YEAR 11 PHYSICS

ELECTRICAL ENERGY IN THE HOME

LESSON 1: INTRODUCING CHARGE

SAMPLE RESOURCES

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3. Charging Objects

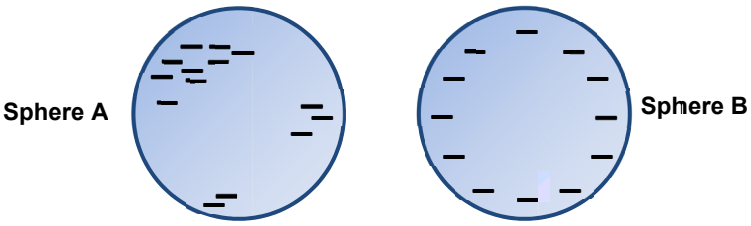
Students learn to:
- identify the difference between conductors and insulators

❒ Conductivity of materials

- The **electrical behaviour** of objects is dependent on the material that makes up the object. It is convenient to have a method for classifying substances based on their behaviour.
- Materials are classified into two broad categories:
  - Conductive materials (Conductors)
  - Non-conductive materials (Insulators)
- Conductors and insulators are defined in terms of their **conductivity**, that is, their ability to conduct electrical charge.

Material	Description
Conductors	• Materials (generally metallic) in which **electric charges move quite freely.** • When charged in some small region, **charge readily distributes itself** over the entire surface of the material.
Insulators	• Insulators are materials such as Perspex, glass, and rubber in which **electric charges cannot move freely**. • When insulators are charged by friction, only the area that is rubbed becomes charged. The charge is unable to move to other regions of the material.

- The diagram below shows two spheres made of different materials.



  - Identify the conductor and the insulator. Justify for your answer.[12]

❒ Giving objects charge

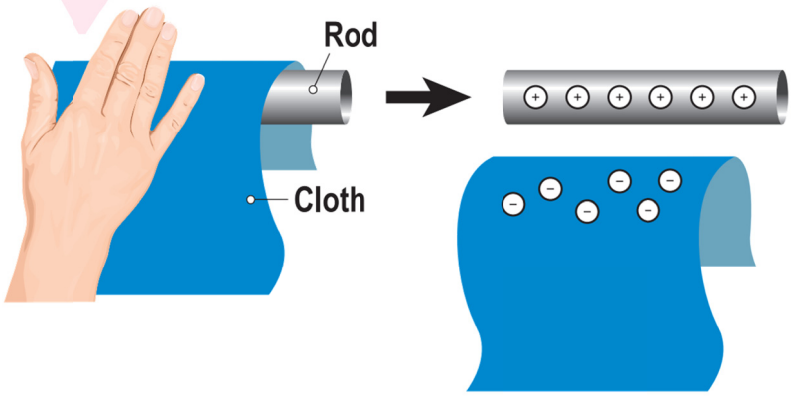
- Most objects are naturally electrically neutral. This means that they contain an equal number of positive and negative charges.

- There are three ways to give a neutral object a net charge.
  1. **By friction** (also referred to as triboelectric charging)
  2. **By contact**
  3. **By induction**

- Regardless of the method of charging an object, **objects gain charge through a transfer of electrons from one to another** since charge cannot be created nor destroyed.

❒ Method 1: Charging objects by friction

- Different objects have different electrical properties. One important property is the **ability for a material to gain charge**.
  - Charging by friction involves the **transfer of charge between two objects that are initially neutral**.
  - When the two **neutral objects are rubbed together**, there is a **transfer of charge** due to the **friction** experienced.
  - As a result, one object gains a net negative charge and the other a net positive charge of the same magnitude.



- The **triboelectric series** shown below ranks various materials according to their tendency to gain or lose electrons.

Acquires a more positive charge ↑	(+)
	Human hands (dry)
	Glass
	Human hair
	Nylon
	Cat fur
	Silk
	Paper
	Cotton (neutral)
	Steel (neutral)
	Wood
	Hard rubber
	Amber
	Ebonite
↓ Acquires a more negative charge	Plastic wrap
	(–)

- **Electrons are transferred from a material higher up on the list to materials lower than itself on the list.**

