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ABSTRACT

This booklet, one of a series developed by the Frederick County Board of Education, Frederick, Maryland, provides an instruction module for an individualized or flexible approach to secondary science teaching. Subjects and activities in this series of booklets are designed to supplement a basic curriculum or to form a total curriculum, and relate to practical process oriented science instruction rather than theory or module building. Included in each booklet is a student section with an introduction, performance objectives, and science activities which can be performed individually or as a class, and a teacher section containing notes on the science activities, resource lists, and references. This booklet is the first of a three part series on electricity and concentrates upon the types of electricity and the generation of electricity. The estimated time for completing the activities in this module is 2-3 weeks. (SL)

Electricity : Part 1

AIDS TO INDIVIDUALIZE THE TEACHING OF SCIENCE

MINI-COURSE UNITS

BOARD OF EDUCATION OF FREDERICK COUNTY

1974

ELECTRICITY: PART I

TYPES AND GENERATION OF ELECTRICITY

Prepared by:

Marvin Blickenstaff

Estimated Time for Completion

2-3 weeks

Frederick County Board of Education

Frederick, Maryland

Frederick County Board of Education

Mini Courses for

Physical Science, Biology, Science Survey,

Chemistry and Physics

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1974

FOREWORD

The writing of these instructional units represents Phase II of our science curriculum mini-course development. In Phase I, modules were written that involved the junior high disciplines, life, earth and physical science. Phase II involves senior high physical science, biology, chemistry, physics and science survey.

The rationale used in the selection of topics was to identify instructional areas somewhat difficult to teach and where limited resources exist. Efforts were made by the writers of the mini-courses to relate their subject to the practical, real world rather than deal primarily in theory and model building.

It is anticipated that a teacher could use these modules as a supplement to a basic curriculum that has already been outlined, or they could almost be used to make up a total curriculum for the entire year in a couple of disciplines. It is expected that the approach used by teachers will vary from school to school. Some may wish to use them to individualize instruction, while others may prefer to use an even-front approach.

Primarily, I hope these courses will help facilitate more process (hands on) oriented science instruction. Science teachers have at their disposal many "props" in the form of equipment and materials to help them make their instructional program real and interesting. You would be remiss not to take advantage of these aids.

It probably should be noted that one of our courses formerly called senior high physical science, has been changed to science survey. The intent being to broaden the content base and use a multi-discipline approach that involves the life, earth and physical sciences. It is recommended that relevant topics be identified within this broad domain that will result in a meaningful, high interest course for the non-academic student.

ALFRED THACKSTON, JR.
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CONTENTS

ELECTRICITY: PART I

TYPES AND GENERATION OF ELECTRICITY

Electricity is a form of energy. We know how important electricity is by what it does. Electricity is probably used in more different ways than any other form of energy. Nearly every activity we do is directly or indirectly related to electricity.

By using electricity we can see the invisible, hear the inaudible, move faster than any other living thing, do more work, and have more fun. Electricity can wake us, warm us, cool us, entertain us, and warn us when we are in danger. Can you think of 25 specific ways that you use electricity in five minutes? Can you name _any_ daily activity which is in no way connected with the use of electricity?

In this mini-course, you will be investigating the two types of electricity and how each of them is generated (made). It will be easy for you to remember these two forms of electricity. Static means _still_, while current means _to flow_. Therefore, static electricity does not move, while current electricity does move. Can you now tell the meaning of both static and current electricity?

A. Electricity Everywhere

OBJECTIVES

The student should be able to:

1. list specific ways that electricity is used in our daily lives.
2. state a simple definition of static and of current electricity.

ACTIVITY

The teacher will lead a class discussion to answer the questions posed in the introduction. Your teacher may also allow your class to have a contest (with individuals or with teams) to determine how much you and your classmates know about the many uses of electricity. Your teacher will tell you how to respond to this activity if there is no contest.

B. Laws of Magnetism

OBJECTIVES

The student should be able to:

3. assemble the materials as directed in the Lab procedures.

4. state the laws of magnetic attraction and repulsion.

ACTIVITY

Lab, Problem 7-2, Magnetism and Electricity, Cambridge, page 197.

Get this worksheet from your teacher and carry out the Lab. Your magnets may not be painted red as mentioned on the worksheet. Look for the letter N which means north and the letter S which means south.

C. Static Electricity and Magnetism

OBJECTIVES

The student should be able to:

5. differentiate between the positive and negative electricity using the terms proton and electron.

6. describe the effect of a proton and an electron which are adjacent (near or next to), as within atoms.

ACTIVITY

Read and study Reference Sheet 7-2, Magnetism and Electricity, Cambridge, pages 206-207. Be sure you can do objectives 5 and 6 before going on to the next objectives. Get Reference Sheet 7-2 from your teacher.

OBJECTIVES

The student should be able to:

7. describe how to produce either a net positive or a net negative charge given the proper materials.

8. state the relationship or similarities between electrostatic forces and magnetic forces.

9. demonstrate the laws of electrostatic attraction and repulsion.

ACTIVITY

Do the Lab on Problem Sheet 7-5, from Magnetism and Electricity, Cambridge, pages 208-209. Get Problem Sheet 7-5 from your teacher.

D. Laws of Electrostatics

OBJECTIVES

The student should be able to:

10. demonstrate the charging of an object by friction (rubbing).

11. state the laws of electrostatic attraction and repulsion.

12. determine which electrostatic charge is mobile (moveable).

ACTIVITY

Do the Lab on Problem Sheet 7-6, from Magnetism and Electricity, Cambridge, pages 210-211. Get Problem Sheet 7-6 from your teacher.

Be sure you can do objectives 10, 11, and 12 before going on.

OBJECTIVES

The student should be able to:

13. describe the changes in location of electrostatic charges while an object is being charged by friction.

ACTIVITY

Do Worksheet 7-2, from Magnetism and Electricity, Cambridge, pages 212-213. Get Worksheet 7-2 from your teacher.

E. Building and Using an Electroscope

OBJECTIVES

The student should be able to:

14. assemble a functional electroscope from provided materials.

15. place a known charge on an electroscope.

16. identify the charge of an object whose charge is unknown.

17. differentiate between charging an electroscope by conduction and by induction.

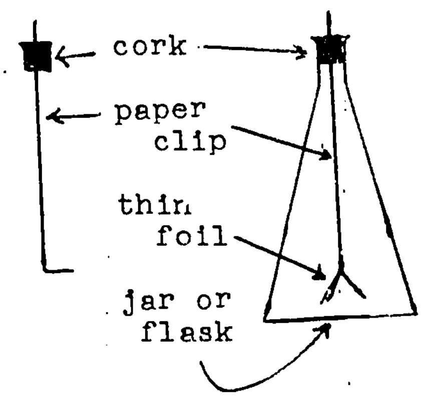
ACTIVITY

Lab Worksheet - Building and Using an Electroscope

Do the following Lab activity recording your observations, interpretations, and conclusions as directed by your teacher.

Materials:

glass jar or erlenmyer flask
cork to fit glass container
paper clip
strip of very thin aluminum foil
glass rod (test tube will do)
plastic rod (plastic comb will do)
silk cloth
fur or flannel material
sharp pencil (#2 lead pencil)
object whose charge is unknown to students



Procedures:

1. Bend paper clip at a right angle ¼ inch from the end after straightening it.

2. Insert the long end of the paper clip through the center of the cork so that ¼ inch extends above the cork. (see diagram above)

3. Cut a narrow strip of foil (about ¼ inch by 2 inches) and fold it in half.

4. Place the folded foil over the bent paper clip as shown in the diagram above.

5. Place the cork (with the paper clip of foil) into the glass container as shown in the diagram. Be sure that the foil does not touch the sides or the bottom of the container. You may need to fold and unfold the foil many times to make sure that it is free to spread apart as shown in the diagram.

6. Charge a plastic rod using fur or flannel; rub the rod for several seconds with back and forth motions. Touch the charged rod to the part of the paper clip that extends above the cork. What happens to the foil? Why? (Note: If nothing happens to the foil, you will need to fold and unfold several more times. Repeat until you can see a change in the foil when you touch your electroscope with a charged object.)

7. Touch the paper clip with your finger. What happens to the foil?

8. Charge a glass rod using the silk cloth as you used the fur in step 6 and then touch the rod to your electroscope. What happened to the foil? Why?

9. Touch the paper clip with your finger. What happened to the foil? Why?

10. Put a known charge on your electroscope. Then ask your teacher for an object which has a charge unknown to you. Without seeing the object and by looking at the foil in your electroscope, you should be able to tell the charge of the object. Be prepared to tell your teacher how you decided the kind of charge your unknown object had. (Note: You will not be allowed to see the object; you will be allowed to see the foil in your electroscope. Knowing the kind of charge you put on your electroscope is important.)

11. You have just charged your electroscope by conduction. Now charge you electroscope by induction as follows:

    a. Charge a plastic rod using fur or flannel.

    b. Hold this charged rod near (as close as possible but not touching) the top of your uncharged electroscope. What charge is on the plastic rod? What happens to the foil when you bring the charged plastic rod near? Why?

    c. Now touch the sharpened end of a lead pencil to the side opposite where you are holding the charged plastic rod. What did the foil do? Why?

d. Now remove the pencil before you remove the charged plastic rod. Remember, do not allow the rod to touch your electroscope at any time in step 11-d. What did the foil do? Why?

