

YEAR 11 PHYSICS

ELECTRICITY AND MAGNETISM

LESSON 1: ELECTRIC CHARGE

SAMPLE RESOURCES

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MATRIX
EDUCATION

THE HSC EXPERTS

4. Forces between charged objects

□ Force between charges or between charged objects

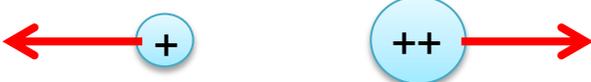
- We have established that charged objects will exert a force on each other. How does the force between charges behave?
 - **Like charges repel and unlike charges attract:**

Two positive charges	
A positive and a negative charge	
Two negative charges	

- The force between charged objects **decreases as distance increases:**

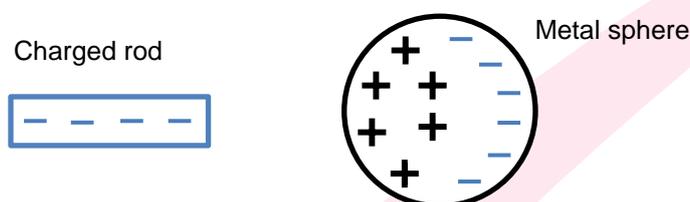
Small distance between charges	
↓	
Large distance between charges	

- The force between charged objects **increases as charge increases:**

Smaller amount of charge	
↓	
Larger amount of charge	

□ Force between charged object and neutral object

- Most objects are naturally **electrically neutral**. This means that they contain an **equal number of positive and negative charges**.
- Neutral objects can still experience an electric force even though they are neutral.
- If the neutral object is a **conductor**, electrons can move freely through it and the object becomes **polarised** (has a positive end and a negative end).
 - When a negatively charged rod is brought near a neutral metal sphere the metal sphere becomes polarised, becoming positive near the rod and negative far from the rod.



- **Explain** why the negative charges move away from the rod in the metal sphere above and why the sphere becomes positive near the rod. ¹⁴

- In the diagram above draw the electric force between the charged rod and the positive part of the metal sphere, and also between the charged rod and the negative part of the sphere.
- Hence determine the direction of net force on the metal sphere.

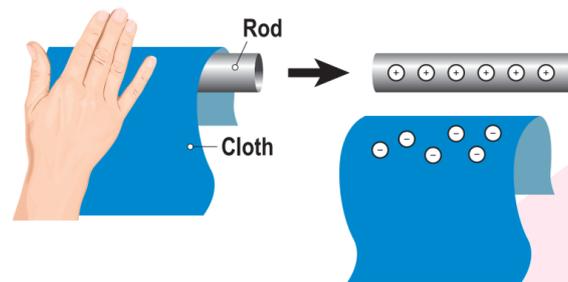
- Thus a neutral object becomes polarised and will be **attracted** to a charged object.
- Polarisation can occur for insulators too. However, because the negative charges cannot separate from the positive charges as well, the net force obtained is much weaker.
- This is how shredded paper and foil becomes attracted to a charged rod.

