# UNIT 13

# ELECTROSTATICS

**After studying this unit, the students will be able to:**

- **a.** Describe simple experiments to show the production and detection of electric charge.
- **b.** Describe experiment to show electrostatic charging by induction.
- **c.** State that there are positive and negative charges.
- **d.** Describe the construction and working principle of electroscope.
- **e.** State and explain Coulomb's law.
- **f.** Solve problems on electrostatic charges by using Coulomb's law.
- **g.** Define electric field and electric field intensity.
- **h.** Sketch the electric field lines for an isolated +ve and -ve point charges.
- **i.** Describe the concept of electrostatic potential.
- **j.** Define the unit "volt".
- **k.** Describe potential difference as energy transfer per unit charge.
- **l.** Describe one situation in which static electricity is dangerous and the precautions taken to ensure that static electricity is discharged safely.
- **m.** Describe that the capacitor is charge storing device.
- **n.** Define capacitance and its unit.
- **o.** Derive the formula for the effective capacitance of a number of capacitors connected in series and in parallel.
- **p.** Apply the formula for the effective capacitance of a number of capacitors connected in series and in parallel to solve related problems.

**Q.1 Define an electric charge. How electric charges can be produced?**

**Answer**

**Electric charge:**

**Definition:**

"Charge is a basic property of a material body due to which it attracts or repels another object."

**1)** Friction produces two different types of charges on different materials (such as glass and plastic).

**2)** Like charges always repel each other.

**3)** Unlike charges always attract each other.

**4)** Repulsion is the sure test of charge on a body.


All of these devices are capacitors, which store electric charge and energy

**Production of electric charges:**

**I)** If a plastic comb is run through the hair and then brought near small pieces of paper, the comb attracts them as shown in fig. 13.1.

**2)** Amber, when rubbed with silk, attracts the small pieces of paper.

This property of attraction or repulsion between substances is due to the electric charges they acquire during rubbing.

Electric charge can also be produced by rubbing a neutral body with another neutral body as shown in the activities below.

**Activity 1:**

Take a plastic rod. Rub it with fur and suspend it horizontally by a silk thread as shown in the fig 13.2.

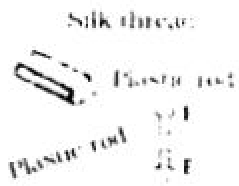


Fig. 13.2: Two plastic rods rubbed with fur repel each other.

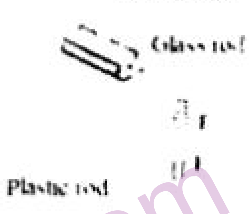



Fig.13.3: Plastic rod rubbed with fur and glass rod rubbed with silk attract each other.

Now take another plastic rod and rub it with fur and bring it near to the suspended rod. We will observe that both the rods will repel each other.

It means during the rubbing both the rods were charged.

**Activity 2:**

Take a glass rod and rub it with silk and suspend it horizontally. When we bring the plastic, rod rubbed with fur near to the suspended glass rod, we observe that both the rods attract each other as shown in the fig. 13.3.

Fig. 13.4: Charged platic rod attracts neutral copper rod

**Conclusion:**

**1)** In the first activity, both rods are of plastic and both of them have been rubbed with fur. Therefore, we assume that charge of both rods would be of the same kind.

**2)** In the second activity rods are unlike and their attraction imply that charge on the two rods are not of the same kind but of opposite nature.

These opposite charges are conventionally called positive and negative charge. During the process of rubbing negative charge is transferred from one object to another object.

**Q.2 Define electrostatic induction. Write the method of charging bodies by electrostatic induction?**

**Answer**

**Electrostatic induction:**

**Definition:**

In the presence of a charged body, an insulated conductor develops positive charge at one end and negative charge at the other end. This process is called the electrostatic induction.

**Activity 1:**

Electrostatic induction is another method of charging a body and is described below.

**i)** Consider a metallic sphere placed on an insulated stand as shown in the fig. 13.5 (a). The sphere is neutral as it carries equal number of positive and negative charges. Now bring a negatively charged rubber rod near the conducting sphere. As shown in the fig. 13.5 (b), left part of the sphere that is close to the rod becomes positively charged while the right part that is away from the rod becomes negatively charged.