Interpretations:

1. Why must you use a glass container instead of a metal container to make an electroscope of this type?

2. Make two sketches showing the foil of your electroscope; show the charges on a neutral electroscope and then the charges on an electroscope which has a net positive charge. Use + and - signs to show charges.

3. Of the two electrostatic charges, which one can move? Explain.

4. Tell what happens to electrostatic particles when you rub a plastic rod with fur or flannel material. What charge does the rod have and what charge does the fur or flannel have?

5. Explain why an electroscope could be valuable in a factory which uses inflammable materials.

6. Could you tell the difference between two electroscopes which are identical but have been charged, one by induction and one by conduction? Why?

Optional 7. What would happen to the foil of an electroscope if it were held near a Van de Graff generator?

Optional 8. What would happen to the foil of an electroscope if it were touched by a Van de Graff generator?

9. If you walk across a carpeted floor and then touch an uncharged electroscope, what would happen to the foil? Why?

Conclusion:

Explain how to build and use an electroscope.

F. A Model for Electricity

OBJECTIVE

The student should be able to:

18. describe a model for electricity.

ACTIVITIES

a. Read and study Chapter 15, Forming a Model for Electricity, Silver Burdett Company. Your teacher will give you directions about how and where to write your responses. Be prepared to discuss a model for electricity. You may want to make changes in the theory that is presented in this model. Note: The reading assignment above is on pp. 9-17 of this mini-course booklet.
b. Discuss with the rest of the class, a model for current electricity.

15 Forming A Model for Electricity

Whenever an elevator goes up, a doorbell rings, a toaster heats, a car starts, a bulb lights, a radio plays, or a buzz saw cuts, electricity is present. You may not be able to see it, smell it, or taste it. But you know that electricity is there because of the things that it does.

But what is electricity anyway? What is it that passes along wires between batteries and bulbs? What is it that flows from a charger to a battery?

A lot of things in this world are hard to define. Asking "What is electricity?" is like asking "What is a school?" You could describe the things that happen in a school, but your description would probably be quite different from that of a teacher, and neither one would be like that of a janitor (and all the descriptions could be "right").

Suppose you wanted somebody to know what your school looks like. You could show him different kinds of "models" of your school. See Figure 15-1.

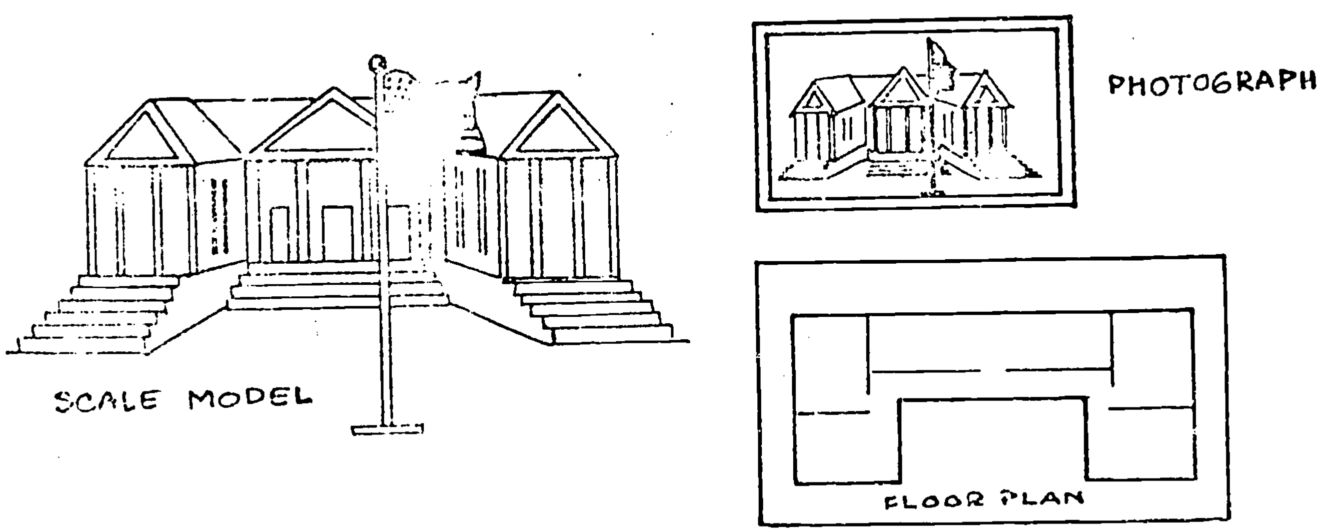


Figure 15-1

Each of these models has a special kind of usefulness. The small scale model might help a builder to make another school like yours. The photograph would be a better model to send in a letter. The floor plan would be the most useful for directing strangers to your classroom. To choose between these models, you must know what they are to be used for.

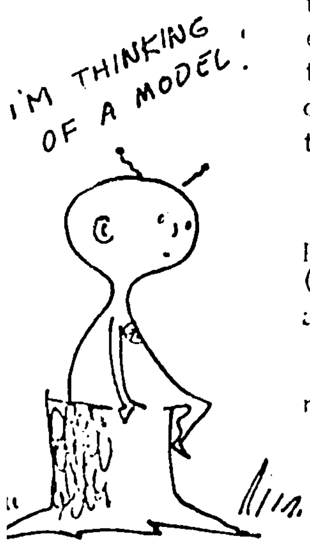
You could describe your school to a stranger by listing everything you know about it. If you did, you would probably tell him much more than he needed to know. You would probably confuse him, too. You could also describe electricity this way by listing every observation about it that anybody has ever made. Then, to find out what would happen in a particular situation, you could just look at the list. The trouble is that this list would take a whole library. And it would take a very good index, indeed, to find what you wanted to know.

A better way to understand electricity is to make a model. The model does not have to be something physical like a photograph or a floor plan. It can be a "mental model" -- a thought description. Making a mental model for electricity is simply thinking of some good way to describe it. If a description is to be a good model, however, it must be very carefully thought through. Any description can be a good model if it:

1) explains the observations made.
2) is simple enough to be used for the purpose in mind.

To be a really good model, though, a description of electricity must allow you to predict things that you haven't even seen yet.

But what if the model you think of is not true? Would this make it a poor one? This depends upon what you mean by "true." If you mean that the model does not agree with your observations, then it is, indeed, a poor one. (If you don't see why, read the characteristics of a good model again.) If you mean anything else, then the question is not a good one because you have nothing except observations to go by. In other words, several models for electricity can be "true" even though they are quite different.



All three models of the school were "true" because they all explained a set of observations. In the same way, there could be (and are) other models for electricity than the one you will learn about here.

Your task in this chapter, then, is to think through one possible model for electricity and become familiar with it. This model will be extremely important in your later work, so be sure that you understand it thoroughly. If something is not clear, ask questions!

Think back for a moment to your work with the electric motor. As you may recall, the motor was able to do work on a sinker only under certain conditions. Two of these conditions were:

1) that the motor had to be connected into a complete circuit with your battery, and
2) that the battery had to be fully charged when the motor was connected to it.

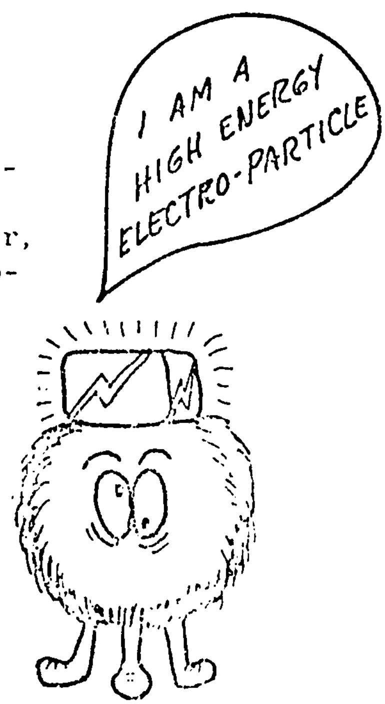
In the language of systems analysis, you concluded that the school power supply (the wall outlet) was the energy supplier for the charger. The charger supplied energy to the battery, and the battery supplied energy to the motor. But how did energy travel between these systems? This is the question that your model must answer first.

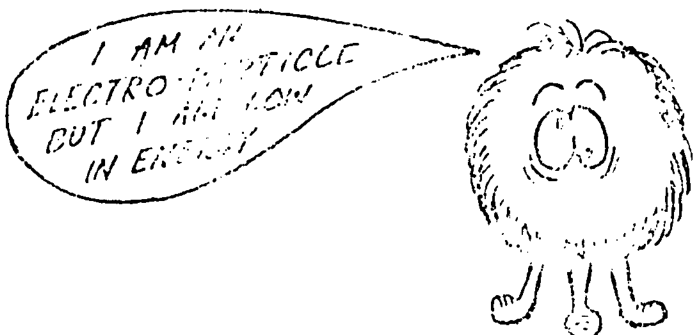
Let's begin by imagining that your battery contains millions of tiny particles called "electro-particles." Thinking this way may bother you at first. No matter how hard you look, you won't see any such particles. Don't let this worry you though; remember that in building a model you are not limited to describing only what you can see.

