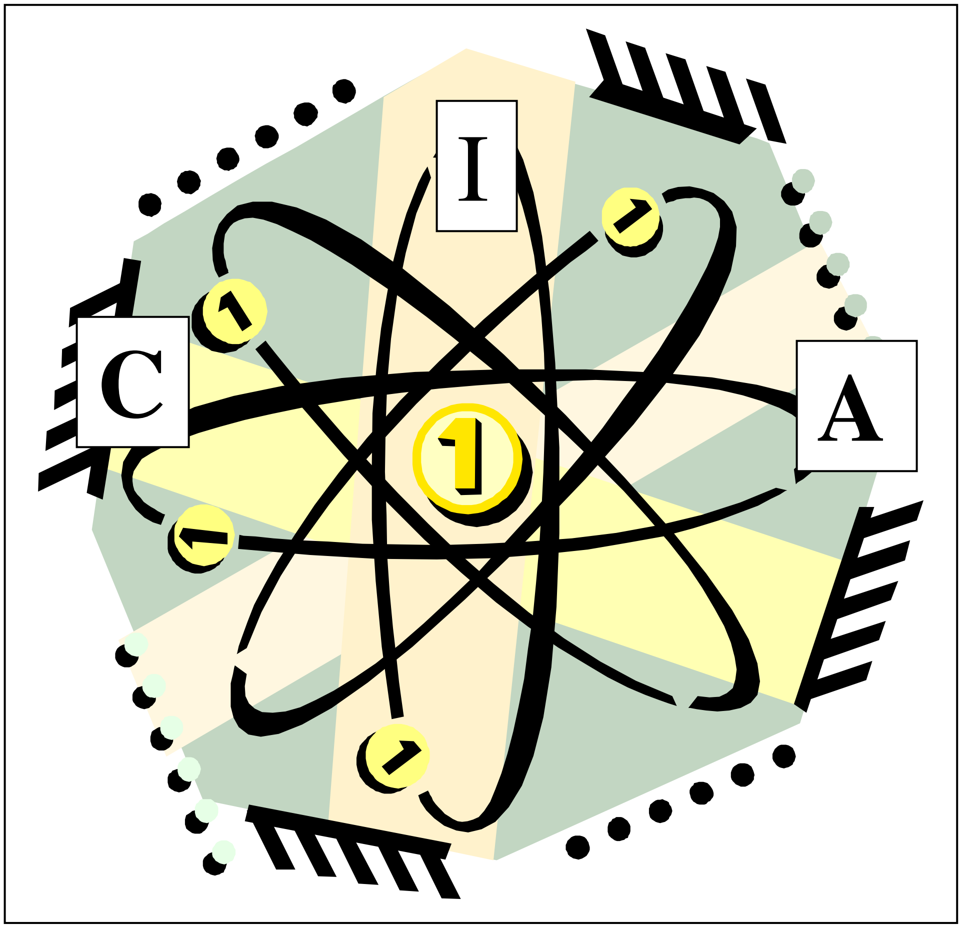
Curriculum, Instruction, Assessment (CIA) Alignment

Science, Grade 4
Unit 4: Electricity and Magnetism

Task Analysis and Hands-on Investigations



Ronald Blocker, Superintendent
Orange County Public Schools
Orlando, Florida

2003-2004

Subject Area: Science
Strand B: Energy
Grade: 4

Benchmarks

SC.B.1.2.1: The student knows how to trace the flow of energy in a system (e.g., as in an ecosystem).

SC.B.1.2.2: The student recognizes various forms of energy (e.g., heat, light, and electricity).

SC.B.1.2.4: The student knows the many ways in which energy can be transformed from one type to another.

SC.C.2.2.1: The student recognizes that forces of gravity, magnetism, and electricity operate simple machines.

TASK ANALYSIS **The student…**
ELECTRICITY AND MAGNETISM
• experiences the effects of statically charged objects on other objects.
• designs a complete circuit to convert electric potential energy to light energy.
• investigates the basic principles of magnetism and relates them to the earth's magnetic fields.
• constructs an electromagnet and conducts experiments to observe the relationship between electricity and magnetism.
• designs and creates electric circuits used to operate machines (e.g., spin art, galvanometer).

DON'T RUB ME THE WRONG WAY

BENCHMARK and TASK
SC.B.1.2.2 The student recognizes various forms of energy (e.g., heat, light, and electricity).
- The student experiences the effects of statically charged objects on other objects.

KEY QUESTION
What effect do statically charged objects have on other objects?

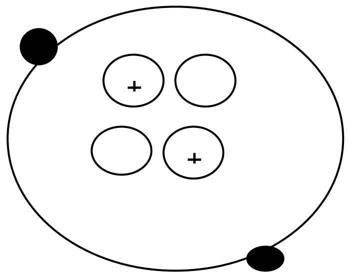
BACKGROUND INFORMATION
All matter is made up of tiny particles called **atoms.** Each atom contains 3 basic parts:
Protons, which have a positive electric charge (+)
Electrons, which have a negative electric charge (-)
Neutrons, which have no electric charge

Protons and neutrons are in the nucleus or core of an atom, while the electrons orbit around the nucleus (see drawing #1). Most objects, such as balloons, have about the same number of electrons and protons, making them electrically balanced (see drawing #2).

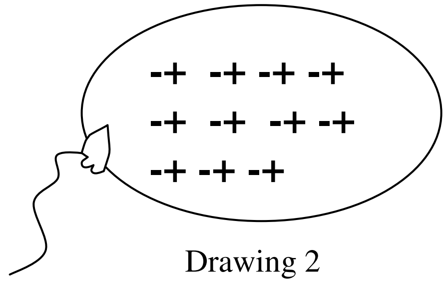
Friction (rubbing two objects together) causes objects to gain or lose electrons. When this occurs, the object becomes electrically charged. This is called static electricity. If an object gains electrons when it is rubbed, it becomes negatively charged, because it has more electrons (-) than protons (+). If an object loses electrons when it is rubbed, it becomes positively charged because it has more protons (+) than electrons (-).
(Note: Atomic structure is very abstract for students. It is enough for them to understand that an electric charge is created. Since there is no way for them to tell whether the charge is negative or positive, simply recognizing that the object has a charge is enough.)

