Chapter ten

STATICAL ELECTRICITY




[We know that every matter consists of protons and electrons. Do you know that there are more than 10^{28} protons and almost equal number of electrons in your body? The basic property of these protons and electrons is charge. The charge of proton is considered as positive and of electron is negative. The charged objects that apply force on each other is known as electric force. The electric force is a basic and important force of nature. In this chapter we will see how a body is charged. We will also learn detect the presence of charge and measure the force between them. As the discussed charges will remain static we will call the chapter Statical Electricity. Finally we will discuss the usage of this static charge and some of its danger and the ways to remain safe from them.]

By the end of this chapter we will be able to-

1. Explain the basic causes of production of charge on the basis of structure of atom.
2. Explain the causes of production of charges by the process induction and friction.
3. Detect the nature of charge by electroscope.
4. Measure the electric force applying Coulomb's law.
5. Explain the cause of production of electric field.
6. Explain the direction of electric lines of force can represent the direction of electric field.
7. Explain the electric potential.
8. Explain the function of capacitor to preserve electric energy.
9. Explain the usage of static electricity.
10. Explain the strategy to be safe from the risk of danger of static electricity.

10.1 Charge

In a winter morning Sourov took his plastic comb to comb his hair. Before combing his hair he rubbed the comb with his woolen pullover for a while. While combing his hair he observed surprisingly that he cannot do it because all the hair was becoming straight and repels away each other. As soon as Sourov brings the comb close to the tale he observes the comb attracting some pieces of paper on the table. Some of you may have the same kind of experience like Sourov. In our daily life we observe that many objects around us behave like the comb of Sourov.

> Do it yourself: Rub your dry hair with your plastic scale for a while and hold it near some pieces of paper.

We see that an object attracts another object in a special condition or becomes charged that is electricity produced in the object. Their charge remains static in the place of its production. So it is called static electricity. Now let us see what we mean by being charged.

We know that each matter is consisted of small particles. The atom of every matter consists of electrons and which revolves around the nucleus. In the nucleus there are two type of particles-proton and neutron. The fundamental and special property of primary particles (electron and proton) of which the matter consist of is electrical property, which is determined by charge. The charges of electrons are negative and the charges of protons are considered to be positive. Neutron is electrically neutral that is it has no charge. The amount of charge in a proton is equal to the charge of an electron. Naturally an atom has an equal number of protons and electrons. As a result in the atom whole atom there is no electrical property to be detected. The number of electrons and protons in different matters is different.

As long as the number of electron and proton are equal in any atom, it is electrically neutral. But if their number is not equal in any atom, then the atom will be charged. If the number of electron decreases, the number of proton increases. This situation is said to be charged positively. Again, if these scattered electrons are joined with any atom, the number of its electron increases, as a result it is charged negatively. The shortage or excess of electrons in any atom is considered to be charged.

The substances through which electricity or electric charge can pass easily are called conductors, e.g. metal, soil, human body etc. Generally the metals are good conductors. Copper, silver, aluminium etc are good conductors. On the other hand the substances through which electricity or electric charge cannot pass easily are called nonconductors or insulator, such as wood, paper, glass etc.

10.2 Electrification by friction:

> Experiment: Suspend a light pith ball freely with a string from a stand or a hook. Rub one end of a glass rod with a piece of dry silk cloth very well. It will be more convenient if the glass rod and the silk are dried to make them warm. Now bring the rubbed end of the glass rod near the freely suspended pith ball.

In normal condition the number of protons and electrons in any atom is equal. But every atom has got affinity for getting excess electrons. This affinity for excess electron is different in different substances. That is why when two bodies are brought in contact with each other, the body which has greater affinity for electron collect electrons from other body and gets charged negatively this happens when a glass rod is rubbed with silk.

Figure: 10.1

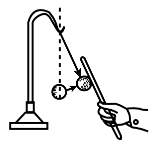


Figure: 10.2

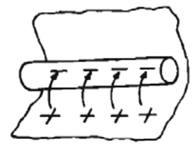


Figure: 10.3

[Fig: 10.1] Silk has more electron affinity than glass and as such these two are rubbed together, the electron of glass goes to silk. As a result, the silk gets charged negatively and the glass rod becomes positively charged. This is why glass rod attracts pith ball [Fig; 10.2]. Again when a rod of ebonite or polythene is rubbed with flannel, polythene rod gets charged negatively and the flannel becomes positively charged. Because polythene has more affinity for electrons than that of flannel and so when they are rubbed together free electrons of flannel moves to ebonite or polythene and gets charged negatively [Fig 10.3].

