CHAPER 13

Static Electricity

At the end of the lesson, I can…

1. **STATE** that there are positive and negative charges, and that charge is measured in coulombs	
2. **STATE** that unlike charges attract and like charges repel	
3. **DESCRIBE** an electric field as a region in which an electric charge experiences a force	
4. **DRAW** the electric field of an isolated point charge and recall that the direction of the field lines gives the direction of the force acting on a positive test charge	
5. **DRAW** the electric field pattern between two isolated point charges	
6. **SHOW** understanding that electrostatic charging by rubbing involves a transfer of electrons	
7. **DESCRIBE** experiments to show electrostatic charging by induction	
8. **DESCRIBE** examples where electrostatic charging may be a potential hazard	
9. **DESCRIBE** the use of electrostatic charging in an electrostatic precipitator, and apply the use of electrostatic charging to new situations	
10. **STATE** that unlike charges attract and like charges repel	
11. **DESCRIBE** an electric field as a region in which an electric charge experiences a force	

1. Electrical Charges

1.1 All matter consists of atoms. Atoms contain three types of smaller particles: electrons, protons and neutrons. Of these three, both the protons and electrons are charged.

1.2 Protons are positively charged and electrons are negatively charged.

1.3 Generally, an atom has a neutral charge as it has equal amount of positive and negative charges. When it loses electron(s), it becomes positively charged and when the atom gains electron(s), it becomes negatively charged.

1.4 Charged atoms are called ions and ions in matter can't move freely.

1.5 Charges are measured in coulombs (C).

1.6 Like charges repel and unlike charges attract.

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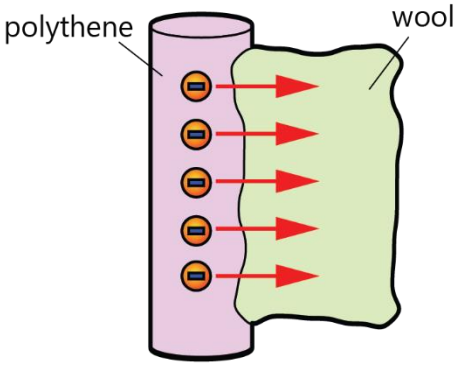
Electrostatic effect of water

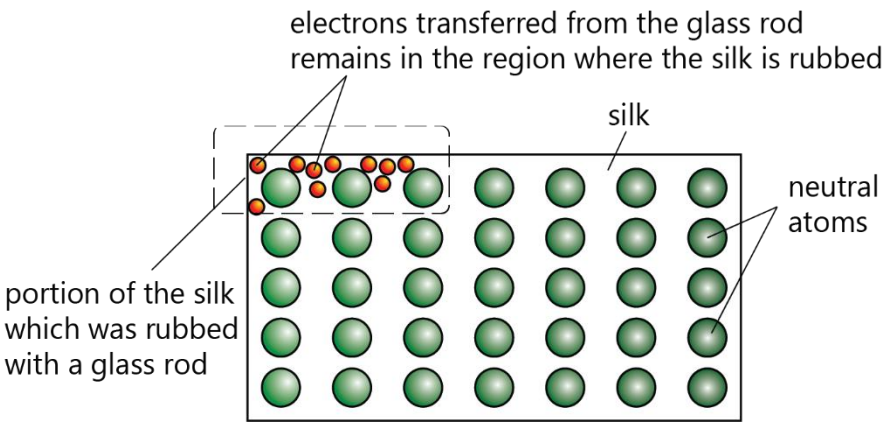
2. Charging By Friction

2.1 When insulating materials rub against each other, they may become electrically charged. The material that attracts electrons weakly will loose electrons and becomes positively charged.

2.2 Rubbing doesn't create charges, it transfers charges.

2.3 When a glass rod is rubbed against a piece of silk, the friction between them causes electrons to gain energy. Electrons from the glass rod gain enough energy to leave the atoms and transferred onto the silk.





