charges, and, as with gravitation, inversely proportional to the square of the distance between them.

4. Between any two charged particles, electric force is vastly greater than the gravitational force. Most observable forces such as those exerted by a coiled spring or friction may be traced to electric forces acting between atoms and molecules.

The Benchmarks for Science Education

1. Without touching them, material that has been electrically charged pulls on all other materials and may either push or pull other charged materials.

2. Electromagnetic forces acting within and between atoms are vastly stronger than the gravitational forces acting between the atoms. At the atomic level, electric forces between oppositely charged electrons and protons hold atoms and molecules together and thus are involved in all chemical reactions. On a larger scale, these forces hold solid and liquid materials together and act between objects when they are in contact—as in sticking or sliding friction.

3. There are two kinds of charges—positive and negative. Like charges repel one another, opposite charges attract. In materials, there are almost exactly equal proportions of positive and negative charges, making the materials as a whole electrically neutral. Negative charges, being associated with electrons, are far more mobile in materials than positive charges are. A very small excess or deficit of negative charges in a material produces noticeable electric forces.

4. Different kinds of materials respond differently to electric forces. In conducting materials such as metals, electric charges flow easily, whereas in insulating materials such as glass, they can move hardly at all.

Glossary

Conductor - a material that offers little resistance to the flow of an electric current because electrons are liberated with ease. The difference between a conductor and an insulator is one of degree, because all substances conduct electricity to some extent.

Electrostatics - the study of electrical phenomenon where the tendency of resinous substances, such as amber, to become negatively charged when rubbed with a piece of fur or woolen cloth.

Electric Force - is the force that exists between any two charged objects. Opposite charges attract while like charges repel. The strength of the force is proportional to the strength of the charges and is inversely proportional to the square of the distance between them. Electric force has the capacity to do work or cause physical change that can produce acceleration in the direction of its application.

Insulator (Nonconductor) - a material that is a very poor conductor of electricity because electrons are tightly bound to atoms, such as rubber, glass, or ceramic.

Static Electricity - the production of opposite charges when two different types of nonconductors are rubbed together.

Review and Extension Questions

1. Describe an example of where energy seemed to be transformed from one form into another form during the video activities?

2. Explain why we do not get static shocks from most of the objects we touch.

3. Explain why the majority of static charges are the result of very small excess or deficit of negative charges in a material?

4. What is a simple description of force? Describe several examples that would support the theory that electrical force is a universal force that exists between any two charged objects.

5. What factors do you think control the strength of electrical force?

6. Explain why you think that electrical force is vastly greater than the gravitational force or the opposite, that gravitational force is vastly greater than electrical force?

7. How are electrical force and gravitational force similar, and how are they different?

8. Explain how a friction force between two different types of nonconductors is involved in the generation of electrostatic charges.

9. Explain why some materials are classified as conductors or as insulators?

10. Explain why you cannot produce electrostatic charges on materials that are conductors?

Science Fundamentals

Getting Charged!

Exploring Static Electricity

KF523

TEACHER'S GUIDE

Video Purpose

The video provides opportunities to begin inquiring about the nature of matter and electricity. Video activities help to develop understanding of the microstructure of matter with the macroscopic and microscopic world of forces and electricity. Activities in the video may stimulate students to describe how they would design an investigation, develop explanations based on scientific information and evidence provided through the video, or recognize and analyze several alternative explanations for static electricity presented in the video. Students need guidance to begin to recognize the relationship between explanation and evidence so that they can understand how background knowledge and theories guide the design of investigations, the types of observations made, and the interpretations of data.

Video Activities:

1. Magic Wand Comb - a comb appears to defy gravity by attracting objects from a distance is an introductory discrepant (counterintuitive) event designed to arouse interest by conflicting with expectations and understanding and to stimulate interest in other possible explanations.

2. Balloon Attraction - introduces how electrostatic charges can be produced and how like charges attract and unlike charges attract.

3. "Electro-Plastics" - demonstrates another example of how to generate electrostatic charges, inducing charges, and objects that are conductors and non-conductors of electricity.