10.3 Electric Induction

We know that when two bodies are rubbed together electric charge is produced. Again when a charged body is brought in contact with another neutral body the later is charged. When the neutral body is placed not in contact with the charged body but close to the charged body, the former becomes charged. This happens due to induction. The process of charging a neutral body by bringing it very near to the charged body is called electrostatic induction. With a simple experiment the electrostatic induction has been explained below.

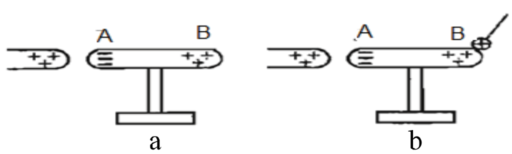


Figure: 10.4

Experiment: A dry glass rod is rubbed with silk. One end of the rod is brought very near to the neutral conductor rod AB keeping the other end of the glass rod in hand [Fig: 10.4(a)]. As a result the free electrons of the conductor are attracted by the positive charges of the glass rod and move the end A. Therefore, the end B falls in short of electrons and is charged positively. The end A is charged negatively. With a charge collector [a small metal sheet attached to a nonconductor handle] if some charges are collected from end B and their nature is detected with the help of an electroscope then the above discussion will be proved.

Here no new charge is produced. Due to the presence of the charges glass rod equal amount of opposite charges are separated only and move towards the end o the conductor. As long as the glass rod is present near the conductor AB, the opposite charges are separated and remain at the end of the conductor.

In the above experiment the positive charges in the glass rod which has created induction in the conductor AB is called inducing charge. The charges which are accumulated in the conductor A are called induced charge.

Extended activities: Rub a balloon full of air with your shirt. Then press the balloon with the wall of your house for a while and then release it. What did you observe? The balloon becomes attached to the wall.

Extended activities: Rub a plastic object with your shirt. Then hold it near a narrow flow of water falling from a tap. The flow of water will bend towards the plastic object.

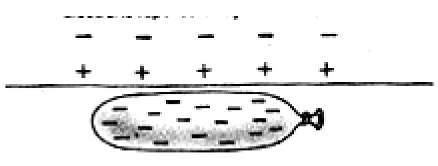


Figure: 10.5

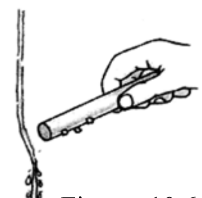


Figure: 10.6

The negative charge of the balloon produces electrostatic induction in the wall. The induced positive charge in the wall attracts the negatively charged balloon [Fig: 10.5]. Same case occurs with the narrow flow of tap water [Fig 10.6].

10.4 Electroscope

The instrument which detects the presence and nature of charge in any body is called electroscope. A metallic circular disk is fixed on the top of brass or any metallic rod R [Fig: 10.7] and at lower end of the rod two light leaves of gold are attached. Instead of gold aluminium or any other light metal can also be used. The lower end of the rod with the leaves is placed in a glass jar passing through a cork of nonconductor matter C. As the apparatus is kept inside a glass jar, the humidity and the wind cannot damage the instrument.

Charging the electroscope:

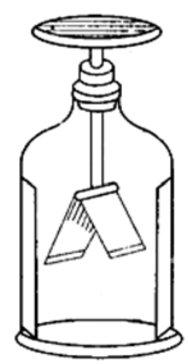


Figure: 10.7

If a glass rod is rubbed with silk, it becomes positively charged. If that charged rod is attached to the disk or sphere of the electroscope, some charge is transferred from the rod to the disk. This charge reaches to the gold leaves through conducting metal rod. As the gold leaves receive similar charges, they repel each other and move away from each other or explode. In this situation, if the glass is removed but the gap between the leaves is not reduced, then it can be decided that the electroscope is charged with positive ions. To charge the electroscope with negative ions, an ebonite rod should be rubbed with flannel and this negatively charged ebonite rod be allowed to touch the disk in the above mentioned process. As a result, the gold leaves of the electroscope will be charged negatively and they will repel each other and will remain in that position. The more is the quantity of charge the more will be the gap between the leaves.

