The NASA "Why?" Files
The Case of the Electrical Mystery

Segment 3

The tree house detectives continue their quest for the solution to the case of the electrical mystery. Because they are eager to go swimming in their neighbor's pool, the tree house detectives hope that the lesson being taught in school will give them the clues they need to solve the case. At school, a NASA Langley Research Center researcher shows the class how to identify the basic components of a circuit (conductor, load, and power source) and how to create simple, open, and closed circuits. The tree house detectives apply their new knowledge to the problem but discover they need to know more about complex circuits. They e-mail the NASA "Why?" Files Kids Club and find a Montreal, Quebec, class that has performed experiments on series and parallel circuits. After reviewing what the Montreal students have discovered about complex circuits, they feel that they are better prepared to find the solution. A KSNN report informs the tree house detectives that the power company claims all lines are repaired and that all main circuits appear to be working. Once again, they revise their hypothesis. The tree house detectives are getting closer to the answer, but will they ever get to swim in Mr. E's pool?

Objectives

Students will
- name the basic components of a circuit (power source, conductor, and load).
- identify and create open, closed, simple, complex, series, and parallel circuits.
- understand how a circuit can be overloaded or short circuited.
- identify the devices (fuses and circuit breakers) used to prevent fires when circuits overload or short circuit.

Vocabulary

circuit breaker - a switch that flips open when the current flow becomes too high, thus breaking the circuit and stopping the flow

closed circuit - a closed path that allows electrons to flow

complex circuit - a circuit that has more than one component

conductors - material that permits electric charges to move easily

fuse - a device containing a thin metal strip that melts and breaks the flow of electricity if the current becomes too high

load - the device that uses the electricity, such as a lightbulb

open circuit - a path that has a break; therefore, electrons cannot flow

parallel circuit - electric circuit in which the different parts of the circuit are on separate branches

resistor - a substance or device that prevents the electrical current from flowing

series circuit - an electric circuit in which all parts of the circuit are connected one after another

simple circuit - a basic circuit consisting of three elements: the conductor (wire), the load (object that uses the electricity), and the energy source (battery or other power source)

switch - a device in an electric circuit that opens and closes the circuit

transformer - a device that increases or decreases the voltage of alternating current

volt - unit of measurement symbolized by the letter "V"

voltage - measure of energy available to move electrons; the push that makes the electrons move

Video Component (15 min)

Before Viewing

1. Briefly summarize and discuss the events in segment 2 with the students.
2. Review the K-W-L chart that the class created earlier (p. 11). Continue to add items in the third column "What have you **learned**?" Are there other ideas you would like to add to the "What do we **want** to find out" list?

3. To assess your students' knowledge about circuitry, use the worksheet, *Light the Bulb*, in the activities section of the guide (p. 39). Have students make predictions about which circuits will light the bulb. Making predictions is central to science and research and can be used to assess thinking and learning. Have students save their prediction sheets for use later.

After Viewing

1. Discuss the questions that are asked at the end of the segment.
   - Why do you think the power is still off across the street?
   - Is an "open circuit" keeping Dr. D's train from working?
   - Do you think the tree house detectives are getting closer to solving the case?
2. Continue working with the display board to reinforce the investigative steps that the tree house detectives are taking to solve the problem. Point out that the detectives frequently stop to summarize what they know and discuss what they need to know. They also revise their hypothesis.
3. Select activities from this lesson guide and the web site to reinforce making circuits.
4. Have students revisit their predictions about simple circuits, *Light the Bulb* (p. 39). Revise predictions as appropriate. Have them analyze similar circuits in a new situation and evaluate their understanding of what is needed to complete a simple circuit.
5. Review the vocabulary and have students write sentences using the vocabulary correctly.
6. Continue updating the display board to reinforce the processes used by the tree house detectives to solve the problem.
7. As a class, hypothesize possible reasons why the houses across the street are still without power. Why doesn't Dr. D's train set work? How does Dr. D show that he uses logical thinking and the components of a good science investigation?
8. Assess students' knowledge of circuits and review if necessary.