How can imagining that there are electro-particles in your battery explain how energy travels from it to the motor? It can't, unless the electro-particles can somehow act as energy carriers. To allow them to do this means that we must assume that electro-particles can:

1) be given energy,
2) move from place to place, and
3) give up energy.

These assumptions lead to a simple explanation of how electrical energy travels. Electro-particles pick up energy in the battery, carry it through the wires, and pass it on to the motor, to the bulb, and so forth. (In our fanciful sketches, the electro-particles are shown as hairy creatures. The size of each particle's hat shows how much energy it has.)





But where do the electro-particles that come from the battery get their energy? You know that the battery cannot supply energy unless it is charged. With this in mind, it is reasonable to assume that charging gives the particles their energy.

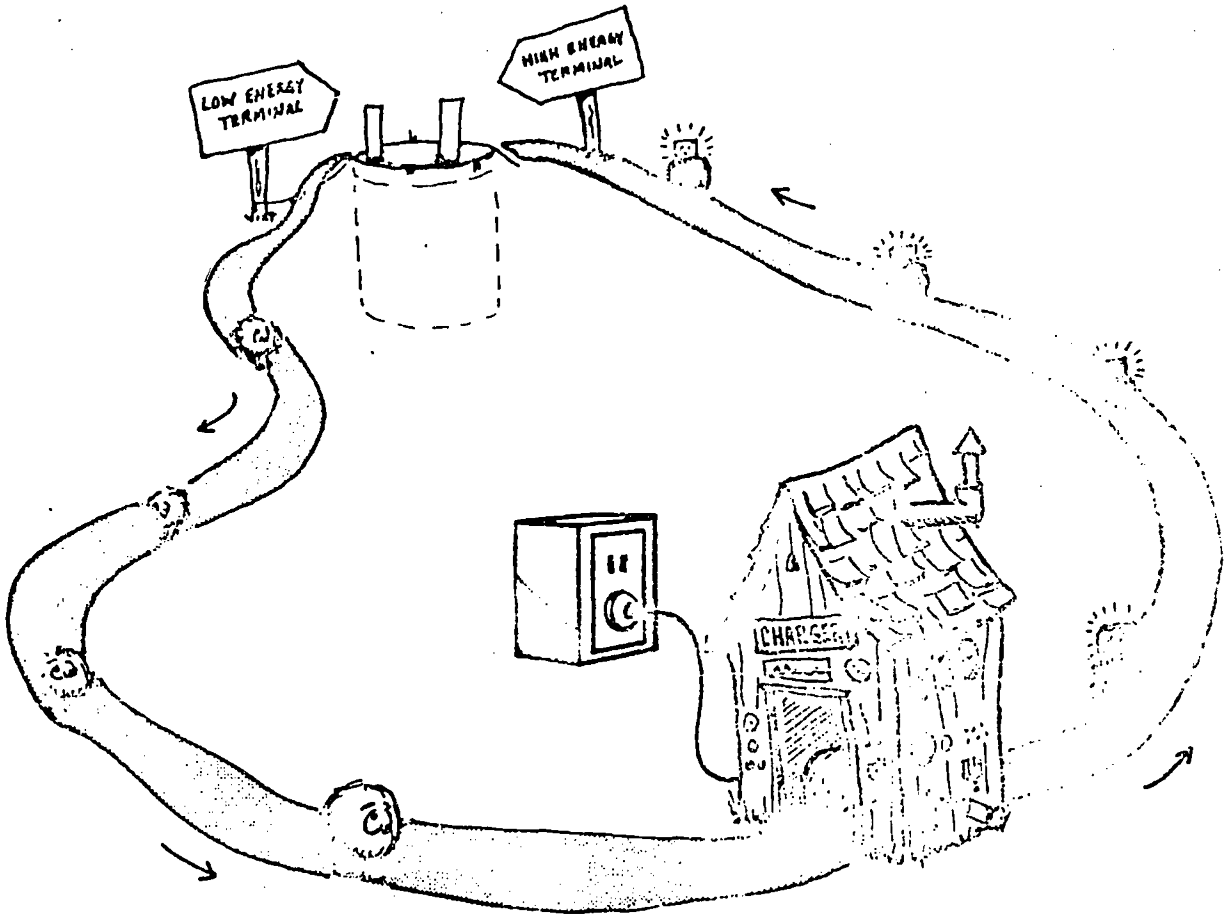


Figure 15-2

Figure 15-2 illustrates what your model says about the charging process. Notice that low-energy particles in the battery are replaced by high-energy particles from the charger. As you know, your battery cannot be charged unless two leads connect it to the charger. To build this into your model, you can assume that one lead forms the path for high-energy electro-particles coming from the charger. The low-energy particles being replaced leave the battery through the other lead.

Notice that the high-energy particles flow into the battery through one terminal. Let's call this the "high-energy terminal." The terminal through which the low-energy electro-particles leave can be called the "low-energy terminal."

Your model accounts for what goes on as a battery is charged. Next, you need to look more carefully at how your imaginary electro-particles can act as energy carriers. To do this, you must make some more assumptions, this time about how electro-particles behave. You must assume:

1) that high-energy electro-particles can and will move through certain materials (like copper wire) as soon as a complete pathway is provided, and

2) that whenever they pass through such a circuit, electro-particles always lose all their extra energy. (See below.)

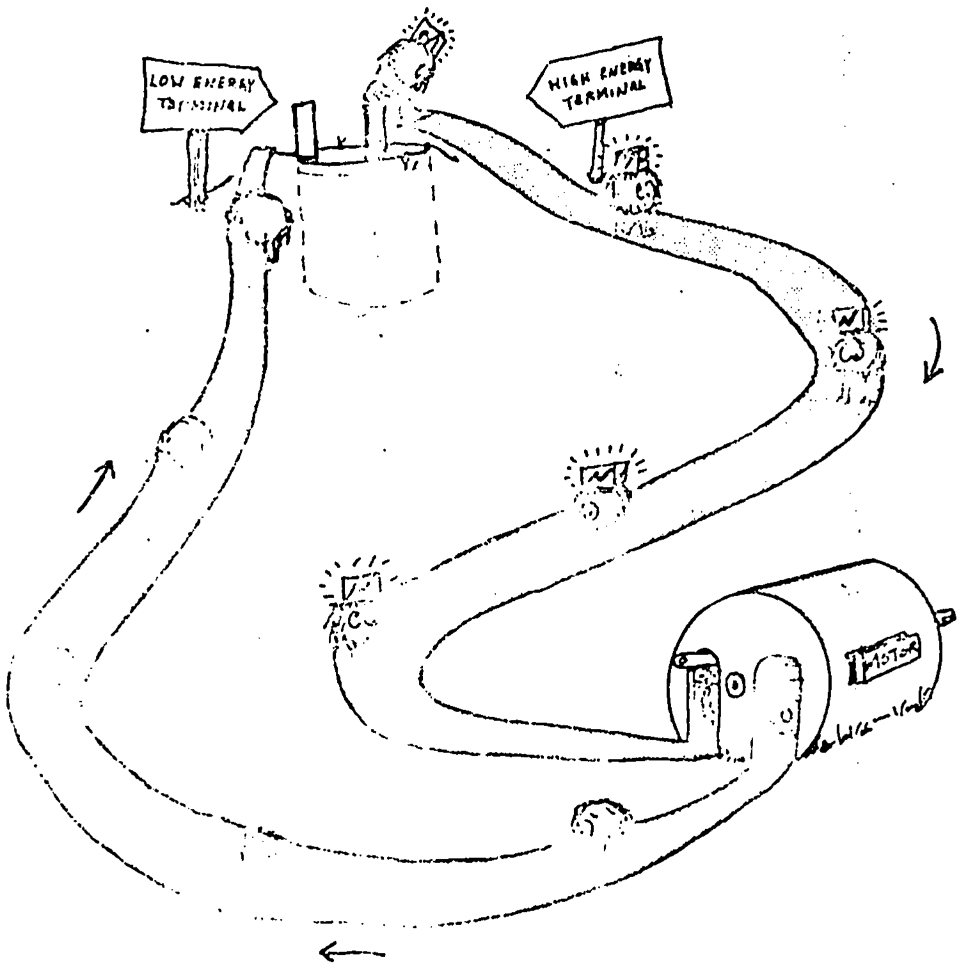


Figure 15-3

Suppose you connected the terminals of your charged battery together with a wire through which electro-particles could pass (Figure 15-4).

Based on the assumptions you have made about the behavior of electro-particles certain things should happen at the numbered places in the circuit shown in Figure 15-4.