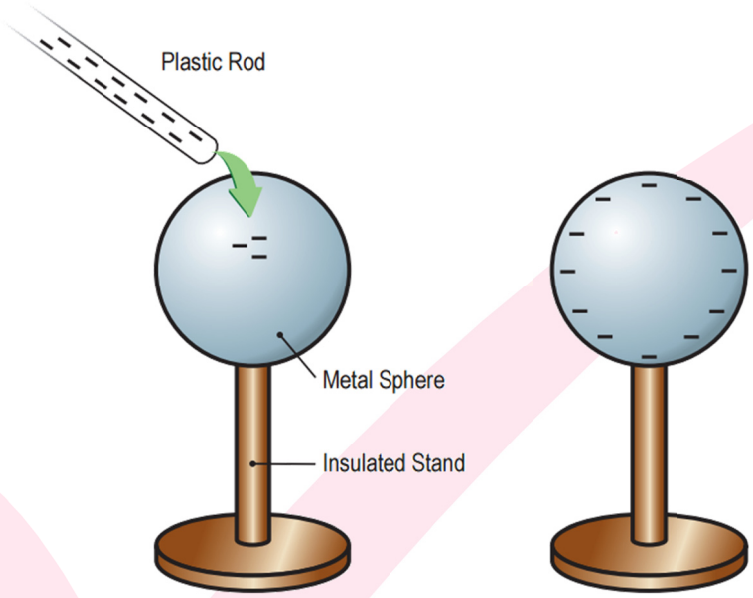
- Use the triboelectric series to predict the net charges on the following objects when they are rubbed together:
  - A glass rod and cat fur[13]

  - Wood and silk[14]

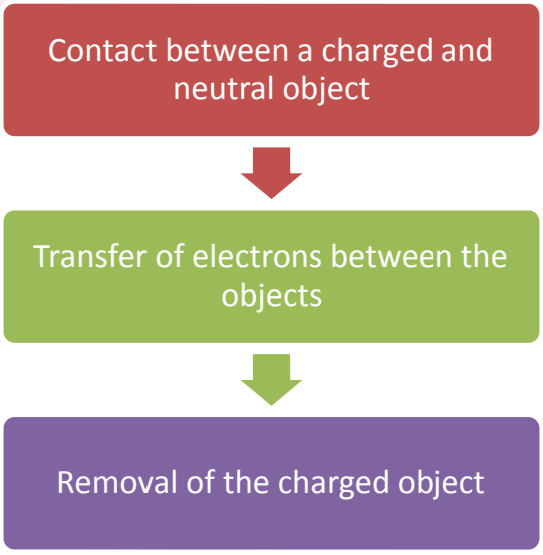
  - Nylon and cotton[15]

❒ Method 2: Charging Objects by contact

- **Charging objects by contact** involves a **transfer of electric charge from a charged object to a neutral object**.
  - The diagram below shows that there is a transfer of electrons from the negatively charged plastic rod to the neutral sphere when they come in contact.

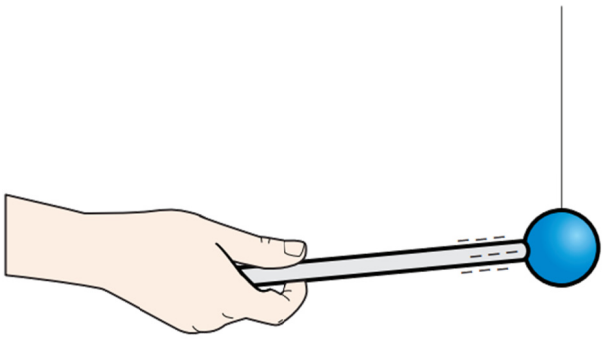


- The flowchart below outlines the processes involved in charging an object by contact.



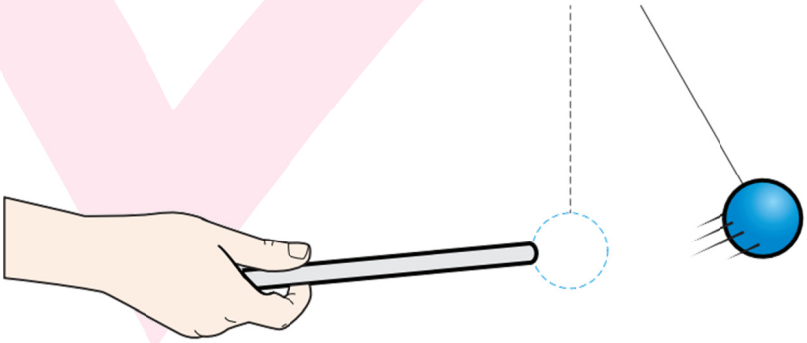
- Consider the interaction between a pith ball suspended by a fine string and a negatively charged hard rubber rod.

  – The pith ball is touched by the negatively charged rubber rod.



  – The pith ball becomes negatively charged. Why?16

  – After this contact between the ball and the rod, the ball moves away from the rod.