A basic principle of electric charges is that like charges repel and unlike charges attract.
When a balloon is rubbed on you hair, it gains electrons from your hair and becomes negatively charged. Your hair becomes positively charged and will stick up because like charges repel. When the negatively charged balloon is brought near your hair, it will be attracted because unlike charges attract.

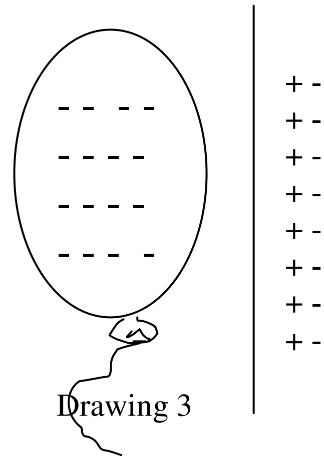
When a negatively charged balloon is brought near a wall, it induces a positive charge near the surface of the wall. (The electrons on the balloon repel electrons near the surface of the wall.) Since opposite charges attract, the balloon clings to the wall (see drawing #3).



Drawing 1



Drawing 2



Drawing 3

MATERIALS

Teacher
2 balloons
tiny pieces of paper
hair dryer (optional)
Discovering Electricity, Natalie Lunis, Ranger Rick (supports whole unit)

Per group
Don't Rub Me the Wrong Way activity sheet
plastic wrap
paper towels
small objects to be tested: safety pins, salt, small pieces of aluminum foil, Styrofoam packing broken into small pieces, dental floss (not waxed), vermiculite, puffed cereal

TEACHING TIPS

1. This activity works best on cool, dry days or inside an air-conditioned classroom. If humidity is high, blow a hair dryer near the balloon and in the area where the experiments will be done.
2. The type of plastic wrap used may affect the results of the experiment since all brands do not build up the same amount of static charge. Experiment with several brands ahead of time.

ENGAGE

1. Inflate two balloons and tie the ends. (This can be done ahead of time.)
2. Give the balloons to two students and ask them to use the balloons to try to pick up tiny pieces of paper from the floor.
3. Next, have the students rub the inflated balloons several times against their hair or clothing.
4. Ask students to use the balloons to again try to pick up the tiny pieces of paper.
5. Ask: *What happened when you attempted to use the balloon to pick up the pieces of paper before you rubbed the balloon against your hair?*
   What happened when you attempted to use the balloon to pick up the pieces of paper after you rubbed the balloon against your hair?

EXPLORE

1. Distribute materials to each group.
2. Ask students to predict what will happen if they charge the plastic wrap and hold it above the objects listed on the activity sheet. Have them record their answers in the blanks provided.
3. Advise students to test one object at a time.

4. Students can charge the plastic wrap by placing it flat on a desk and rubbing it with a paper towel.
5. Two members of the group should lift the charged plastic wrap by the four corners and slowly lower it until it is 6-10 cm above one of the objects to be tested.
6. Students should record the results on the activity sheet.
7. Students should choose additional items to be tested. Each item and the results of the testing should be recorded on the activity sheet.

EXPLAIN

What caused the plastic wrap to stick to the table and other objects when it was rubbed with a paper towel? (Rubbing the plastic wrap created an electric charge that the table and tested objects did not have.)
Once the plastic wrap is charged, why did it pick up some objects, but not others? (The attractive force caused by static electricity was enough to overcome the force of gravity for the lighter objects but not the heavier ones.)

EXTEND/APPLY

1. Ask students to think of times when they observed the effects of statically charged objects on other objects, especially in their homes.
2. Ask students to rub their feet on the carpet and touch the wall. Discuss what happens.
3. Share the book, *Discovering Electricity,* by Natalie Lunis.

EXTENSION

Students can make "magic wands" by rubbing plastic straws or pens with a paper towel. The wands will attract light objects.

ASSESSMENT

Explain what would happen if a positively charged object and a negatively charged object were brought together.
Explain what would happen if two positively charged objects were brought together.
Explain what would happen if two negatively charged objects were brought together.

STUDENT SCIENTISTS: ____

DON'T RUB ME THE WRONG WAY

DIRECTIONS: Choose an object to be tested. Predict whether or not it will be attracted to the plastic wrap. Charge the plastic wrap by placing it flat on the desk and rubbing it with a paper towel. Two team members should lift the charged plastic wrap by the four corners and slowly lower it until it is 6-10 cm above the object to be tested. Observe. Record the results.

MATERIAL TO BE TESTED	PREDICTION (Will the material be attracted to the plastic wrap?)	RESULTS

I FINALLY SEE THE LIGHT

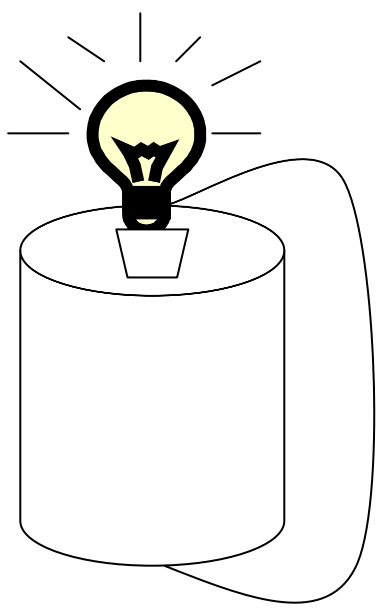
BENCHMARKS and TASK
SC.B.1.2.1 The student knows how to trace the flow of energy in a system. (e.g., as in an ecosystem).
SC.B.1.2.2 The student recognizes various forms of energy (e.g. heat, light, and electricity).

