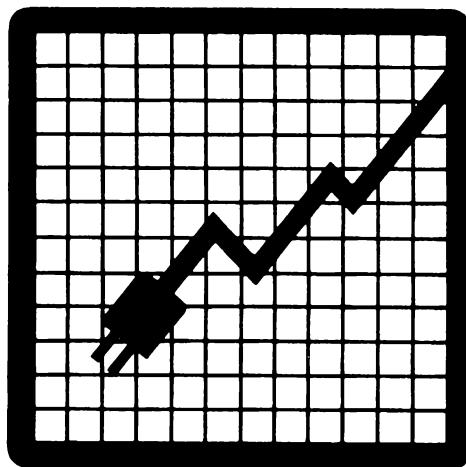


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# 4-H ELECTRIC PROJECT LEADER'S GUIDE FOR **Junior Electric Energy Curriculum**



Virginia Cooperative Extension

Virginia  
 Tech

VIRGINIA POLYTECHNIC INSTITUTE  
AND STATE UNIVERSITY

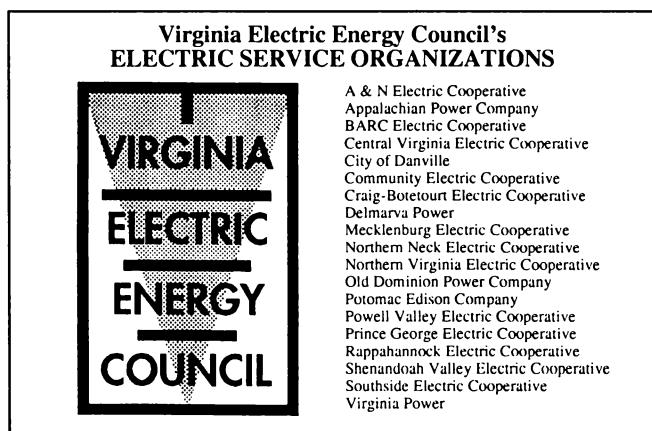
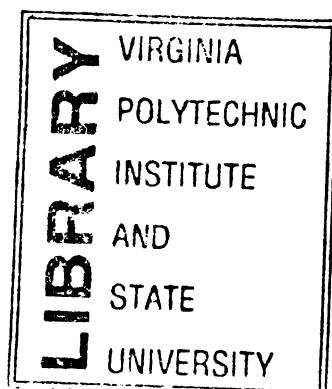
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# 4-H ELECTRIC PROJECT LEADER'S GUIDE FOR Junior Electric Energy Curriculum

*Lori S. Marsh\**

This guide outlines the use of lesson plans developed for 4-H youth, ages nine to eleven, who are interested in learning about electric energy. The lessons have been divided into two units. The first unit, **Basic Electricity**, consists of four lessons that explore basic electrical concepts. The second unit, **Applied Electricity**, consists of five lessons that explore applications of electricity. The lessons should be completed in order, since each lesson builds on concepts presented in previous lessons. Because the curriculum is divided into two units, you need only commit to teaching a series of lessons designed to run for four to five meetings.

The electric energy curriculum is intended to provide 4-H members with a basic understanding of electricity and the important role it plays in our daily lives. Upon completion of these lesson plans, 4-H members should be more knowledgeable consumers of electricity and be able to make responsible decisions concerning its use.

You are encouraged to seek out and take advantage of community resources. The local electric utility or rural electric cooperative, electrical contractors, and electrical supply warehouses may be willing to donate time, supplies, or personnel to assist you in leading an electric program. In addition, many counties have identified and trained a Master Electric Volunteer to assist club leaders and teachers who elect to use these lesson plans. The supplies necessary to conduct the first lessons are available from your county's Master Electric Volunteer or the District Office serving your county. Please ask your local 4-H agent for help in locating supplies.

The mission of Virginia 4-H is to assist youth, and adults working with those youth, to gain additional knowledge, life skills, and attitudes that will further their development as self-directing, contributing, and productive members of society. In keeping with that goal, this guide outlines a teaching method, cooperative learning, that is designed to teach social skills as well as science facts.

## What is Cooperative Learning?

Cooperative learning is an instructional strategy that has been proven to promote higher achievement than traditional, competitive learning situations. Because cooperative learning requires that students verbalize concepts and discuss ideas with each other, students gain a better grasp of the material. Also, exposure to others' views increases tolerance and respect for diverse personal views and prepares youth for an increasingly collaborative work force. But cooperative learning is more than just asking youth to work together in groups. Youth must be taught essential interpersonal social skills that will allow them to work together to achieve a common goal, to share ideas, and to provide each other with encouragement and praise. This guide provides learning structures that teach children to work cooperatively.

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\*Extension Specialist, Agricultural Engineering, Virginia Tech

## **Necessary Elements For Cooperative Learning**

Johnson et al. (1984) outline four basic elements that must be included for small group learning to be truly cooperative. They are:

**1) Positive interdependence.**

Group members must understand that the group can only accomplish the task if they work together. There are many ways you as leader can assure that interdependence exists. You can assign roles to each team member; you can divide needed resources or information among the team members; you can plan on some type of team reward for an outstanding effort.

**2) Face-to-face interaction.**

In addition to positive interdependence, group members must have an opportunity to interact.

**3) Individual accountability.**

It is necessary that each student be responsible for mastering the material. One good way to make each group member accountable is to explain to the groups that you will select one member from each group to explain an activity. Since they don't decide who reports, it will be necessary for the group to make sure every member understands the task well enough to describe it.

**4) Appropriate use of interpersonal and small group skills.**

Placing youth who lack the necessary social skills in a group and telling them to cooperate will not be successful. Youth must be taught social skills.

## **Necessary Social Skills for Cooperative Learning**

- Form groups quickly and quietly;
- stay in group and use quiet voices;
- everyone participates;
- speak clearly and address classmates by name;
- listen attentively;
- praise others and seek others' ideas;
- paraphrase other members' ideas for the group;
- elaborate on ideas;
- summarize material;
- provide reasons for your answers;
- criticize ideas, not people;
- combine a number of ideas into a single conclusion;
- ask questions to arrive at answers;
- check answers/conclusions with original assignment.

## Teaching Social Skills

It cannot be stressed enough that social skills must be taught. To accomplish this, you should introduce one or two new skills each lesson by describing the skill or skills and explaining why the skill is important. Give an example of the skill and set up a practice situation for the youth to follow. Allow time at the end of each lesson to discuss the social skills. Let the children think about whether they used the skill in the session or not.

One easy way to discuss social skills is to make a large chart and brainstorm with the kids to fill in the chart. An example chart with possible responses is shown below:

SOCIAL SKILLS CHART

|   |                                |
|---|--------------------------------|
| <b>SKILL:</b> listen actively                       |                                |
| <b>LOOKS LIKE:</b>                                  | <b>SOUNDS LIKE:</b>            |
| look at person who is talking.                      | if you're listening you aren't |
| only one person talking                             | one quiet voice                |
| wait your turn to talk                              |                                |
| ask questions that build on the last person's idea. |                                |

One way to help make sure all team members contribute equally is to give them tickets with appropriate behaviors written out. Each time a student exhibits one of the behaviors on the ticket, the ticket is "spent." Youth cannot contribute without spending a ticket and they should try to spend all tickets by the completion of the exercise. Possible tickets include: answer a question; ask a question; give an idea; respond to an idea; reword; summarize progress; check for understanding; keep group on task; and encourage the group. A reproducible copy of these tasks in ticket form is included in Appendix A. If possible, xerox the tickets on paper of several different colors so that each child within a group has a unique color.

A good way to evaluate social skills after the exercise is to take a few minutes for teams and individuals to evaluate themselves by completing an evaluation form. A reproducible evaluation form is included in Appendix B.

You may wish to assign roles within each group. Providing badges that declare the role will help group members remain on task. Possible roles include: Checker (makes sure each group member can explain what the group is doing); Materials Manager (gets supplies, checks work for accuracy); Recorder (writes answers for the group). Feel free to invent other roles. It is important to explain the roles to the students and help keep them on task.

## **Getting Started**

It is probably best to start with groups of two or three to help assure that everyone participates. An easy way to get students into groups is to have them number off and then form groups of common numbers. For example if you have 12 students and you want to put them into four groups of three each, have them number-off one through four and then all the “ones” become one group, the “twos” become the second group, and so on. Try to keep the same groups throughout an entire unit.

## **Using This Guide**

Everything you need to know to conduct each lesson is included in this guide. The required materials are listed first, followed by a few suggestions for conducting the lesson. Finally, the lesson plan, including answers, is presented.

# UNIT 1: BASIC ELECTRICITY

## Lesson 1 - Static Electricity

### Materials Required:

- one balloon for each child
- a piece of string (about 1 foot long) for each child
- paper for tearing into small pieces
- pencils
- a plastic comb
- comb and sink with running water<sup>1</sup>

Before separating youth into working groups and distributing work materials, discuss the concept of an atom. At the end of the discussion youth should understand that matter is composed of atoms and that atoms are composed of a center called a nucleus that is orbited by negative particles called electrons. If you rub your feet across a carpet or a balloon across your shirt you build up an excess number of electrons and the result is a negative charge called static electricity.

Discuss a few social skills such as taking turns talking, using quiet voices so as not to disturb other groups, staying in their group, providing positive reinforcement, and paraphrasing ideas for clarification. Distribute participation “tickets” if you wish.

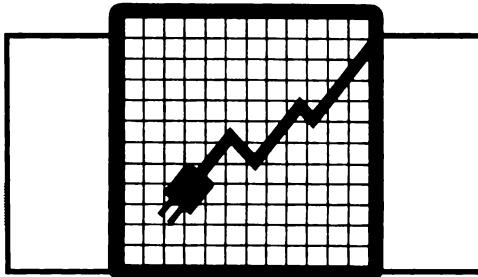
Make one child in each group the Recorder, who is responsible for recording the group’s answers. Another person should be the group’s spokesperson, with responsibility for communicating questions to the adult leader. If you make it clear that only the spokesperson can talk to the adult leader(s), you will reduce the bedlam significantly. You might want the children to make and wear badges that announce their role. This will help both you and them as they learn to work as a group.

Give the groups time to work through an exercise and record their results. Choose a spokesperson from one group to describe what they observed in the exercise. Then proceed to the next exercise.

If time permits, pass out the “How We Did” questionnaires and have the students complete them and share their results. Again, a group discussion where the students exercise their skills by taking turns speaking, listening attentively, paraphrasing ideas, etc., will reinforce the social skills presented.

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<sup>1</sup>Since it requires a sink and running water, you may wish to suggest that children try this exercise at home.



## **Junior 4-H Electric Energy Curriculum**

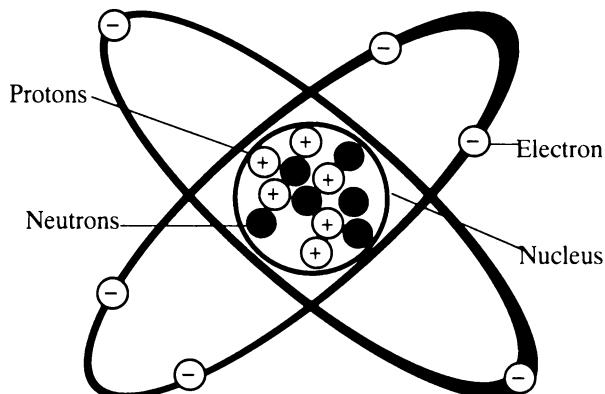
### **Lesson 1 - Static Electricity**

*Lori S. Marsh and Henry J. Sullivan\**

All matter is composed of atoms. Even though we can't see the atom, scientists have discovered several interesting things related to the atom and electricity.

An atom carries a balance of positive and negative charges. The center of an atom, called the nucleus, contains neutrons and protons. Neutrons have no electrical charge. Protons have a positive charge.

Moving in an orbit around the nucleus are electrons. Electrons have a negative charge. They are the only particle in an atom that is free to move. The movement of electrons makes it possible for atoms to share electrons. The movement of electrons from atom to atom is what binds matter together.

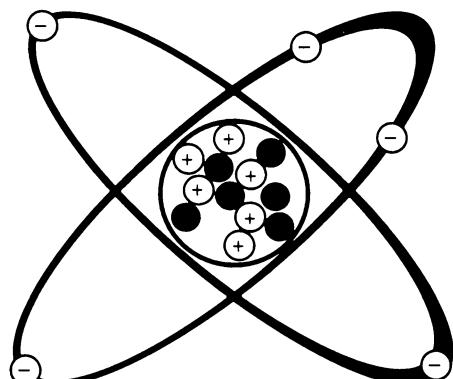


**A Carbon Atom**

Electrons nearest the outer limits of an atom (those farthest away from the nucleus) are easy to move. When it is cold and dry and you rub your feet across the carpet, you develop a static charge on your body. This charge is a result of rubbing off electrons from

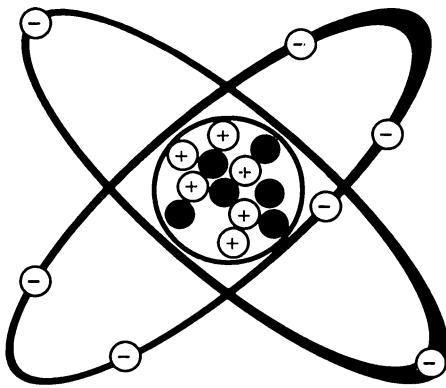
atoms in the carpet, which adds a number of electrons to your body. Because electrons have a negative charge, you now carry a negative charge in relation to other things around you. This negative charge is called static electricity.