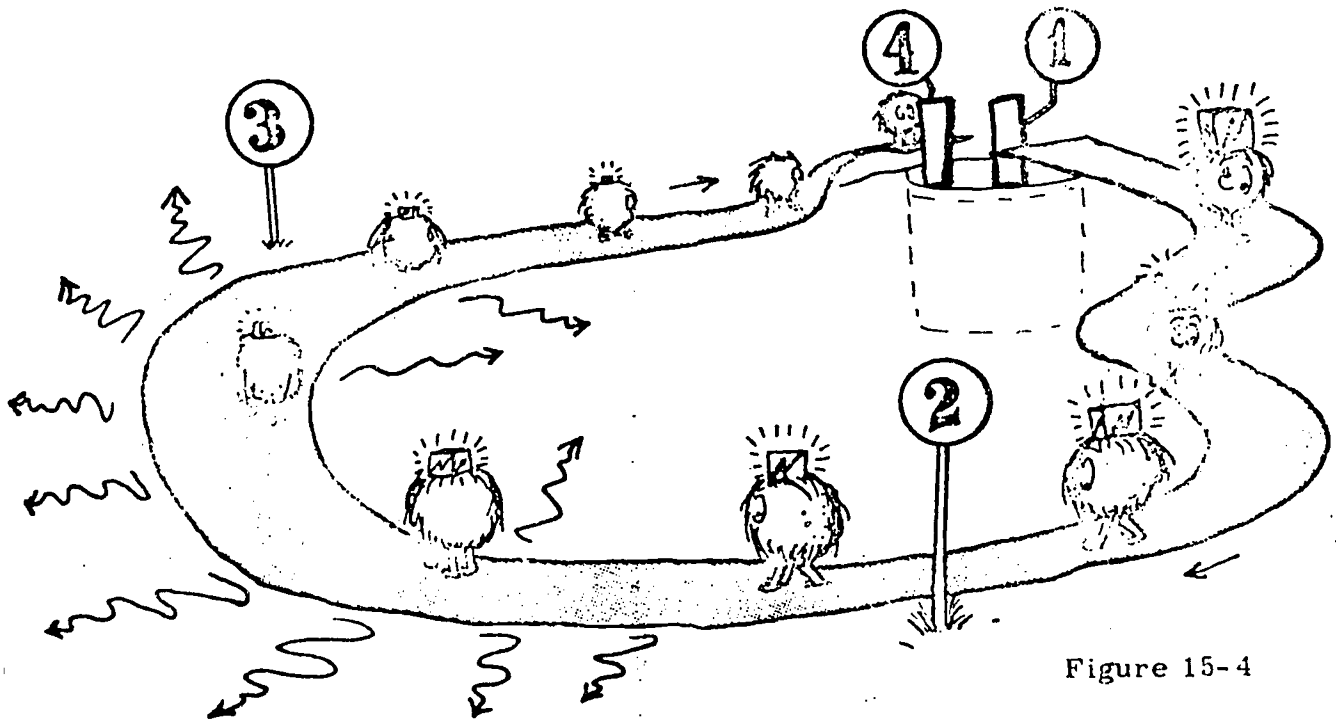


Figure 15-4

● 15-1. What kind of electro-particles come out at point 1? ______

____

● 15-2. What is happening to the electro-particles as they pass through the circuit (points 2 and 3)? ____________________

____

● 15-3. What will happen to the electro-particles at point 4? ______

____

● 15-4. What is the difference between the electro-particles at points 1 and 4? ____________________________________

● 15-5. What do the wavy arrows between points 2 and 3 represent? (Hint: What did you find when you felt the nichrome wire? See page 14-4.) ____

If you understand the model, Questions 15-1 through 15-5 should have been fairly easy. A complete circuit between the two terminals forms a path for the electro-particles to follow. This allows the high-energy electro-particles to move from the high-energy terminal toward the low-energy terminal. The movement of electro-particles continues until all the high-energy particles have left the high-energy terminal. The high-energy electro-particles give up their extra energy as they pass through the wire. Most of the energy is given off as heat (wavy lines in Figure 15-4).

Do you suppose that something has to move through the wire to carry energy from one end to the other? Could the energy be sent along the wire in some other way? Take a look at Excursion 15-1, Motion Without Moving.

Now, suppose you connected a bulb and a switch to your charged battery (Figure 15-5). Suppose that you also placed a small compass over the wire.

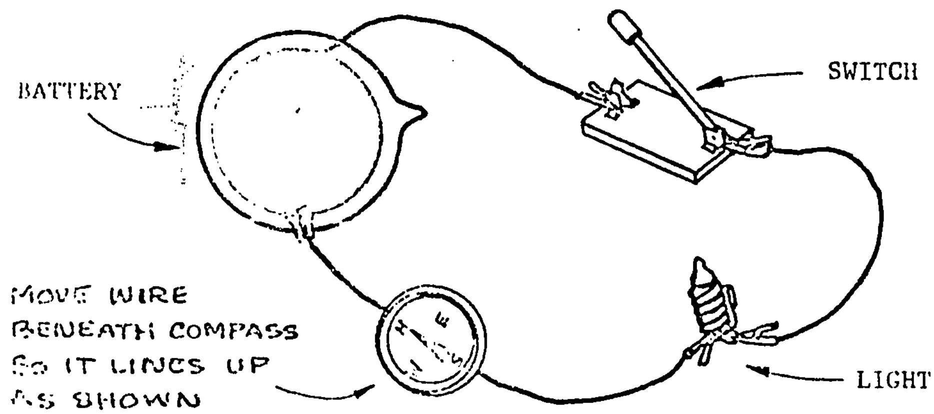


Figure 15-5

15-6. What do you predict would happen if the switch were closed?

____

____

Hook up the circuit shown and find out what actually does happen.

15-7. What happens to the bulb? ______________________________

____

____

____

15-8. What happens to the compass needle? ______________________

____

This last activity and your earlier experience with the coil and magnet should suggest one final assumption about electro-particles. You must assume that electro-particles passing through a wire cause it to act like a magnet. (See Figure 15-6.) You must also make the assumption that the more electro-particles that move through a wire in a certain time the greater the magnetic effect.

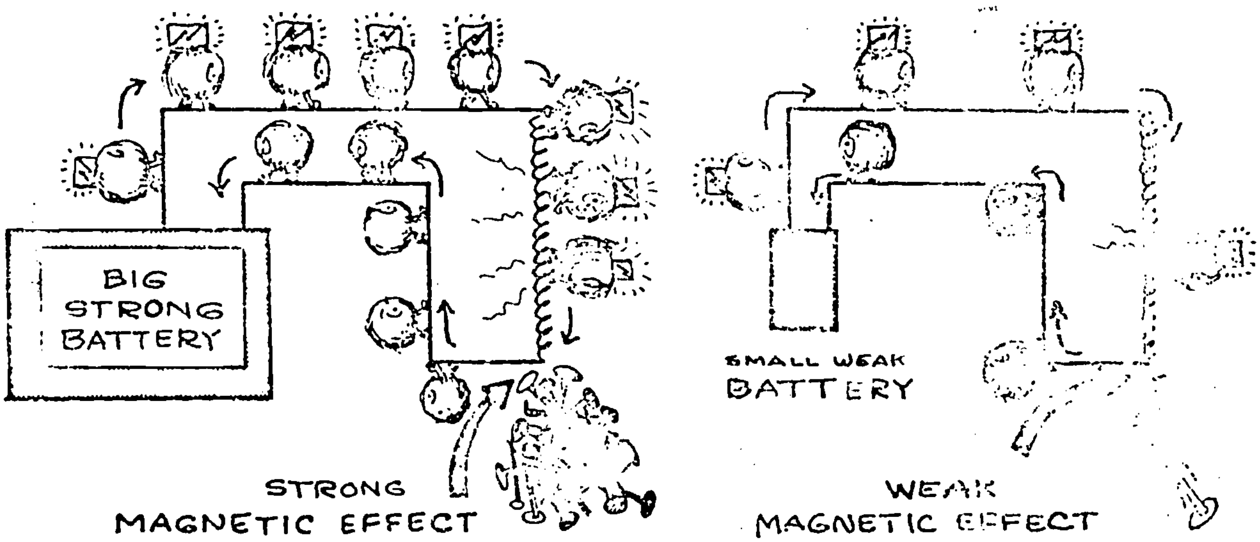


Figure 15-6

This completes your model for electricity.

Do electro-particles really have three legs and fuzz? The ones shown for your model do! Add a leg to them or shave them off if you like. But don't take the loads of energy off their heads. What the electro-particles look like is not at all important to this model. They are drawn this way to remind you that they are part of a model. (If you know about electrons, don't confuse electro-particles with electrons. Electrons are part of another model.)

By now, you may think that the electro-particle model accurately and completely explains what electricity is and how it behaves. As you go on, you may believe this even more. The model will allow you to account for many new observations. Despite its usefullness, however. this model cannot answer many questions. Some of these are:

1) How can electro-particles pass through the solid wire?
2) How does the flow of electro-particles cause a wire to act like a magnet?
3) How does an electro-particle actually carry energy?

Because your model does not give answers to these and other questions does not mean that it is not a good model. If you could give such a perfect description, you would not need a model. Since the model does explain your observations, however, it is a good one for your purposes.

You may have learned by experience that it is better to buy a string of Christmas tree bulbs that is connected in a parallel circuit. If one bulb burns out, they don't all go out. But do you know whether the bulbs in a parallel circuit would burn brighter than those in a series circuit? Look at E 15-2 for the answer. You will also find there one of the reasons why your hairy electro-particle model is not a perfect explanation of electricity.

G. Conductors and Insulators

OBJECTIVES

The student should be able to:

19. define the terms conductor and insulator in terms of electricity.

20. demonstrate the difference between a conductor and an insulator given a power supply, wire, bulb, socket, a conductor, and an insulator.

21. state a use for conductors and insulators.