- The student designs a complete circuit to convert electric potential energy to light energy.

KEY QUESTION
How can you light a bulb?

BACKGROUND INFORMATION
A battery has a positively charged terminal and a negatively charged terminal. In a closed circuit, electric charges are repelled by one terminal and attracted to the other terminal. This attraction and repulsion provides the push that keeps the electric charges moving.

In order for current to flow through a bulb, the bulb must be connected to the circuit at two points, the tip contact (the metal button at the bottom of the bulb) and the base contact (the metal side of the bulb's base). Students will discover this through exploration with the materials. To make the bulb light with the materials in the following activity, either the base contact or the tip contact of the bulb must touch one terminal of the D-cell. The paper clip or wire must connect the cell's other terminal to the remaining contact. (One way to do this is shown in the illustration below. Students will discover other ways.)



A light bulb contains a wire called a filament. When current passes through the filament, electric energy is converted into thermal energy. Eventually, the filament gets so hot that it starts to glow, giving off light.

<u>MATERIALS</u>

<u>Teacher</u>

The Way Things Work by David Macaulay

<u>Per pair of students</u>

(Part 1)

bag containing:

- 1 D-cell
- 1 flashlight bulb
- 10-15 cm wire
- *I Finally See the Light* activity sheet
- wire strippers (if needed)

(Part 2)

additional wire

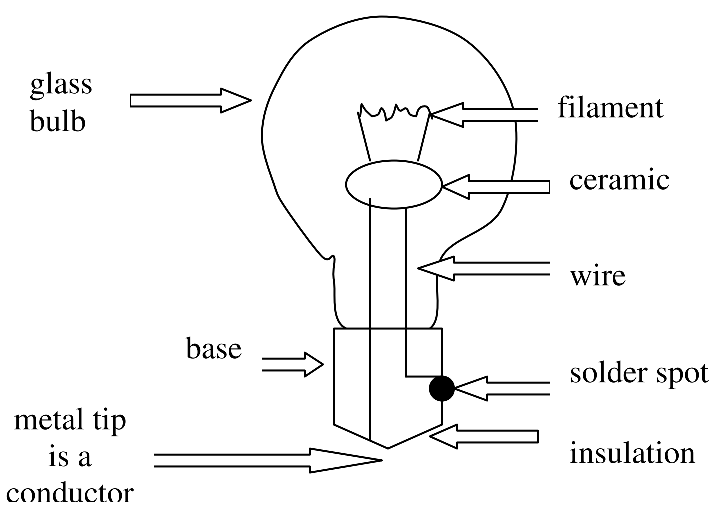
Will I See the Light? activity sheet

<u>TEACHING TIPS</u>

1. Test bulbs and cells beforehand to be sure they are working.
2. Part 1: The D-cells, bulbs and wire should be placed in baggies ahead of time. Each pair receives one bag.
3. Although D-cells work best for this activity, C- or AA-cells can also be used.
4. About 2-3 cm of insulation should be stripped from the ends of the wires so that a good connection can be made. (A good substitute for wire is narrow strips of aluminum foil backed with masking tape and folded in half lengthwise with the masking tape on the inside.)
5. Part 2: Reserve the additional wire to distribute during this part.

<u>ENGAGE</u>

1. Using David Macaulay's book, *The Way Things Work,* examine the components of a light bulb and discuss how they work.
2. Show students a cross section of a light bulb. Have students sketch the bulb and label the parts.



3. Show students a flashlight bulb. Ask: *How can I light this bulb?* Record students' responses.

EXPLORE (Part 1)

1. Distribute a plastic bag of materials and the *I Finally See the Light* activity sheet to each pair of students. Challenge students to light the bulb using only the materials in the bag.
2. After students have succeeded at lighting the bulb, encourage them to continue their exploration using the same materials to discover other ways to light the bulb.
3. Have students record their results on the *I Finally See the Light* activity sheet.

EXPLAIN Part 1)

1. Ask:
   What were some ways you were able to light the bulb? (Choose different student pairs to draw their ideas on the board.)
   How many different ways were you able to light the bulb with these materials? (Direct students' attention to the drawings on the board and count the number of different ways to light the bulb.)
   When examining the different ways in which you were able to light the bulb, what were the similarities among the systems that worked?
2. Discuss the concept that in order for the bulb to light, either the base contact or the tip of the bulb must touch one terminal of the D-cell. The wire must connect the cell's other terminal to the remaining contact, which is on the side of the bulb.
3. Introduce the term *complete circuit*. Explain that any system that caused the bulb to light is a complete circuit.

EXPLORE (Part 2)

1. Distribute *Will I See the Light?* activity sheets and the extra wire to each pair of students.
2. Have students predict which of the pictured systems will light. Students should write *yes* or *no* in the prediction box provided.
3. Instruct students to build each system pictured and observe whether or not it lights the bulb. Students should record *yes* or *no* in the actual box. (Note: Systems 1, 2, 3, 6 and 8 show complete circuits.)
4. When groups have finished testing all the systems, have them compare their predictions to the actual results.

EXPLAIN (Part 2)

Which systems did not light the bulb? (4, 5, 7)
Why did these systems not work? (They were not complete circuits.)

EXTEND/APPLY

Show students some burned-out light bulbs. Try to determine where the complete circuit was broken. It is usually the filament. (Note: Students should not handle broken bulbs.)

EXTENSION

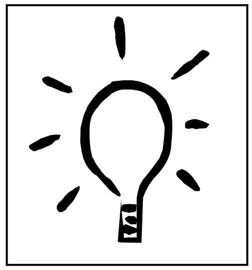
Have students use a battery (two or more cells linked together) as a part of the circuit and notice any difference in the brightness of the bulb. (Note: Don't let students use more than two cells or bulbs may be burned out quickly.)