Atoms carry a balance of protons and electrons in their atomic structures—they are neutral. However, because the electrons are easily removed from the structure, the balance of electrical charges can be altered. When an atom becomes unbalanced due to a loss or gain of electrons, the resulting particle is called an ion. A positive ion, called a **cation**, results when an atom gives up an electron. A negative ion, called an **anion**, results when an atom gains an electron. Ions carry a negative or positive charge because the balance of charges is disrupted. Since electrons move freely and since substances tend to maintain electrical balance, electrons will flow from the substance that contains more electrons than normal to a substance that has fewer electrons than normal.



**Positive Ion**

\*Extension Agricultural Engineer, Virginia Tech; Programs Manager, Appalachian Power Company, Roanoke, VA, respectively



**Negative Ion**

This effect can be demonstrated easily. Build a static charge by rubbing your feet across a carpeted floor on a day that is fairly dry. Then touch a metal lamp, a door knob, or another person. Just before your finger touches the metal object or another person, a spark will leap across the gap. This is an electrical discharge. When electrons leap across the gap you may feel a slight shock or, if it is dark enough, see a spark.

The spark isn't the electron jumping but the result of the movement of the electrons through the air. The friction of the electrons, moving at the speed of light, creates intense heat that can be seen as a spark.

Another interesting property of electrical charges is that like charges repel and unlike charges attract.

## Static Electricity

- Blow up a balloon and tie a knot in the end. Rub the balloon several times with a piece of wool. Hold the balloon near a friend's head. What happens? Why?

**Answer:** The friend's hair "stands up" or is attracted to the balloon. When you rubbed the balloon with the cloth, electrons were stripped away from the balloon and collected by the cloth. Because the balloon has lost negatively charged electrons, it carries a positive charge. The positively charged balloon attracts the negatively charged electrons in the friend's hair.

- Tear a sheet of paper into small pieces, about one-fourth inch square. Place the pieces of paper on a table. Now, "charge" the comb by rubbing it several times with a piece of cloth. Place the comb near the paper pieces. What happens? Why? Can you do the same thing with a balloon?

**Answer:** The pieces of paper are attracted to both the charged comb and balloon. Again a net positive charge exists on the comb and balloon (due to a loss of electrons) that attracts the electrons in the paper pieces.

- Tie about 12 inches of string to a balloon. Next, tie another 12-inch piece of string to a second balloon. Now hold each balloon by the string so that the balloons hang down and bring them close together. What happens? Why?

**Answer:** The two balloons move away from each other. Since both balloons carry a positive charge they repel each other. Opposite charges attract each other; like charges repel each other.

- Again "charge" the comb by rubbing it with the cloth. Turn on a water faucet to create a small stream of water. Hold the comb near the stream of water. What happens? Put the comb into the stream of water, then remove it and again hold it near the stream of water. Does the comb still attract the water? Why or why not?

**Answer:** The stream of water "bends" toward the comb. This happens because the positive charge on the comb attracts the electrons in the water. When the comb is put in the stream of water it gains electrons and is no longer charged. Therefore, the comb no longer attracts the stream of water.

## **Lesson 2 - Current Electricity**

### **Materials required:<sup>2</sup>**

- a copy of the lesson plan for each child
- 1.5 volt, D-cell batteries, 3 per group
- flashlight bulbs, 3 per group
- #22 insulated copper wire, about 3 feet per group
- wire strippers, 1 per group
- bulb holders, 3 per group
- battery holders, 3 per group

Before letting the children get in their work groups, review the concept of an electron, a negatively charged particle that generally orbits around a nucleus in an atom. Explain that electrons can exist by themselves, outside of an atom. Electrons not associated with an atom are called “free” electrons. The mass movement of free electrons is called current electricity.

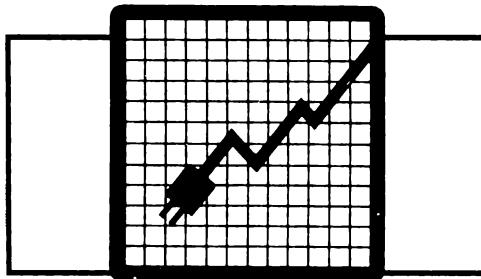
The exercises in this lesson are a great deal more challenging than those in the first lesson. It is probably best to let the students work in groups of three. Again discuss skills needed for cooperative learning. Assign a role for each child. Possible roles include materials manager (gets supplies), spokesperson, and recorder.

Try to refrain from showing the students how to solve the exercises. If a group is stuck, try to ask them questions to lead them to a solution. Another tactic is to let a child from another group help them along.

After each exercise is completed, select someone from one group to explain how his or her group accomplished the exercise.

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<sup>2</sup>Check with your local 4-H agent or electric power supplier to see if these materials are available on a loan basis.



## **Junior 4-H Electric Energy Curriculum**

### **Lesson 2 - Current Electricity**

*Lori S. Marsh and Henry J. Sullivan\**

In Lesson 1 we explored static electricity. Another form of electricity, besides static electricity, is current electricity. Unlike static electricity, which discharges instantly, current electricity maintains a charge and electrons flow for a controllable period of time.

Electrons that have been knocked out of the outer shell of an atom are called "free" electrons. These free electrons can exist by themselves, outside of the atom. The mass movement of free electrons is called current electricity.

All substances contain some free electrons that can move from atom to atom. Metallic substances have many free electrons and are capable of carrying an electric current; they are called conductors. Examples of good conductors include copper, aluminum, and silver. Substances with few free electrons will not carry an electric current. They are called insulators. Rubber and glass are examples of good insulators. Materials with an intermediate number of free electrons are called semiconductors. The more free electrons present in a substance, the better it is at conducting electricity.

By covering a good conductor, such as copper, with a good insulator, such as plastic, we can control the flow of electrons. In this way we put electricity to work for us.

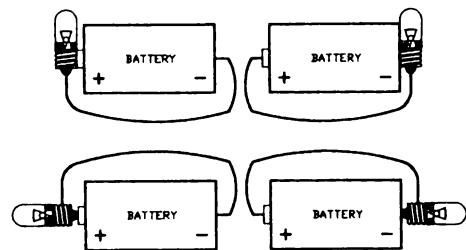
A dry cell battery will induce electron flow; that is, it will cause current electricity to flow if a conductor is available. If a wire is connected from the negative

end (-) of a dry cell to the positive end (+) of the same cell, electrons will flow from the negative end where more electrons are collected to the positive end where relatively fewer electrons are collected. The flow or current will continue until the wire is disconnected or the cell's capacity to produce potential energy is exhausted.

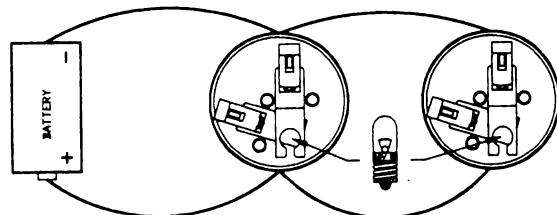
#### **Circuits**

Try these demonstrations:

1. Using a dry cell, a piece of wire, and a light bulb, connect the three to light the bulb. This can be accomplished in several ways. Draw the path the electrons use (the electrical circuit).

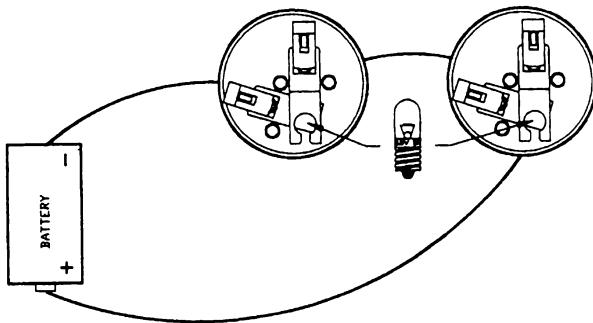


2. Using only one dry cell, connect two bulbs so that each burns as brightly as the single bulb in the first circuit you built. Draw the circuit.

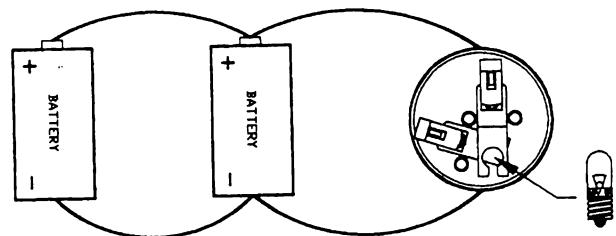


\*Extension Agricultural Engineer, Virginia Tech; Programs Manager, Appalachian Power Company, Roanoke, VA, respectively

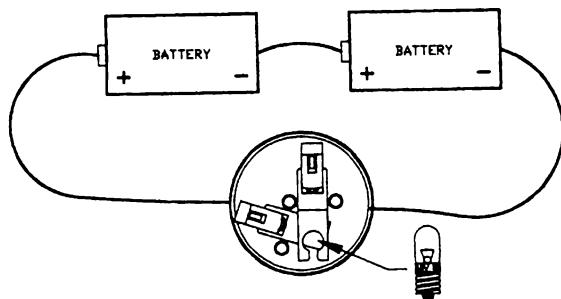
- 3) Now connect two bulbs to one dry cell so that they are each dimmer than the single bulb in the first circuit. Draw the circuit.



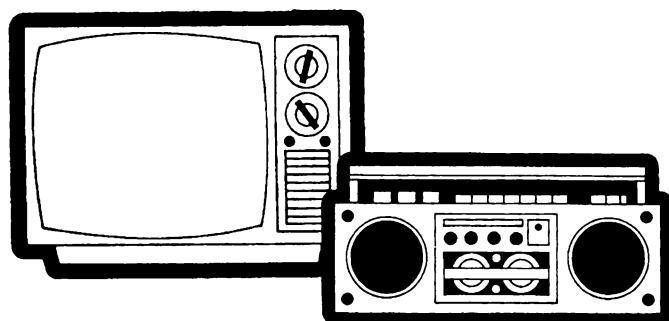
- 5) Using a circuit that contains a battery of two dry cells, make one bulb burn as brightly as a bulb in a circuit containing only one dry cell. Draw the circuit.



- 4) Using a circuit that contains a battery of two dry cells and one bulb, make the bulb burn brighter than the bulb in the circuit with a single dry cell. Draw the circuit.



So far we have looked at two forms of electricity, static charges and moving charges. Static charges are potential energy like the energy stored in a dry cell or your body when you rub your feet across a carpeted floor in dry weather. When charges are moving in a conductor, energy, in the form of current electricity, is transported from one place to another. When current flows through output devices such as lights, motors, and televisions, the energy is converted from one form to another.



# **Lesson 3 - Electricity and Magnetism**

## **Materials required:**

a copy of the lesson plan for each child

### **exercise 1**

bar magnets, 2 per group  
iron filings  
paper

### **exercise 2**

bowl or saucer of water, 1 per group  
sewing needle or pin, 1 per group  
small styrofoam disk (the bottom of a styrofoam cup works great). This is to make the mariner's compass. (Please note that the lesson plan suggests using a piece of cork. Cork is also fine, but I suspect that styrofoam cups are easier to find!)

### **exercise 3**

compass, 1 per group  
#22 insulated copper wire, about 2 feet per group

### **exercise 4**

1.5 Volt, D-cell battery, 1 per group  
large nail, 1 per group  
paper clips or other metal "trash"  
#22 insulated copper wire, about 3 feet per group

### **exercise 5**

enamel-coated wire, about 1 foot per child  
#20 bare copper wire, about 6 inches per child  
small square magnets, 1 per child  
1.5 Volt, D-cell battery, 1 per child  
masking tape

Lesson 3 contains more exercises than can be accomplished in a single meeting. You may skip some exercises and/or present the "Motor Works" as a separate lesson. Children are quite impressed with the motors, and ideally you will make time for them to each build a motor and keep it.

Before handing out project materials, discuss the concept of magnetic fields—invisible fields of force exerted by a magnet. Explain that scientists have discovered that whenever electric current is flowing, a magnetic field is generated.

Review again social skills necessary for successful cooperative learning. Perhaps you would like to pass out participation "tickets" to help the students track their group behavior skills.

Let the youth divide up into their working groups. Distribute materials and give them a few minutes to complete the first exercise with magnets and iron filings. After all groups have had an opportunity to “see” the lines of force about the bar magnets, explain that a magnet is said to have two poles, called north and south. Explain that the earth also acts like a huge magnet with north and south poles. The magnetic field around the earth is what attracts the needle in a compass and makes it point in a north-south direction.