ACTIVITIES

a. Read and study pages 10-11, Pathways in Science - Physics 1.

b. Do Lab Problem No. 8, Through Which Materials Can Electricity Flow?, pages 37-40, in Laboratory Workbook for Pathways in Science. Your teacher will tell you how to collect and record your data and in what form to make your lab report.

H. Making Electricity Using Chemicals

OBJECTIVES

The student should be able to:

22. assemble a simple wet cell given the proper materials.

23. attach a voltmeter or galvanometer to the wet cell electrodes and determine a reading indicating an electron flow.

24. describe changes in electrodes of a wet cell as it produces an electron flow.

25. state a model which explains the transfer of chemical energy to electrical energy.

ACTIVITIES

a. Read and study pages 11-12, Pathways in Science - Physics 1.

b. Do Lab Problem No. 6, How Can You Make Electricity From Chemicals?, pages 27-30, in Laboratory Workbook for Pathways in Science - Physics 1. Your teacher will give directions concerning how you will report your results.

c. Bring lemons from home (one per team will be enough or you may bring your own). On the day of this lab, squeeze the lemons with enough force to break the internal sections but not the rind. Insert two clean dissimilar metals about 1/3 of the way into the lemon. Keep the two strips of metal (about ½ inch x 2 inches) close enough together for a person to touch their tongue to both pieces at the same time. What do you notice when you touch the two different metals with your tongue? (Other fruits, even a potato, may be used as a substitute for a lemon.) Note: If you use lemons, you may want to keep them in a refrigerator (school's refrigerator) because they would make a very interesting project later when you study about series circuits.

d. Optional. Someone may want to study different fruits using a galvanometer to find which one can produce the most electricity. If you do this project, you should do some reading in chemistry. Find out about acids, ions, and electrolytes before you begin.

I. Magnetism and Electricity

OBJECTIVES

The student should be able to:

27. demonstrate the magnetic effect caused by electricity flowing through a conductor (wire).

28. list factors which affect the strength of magnetic fields which are induced by an electric current.

ACTIVITIES

a. Read Pathways in Science - Physics 1, pages 90-95.

b. Do Laboratory Problem No. 10, How is Magnetism Related to Electricity?, in Laboratory Workbook for Pathways in Science - Physics 1, pages 45-48. Your teacher will tell you how to record your data and make your report.

J. Making Electricity from Magnetism

OBJECTIVES

The student should be able to:

29. assemble a simple alternating current generator that functions, given the proper materials.

30. develop a model which explains why magnetic fields induce an electron flow in a conductor.

ACTIVITIES

a. Read pages 103-105 in Pathways in Science - Physics 1.

b. Do Laboratory Problem No. 3, How Can Magnetism Make Electricity?, in Laboratory Workbook for Pathways in Science - Physics 1. Use the same style as you have been using when making your lab report.

K. Review

OBJECTIVE

The student should be able to complete all 30 objectives of this mini-course.

ACTIVITIES

a. Cryptogram - Ask your teacher for this worksheet.

b. Crossword Puzzle - Ask your teacher for this worksheet.

Each section of this mini-course is designed to be completed in one class period, depending on the ability and motivation of your students. You should duplicate all materials before starting the mini-course. Another suggestion would be to make sure that you have all materials available for the entire unit because each section should be done in sequence. Part II of this mini-course on electricity uses essentially the same resources but the lab equipment is more sophisticated.

A. Electricity Everywhere

Use your ingenuity in the development of the two objectives of this activity. Some suggestions regarding a contest which you might hold to generate interest are: (1) Have each student list as many specific ways (examples - light bulb, radio, TV, etc.) as he/she can in a specified time; (2) Choose two or more teams (each with a recorder) and hold competition between teams; (3) Work against the clock; determine how many specific uses of electricity can be listed by the entire class on the chalkboard. Repeat this process using the same time interval and compare the number of new uses not on the original list; (4) Request each member of the class to mention a specific use of electricity as you "go around" the room. Keep a list on the chalkboard. Allow only a certain number of seconds for each student to respond. Counting the time needed to write the responses on the board, ten seconds or less should be plenty of time for most students.

These last two techniques provide an opportunity for further discussion since a composite list will be available for all to see. You may need to repeat some of these exercises if a particular class is "slow" to think of the myraid of uses for electricity. You may even challenge a particular class to find an activity that is in no way connected with electricity. (This may sound easy but it is not easy to find activities that cannot be affected by electricity in anyway.)

Should you choose not to have a contest, the students should be instructed as to how and where to make their lists. Certainly some discussion will result concerning the difficulty of finding daily activities which do not involve electricity.

B. Laws of Magnetism

If your students can demonstrate that they already know the law of magnetic attraction and repulsion, you may omit this section.

You will need to duplicate this Lab which is Problem 7-2 in Magnetism and Electricity, Cambridge, page 197. Be sure that the materials you provide your students are similar to those listed in the text and, if not the same, give an explanation for those items you substituted.

Materials: 2 bar magnets
thread
support (ring stand and ring works well)

C. Static Electricity and Magnetism

You will need to duplicate Reference Sheet 7-2 from Magnetism and Electricity, Cambridge, pages 206-207. The reading level of any particular class may dictate that supervised (oral) reading be used with this activity. You may need to review the model of atoms and explain "a little" about electron spin.

Transparency #5 of the Milliken book will help you explain the electron spin theory of magnetism in rather simple language. There is also a ditto master with the transparency mentioned above. Both are in the book titled Magnetism and Electricity.

You will also have to duplicate the Lab, Problem Sheet 7-5, from Magnetism and Electricity, Cambridge, pages 208-209.

Materials: tissue paper
piece of wool cloth
plastic or rubber rod
glass rod (test tube will work)
piece of silk cloth

During the discussion of this lab, you may find Transparency #1 of the Milliken book, Electricity, very helpful. You may want to discuss the placement of electrostatic charges by friction but do not draw any conclusions since this will be the subject of another investigation.

As an optional activity, the teacher may present an impressive demonstration using a Van de Graff generator at this point or at the conclusion of the next activity.

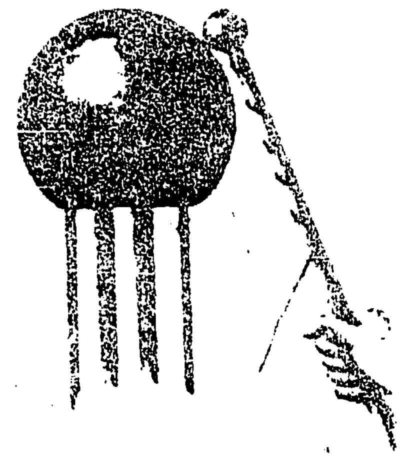
Unless you are extremely familiar with and feel secure in the operation of a Van de Graff generator, do not undertake this activity. See pages 502-504 in Sourcebook for Physical Sciences, Harcourt, Brace, and Jovanovich, for some ideas and techniques for using a Van de Graff generator. Directions for constructing a Van de Graff generator are given in the event that your school does not have access to one.

Below is some additional information concerning demonstrations using the Van de Graff generator.

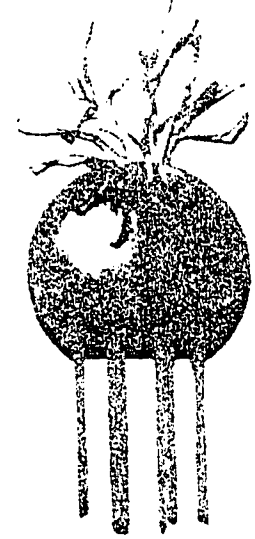
Demonstrate a Van de Graff Generator

1. Secure a Van de Graff generator. Use a metal ball attached to wire leading to a water faucet or other good ground to discharge the generator. Provide the ball used to discharge

the generator with at least a two-foot dry wood handle such as a broom stick or plastic rod, in order to enable you to manipulate the ball without receiving a shock.

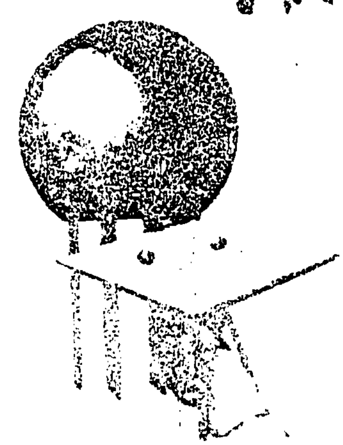


2. Operate the generator and notice the spark as you discharge it through the metal ball. Instead of a round ball, attach the ground wire to the metal of a screw driver or other pointed object. You will find that you will not get a long spark, if any at all. The static charge is drained off continuously through a pointed metal object and demonstrates the function of a lightning rod.



3. Attach tissue paper streamers to the metal ball to resemble hair. Note how the paper streamers stand away from each other showing the behavior of objects having like charges.

4. Move close to the ball without touching any grounded object and without getting quite close enough to draw a spark. Now step away and hold a faucet or radiator. You should hear a spark. You may be able to cause a neon tube to flash. Your body has become charged by the generator, either drawing electrons onto your body leaving you with a negative charge, or driving electrons from you leaving your body with a positive charge. The ball of the generator may be charged either positively or negatively depending on the construction. Thus when you approach the radiator, electrons jump either to you or from you.



