National Next Generation Science Standards

Students who demonstrate understanding can:

3-PS2-3. Ask questions to determine cause and effect relationships of electric or magnetic interactions between two objects not in contact with each other.

MS-PS2-5. Conduct an investigation and evaluate the experimental design to provide evidence that fields exist between objects exerting forces on each other even though the objects are not in contact.

MS-PS3-2. Develop a model to describe that when the arrangement of objects interacting at a distance changes, different amounts of potential energy are stored in the system.

HS-PS2-4. Use mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects.

Standards Key

K = Kindergarten
3 = 3rd Grade
(numbered by grade)
MS = Middle School
HS = High School
PS = Physical Science
LS = Life Science
ES = Earth Science

HS-PS3-5. Develop and use a model of two objects interacting through electric or magnetic fields to illustrate the forces between objects and the changes in energy of the objects due to the interaction.

TEACHERS GUIDE

FRICTION ROD SET
ITEM # 3128-07

ENERGY - ELECTRICITY

The science explaining electrical potential energy (when excess charge is static) versus electrical kinetic energy (when electrons are moving) can be explored safely with the small excess of charge generated with the materials in this kit. Students can develop a model of what is happening to the electrons around the atoms in a conductor versus an insulator.

Materials

- Rod and fabric kit (Friction Rod Set)
- balloons
- string
- aluminum cans
- paper
- aluminum
- plastic wrap
- Styrofoam cups
- aluminum pie plate
- flat foam plate/block

Goals & Objectives

See page 8 for National Next Generation Science Standards

History

The Greeks observed that amber repelled and attracted different materials when it was rubbed (amber = elektron in Greek). Since that time, through the work of many such as Dalton, Thomson, Rutherford, and Millikin we have been able to detect and quantify this mobile subatomic particle called the electron.

Introduction

Investigate the nature of the mobile subatomic particle called the electron! The force created when an object has an unequal number of positive and negative charges can cause neutral objects to move at a distance, that is, without contact. These activities will provide rich discussion about what is happening to the electrons in insulators versus conductors. Why is paper, an insulator, attracted to a charged object and how do the electrons in aluminum, a conductor, behave differently? The science explaining electrical potential energy (when excess charge is static) versus electrical kinetic energy (when electrons are moving) can be explored safely with the small excess of charge generated with the materials in this kit. Students can develop a model of what is happening to the electrons around the atoms in a conductor versus an insulator.

Discussion

Additional Discussion and Real Life Applications

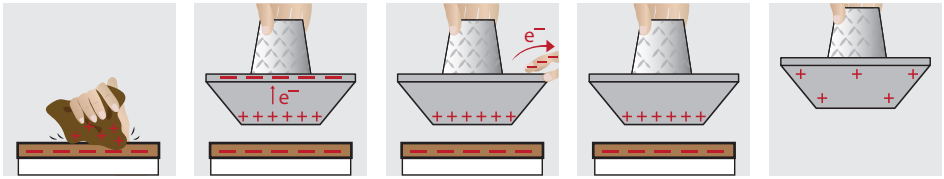
1. Have students research the difference between electrical potential energy versus electrical kinetic energy. How are the electrons behaving differently? (Kinetic energy is movement of the electrons – Potential energy is due to position of the electrons)
2. How is electricity generated and stored? Trace the generation of electrical energy to your home. How long has this energy been available to us?
3. What are the other forces that act at a distance on objects? (gravitational and magnetic).
4. Who developed how electrical energy is used by society?

Activities

Student Activities *continued*

Charging an Aluminum Pie Plate by Induction

Diagram from activity 3 a on page 5.



A foam plate is rubbed with fur and given a negative (-) charge

An aluminiums plate is brought near the foam, inducing e- movement to rim

When touched on the rim, e- movement through the hand go to the ground

The aluminium plate, having lost e-, now has a + charge

Remaining e- move around until the + charge redistributed

Assessment

1 Vocabulary, Participation, Discussion

2 **Glossary/Vocabulary:**

- triboelectric series
- friction
- induction
- conduction
- grounding
- polarization
- conservation of charge
- conductors
- insulators

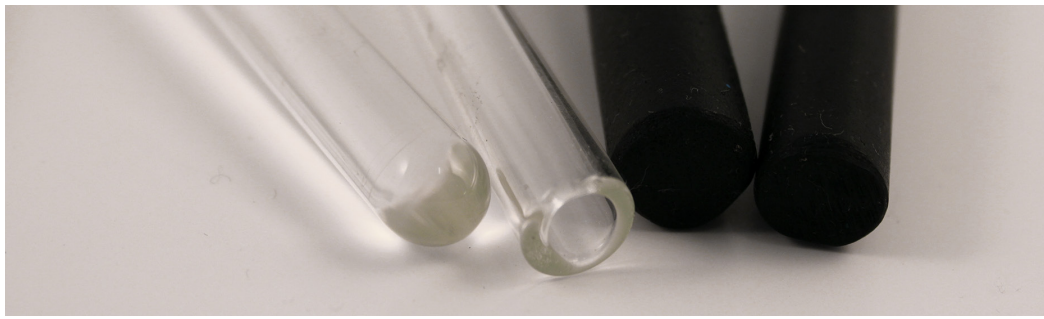
How it works

Triboelectric Series – Shows the tendency of a material to gain electrons (become negatively charged) or lose electrons (become positively charged) -- See chart to the left.

