STATIC ELECTRICITY

From
Electricity and Magnetism
A Unit of Study

Produced by
Colgren Communications

Written by
John Colgren

Distributed by...

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800.323.9084 | FAX 847.328.6706 | www.unitedlearning.com

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STATIC ELECTRICITY
from
Electricity and Magnetism A Unit of Study
Grade Levels: 5-8
Viewing Time: 15 minutes

INTRODUCTION

This live-action program is designed for use with the intermediate grade levels (5-8).

This program is about static electricity. The program introduces students to the three primary particles of an atom and relates how lightning, balloons sticking to the wall, and shocks behind the ear from a sneaky friend are all examples of static electricity. Static electricity is a buildup of electrical charge on an object. It's called static because the charge stays on the object until there is another path through a conductor present.

INSTRUCTIONAL NOTES

Before presenting this lesson to your students, we suggest that you preview the program and review this guide and the accompanying blackline master activities in order to familiarize yourself with their content.

As you review the materials presented in this guide, you may find it necessary to make some changes, additions, or deletions to meet the specific needs of your class. We encourage you to do so, for only by tailoring this program to your class will they obtain the maximum instructional benefits afforded by the materials.

It is also suggested that the program presentation take place before the entire group under your supervision. The lesson activities grow out of the context of the program; therefore, the presentation should be a common experience for all students.

LINKS TO CURRICULUM STANDARDS

This Unit of Study addresses the following National Science Education Standards for grades 5-8:

Science as Inquiry
Content Standard A:
• Abilities necessary to do scientific inquiry
  Plan and conduct simple investigations.
  Employ simple equipment and tools to gather data.
  Use data to construct a reasonable explanation.
  Communicate investigations and explanations.
• Understanding about scientific inquiry

Physical Science
Content Standard B:
• 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.
• Electrical circuits provide a means of transferring electrical energy when heat, light, sound, and chemical changes are produced.

Science and Technology
Content Standard E:
• Abilities of technological design
• Understanding about science and technology
  People have always had questions about their world.
  Science is one way of answering questions and explaining the natural world. People have always had problems and invented tools and techniques to solve problems.
  Scientists and engineers often work in teams.
  Tools help scientists make better observations, measurements, and equipment for investigations.

History and Nature of Science
Content Standard G:
• Science as a human endeavor
  Science and technology have been practiced for a long time.

Men and women have made a variety of contributions throughout the history of science and technology. Although men and women using scientific inquiry have learned much about the objects, events, and phenomena in nature, much more remains to be understood. Science will never be finished. Many people choose science as a career and devote their entire lives to studying it.

STUDENT OBJECTIVES

After viewing the program and participating in the lesson activities, the students should be able to do the following:

• Define static electricity.
• Identify the three particles that make up atoms.
• Describe precautions that should be taken when lightning is a threat.
• Identify the Van de Graaf generator as a tool for producing static electricity for investigation and exploration.

ASSESSMENT TOOLS

This lesson provides you with three different assessment tools. Together they make it possible to closely follow the progress of your students and to judge their mastery of the subject matter.

The **Pre-Test** (**Blackline Master 1**) can be used to get some idea of students' understanding of the topic before the program is presented.

The **Program Quiz** and its accompanying answer sheet (**Blackline Master 2**) can be used either as a way to introduce the topic prior to showing the program or to judge student mastery once the program has been presented.

The **Post-Test** (**Blackline Master 6**) can be used as a final test for the lesson.

UNIT TEST

An optional Unit Test has been provided with this lesson. It can be used as a final test to gauge student comprehension of the material presented in all five lessons of this Unit of Study. Answers to the Unit Test are provided in the Answer Key of this instructor's guide.

TEACHER PREPARATION

View the program and review the accompanying activities. Duplicate any blackline masters you wish to distribute. If you plan to use the **Program Quiz**, which immediately follows the program presentation, you may wish to have copies of the quiz ready to distribute at the completion of the program. Also, plan to pause the tape between questions if students require more time.

INTRODUCING THE PROGRAM

Remind students that there are two different kinds of electricity: static and current. Static is electrical charges that build up on something and then jump to something else. Current electricity is electricity that flows and is the kind we use to run all our many appliances and devices. Current electricity must have a complete circuit on which to travel. The circuit is made of a source of electricity, a path for the electrons to travel along, and a device to use the electrons.

VIEW THE PROGRAM

Viewing time for this program is 15 minutes. The program quiz that follows the presentation will take about three minutes when you build in pauses for recording answers.