Negative charge in the rod repels the negative charge of the sphere and shifts it to the opposite region of the sphere that is away from the rod. Thus, there is excess of positive charge in the region of sphere close to the rod while there is excess of negative charge in the region of the sphere away from the rod. But as a whole the sphere is still neutral, since no charge has been added or subtracted.

**ii)** Now if we remove the rod away from the sphere, the charge again will spread uniformly on the whole surface of the sphere.

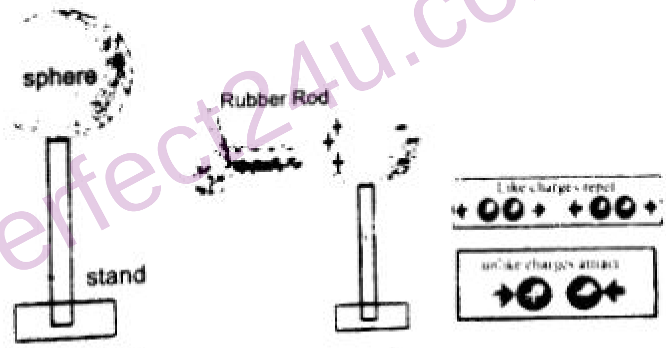



Fig.13.5 (a)
Neutral metal is placed on insulating stand

Fig.13.5 (b)
Electrostatic induction

The leafs of electroscope repel each other and diverge because each leaf gets similar charge. The divergence of leafs will depend on the amount of charge.

**2)** Detecting the type of charge:

For the detection of type of charge, electroscope is first charged either positively or negatively. Suppose the electroscope is positively charged as explained before.

Now in order to detect the type of charge on a body, bring the charged body near the disk of the positively charged electroscope.

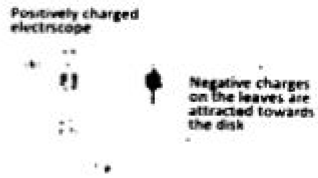



Fig. 13.11 (a): Detecting positive charge on body.

If the divergence of the leafs increases, the body carries positive charge as shown in the figure 13.11 (a).

On the other hand, if the divergence decreases, the body has negative charge as shown in the figure 13.11 (b).

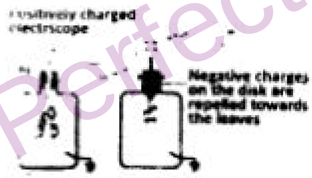



Fig. 13.11 (b): Detecting negative charge on body.

**3)** Identifying conductors and insulators:

Electroscope can also be used to distinguish between insulators and conductors. Touch the disk of a charged electroscope with material under test. If the leafs collapse from their diverged position the body would be a good conductor.

If there is no change in the divergence of the leaves, it will show that the body under test is an insulator.

**Q.4 How an electroscope be charged by electrostatic induction and conduction as well?**

**Answer**

Charging the electroscope by electrostatic induction:

Electroscope can be charged by the process of electrostatic induction. In order to produce positive charge of the electroscope, bring a negatively charged body near the disk of the electroscope as shown in the figure 13.10 (a).

13.10 (a) Charging the ...troscope positively

Positive charge will appear on the disk of the electroscope while negative charge will shift to the leafs.

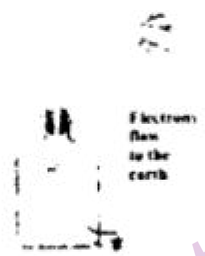



Fig. 13.10 (b): Charging the electroscope positively

Now connect the disk of electroscope to the earthed aluminum foil by a conducting w ire as shown in the fig. 13.10 (b). Charge of the leafs will flow to the earth 'through the wire.

Fig. 13.10 (c): Charging the electroscope positively

Now if we first break the earth connection and then remove the rod the electroscope will be left with positive charge.

Similarly, electroscope can be charged negatively with the help of a positively charged rod.

**Charging of electroscope by conduction:**

Electroscope can also be charged by the process of conduction. Touch a negatively charged rod with the disk of a neutral electroscope. Negative charge from the rod will transfer to the electroscope and will cause its leafs to diverge:

**Q.5 State coulomb's law. Derive the expression of electrostatic force?**

**Answer**

**Coulomb's law: (statement):**

The force of attraction or repulsion between two-point charges is directly proportional to the product of the quantity of charges and inversely proportional to the square of the distance between them.

