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.

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.

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

TEACHERS GUIDE

PITH BALL ELECTROSCOPE

ITEM # 3134-01

ENERGY - ELECTRICITY

For demonstrating the attraction and repulsion of electric charges. Consists of a insulated brass pillar and hook on a base. Supplied with two colored pith balls with strings attached.
Pith ball electroscopes are perfect to initiate a discussion on electrical forces and energy. Electrostatic forces are responsible for chemical bonding, states of matter, and electrical potential energy..

Materials

- Pith Ball Electroscope
- natural fur
- silk fabric
- glass rod
- plastic rod
- ebonite rod
- 1 inch long strip of paper
- 1 inch strip of foil
- balloon
- styrofoam plate
- paper plate
- foil pie plates
- styrofoam peanuts
- foil pom-pom
- cellophane tape
- meterstick
- stopwatch

Optional:

- Wimshurst machine
- Van de Graaff generator

Goals and Objectives

see page 8 for National Next Generation Science Standards

Introduction

Pith ball electroscopes are a classical means for detecting electrostatic forces. They are perfect to initiate a discussion on electrical forces and energy. Electrostatic forces are responsible for chemical bonding, states of matter, and electrical potential energy. Once those charges are no longer static – we have electric kinetic energy (moving electrons). Students can investigate how objects not in contact with each other can still exert a force on one another. Those forces can be attractive or repulsive (unlike gravity which is attractive only) and the magnitude of the charge can be inferred from the pith ball electroscope because the distance between the pith balls will differ. Observe one pith ball doing work to the other and a discussion on transfer of static potential electrical charge as the source of electrical kinetic energy will develop. Electricity, arguably the most important technological progress of the 20th century is moving electrons and electrons are easily detected by electroscopes. Coulombic forces of attraction and repulsion explain how matter is held together in molecules, ionic salts, and solids, liquids, and gasses. Use the pith balls to help students develop the subatomic model needed to understand interactions in matter

Assessment

1
- Participation
- Vocabulary

2 Vocabulary List
- Negative and positive charges,
- attractive and repulsive forces,
- Coulombs law,
- coulombic attraction and repulsion.

Discussion

1 Discussions with students vary depending on the age level and course you are teaching. For young children you should include identifying that charge exists and that it can move. It can then induce attractive and repulsive forces of attraction. The size of the attraction or repulsion can be qualified by the distance between the pith balls and it can be quantified with voltmeters.

Encourage them to design an experiment with simple materials that determines which fabrics or rods create attractive or repulsive attractions.

2 Physics students can discuss electrical fields and how moving charges in a coil of wire can generate a magnetic field – an electromagnet.

Can more coils in the wire generate larger magnetic fields?

Does surface area affect the size of attraction or repulsion?

3 Chemistry students can discuss evidence of a moving charge that is smaller than an atom – the electron. Electron transfer is responsible for ionic chemical bonding and electron sharing is responsible for covalent bonding.

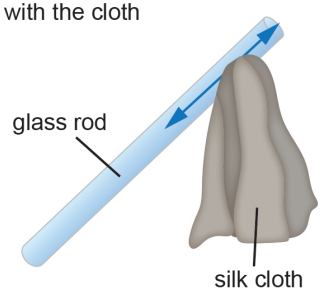
Electron density around atoms and molecules determine if matter is a solid, liquid, or gas at room temperature (intermolecular forces of attraction or repulsion).

The more electrons transferred or shared determines how strong bonds are. All ages can research how electricity is generated in power plants using heat energy, magnets, and coils of wire.

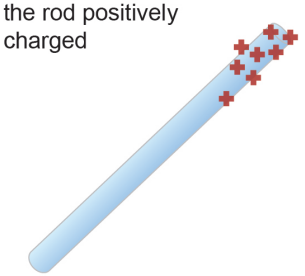
How it works

When you touch one of the pith balls with a charged object, the charge will transfer to the pith ball. One pith ball then attracts the other because they have opposite charges. However, once they touch the charge distributes between them and they have the same charge and now repel each other. The distance between the pith balls roughly reflects the magnitude of the electrostatic charge.