DISCUSSION QUESTIONS

You may wish to conduct a discussion after viewing the program based on the following:

1. Review with the class the three primary particles that make up all atoms. Go over the charges they have and describe how the protons and neutrons are found in the nucleus and that the electrons are in orbit in shells around that nucleus.
2. Review safety tips and precautions that everyone should take when lightning poses a threat. Have any of the students ever witnessed a spectacular lightning storm?

DESCRIPTION OF BLACKLINE MASTERS

This program contains six blackline masters that can be used to reinforce ideas and information presented in the program.

• **Blackline Master 1, Pre-Test**, provides a way of finding out how much students know about the material covered in this lesson before you present it. Students' scores on the **Pre-Test** can be compared with their scores on the final Post-Test (**Blackline Master 6**).

• **Blackline Master 2, Program Quiz**, is to be used at the end of the program. At the completion of the program, there is a short quiz. The narrator will read the questions, which are displayed on the screen. Students can use **Blackline Master 2** to record their answers. Answers to the questions are provided in the Answer Key section of this instructor's guide.

• **Blackline Master 3, Static Electric Transfer**, is an experiment designed to demonstrate how static electricity can travel from one conductor to another.

· **Blackline Master 4, Matter of Fact**, is an information sheet with explanations of the makeup of an atom and the electrical charges that occur between protons and electrons.

• **Blackline Master 5, Can You Explain It?**, contains four simple experiments for students to try. Then they are asked to explain how each experiment works. There is also a place for students to list their own examples of static electricity in action.

• **Blackline Master 6, Post-Test**, is an evaluation tool for this unit.

ENRICHMENT ACTIVITIES

1. If you can borrow a Van de Graaff generator, you can duplicate some of the demonstrations shown in the program. Just remember to insulate someone by having him or her stand on an insulating material such as a thick rubber mat or a rubber stepping stair used in gym classes for exercise classes.

2. Challenge the class to use the ideas presented in the "Static Electricity Transfer" experiment to devise a method for sending a static charge the length of the classroom. Supply plenty of wax, juice cans, wood blocks, string, tacks, and bell wire.

ANSWER KEY

Blackline Master 1, Pre-Test

I. Matching

1. e
2. a
3. d
4. b
5. c
6. f

II. Short answer

1. As the feet move across the carpet, electrons from the carpet come into the person's body and a buildup of negative charges occurs. If there is a path for the electrons to jump to, then the electrons will leap, in this case, to the metal doorknob.
2. Rubbing the wool on the hair causes some of the electrons from the wool to go into the hair. This causes a buildup of electrons on the hair. Since all the hairs have the same charge, they repel each other because like charges repel.
3. Protons have a positive charge. Neutrons have no charge. Electrons have a negative charge.
4. Like charges repel each other. Unlike charges attract each other.

Blackline Master 2, Program Quiz

1. c	5. b
2. a	6. c
3. b	7. b
4. d	8. d

9. Answers will vary but could include: don't be in an open area, get out of the water, don't go under a tree, don't hold or touch anything metal, get off the phone, don't be the tallest thing around.

Blackline Master 3, Static Electricity Transfer

<u>Observations:</u>

1. Electrons from the plastic wrap go into the can and the tack is attracted to the can where some of these electrons go into the tack. Then the tack pushes away (repels) from the can and jumps over to the other can. Then it jumps back to the first can.
2. The time that you can keep the tack moving back and forth will vary with the students conducting the experiment.

<u>Conclusions:</u>

1. The tack picks up electrons from the first can and carries them to the second can, where it drops them off. The first can is sitting on wax, which is an insulator, so the electrons can't go from the can onto the table or ground. The tack is made of a conductor, which allows the electrons to go into the tack. When the tack has an ample number of electrons, the tack is repelled from the can. The tack carries the electrons to the other can where the electrons go into the can and then onto the table and ground.
2. The wax is an insulator, which blocks the flow of electrons.

Blackline Master 5, Can You Explain It?

1. The comb will pick up pieces of paper. The comb gains electrons and a static charge so the paper is attracted.
2. The paper clings to the wall. This happens because the pencil rubbing across the paper causes the paper to lose electrons, so it is attracted to the electrons in the wall.
3. Rubbing your feet on the carpet causes electrons from the carpet to go into the person's feet and body. They will be discharged when the person comes close to something that conducts electricity.