**Explanation:**

A French scientist Charles Coulomb in 1785 experimentally established this fundamental law of electric force between two stationary charged particles.

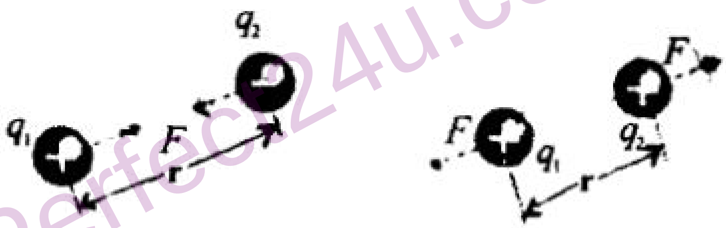



Fig. 13.12 (a): Attraction between opposite charges

Fig. 13.12 (b): Repulsion between similar charges

Suppose two charges $q_1$ and $q_2$ are separated at a distance r. The electric force between these two charges is given as:

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

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

Combinig equation (1) & (2), we get,

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

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

The above equation is known as "Coulomb's law".

Where 'F' is the force between the two charges and is called the coulomb force, qi and q2 are the quantities of two charges separated by a- distance 'r'. 'k' is the constant of proportion given by,

$$k = \frac{1}{4}\pi E_o$$

The value of 'k' depends upon the medium between the charges and the system of units in which F, q and r are measured, €$_0$' is the permittivity of free space.

Now if the medium between the two charges is air then the value of 'k' in SI units will be $9 \times 10^9$ $Nm^{-2}$ $C^{-2}$.

**Q.6 What is meant by electric field and electric intensity?**

**Answer**

**Electric field:**

"The electric field is a region around a charge in which it exerts electrostatic force on another charge."

According to coulomb's law if a unit positive charge '$q_0$' is brought near a charge q placed is space, the charge 'go' will experience a force. The value of this force would depend upon the distance between the two charges.

**For your information**
In SI, the unit of charge is coulomb (C). It is equal to the charge of $6.25 \times 10^{19}$ electrons. This is very big unit. Usually charge is measured in micro coulomb. One micro coulomb is equal to $10^{o}$C.

If the charge '$q_0$' is moved away from 'q' this force would decrease till at a certain distance the force would practically reduce to zero. Now the charge 'q' is out of the influence of charge `q'.

**Electric field intensity:**

"The strength of electric field at any point in space is known as electric field intensity."

In order to find the value of electric intensity at a point in the field, the charge `+q', we place a test charge `$q_0$' at that point as shown in the fig 13.13.

If F is the force acting on the test charge 'go', the electric field intensity would be given by:

$$E = \frac{F}{q_o} \text{..........(1)}$$

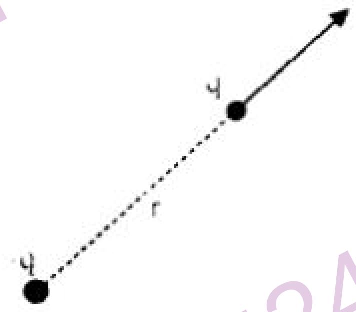



Fig. 13.13 A charge ... at a distance r from charge +...

Thus, the electric field intensity at any point is defined as, the force acting on a unit positive charge placed at that point.

SI units of electric intensity is $NC^{-1}$.

If the electric field due to a given arrangement of charges is known at some point, the force on any particle with charge `q' placed at that point can be calculated by using the formula:

$$F = qE \text{..........(2)}$$

**1)** Electric intensity being a force is a vector quantity.

**2)** Its direction is the same as that of the force acting on the positive test charge.

**Q.7 What are electric field lines? How field lines are related to the electric field intensity?**

**Answer**

**Electric field lines:**

"The direction of electric field intensity in an electric field can also be represented by drawing lines. These lines are known as electric lines of force."

These lines were introduced by Michael faraday.

The field lines are imaginary lines around a field charge with an arrow head indicating the direction of force.