Charging by Friction – a material is rubbed vigorously and charge is transferred from one material to another. Predictions can be made using a triboelectric series. Example: rubbing a balloon with wool.

Charging by Induction – a charged material is brought close to another object without actually touching it. This induces the electrons to move to one side of the object causing polarization – one side will be positively charged while the other is negative. Example: balloon sticking to a wall.

Charging by Conduction – a charged object touches a neutral object and charge is transferred to the neutral object, charging it by contact. Charging by conduction requires a conductor – insulators cannot transfer charge, only polarize. The conductors will act as one object sharing the charge, but insulators will only give up the charge – like a lightning strike. Example: touching an electroscope.



ACTIVITIES

1 Charging by friction:

a Hang two balloons from the same spot on ceiling next to each other at about head height. Fold the piece for fur in half between the two balloons and rub vigorously. The rubber has a higher affinity for electrons than the fur and charge will be transferred to the balloons. They will now repel each other when the fur is removed. The balloons can act as a large electroscope.

b Rub the hard plastic rod with the fur. How do the balloons behave? How do they behave when you bring the fur close?

c Rub the glass rod with the piece of silk. How do the balloons behave? What conclusions can you make about the charge transferred since you know the rubber balloon is negatively charged?

d Use different combinations of fabric and rods to observe behavior. Can you rank the materials for electron affinity? Compare your results with a triboelectric series.

e Make a pile of paper bits on the table. Bring a charged rod close to the paper. What do you observe? Repeat with bits of aluminum. What was different? Can you explain it?

2 Charging by induction:

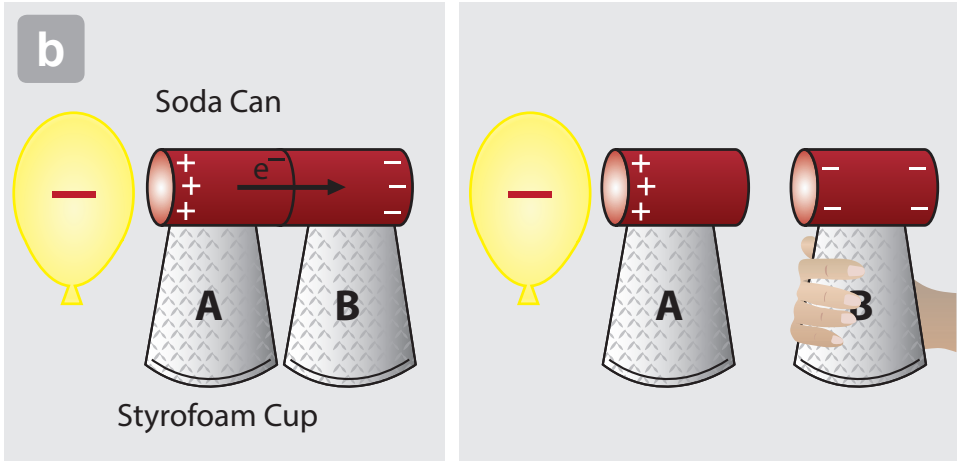
a Lay an aluminum can on its side. Charge a rod with the fur. Bring it close to the can. What happens? (the can rolls) Can you get a different result with the different rods and materials?

***Note**

It is always best to DO an experiment ahead of time to be able to best present it to the class.

b Two sphere system using 2 aluminum cans and a charged balloon after rubbing with animal fur. Tape two aluminum pop cans to the top of two Styrofoam cups. The styrofoam will insulate your spheres to prevent grounding. Make sure the two cans can touch when next to each other. Rub an inflated balloon with the fur to transfer charge by friction to the balloon. Bring the balloon close to one can without touching it. This will induce the electrons to move from one can to the other. Separate the cans while still holding the balloon close. One can will be positively charged and the other will be negatively charged. One will attract the balloon and one will repel it. Repeat this experiment with the silk and glass rod. How are your observations different?

ACTIVITIES



3 Charging an aluminum pie plate by induction:

a *See page 6 for diagram*

The animal fur is rubbed on the flat plate of foam to distribute negative charge on the foam (it loves electrons more than the fur). The foam is an insulator so the charge stays where is is transferred instead of distributing evening on it (like a conductor would). Tape a foam cup to an aluminum pie plate. The cup is an insulating handle. The pie plate is brought near the foam (without touching) and the electrons in the aluminum move as far away as they can. Electrons do not transfer from the foam – the aluminum is polarized. Touch the edge of the pie plate to ground (remove the charge) from the plate. It is now positiely charged and will attract one balloon and repel the other.

b Charging by conduction:

Use the pie plate with the foam cup from the previous experiment. Transfer extra electrons to the aluminum plate by touching a charged rod to it. Check to see if it is charged by bring it close to the hanging balloon electroscope. How far can it push the balloon? Touch the aluminum pie plate to another exactly like it. Be sure to use the foam cup insulator again. Does that pie plate now repel the balloon? Does it repel it as far? How about the original pie plate? Does it repel the baloon as far now?