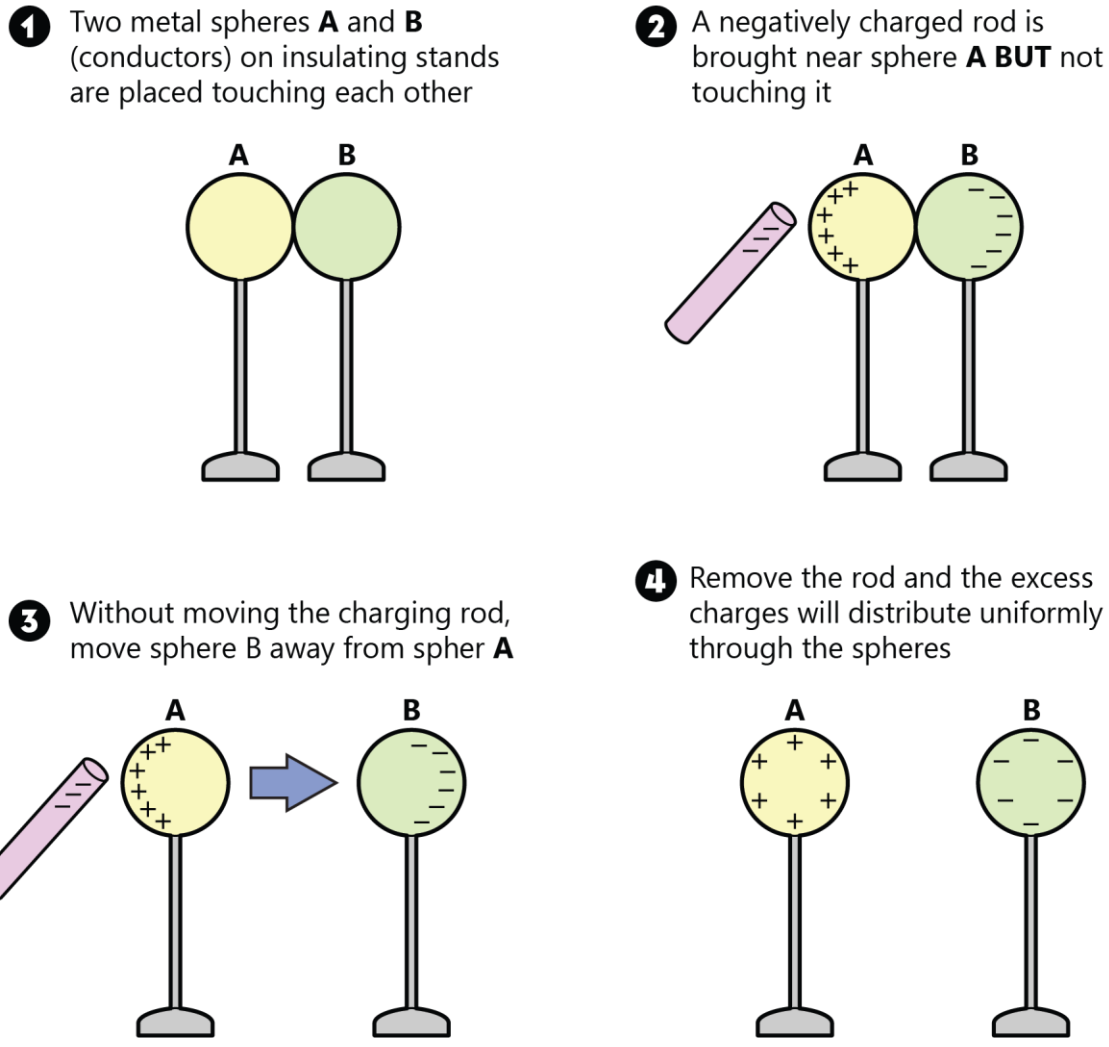
2.4 Both the glass and the silk are *insulating materials*. Insulators prevent the electrons *from moving* and so the charges remain *static*.

3. Charging Conductors By Induction

3.1 Conductors cannot be charged by friction because *electrons* can be *transferred* between them once they are in contact.