Field lines always move away from positive charge but toward negative charge. The spacing between the field lines shows the strength of electric field as shown

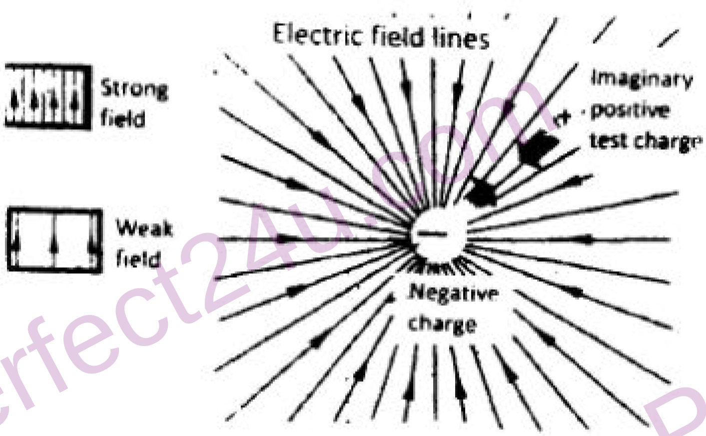



Fig. 13.14

in fig. 13.14.

**Relation between field lines and electric field intensity:**

Field lines are related to the electric field intensity in any region of space in the following way.

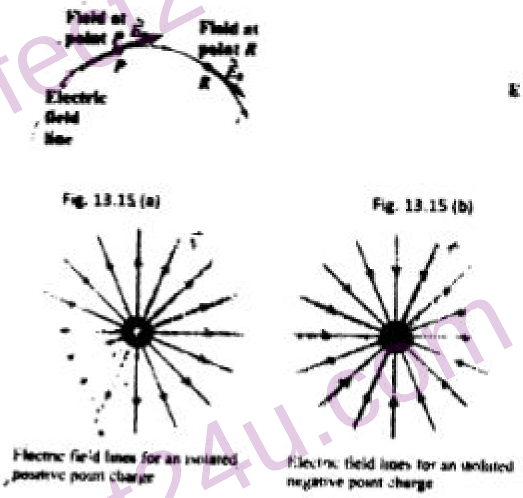
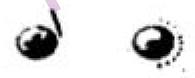



Fig. 13.15 (a)

Fig. 13.15 (b)

**1)** The electric field intensity is tangent to the electric field lines at each point as shown in fig. 13.15 (a).

**2)** The number of lines per unit area through a surface perpendicular to the lines is proportional to the electric field strength in a given region as shown in fig. 13.15 (b).



Electric field lines for two opposite and equal point charges

Electric field lines for two positive point charges

Electric field lines for two negative point charges

**3)** Electric field is strong when the field lines are close together and weak when the lines are far apart.

**4)** No two lines cross each.

**5)** Electric field lines for an isolated positive and negative point charges are shown in the figure above.

**Q.8 Define potential difference between two points? Show that potential difference can be described as energy transfer per unit charge between the two points?**

**Answer**

**Electrostatic Potential:**

"Electric potential at a point in an electric field is equal to the amount of work done in bringing a unit positive charge from infinity to that point".

**Do you know?**
The volt is named after the Italian physicist Alessandro Volta (1745-1827), who developed the first practical electric battery, known as a voltaic pile. Because potential difference is measured in units of volts, it is sometimes referred to as voltage.

If 'W' is the work done in moving the unit positive charge from infinity to a certain point in the field, the electric potential V at this point would be given by:

$$V = \frac{W}{q} \quad \text{..........(1)}$$

It implies that electric potential is measured relative to some reference point and like potential energy we can measure only the change in potential between two points.

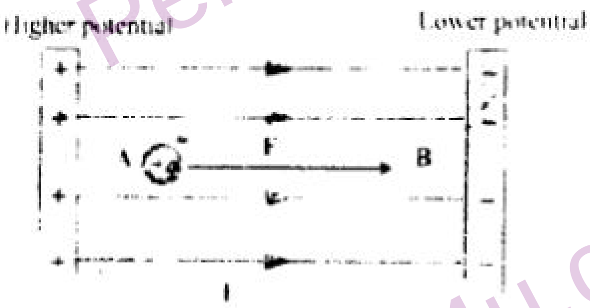



Fig 13.16: Potential difference between two points

**1)** Electric potential is a scalar quantity.

**2)** Its SI unit is volt which is equal to $JC^{-1}$.

**Volt:**

If one Joule of work is done against the electric field in bringing one coulomb positive charge from infinity to a point in the electric field then the postritual at that point will be one volt, or

If the potential energy of one coulomb of charge at a point in the electric field is one Joule, the potential of that point will be one volt.