If time permits, let the children make the mariner’s compass. Before they start, tell them that the lesson describes using a piece of cork to float the needle, but that you plan to use styrofoam.

If the students do not make compasses, distribute a compass to each group. Let them play with the compass and magnet and observe that the magnetic field generated by a magnet near the compass is stronger than the earth’s magnetic field. By using the magnet, they can make the compass needle point in any direction they choose.

Next remind the children that a magnetic field always exists around electric current. To demonstrate this, have each group make a coil of two or three loops of wire and place a compass inside the loop so that the needle is free to move. When the ends of the wire coil are connected to a battery (so that electric current is present), the needle on the compass will point in a direction perpendicular to the wire. If one end of the coil is held against the battery terminal and the other end is tapped on the other battery terminal so that the current flow alternates on and off, the compass needle can be made to spin.

After this exercise let one of the children summarize what their group has learned.

Now pass out nails and metal paper clips and let the groups construct an electromagnet.

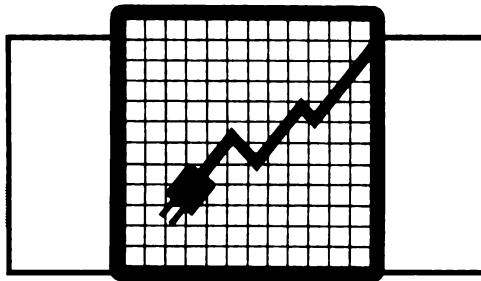
## **Motor Works**

This simple motor demonstrates the relationship between electric current and magnetism. It also demonstrates one of the many ways that we put electricity to work for us. You may want to spend an entire meeting building the motor. Before passing out the project materials, remind everyone that an electric current produces a magnetic field.

To construct the rotor, wrap the enamel-coated wire around two finders, leaving a one-and-one-half inch tail on each end. Next wrap the tail around the coil. Scrape **all** the enamel coating off one tail. On the second tail, scrape the enamel coating off **one side** in a horizontal plane (see the lesson plan). **Please note:** The lesson plan suggests using the blade from a pair of scissors to scrape off the enamel coating. However, sandpaper works equally well and is easier to handle. Next fashion the supports, and put the motor together.

### **Note:**

If the rotor does not spin, the most common problem is that too much enamel remains on the end where “half” was removed. Remove a generous half (perhaps more like two-thirds). Another common problem is that the supports are not making contact with the battery terminals.



## **Junior 4-H Electric Energy Curriculum Lesson 3 - Electricity and Magnetism**

*Lori S. Marsh and Henry J. Sullivan\**

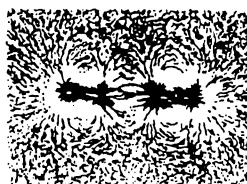
As early as the 1400's, it was observed that certain fragments of iron ore, called lodestones, would attract other pieces of iron. During the Middle Ages, this attraction was considered magic. The beginnings of a scientific understanding of magnetism are attributed to William Gilbert, who published a book in 1600, summarizing the experimental facts then known.

In 1820, Hans Christian Oersted observed that an electric current could exert a force on iron: that is, that an electric current produces a magnetic field. This exciting relationship between electricity and magnetism is used to turn electric motors and to generate electricity.

Now let's try some experiments to explore magnetic fields.

### **Magnets**

Place two bar magnets on a piece of cardboard end to end so they attract each other (opposite poles facing). Separate the magnets about one-fourth inch and tape them down to the cardboard. Next cover the magnets with a piece of paper and sprinkle the paper with iron filings. Draw what you see.



Now reverse one of the magnets so that they are repelling each other (like poles facing) and again tape

them about one-fourth inch apart. Cover with paper and sprinkle with iron filings. Draw what you see.



**Discussion.** Magnetic fields are invisible lines of force that exist near magnets. A magnet is said to have two poles, a north and a south, and the magnetic field is described as invisible lines of force that come out of the north pole and enter the south pole. The pattern formed by iron filings sprinkled over a bar magnet allows visualization of the magnetic fields. The pattern shows that the lines of force are heavily concentrated at the N and S poles of the magnet and then spread out into the air between the poles. The attractive force is equal at each pole. Note that the force of attraction on the iron filings is greatest where the concentration of magnetic lines is greatest. For a bar magnet this is at the poles.

The earth acts like a huge magnet with North and South poles. The needle of a compass is a magnet that is attracted to the earth's magnet poles. Try this demonstration:

### **Mariner's Compass**

Hold the needle at one end between your pointer finger and thumb and stroke it 20 times **in the same**

\*Extension Agricultural Engineer, Virginia Tech; Programs Manager, Appalachian Power Company, Roanoke, VA, respectively

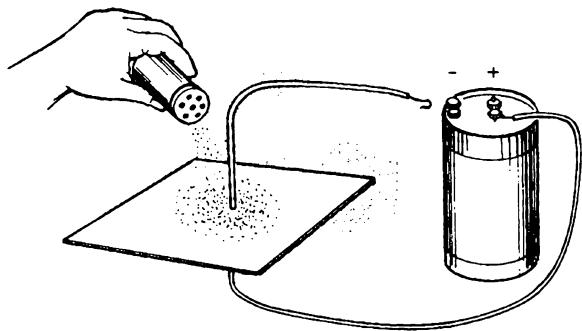
**direction** on one end of a magnet. This will magnetize the needle. Do not rub the needle back and forth. The adult leader should make a slit in a piece of cork. Next place the needle into the groove in the piece of cork so that it lies horizontally. Place the cork in a bowl of water and watch as the needle points in a north-south direction.

If you place the bar magnet near the needle what happens? Why?

**Answer:** *The needle is attracted by the magnet because the bar magnet's magnetic force is stronger than the earth's magnet pull when the bar magnet is close to the needle.*

We said before that electric current creates an electric field. Let's try some experiments to demonstrate this.

1. Scrape about an inch of insulation off each end of a piece of wire. Push the length of wire through a piece of paper. Connect the wire to a dry cell. Sprinkle iron filings around the wire. Draw what you see.



2. Make a coil of insulated wire by wrapping wire around your fingers. Attach one end of the wire to a dry cell. Hold a compass inside the wire loop in such a way that the compass needle is free to move. Tap the free end of the wire coil on the other end of the dry cell. Discuss what you see.

**Answer:** *By tapping the end of the coil of wire on the battery terminal the current alternates between flowing through the wire (when the wire makes contact with both battery terminals) and not flowing through the wire (when one end is disconnected from the battery). When the current is flowing, a magnetic force field is present and the needle will turn into the lines of force (perpendicular to the coil of wire). When*

*the current stops flowing, the needle will continue to move for an instant. (It continues to move because of its momentum.) If the current, and therefore the magnetic force field, resumes quickly, the needle will again turn to line up with the force field. In this way, by tapping one end of the coil of wire on the battery terminal and maintaining contact with the other end of the coil on the other battery terminal, the compass needle can be made to spin.*

*You might mention that engineers and scientists used an instrument called a galvanometer to detect small electric currents. A galvanometer works much like the coil of wire, battery, and compass. It is based on the idea that an electrical current always produces a magnetic field.*

## An Electromagnet

Scrape about one inch of insulation off each end of a 4-foot piece of insulated copper wire. Wrap the wire around a 3-inch or bigger nail, leaving several inches of wire free at both ends. Attach the ends of the coil to the terminals of a dry cell. Now try to pick up paper clips or tacks with the nail. What happens? Remove one end of the coiled wire from the battery and try to pick up the paper clips. What happens? Why?

**Answer:** *When both ends of the wire are connected to a battery, electric current flows through the wire and a magnetic field is created. The magnetic field is concentrated by the nail. When you remove one end of the coil from the battery, the electric current is no longer present, so the magnetic field is not present. Therefore, the nail no longer works like a magnet.*

**Discussion.** As you saw, electricity and magnetism are not two separate phenomenon. In fact, whenever electricity flows, a magnetic field is present. The magnetic field around a straight wire is very weak. By wrapping the wire in a coil, stronger magnetic fields are produced. The needle on the compass moved when you placed it in the coiled wire and completed a circuit with the dry cell. By tapping the wire on the dry cell, you turned the magnetic field on and off and should have been able to make the needle on the compass spin.

A wire wrapped in a spiraling loop is known as a solenoid. By forming a solenoid, the force of the magnetic field is increased without increasing the current. Placing an iron core (such as a nail) within the spiraling wire increases the magnetic field even more because the electrons within the iron core align themselves with the magnetic field produced by the current. The electromagnet you made is an example of an iron-core solenoid.

## Motor Works

The relationship between electricity and magnetism can be used to make a motor. Let's try.

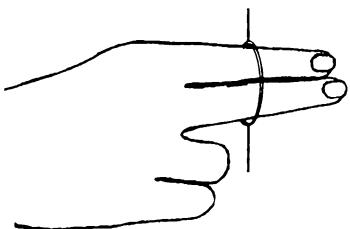
### Roles:

#### Inspector

Inspect assemblies for accuracy. Help the group problem-solve.

#### Rotorer

Construct the rotor as illustrated. Wind the coated wire around two fingers several times to make a loop.



Wrap the ends around the opposite sides of the coil as shown.

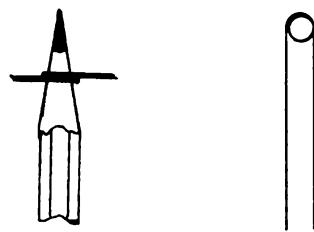


Scrape all of the coating from one end of the coil and only one-half the coating (horizontally) from the other end.



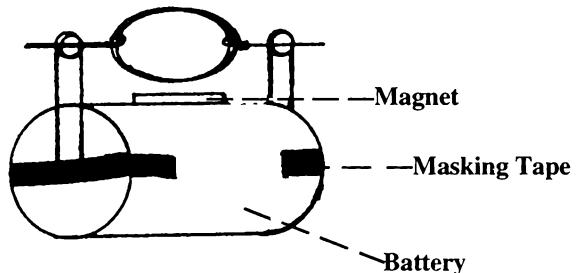
### Supporter

Fashion two support pieces as shown. Make the loop at the top by wrapping the wire around the tip of a pencil.



### Motorer

Assemble the motor and adjust to make it run. If the rotor doesn't spin, try scraping more of the coating off the end that has half the coating remaining.



### Conclusions:

Motor Works

How many magnets are in this motor?

*Answer: Two. One is a permanent magnet and the other is an electromagnet that is turned on when the scraped side of the coil touches the supports from the battery terminals so that current electricity flows.*

Why did you scrape only one-half of the insulation from one side of the coil?

*Answer: Leaving the insulation on one-half of one side of the coil causes the electromagnet to "turn off" when the insulation touches the support from the battery terminal.*

Why does the motor turn?

*Answer: The motor turns for the same reason the needle in the compass turned when you tapped one end of the coiled wire on the battery terminal. Let's trace the process:*

**(Answer continued)**

*When the scraped side of the rotor is down (remember that one side is completely scraped and therefore always in contact with the battery terminal), both ends of the rotor are in electrical contact with the battery terminals and an electric current flows. The electric current causes a magnetic field to be present around the rotor. The magnetic field associated with the rotor is attracted to the opposite pole of the permanent magnet. This causes the rotor to flip over. When it flips over, the insulation present on the rotor (the half you didn't scrape) prevents electricity from flowing, so there is no longer a magnetic field present to be attracted to the permanent magnet. However, once the rotor is set in motion, it has enough momentum to continue spinning long enough for the scraped portion*

*of the rotor to contact the support from the battery to re-establish the magnetic field and the entire process begins again.*

Where is the switch in this motor?

**Answer:** *It doesn't have one. To turn it off, you must remove the rotor.*

How can you make the rotor spin in the opposite direction?

**Answer:** *Turn the permanent magnet over. This will reverse the poles on the permanent magnet and reverse the direction of attraction with the magnetic field of the electromagnet.*

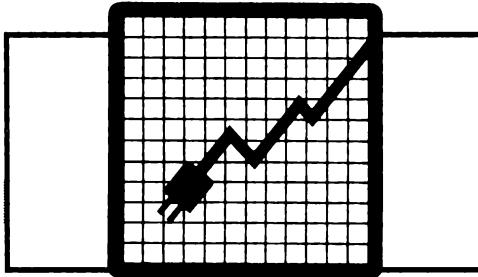
## **UNIT 2: APPLIED ELECTRICITY**

### **Lesson 4 - Electrical Safety**

#### **Materials required:**

copies of the lesson plan for each student.

Electrical safety cannot be over stressed. Prior to this lesson you might want to contact your electric power supplier to see if they could provide a speaker or a video or slide set to emphasize electrical safety. Youth who attend 4-H summer camp may have seen a high-voltage-line safety demonstration. If so, you might ask them to describe what they saw. You might want to distribute the safety lesson handout at a meeting prior to the safety discussion, so that students can conduct the safety audit in their home and report back the results.