Detection of existence of electric charge:
To determine the presence of charge in any body, the body may be brought to an unchanged electroscope. If the two leaves move away from each other then it is understood that there is an existence of charge in the body but if they don't move away from each other then it is understood that the body has no charge.

Detection of the nature of charge:
To know the nature of charge in any charged body, the electroscope should be charged either positively or negatively. Suppose the electroscope is charged positively. In this position, the leaves having positive charge will stay apart. Now if the experimental body is brought in contact with the disk of the electroscope and if the gap between the leaves decreases, then it is understood that the body is charged negatively. On the other hand if the gap increases due to touching the disk with the experimental body, then it is understood that the body is positively charged.

10.5 Electric Force:
Nature of force:
A positively charged plastic rod is suspended by nylon string. [Fig: 10.8]

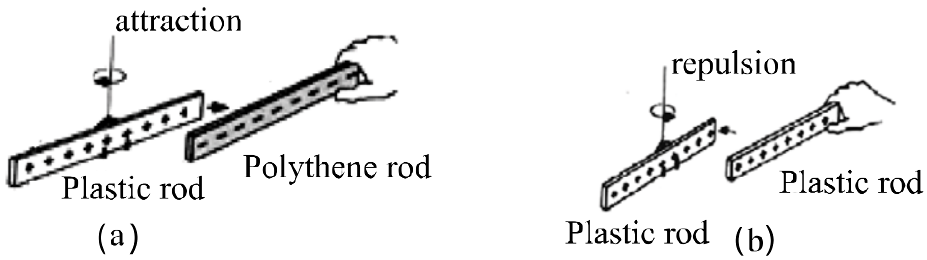


Figure: 10.8

Now a negatively charged polythene rod is brought near it. What do you observe? The plastic rod will move towards the polythene rod. So, it is proved that two oppositely charged object attract each other. [Fig: 10.8 (a)]

Now what will you observe when a positively charged plastic rod is brought near a freely suspended positively charged plastic rod the suspended rod will move apart quickly. That is charges of same nature repel each other.

Coulomb's Law:
We know that the charges of opposite nature attract each other and charges of same nature repel each other. The force of attraction or repulsion between the two charges depends on,

1. quantity of charges.
2. distance between two charges.
3. the nature of the medium between the two charges.

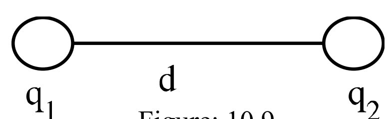


Figure: 10.9

Scientist Coulomb states a law about the force of attraction or repulsion between the two charges. This is called Coulomb's law.

Law:

The forces of attraction or repulsion between two charged bodies in particular medium is directly proportional to the product of the charges and inversely proportional to the square of the distance between them and the force acts along the straight line connecting them.

Suppose, two charges q_1 and q_2 are at a distance d from each other [Fig: 10.9]. If the force of attraction or repulsion between these two is F, then according to Coulomb's law,

$$F \propto \frac{q_1q}{d^2}$$

$$\text{or, } F = \frac{Cq_1q}{d^2} \qquad (10.1)$$

Here C is a constant of proportionality. Its value in vacuum is $9 \times 10^9\ Nm^2C^{-2}$. Sometimes it is called coulomb's constant.

Unit of charge: The unit of charge is coulomb (C). It is a derived unit. Coulomb is defined from ampere.

If 1 ampere (1 A) current flows through a conductor for 1 second (1 s), then the amount of charge that passes through any cross section of the conductor is called coulomb (1 C).

Mathematical Example 10.1: Two bodies of charges 20C and 50C are placed at a distance of 2m in vacuum. Find the amount of force between the charges.

We know,

$$F = \frac{Cq_1q_2}{d^2}$$

$$= \frac{9 \times 10^9\ Nm^2C^{-2} \times (20C \times}{(2m)^2}$$

$$= 2.25 \times 10^{12}\ N$$

Here,
1st charge, q_1= 20C
2nd charge, q_2= 50C
Distance = 2m
Force, F = ?

10.6 Electric Field

Suppose A is a positively charged body. Now if a charge $+q$ is placed at point P, then due to the charge of A, the $+q$ charge will gain a force. We say that at point P there is a an electric field, the source of which a charged body A. That is if a charged body, in which the influence of the charged body exists is called the electric field of the charged body.