5. Charging Objects

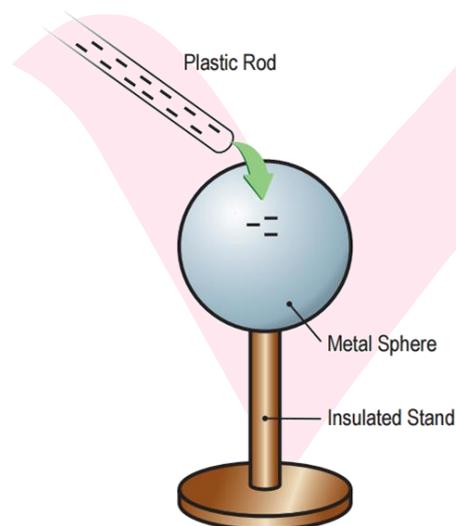
□ Giving objects charge

- 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**

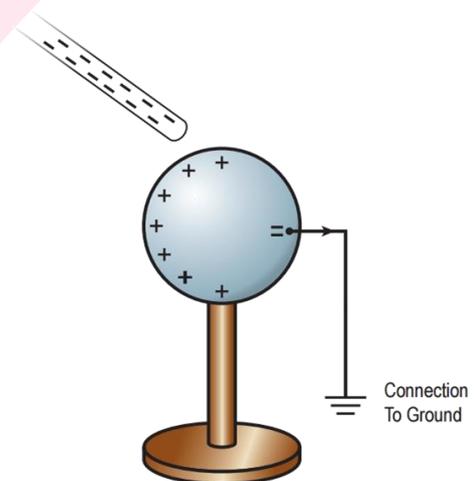
The diagrams below summarise these three processes.



Charging by friction



Charging by contact

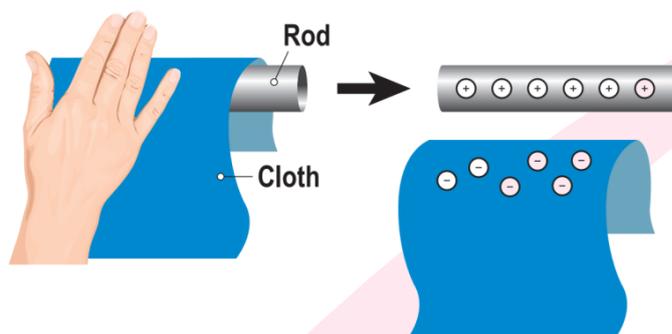


Charging by induction

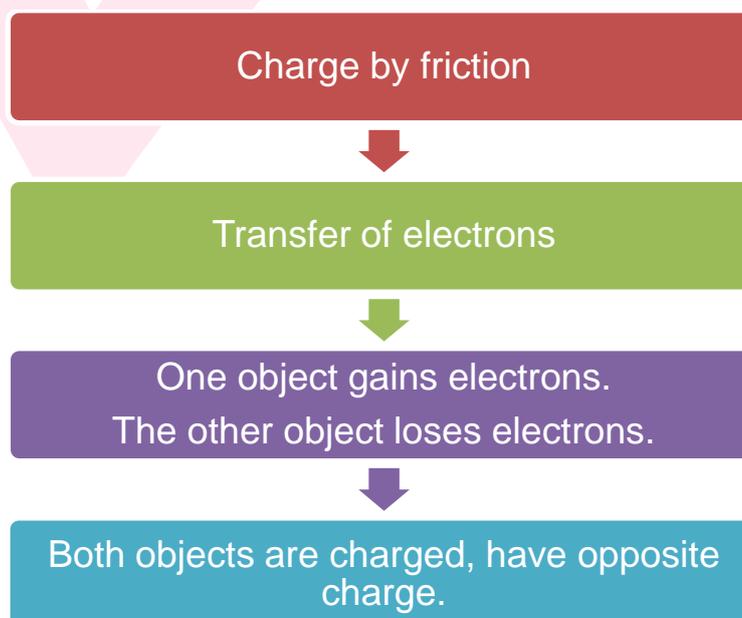
- Regardless of the method of charging an object, **objects gain charge through a transfer of electrons from one to another** since charge cannot be created nor destroyed.

□ 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 objects 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 electrons** due to the **friction** experienced, and hence a **transfer of charge**.