5. You can demonstrate how charged particles are accelerated by the Van de Graff generator by charging a proof plate (round disc with insulated handle) opposite to that of the generator ball. Drop pith balls onto the plate as you hold it with the plate facing the ceiling. Now approach

the ball of the Van de Graff generator from below with the pith balls on the proof plate. The pith ball should hop to the ball as a result of the opposite charge attracting them.

6. Attach one proof plate with a wire to large ball of the Van de Graff. Attach a wire to a second plate to a good ground. Place some pith balls on one proof plate with plate facing the ceiling. Approach the first proof plate with the second proof plate from above with the second plate facing downward. The pith balls should be first attracted as a result of an opposite charge and then repelled downward as a like charge accumulates. The pith balls should continue to move back and forth as long as the generator is operating and you keep yourself insulated from the system by the use of the insulating handles of the proof plates.

D. Laws of Electrostatics

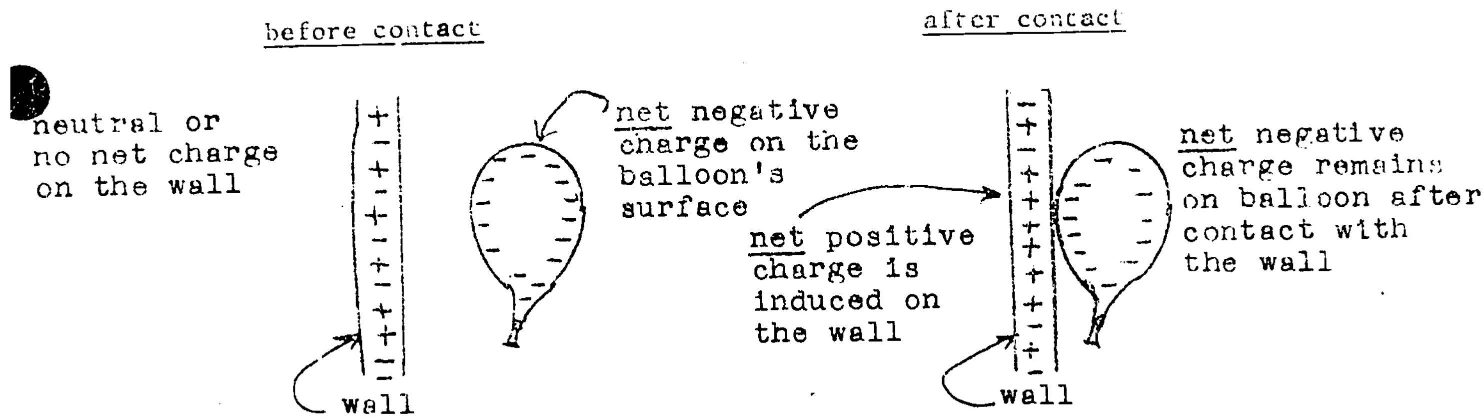
You will need to duplicate Problem Sheet 7-6, Magnetism and Electricity, Cambridge, pages 210-211.

Materials:
- 1 support (ring and ring stand)
- 2 plastic coated wire (bent in the shape of a stirrup)
- 2 thread (about a foot long)
- 2 plastic rods
- 2 glass rods (test tubes will work)
- 1 wool cloth
- 1 silk cloth

You will need to duplicate Worksheet 7-2 from Magnetism and Electricity, Cambridge, pages 212-213.

To help you review the laws of electrostatics with your class, use Transparencies #8 and #9 from the Milliken book, Magnetism and Electricity. Ditto masters are also provided with these transparencies.

As a part of your discussion of this lab and worksheet you may do the following demonstration. Have a student blow up a balloon and tie it so that it remains inflated. Then have student rub the inflated balloon several times across his/her hair. Now ask the student to hold the balloon against a wall where the entire class can see it. Ask the class to explain why the balloon remains "attached" to the wall. An acceptable answer appears on the following page in diagram form.



On contact with the wall, the net negative charge on the balloon repels some of the negative charges into the ground. This produces a net positive charge in the wall at the point of contact with the negatively charged balloon. The net negative charge on the balloon and the net positive charge in the wall cause an electrostatic attraction which is great enough to support the weight of the balloon. This demonstration does not work well if the humidity is high. Ask your class to explain what part humidity plays. You may want to try this experiment before your students arrive. In fact, you should always try your experiments before asking your students to do them. It will save you from many embarrassing moments if you do.

E. Building and Using an Electroscope

Materials:
- glass jar or erlenmyer flask
- cork to fit glass container
- paper clip
- strip of very thin aluminum foil
- glass rod
- plastic rod
- silk cloth
- fur or flannel material
- sharp pencil (#2 lead pencil)
- object whose charge is unknown to students

If your school has commercial electroscopes, you may decide to omit the first five steps in this lab. When students have difficulty in getting the leaves (foil) of their electroscopes to move, check the effectiveness of the rods and other materials. If the humidity is extremely high, you may have to postpone this lab. If the foil you have available is very thick, you probably will have to fold and unfold it many times. When you present the object of unknown charge to your students, have the student turn his/her back while you charge the object. Do not allow the student to see the object since they may be able to predict what charge a given material may have. Allow the student to see what happens to the leaves of the electroscope while you conceal the object as you touch it to the electroscope.

F. A Model for Electricity

a. ________

b. Your class may require that you have directed (oral) reading of this activity. Pointing out the importance of the term model should be stressed because there is no one accepted model which explains electricity to the satisfaction of all scientists. If you have creative students, you may want to assign special projects which would involve the writing of other models for electricity. A student talented in art may make an enlarged copy of the "fuzzy creature" model for electricity, which could be posted in some prominent place in your room as a display and for future references.

The Milliken transparency and ditto sheet #11 from Magnetism and Electricity will help develop a model for electricity.

G. Conductors and Insulators

a. Students should read paragraphs 1 and 2 only since they will be doing activities on chemical generation of electricity at a later date.

b. You will need to duplicate Lab. No. 8 from the Pathway Series, Workbook, Physics Book 1, pages 37-40.

Materials:

dry cell	penny
miniature socket	dime
1½ volt flashlight bulb	rubber band
3 insulated wires	wooden pencil
iron nail	plastic comb
paper clip	foot of string
wire cutter and stripper (optional)	

If your school does not have cells, bulbs, wire, etc., you may do this activity as a teacher demonstration. Place a single light bulb in a circuit using household current. Using a 100 watt bulb will enable students in any part of the room to see whether or not specific materials conduct electricity. Be careful of any bare wires if you use a student as an assistant during the demonstration.

During the discussion of this lab, an important concept to stress is that insulation is needed whenever electricity is involved with objects that we are likely to touch, for example, electrical appliances.

During your discussion of conductors and insulators, you should use the Milliken transparency #2 from the book Electricity.

For the sophisticated student, you probably will need to differentiate between the terms conduction (as used with charging objects electrostatically) and conductor, which means any substance which can carry a flow of electrons (electricity).

The Milliken book, Magnetism and Electricity, has a transparency and a ditto master # 10, which should help you on this topic.

H. Making Electricity Using Chemicals

a. Read paragraphs 3, 4, 5, and 6 of Pathways in Science - Physics 1, pages 11-12. Paragraphs 5 and 6 will be discussed later but they are appropriate now.

b. If your school does not have class quantities of voltmeters or galvanometers, you may be able to get a small light bulb to glow. Another alternative would be to do this experiment as a demonstration with students gathered around one (hopefully large) voltmeter.

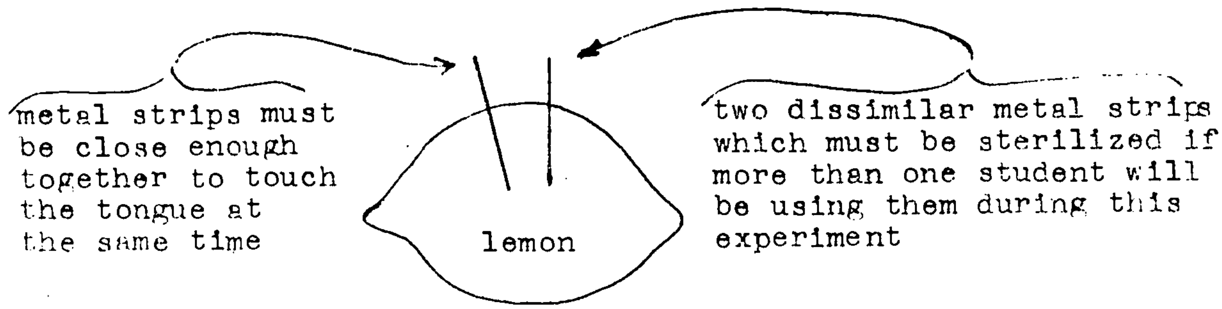
During the class discussion you will find the Milliken transparency #3 from the book, Electricity, to be useful.

If your school has the equipment, you should demonstrate the principles involved in the operation of thermocouples and turbines. Stress in your discussion that only direct current has been mentioned thus far and that alternating current will be studied later. Discuss dry cells at this point. Milliken transparency #4 from the book Electricity will be useful here. Although you should not mention the term series at this point, you should introduce and discuss the storage battery as a source of direct current. Milliken transparency #5 from the book, Electricity, will aid your discussion.