ASSESSMENT

Ask students to respond to this question in their journals: *Why is filament important in a light bulb and what would happen if it were broken?*

Names ____

I FINALLY SEE THE LIGHT!



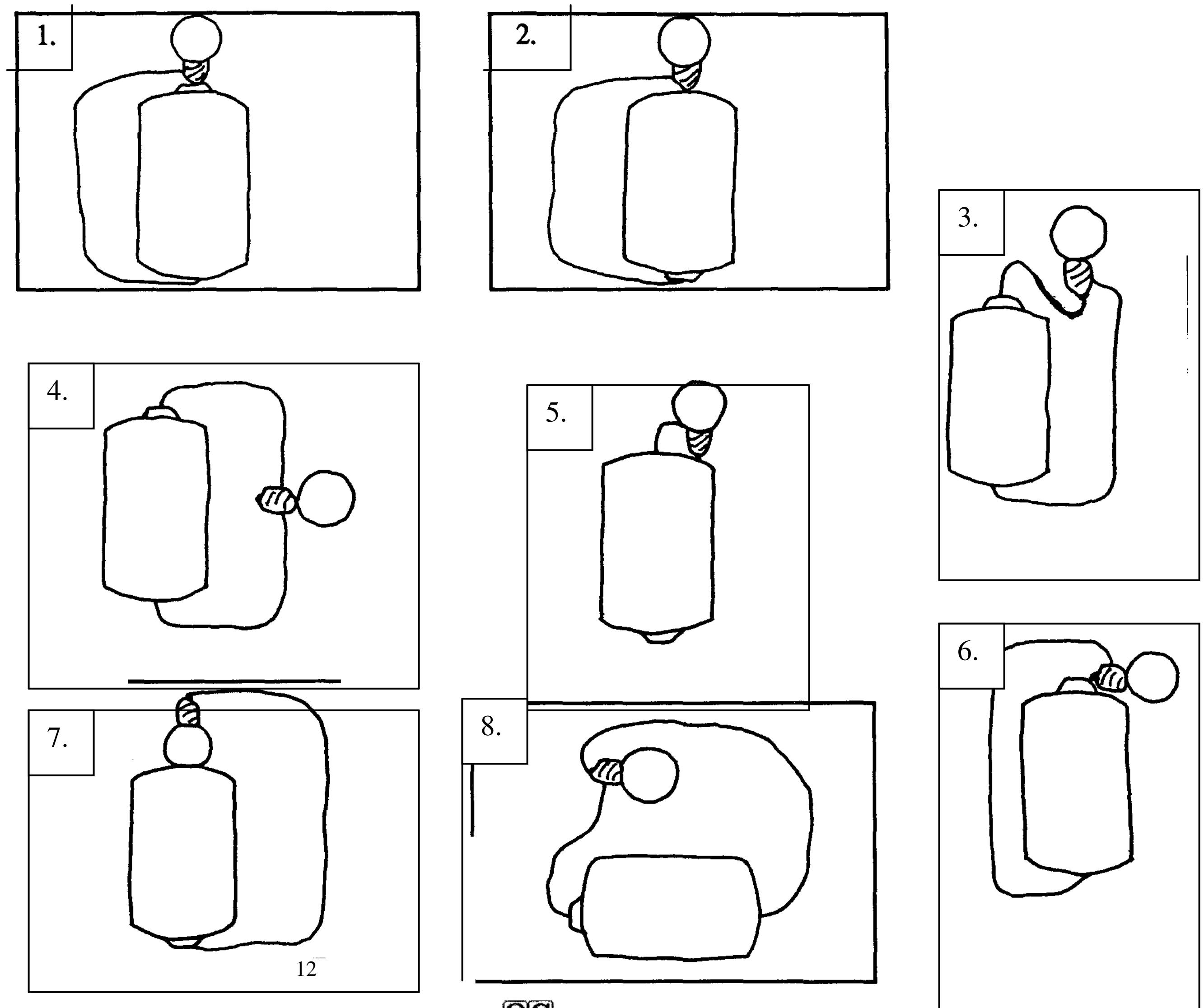
Draw pictures to represent all the ways you were able to light the bulb.

WILL I SEE THE LIGHT?

Names ____

Write Yes or No

	Prediction	Actual
1.		
2.		
3.		
4.		
5.		
6.		
7.		
8.		



LET IT FLOW, LET IT FLOW, LET IT FLOW

BENCHMARKS and TASK

SC.B.1.2.1 The student knows how to trace the flow of energy in a system (e.g., as in an ecosystem).

SC.B.1.2.2 The student recognizes various forms of energy (e.g., heat, light, and electricity).

- The student designs a complete circuit to convert electric potential energy to light energy.

KEY QUESTION

What is the difference between the flow of electricity in a series circuit and a parallel circuit?

BACKGROUND INFORMATION

There are two basic types of electric circuits – series and parallel. In both types of circuits, a complete path beginning and ending with the power source (the D-cell) is necessary before current can flow and provide energy to the power users (the bulbs). Any break in the path stops the movement of charges. In a series circuit, there is only one pathway for the current and a break in the circuit will stop the current. In a parallel circuit, there may be several pathways. If there is a break in one pathway, the current will pass through the other pathways. The current will stop only if all of the pathways have breaks.

Resistance is also a factor in electric circuits. Resistance is any thing that hinders the flow of electricity. The amount of resistance is determined by the material, length, thickness, etc. of the conductor; the number of electrical devices, such as motors, bulbs, etc. that are part of the circuit; and the type of circuit – series or parallel.

MATERIALS

Teacher

string of Christmas lights

Per group

2 D-cells

3 flashlight bulbs and holders or
  miniature Christmas lights (optional)

7 pieces of wire (15-20 cm)

2 pieces of wire (30-40 cm)

Let It Flow, Let It Flow, Let It Flow sheet

wire strippers

TEACHING TIPS

1. Strip 3 cm of insulation from the ends of the wire or substitute aluminum foil strips backed with masking tape for the wire.
2. Miniature Christmas tree lights can be cut apart and substituted for the flashlight bulbs and bulb holders.