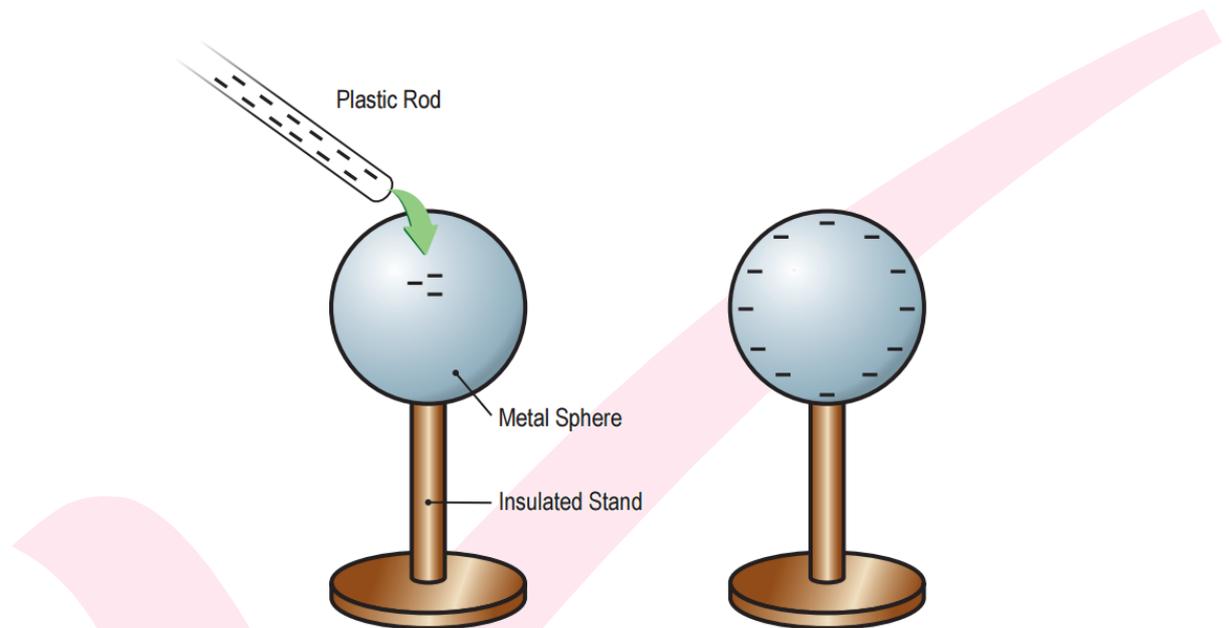


- As a result, one object **gains electrons and hence a net negative charge**. The other **loses electrons and remains with a net positive charge** of the **same magnitude**.
- Charging by friction is summarised below:

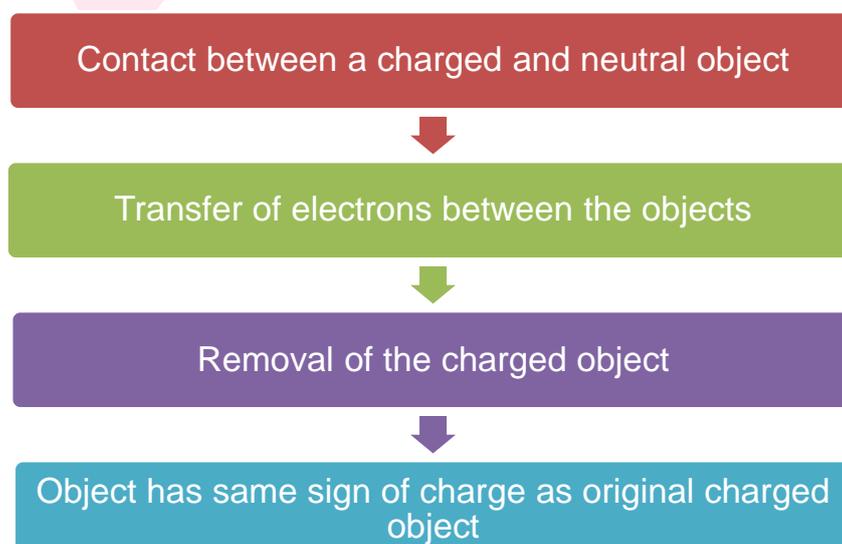


❑ Method 2: Charging Objects by contact

- **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.