  – Explain this observation.17

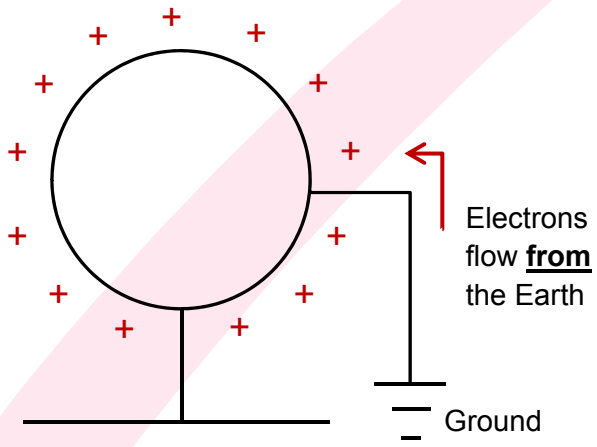
- **WATCH VIDEO (Length: 0:33):** Pith ball electroscope.

❒ Grounding conductors (earthing)

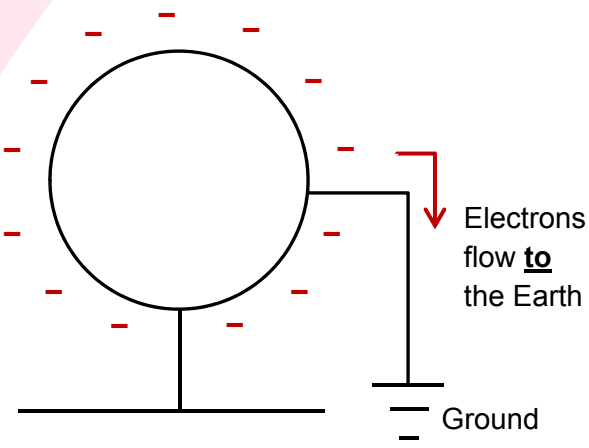
- The **ground** (also called the **earth**) can be considered as an infinite reservoir or "sink" to which (or from which, depending on the situation) **electrons can easily migrate**.

> **NOTE TO STUDENTS**
> The Earth is very large so any excess charge gets spread over a very large area, and we can consider the earth to remain electrically neutral.

- A conductor connected to the earth by means of a conducting wire or pipe is said to be **grounded**.
- When charged objects are grounded:
  - Electrons flow from the ground to a positively charged object



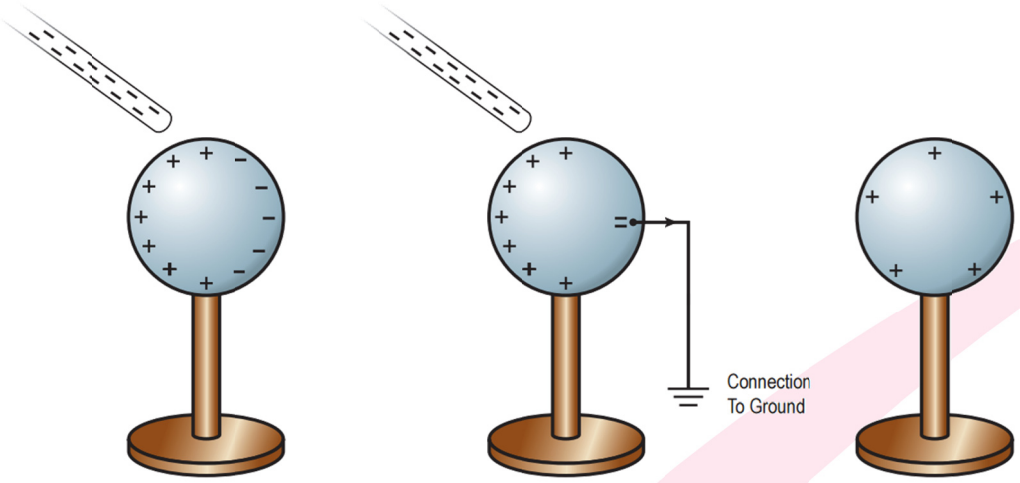
  - Electrons flow from a negatively charged object to the ground