ENGAGE

Display a string of Christmas tree lights. Plug the lights into the outlet. Explain that many years ago all Christmas tree lights were connected in such a way that if one light burned out, the whole string of lights would go out. Someone would have to check each bulb to find the one that was burned out.

Today newer strands may have an alternate path for electricity to flow through if a bulb burns out. Tell students that they are going to explore both types of circuits.

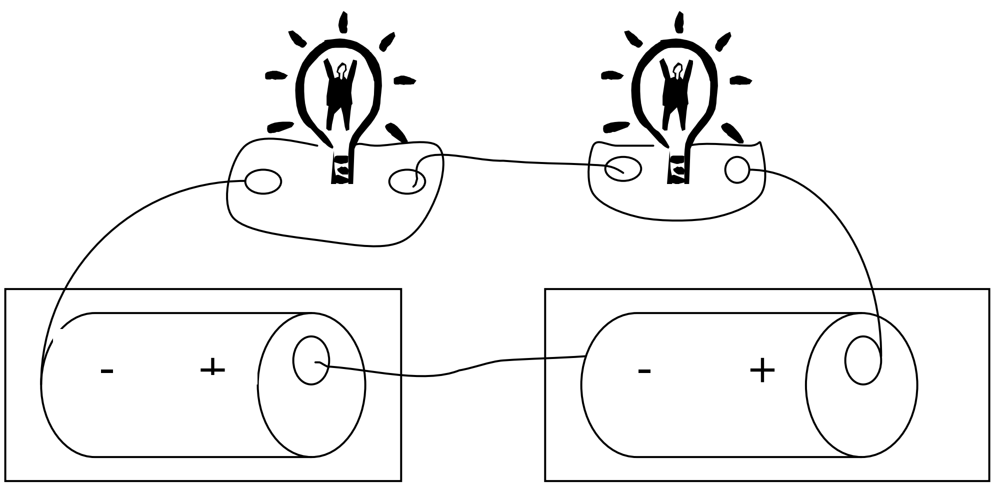
EXPLORE

Distribute materials to each group.

1. Pose the following questions:
   How can you make two light bulbs…
   a. light in such a way that when you unscrew one, the other one goes out?
   b. light in such a way that when you unscrew one, the other one stays lit?
2. Allow ample time for students to explore their ideas. If a group finishes early, encourage them to continue exploring ways to answer the question.
3. Remind students to draw their results on the activity sheet.
4. Ask students to compare the brightness of the bulbs in each of the types of circuits they construct.
5. Tell students to record their observations on the activity sheet.

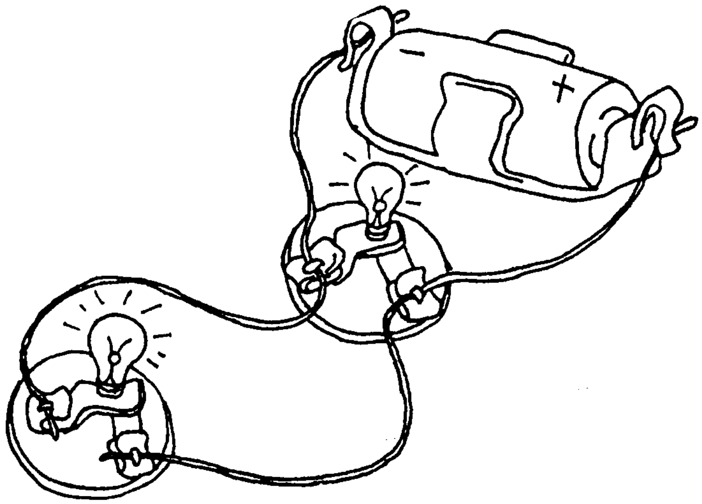
EXPLAIN

1. Ask: *How did you make two bulbs light so that when you unscrewed one the other one also went out?* Ask volunteers to present examples of this type of circuit to the class. (Note: They may either build it or draw it.)
2. Introduce the term series circuit. In a series circuit, there is only one path for the current and a break in the circuit stops the current. One example is shown below.



3. Ask:
   Why did the second bulb in the series circuit go out when one bulb was removed?
   How did you make two bulbs light so that when you unscrewed one, the other one stayed lit?
4. Encourage volunteers to present examples of this type of circuit to the class by drawing or building circuits.

5. Introduce the term parallel circuit. In a parallel circuit, there are multiple pathways or branches. If there is a break in any branch, the current will still go through the other branches. One example is shown below.



6. Ask:
   Why did the other bulbs in the parallel circuit stay lit when one bulb was removed?
   In which circuit were the bulbs brighter – series or parallel?
   What do you think is the most common household circuit used - series or parallel? Why would that type circuit be better?

EXTEND/APPLY

1. Say: *Remember the Christmas tree lights that I showed you earlier - where all the bulbs would go out when only one bulb burned out? Do you think they were connected in a series or a parallel circuit? Why?*
2. Ask students to think about why a plug on an electrical device has at least two prongs. (A circuit must provide a complete, unbroken path before charges can move from the power source through the power user and back to the power source. The two prongs provide a way for the current to come into the appliance that uses the electricity and also to return to the power source.)

EXTENSIONS

1. Add switches to the circuits.
2. Try three or more bulbs in the circuits. Have students predict what will happen.

ASSESSMENT

Divide a piece of drawing paper in half. On the left side of the paper, draw and label a picture of a series circuit. On the right side of the paper, draw and label a picture of a parallel circuit. Compare and contrast the two types of circuits.

Investigators____

LET IT FLOW, LET IT FLOW, LET IT FLOW

1. Our circuit looked like this when …
   2 bulbs were lit, we unscrewed one, and the other one went out.
   (Draw the circuit.)

