Electricity

Preparation

Grade Level: 3-6	Group Size: 20-30
Time: 45-60 Minutes	Presenters: 3-5

Objectives

This lesson will enable students to:

- Observe and explain the effects of a magnetic field
- Build a simple compass
- Observe positive and negative charges
- Create static electricity
- Conduct electricity using a lemon battery
- Build a circuit
- Build and identify series and parallel circuits

Standards

This lesson aligns with the following National Science Content Standards:

- Science as Inquiry, K-4
- Physical Science, K-4

Materials

Introduction

- "Electricity" PowerPoint slides – http://www.micron.com/k12/resources.aspx
- 1 liter clear soda bottle
- 2-3 feet of surgical tubing (small diameter)
- Soda bottle top with hole drilled slightly smaller than the surgical tubing
- Shallow dish pan or bucket
- Food coloring
- Water

Magnet Experiments

- 4-6 pairs of magnets
- Clear plastic cup or paper plate
- Iron filings
- Needle
- Cork or Styrofoam cup bottom
- Shallow clear bowl or pie plate
- Spool of wire
- Battery holder with Fahnestock clips
- 4-inch galvanized nails
- D-cell battery
- Magnetite
- 1 box of small paperclips

Static Experiments

- Balloons
- Small bits of cut paper
- Scotch tape
- Matches or lighter
- Anti-static booties
- Memory devices

Lemon Battery Experiments

- Multimeter to measure voltage
- 6 alligator clips
- 2-4 lemons or other citrus fruit
- 4-inch galvanized nails
- Copper wire
- "Lemon Battery Data Sheet" – Appendix A
- "Lemon Battery Answer Key" – Appendix B

Circuit Experiments

- 1 D-cell battery for each pair of students
- 1 small bulb for each pair of students
- 1 small bulb socket for each pair of students
- Battery holder with Fahnestock clips for each pair of students
- 6-inch pieces of wire for each pair of students
- Electric buzzers or small motors

Preparation

Set up each of the stations with the necessary equipment. Request the teacher divide the class into four groups and assign one presenter to each group. At the end of the introduction have the class divide into the groups and go to the assigned station. The students will work at each station approximately 10 minutes and then will rotate to the next station

Introduction

Have all of the volunteers introduce themselves. Use the "Electricity" PowerPoint slides for the introduction. Slides are available at www.micron.com/k12/resources.aspx .

Today we are going to talk about electricity.

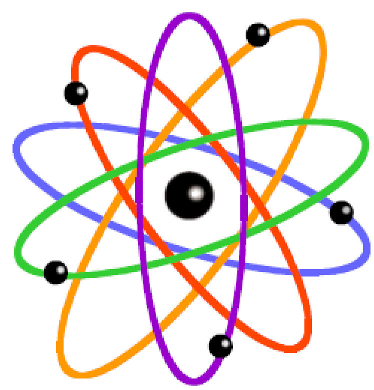
Q: What items in your classroom use electricity?
A: *Encourage participation. Answers will include the obvious like lights and the TV, but encourage them to think of things they might not realize use electricity such as the intercom for announcements, clock, bell, etc.*

Q: What happens when we have a bad storm and the power goes out?
A: *Answers will vary.*

Q: Do you know how electricity is made?
A: *Answers will vary.*

Today's lesson is about positive and negative charges and how to make electricity.

Q: Who knows what electricity is?
A: Electricity is the movement of electrons. Every single item in the whole world is made up of tiny, tiny things called atoms. Electrons are inside each of these tiny atoms circling around the nucleus.



Pull out one hair. Atoms are so small that it takes a million of them to stretch across the width of one hair.

Q: What type of a charge do electrons have?
A: Electrons have a negative charge. Most electrons stay inside their own atom, but sometimes they leave one atom and jump to the next. This is because the negative charge causes electrons to push away from or repel each other. The electrons then make a stream that runs from one atom to another. This stream is called an electric current.

Q: What do you think the word current means?
A: Current can be defined as to run or flow. You have probably observed water current in a river or stream. When electrons run or flow through conductive material it is known as an electric current.

Fill the clear bottle ¾ full with water, add blue food coloring, and assemble it with the tubing as shown.

Water Demonstration

To visualize the concept of electricity, electrons, and electric current, envision electrons as water. The water in the liter bottle represents electrons. Water movement through the tube represents the flow of electrons that is electrical current. You can also think of electrical current like the current of a river or a stream. What creates the current in a river or stream? What elements have to exist for the current to become more rapid or calm?

Hold the tubing higher than the bottle.

Q: Is the water coming out of the tube?
A: No.

Describe where the water is in the tube.

Q: What do I have to do to make the water move through the tubing?
A: Move the height of the tubing below the height of the water.

Q: Where would I hold the tubing to create a slow stream of water through the tubing?
A: Slightly below the level of the water in the bottle.

Q: Where would I hold the tubing to speed the flow and volume of water/electron flow?
A: Hold the tubing below the level of the water in the liter bottle.

Q: What are we comparing the flow of water to?
A: The flow of water is like the flow of electrons through conductive material.

Let's think about what is happening as we change the height of the tubing in relation to the level of the water in our bottle. As we raise the tubing higher we decrease the potential for the water (or electrons) to flow through the tubing. As we lower the tubing we increase the potential for flow. This change in potential relates to another electrical term called voltage.

Voltage is defined as the difference of electrical potential between two points of a conductor carrying a current.