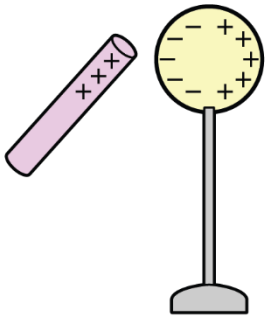
3.2 *Induction* is charging an electrical conductor without any contact between the *conductor* and the *charging body*.

3.3 ***Charging Two Conductors with Equal and Opposite Charges***

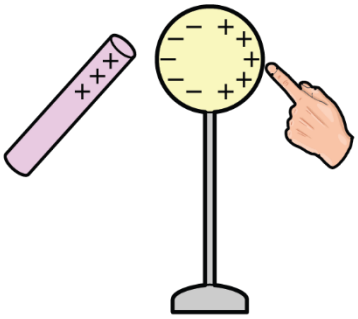


3.4 ***Charging A Conductor by Earthing.*** Earthing is the process of removing excess charges (can be positive or negative) on a conductor by means of *transferring electrons* between it and another object with *a source of mobile electrons*. This can be a large metal plate or the Earth itself.

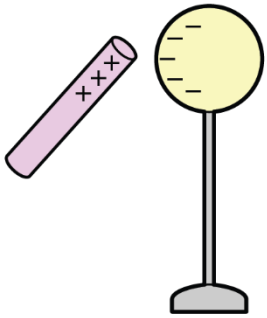
1 A positively charged rod is brought near a metal sphere BUT not touching it



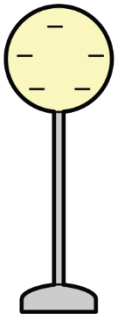
2 With the charging rod in place, earth the negatively charged side of the conductor by touching it



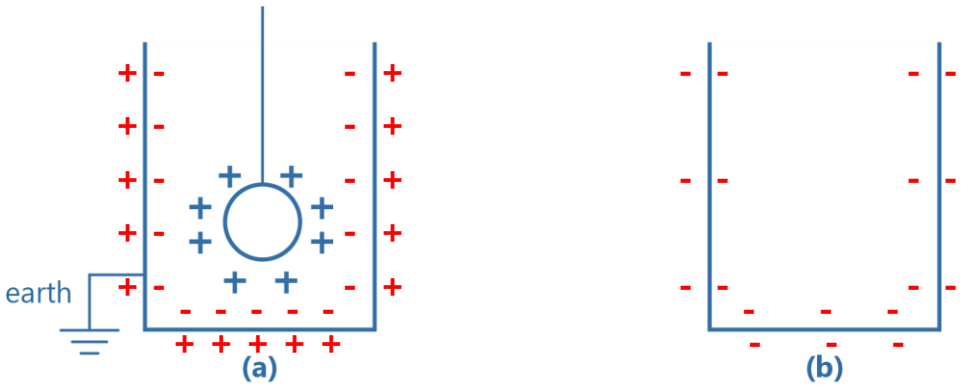
3 With the charging rod in place, stop the earthing process by remving the hand from the sphere



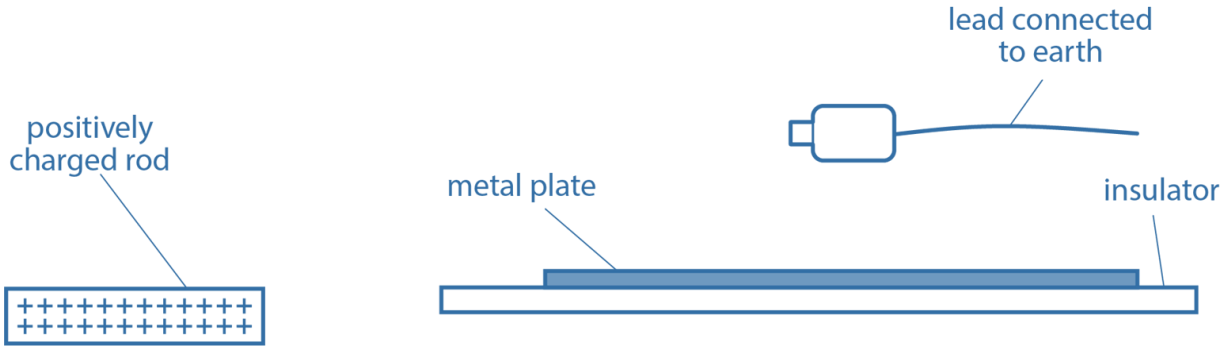
4 Remove the charging rod and the excess negative charges will redistribute uniformly over the sphere