**Electric potential difference:**

A body in gravitational field always tends to move from a point of higher potential energy to a point of lower potential energy. Similarly, when a charge is released in an electric field, it moves from a point of higher potential say 'A' to a point of lower potential say 'B', as shown in the fig 13.16.

If the potential of A is '$V_a$' and that of point B is '$V_h$', the potential energy of the charge at these points will be $qV_a$ and $qV_h$ respectively.

The change in potential energy of the charge when it moves from point A to B will be equal to $qV_a - qV_b$. This energy is utilized in some useful work. Thus:

Energy supplied by the charge = $q\,(V_a - V_b)$

If 'q' is equal to one unit, then the potential difference between two points becomes equal to the energy, supplied by the charge. Thus, we define potential difference between two points as:

The energy supplied by a unit charge as it moves from one point to the other in the direction of the field."

If a positive charge is transferred from a point of lower potential to a point of higher potential i.e. against the field direction, energy would have to be supplied to it.

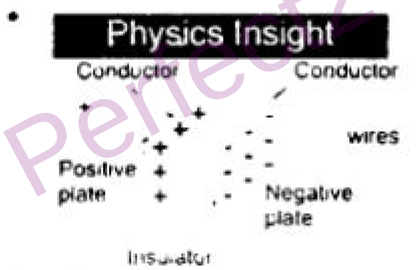
When we release a negative charge in an electric field, its behavior will be opposite to that of positive charge. Amore useful unit for the electrical energy is electron volt (ev).

**Q.9 Describe capacitor as an energy storing device. What do you mean by capacitance of a capacitor? Define units of capacitance?**

**Answer**

**Capacitor:**

A device consisting of two metal plates used for storing charge is called a capacitor, or parallel plate capacitor.




Parallel plate capacitor consists of two metal plates separated with an insulator. The presence of charge Q on plate. A induces a -Q charge on the inner surface of plate B.

**Explanation:**

A capacitor consists of two thin metal plates, parallel to each other separated by a very small distance as shown in the figure 13.17.

The medium between the two plates is air or a sheet of some insulator. This medium is known as "dielectric."

If + Q amount of charge is given to plate A of a parallel plate capacitor, due to electrostatic induction, it would induce — Q charge on the inner surface of the plate B and +Q on its outer surface. The lines of force between the plates 13.17 (b).

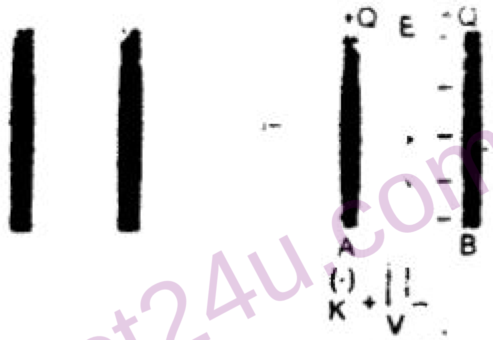



Fig. 13.17 (a): Parallel plate capacitor Fig. 13.17 (b): Plates of capacitor connected with battery

There exists a force of attraction between the charge + Q stored on the plate A and the charge - Q induced on the inner surface of plate B. Due to this force of attraction, the charges are bound within the plates and remain stored for long periods.

Due to presence of charges on the plates, a potential difference 'V' is developed across them which is directly proportional to the charge 'Q' deposited on the plate A.

**Energy Stored in a Capacitor**
Capacitor stores energy in an electric field between two plates in the form of electrostatic potential energy.

i.e. $Q \propto V$

or. $Q = CV$

**Capacitance of a capacitor:**

In the expression Q = CV, 'C' is the constant of proportionality called the capacitance of the capacitor and is defined as. "the ability of the capacitor to store charge."

It is given by the ratio of charge and the electric potential as:

$$C = \frac{Q}{V}$$

The unit of capacitance is "Farad".

**Physics insight**
A voltage across a devise, such as capacitor, has the same meaning as the potential difference across the device. For instance, if we suppose that the voltage across a capacitor is 12V, it also means that the potential difference between its plates is 12 V.

