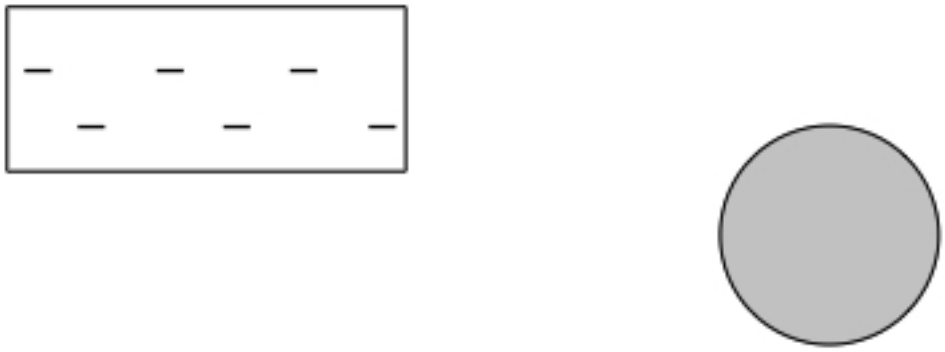
Charging by Conduction

Charging by **conduction** involves the touching of a charged object to a neutral object. For example, when a negatively charged metal sphere is touched to a neutral metal sphere, the neutral sphere becomes charged. Because charging by conduction involves contact, it is often called charging by contact.

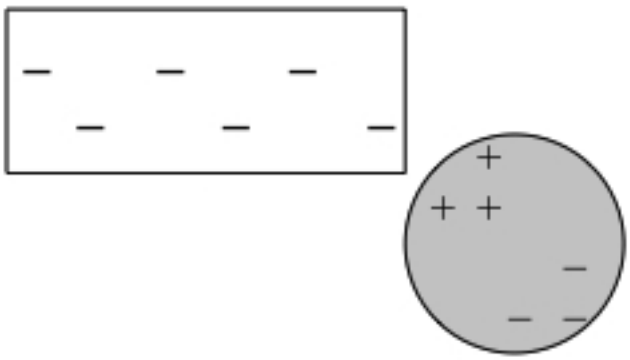
Charging by Conduction Using a Negative Object

To explain the process of charging by conduction, we will first consider using a negatively charged rod to charge a neutral metal sphere.

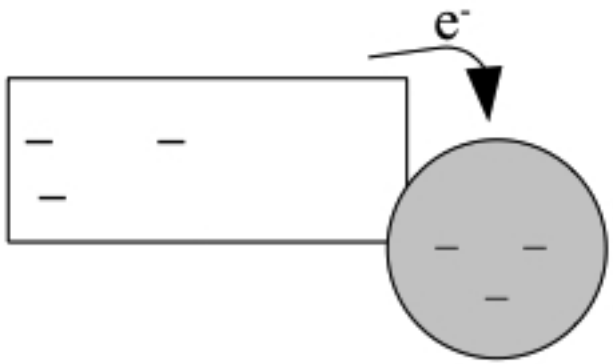
A negatively charged rod has an excess of electrons. These electrons repel each other, and want to get as far away from each other as possible. Since the rod is an insulator, the charges can't move around very much, so they will be largely concentrated at the end of the rod that was rubbed.



When the rod is brought near the neutral sphere, the positive charges in the sphere will be attracted to the rod. At the same time, the negative charges in the sphere will be repelled by the rod. This will cause a **charge separation** in the sphere. The side of the sphere closest to the rod will become positive, while the side farthest from the rod will become negative. The sphere, however, is still neutral.

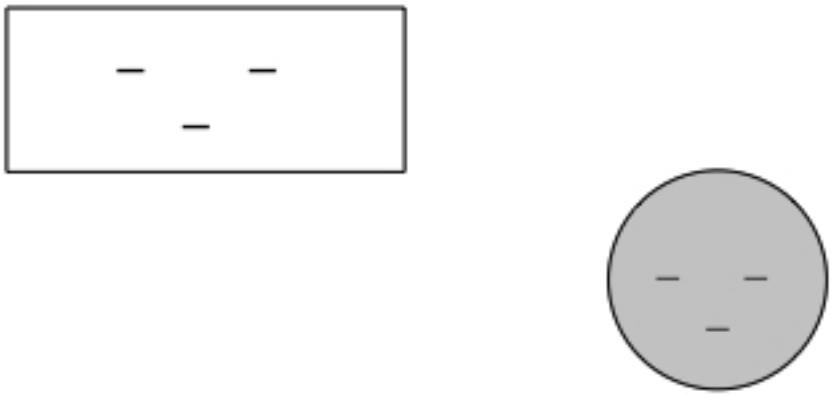


When the rod is touched to the neutral metal sphere, the sphere provides a conducting pathway. Electrons from the surface of the rod take advantage of this pathway and use it to move farther away from the other electrons on the rod. In other words, a large number of electrons from the rod move onto the metal sphere.



Since the metal sphere was originally neutral (meaning it had an equal number of protons and electrons), the addition of more electrons will give it a negative charge.

The rod remains negatively charged, but is less negative than it was before touching the sphere. Since the sphere is also negative, the rod and sphere should now repel each other.



Charging by Conduction Using a Positive Object

The process of using a positively charged rod to charge a neutral metal sphere is nearly identical to the above procedure.