Careers

electronics engineer

electronics engineering technician

electromechanical engineer

electromechanical engineering technician

Resources

Books

Brown, Janet Harley and Shavelson, Richard J.: *Assessing Hands-On Science: A Teacher's Guide to Performance Assessment.* Corwin, Pr., 1996, ISBN 0803964420

Dispezio, Michael: *Awesome Experiments in Electricity and Magnetism*. Sterling Publishing Company, Incorporated, 1999, ISBN 0806998199

Graf, Rudolf F.: *Safe and Simple Electrical Experiments.* Dover Publications, Incorporated, 1991, ISBN 0486229505

Hein, George and Price, Sabra: *Active Assessment for Active Science: A Guide for Elementary School Teachers.* Heinemann, 1994, ISBN 0435-083619

Web Sites

Kids Schoolhouse
A student web site about energy and electricity that makes the "classroom" fun. The on-line classroom includes a homeroom, a history class, a science lab, field trips and much more.
http://www.EnergyMatch.com/schoolhouse/

The Shocking Truth about Electricity
The site was created by kids and entered into the ThinkQuest Junior web site contest for 2000! The topics included in the site are History of Energy, About Electricity, Power Failures, and Circuits. Home experiments, an on-line quiz, and other related internet resources are provided.
http://tqjunior.advanced.org/6064/

NASA "Why?" Files Web Site
Official web site of the NASA "Why?" Files. Student, teacher, and parent friendly.
http://whyfiles.larc.nasa.gov

Activities and Worksheets

In the Guide

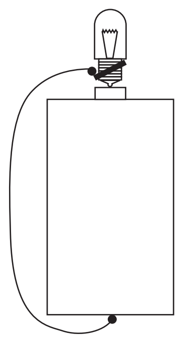
On the Web

You can find the following activities on the Web at http://whyfiles.larc.nasa.gov.

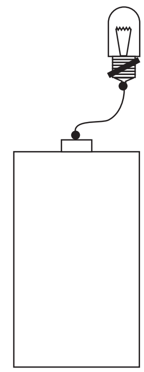
Circuit Construction Exploration
Students explore creating circuits to discover the difference between series and parallel.

Light the Bulb

Will the bulb light? Below each picture, make your prediction by writing either “on or “off.”



1 ____________________



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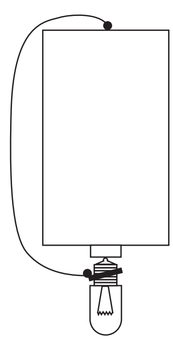
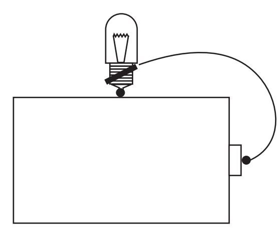
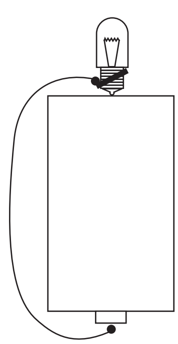


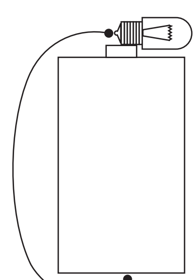
3 ____________________



4 ____________________



5 ____________________



6 ____________________

Series Circuits

Purpose

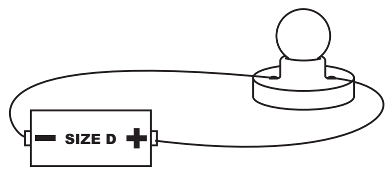
To give students an opportunity to explore series circuits.