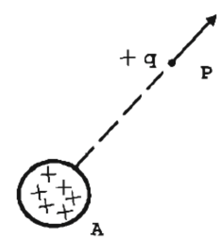


Figure: 10.10

Electric Intensity:

According to coulomb's law, it is found that the nearer the point P [Fig 10.10] to the charged body A, the more will be the strength of electric field at that point. The strength of the electric field is called intensity. If at any point of an electric field a unit of positive charge is placed and the force that it acquires is called the electric intensity at that point. If the charge at point P acquires a force F, then the intensity of electric field at that point P,

$$E = \frac{F}{q} \qquad (10.2)$$

Electric intensity is a vector quantity and its direction is along the force acting on a unit positive charge placed in an electric field. The unit of electric charge is newton/coulomb (NC^{-1}).

Mathematical Problem 10.2: If a body of charge 5C is placed at a point in an electric field then it gains a force of 200N. Find the magnitude of electric intensity of that point.

We know,

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

$= \frac{200N}{5C}$

$= 40\ NC^{-1}$

Ans: $40\ NC^{-1}$

Here,
Charge, $q = 5C$
Force, $F = 200N$
Electric intensity, $E = ?$

Electric Lines of Force:

Michel Faraday introduced electric lines of force to get an idea about electric field. If a positive charge is placed in an electric field it would experience a force. If the charge is a free one, gaining this force instead of remaining stationary it would move in a definite path. Electric line of force is the path of a free positive charge that moves in an electric field. There is no real existence of lines of force. These lines are imaginary. The electric lines of force are used to for measuring the electric intensity and explaining its direction at a point in an electric field. The lines of force of an electric field are such that, the tangent drawn at a point to a line of force indicates the direction of electric intensity at that point. The number of lines of force passing through unit area perpendicular to the lines of force at a point in the electric field is proportional to magnitude of the electric intensity at that point. In a diagram of lines of force of an electric field, the gap between the lines indicates the magnitude of intensity of electric field. In an electric field where the lines of forces are closer magnitude of E is greater there and where the lines of forces are away magnitude of E is less there.

For different positions of charged object, the nature of the lines of force of an electric field varies. Lines of force of a few electric are described below. For the simplicity of description the conductors are taken as spherical.

1. For an isolated positive charge the nature of lines of force is shown in figure 10.11(a). In this case the lines of force emerged uniformly from the surface of the conductor perpendicularly. If the charge of the body increases then the number of lines of force also increases.
2. The lines of force of an electric field produced by two equal and opposite charges are shown in figure 10.11(b). In this case the line of force emerges from positive charge and terminates at negative charge.
3. The lines of force of an electric field produced by two equal positive charges placed nearby are shown in figure 10.11(c). In this case the lines of force go far away from each other; as a result there will be no lines of force in between them.

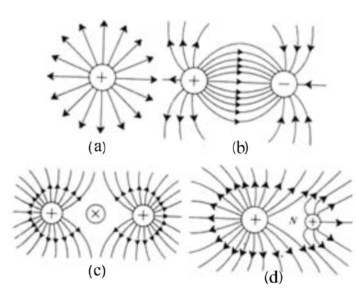


Figure: 10.11

In figure this place is indicated by 'X' sign. If a charge is placed at this place it will experience no force. This point is called neutral force.

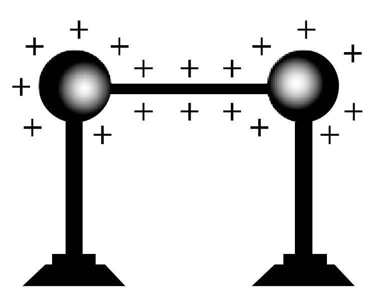
4. The lines of force of an electric field produced by two unequal positive charges placed nearby are shown in figure 10.11(d). In this case, the neutral point 'N' would not be nearer to the smaller charges.

