Vector Form of coulomb's law $\vec{F} = \frac{kq_1 q_2}{r^2} \hat{r}$; $\vec{r} = \frac{\vec{r}}{|\vec{r}|}$ ⇒ $\vec{F} = \frac{kq_1 q_2}{|\vec{r}|^3} \vec{r}$

Intensity of electric field (\vec{E}) :

The intensity of electric field at a point in the electric field is defined as the force experienced by a unit positive charge placed at that point

$$\vec{E} = \frac{\vec{F}}{q_0}$$

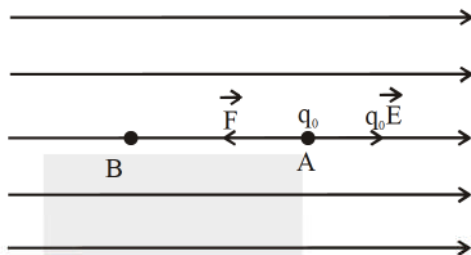
where $q_0 = 1$

$$F = K \frac{q \times 1}{r^2}$$

In terms of magnitude, $E = \frac{F}{1} = K \frac{q}{r^2}$ where $K = \frac{1}{4\pi\epsilon_0}$

Electric field is vector quantity and SI unit of electric field is N/C

1.4 ELECTRIC POTENTIAL AND POTENTIAL DIFFERENCE :



If a positive test charge q_0 is placed at a point A in an uniform electric field (see figure), a **force** $q_0 \vec{E}$ will act on this charge along the direction of electric field. Now if test charge q_0 is displaced from A to B, by applying a force $\vec{F} = q_0 \vec{E}$ in opposite direction to electric field intensity, then we have to do some work.

Let this work be W_{AB} .

In this way, work done in carrying a unit positive charge from point A to B is defined as potential difference between points B and A. i.e. potential difference between point B and A –

$$V_B - V_A = \frac{W_{AB}}{q_0}$$

The electrons (negative charges) in a conductor or a wire flow from one end to another end of the conductor if there is electric pressure difference called electric potential difference between the ends of the conductor.

If point A is considered as a reference point (initial point where potential is zero) at infinity, then–

$$V_B = V_B - 0 = \frac{W_{\infty B}}{q_0}$$

Electric potential at point B is defined by **above** equation. That is, work done in carrying a unit positive charge from infinity ($V = 0$) to the point under consideration in electric field, without change of its kinetic energy, is called the electric potential of that point.

The S.I. unit for electric potential and potential difference is **joule/coulomb**, which is also known as **Volt**. "One volt potential at a point means that work done in carrying one coulomb charge from infinity to this point would be one joule." Electric potential and potential difference are **scalar quantity**. It is to be noted that "positive charge always moves from high potential to low potential, similarly negative charge moves from low potential to high potential." From reference point of view, the electric potential of earth is considered as zero.



Smaller units of electric potential

1 mili volt (mV) = 10^{-3} V

1 micro volt (μ V) = 10^{-6} V

Larger units of electric potential

1 kilovolt (kV) = 10^3 V