Materials

2 D cell batteries
2 D cell battery holders (optional)
2 lamps (bulbs)
2 lamp holders
4 pieces of insulated wire 25-30 cm long with ends stripped off

Procedure

1. Create a circuit as illustrated below.

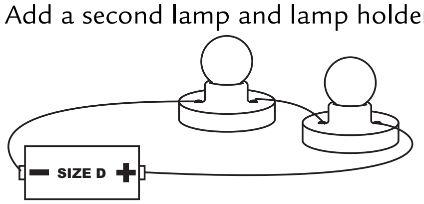


2. Describe the brightness of the bulb. ____________________

____

____

3. Add a second lamp and lamp holder, as illustrated, and connect the battery.



4. How did the brightness change? ____________________

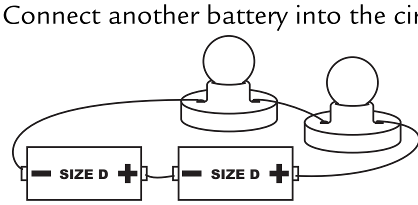
____

5. Unscrew one of the lamps and describe what happened to the other lamp. __________

____

____

6. Connect another battery into the circuit as illustrated below.



7. Describe the brightness of the lamps. ____________________

____

8. Write a definition of a series circuit and draw a diagram. ____________________

____

In a series circuit, each lamp is dependent on all the other lamps for a complete circuit. When batteries are connected in a series, the voltage in the circuit is increased by each added battery. For example, two 1 1/2 -volt batteries act as one 3-volt battery.

Parallel Circuits

Purpose

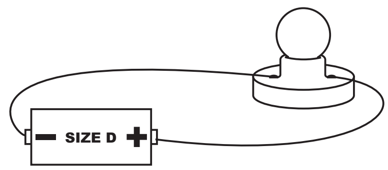
To give students an opportunity to explore parallel circuits.

Materials

2 D cell batteries
2 D cell battery holders (optional)
2 lamps (bulbs)
2 lamp holders
6 pieces of insulated wire 30 cm long with ends stripped 2 cm

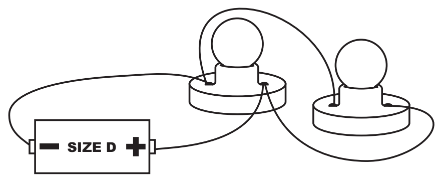
Procedure

1. Create a circuit as illustrated below.



2. Describe the brightness of the lamp. ______________________________

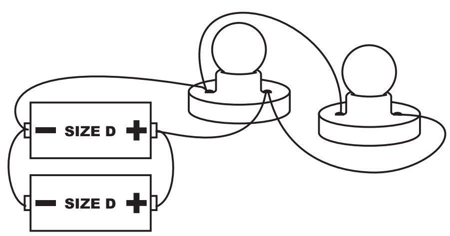
3. Add a second lamp to the circuit as illustrated.



4. How did the brightness change? ______________________________

5. Remove one of the lamps. What happened to the other lamp? ______________________________

6. Connect a second 1 1/2-volt battery in parallel as illustrated.



7. How did the brightness change? ______________________________

In parallel circuits, each lamp receives the full voltage produced by the battery. Batteries can also be connected in a parallel arrangement. When two 1 1/2-volt batteries are connected in parallel, they will only produce 1 1/2-volts for the circuit. They will, however, cause the lamps to burn twice as long before the batteries wear out.

Conclusion

Draw a parallel circuit and explain the flow of the current. Explain what happens when you remove one of the lamps from a parallel circuit.

Conductors and Insulators

Purpose

Students will discover which types of materials make good conductors of electricity and which types are good insulators.

Materials

D cell battery
(Per group)
D cell battery holder
lamp
lamp holder
3 pieces of insulated wire 30 cm long with ends stripped 2 cm
various objects for testing such as wooden pencil, penny, aluminum foil, paper strip, plastic pen, metal pen, and so forth

Procedure

1. To create a simple conductivity tester, place the battery in the battery holder and connect a wire to each end of the holder.
2. Make sure the lamp is screwed into the lamp holder and connect the wire from the positive terminal of the battery holder to one of the contacts on the lamp holder.
3. Connect the third wire to the other lamp holder contact. You now have two wires that are not connected. See Diagram 1.