10.7 Electric Potential

As there is intensity of an electric field, it also has electric potential. Potential determines the direction of motion of a charge in an electric field and also determines the direction in which the charge will flow when two charged conductors are connected by a conductor wire. If the charge creating field is positive, some work is done against the force of repulsion if another positive charge is brought near it. Therefore, the more positive charge is brought from a point at infinity nearer to the body, the more work will have to be done. So, within the electric field of a positively charged body, the more a point is brought nearer to the body, the more will be the quantity of potential. If any electric field created by a positively charged body and a free positive charge is placed and allowed to move freely, it would go away from the body. Therefore, we can say that positive charge moves from higher potential to lower potential. On the other hand, negative charge moves towards positively charged body. Thus, negative charge moves from lower potential to higher potential. If the body creating the electric field is charged negatively, then some work will be done due to attraction of a unit positive charge bringing towards it. A positive charge itself does work while coming from infinity towards a negatively charged body, which creates an electric field. As a result the charge loses energy and the potential at a point in the electric field is considered as negative.

Measurement of potential: The work done to bring a unit positive charge from infinity to a point in an electric field is called the potential of that point. Again from infinity if a unit of positive charge is brought near to the conductor, the work done by the electric force or against the electric force is called potential of that conductor.

If a unit positive charge q is brought very near to the conductor from a point at infinity and if the amount of work done is W, the potential 'V' of the conductor or of that point will be, $V= \frac{W}{q}$



Electric potential determines in which direction the flow of electric charge takes place when two charged conductors are electrically connected.

If two positively charged metallic spheres are connected by conducting wire (fig:10.12) then any of the following phenomena may occur.

1. Some charge from the left sphere may go to the right sphere.
2. Some charge from the right sphere may go to the left sphere.
3. The charges may remain as it is.

The movement of charge from one sphere to another does not depend on the quantity of charge of the spheres but it depends on electric potential. The positive charge will flow from sphere to sphere of higher potential to that if lower potential. This flow of charge will continue until the potential of these two spheres become equal. So, potential is an electric condition of a charged conductor that determines whether it takes or gives up charge when connected to another charged conductor by a connecting wire.

Similarity between potential and temperature and free surface of liquid:

The role which is played by temperature and the height of free surface of liquid in heat and hydrostatics respectively, potential plays the same role in electrostatics. We know, if we connect two bodies thermally, there may be exchange of heat between them. The flow of heat does not depend on the mass of i.e. inherent heat within it, but on the temperature. If we connect a highly heated body with another body which is much heavier but of low in temperature, then heat will flow from the small body to the large body, though the amount of heat is much greater in the larger body than the smaller one.

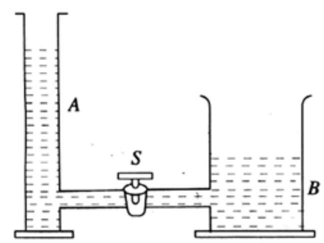


Figure: 10.13

Two tubes A and B are placed at same horizontal level. They are connected by a tube with a stop cock S (Fig: 10.13). Closing the stop cock water is poured in to A and B tubes in such a way so the height of water column is same in two tubes. As the diameter of B is much greater than that of A, to raise the water level at same height much more water is requires for tube B. Now if the stop cock is opened there would be no change in water height i.e. there is no flow of water. Though the amount of water is different in two tubes, but as there is height is same, so there is no flow of water. Now if closing the stop cock a little amount water is poured into A tube, the amount of water in it will still be less than that of B, but the height of water level will increase slightly. After if the stop cock is opened, then water will flow from A to and the height of the water column will w same in both A and B. It is thus understood that flow of water does not depend on the amount of water rather the height.

Suppose two conductors are positively charged. The amount of charge in first conductor is greater than that of second conductor but the potential of the first one is less than that of the second. Now if, two conductors are connected electricity then positively charge will flow from second conductor to first conductor. Though the amount of charge is greater in first conductor yet it will take charge because its potential is low. As a result of flow of charges when the potential of the two conductor become equal then the flow will stop.

Therefore it can be said, the role of temperature in heat, role of free surface of liquid in hydrostatic and the role of potential in electrostatic are same.

Electric Potential of Earth:

Earth is an electric conductor. When a charged body is connected to the earth, it becomes electrically neutral. When a positively charged body is grounded electrons coming from the earth neutralize the body. When a negatively charged body is grounded electrons from the body flow to the earth and the body becomes neutral. The earth is so big that if charge is added or taken away from it its potential does not change at all. Likewise if water is taken away from sea or poured in the water level does not change. The earth is always taking charge from different bodies and simultaneously it supplies charge to other bodies. Hence earth is considered charge less. To determine the height of a place the height of the sea level is taken as zero, similarly to determine the potential of a body, the potential of earth is taken as zero.