If you are very careful, you might bring to your class an old auto battery. Charging and discharging, as well as recharging, should be considered optional topics, depending on the sophistication of your class.

Milliken transparency and ditto master #12 from Magnetism and Electricity will help you explain electrochemistry.

c. When you do the mini-lab using lemons, make sure that each student has separate strips (pairs) of metal or that you provide a way to sterilize the metal strips before they are used by more than one student.



In a later lab on series circuits, a large number of <u>lemon cells</u> connected in series <u>may</u> produce enough current to light a small bulb. You may want to allow a student (or a team of students) to save these <u>lemon cells</u> and demonstrate this idea when you come to series circuits.

I. Magnetism and Electricity

a. Remind students to check the lists of main ideas as they read; for example, on pages 92, 93, and 94 each has such a list titled, <u>YOU NOW KNOW</u>. At the completion of the reading, a teacher demonstration of the concepts shown in figures 91-1 and 91-2 on page 91 will make the reading more meaningful.

b. Materials needed for Lab #10, <u>Pathways</u> Workbook, pages 45-48:
   - switch (single pole if possible)
   - compass
   - dry cell or DC power supply
   - 5 feet of bell wire
   - wire cutter and stripper (optional)

Use Milliken transparency #9 from the book <u>Electricity</u> in your discussion of the magnetic effect of electricity.

J. Making Electricity from Magnetism

a. If your school has a hand operated dynamo, it could be used at the conclusion of the reading and <u>before</u> starting the next lab.

b. Materials for Lab #3 in <u>Pathways</u> Workbook, pages 13-17:
   - 6 feet insulated wire
   - direction finding compass or galvanometer
   - bar magnet
   - 6 inch piece of dowel rod (broom stick will work)
   - string
   - wire cutter and stripper (optional)

During the discussion, you may want to refer back to Milliken transparency #3 from <u>Electricity</u> (at top of transparency) <u>and</u> to information found in <u>World Book</u>, page 127, Volume 6, 1972. Make a transparency or duplicate this page for your students. Both of these sources will show the essential difference between AC and DC generators. Note that AC generators have two slip rings while DC generators have a split ring known as a commutator. Both are the same in structure and in operation.

K. Review

Each teacher probably has a preference for review. For those who like crossword puzzles and cryptograms, you may duplicate either or both. The cryptogram could be used for "slow" students. The crossword puzzle is more difficult to solve but average students should not have excessive difficulty with it.

CRYPTOGRAM

Below is a list of words which can be found in the cryptogram. One list word is not in the cryptogram. Which one is it?

V	A	N	D	E	G	R	A	F	F	G	E	N	E	R	A	T	O	R	F	V
B	L	T	Y	F	I	H	T	R	O	N	V	E	V	I	T	A	G	E	N	W
C	T	V	N	G	N	T	W	K	L	I	S	W	X	M	T	N	D	C	G	N
D	E	W	A	H	D	U	P	X	T	N	W	V	Y	L	R	O	C	O	H	O
F	R	X	M	J	U	O	L	Y	S	T	X	E	G	R	A	H	C	N	J	I
G	N	Y	O	K	C	S	A	Z	R	H	Y	T	Z	K	C	P	B	D	K	T
M	A	G	N	E	T	I	S	M	Q	G	Z	S	B	J	T	Q	Z	U	E	C
H	T	E	N	L	I	P	T	O	P	I	W	R	C	H	I	E	Y	C	L	I
N	I	N	O	M	O	Q	I	D	E	L	E	C	T	R	O	L	Y	T	E	R
O	N	E	R	Y	N	E	C	E	C	I	T	A	T	S	N	E	P	O	C	F
I	G	R	T	T	L	V	R	L	N	B	C	Q	N	E	R	C	P	R	T	R
S	S	A	C	I	L	I	O	S	M	E	E	P	O	N	T	T	R	L	R	O
L	R	T	E	C	E	T	D	O	L	D	L	N	I	E	C	R	O	F	O	T
U	Q	O	L	I	C	I	V	U	K	O	L	M	T	R	E	O	T	M	N	A
P	P	R	E	R	Y	S	T	B	J	R	G	L	C	G	R	S	O	N	F	L
E	L	E	C	T	R	O	S	T	A	T	I	C	U	Y	I	C	N	P	L	U
R	N	Z	D	C	D	P	R	C	H	C	F	K	D	G	D	O	X	Q	O	S
J	M	T	N	E	R	R	U	C	G	E	D	J	N	F	S	P	W	R	W	N
K	L	B	C	L	N	R	F	D	F	L	C	H	O	D	T	E	V	S	T	I
B	A	T	T	E	R	Y	S	D	L	E	I	F	C	I	T	E	N	G	A	M

direct
current
electricity
energy
static
insulator
conductor
proton

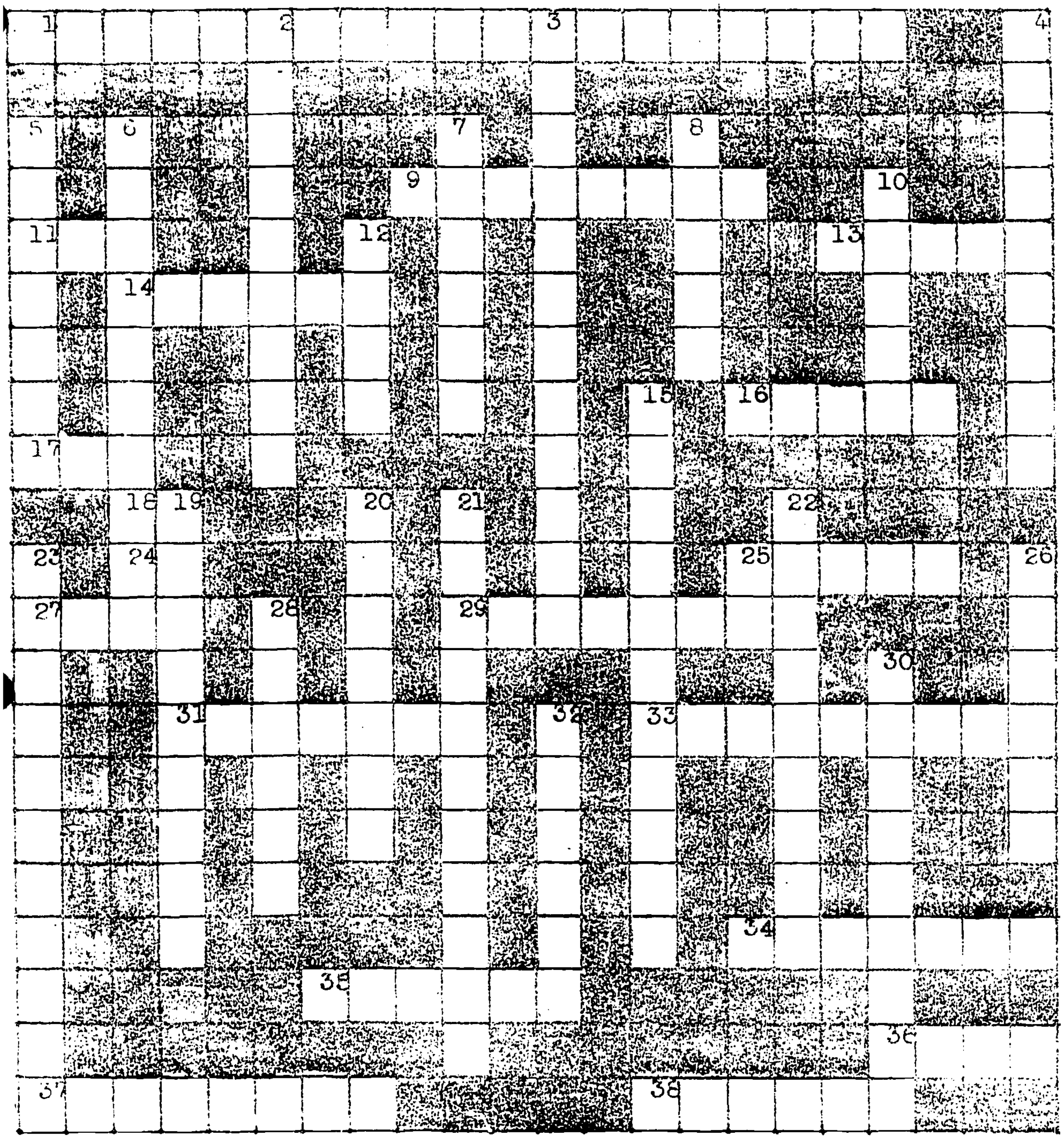
fur
electron
alternating
induction
conduction
silk
wet cell
electron flow