This is an example of a _________________________ circuit.

- -

2. Our circuit looked like this when…
   2 bulbs were lit, we unscrewed one, and the other one stayed lit.
   (Draw the circuit.)

This is an example of a _______________________ circuit.

- -

3. ____________ circuits are brighter because __________________________

____

INSULATOR OR CONDUCTOR?

BENCHMARKS and TASK

SC.B.1.2.1 The student knows how to trace the flow of energy in a system (e.g., as in an ecosystem).

SC.B.1.2.2 The student recognizes various forms of energy (e.g., heat, light, and electricity).

- The student designs a complete circuit to convert electric potential energy to light energy.

KEY QUESTION

What materials will conduct electricity?

BACKGROUND INFORMATION

A direct electric current is a continuous flow of electric charges through a medium called a conductor. In solid conductors (which include all metals), it is the negatively charged electrons that flow and make up the electric current. (In liquids that conduct electricity, the electric charges that flow can be positive, negative, or both.)

Materials that do not normally conduct electricity are called insulators. Other materials that conduct electricity to a lesser degree than conductors, but more than insulators, are called semiconductors.

MATERIALS

Teacher

1 appliance or extension cord

Per group

wire (15-25 cm long with ends stripped)
D-cell
flashlight bulb
1 battery holder
1 bulb holder
various materials to be tested (see activity sheet)
Insulator or Conductor? activity sheet
wire strippers

TEACHING TIPS

1. Prior to the lesson, familiarize students with the correct procedure for using the battery and bulb holders.
2. Prior to the lesson, make a sample circuit to test the conductivity of the materials with which students will be working.
3. Place the items to be tested in a bag for ease of distribution.
4. Strip the ends of the wire ahead of time or let student groups do this.

ENGAGE

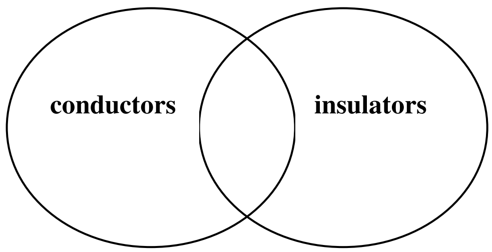
1. Ask: *Why are many wires coated with plastic or some other material?*
2. Show students an appliance or extension cord. Ask: *If this cord were not covered with this coating, what would you see?*
3. *Would it be safe to use this cord or appliance if any of the wires wrapped in the coating were exposed?*

EXPLORE

1. Discuss what the terms insulator and conductor mean.
2. Distribute the materials to each group.
3. Demonstrate how to build a circuit to test the conductivity of materials using the D-cell, wire, light bulb, bulb holder and battery holder.
4. Students should predict whether or not the materials will conduct electricity and record their predictions on the activity sheet.
5. Have students place one object in the circuit and record the results.
6. Encourage students to choose additional objects to test.

EXPLAIN

1. As the students share their findings, record the names of items that were insulators or conductors in a Venn diagram and have students justify their answers.



2. Ask:
   How did the tester help you determine if an object was an insulator or a conductor?
   What similarities exist among the conductors?
   What similarities exist among the insulators?
3. Create a Double Bubble to compare conductors and insulators.
4. Refer students to both the Double Bubble and the Venn diagram. Ask: *What is the difference between an insulator and a conductor?*
   Did any objects act as both an insulator and a conductor? How is this possible? (Some objects, like pencils, are both, depending on what part of the object is placed in the test circuit.)

EXTEND/APPLY

Discuss electrical safety with students and brainstorm a list of safety tips for working with electrical devices. The discussion may include:

- why certain tools have plastic-covered handles
- why it is an unsafe practice to place electrical cords under carpets

EXTENSION

Students should continue to test materials found in the classroom or at school and items brought from home.

ASSESSMENT

Have students differentiate between a conductor and an insulator and give examples of both.

Investigators ____

Insulator or Conductor?

Conductors complete a circuit by allowing electrons to flow freely through them. Insulators do not.

Try to complete the circuit with each object. Record the results of each test on the table below. Then choose other objects you would like to test.

Object	Prediction	Conductor	Insulator
penny			
brass fastener			
plastic			
pencil			
microscope slide			

WHAT'S MY LINE?

BENCHMARK and TASK

SC.B.1.2.4 The student knows the many way in which energy can be transformed from one type to another.

- The student investigates the basic principles of magnetism and relates them to the earth's magnetic fields.

KEY QUESTION

Where are the magnetic field lines of a magnet?

BACKGROUND INFORMATION

A **magnetic** field exists in a magnet and in the space around it. The magnetic field is strongest near the poles. The shape of a magnet's magnetic field is shown by the magnetic field lines that spread out from both poles and meet in a series of extended arcs. The magnetic field lines may also be called flux.

The earth acts as if there were a large bar magnet running from north to south through the middle of it. The earth does have magnetic north and south poles and a magnetic field, but the magnetic north pole is not at the earth's geographic north pole; it moves constantly at a rate of about fifteen miles per year.

