

A Place Where Electrons Get Pushed Around

Think about This

It would be fun to be able to detect the presence of an electrostatic charge on various objects. With the following procedure you can make a simple but effective electroscope, which can do just that.



Hans Christian Oersted (1777 – 1851) was a Danish physicist and chemist. He is best known for discovering that electric currents can create magnetic fields.

Procedure & Observations

First, make a simple electroscope from these instructions.

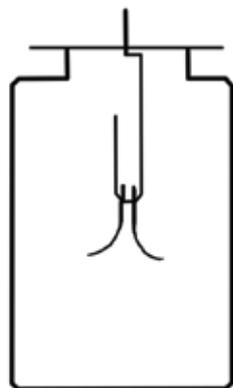
1. Straighten a paper clip and bend it into the shape shown below. Push the straight end of the clip through the cardboard and tape the clip to the cardboard.



2. Cut two strips of aluminum foil, each measuring one centimeter by four centimeters. Carefully smooth the foil. Push both pieces of foil through the bent end of the clip.



3. Place the cardboard over the glass container: This is your electroscope. The two pieces of aluminum foil will push apart from each other when there is an electrostatic charge on a nearby object.



The Investigative Problems

How can I make an electroscope?

What does an electroscope detect?



To see how it works, blow up the balloon and use a piece of wool to rub the balloon. This will cause the balloon to acquire an electric charge. Slowly move the balloon until it touches the top of the wire. Watch the little pieces of foil. What happens to the pieces of foil when a charged balloon touches the wire on the top of the electroscope?

Discharge the electroscope by touching the wire on top of the electroscope. This will get rid of the extra electrons. Charge the balloon again and move it near the top of the wire, but don't let them touch. What happens to the piece of foil when a charged balloon is brought near the wire?

Discharge the electroscope again by touching the wire. Test the following objects: a wooden pencil, a green leaf, and a glass cup. Touch each test object with your hand, but don't rub them with anything. Bring each object close to the wire on top. Record what the two aluminum foil pieces do.

Discharge the electroscope by touching the wire after each test. Try charging some objects by rubbing them with another material. Things like rubber, paper, and plastic objects tend to hold a charge. Wool, nylon, and silk are likely to produce a charge on these objects. Try charging a variety of objects by rubbing them with wool, nylon, silk, or something else. Bring each object near the wire. Keep up with how you charged each object you test. Record whether or not the charge was detected by the electroscope each time.

Object tested	Rubbed with	Ch. Detected by Elec.
1		
2		
3		
4		
5		

The Science Stuff

You need to keep the foil in the container because it is so thin that the slightest breeze will cause it to move. You want the movement of the foil you observe to be only from the charge it receives.

Glass and cardboard not only shield from wind, but they are also good **insulators** of electricity. Things like glass, cardboard, rubber, paper, and plastic are good **insulators** of electricity, because electrons cannot move easily through these materials.

Electrons can move easily through steel, aluminum, and other metals. These materials are good **conductors** of electricity.

The electroscope is designed in such a way that electrons can only move through the paper clip and the aluminum foil (conductors), and not through the glass or the cardboard (insulators).



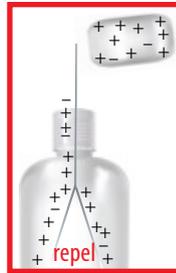
Recall that there is a magnetic field around a magnet, and there is also an **electric field** around a charged object (+ or -).

If a charged object that has a negative charge is brought near the wire, its electric field will push some of the loosely held (negative) electrons down the wire. Extra electrons will go into both pieces of the foil, making both pieces negative. As you know, the like charges will repel, so the pieces of aluminum foil will move away from each other.

If a charged object that has a positive charge is brought near the wire, its electric field will attract some of the loosely held (negative) electrons and they will move up the wire and out of the foil. This will leave the foil with fewer electrons and an overall positive charge. Two positive charges will repel and the pieces of aluminum foil will move apart.

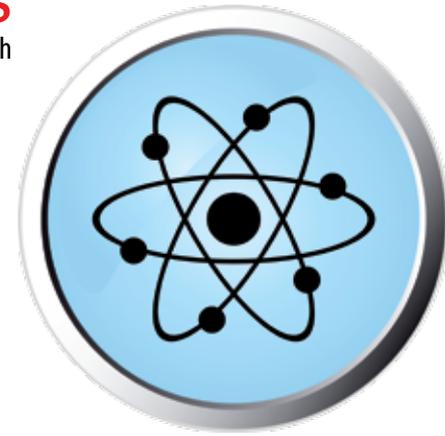
Essentially the same thing happens when a charged object touches the wire in the electroscope, except that electrons move into or out of the charged object.

An item has a positive or negative charge on it if the pieces of aluminum foil move apart when the item is brought near the electroscope. (You can't tell whether the charge is positive or negative.) The pieces of aluminum foil will not move if you bring an uncharged object near the electroscope.