4. A wool sweater will easily lose electrons. The electrons go into the hair; because the hairs all have the same charge, the hairs repel each other and stick up.

Blackline Master 6, Post-Test

1. When two charges that are the same come close, they repel, or push apart.
2. When two charges that are opposite come close, they attract, or come together.
3. Static electricity happens when two objects rub and gain or lose electrons.
4. Current electricity is the flow of electrons through a conductor.
5. Atoms are the smallest possible part of an element. They are made up of three primary particles called protons, neutrons, and electrons.

II. Short Answer

1. Protons are positive. Neutrons are neutral with no charge. Electrons are negative.
2. One can is placed on the wax and the other can is placed about an inch away. The second can has a block of wood on it. Suspended from the wood is a piece of string with a tack attached at the end, dangling between the two cans. A piece of plastic wrap is charged with wool. The wool is rubbed back and forth across the plastic wrap so that electrons will go from the wool into the plastic wrap. Then the plastic wrap is brought near the can on the wax and it clings to the can. Electrons from the plastic wrap go into the can. The can becomes charged with electrons, but there is nowhere for the electrons to go because the wax is an insulator. The tack is then pulled by the electrical charge to the can. The tack clings to the can and picks up electrons. When the tack has a sufficient number of electrons on it to be repelled by the electrons in the can, it jumps to the other can, which is electrically neutral. The extra electrons on the tack jump onto the second can. When the tack has given up enough extra electrons, it is once again attracted to the first can.
3. The rubber balloon picks up electrons from the hair so that it becomes charged with extra electrons. When the balloon is brought near the wall, the electrons in the wall are repelled and move further into the wall. This leaves the surface of the wall

with a positive charge. So the negatively charged balloon is attracted to the positive wall.
4. Electrons from the carpet go into the person, causing a buildup of negative charges. When the person comes near something that conducts electricity, the electrons jump from the person into the conductor.
5. Lightning can be very dangerous. People need to learn to take precautions when a lightning storm approaches. Here are some suggestions: seek shelter; don't be the tallest thing around; avoid trees; get out of the water; don't touch anything made of metal; get off the phone; if you can't get inside, then find a ditch or crotch down and roll up like a ball with very little contact with the ground.

• **Unit Test**

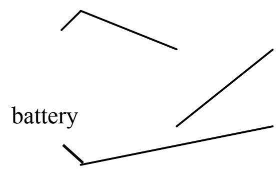
I. Matching

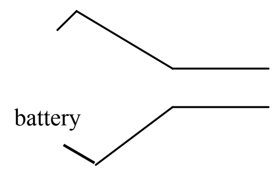
1. d	6. g
2. h	7. c
3. f	8. e
4. a	9. b
5. i	

II. Short Answer

1. copper, silver, gold
2. wood, glass, rubber, cloth, plastic
3. Insulators are used to stop the flow of electricity. Insulators around a wire will stop the electricity from moving out of the wire and into another conductor.
4. A generator produces electricity. It is made of either a coil of wire spinning in a magnetic field or a magnet spinning in a coil of wire. In either case, a flow of electrons is created.
5. An electromagnet can be made with a source of electrons, some wire, and an iron nail. Wrap the wire around the nail. Connect the wire ends to the terminals of the battery and you have an electromagnet.
6. An electromagnet can be turned on and off, but a regular bar magnet can't.
7. A source of electrons, a path for the electrons to flow along, and something to use the electrons.

8.





9. A series circuit has one path on which electricity flows. If a bulb in a series circuit burns out, all the lights go out. A parallel circuit has two paths on which electricity flows. If one bulb burns out, there is still a path for the electricity to flow along, so other bulbs in the circuit stay lit.
10. Fuses and circuit breakers will automatically trip, or stop, the flow of electricity if the circuit becomes overloaded by the flow of current.
11. Answers will vary.
12. The sun's energy through the use of solar cells, wind turbines, geothermal energy, chemical energy
13. They would move apart because they would be repel-led.
14. They would come together because they are attracted.
15. a. 4 amps b. 8 amps c. 6 amps

INTERNET RESOURCES

The following websites may be valuable sources of additional information to reinforce the objectives of this lesson.