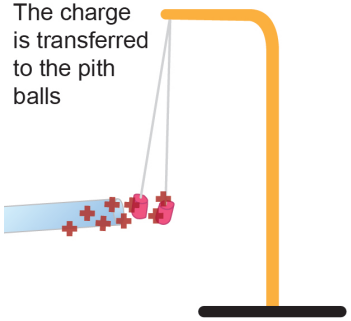
1 Rub the rod with the cloth



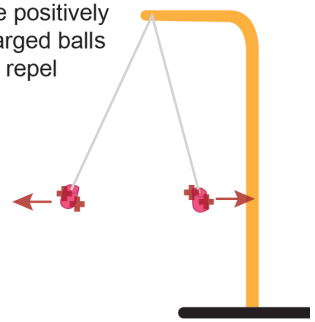
2 This will leave the rod positively charged



3 The charge is transferred to the pith balls

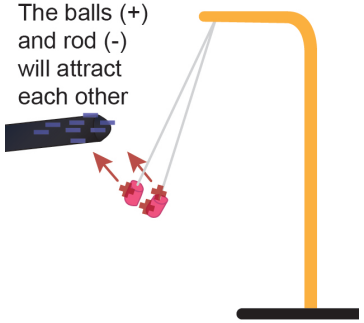


4 The positively charged balls will repel



5 Rub the rod with the fur *(this will leave it negatively charged)*

6 The balls (+) and rod (-) will attract each other



Activities

1. Rub the plastic rod vigorously with the piece of rabbit fur. The fur transfers some of the electrons and the rod becomes negatively charged. Touch one of the pith balls with the rod and it transfers the charge to the pith ball. As you bring the rod close you should observe the pith ball is attracted to the rod because it induces the electrons to move away from it and then the pith ball is attracted. Once you touch it the pith ball will transfer the charge to the other pith ball. They will both have the same charge now and therefore repel each other.

2. Rub the glass rod with the silk will remove some of the negative charge from the glass rod and the glass rod will become positively charged. One of the pith balls will be attracted to it and the other will be repelled.

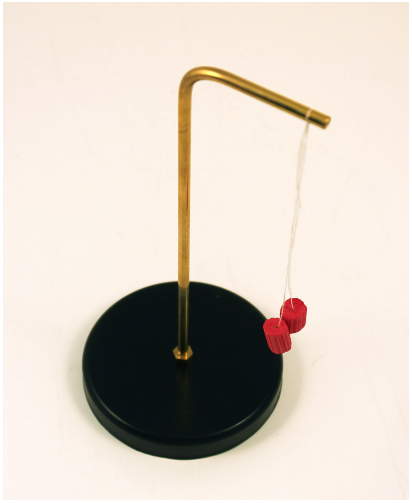
3. Discharge the pith balls by touching them. Wrap one around the wire frame. Charge the remaining pith ball with the plastic rod and fur. Brings the rod close will repel the pith ball. Charge the glass rod with the silk and it will attract it.

4. Charge one pith ball again. Bring the strip of foil close. Why is it attracted or repelled? Does using the glass and silk produce a different effect than the plastic and fur? (the electrons in the foil will either move toward the pith ball or away) Bring the strip of paper close. Does it also exhibit attraction or repulsion? Most children are familiar with metal conducting electricity but paper does not. How are their atoms and electrons different? Metals have delocalized electrons but paper has localized electrons. Meaning the electrons in paper stay with their individual atoms but move to one side of each but the foil electrons do not stay with their individual atoms and all move to one side of the piece of foil. The foil is more attracted or repelled than the paper because the electrons move more in response to the electrical force.

5. Measure the charge induced by the balloon when you rub hair.

6. You can transfer charge using cellophane tape in two different ways and measure their direction and magnitude of charge. Place on piece of tape on a table. Stick another piece of tape on top of it. Remove both pieces together from the table and then remove one piece of tape from the other piece of tape. How does each

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



piece affect the charge pith ball electroscope? How do they affect each other? Now, stick one piece of tape on the table and another piece on the table separate. Pull both pieces from the table. Do they attract or repel the electoscope? Do they attract or repel each other. Ask students to explain based on moving charge (electrons).

7. High school classrooms that have a Van de Graaff generator or Wimshurst machine can generate larger static charges and use the pith balls to qualify charge. Be sure to read safety instructions carefully for use of these machines in the classroom.

8. Place the foil pie plates with Styrofoam peanuts on the turned off and discharged Van de Graaff generator. Turn on the generator and observe the motion of the peanuts and pie plates as charge builds.

9. Students can design simple experiments to measure distance between the pith balls and charge magnitude. How many times do they need to rub the rod with the fur? A balloon? Have them make a simple line graph to describe the charge magnitude. Can they make a mathematical expression to predict other experiments? A simple linear regression expression? Perhaps time they rub the rod to charge it versus distance. Or a bar graph to describe the difference between materials and the distance between the pith balls.