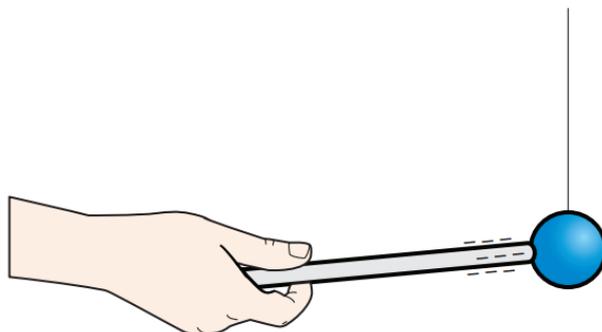


- The flowchart below outlines the processes involved in charging an object by contact.



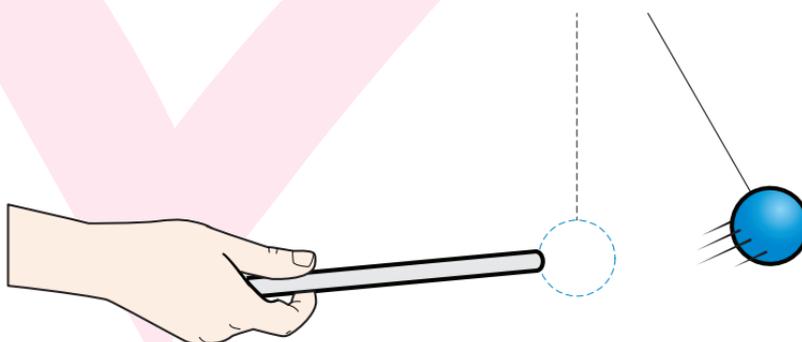
- Consider the interaction between a **pith ball** suspended by a fine string and a negatively charged hard rubber rod.

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



- The pith ball becomes negatively charged. Explain.¹⁵

- After this contact between the ball and the rod, the ball moves away from the rod. Explain this observation.¹⁶



- [WATCH VIDEO \(Length: 0:33\):](#) Pith ball electroscope.

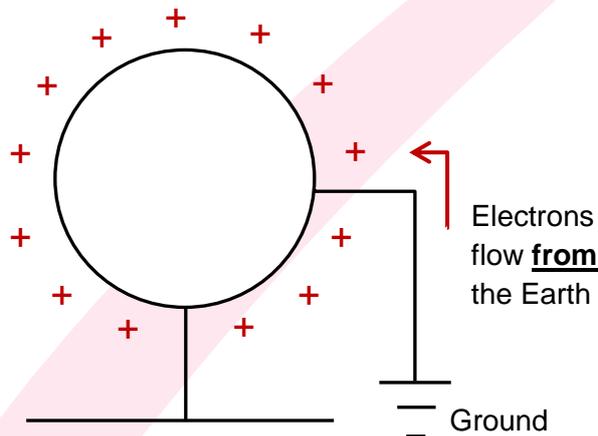
□ Grounding conductors (earthing)

- 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**.