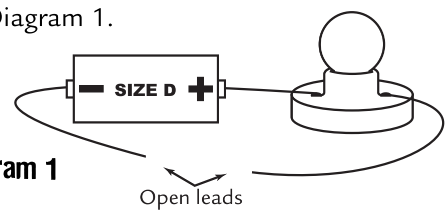


Diagram 1

The ends of the two wires are the open leads, and they will be used to test the objects.

4. Conduct a test to make sure that your setup is working. Touch the two open leads to each other. If setup is working, the lamp will light.
5. To test objects, touch the ends of both open leads to the object, forming a complete circuit. If the lamp lights up, the material the object is made from is considered a conductor. If not, the material is an insulator.
6. Begin your test of objects and fill in the chart below. As you discover conductors, observe the brightness of the lamp.

Object Tested	Conductor Insulator	Brightness of Lamp

Conclusion

1. What did the objects that were conductors have in common? ____________
2. What conclusion can you make? ____________
3. Name five other objects that are conductors of electricity. ____________
4. How did the brightness of the lamp vary between conductors? Explain. ____________

Assessment

For class assessment of learning, place objects on a table and have the class sort the objects into two piles and label each pile as either conductors or insulators. Have the students explain their choices. For small group assessment, a shoe box filled with various objects could be sorted, with students writing explanations in science journal.

Tap, Tap, Tap: Telegraphs and Morse Code

Purpose

To give students an opportunity to build a telegraph, use Morse Code, and learn an effective use for electricity.

Materials

6-volt lantern battery
lamp in lamp holder
10 m of insulted wire
wire cutters/strippers
Morse Code Sheet

Procedure

1. Cut the wire in half and strip 2-3 cm of insulation from the end of each piece.
2. Connect one end of each wire to the lamp holder connections. See Diagram 1.
3. Connect one end of one wire to the positive terminal of the battery, but do not connect the other wire. See Diagram 2.
4. With the end of the wire that is not connected, touch the negative terminal to see if your lamp lights up (to test the telegraph).
5. Place the lamp in one area of the room and the battery in another area of the room.
6. Your partner and you are now ready to send messages. Decide who will be the "sender" and who will be the "receiver."
7. The "sender" will first write his/her message in English, then use the code sheet to translate it into a series of dots and dashes.
8. To send the message on your telegraph, you will need to follow these rules:
   - Make a dash by holding the battery connection for one full second.
   - Make a dot by just touching the battery connection and removing it immediately.
   - Pause two full seconds between letters and four full seconds between words.
9. When receiving a message, first copy the message in dots and dashes, then use the Morse Code sheet to translate it back into English.
10. Compare the messages both sent and received. Do they match closely?
11. Switch jobs with your partner and repeat sending a new message.

Extensions

1. This telegraph system only works in one direction. How might you change it so you both could send and receive messages? What additional parts would you need?
2. In a Morse telegraph system, operators used a telegraph key that was a type of switch that allowed them to open and close the circuit much faster than taking a wire on and off a battery. Design a telegraph key for your telegraph system using such items as paper clips and brass paper fasteners. Draw a diagram first and then test your idea.
3. Design your own secret code and practice using it with your telegraph.

Diagram 1.

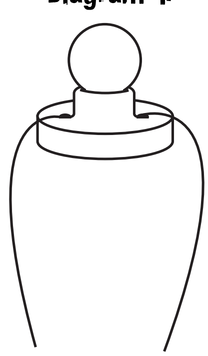
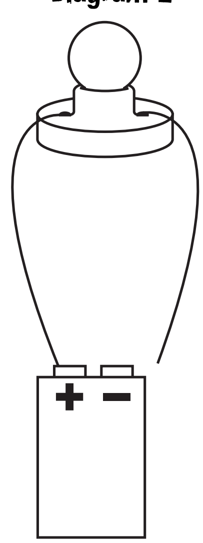


Diagram 2



Morse Code

In 1838, Samuel Morse developed a system of dots and dashes to translate messages to and from English. This system became known as "Morse Code." In 1840, he strung a line from Washington, D.C to Baltimore, Maryland and sent the message "What hath God wrought?" to demonstrate that his telegraph and Morse Code would work. He was successful, and soon telegraph lines were strung across the country. The chart below is a Morse Code conversion chart for you to use in writing and decoding your messages.