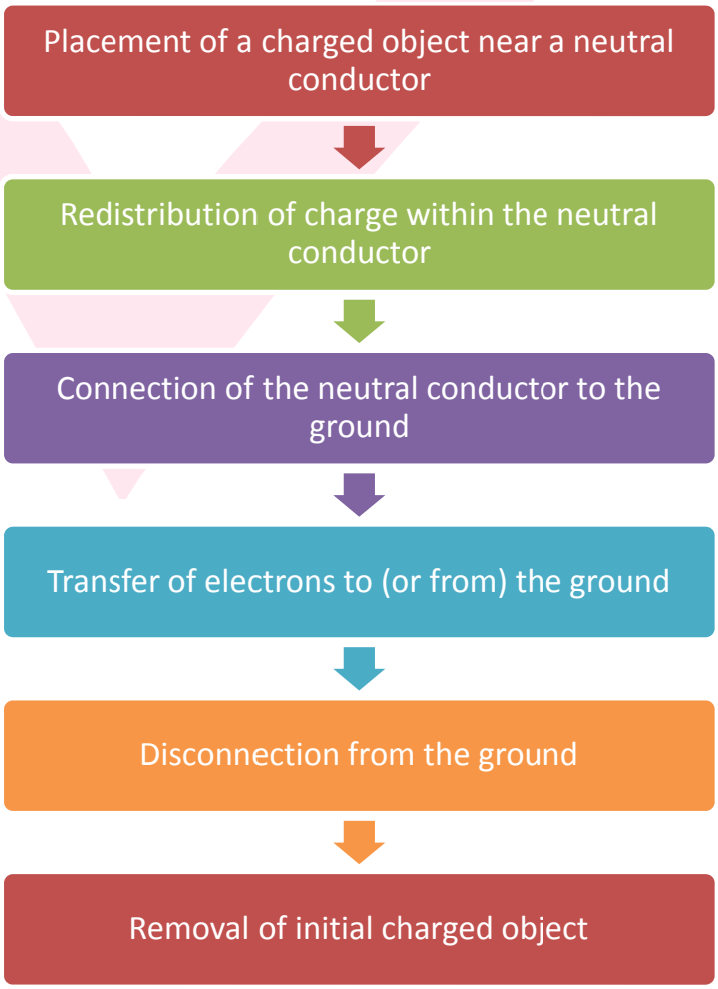
- **WATCH VIDEO (Length: 5:19):** Brainiac investigates the effect of electric current through people.

❒ Method 3: Charging objects by induction

- **Charging objects by induction** is a **contactless** method for giving neutral conducting objects a net charge.

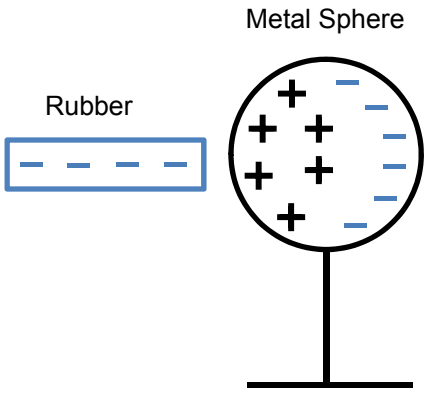


- The flowchart below outlines the processes involved.



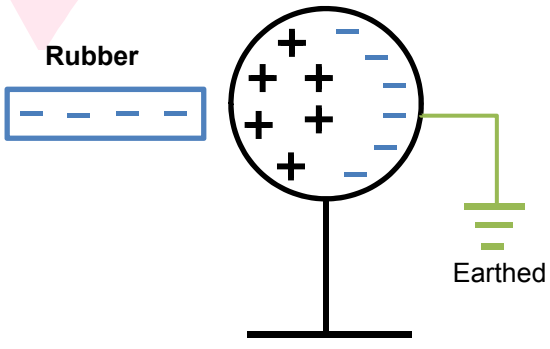
- Let us consider the **process of charging a neutral conductor positively by induction**.

STEP 1



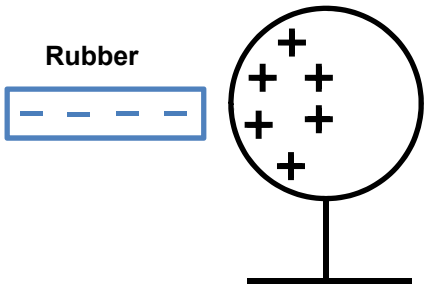
- The neutral conducting sphere is **insulated** from the ground. That is, there is no conducting path to ground.
- When a negatively charged rubber rod is brought near to a metal sphere, the region of the sphere closest to the rod obtains an excess of positive charge while the region furthest away from the rod obtains an equal build-up of negative charge.
- Explain this migration of charge.[18]

STEP 2



- The sphere is now connected to the ground via a conducting wire. What happens?[19]

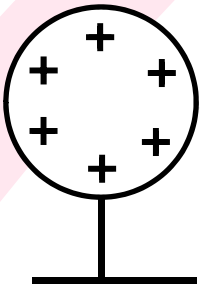
STEP 3



- When the connection to the ground is removed, the conducting sphere is left with an excess of **induced** positive charge.
- Why is this charge said to be 'induced'?[20]

- The positive charges remain in the region closest to the negatively charged rod.

STEP 4



- When the rubber rod is removed from the vicinity of the sphere, the induced positive charge remains on the ungrounded sphere.
- The charge remaining on the conducting sphere is **uniformly distributed** over its surface because of the repulsive forces between the like charges. (Note: electrons are moving around to give this result.)
- Throughout this interaction, the electrified rubber rod loses none of its charge, yet the conducting sphere gains a net charge.

- **WATCH VIDEO (Length: 3:13):** Demonstrations of different examples of charging by induction.

NOTE TO STUDENTS:
Students are required to describe the process of charging by induction.