QUESTION: A **positively charged** sphere is suspended by an insulating thread inside a metal can. **Draw on the can** the charges when **(a)** it is earthed; **(b)** the earth and charged sphere are removed.



QUESTION: A positively charged, insulated rod, an uncharged metal plate resting on an insulator and a lead connected to earth.



The apparatus is used to charge the metal plate by the process of induction and to leave the metal plate with a charge spread over all its surface.

State the steps taken to charge the metal plate.

State and explain what happen to the charge on the metal plate during the charging process.

(a) (1) bring the positively charged rod near the metal plate but not touching it; (2) bring the lead connected to earth to touch the metal plate; (3) Remove the positively charged rod and the earth lead.

(b) (1) Electrons in the metal plate moved closer to the positively charged rod; (2) electrons flow from the earth to neutralise the positively charged particles on the metal plate; (3) excess electrons distributed evenly on the metal plate.

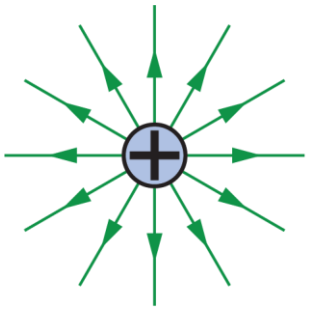
4. Electric Field

Electric field simulator

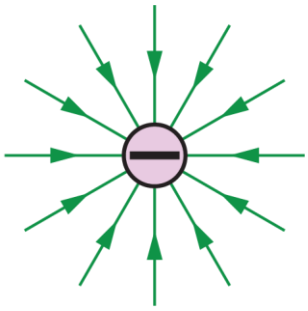
4.1 An electric field is a region where an object experiences an electric force because of the charges it has.

4.2 An electric field is shown by drawing electric lines of force. An electric line of force shows the direction a positive charge would move.

4.3 The electric fields of a positive and negative charge. The fields lines are straight and evenly spaced out along the radius with the charge at the centre.

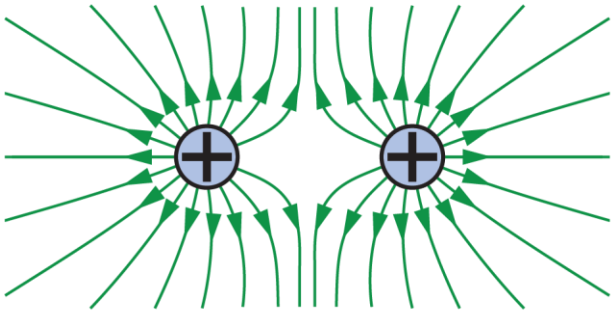


(a) positive charge

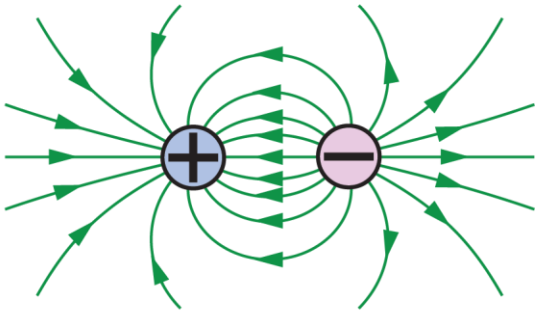


(b) negative charge

4.4 The electric fields of two charges. The field lines are symmetrical about the charges and further apart when they are further from the charges. The closer the field lines are, the stronger the field is.