Zero, Positive and Negative Potential:

The potential of an uncharged conductor is taken as zero. When a charged conductor is connected to the earth its potential becomes zero. Because, in the connected state , both the conductor and the earth is considered as a single conductor. The potential of a positively charged body is positive and negatively charged body is negative.

Unit of potential, Volt:

If the work done in bringing 1 coulomb (1C) of positive charge from infinity to a point in the electric field is 1 joule (1J), then the potential at that point is called 1 volt (1V).

The potential at a point in an electric field is 20V means to bring 1 coulomb (1C) positive charge from infinity to that point 20J work is to be done.

Potential difference:

Let, in an electric field A and B are two points and the potentials of the points are V_A and V_B respectively (fig: 10.14). The work done in bringing a unit positive charge from infinity to point A is V_A and to point B is V_B. Therefore the work done in bringing a unit positive charge from point B to point A is $V_A - V_B$ i.e. the potential difference between these two points.

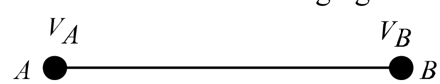


Figure: 10.14

The work done in transferring a unit positive charge from one point to another point in an electric field is called potential difference between two points.

10.8 Electric capacitor:

The capability of storing energy as electric charge is called capacitor. Capacitor is the mechanical device designed to sustain the capacitance. Capacitor stores energy from a source such as electric cell and again uses it. A capacitor is made by placing an insulating material such as air, glass, plastic etc. Therefore, the mechanical process of storing energy as electric charges by placing an insulating medium in between two nearby conductors is called capacitor.

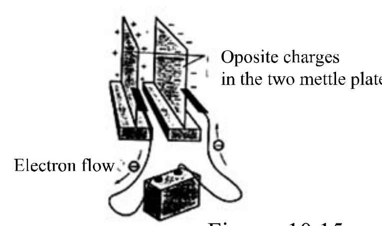


Figure: 10.15

A simple capacitor is made by placing two insulating metal plates parallel to each other. When a battery is connected to its two plates (Fig:10.15) then electrons may flow to a plate from its negative rod and is charged negatively. Electrons flow to the positive rod of battery from the other plate of the capacitor. As a result that plate is charged positively. The amount of charge deposited in the plates depends on the voltage of the battery.

Capacitors are used in radio, television, record player and the circuits of other electronic devices widely.

10.9 Uses and Dangers of Static Electricity:

1. Electrostatic Painting Spray: Nowadays painting spray is used to colour car, cycle, cupboard or other things with help of static electricity. Spray gun is made in such a way that it produces very small charged particles of colour. The sharp edge of the painting spray gun is connected to a terminal of the static electrical generator. The other terminal of the generator is connected to the metal plate to be coloured which must be connected with earth. In case of colouring a car the charged small particle emitted from the spray gun attracts the outer frame of the car. As a result a uniform layer of colour is formed on the outer surface of the car. Moreover these small particles move along the electric lines of force and reach the narrower places of its surface and colour it.

Figure: 10.16

2. Ink Jet Printer: This is the most ordinary printer which remains connected to the computer. An ink-gun with its narrow mouth projects very small particles of ink. These small particles are positively charged. These ink particles move through the space between two plates. These positively charged ink particles are repelled by the positive plate and attracted by the negative plate.

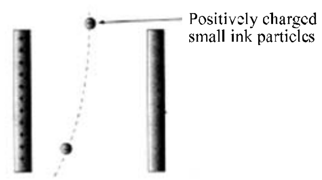


Figure: 10.17

A computer controls the voltage of the plates in such a way that the plates are sometimes positively charged and sometimes negatively charged. And the ink particles fall on moving paper scattered in different places to give the necessary shape of letters and pictures. For colour print four kinds of colour are used.