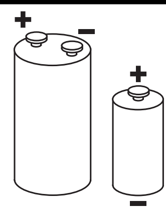
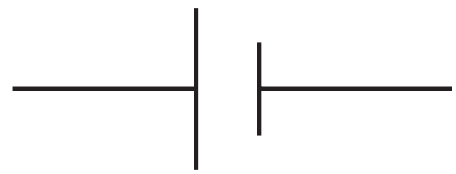
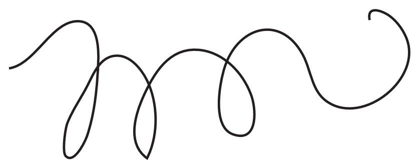
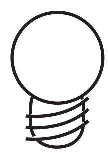
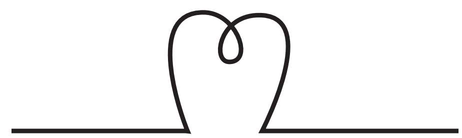
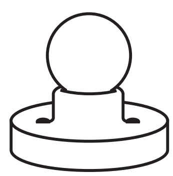
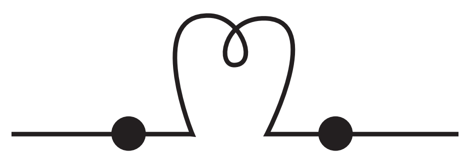
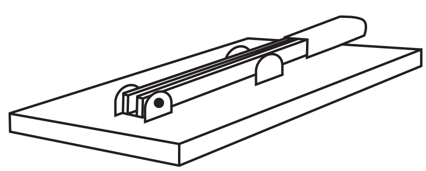
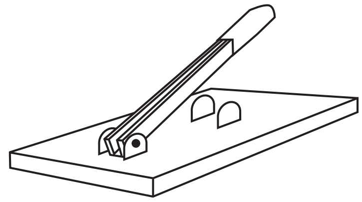
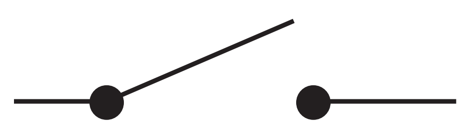
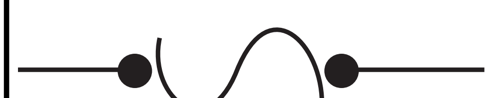
A • –
B – • • •
C – • – •
D – • •
E •
F • • – •
G – – •
H • • • •
I • •
J • – – –
K – • –
L • – • •
M – –
N – •
O – – –
P • – – •
Q – – • –
R • – •
S • • •

T –
U • • –
V • • • –
W • – –
X – • • –
Y – • – –
Z – – • •

1 • – – – –
2 • • – – –
3 • • • – –
4 • • • • –
5 • • • • •
6 – • • • •
7 – – • • •
8 – – – • •
9 – – – - • •
0 – – – – –

Drawing Circuits

Many electricians and electrical engineers use a symbolic language called a schematic to draw a circuit. The chart below shows some schematic symbols commonly used in electricity experiments. Use these symbols to draw several different circuits and then try building the circuits to match.

Component	Picture Schematic	Lamp (bulb)
Dry Cell		
Wire		
Lamp Bulb		
Lamp Bulb in Socket		
Switch (open)		
Switch (closed)		
Fuse		

Switch, Switching, Switches

Purpose

Students will discover how a switch works to open and close circuits.