Making Connections

This should remind you of how magnets and objects with a static electric charge are alike. Both have invisible fields around them. The **magnetic field** around a magnet can affect other magnets without touching them. Charged objects have an **electric field** around them that can affect other charged objects without touching them. Electrons (negative charges) are repelled by negative charges and attracted by positive charges, very much like two north poles (or two south poles) of magnets repel each other, and a north pole and a south pole attract each other.



Dig Deeper

Electroscopes have been used by scientists since the 1700s. Do some research on the history of electroscopes. This was an important piece of equipment for some scientists. How did some of the early scientists use them?

What Did You Learn?

1. Explain what might cause some of the electrons to get pushed down to the foil in the electroscope and make the foil move apart.
2. Explain what might cause some of the electrons to get pulled up from the foil in the electroscope and make the foil move apart.
3. Can an electron be pushed or pulled by the electric field around a charged object even though the object is not touching the electron?
4. What do we call materials that electrons can move through easily? Give two examples.
5. What do we call materials that electrons cannot move through easily? Give two examples.
6. How do you discharge an electroscope?
7. What are some ways in which magnets and objects with an electric charge around them are alike?

How Two Simple Ideas Became Huge

Static electricity and magnetism had long been suspected as being connected in some way. They both had invisible fields around them. They both obeyed the rule of “likes repel and unlikes attract.” Until 1820, no one had found a way in which electricity and magnetism were connected. The discovery that there is a connection between electricity and magnetism turned out to be one of the most important scientific discoveries in history.

The first connection was made in 1820 while a science lesson was being taught. The teacher was Hans Christian Oersted, who was a professor at a university in Denmark. He had arranged to do some science demonstrations in his home for a group of friends and students. He built a battery from chemicals and sheets of metal to demonstrate how an electric current could heat a wire. He also brought a compass needle mounted on a wooden stand as part of some other demonstrations about magnetism.

During the demonstrations, Oersted noticed something unexpected. Every time the electric current was switched on, the compass needle moved. After the demonstrations were over, he and some of the students continued to play around with the battery and the compass.

Each time they made a complete circuit by connecting the battery to the wires, the compass needle would move. When the wires were disconnected, the compass needle would move back and point north again. There was something invisible affecting the compass needle when the current was on. The wire was acting like some kind of strange magnet.

Professor Oersted published the results of this experiment. In just a few years, other scientists, like Joseph Henry, had made powerful electromagnets by wrapping wires around a soft iron core and connecting the wires to a battery. One of the advantages of electromagnets was that they could be turned on and off. Another advantage was that they could be made much stronger than ordinary magnets. Henry built an electromagnet that could pick up over two thousand pounds.



Electromagnets led to the invention of the telegraph. Joseph Henry was the scientist most responsible for the long-distance telegraph. However, Samuel Morse was the person who got the patent for it. Morse also devised a code known as the Morse Code that was used to send messages.

Oersted had shown that a moving electric current could produce a magnetic field. Michael Faraday from England and Joseph Henry from America were two scientists who wondered if a magnetic field could make an electric current. In fact, they made this discovery at about the same time, independent of each other, in 1831.

Subsequently, it was discovered that there was a very simple way to make an electric current just using wires and magnets. Simply take the two ends of a piece of wire and twist them together, making a circular loop of wire. Hold two bar magnets apart with opposite poles facing each other so that magnetic lines of force form between them. Have someone move the connected loop of wire back and forth between the magnets. Every time the wire moves down and cuts through the magnetic lines of force, electrons in the wire are pushed in one direction. Every time the wire comes back up through the lines of force, the electrons are pushed in the opposite direction. (Even though you won't see or feel anything, electrons are moving back and forth in the wire.)

You just produced an A.C. electric current, where the electrons move back and forth. Obviously the current is very weak and you would get tired trying to keep the wire moving back and forth.

However, wind power, water power, and steam can be used to keep many loops of wires inside electric generators moving across magnetic lines of force. The loops in a generator actually rotate instead of moving up and down. Most of our A.C. electricity is produced by electric generators.

So, by 1831, two important scientific ideas had been discovered: (1) An electric current can produce magnetism, and (2) magnetism can produce an electric current. Years passed while research and technology based on these two little ideas continued. The work was done by both scientists and inventors. Not only were telegraphs invented, but by the late 1800s, electric generators had been built, along with light bulbs and other electric devices. Electric motors were also being built.

Our demand for electricity seems to constantly increase. Recall that electric energy cannot be created. It can only change from another form of energy. As the need for electricity continues to grow, we will need to look for more sources of energy. The most promising sources are the renewable ones, such as solar energy, geothermal energy, wind energy, and biomass. At the same time, we need to find better ways to conserve our nonrenewable energy sources, such as coal, oil, natural gas, and nuclear energy.

Discussion:

Make a list of things you use frequently that require current electricity.

What is an electric generator? Why does it have to turn in order to produce electricity?

The discoveries that (1) an electric current can produce magnetism and (2) magnetism can produce an electric current are the basis for much of our technology today. Who were the scientists responsible for each of the discoveries? List some of the technology we have today because of these discoveries.