1. "What Is Electricity?" by Energy Information Admini-stration.
http://www.eia.doe.gov/kids/electricity.html

2. Clark County Public Utilities in the state of Washington has a wonderful site with excellent pages on topics related to electricity.
http://clarkpud.apogee.net/kids/

3. Energy Story at the Energy Quest Site.
http://www.energyquest.ca.gov/story/index.html

4. Theater of Electricity at the Museum of Science in Boston.
http://www.mos.org/sln/toe/

5. "What is Static Electricity?" by *Science Made Simple*.
http://www.magpage.com/~science/january.html

6. "Lightning Primer" is a site by NASA on lightning information.
http://thunder.msfc.nasa.gov/primer/

SCRIPT OF NARRATION

What does lightning, a balloon sticking to a wall, and a shock from walking across the carpet have to do with one another?

Well, they are all examples of static electricity. Static electricity is a build up of electrical charge on an object.

It might happen when you pull a wool sweater on and off over your head. As the wool rubs across your hair, electrons from the sweater move into your hair. You may end up with a bozo the clown hairstyle. That's because your hairs have picked up an extra charge of electrons. The like charges of these extra electrons repel each other and the hairs, in an attempt to stay away from each other, push apart. It's a cool look and should catch on without a problem.

There are two types of electricity, static and current. Current electricity is defined as the flow of electrons and is the type of electricity we use from our home outlets or from batteries.

Static electricity is the buildup of electricity on an object. It will stay on an object until it has a way to get to another object that conducts or allows electricity to flow through it easily. That's what conductors do. They allow electrons to travel into and through them easily.

Objects that don't allow electrons to flow easily through them are called insulators. They resist the flow of electrons.

ELECTRONS

To understand electricity, we must understand electrons and how they behave.

Electricity is simply defined as the flow, or movement, of electrons.

Electrons are found in atoms. In fact, electrons are one of the building blocks of atoms. There are three main particles found in all atoms.

They are protons, neutrons, and electrons.

The protons and neutrons are found in the center of the atom in what is called the nucleus. The electrons are found orbiting the nucleus in energy shells.

So how big are atoms you may ask? Well, here are some examples.

The thickness of a regular sheet of writing paper is about one million atoms wide.

If we made an atom the size of a professional football or baseball stadium, the electrons would be the size of bee bee pellets.

The protons have a positive charge and the electrons have a negative charge. These opposite charges attract each other and, as a result, the fast moving electrons are kept in orbit.

The neutrons, which are also found in the nucleus, have no electrical charge. You can remember that by thinking of the words neutron and neutral.

When a car is in neutral, it is neither in drive nor reverse, it will be still, if on a level surface.

You can remember that the proton has a positive charge by thinking of pee pee. No, not a trip to the bathroom.

The letters p and p—proton positive.

So electrons are found orbiting the center of atoms. Everything is made of atoms. Atoms are the building blocks of all matter.

Some atoms can loose an electron easily.

Good conductors of electricity, such as copper, are used as wires for electrical devices because they allow electrons to flow through them easily.

The atoms of copper each have a loosely held electron in their outer shells. These electrons can move from one atom to another very quickly.

If additional electrons are pushed into the copper wire, the flow of electrons begins. Electrons move from one atom to another. Because the electrons have the same electrical charge, they repel, or push against, each other. So as one electron comes into the outer shell of an atom, the electron in that outer shell may be electrically pushed or repelled out of its shell and into the outer shell of another atom. This continues over and over throughout the entire length of the wire.

Thus, there is a flow, or movement, of electrons and an electrical device connected to the wire can now use those electrons to spin a motor or heat up a filament to give off light.

BALLOONS ON THE WALL

When we rub a balloon in our hair, electrons from our hair go into the balloon. The balloon has a buildup of electrons. If the balloon is brought near a wall, the extra electrons on the balloon surface repel electrons in the wall, causing them to move away.

Now the surface of the wall has more protons than electrons, and therefore, a positive charge results. The opposite charges attract each other and the balloon is magically held in place on the wall.

When you walk across a carpet on a dry humid day, electrons from the carpet move into your body, giving your body an excess, or greater number, of electrons. Then if you touch a conductor, such as a metal doorknob or someone else, the extra electrons jump from you to the new conductor as a sudden spark of electricity we call static discharge.

LIGHTNING

During a lightning storm, the movement of water droplets inside a cloud causes positive charges to develop at the top of the cloud and negative charges to develop in the lower part of the cloud.

When that charge becomes strong enough, a bolt of lightning results. The negative charge from the cloud flashes towards the ground at fantastic speed and great force. Objects in the way can be severely damaged.

Trees may explode as water inside the branches or the trunk is suddenly heated to a boiling point in a fraction of a second. To protect buildings, methods to carry the electrical charge safely to the ground are utilized.