MATERIALS

Teacher

2 magnets
1 compass (if poles of magnets are not marked)
iron filings
1 small, clear jar with lid
cooking oil

Per pair of students

rod or bar magnet (1 per student)
iron filings (or steel wool)
What's My Line? activity sheet
1 map with a global view of the earth
1 blank transparency
variety of magnets: bar, ring, horseshoe

Per student

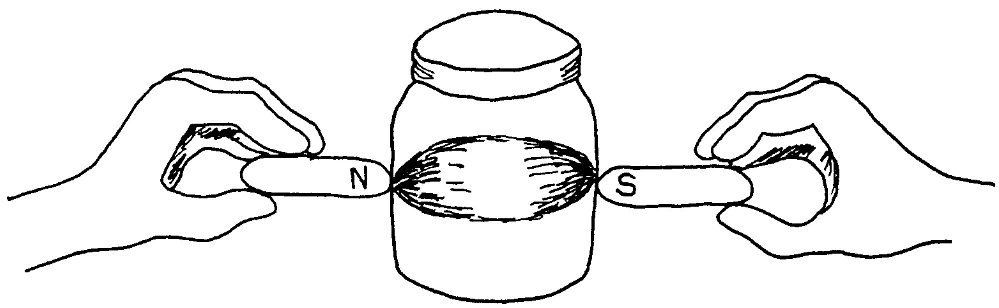
science journal
safety goggles (if handling iron filings)

TEACHING TIPS

1. Although it may be less effective, you may place a plastic sandwich bag with iron filings on top of the transparency and magnet, instead of sprinkling the iron filings directly on the transparency.
2. If iron filings are not available, rub two pieces of steel wool together above the magnet, and the magnetic lines of force will also be revealed.(Caution: The bits of steel wool can irritate your skin.)
3. Caution students to be careful when working with iron filings. The filings could irritate the eye if students handle the filings and then touch their eyes.

ENGAGE

1. Allow time for students to explore with the magnets and share their findings.
2. Review the terms – attract and repel.
3. Ask: *Does your magnet attract or repel your partner's magnet?*
   How many poles do magnets have?
   Where are they located?
4. Teacher Demonstration:
   If necessary, use a compass to identify the north end of one magnet and the south end of another. Fill a small jar with cooking oil. Add some iron filings to the jar. Cover the jar tightly and shake it to disperse the iron filings. Immediately hold two magnets on either side of the jar with opposite poles touching the jar. The magnetic field around the ends can be easily observed.



EXPLORE

1. Tell students to place the bar magnet on the table and lay the transparency over it.
2. Have students gently sprinkle the iron filings onto the transparency so that the magnetic field lines are revealed. (Note: It is very important for students to sprinkle the iron filings near the poles.)
3. Instruct students to draw the magnet and the magnetic field lines on the *What's My Line?* activity sheet.
4. Have students repeat the investigation using pairs of magnets side-by-side, first with unlike poles together and then with like poles together. Compare the results.

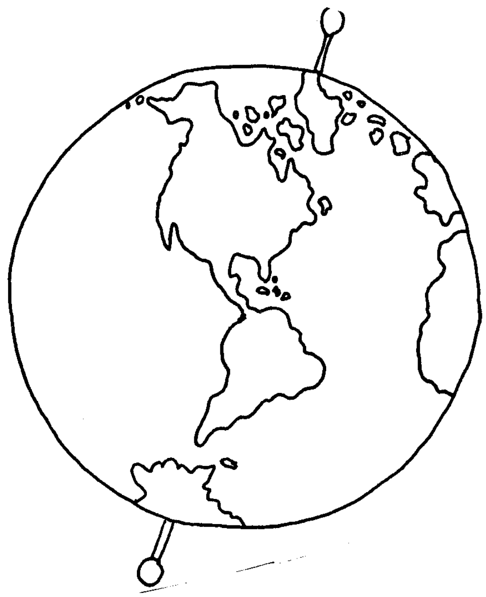
EXPLAIN

How would you describe the pattern formed by the iron filings?
Where were the lines closest together? What do you think this means?
Where were the iron filings the most concentrated?
Where were there fewer iron filings?
What do magnetic field lines reveal?
Which part of the magnet do you think has the strongest magnetic power?

EXTEND/APPLY

1. Students can illustrate the earth's magnetic field lines using a map, a magnet, a transparency and iron filings. Distribute materials to groups.

2. Instruct students to place a bar magnet on the table. Have them place a map showing a global view of the world on top of the magnet and cover the map with a transparency. Students should then sprinkle iron filings on the transparency until the magnetic field lines are visible.



3. Repeat the activity several times.
4. Ask:
   Where on the map were the most iron filings concentrated?
   Which part of the earth has the strongest magnetic power?
   Do the magnetic field lines fall in the same place each time?

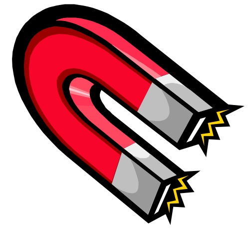
EXTENSIONS

1. Instruct students to repeat the investigation using a magnet of a different shape.
2. Substitute blueprint paper for the transparency. After the magnetic field lines are formed, place the entire experiment in the sun for 3-5 minutes. Bring the paper inside, shake off the iron filings, and rinse the paper in water. The magnetic field lines will be visible on the paper.

ASSESSMENT

Have students record in their science journals what they have learned about the magnetic field lines of a magnet.

Names ____



WHAT'S MY LINE?

1. Place a bar magnet on the table and cover it with a transparency. Sprinkle iron filings on top of the transparency. Draw a picture to show the magnetic field lines. Be sure to label the poles of the magnet.

2. Place two bar magnets side-by-side with unlike poles together under a transparency. Sprinkle iron filings on top of the transparency. Draw a picture to show the magnetic field lines. Label the poles of the magnet.

3. Place two bar magnets side-by-side with like poles together under the transparency. Sprinkle iron filings on top of the transparency. Draw a picture to show the magnetic field lines. Label the poles of the magnets.

GALLOPING GALVANOMETER

BENCHMARKS and TASKS

SC.B.1.2.1 The student knows how to trace the flow of energy in a system (e.g., as in an ecosystem).

SC.B.1.2.2 The student recognizes various forms of energy (e.g., heat, light, and electricity).

SC.B.1.2.4 The student knows the many ways in which energy can be transformed from one type to another.

SC.C.2.2.1 The student recognizes that forces of gravity, magnetism, and electricity operate simple machines.

- The student constructs an electromagnet and conducts experiments to observe the relationship between electricity and magnetism.
- The student designs and creates electric circuits used to operate machines (e.g., spin art, galvanometer).