## **Junior 4-H Electric Energy Curriculum**

### **Lesson 4 - Electrical Safety**

*Lori S. Marsh and Henry J. Sullivan\**

Now that you have experienced some of the amazing properties of electricity and magnetism, we will explore the ways that we use electricity every day. However, before we go any further, we must discuss **Electric Safety**.

When used properly, electricity is a safe and convenient form of energy. However, when used carelessly, electricity can cause fires, serious injuries, and even death. Based upon what we learned from building circuits, let's think about ways electrical accidents happen.

Remember, for electricity to flow, there must be a complete circuit or path for the electrons to follow. Wiring in your home and cords on appliances provide the necessary path for electricity. However, if the insulation on the wires becomes frayed or broken and touches another object, a new, **unintended** path for the electricity can occur. This new path is called a short circuit. If too much current flows through the circuit, the wires will heat up and a fire could result. If a person accidentally provides a path for electricity, he/she could be severely burned or even killed if the electricity shocks the heart and causes it to stop beating.

Houses are wired with fuses or circuit breakers to guard against too much current flowing. However, these safety measures are not adequate to protect humans or animals. Additional protection, called ground fault circuit interrupters (or GFCI's for short), is needed to protect living things against shocks. We will discuss these safety devices in

detail when we study Home Wiring.

Let's conduct a Home Electrical Safety Check.

1. Look for frayed cords on electrical appliances, especially near the plug. Show all damaged cords to your parents. Make sure cords are not placed where people can trip over them or where they receive excessive wear. When you've checked all the cords in your house put a  in the Cords column. Remember-**Never touch bare wires from a damaged cord while the cord is plugged in!!!**
2. If there are small children in the house, unused outlets should be covered. This prevents children from poking objects in the outlet and becoming a path for electricity. After you have covered unused outlets, put a check in the Outlet column.
3. Never leave light sockets open. If a bulb burns out, do not remove it until you have a new bulb to replace it. A finger in an open light socket makes you a path for electricity! **Always turn off or unplug a lamp before changing a light bulb.** After you have checked all the lamps to make sure there are no open sockets, put a check in the Light Socket column.
4. Electricity and water make a deadly combination. Do not leave electrical devices plugged in near sinks or tubs. People can be electrocuted if they are sitting in a tub and a hair dryer falls in, even if the dryer is turned off. Do not use an electrical

\*Extension Agricultural Engineer, Virginia Tech; Programs Manager, Appalachian Power Company, Roanoke, VA, respectively

appliance if you are wet or standing in water. GFIC's should be placed on every outlet that is near a source of water or outdoors. After checking for appliances located near water and discussing the problem with your parents, put a check in the Water Safety column.

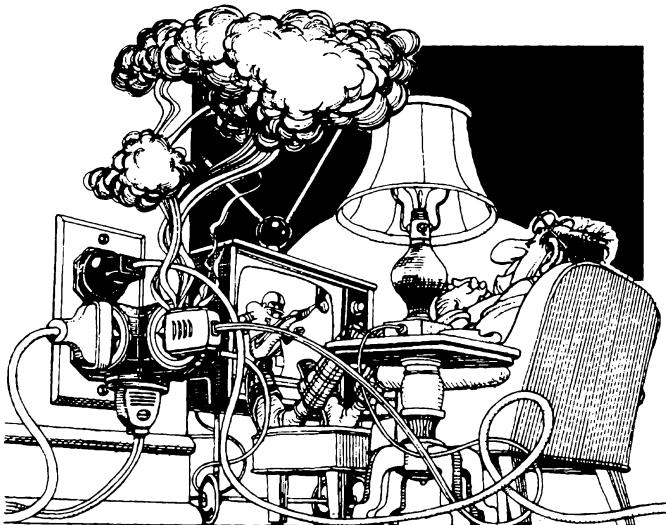
## Electrical Safety Checklists

| <b>Electrical Appliances</b> | <b>Cord Not Frayed</b> |
|------------------------------|------------------------|
| Television                   |                        |
| Radio                        |                        |
| VCR                          |                        |
| Microwave                    |                        |
| Iron                         |                        |
| Vacuum Cleaner               |                        |
| Toaster                      |                        |
| Lamps                        |                        |
| Hairdryer                    |                        |
| Computer                     |                        |
| Clocks                       |                        |
| Others                       |                        |

| <b>Room</b>   | <b>Outlet Covered</b> | <b>Light Sockets Not Empty</b> |
|---------------|-----------------------|--------------------------------|
| Bedroom No. 1 |                       |                                |
| Bedroom No. 2 |                       |                                |
| Bedroom No. 3 |                       |                                |
| Bedroom No. 4 |                       |                                |
| Living Room   |                       |                                |
| Family Room   |                       |                                |
| Bathrooms     |                       |                                |
| Kitchen       |                       |                                |
| Den/Study     |                       |                                |
| Other         |                       |                                |

Here are some more safety tips to help you avoid an electrical accident:

1. Keep combustible materials away from lamps or heating appliances.
2. Stay away from power lines! When using a ladder, or erecting an antenna, make sure that you stay clear of all power lines. Never climb a tree that is touching power lines. Do not fly kites near power lines and **never** attempt to recover a kite caught in power lines. Never approach a power line that has broken—call your power company and tell them what has happened.
3. In case of electrical shock, do not touch the victim until the electricity is shut off. If the victim is in contact with power lines, the only safe procedure is to call the power company.



## Lesson 5 - Electrical Terms

### Materials required:

- a copy of the lesson for each child
- 30 index cards for each group

Before dividing into groups, review social skills for group learning. Explain that today they are to help each other learn electrical terms and prepare for an Energy Quiz game. Also explain that they will write the questions for the quiz game. Questions can be multiple choice, fill in the blank, or true/false. Give an example of an appropriate question. Next, divide the children into groups of four. Have each group write a set of questions, one question per index card. A “set” of questions should include at least one question about every term defined in Lesson 5.

After the questions are written, have the groups divide again into pairs. Each pair takes half the questions. Within each pair, one child plays the role of teacher and one the student. The “teacher” reads each question to the “student” and then reads the answer. They should discuss the answer and try to come up with “tricks” to remember the answer. After they have gone through all the questions, they switch roles and go through the cards again. Have the children go through the cards a second time, but this time the “teacher” reads the questions and the “student” answers, with some prompting from the “teacher” if needed. If the “student” answers correctly, he “wins” the card and receives lots of praise from the “teacher.” The questioning continues until all cards are “won.” Then the roles are reversed. Finally, each pair should exchange cards with the other pair in their group and the entire study process repeated.

After everyone has studied all the cards, collect and shuffle them. Select two teams and conduct an “Energy Bowl.” You can add a new twist by playing “Jeopardy”—you read an answer and the players must phrase a question. To assure individual accountability, you can structure the game so that each participant gets an individual question (that only he/she may answer) followed by a toss-up question addressed to the teams at large. Before starting, decide on the end point, either after a set amount of time (say 10 minutes) or when one team has answered 10 questions correctly. You might wish to repeat the Energy Bowl at a later meeting and award prizes to the winning teams.

### Note:

At first glance, the concept of an Energy Bowl might seem to go against the philosophy of cooperative learning. This is not so! The idea is for cooperation to occur within the team. If the team members understand that the success of the group requires that all members of the group learn the terms, then they will be motivated to help each other master the terms. A common goal for the team is one way to achieve the sense of interdependency that is necessary for cooperative learning.

Before the meeting ends, ask if any of the children have calculators that they could bring to the next meeting.



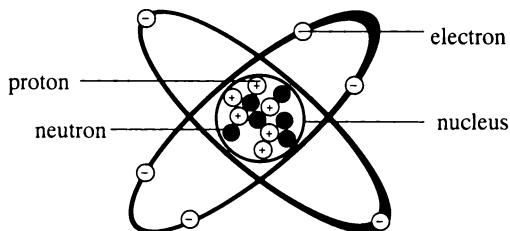
## **Junior 4-H Electric Energy Curriculum**

### **Lesson 5 - Electric Terms**

*Lori S. Marsh\**

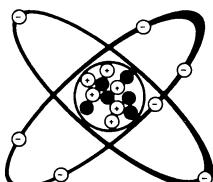
There are many terms used to describe electricity. Learning these terms will prepare you to discuss how electricity works for you. You have already seen several of these terms but there will probably be several that are new to you. Discuss these terms with your partners and quiz each other until you all know them. Then you'll be ready to win an **Energy Quiz Bowl!**

**Electron:** A negatively charged particle that is part of an atom.

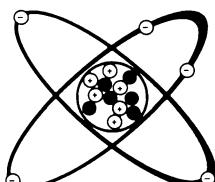


**Free electrons:** Electrons that are not associated with an atom. In other words, an electron that has been "knocked" out of its shell in an atom.

**Ion:** An atom that has lost or gained an electron. If an atom loses one or more electrons, it has a positive charge and is called a cation. If an atom gains one or more electrons, it has a negative charge and is called an anion.



Negative Ion—anion



Positive Ion—cation

**Current electricity:** The flow of electrons through a conductor.

**Static electricity:** Free electrons not in motion. Static means not moving.

**Alternating current (also called a.c.):** a flow of free electrons that reverses its direction at regular intervals.

**Direct current (also called d.c.):** electrons flowing in one direction in a circuit.

**Resistance:** the opposition to the flow of electric current.

**Conductor:** A material that allows electrons to flow with little resistance.

**Insulator:** A material that provides a high resistance to the flow of electrons.

**Ampere (called amp for short):** A unit of measure for electric current.  $6,200,000,000,000,000,000$  ( $6.2 \times 10^{18}$ ) electrons passing a point in one second equals one ampere.

**Ohm:** A unit of measure of electrical resistance. One volt will force a current of one amp through a resistance of one Ohm.

**Volt:** A unit of measure of the potential force to push electrons in a circuit. One volt will cause one amp of electricity to flow in a circuit with a resistance of one Ohm.

\*Extension Agricultural Engineer, Virginia Tech

**Watt:** A unit of measure of power or the rate at which work is done.

**Kilowatt:** One thousand watts make a kilowatt. Kilo means 1000.

**Kilowatt-hour:** a unit of measure of energy. When one kilowatt is used steadily for one hour one kilowatt hour of energy is used.

**Electric meter:** A device used to measure electric energy consumption in kilowatt-hours. Every home has an electric meter that the power company reads each month. That is how the power company determines how much electricity was used and how much to charge for the energy.

**UL:** UL stands for Underwriters Laboratories, Inc. UL tests appliances to determine if they are reasonably safe from fire, shock, or other safety hazards when used as directed. There is no law that requires manufacturers to have their equipment tested by UL, but it helps assure you of a safer product when you see the UL\* Mark.



\*Courtesy of  
Underwriters  
Laboratories, Inc.

**Nameplate:** The area on an electrical appliance that contains information describing its voltage and current requirements.

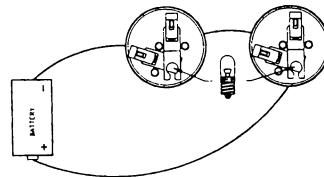
**Generator:** A device that produces an electric current. Generators use falling water, wind, or steam to spin a turbine that turns a coil of wire in the presence of a magnetic field.

**Circuit:** A path through which electric current may flow.

**Open circuit:** A circuit with an incomplete path through which electric current cannot flow; an incomplete circuit.

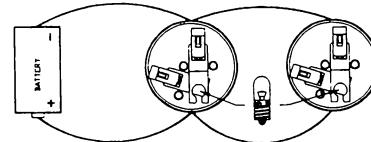
**Series circuit:** a circuit in which all the current flowing passes through every element without branching. If two light bulbs are wired in series and one bulb is removed, the other bulb will not light because the missing bulb has caused an open circuit.

An example of a Series circuit:



**Parallel circuit:** A circuit in which the current branches. If two light bulbs are wired in parallel and one is removed, the other will continue to light.

An example of a Parallel circuit:



**Turbine:** a motor that has its shaft rotated by a stream of water, steam, air, or other fluid forced against the blades of a wheel.

**Transformer:** a device that can increase or decrease the voltage of alternating current.

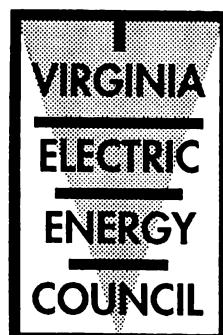
**Electric Transmission System:** All the equipment required to get electricity from the point where it is generated to a substation.

**Transmission lines:** wires or cables that carry high voltage electricity to substations, often for great distances.

**Substation:** an electric power station that serves as a control and transfer point from transmission to distribution in an electric system.

**Electrical distribution system:** All the electrical equipment required to get electricity from substations to the points where it is used.