Ben Franklin was the inventor of the first such device called a lightning rod.

It is a long metal rod placed at the highest point on a building or barn. Attached to this rod is a wire cable capable of carrying the charge of electricity to the ground.

People use to say that lightning never strikes the same place twice. This was not a true statement for a couple of reasons. First of all, what we think is a single lightning strike is actually a series of separate strikes.

There is the initial strike and then a return bolt that goes from the ground up to the cloud and then often a few more back and forth bolts. We can see this happening when we slow down video footage of a lightning strike. All this is happening within a second.

Another way to disprove the old saying about lightning never striking the same spot twice is the fact that tall skyscrapers, like the Sears Tower in Chicago, are often struck multiple times during a single storm. The Sears Tower is struck hundreds of times a year.

Well, what should you do if a lightning storm sneaks up on you?

To be safe from a lightning flash, you want to avoid being the tallest thing around. You want to avoid trees, flagpoles, mountain tops, open fields, and open bodies of water. If you are out on the water, get back to shore. Seek shelter. Don't go under trees. Go to low areas.

Dan Davis from the Museum of Science in Boston is demonstrating how to crouch down if you can't find shelter and you are out in the open. Don't lie down because if lightning strikes nearby, it can spread out and travel through the ground and you. So crouch down so just part of your feet are in contact with the ground.

A thunderstorm doesn't have to be occurring where you are for lightning to strike. Often lightning will happen from a cloud that is a mile or so away. You could be in perfectly clear skies and have wonderful weather when a bolt jumps from the backside of a storm. Any sign of a storm should be a signal to get out of the open.

ELECTRIC FERRY

We can develop static electrical charges for experimentation. This setup is called an electric transfer. We need some simple supplies. Two coffee or juice cans, a piece of paraffin wax, a block of wood, a thumbtack, some string, plastic wrap, and wool.

Tie a piece of string to the thumbtack as shown. Place one can on the wax. Put the piece of wood on the other can. Tape the other end of the string to the wood block so that the tack hangs between the two cans with a little space on either side. Now take the plastic wrap and tear off a section about the size of an unfolded napkin. Place it flat on a table surface. Use the wool to charge up the plastic wrap. When you briskly rub the wool across the plastic wrap, electrons from the wool go onto the plastic wrap. Now carefully pick up the plastic wrap and touch it to the can that is sitting on the wax. The tack should immediately jump to that can and then push away and jump to the other can. Then it will jump back to the first can and repeat this over and over until it has no more electrons to carry, or transfer, across this little gap. You can time how long the tack makes it back and forth trip on one charge of the plastic. When the tack slows down, pull the wrap quickly away from the can and it should start up again.

Can you tell why the one can is sitting on the wax? Well, wax is an excellent insulator. So it is preventing the electrons that move from the plastic wrap to the can from going directly into the table. So the electrons build up on the can until they attract the metal tack. The tack moves to the can and sticks to it as electrons move from the can into the tack. When the charge of the tack is strong enough, it is repelled by the can, which has a negative charge as well.

Remember, like charges repel, or push away, from each other. The tack is pushed to the other can. This can is also a good conductor but it doesn't have a charge so the tack sticks to it and releases electrons into that can. When the extra electrons from the tack are gone, it moves away and is again attracted to the charged can for a new supply of electrons. The electrons that come to the second can can go into the table because this can isn't insulated like the can sitting on the wax. Try to figure out ways to make the tack jump back and forth for longer periods of time. Or figure out a way to transfer a static charge across the room using three or four cans and some lengths of wire.

VAN DE GRAAFF GENERATOR

This device is called a Van de Graaff generator. It was designed to develop large static electrical charges.

This is the original Van de Graaff generator built in 1929. It was used to smash atoms, but now that more sophisticated equipment has been developed, it is used to study large electrical discharges. Every day the Van de Graaff is demonstrated at the Museum of Science in Boston.

We'll use this small Van de Graaff to explain how it works. Even though it is called a generator, it really doesn't generate an electrical charge. It is plugged into an outlet. It gets the electric charge from the power plant. The Van de Graaff separates the positive and negative charges sending the positive charges into the ground and carrying the negative charges to the dome.

The negative charges are carried to the dome by a belt similar to the conveyor belt you see at the grocery store. The negative charges are deposited on the metal dome. This dome is insulated from the ground so that the negative charges have no where to go. The charge on this small Van de Graaff can build up to seventy thousand volts.