Van de Graff generator
north
electrolyte
dynamo
lightning
south
magnetism
force

friction
attraction
repulsion
electrostatic
electroscope
charge
positive
negative

magnetic field
electrode
plastic rod
glass rod
dry cell
generator
battery
model

CROSSWORD PUZZLE



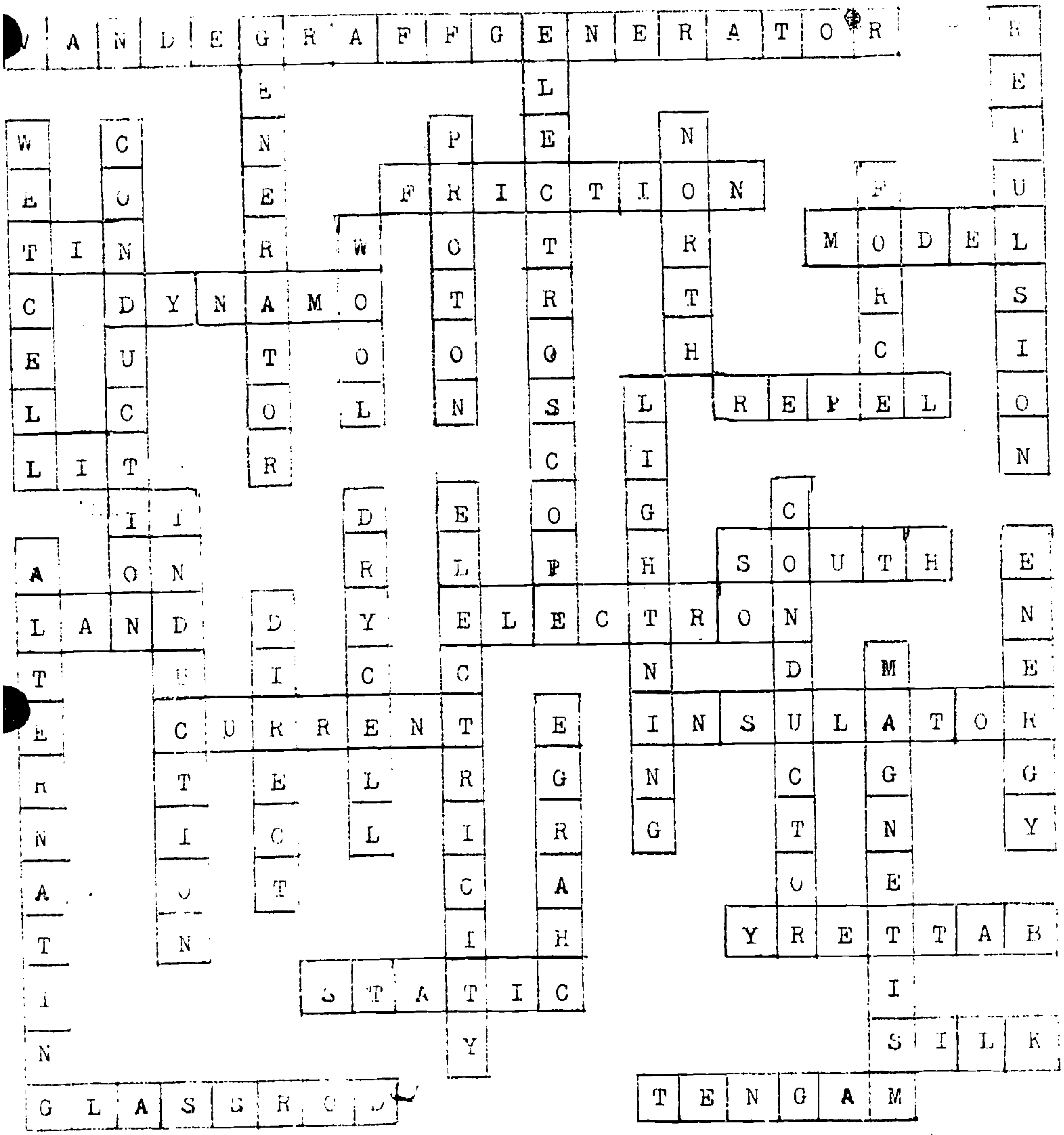
ACROSS

1 motor driven device which makes large amounts of static electricity
9 the force of resistance of two objects as they move over or through each other
11 a metallic substance which can conduct electricity, also used to plate other metals to prevent corrosion
13 a mental picture which explains how or why some process works; a scaled representation of an object
14 a generator of electricity
16 to push apart - to force in opposite directions
17 past tense of light
18 abbreviation for India Ink
24 over or in contact with
25 opposite of north
27 solid part of the earth
29 negatively charged particle found in an atom
31 to flow, as electricity flowing through a wire
33 a substance which does not conduct electricity and is used to protect us from electrical shocks when using electrical appliances
34 battery spelled backwards
35 not moving, electricity which is not flowing through a conductor
36 a type of cloth used to cause a positive charge to form on a glass rod through friction
37 straight, slender bar made of glass
38 magnet spelled backwards

DOWN

2 to make, i.e., a device which makes electricity
3 a device used to tell the kind of electrostatic charge on an object
4 the action of pushing apart of two objects
5 a device which produces electricity using chemicals in liquid form
6 the action of carrying, as electricity being carried through a conductor
7 positive particle found in atoms
8 opposite of south
10 a push or a pull, magnetism is an example
12 the short, thick hair of some animals which can be made into a type of cloth
15 discharge of extremely large amounts of static electricity in the atmosphere during storms
19 causing an electrostatic charge to form on an object
20 the true or real name for "flashlight battery"
21 a form of energy - the flow of electrons through a conductor
22 an object which can carry electricity or heat
23 changing direction as in AC electricity
25 as a result; therefore
26 the ability to do work, for example, heat, electricity
28 electricity which flows in only one direction
30 the force associated with the area around a magnet
32 the word charge spelled backwards

CROSSWORD PUZZLE ANSWERS



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UNIT OBJECTIVES

The student should be able to:

1. list specific ways that electricity is used in our daily lives.
2. state a simple definition of static and current electricity.
3. assemble the materials as directed in the lab procedures.
4. state the laws of magnetic attraction and repulsion.
5. differentiate between positive and negative electricity using the terms proton and electron.
6. describe the effect of a proton and an electron which are adjacent (near or next to), as within atoms.
7. describe how to produce either a net positive or a net negative charge given certain materials.
8. state the relationship or similarity between electrostatic forces and magnetic forces.
9. demonstrate the laws of electrostatic attraction and repulsion.
10. demonstrate the charging of an object by friction (rubbing).
11. state the laws of electrostatic attraction and repulsion.
12. determine which electrostatic charge is mobile (moveable).
13. describe the changes in location of electrostatic charges while an object is being charged by friction (rubbing).
14. assemble a functional electroscope from provided materials.
15. place a known charge on an electroscope.
16. identify the charge on an object whose charge is unknown.
17. differentiate between charging an electroscope by conduction and by induction.
18. describe a model for electricity.
19. define the terms conductor and insulator in terms of electricity.
20. demonstrate the difference between a conductor and an insulator given a power supply, wire, bulb, socket, a conductor and an insulator.

21. state a use for conductors and insulators.

22. assemble a simple wet cell given the proper materials.

23. attach a voltmeter or galvanometer to the wet cell electrodes and determine a reading indicating an electron flow.

24. describe changes in electrodes of a wet cell as it produces a flow of electrons.

25. state a model which explains the transfer of chemical energy to electrical energy.

26. state a definition of direct current electricity.

27. demonstrate the magnetic effect caused by electricity flowing through a wire.

28. list some factors which affect the strength of magnetic fields induced by an electric current.

29. given the proper materials, assemble a simple alternating current generator that functions.

30. develop a model which explains why magnetic fields induce electron flow in a conductor.

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Evaluation Form for Teachers

Name of mini-course ______________________________

Evaluation Questions	Yes	No	Comments
1. Did this unit accomplish its objectives with your students?			
2. Did you add any of your own activities? If so, please include with the return of this form.			
3. Did you add any films that other teachers would find useful? Please mention source.			
4. Were the student instructions clear?			
5. Was there enough information in the teacher's section?			
6. Do you plan to use this unit again?			

7. Which level of student used this unit? ______________________________

8. How did you use this unit - class, small group, individual? ______________________________

PLEASE RETURN TO [illegible] SUPERVISOR'S OFFICE AS SOON AS YOU COMPLETE THE COURSE.

SCIENCE MINI-COURSES

PHYSICAL SCIENCE	Prepared by
ELECTRICITY: Part 1 (Types of Generation of Electricity)	Marvin Blickenstaff
ELECTRICITY: Part 2 (The Control and Measurement of Electricity	Marvin Blickenstaff
ELECTRICITY: Part 3 (Applications for Electricity)	Marvin Blickenstaff
CAN YOU HEAR MY VIBES? (A Mini-course on Sound)	Charles Buffington
LENSES AND THEIR USES	Beverly Stonestreet
WHAT IS IT? Identification of an Unknown Chemical Substance	Jane Tritt
BIOLOGY	
A VERY COMPLEX MOLECULE: D.N.A. The Substance that Carries Heredity	Paul Cook
Controlling the CODE OF LIFE	Paul Cook
Paleo Biology – BONES: Clues to Mankind's Past	Janet Owens
A Field Study in HUMAN ECOLOGY	Janet Owens
Basic Principles of GENETICS	Sharon Sheffield
HUMAN GENETICS – Mendel's Laws Applied to You	Sharon Sheffield
SCIENCE SURVEY	
WEATHER Instruments	John Fradiska
TOPOGRAPHIC Maps	John Geist and John Fradiska
CHEMISTRY	
WATER	Ross Foltz
PHYSICS	
PHYSICAL OPTICS	Walt Brilhart