KEY QUESTION

What is a galvanometer?

BACKGROUND INFORMATION

A galvanometer is a device that detects and measures small electric currents. Johann Schweigger, a German physicist, constructed the first galvanometer shortly after Oersted's discovery of the link between electricity and magnetism. Schweigger's galvanometer was comprised of a magnetized needle surrounded by a coil of wire. When an electric current was present in the coil, it produced a **magnetic** field that deflected the needle. When the current to the coil was reversed, the needle was deflected in the opposite direction. The polarity of the magnetic field depends on the direction of the current in the wire.

MATERIALS

Teacher

masking tape
1 AA-cell
sewing thread
2 straws
1 piece of insulated wire about one meter long, cut into strips
1 chunk of modeling clay
1 flashlight bulb and holder
2 small bar magnets (each about 2.5 cm long)
wire cutters
optional: battery holder and switch

Per group

50 cm of insulated wire, stripped 3 cm from the ends
1 D-cell
1 magnetic compass
wire strippers
1 battery holder

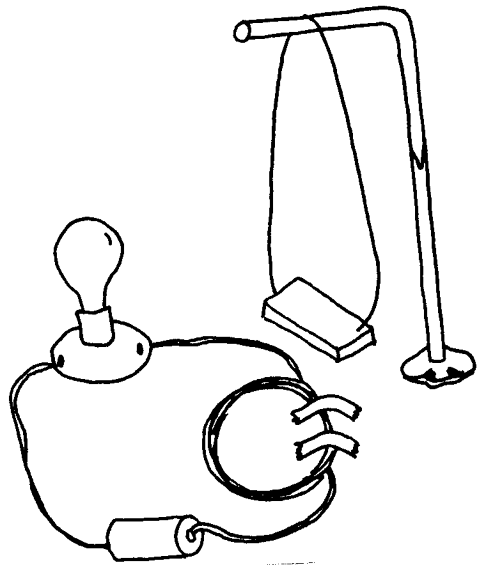
Per student

science journal

TEACHING TIPS

1. Any magnetic compass will work for this activity.
2. Construct the electromagnetic swing ahead of time and use for a class demonstration. The swing will help to demonstrate the relationship between electricity and magnetism.

3. To construct the swing follow these directions:



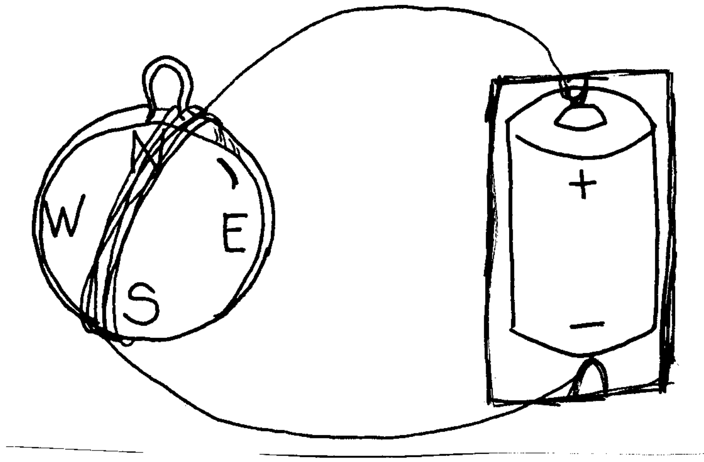
- Form a base with the modeling clay.
- Insert one straw into the other straw about one centimeter and place the extended straw into the clay base. The top one-third of the straw should be bent at a ninety-degree angle.
- Attach sewing thread to the magnet with a piece of tape, tying the thread over the straw overhang so the magnet swing rests approximately 1 cm above the table.
- Construct a circuit using the wire, battery, flashlight bulb, and bulb holder.
- Tape the battery in place and cut the wire so there is a short piece that connects one battery terminal to the holder and a long piece that connects the holder to the opposite battery terminal.
- Strip the ends of both wires, arranging the long wire so that it loops two to four times.
- Connect the circuit with tape, leaving one terminal open.
- Test the circuit by touching the stripped wire to the open terminal. After testing the circuit, leave it open.
- Adjust the setup until the magnet hangs just above the wire on one side of the loop.
- Once everything is in place, firmly tape the circuit to the work surface. One option that will ensure stable connections is to use a battery holder and a switch.
- Close the circuit. In order to keep the swing going and to send it even higher, the circuit must be opened and then closed again whenever the magnet hangs directly over the wire loop.

ENGAGE

1. Demonstrate the swing for the students. Ask:
   How does this resemble an "ordinary" swing?
   What is causing the magnet to swing back and forth?
2. Challenge students to think of another method to set the magnet swing in motion.
3. Make the swing accessible to students so they can explore on their own.

EXPLORE

1. Distribute materials to each group. Have students build a galvanometer:



- Students should wrap wire around the compass in a North/South orientation, leaving about 10 cm free at each end.
- Have student align the compass so the needle points north.
- Students should then place the D-cell in the battery holder and thread the ends of the wire through the loops on the battery holder.

2. Ask students to observe what happens. Record students' responses on the board or chart paper.
3. Tell students to reverse the D-cell and attach the ends of the wires again.
4. Ask students to make observations and record their responses.

EXPLAIN

What happened when the D-cell was attached to the galvanometer? (The compass needle was deflected.)
What caused this to happen? (The current in the coil of wire produces a magnetic field that interacts with the magnetic field of the compass.)
What happened when you reversed the D-cell? (The needle was deflected in the opposite direction.)
What does this demonstrate? (The direction of the current determines the polarity of the magnetic field.)

EXTEND/APPLY

Students can continue to experiment with the galvanometer by using various gauges or lengths or wire and more than one cell.

EXTENSION

Follow directions for making a simple electric motor.

ASSESSMENT

Have students respond in their journals to this question: *What does a galvanometer measure and how does it work?*