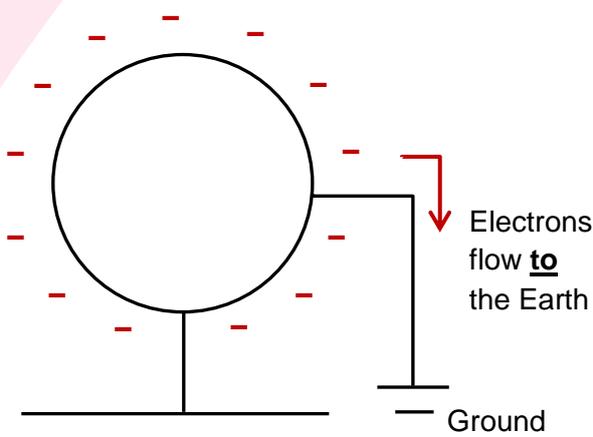
NOTE TO STUDENTS

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



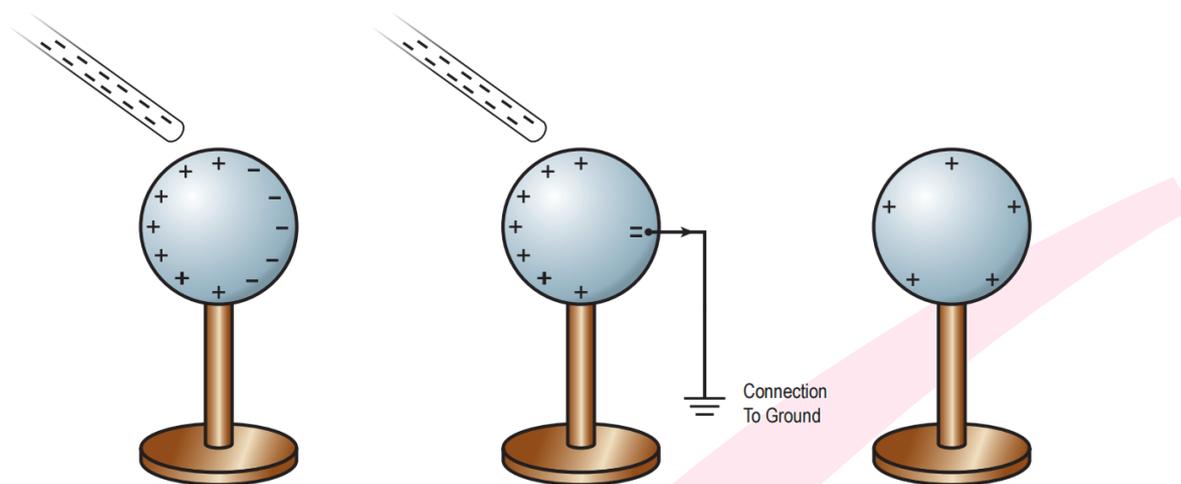
- Electrons flow from a negatively charged object to the ground



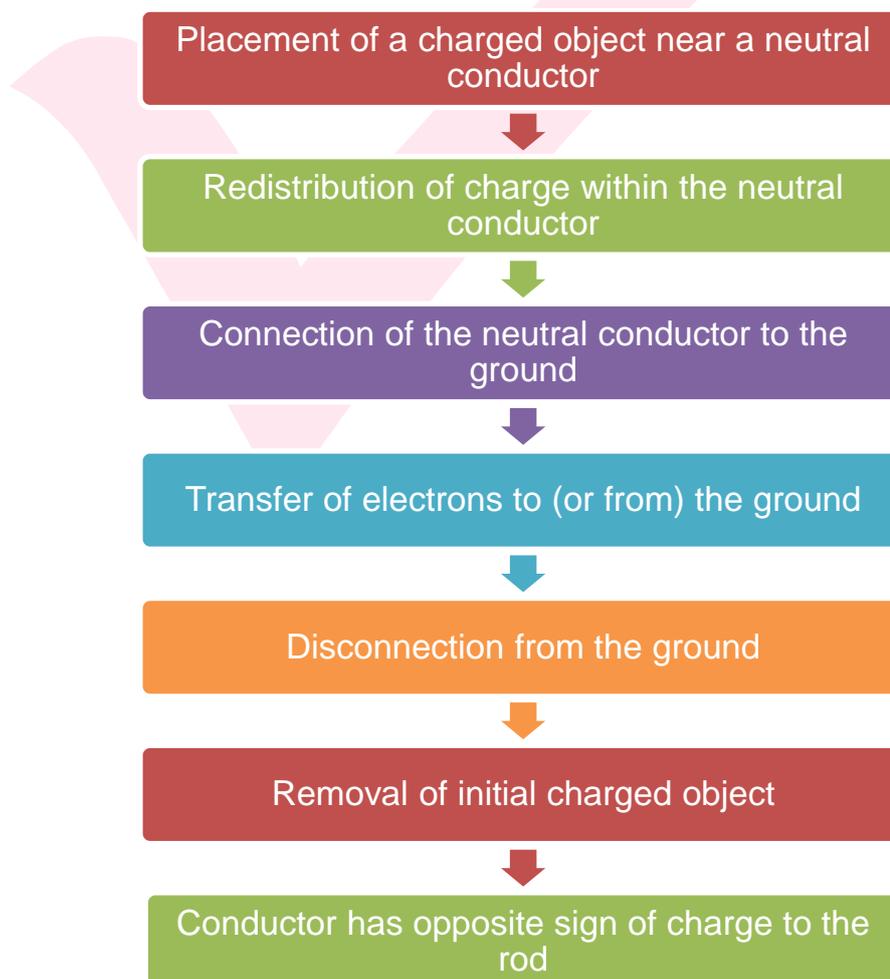
- [WATCH VIDEO \(Length: 5:19\)](#): Brainiac investigates the effect of electric current through people.