3. Photocopier: Nowadays photocopier or photocopy machine is very essential and thus it has become very popular machine. Not only the educational institutions and other offices but also general people use this machine to photocopy any kind of necessary papers and documents. Static energy is also used in this machine. There is a rotating dram inside the dark part of the photocopier. Positive charge is sprayed over the dram. A bright light lights up the page to be photocopied. The white part of the page reflects light but the dark or printed part does not reflect light. The reflected light centers on the dram. Charges releases from the part of the dram where the reflected light from white paper falls. Only the dark part of the dram is charged positively. Negatively charged ink of carbon powder (toner) is sprayed over the dram. Negatively charged ink particles get stick to the positively charged part of the dram. A piece of white paper is positively charged and is kept pressed with the dram. This paper picks up the pattern of carbon powder on its surface from the dram. Positively charged paper attracts the negatively charged toner. Then the paper is passed through the heated roller. As a result the ink of the toner gets melted and mixed with the paper and makes a permanent copy.

Danger of static electricity:

Sometimes the presence of static electricity is harmful and may cause danger.

Loading of fuel in aero plane: When aero plane flies in the air it may electrify due to the friction with air. If the charge increases continuously the potential difference between the aero plane and the earth increases simultaneously. Due to this high potential difference when the fuel is loaded there is possibility of releasing some charge to the ground which may create spark. This spark may lead to a huge explosion. This is why the wheels of aero plane are made of conductor rubber so that the stored charges in the aero plane can be released safely to the ground when it lands.

The solution of the problem is that a conductor is to be connected to the aero plane and to the ground as soon as it lands and just before the loading is started.

Loading of Fuel into Tanker: Sparking or explosion may occur when a truck or tanker etc carries fuel from one place to another. To prevent this type of danger the tanker should be connected to the ground by a conductor.

Television and Monitors of Computer: During the operating period television and monitor of computer, electrostatic charges are produced. These charges attract the uncharged dust particles thus they become dirty soon.

Change of clothes: Sometimes our wearing clothes may be charged due to the friction with us. When we change our clothes, there is a possibility of getting light shock as the charges pass to the ground through our body.

Operation Theater: Necessary measures have to be taken to keep the surgeons, concerned people and treatment equipments of the operation theater in a hospital free from electric charges as they attract dirt and germs. This is why they have to wear conductor shoes of rubber and use rubber gloves. So that electron can pass through them to the ground.

Hanging metal chain with petrol transporting truck: A metal chain has to be hung touching the road with the trucks that carries petrol, diesel or other liquid fuels. When a truck moves along the road, the petrol in the tank dashes against the inner surface of the tank and oscillates to and fro. As a result of this, friction charge is stored in petrol. If any spark takes place from the edge of the tank it may cause serious accident and may set fire. So the charges in petrol are not safe. Therefore a chain is connected at the back of the tank so that the charge can pass through it to the ground easily as metal is a good conductor.

No direct connection between metal pillar and electric line: The metal pillars on the road have no direct connection with electric lines pulled over the pillars. As metals are good conductors, the electricity of the wire may pass through the pillar to the ground if the pillar has connection with wires. If anyone touches the pillar he could immediately be electrified causing serious accident. So the wires are connected to the pillars by a porcelain cup.

Thunder bolt and lightning conductors: We know that there is water vapor in atmosphere. This water vapor being condensed on the charged ions on the atmosphere and form water droplets and become charged with electricity. When these water droplets gather together cloud is formed. Cloud can be charged either positively or negatively. When two oppositely charged clouds come close to each other then electrical discharge takes place between them and makes huge spark. This is called lightning or electric flash.

During electric flash the air around the cloud expands suddenly by getting heated. Due to sudden expansion the pressure of the air lowers much. Then neighboring air at higher pressure contracts the expanded air. Due to this sudden expansion and contraction of air, violent sound is produced. This is known as roaring of thunder. If there is too much charge on a cloud then it includes opposite charge on the surface of the earth and electric discharge takes place. This is known as thunder bolt.

Lightning conductor or lightning arrester: In order to protect buildings from the ravage of lightning the lightning conductor is used. The metallic rod R (Fig 10.18) with several sharp points at the top is fixed in such a way that its upper end extends several feet above the roof of the building and lowers end runs down along the outer surface of the building and buried well inside the moist earth.

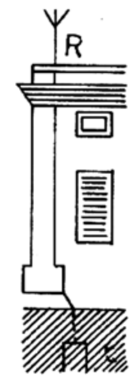


Fig: 10.18

When a charged cloud passes above the building then the charge of opposite kind is induced in the conductor rod R. The accumulation of charge is at maximum at the pointed ends of lightning conductor and pointed ends discharges their charge to the air particles around it. The air particles around the sharp points are charged by conduction and are attracted by the opposite charges of cloud and moves towards the cloud is neutralized. As a result the probability of thunder bolt decreases.