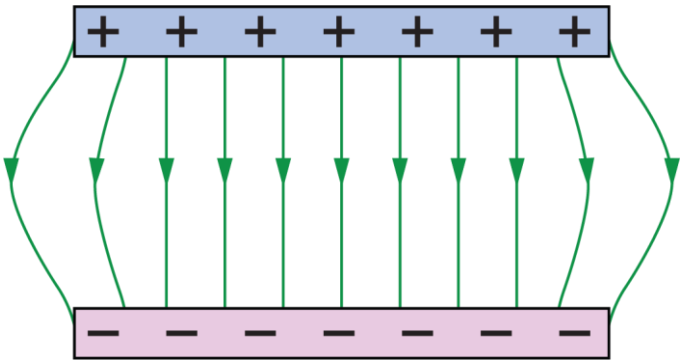


(a) two positive charges



(a) two opposite charges

4.5 The electric field between two long parallel oppositely charged plates is *uniform* at the *central region* and *non-uniform* at the two edges.



5. Hazards of Electrostatics Charging

5.1 Lightning are due to the *discharging of large quantity* of electric charges built up in the thunderclouds. These charges *ionise the air* and the ionised air then provides a *conducting path* for the charges to be discharged to the nearest or sharpest object on the ground.

5.2 A lightning rod provides a conducting path for the excessive electrons in the air to flow from the top of the building into the earth.

5.3 Rotating Tyres of a moving truck acquire negative charges from the road *by friction*. Parts of the *metal body of the truck* near the tyres then become positively-charged by induction and sparks may be produced, which *could ignite* any highly flammable load and cause a fire.

5.4 Hence transport petrol or other highly flammable liquids usually have a *metal chain* at the rear end, dangling to the ground, for the charges to *discharge to the ground*.

6. Electrostatic Precipitator

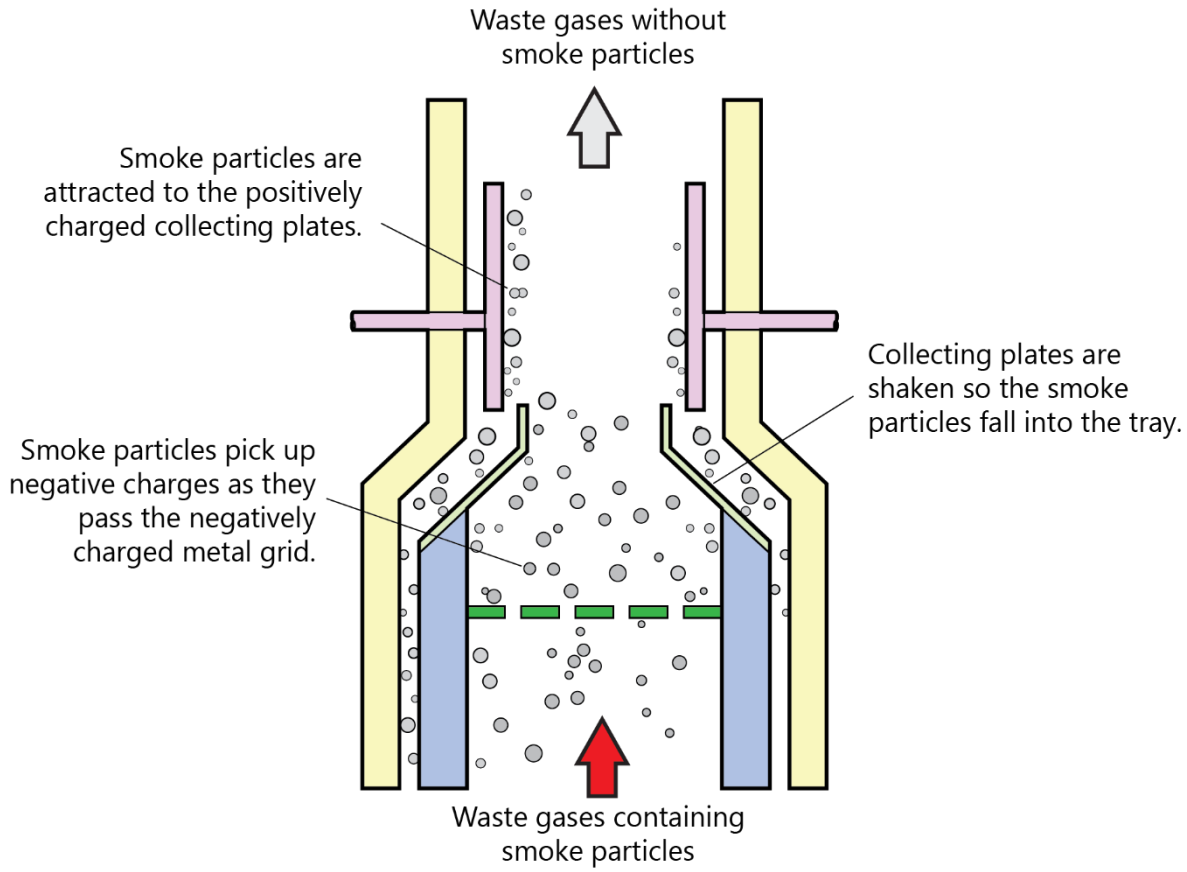
6.1 The electrostatic precipitator is a device fitted to factory and power station chimneys to *collect dust* so that air leaving the chimneys is clean from harmful pollutants.