## Farad:

If one coulomb of charge given to the plates of a capacitor produces a potential difference of one volt between the plates of the capacitor then its capacitance would be one Farad.

It's a large unit usually we use smaller units i.e. μF and PF.

**Q.10 Derive a formula for the effective capacitance for a parallel combination of a number of capacitors?**

**Answer**

**Capacitors in parallel:**

In this method the left plate of each capacitor is connected to the positive terminal of the battery by a conducting wire. In the same way the right plate of each capacitor is connected to the negative terminal of the battery as shown in the fig. 13.18.

This type of combination has the following characteristics.

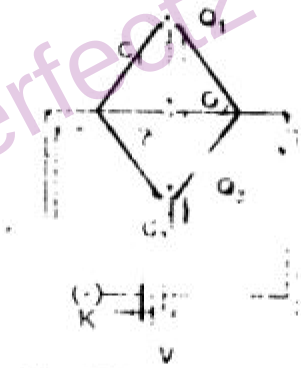


Fig. 13.18: Capacitors in parallel combination.

**1)** Each capacitor connected to a battery of voltage V has the same potential difference V across it. i.e.

$$V = V_1 = V_2 = V_3$$

**2)** The charge developed across the plates of each capacitor will be different due to different value of capacitances.

**3)** The total charge 'Q' supplied by the battery is divided among the various capacitors. Hence:

$$Q = Q_1 + Q_2 + Q_3$$

Or $$Q = C_1V + C_2V + C_3V$$

Or $$Q = V(C_1 + C_2 + C_3)$$

Or $$\frac{Q}{V} = C_1 + C_2 + C_3$$

**4)** Thus, we can replace the parallel combination of capacitors with one equivalent capacitor having capacitance such that,

$$C_{eq} = C_1 + C_2 + C_3$$

In the case of 'n' capacitors connected in parallel, the equivalent capacitance is given by;

$$C_{eq} = C_1 + C_2 + C_3 + \quad + C_{n+} \ldots\ldots\ldots + C_n$$

**5)** The equivalent capacitance of a parallel combination of capacitors is greater than any of the individual capacitances

**For your information**
Three factors affect the ability of a capacitor to store charge.
1. Size of capacitor plates.
2. Distance between the Plates.
3. Type of insulator Between the plates.

**Q.11 Derive a formula for the effective capacitance for a series combination of a number of capacitors?**

**Answer**

**Capacitors in series:**

In this method the capacitors are connected side by side i.e. the right plate of one capacitor is connected to the left plate of the next capacitor as shown in the figure 13.20.

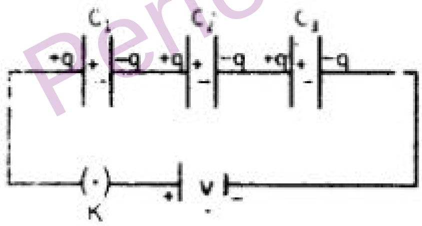



Fig. 13.20: capacitors in series combination.

This type of combination has the following characteristics.

**1)** Each capacitor has same charge across it. If the battery supplies + Q charge to the left plate of the capacitor $C_1$. Due to induction — Q charge is induced on its right plate and + Q charge on the left plate of the capacitor $C_2$ i.e.

$$Q_1 = Q_2 = Q_3 = Q$$

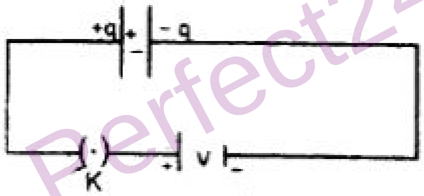



Fig. 13.21

**2)** The potential difference across each capacitor is different due to different values of capacitances.

**3)** The voltage of the battery has been divided among the various capacitors. Hence:

$$V = V_1 + V_2 + V_3$$

$$= \frac{Q}{C_1} + \frac{Q}{C_2} + \frac{Q}{C_3}$$

$$= Q\left[\frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}\right]$$

Or $$\frac{V}{Q} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$$

**4)** Thus we can replace series combination of capacitors with one equivalent capacitor having capacitance $C_{eq}$ie..:

$$\frac{1}{C_{eq}}=\frac{1}{C_1}+\frac{1}{C_2}+\frac{1}{C_3}$$

**5)** In the case of n capacitors connected in series, we have:

$$\frac{1}{C_{eq}}=\frac{1}{C_1}+\frac{1}{C_2}+\frac{1}{C_3}+\ldots\ldots\ldots+\frac{1}{C_n}$$

**Q.12 Discuss different types of capacitors?**

**Answer**

**Types of capacitors:**

**1) Parallel plate capacitors:**

Parallel plate capacitors are not commonly used in most devices because in order to store enough charge their size must be large which is not desirable.