Electricity always passes following the shortest path through a conductor. The charge produced in the clouds tends to reach the earth through the high standing objects. During storm and rain it is rather good to wet in rain than to stand under an umbrella, any tree, near any conductor, iron bridge or fence of sharp iron wire.

Investigation:10.1

Production of the charge in the process of friction and induction.

Objectives: Demonstration of charges produced in the process of friction and induction.

Apparatus: Pith ball, glass rod, silk cloth, piece of rubber and a conductor rod.

Working procedure:

1. Suspend a light pith ball from a stand or a hook by a string.
2. Take a dry glass rod.
3. Cover one end of a glass rod by a piece of rubber and hold it.
4. Rub the other end of the glass rod by a piece of silk cloth properly.
5. Bring the rubbed end of the glass rod near a freely suspended pith ball.
6. The glass rod attracts the pith ball towards it as the glass rod is charged due to friction.
7. The glass rod is charged positively. (You can prove that with the help of an electroscope)
8. Now bring the charged glass rod near to an end of an uncharged conductor.

9. Due to induction the uncharged conductor will be charged. The near end of the conductor will be negatively charged and the far end positively.
10. If the far end of the conductor is connected to earth by a wire or if touched barefooted without displacing the glass rod, electron from the ground will neutralize the positive charges of the conductor. As a result, only the negative charges will remain in the conductor.
11. Now if the conductor is brought near a pith ball it will be attracted.
12. The conductor is charged by the process of induction.

Exercise

A. Multiple Choice Questions

Tick (√) the correct answer

1. The name of the apparatus used to determine the presence of charge is –

   a) Ammeter b) Voltmeter

   c) Microscope d) Electroscope

2. On which factor below the electrostatic force between two charges does not depend on?

   i) the distance between the charges

   ii) the nature of the medium in which the charges are placed

   iii) the masses of the charges

Which one of the following is correct?

   a) i & ii b) i & iii

   c) ii & iii d) i, ii, & iii

3. The unit of electric field intensity is-

   a) N b) Nm

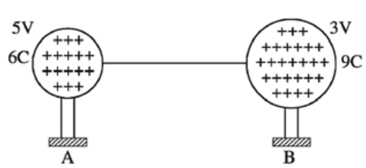
   c) Nm^{-1} d) NC^{-1}

4. Volt is the unit of what?

   a) electric field b) electric potential

   c) electric charge d) electric current

5. In the following figure-



   i) some charges from the sphere A will flow to the sphere B

   ii) some charges from the sphere B will flow to the sphere A

   iii) the charge difference remains same.

Which one of the following is correct?

a) i b) ii

c) iii d) i. ii. And iii

B. Creative Questions:

1. Rima after combing her hair observes that her comb attracts small pieces of paper. Shima says that it happens so because the comb is charged positively. Rima says that the comb is charged negatively. To solve the problem, Rima and Shima look for their physics teacher and find him in the physics laboratory. Hearing everything he asks them to find the nature of charge with the help of an electroscope.

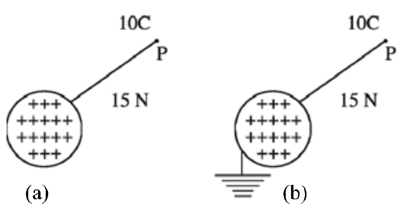
a) What do you mean by charge?

b) Explain why an object is charged by friction.

c) Describe why the comb is charged.

d) Explain how the nature of charge of the comb can be determined by the electroscope.

2.



a) What is electric field?

b) If the position of the object at P is charged what kind of change of force it takes?

c) Find the electric field intensity at point P of fig. a.

d) Explain the change of force of fig. a than fig. b.

C. General Questions

1. Explain the phenomenon of charging a body on the basis of structure of atom.
2. How an object can be charged by the process of friction?
3. What is electrostatic induction?
4. What do you mean by inducing charge and induced charge?
5. Describe how a body is charged by the process of induction.
6. Describe the construction of a gold leaf electroscope.
7. Describe how a gold leaf electroscope can be charged positively.
8. How the nature of charge of a charged body can be determined by a gold leaf electroscope?
9. What are the factors on which the electrostatic force between two charges depends?