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Central Virginia Electric Cooperative  
City of Danville  
Community Electric Cooperative  
Craig-Botetourt Electric Cooperative  
Delmarva Power  
Mecklenburg Electric Cooperative  
Northern Neck Electric Cooperative  
Northern Virginia Electric Cooperative  
Old Dominion Power Company  
Potomac Edison Company  
Powell Valley Electric Cooperative  
Prince George Electric Cooperative  
Rappahannock Electric Cooperative  
Shenandoah Valley Electric Cooperative  
Southside Electric Cooperative  
Virginia Power

## **Lesson 6 - Reading an Electric Bill**

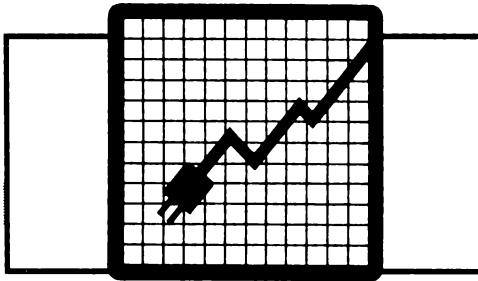
### **Materials required:**

- a copy of the lesson plan for each child
- a calculator for each group
- an electric bill

Before dividing into groups, discuss how to read an electric meter. Like all things, it's not hard once you know how. The easiest way to read the meter is from right to left, recording the answer from right to left. Notice that the numbers on the face of the first dial (on the far right) increase in a clock-wise direction, while the numbers on the second dial from the right increase as you go counter clockwise. If the pointer is between two numbers, always read the smaller number. If you aren't sure if one dial has reached a number yet or not, look at the dial to the right of the one in question. If it is pointing to a large number, say eight or nine, then the dial in question has not yet reached the number and you should record the smaller number. In other words, when the dial on the far right makes one complete revolution, the second dial from the right will have advanced to the one. If the dial on the right has not quite made a full revolution, but is on the nine, then the second dial from the right will be almost (but not quite) to the one.

Divide the children into working groups and have them complete the exercises in the lesson plan. Encourage them to take the lesson plan home and complete the log of electric meter readings for their house. Discuss with the students why the amount of electricity used will change from week to week. Possible reasons include: changes in weather that require more or less heating/air conditioning; changes in hot water consumption (assuming they heat water electrically) due to more/less people in the house; more/less cooking; more/less time spent at home (due to holidays, etc.).

Before dismissing the youth, ask them to bring their calculators again for the next meeting.



## **Junior 4-H Electric Energy Curriculum**

### **Lesson 6 - Reading an Electric Bill**

*Lori S. Marsh\**

Electric utilities and electric cooperatives sell electric energy, measured in kilowatt-hours. The amount that the utility charges is usually determined by state public utility commissions. The cost of the kilowatt-hour is determined by several factors including the cost of fuel used to generate electricity; the wages paid to employees; the cost of all equipment required to provide electricity; the cost of maintenance; and the cost of money to buy equipment or construct power plants. Regulations allow the investor-owned utilities to charge customers enough to recover costs and to earn a profit for their investors—stockholders. Electric Cooperatives, which are not-for-profit organizations, are a little different. Again the public utility commission determines how much money the cooperative needs to charge to recover all their costs, but any excess monies are returned to the customers who are members of the electric cooperative.

The cost of electricity varies from one electric utility or electric cooperative to another. Also, some power suppliers charge more for electricity during one season, such as summer, than during other seasons.

You can determine what your family pays for each kilowatt hour by looking at your electric bill. Divide the dollar amount of the bill by the total number of kilowatt-hours used and the result will be your family's electric cost in \$/kilowatt-hour. For most families in Virginia, the cost will be between \$0.05 and \$0.09 per kilowatt-hour (that is, 5 to 9 cents per kilowatt-hour).

The power company knows how much electrical

energy your family uses each month by reading your electric meter. Let's learn how to read an electric meter. The face of the meter has five dials with the numbers 0 through 9 on each dial. The order of the numbers and the direction that the pointer moves alternates from dial to dial. See how on the first dial the numbers get larger in the clock-wise direction but on the second dial the numbers get larger in the counter-clockwise direction? To read the meter, you read each dial from right to left and write the numbers down from right to left. Remember, that's backwards from the way we usually read and write! If the pointer is between two numbers, you always record the smaller number. Here are two examples:

On March 1st my electric meter looked like this:



On April 1st my electric meter looked like this:



How much electricity did I use in March? To answer that I subtract the reading on March 1 from the reading on April 1:

$$12500 - 11400 = 1100 \text{ kilowatt-hours.}$$

My electric bill for March was \$62.00. So I paid  $\$62/1100 = \$0.056$  for each kilowatt-hour of electricity.

\*Extension Agricultural Engineer, Virginia Tech

If my meter looks like this on May 1:



How much will my electric bill be? Here's how to figure out how many kilowatt-hours I used and what the cost will be:

**Step one:** Write down the meter reading for May 1:

13453

**Step two:** Write down the meter reading for April 1:  
**12500**

**Step three:** Subtract to find the difference in the two readings. This is the kilowatt- hours used.

**953 kWh**

**Step four:** Multiply the result from step three by the cost of electricity in dollars (.056 in this example).

**953 kWh x \$0.056/kWh = \$53.37**

Now try these:

- If the Smith family's meter looks like this at the start of the month:



and like this at the end of the month:



and electricity costs \$0.05 per kilowatt-hour, what will their electric bill be?

**(96401 kWh - 95392 kWh) x \$0.05/kWh = \$50.45**

- If the Jones' meter looks like this at the start of the month:



and like this at the end of the month:



and electricity costs \$0.05 per kilowatt-hour, what will their electric bill be?

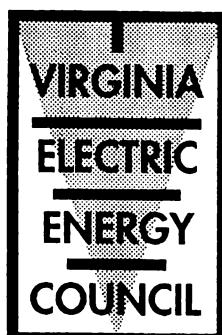
**(27591 kWh - 26371 kWh) x \$0.05/kWh = \$61.00**

Try reading your electric meter at home and keeping a record of the electricity your family uses. Take the reading once a week at about the same time each week. Perhaps Saturday morning would be a good time. Does your family use the same amount of electric energy every week? Can you suggest some reasons why the amount used might be different from week to week?

## Log of Electric Meter Readings

\*Subtract today's reading from last week's reading to get the electricity used in kilowatt-hours.

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Delmarva Power  
Mecklenburg Electric Cooperative  
Northern Neck Electric Cooperative  
Northern Virginia Electric Cooperative  
Old Dominion Power Company  
Potomac Edison Company  
Powell Valley Electric Cooperative  
Prince George Electric Cooperative  
Rappahannock Electric Cooperative  
Shenandoah Valley Electric Cooperative  
Southside Electric Cooperative  
Virginia Power

## **Lesson 7 - What's on a Nameplate?**

### **Materials required:**

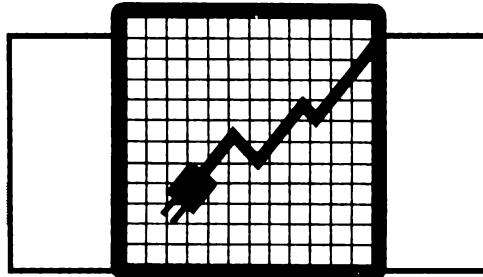
- a copy of the lesson for each child
- several electrical appliances with accessible nameplates
- one calculator per group

Discuss the concept of a nameplate with the students. Also review the terms *wattage*, *voltage*, *current*, and *Underwriters Laboratories*. Let the youth get into their working groups to complete the exercises in the lesson. Small appliances can be passed from group to group. After they have completed this task have them plan a brief presentation of their results. Encourage them to be creative and present things like:

- 1) how much it costs to watch a popular TV show;
- 2) how much it costs to operate a lamp to read a book; or
- 3) how much it costs to cook a waffle.

Make sure each group explains assumptions such as how long the TV show lasts, the wattage of the light bulb, how long it takes to read a book, how long the waffle iron must operate to cook a waffle, etc.

Before dismissing the children, distribute copies of Lesson 8. Suggest that they read the lesson and ask their parent to show them their home's electric system.



## **Junior 4-H Electric Energy Curriculum**

### **Lesson 7 - What's on a Nameplate?**

*Lori S. Marsh\**

Every electric appliance sold in America has a nameplate on it that provides information about the appliance. The information generally includes the voltage required and the wattage. Sometimes, the amount of current the appliance draws will also be listed.

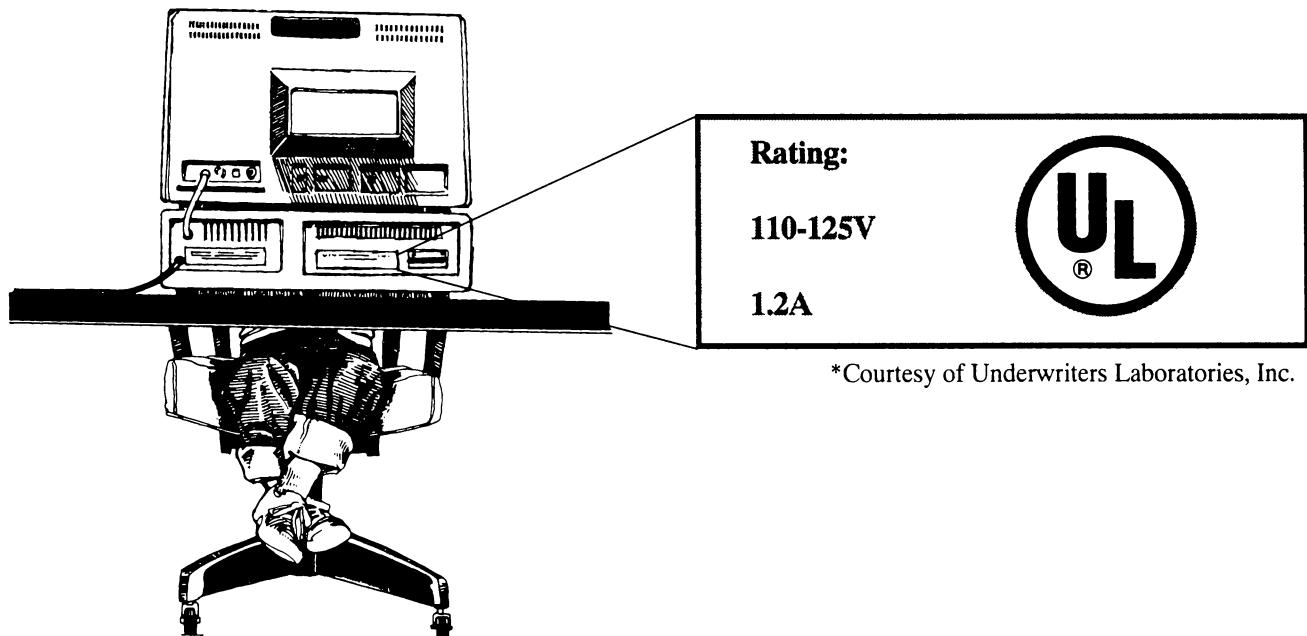
Often you will find the letters "UL" on the nameplate. UL stands for Underwriters Laboratories, Inc., which is an independent, not-for-profit organization that conducts investigations on more than 14,000 different product types. The UL Mark on a product means that samples of the product have been tested to recognized safety standards and found to be reasonably free from fire,

electric shock, and related safety problems. Testing by Underwriters Laboratories is voluntary; it is not required by law. However, the UL mark on products means that samples of the products have been tested and been found to meet nationally recognized safety standards.

Find three appliances and record the information located on the nameplate. One example is provided.

If you only found the voltage and wattage listed on the nameplate, calculate the current (amperage) by dividing the wattage by the voltage. That is:

$$\text{current} = \frac{\text{wattage}}{\text{voltage}}$$



\*Courtesy of Underwriters Laboratories, Inc.

\*Extension Agricultural Engineer, Virginia Tech

| Appliance Type         | Voltage<br>(volts) | Wattage<br>(watts) | Amperage<br>(amps) | UL<br>(y/n) | Cost to<br>run 1 hr (\$) |
|------------------------|--------------------|--------------------|--------------------|-------------|--------------------------|
| Hot-air popcorn popper | 120                | 1440               | 12.0               | y           | \$0.079                  |
|                        |                    |                    |                    |             |                          |
|                        |                    |                    |                    |             |                          |
|                        |                    |                    |                    |             |                          |
|                        |                    |                    |                    |             |                          |
|                        |                    |                    |                    |             |                          |

Using the information on the nameplate and the cost of electricity that you determined from an electric bill, it is possible to determine how much it costs to operate the appliance. To figure out how much it costs to run an appliance for one hour, you divide the wattage by 1000 to get kilowatts and then multiply times one hour (to get kilowatt-hours) and then multiply by the cost of electricity. For example, if my electricity costs \$0.055/kilowatt-hour and I make a batch of popcorn in my hot-air popper (it takes about three minutes to pop a batch) it will cost me:

1440 watts x 1 kilowatt/1000 watts x 3 min x 1 hour/60 minutes x \$0.055/kilowatt-hour = \$0.0039 or less than one-half of a cent!



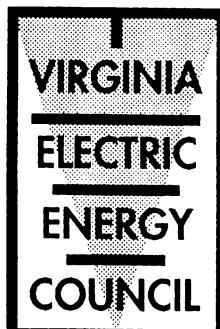
What does it cost to watch TV for an hour? To find out, you need to look at the nameplate on your television and see what its wattage is. The nameplate on my television reads 120 volts, 96 watts. Therefore it costs me (assuming electric costs of \$0.055) \$0.0053 or just over 1/2 cent to watch TV for an hour.