A parallel plate capacitor has a dielectric between its plates and is made of a flexible material that can be rolled into the shape of cylinder. In this way we can increase the area of each plate while the capacitor can fit into a small space.

Some other types of capacitors use chemical reactions to store charge, like tiny batteries.

**2) Paper capacitor:**

Paper capacitor is an example of fixed capacitor as shown in the fig. 13.22.

Fig. 13.22: Paper capacitor

The paper capacitor has a cylindrical shape. Usually an oiled or greased paper or a thin plastic sheet is used as a dielectric between two aluminum foils. The paper or plastic sheet is firmly rolled in the form of a cylinder and is then enclosed into a plastic case.

**3)Mica capacitor:**

In these capacitors, mica is used as dielectric between the two metal plates. For convenience and safety purposes, it is enclosed in a plastic case or in a case of some insulator. Wires attached to plates project out of the case for making connections as shown in fig. 13.23.

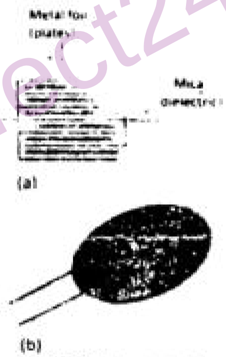


Fig. 13.23: Mica capacitor

If the capacitance is to be increased, large number of plates is piled up, one over the other with layers of dielectric in between and alternative plates are connected with each other.

**4) Variable capacitors:**

In variable type of capacitors some arrangement is made to change the area of the plates facing each other as shown in the figure 13.24.

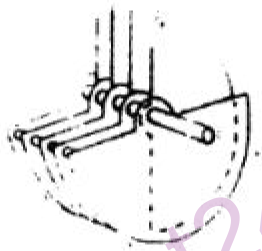


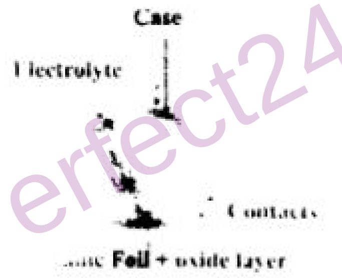
Fig. 13.24: Variable capacitor

It is generally a combination of many capacitors with air as dielectric. It consists of two sets of plates. One set remains fixed while the other set can rotate so the distance between the plates does not change and they do not touch each other. The common area of the plates of the two sets which faces each other, determines the value of capacitance. Thus, the capacitance of the capacitor can be increased or decreased by turning the rotatable plates in or out of the space between the static plates. Such capacitors are usually used for tuning in radio sets.

**5) Electrolytic capacitor:**

An electrolytic capacitor is often used to store large amounts of charge at relatively 16W voltages as shown in the fig. 13.25.

It consists of a metal foil in contact with an electrolyte a solution that conducts charge by virtue of the motion of the ions contained in it. When a voltage is applied between the foil and the electrolyte, a thin layer of metal oxide (an insulator) is formed on the foil, and this layer serves as the dielectric. Enormous capacitances can be attained because the dielectric layer is very thin.




Electrolytic capacit

**Q.13 Briefly write the uses of capacitors?**

**Answer**

**Uses of capacitors:**

Capacitors have wide range of applications in different electrical and electronic circuits. For example:

**1)** They are used for tuning transmitters, receivers and transistor radios. They are also used for table fans, ceiling fans, exhaust fans, fan motors in air conditioners, coolers, motors, washing machines and many other appliances for their smooth working.

**2)** Capacitors are also used in electronic circuits of computers etc..

**3)** Capacitors can be used to differentiate between high frequency and low frequency signals which make them useful in electronic circuits. For example, capacitors are used in resonant circuits that tune radios to particular frequencies. Such circuits are called filter circuits.