6.2 It consists of *oppositely charge plates* over which smoke containing pollutants and dust pass.

1 smoke particles pick up a *negative charge*

2 smoke particles are *attracted* to the collecting plates and neutralised

3 the collecting plates are *shaken* to *remove* the smoke particles

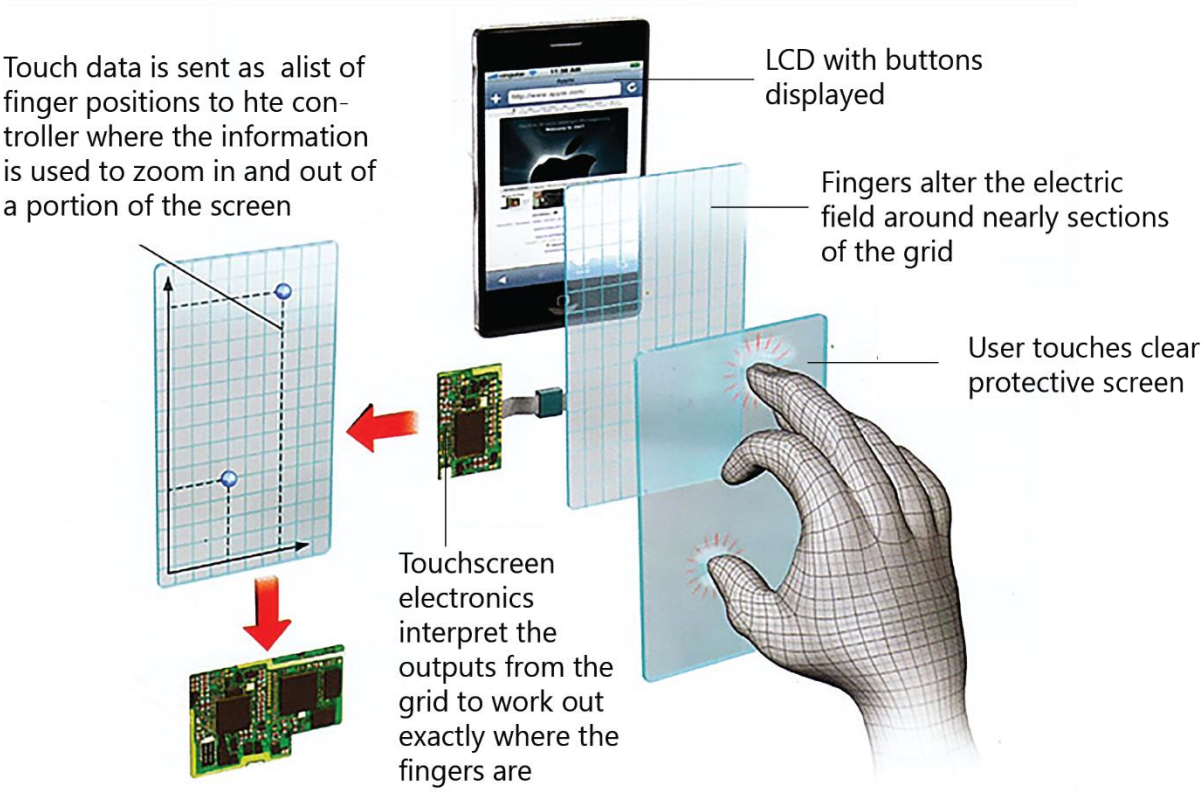


2.3 The particles are then routed past positively charged or earthed plates, which attract the negatively charged ash particles. Air leaving the plates is thus clean from harmful pollutants. The ash particles stuck to the positive plates are collected and used as a bonding agent in cement.

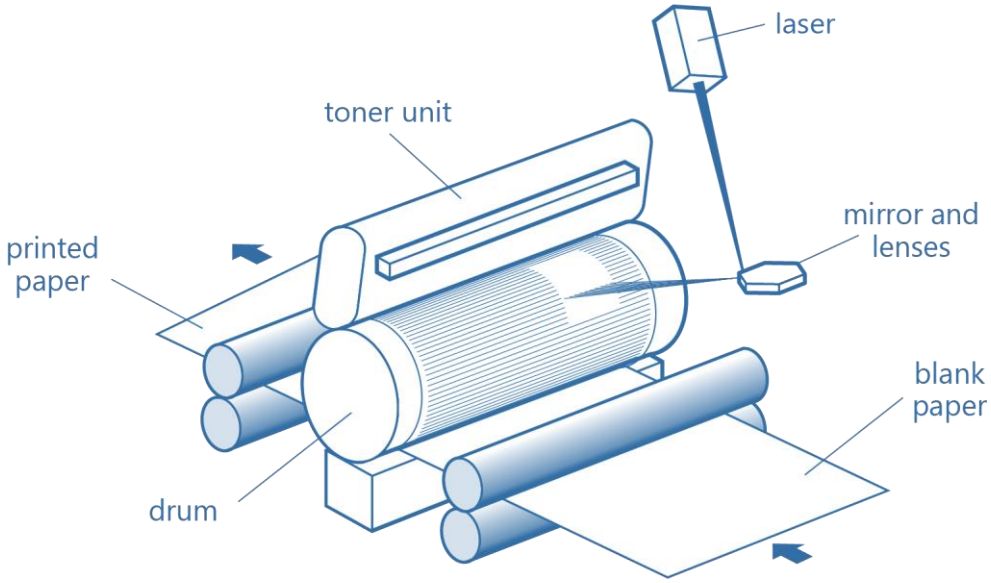
7. Touchpad

7.1 A touchpad is a device that uses changes in electric field to detect the presence and location of a finger or other conductive object on its surface.

7.2 A sensor circuit measures the changes in the electric field and determines the position and pressure of the touch.



QUESTION: The working parts of one type of laser printer are shown:



Initially, the surface of the drum is insulating and is positively charged. It is in the dark. The inside of the drum is made of metal and is connected to earth.

The regions where light strikes the drum become conducting.

(a) Explain what happens to the charge on the drum in the regions that the light strikes.

When the light strikes on the drum, the charges are neturalised by the light striking on it.

(b) The toner, a fine black powder, is charged and sprayed on to the drum. The toner does not stick where the drum is positively charged. In such places the final print appears white. Where light strikes the drum, the final print is black.

1. Suggest why the toner does not stick to the positively charged regions of the drum.
2. Suggest why the toner does stick to the conducting regions of the drum.

1. *black powder is charged positively before spraying onto the drum.*
2. *toner induces opposite charges on the conducting regions and hence attracted to it.*