Background

The students will be making and testing four different types of switches. They will make the four switches but will have only one battery setup. If possible, it would be ideal for all four switches to have their own battery. You may wish to have each group build a different type of switch and then demonstrate and discuss their design.

Materials

4.5-volt battery
lamp
lamp holder
3 pieces of insulated wire 30 cm long with 2 cm stripped from each end.
4-5 paper clips
2 strips of tinfoil approximately 3 cm X 10 cm each
2 thumbtacks
1 thin strip of copper approximately 3 cm X 12 cm
1 thin strip of copper approximately 3 cm X 5 cm
3 pieces of balsa wood approximately 5 cm X 10 cm
1 piece of cardstock approximately 5 cm X 20 cm
pliers
slice of cork
2 alligator clips
lead pencil split open to reveal the lead center (ADULT—soak pencil in water and slice it down the middle using a sharp knife.)
tape
glue

Procedure

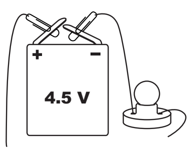


Diagram 1

Battery Setup

1. Attach a paper clip to one end of a wire and then attach the paper clip to the positive terminal of the battery.
2. Repeat with second wire, attaching paper clip to the negative terminal of the battery. Attach the other end to the lamp holder.
3. Attach third wire to the other connector on the lamp holder. See diagram 1.

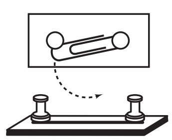


Diagram 2

Simple Switch

1. Place a paper clip in the center of one of the pieces of balsa wood.
2. Push a thumbtack into an open end of the paper clip to hold it in place, and place the other thumbtack at the edge of the other end of the paper clip. Do not place it inside the open end. It should be able to slide back and forth. See diagram 2.
3. Attach the end of the wire from the positive terminal to one of the thumbtacks and then attach the end of the wire from the lamp holder to the other thumbtack. See diagram 3.
4. Slide the "switch" (paper clip) away from the thumbtack to open the circuit and then slide it so that it touches the thumbtack to close the circuit. Record your observations in your science journal.

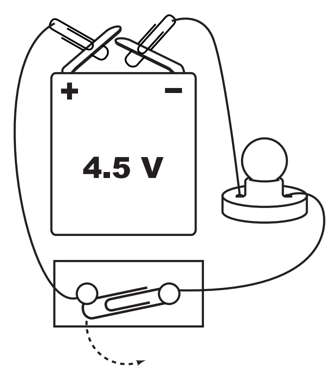


Diagram 3

Pressure Switch

1. Fold the cardboard in half.
2. Wrap one strip of foil around the middle of one side of the folded cardboard. Repeat with the other strip of foil for the other side of the cardboard. Strips must meet when pressed together. You may use a small piece of tape to hold foil in place. See diagram 4.
3. Tape the end of the wire from the positive terminal to one side of the cardboard on the outside.
4. Tape the end of the other wire from the negative terminal to the other piece of cardboard on the outside. See diagram 5.
5. Press the cardboard so that the strips touch to create a closed circuit. Observe the lamp. Record your observations in your science journal.

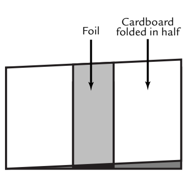


Diagram 4

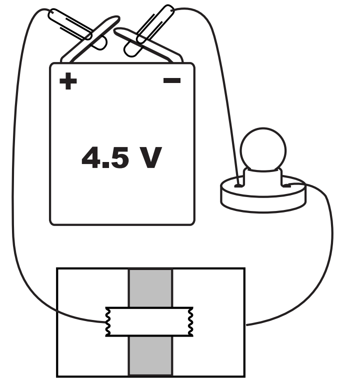


Diagram 5

Switch, Switching, Switches (continued)

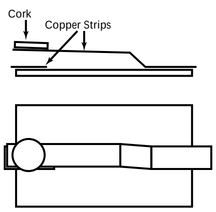


Diagram 6

Tapper Switch

1. Glue the short strip of copper to one end of the balsa wood so that it hangs over the edge a little.
2. Using pliers, bend the long strip of copper to match the shape in diagram 6 and glue into place.
3. Glue a slice of cork to the top of the straight end of the long copper strip.
4. After the glue has dried, attach the end of the wire from the positive terminal to the bent end of the long copper strip.
5. Attach the other paper clip to the end of the short copper strip. See diagram 7.
6. Press the cork so that the copper strips touch and close to form a closed circuit. Observe the lamp and record observations in your science journal.

