Forces Between Charges

Overview

Static charges are created when you rub a piece of fleece material on plastic pipes and styrofoam cups. Can you determine which rod has a positive charge, and which one has a negative charge?

We let students ponder this question by having them consider a related question: How can you move the cup without touching it? Why does the cup move towards the pvc pipe and away from the acrylic rod?

Theory

Necessary materials:

- 1 styrofoam cup
- 1 clear acrylic rod
- 1 pvc pipe
- 1 square of fleece material

Atoms are made of protons, neutrons, and electrons. The protons have a positive electrical charge, the neutrons are neutral and have no charge, and electrons have a negative charge. An electron has a negative charge that is equal in strength to the charge of one proton. When an atom has the same number of protons as electrons, the atom itself has no charge. The protons and neutrons in the nucleus of the atom are held together very tightly, but some of the outer electrons are held very loosely and can move from one atom to another. An atom that loses electrons has a positive charge and an atom that gains electrons has a negative charge. Static electricity is the imbalance of positive and negative charges.

Some materials hold their electrons closely and are insulators, while others hold electrons loosely and are conductors. Most metals are conductors. One common way to move electrons is to rub two objects together. Rubbing two insulators of different materials together may cause electrons to transfer. The more rubbing, the more static builds up.

It is not the friction from rubbing, but the increased contact area that causes this transfer. You may have experienced static being created as you walk across a carpet. Electrons move from the carpet to you giving you a negative static charge. Now when you touch a metal door handle - zap! Electrons jump from you to the metal conductor and you feel the shock. Moisture in the air helps electrons move off you more quickly, so we notice static more during dry winter months.

Two things with the same charge will repel each other and objects with the opposite charges will attract. The electrostatic force acts at a distance, so we can observe objects moving together if they are opposite charges and moving apart if they are the like charges.

Doing the activity

1. Pose the question to your students: Do you think we can move the cup with the rods without touching the cup? Gather their ideas and assess what they understand about static electricity. Demonstrate how to charge the rods and cup by rubbing them vigorously with the fleece. Then explain that you have an activity that will help them answer this question.

2. Give students a chance to observe the pvc pipe repelling and the acrylic rod attracting the cup. A hard surface such as a table or desks pushed together will work best.

3. Have a discussion with your class about what they think is happening and why.

4. Now, say to the class: There are two charges: positive and negative. Charges that are alike repel each other. Act this out briefly with volunteers being assigned a charge and showing the positive repelling or pushing away from the other positive and going towards and touching the negative. Add another negative and ask the students to predict who they will want to go towards (a positive) and away from (the other negative).

5. Say: The fleece has created a negative charge on the pvc pipe. Now you need to figure out what charge the cup and acrylic rod have. Collect predictions and then have a student practice this up front by identifying and saying that the cup is negatively charged because the PVC pipe repels it and the acrylic rod is positive because the cup is attracted by it.

6. If there is time, ask them what they predict will happen if they put the acrylic rod inside the pvc pipe. Try it and see. (The charges should cancel each other out, although sometimes the pvc pipe is better charged and will still repel the cup.)

Extension Ideas

Have students brainstorm different materials they could try to rub on the cup and pipes. They could try a cotton sock, a wool sock, fur, etc. What would happen if they used an aluminum soda can or other types of cans rather than the cup? What if they tried a balloon instead of the pipes? Would a balloon repel or attract a tiny stream of water? What about a bubble?

Summing up

Negative static charges are created when objects take on extra electrons. Similar charges repel, or push away. Opposite charges attract. These charges, although invisible, are strong enough to move lightweight objects even at a distance.

For more information

Little Shop of Physics: https://www.lsop.colostate.edu

Colorado State University College of Natural Sciences: https://www.natsci.colostate.edu