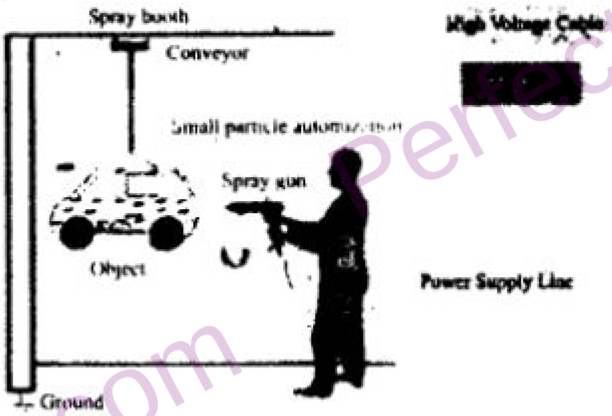
**4)** Ceramic capacitors are generally superior to other types and therefore can be used in vast ranges of applications.

**Q.14 Discuss the applications of electrostatics?**

**Answer**

**Applications of electrostatics:**

**I) Electrostatic air cleaner:**




An electrostatic air cleaner used in homes to relieve the discomfort of allergy sufferers. Air mixed with dust and pollen enters the device across a positively charged mesh screen.

The air borne particles become positively charged when they make contact with the screen. Then they pass through a second negatively charged mesh screen.

The electrostatic force of attraction between the positively charged particles in the air and the negatively charged screen causes the particles to precipitate out on the surface of the screen. Through this process we can removes a very high percentage of contaminants from the air stream.

**2) Spray painting:**

Automobile manufacturers use static electricity to paint new cars.

The body of car is charged and then the paint is given the opposite charge by charging the nozzle of the sprayer as shown in the figure.

Due to mutual repulsion, charge particles coming out of the nozzle form a fine mist and are evenly distributed on the surface of the object.

**For your information**

During flight, body of aeroplane gets charged. As the aeroplane lands, this charge is transferred to ground and the charge of sparking is eliminated while petrol is filled in it

The charged paint particles are attracted to the car and stick to the body, just like a charged balloon sticks to a wall. Once the paint dries, it sticks much better to the car and is smoother because it is uniformly distributed. This is a very effective, efficient and economical way of painting automobiles on large scale.

**Q.15 What are hazards of static electricity?**

**Answer**

**Some hazards of static electricity**

**I) Lightening:**

The phenomenon of lightening occurs due to a large quantity of electric charge which builds up in the heavy thunder clouds. The thunder clouds are charged by friction between the water molecules in the thunder-clouds and the air molecules. When the charge on the thunder clouds is sufficiently high it can produce positive and negative

charges in the air.

The huge amount of negative charge is discharged to the highest object on the ground and can harm them.

This explains why it is very dangerous to swim in the open sea, play in an open field or hide under a tree during a thunderstorm.

**Physics of Field Lines**

Some animals produce electric fields to detect nearby objects that affect the field.

To prevent lightening from damaging tall buildings, lightening conductors are used. The purpose of the lightening conductor is to provide a steady discharge path for the large amount of negative charge in the air to flow from the top of the building to the earth.

In this way, the chances of lightening damage due to minimized.

**2) Fires or explosions:**

Static electricity is a major cause of fires and explosions at many places. A fire or an explosion may occur due to excessive build-up of electric charges produced by friction. Static electricity can be generated by the friction of the gasoline being pumped into a vehicle or container. It can also be produced when we get out of the car or remove an article of clothing. Static charges are dangerous. If static charges are allowed to discharge through the areas where there is petrol vapor a fire can occur. The results are frightening and may be devastating.

Portable oil containers can build up a static electric charge during transport. Consequently, when the container is not placed on the ground for filling, its static electricity could be discharged and result in a fire when filling begins. Containers should be placed on the ground during filling and the nozzle should be kept in contact with the container. Containers should not to be filled while inside a vehicle.

**Dangers of Static Electricity**

Static electricity can spark a fire or explosions. Care must be taken to avoid sparks when putting fuel in cars or aircraft. Spark may be produced due to friction between the fuel and the pipe. This can cause a serious explosion. The spark can be avoided if the pipe nozzle is made to conduct by connecting an earthing strap to it. The earthing strap connects the pipe to the ground.