Students Naïve Conceptions

As students grow up they have many experiences for which they form explanations based on a variety of anchoring experiences, such as, jumping and falling, riding swings and bicycles. While these explanations make sense for the student, they may conflict with the results of science investigations, and they are sometimes called naïve conceptions. Student's naïve conceptions should not be treated as wrong as such but as conceptions based on insufficient analysis of their experiences. The activities in this video are designed to help students recognize their explanations and develop a more analytic view. Using models to help understand and explain physical phenomena plays a vital role in science. It is also important to remember that even if they learn all of the terminology, students may sometimes incorrectly apply the experiences they have at the macroscopic level to the microscopic level. Students may only remember the model and not the concept behind the model or attributing the literal behavior of the model to the phenomena that it is supposed to represent.

Telling or showing students the explanations that science uses may not change their beliefs. There are several strategies that can be used to facilitate a deeper understanding. Students need to become aware of their own preconceptions about a concept and expose these beliefs by sharing their ideas with other students in small groups in an uncritical environment to help them begin a deeper analysis of their experiences. They should be encouraged to make predictions based on their conceptions before activities begin. This will help students to begin to confront and test their beliefs and provide motivation for looking for other plausible conceptions. Students need to have time to work toward resolving conflicts between their ideas and their observations, thereby accommodating new concepts. Students need opportunities to extend new concepts by trying to make connections between the new concept and other situations in their daily lives. Students should also be encouraged to go beyond these initial steps by choosing additional questions or problems related to the concept to expand their understanding. These strategies are used to organize suggested activities into the following groups: exposing beliefs, committing to outcomes, confronting beliefs, accommodating concepts, extending concepts, and expanding inquiry.

Sample Support Activities

Exposing Beliefs

Use an activity like "Think, Pair, and Share" to have students begin thinking about their explanations of topics, such as, how static charges are produced, and then share their ideas with a partner. Two pairs can then be combined to share their views and each group of four can have a one person share the different explanations. Moving from small to whole group in a secure and uncritical environment gives students an opportunity to see that others are also uncertain and bring a variety of views to their experience.

Committing to Outcomes

Use the different activities in the video as opportunities to have students predict what they think will happen, for example, the in the balloon activity. Simply stop the video just before the professor places the two charged balloons together and have students share with a partner or write their predictions of what will happen. It is important that they make a verifiable commitment so that they can begin to address their beliefs.

Confronting Beliefs

Have students test their ideas by recreating one of the activities on the video or related activities that they found interesting. For example, pairs of students could make the polyethylene strips or other video activities and describe their observations and explanations. Working in small groups, students could then debate their explanations, conduct interviews, and check written materials before presenting their results. This is an opportunity for students to confront their beliefs.

Accommodating Concepts

Students need to begin to question their observations and their discussions to help them process information and begin to make sense of the explanations behind the observations. During this time, students begin to resolve the conflict that may exist between beliefs and observations. Class presentations of observations of activities and explanations along with carefully posed teacher questions and follow-up small group discussions will assist with the process of accommodating new concepts.

Extending Concepts

Asking students to give examples of where they have seen the concept discussed or demonstrated or giving examples of how they thing the concept is connected to other situations will help students extend their understanding of the concept. Students could describe situations where they were "shocked" by a buildup of static charges and then analyze how the charges were produced and why they felt the electric shock.

Expanding Inquiry

To encourage students to continue thinking about the concept, opportunities should be provided that invigorates them to investigate additional questions and problems that interest them.

Correlations to National Standards

The video activities and content address the following National Science Education Standards or The Benchmarks for Science Education *

National Science Education Standards

1. Energy is a property of many substances and is associated with heat, light, electricity, mechanical motion, sound, nuclei, and the nature of a chemical. Energy is transferred in many ways.

2. Matter is made of minute particles called atoms, and atoms are composed of even smaller components. These components have measurable properties, such as mass and electrical charge. Each atom has a positively charged nucleus surrounded by negatively charged electrons. The electric force between the nucleus and electrons holds the atom together.

3. The electric force is a universal force that exists between any two charged objects. Opposite charges attract while like charges repel. The strength of the force is proportional to the