Calculate how much it would cost to run each of the appliances you listed for one hour. The longer an appliance operates, the more it costs. What do you think some of the big energy users in your home are?

The following table lists typical wattages of common household appliances and the number of kilowatt-hours each appliance typically consumes in a year. These numbers are typical but your family's actual usage could be quite different.

| Appliance               | Wattage<br>(watts) | Typical hours<br>of use in<br>a year | Typical<br>kilowatt-hours<br>used in a year |
|-------------------------|--------------------|--------------------------------------|---|
| Can opener              | 100                | 3.3                                  | 0.3   |
| Toaster                 | 1146               | 35                                   | 39  |
| TV                      | 96                 | 1500                                 | 144   |
| Oven*                   | 12,200             | 55                                   | 60  |
| Clothes washer*         | 512                | —                                    | 103   |
| Electric clothes dryer* | 4856               | 200                                  | 993   |
| Hot Water Heater*       | 4500               | 1100                                 | 4950  |
| Iron                    | 1100               | 55                                   | 60  |
| Refrigerator            | —                  | —                                    | 1500  |

We gratefully acknowledge the support of Virginia Electric Energy Council's ELECTRIC SERVICE ORGANIZATIONS



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## **Lesson 8 - Home Wiring**

### **Materials required:**

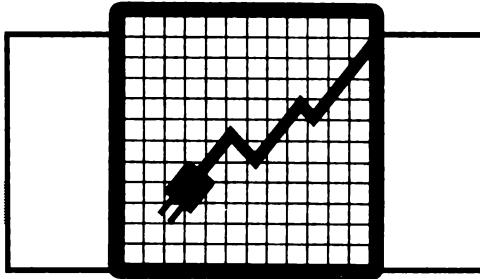
- a copy of the lesson plan for each child; and
- a calculator for each group.

This lesson is designed to reinforce basic concepts and to show how these concepts are applied to home wiring. Review the concepts of series and parallel wiring and ask if home wiring is in series or parallel. Explain that houses are wired in parallel so that turning off one appliance won't cause every other electrical device on the same circuit to go off.

Explain that home wiring consists of more than one circuit and that each circuit is called a branch circuit and has its own fuse or circuit breaker. The reason we need several circuits in a house is that there is a limit to how much electricity a wire can safely carry. Point out the chart on page 2 of Lesson 8, which shows how much electrical current various wire sizes can safely carry. Divide the youth into their working groups and ask them to determine if a 14 gauge wire would be large enough to safely operate a 1200 Watt dryer, three 100 Watt light bulbs, and a 500 Watt stereo. After a few minutes, ask for volunteers to demonstrate how a group arrived at its solution. [Remember—Wattage equals current in amps multiplied by the voltage in volts. Therefore, a 14 gauge wire, rated to carry 15 amps, can safely operate  $15 \text{ amps} \times 120 \text{ Volts} = 1800 \text{ Watts}$ .] You may want to pose several more example questions using data from Lesson 7. You can also pose questions of the form: how large must a wire be to safely operate \_\_\_\_\_? [A 3000 Watt appliance, for example. To answer questions of this form divide the Wattage by the operating voltage to arrive at the operating current. A 3000 Watt appliance, operating at 120 Volts, draws  $3000/120 = 25$  amps. From Table 1 we see that a 10 gauge wire would be required to carry a 3000 Watt load.]

Ask if anyone toured their home's electrical system. If so, ask them to describe the system. Do they have circuit breakers? Do they have overhead or underground electrical service? Do they have GFCI protection? If so, what kind? If possible, "tour" the electrical service entrance at the place where you are meeting. Find the service panel; look to see if it contains circuit breakers or fuses; point out the main disconnect; point out GFCI protection if it is present.

Before ending the meeting, suggest that anyone who hasn't looked at their home's electrical system, do so with the help of an adult. Suggest that they survey their bedroom's electrical system and sketch where each outlet, light, etc., is located.

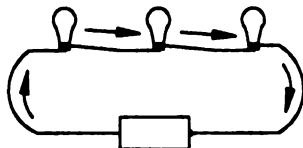


## **Junior 4-H Electric Energy Curriculum**

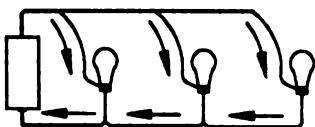
### **Lesson 8 - Home Wiring**

*Lori S. Marsh\**

In Lesson 2 we built electric circuits using light bulbs and dry cells. We saw that for electricity to flow and do useful work for us, it must have a complete path or circuit from its source to the point of use and back again. We learned that when several devices (we used light bulbs) are connected to a circuit they can be in parallel or series. When devices are in series, the current must travel through each one to get to the next. If a bulb burns out or is removed, all the lights in the series circuit go out.

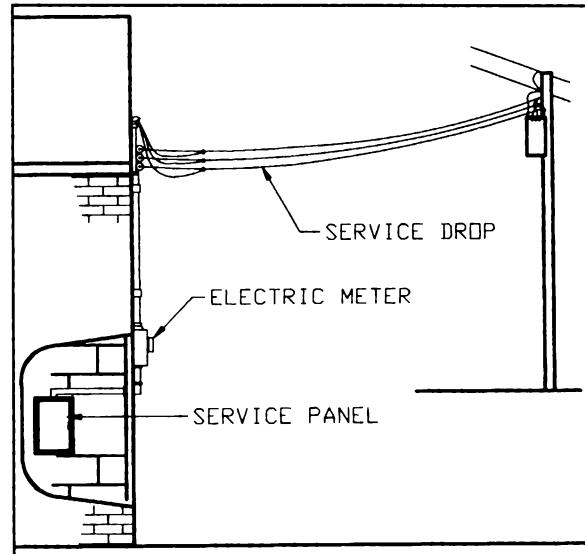


When lights are wired in parallel, the current splits and goes through each bulb separately. When a bulb is removed in a parallel circuit, the other bulbs in the circuit are not affected.



Each separate wire in your home is a parallel circuit. For example, all the outlets and lights in your bedroom and perhaps another room may be connected in parallel to one electrical circuit. All the lights and outlets in the living room may make up another parallel circuit. Large appliances, such as an electric hot water heater, may have their own circuit. In general, a house will have several parallel circuits for lights and outlets and several for large appliances. Each circuit is called a "branch" circuit.

Each branch circuit is connected in parallel to the main power supply entering the house. These main lines are called a "service drop" because the lines are usually dropped from a utility pole to service your home. Today many subdivisions use underground wiring so the "service drop" doesn't really drop at all!



In Lesson 6 you learned how to read an electric meter. The electric meter is connected to the service drop to record how much electricity is used. After traveling through the meter, the service wire goes to a service entrance panel. This panel contains a main breaker that can disconnect all the power to your house. You will also find either circuit breakers or, if you have an older home, fuses in the service entrance cabinet. Each branch circuit has its own circuit breaker or fuse. These circuit breakers or fuses are designed to protect your home from too much current that could cause a fire.

\*Extension Specialist, Agricultural Engineering, Virginia Tech

Why do we need branch circuits? Why can't we just use one big circuit for an entire house? The answer is that there is a limited amount of current that one wire can safely carry. The larger a wire the more current it can carry, but there is a practical limit to how big a wire can be.

Table 1 shows wire sizes commonly found in homes. Wire sizes are standardized according to a code called the American Wire Gauge (AWG) code. In this code wire sizes have numbers such as 12, 14, 16, etc. Wire gauges are always even. The larger the wire size, the smaller the gauge. The wire you used to build circuits with batteries and bulbs carried very little electricity and was very thin, probably a 20 or 22 gauge. The wire used on small appliances such as a lamp or electric toothbrush is probably a 16 or 18 gauge.

**Table 1.**

| Wire Size<br>(AWG) | Current Carrying Capacity<br>(Amps) at 70 F |
|--------------------|---|
| 14                 | 15  |
| 12                 | 20  |
| 10                 | 30  |
| 8                  | 45  |

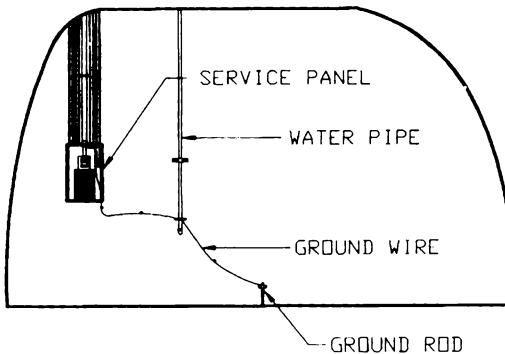
Table 1 also shows how much current a given wire size can safely carry. For example, a 14 gauge wire can safely carry 15 amps or  $15 \text{ amps} \times 120 \text{ volts} = 1800 \text{ watts}$ . Suppose your room is served on a branch circuit with 14 gauge wire. If you turn on two 100 watt light bulbs, a 12 watt radio and a 120 watt fan, you'll be using  $(100 \times 2 + 12 + 120) 332 \text{ watts}$ . A 14 gauge circuit would have no trouble with that load. But what happens if you also plug in a 600 watt room air conditioner, a 600 watt microwave oven, and a 1200 watt hair dryer all at the same time? Now you have 332 Watts from before plus another 2400 watts for a total of 2732 watts. Now you have an overload!

When a wire tries to carry too much current it heats up and could cause a fire. However, the circuit breaker or fuse in the service entrance panel is put there to prevent fires from occurring. The fuses are sized to "blow" and the circuit breakers to "trip" if too much current is flowing in the circuit. When this happens, the circuit opens (is no longer a complete path for electricity) and everything is turned off.

Before replacing the fuse or resetting the breaker, you have to turn something off; otherwise, it will just blow or trip again.

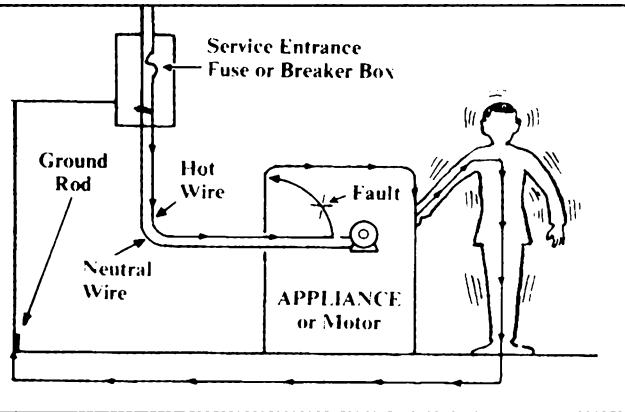
While circuit breakers or fuses protect your home and equipment from electrical overloads, they do not protect people or animals. It takes very little electrical current to seriously injure living things. A safe electrical system must be grounded. What is grounding?

Electricity flows from high to low voltage potential. The earth is at zero voltage potential, so electricity will always seek a path to ground. What does this mean? At the service entrance panel, two of the entering wires are at a high voltage (120 volts) and one is neutral or zero volts. The neutral wire is connected to a neutral terminal strip inside the panel and this strip is connected to the ground. To be well-grounded electrically, a wire from the neutral is connected to a metal water pipe that is buried in the ground. Metal water pipes are not the only way to achieve a good ground connection. A rod (or several rods) driven several feet into the ground can make an effective ground connection.



Now let's see how grounding helps prevent accidents. Every branch circuit in a house consists of three wires. One wire (usually black) is "hot," that is, it is 120 volts relative to ground. A second wire (usually white) is neutral. A third wire (either green or bare copper) serves as the ground wire. At the service entrance panel, both the neutral and ground wire are connected to the neutral terminal strip, which is connected to ground. When an appliance is working properly the high voltage line is always insulated from the appliance frame.

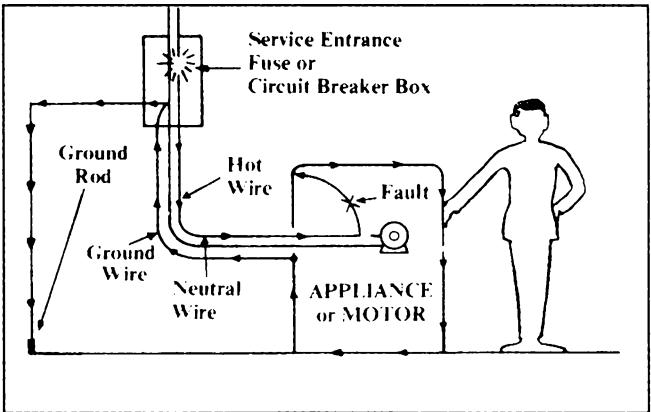
But if the insulation on a hot (120 volt) wire gets worn or damaged and touches the frame of an appliance, it becomes energized. If a person touches



**Ground Fault through a person. No grounding wire was present.**

the appliance frame they could become the path that electricity uses to reach the ground. When electricity has an unintended or accidental path to ground it is called a ground fault. There are two ways to help prevent people or animals from becoming a path for electricity. One way uses the ground wire. If the frame of the appliance is connected to the bare copper wire in the branch circuit, then if the frame should become energized, the electric current will take the easiest path (the grounding wire) back to ground instead of traveling through a person.