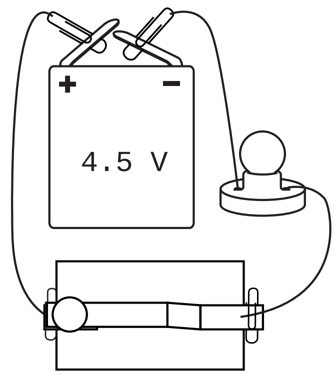


Diagram 7

Dimmer Switch

1. On the battery setup, attach alligator clips to the ends that will be attached to the switch. See diagram 8.
2. Lay the opened pencil on a piece of balsa wood. Attach the alligator clips to opposite ends of the pencil lead.
3. Gradually slide one clip toward the other and observe what happens. Record observations in science journal.

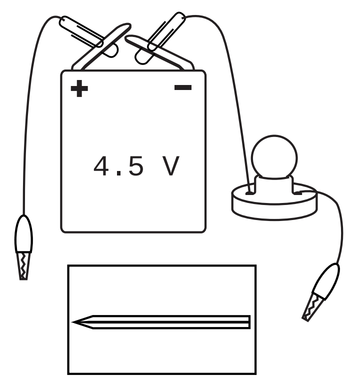


Diagram 8

Conclusion

1. What is an open circuit? A closed circuit? ________________

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2. Why did the lamp light only during a closed circuit? ________

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3. Was there a closed or open circuit in the dimmer switch? Explain what happened as you slid the alligator clips toward each other and tell why. ________________________

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Teacher Background

In a simple switch, the current will flow through the circuit when the circuit is on (closed) and will stop when it is off (open). This is a simple on/off switch that is common in all households and on most appliances. The pressure switch is a type of switch used to make a doorbell ring. Aluminum acts as a conductor; therefore, when the foil strips touch, they complete the circuit and cause the lamp to become lit. A tapper switch is the type of switch used by Morse Code operators. The operator has control over the length of time the circuit is open or closed. When the two copper strips touch, they complete the circuit and will return automatically to the open position (off) when not in use. In the dimmer switch, electricity can pass through the graphite, but not easily. Graphite is a resistor that offers a resistance to the electric current. The farther away the alligator clips are from each other, the more resistance and the dimmer the lamp. The closer the clips come to each other, the less resistance and the brighter the lamp.

Answer Key

Light the Bulb
1. yes
2. no
3. yes
4. no
5. yes
6. no

Series Circuits
2. Answers will vary.
4. The brightness of the lamp decreased.
5. The lamp went out.
7. The brightness of the lamp increased.
8. Answers will vary.

Parallel Circuits
2. Answers will vary.
4. The brightness of the lamp stayed the same.
5. It stayed lit.
7. The brightness of the lamps stayed the same.

Conductors and Insulators
1. Objects that are conductors are made from metal.
2. Metal is a conductor of electricity.
3. Answers will vary.
4. Answers will vary.

Switch, Switching, Switches
1. An open circuit is a circuit with a break in it.
2. A lamp lit only during a closed circuit because the current can only flow in a closed circuit. If the circuit has a break in it, the current would be unable to reach the bulb or return to the battery.
3. Closed circuit. Graphite is a conductor of electricity. However, it does not pass easily; therefore, we say it is a resistor. The farther away the alligator clips are from each other, the more resistance and the dimmer the lamp. The closer they are to each other, the brighter the lamp.