☐ **Method 3: Charging objects by induction**

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

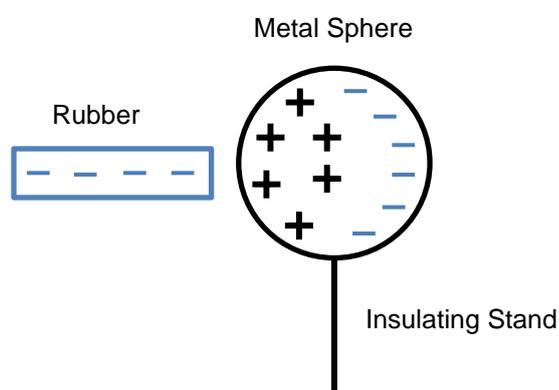


- The flowchart below outlines the processes involved.



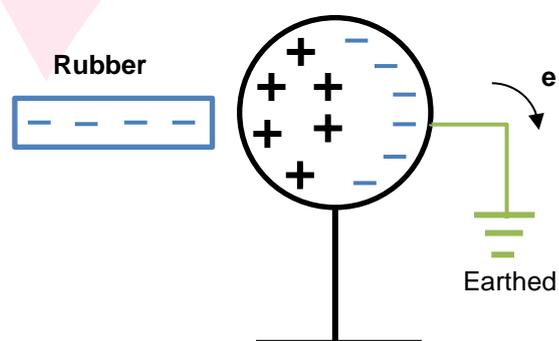
- Let us consider the **process of charging a neutral conductor positively by induction**.

STEP 1



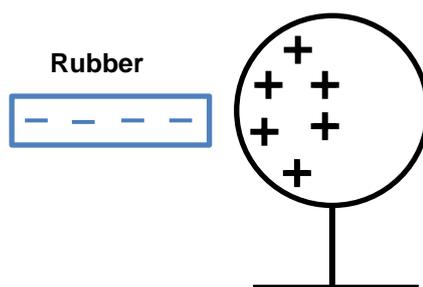
- The neutral conducting sphere is **insulated** from the ground. That is, there is no conducting path to ground.
- When a negatively charged rubber rod is brought near a metal sphere, the region of the sphere closest to the rod obtains an excess of positive charge while the region furthest away from the rod obtains an equal build-up of negative charge.
- Explain this migration of charge.¹⁷

STEP 2



- The sphere is now connected to the ground via a conducting wire. What happens?¹⁸

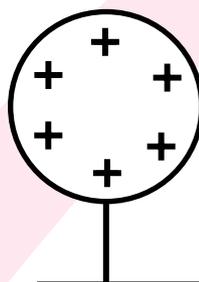
STEP 3



- 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’?¹⁹

- 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.

When charging by induction, it does not matter where the earth wire touches the conducting sphere.

☐ **Methods of charging summary**

Method	Summary
Charging by friction	<ul style="list-style-type: none"> • Two neutral objects are rubbed together. • Electrons are transferred from one object to the other. • The two objects end up with the opposite charge.
Charging by contact	<ul style="list-style-type: none"> • A charged object is brought into contact with a neutral object. • Electrons are transferred from one to the other. • The two objects end up with the same sign of charge.
Charging by induction	<ul style="list-style-type: none"> • A charged object is brought near a neutral conducting object but does not make contact. • Charges in the neutral conducting object move in response to the charged object. • The neutral conducting object is earthed. • Electrons move to/from the ground to the conducting object. • The two objects end up with the opposite sign of charge.