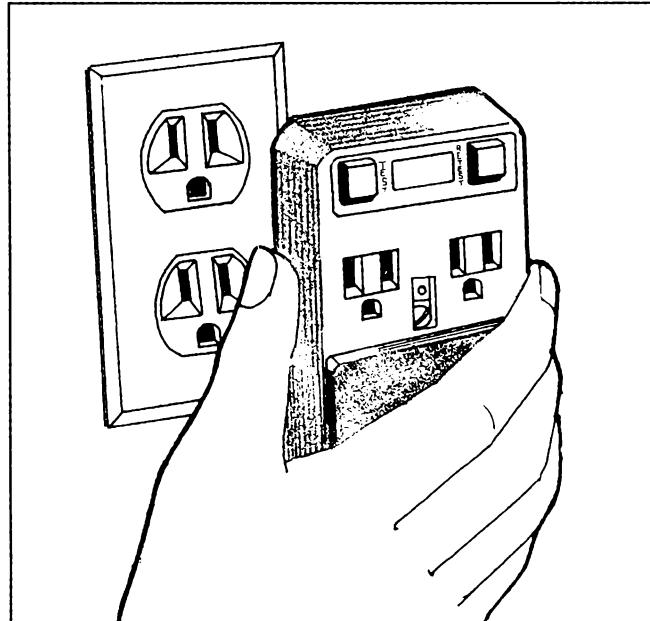
The best protection against ground faults is an electronic device called a ground fault circuit interrupter or GFCI for short. The GFCI checks to make sure that the current flowing into a circuit is



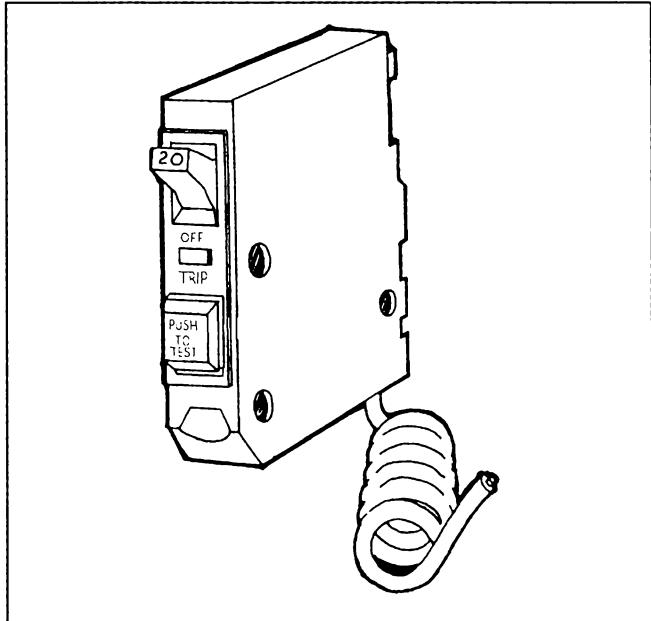
**Fault current takes the path of least resistance through the ground—not through a person.**

the same as the current flowing out of the circuit. If it's not the same, then some current is leaving the circuit by an unintended path! If this happens, the GFCI opens up, cutting off the current flow. Because the GFCI can detect very small current leakages, it can stop the current before it has a chance to seriously injure anyone.

There are three types of GFCI's. One type is located on the circuit breaker; another is located on the outlet receptacle; the third type is portable—it plugs in to any wall receptacle. Because water is a good conductor of electricity, many electrical accidents occur in bathrooms, kitchens, basements, and outdoors—places that are likely to be wet. These are the places where GFCI's should be located.



**Plug-in GFCI protection.**



**GFCI protection on a circuit breaker.**

# Your Home's Electrical System

Ask your mom or dad to show you the service entrance panel for your home or apartment. Record answers to the following questions:

- Do you have fuses or circuit breakers?

\_\_\_\_\_

- Do you have any GFCI protection?

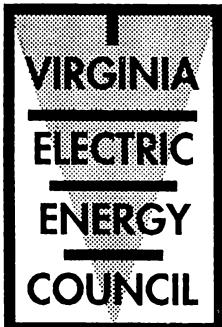
\_\_\_\_\_

- If you have GFCI's are they:

- a. GFCI breakers
- b. GFCI outlets
- c. Portable plug-in GFCI's

- Draw a "map" of your room and show where all the electric outlets, switches and light fixtures are located. A sheet of graph paper is provided for you to draw on. A map of my room is included to help get you started.

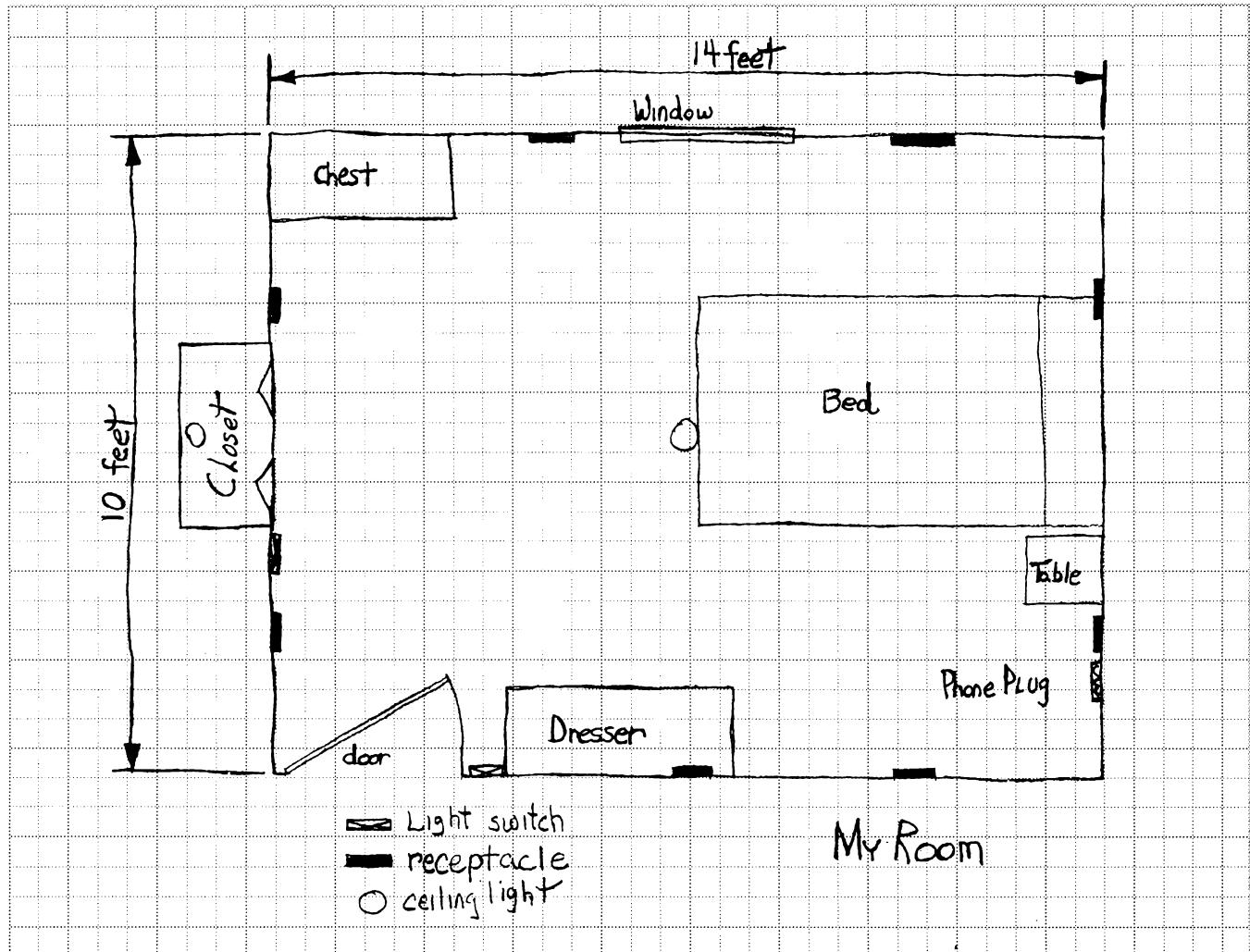
## Virginia Electric Energy Council's ELECTRIC SERVICE ORGANIZATIONS