A positively charged rod has an excess of protons. Another way of looking at it is, the rod has a shortage of electrons. Each excess proton in the rod will be "unhappy" until it can find an electron to pair up with. Unfortunately, since protons can't leave the nucleus, it is not capable of leaving the atom to find an electron. However, it can attract an electron towards itself.

When the rod is brought near the neutral sphere, the negative charges in the sphere will be attracted to the rod. At the same time, the positive charges in the sphere will be repelled by the rod. This will cause a **charge separation** in the sphere. The side of the sphere closest to the rod will become negative, while the side farthest from the rod will become positive. The sphere, however, is still neutral.

When the rod is touched to the neutral metal sphere, the sphere provides a conducting pathway. Electrons from the sphere take advantage of this pathway and use it to move towards the excess protons on the rod. In other words, a large number of electrons from the sphere move onto the rod.

Since the metal sphere was originally neutral (meaning it had an equal number of protons and electrons), the loss of some electrons will give it a positive charge.

The rod remains positively charged, but is less positive than it was before touching the sphere. Since the sphere is also positive, the rod and sphere should now repel each other.

Grounding — The Removal of Charge

Grounding is the process of removing excess charge from an object by means of the transfer of electrons between it and another object of substantial size (called a ground). When a charged object is grounded, the excess charge is balanced by the transfer of electrons between the charged object and a ground.

A **ground** is simply an object that serves as a seemingly unlimited reservoir of electrons. The ground is capable of transferring electrons to or receiving electrons from a charged object in order to neutralize that object.

As an example of how grounding occurs, consider a negatively charged sphere. Since the sphere is negative, it has an excess of electrons. If it is to have its charge removed, then it must lose those excess electrons. Once the excess electrons are removed, the sphere will become neutral (since it will have equal numbers of protons and electrons).

To remove the excess electrons from a negative sphere, the sphere is connected by a conducting pathway to an object that is capable of receiving those electrons. This other object is the ground. In a typical electrostatic experiment, this is usually done by touching the sphere with a finger. The finger acts as the conducting pathway, carrying the excess electrons into the person who touches it. The person is the ground in this case.

Grounding of a positively charged object works in a similar way. Since the sphere has an excess of protons, it must gain electrons in order to be neutralized. When connected to the ground, electrons will move from the ground onto the sphere until the overall charge is neutral.

Worksheet

1. During a physics lab, a plastic strip was rubbed with cotton and became positively charged. The correct explanation for why the plastic strip becomes positively charged is that

   a) the plastic strip acquired extra protons from the cotton.
   b) the plastic strip acquired extra protons during the charging process.
   c) protons were created as the result of the charging process.
   d) the plastic strip lost electrons to the cotton during the charging process.

2. If Nylon is rubbed against Saran Wrap, which would end up with the negative charge? Explain.

3. A physics teacher rubs a glass object and a felt cloth together and the glass becomes positively charged. Which of the following statements are true? Circle all that apply.

   a) The glass gained protons during the rubbing process.
   b) The felt became charged negatively during this rubbing process.
   c) Charge is created during the rubbing process; it is grabbed by the more charge-hungry object.
   d) If the glass acquired a charge of +5 units, then the felt acquires a charge of -5 units.
   e) This event violates the law of conservation of charge.
   f) Electrons are transferred from glass to felt; protons are transferred from felt to glass.
   g) Once charged in this manner, the glass object and the felt cloth should attract each other.

4. A neutral metal sphere is touched by a negatively charged metal rod. As a result, the sphere will be _____ and the metal rod will be _____.

5. A neutral metal sphere is touched by a negatively charged metal rod. During the process, electrons are transferred from the _____ to the _____. The sphere acquires a _____ charge.

6. A neutral metal sphere is touched by a positively charged metal rod. During the process, electrons are transferred from the _____ to the _____. The sphere acquires a _____ charge.

7. A metal sphere is electrically neutral. It is touched by a positively charged metal rod. As a result, the metal sphere becomes charged positively. Which of the following occur during the process? Circle all that apply.

   a) The metal sphere gains some protons.
   b) Electrons are transferred from the sphere to the rod.
   c) The metal sphere loses electrons.
   d) The overall charge of the system is conserved.
   e) Protons are transferred from the rod to the sphere.
   f) Positive electrons are moved between the two objects.

8. A positively charged pop can is touched by a person standing on the ground. The pop can subsequently becomes neutral. The pop can becomes neutral during this process because

   a) electrons pass from the pop can to the person (ground).
   b) electrons pass from the person (ground) to the pop can.
   c) protons pass from the pop can to the person (ground).
   d) protons pass from the person (ground) to the pop can.

9. A physics student, standing on the ground, touches an uncharged plastic baseball bat to a negatively charged sphere. This will cause

   a) the sphere to be grounded as electrons flow out of the sphere.
   b) the sphere to be grounded as electrons flow into the sphere.
   c) the sphere to be grounded as protons flow out of the sphere.
   d) the sphere to be grounded as protons flow into the sphere.
   e) the baseball bat to acquire an excess of protons.
   f) absolutely nothing (or very little) to happen since the plastic bat does not conduct.

10. TRUE or FALSE: An object that becomes grounded gains neutrons during the grounding process.