Now a person stands on an insulated surface, such as this plastic step stool, and places a hand on the surface of the dome. The generator is turned on and the negative charge on the dome begins to build. The charge goes through the person's hand and arm and into their body. Their hair begins to react as individual strands repel each other. This happens because the hairs have all taken on a negative charge and like charges repel, or push apart. Even after the generator is turned off, the hairs continue to repel each other. This is because there is no place for this static charge to go. There is no path to the ground because the person is standing on the insulated stool. When the charged person touches someone else who provides a path to the ground, the static charge is instantly transferred. Neither person is harmed even though a charge of seventy thousand volts has just traveled through their bodies. That's because the voltage may have been high, but the current or rate of electric charge was very low. An outlet has a voltage of only 120 volts but a greater current or number of charges. The outlet could be very harmful if used or touched improperly. Voltage tells the energy that each charge has, but if there are few charges, it isn't harmful.

Every day presenters at the Museum of Science use the original Van de Graaff to demonstrate that a car is a safe place to be during a lightning storm. Many people think that a car is safe because of the rubber tires. They know that rubber is a good insulator. Well, the fact is that a few inches of rubber isn't going to stop a lightning bolt that has just traveled miles through another good insulator, air. What protects people in a car is the metal of the car. You are surrounded in metal. So every day presenters climb into this metal birdcage which is lifted near the domes of the Van de Graaff. Then the giant two story Van de Graaff, which can generate two hundred fifty thousand volts of electric charge, is turned on. As huge sparks hit the metal cage, the presenter is completely safe because of an effect called the skin effect. The static charge creates a rapidly changing magnetic effect, which pushes the charge to the outside, or skin, of the cage. As long as the presenter doesn't touch the outside of the cage, they are safe. In fact, they can touch the inside of the metal cage without any harm.

Here is a small version of the Van de Graaff.

In this demonstration, an animal skin which contains a lot of fur is placed on the dome. The generator is turned on and soon the skin is air born as the like charges of the fur and dome repel each other.

Here we put a beaker full of styrofoam particles on the dome. It doesn't take long before the particles are flying out of the beaker like lava out of a volcano. Let's look at it again, but this time in slow motion.

Now a metal wand is brought near the Van de Graaff, and, as you can see, sparks jump from the dome to the wand, which is safely grounded.

Here we are using a rubber rod and fur to develop a static charge. The rubber rod is rubbed with the fur and then the rod is brought near the pith ball hanging by a string from this coat hanger support. A pith ball is very lightweight and responds to static electricity. When the charged rod is brought near, the pith ball jumps to the rod and momentarily clings to it. Then when the ball has picked up enough electrons, it jumps away because like charges repel. Now the rod repels the pith ball. As the rod is moved around, the pith ball jumps to stay away. If we set up two pith balls, we can charge them and they will each take on a negative charge and repel each other.

Here is another static electricity example that requires some simple materials. This is a golf club sleeve. A rubber stopper with a dowel rod stuck in it is inserted into one end of the sleeve. A piece of styrofoam packing material is taped into a loop. A piece of wool is used to give the golf club sleeve a static electric charge. The packing material is then picked up with the dowel rod and flipped in front of the sleeve. You can move about the room and the loop will magically float in front of the sleeve. You could have races around the room.

So next time you get a shock from a friend, or see the flash of a lightning bolt, you know that these things are possible because of static electricity.

Now it is time for the program quiz. The first eight questions are multiple choice and the final question is a short answer question.

1. Electricity is defined as the flow of ________.
   a. protons
   b. neutrons
   c. electrons
   d. atoms

2. The center of an atom is called the ________.
   a. nucleus
   b. proton
   c. orbit   d. electrons

3. Objects that don't allow electrons to flow easily through them are called ________.
   a. protons
   b. insulators
   c. conductors
   d. neutrons

4. There are two kinds of electricity called static and ________.
   a. protons
   b. conductors
   c. electrical
   d. current

5. Charges that are unlike will _________.
   a. repel
   b. attract
   c. conduct
   d. current

6. What kind of charge does a proton have?
   a. repel
   b. neutral
   c. positive
   d. negative

7. What kind of charge does a neutron have?
   a. repel
   b. neutral
   c. positive
   d. negative

8. What kind of charge does an electron have?
   a. repel
   b. neutral
   c. positive
   d. negative

9. Name some things you should avoid if a lightning storm comes near.