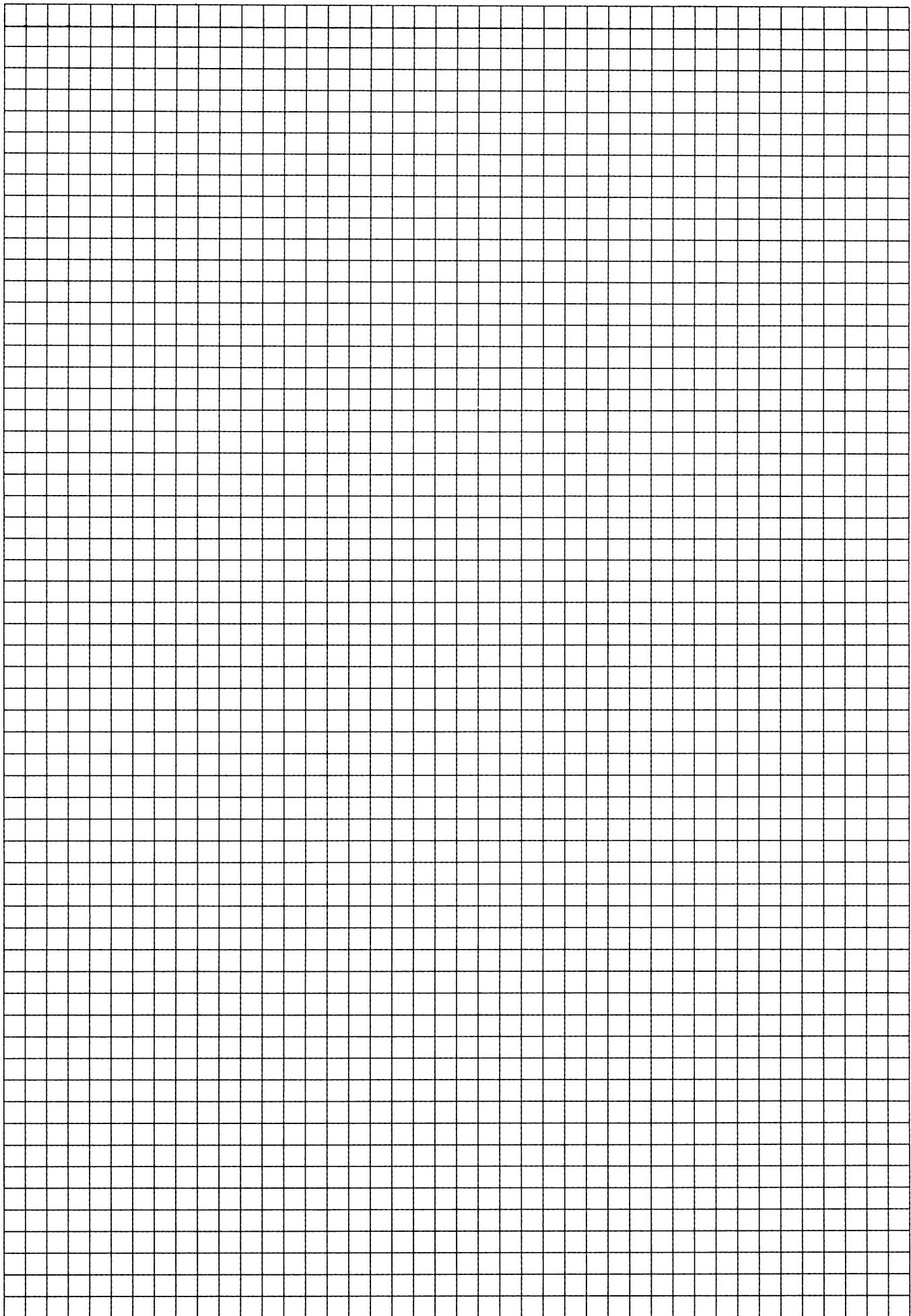


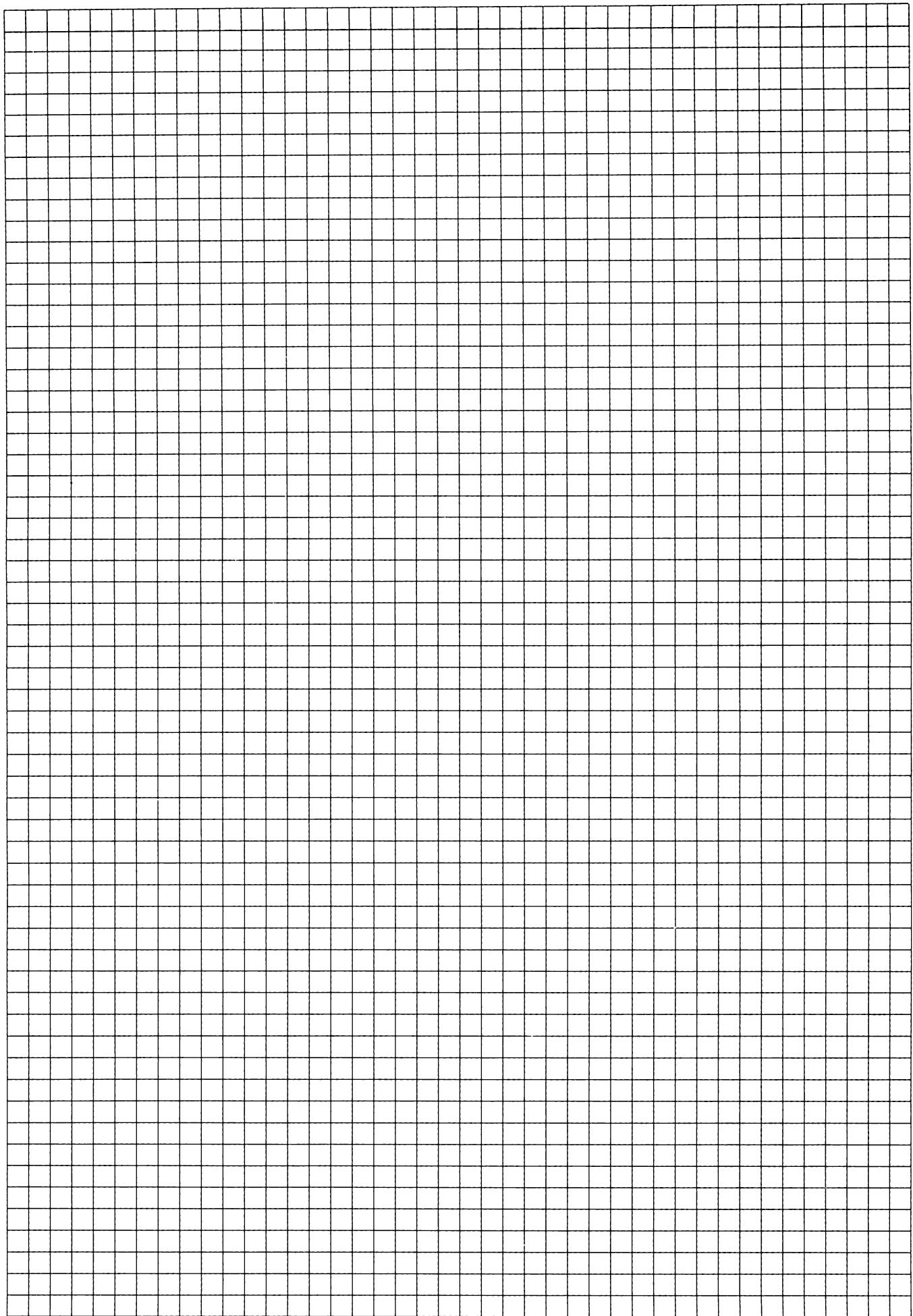
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After you have drawn your room, answer the following questions:

- Do you have enough outlets in your room for everything you want to power?
- Do you have any extension cords in your room?
- If you could change it, what would you want the electric circuit in your room to look like?







## **Appendix A**

Copy these “tickets” onto paper of different colors and distribute to each team member. Using the tickets will help make students aware of how they interact within their group.

|                           |                          |                                |
|---------------------------|--------------------------|--------------------------------|
| <b>answer a question</b>  | <b>answer a question</b> | <b>answer a question</b>       |
| <b>ask a question</b>     | <b>give an idea</b>      | <b>respond to an idea</b>      |
| <b>give an idea</b>       | <b>ask a question</b>    | <b>respond to an idea</b>      |
| <b>summarize progress</b> | <b>reword</b>            | <b>keep group on task</b>      |
| <b>paraphrase</b>         | <b>encourage group</b>   | <b>check for understanding</b> |

## Appendix B

### Social Skills Evaluation Form

#### How We Did

**Group:** \_\_\_\_\_

**Date:** \_\_\_\_\_

1. We took turns talking:

\_\_ sometimes \_\_ usually \_\_ not much

2. We each contributed ideas:

\_\_ sometimes \_\_ usually \_\_ not much

3. We asked questions to get us working again:

\_\_ sometimes \_\_ usually \_\_ not much

4. We stayed on task:

\_\_ sometimes \_\_ usually \_\_ not much

5. We paraphrased each other's ideas:

\_\_ sometimes \_\_ usually \_\_ not much

6. We checked to make sure everyone understood:

\_\_ sometimes \_\_ usually \_\_ not much

#### How I Did

**Name:** \_\_\_\_\_

1. I waited my turn to talk:

\_\_ sometimes \_\_ usually \_\_ not much

2. I contributed ideas:

\_\_ sometimes \_\_ usually \_\_ not much

3. I asked questions to get us going again:

\_\_ sometimes \_\_ usually \_\_ not much

4. I helped keep us on task:

\_\_ sometimes \_\_ usually \_\_ not much

5. I reworded someone else's ideas:

\_\_ sometimes \_\_ usually \_\_ not much

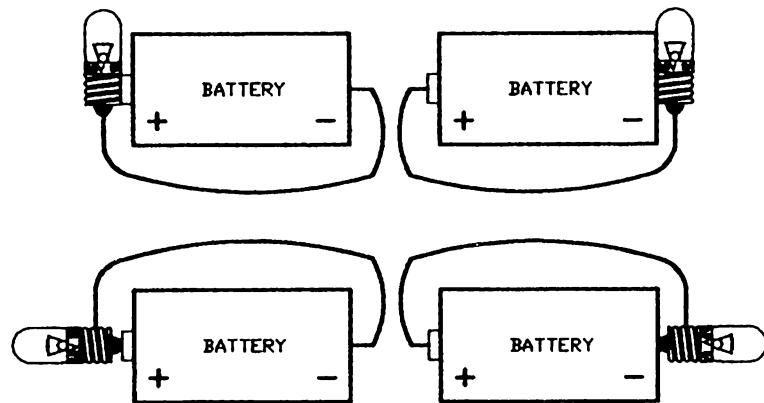
6. I checked to make sure a team mate understood:

\_\_ sometimes \_\_ usually \_\_ not much

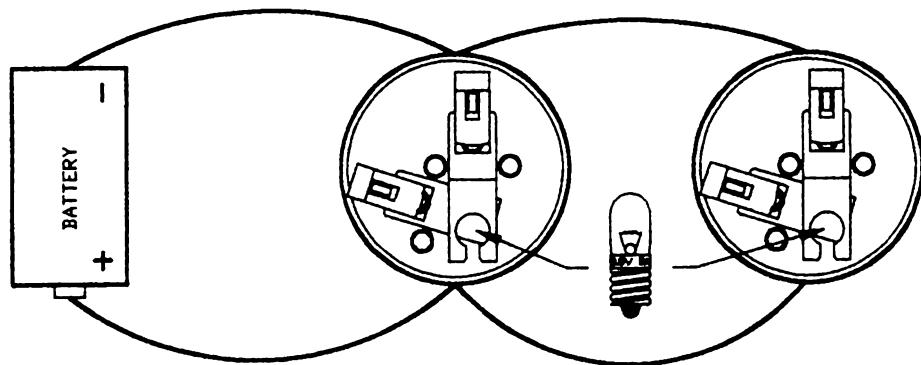
## Appendix C: Overheads

The following graphics have been reproduced from lessons 2 and 3. You may wish to share copies with your students after they complete the exercises. They may also be used to produce overheads to help stimulate group discussion.

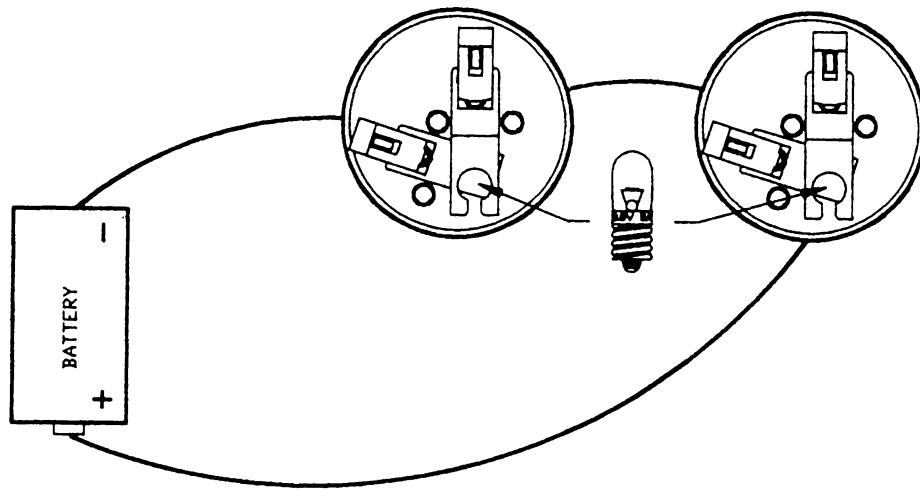
### Lesson 2 Graphics



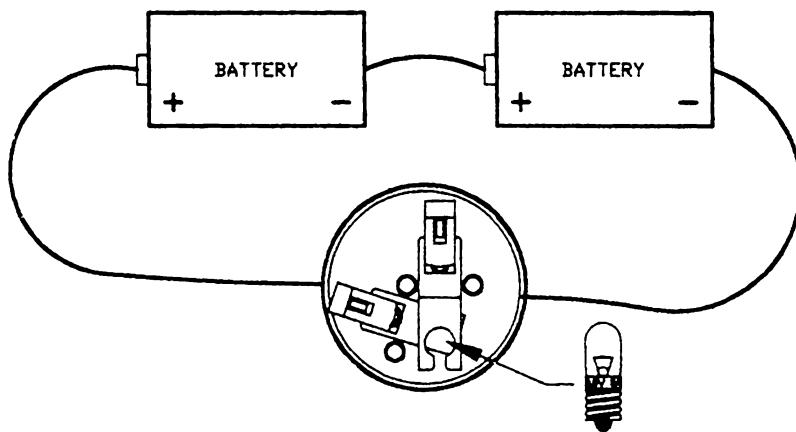
### Lesson 2: Exercise 1



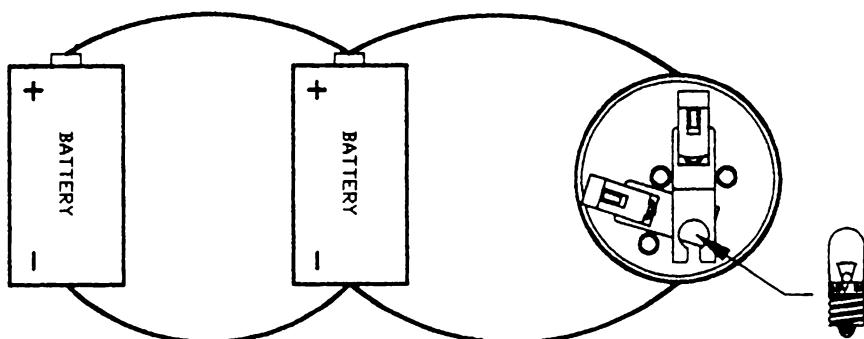
### Lesson 2: Exercise 2



Lesson 2: Exercise 3

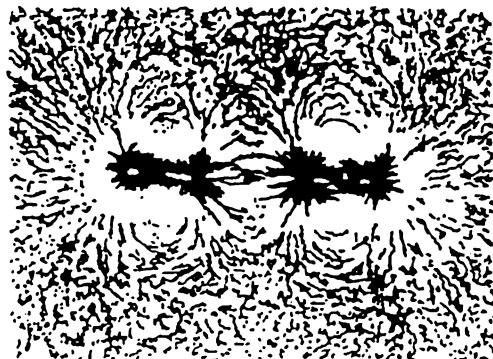


Lesson 2: Exercise 4



Lesson 2: Exercise 5

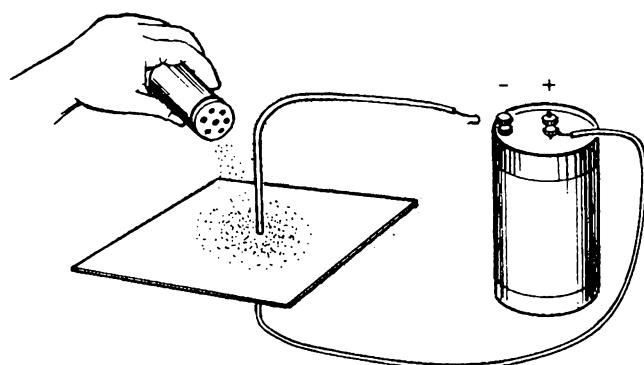
## Lesson 3 Graphics



Lesson 3: (opposite poles facing)



Lesson 3: (like poles facing)



Lesson 3: Exercise 1

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