Q: What does that mean?
A: For our example we know the current is the flow of water, which represents the flow of electrons. The difference of potential is then the difference between the height of the opening at the end of our tubing and the level of water in the bottle. When there is no difference between their heights or level there is no flow of water (or current). When there is a large difference, with the tube lower than the level of water, there is a maximum flow of water (or current). The difference between the water level in the bottle and the height of the tube represents the potential for the water to move or for the current to flow. When working with electrons, rather than water, this potential is called voltage. Voltage represents the amount of potential there is for electrons to flow.

We have been calling the flow of electrons the current. The amount of current flow is measured in amperes (amps). In our demonstration, amps can be likened to the measure of how much water moves through the tubing over time. One amp is equivalent to 6.24 million trillion ($6.24E^{18}$) electrons moving past one point in one second.

To summarize:

- Current is the flow of electrons through a conductor (water flowing through our tube in this demonstration).
- Voltage is the potential for a conductor to carry current (height of the tube in relation to the water level in the bottle).
- Amps measure the amount of current flow (how much water flows through our tube).

Some materials make good paths for electric current, and others block electric current.

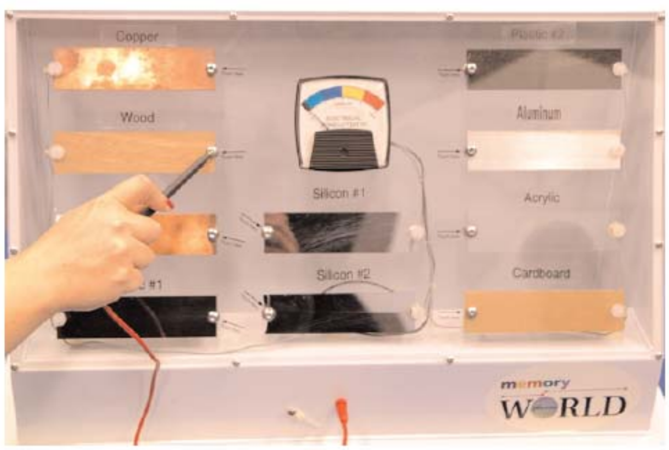
Q: Who knows what it means for a material to be conductive?
A: It means that current runs through the material easily. The electrons are loosely bound.

Q: In our demonstration what type of material would the tubing have to be if we wanted electricity to flow through it?
A: A conductive material.

Q. What are some examples of conductive materials?
A: *Help the students think of materials that transmit electric current.* Examples include: gold, copper, aluminum, and other metals.

Use the conductivity display. If you do not have access to Micron's conductivity display, collect a variety of conductive and insulator materials to share with students. If you have a multi-meter, you can measure the conductivity of these materials.

Q: What is the opposite of conductive? Who can give an example?
A: Insulators are the opposite of conductors. Insulators are materials that have tightly bound electrons, and electric current does not pass through them. Some examples are plastic, wood, rubber, glass, and cardboard.



Electricity exists naturally in static and magnets but we can also generate electricity through mechanical or chemical action. We'll show all three today in our experiment stations.

Magnets

Experiment with concepts of attraction and repulsion

Each magnet has a north pole and a south pole.

Q: What happens when like poles are positioned next to each other?
A: When two north poles or two south poles are placed together, they push away from each other or "repel," but when a north poles is put next to a south pole, they attract each other and stick together.

Allow the students to experiment with the magnets. Have students identify the north and south magnetic poles. Like poles will repel, and opposite poles will attract.

Observe the effects of a magnetic field using filings

Spread iron filings evenly on a paper plate. Move a magnet under the paper plate.

Q: Can the effect of a magnetic field be seen? If so, how?
A: Yes. The lines along which the filings arrange themselves are the lines of force of the magnetic field.

Important: Avoid contact with eyes and skin, as it may cause irritation. If filings get into eyes, wash with plenty of water for at least 15 minutes.

Place the filings in a clear plastic cup and run the magnet along the exterior of the cup to show another method of observing the force of the magnetic field.

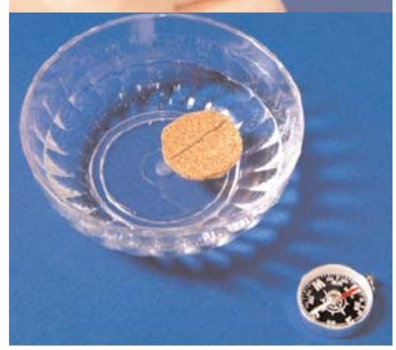
To allow for filings to be reused and eliminate the need to remove the filings from the magnets, do not place the magnets directly in the filings.

Build a simple compass

Q: How does a magnetic compass work?
A: The magnet, or needle, of the compass detects the magnetic field in the Earth's core, which is almost 4,000 miles from the surface. The Earth is nearly 8,000 miles in diameter. Because

the magnetic force has to travel so far, the magnetic field on the surface is fairly weak. For the field to be able to affect your compass, it's important to have a lightweight magnet (needle) and frictionless bearing (cork).

Note: Chinese historians date the discovery of the magnetic compass to 2634 B.C. The Chinese seem to have been the first people to discover that magnetism could be useful in navigation.



Step one: Turn the needle into a magnet by rubbing a magnet along the needle 10-20 times.

Step two: Fill a clear plastic dish ½ full of water, and place your float/cork in the middle of the dish of water.

Step three: Center your magnetic needle on the float. It will slowly point north.

Step four: Place a compass next to the dish of water.

Keep the compass and magnet separate from one another. If the two are placed together, the compass may become magnetized and always point north.

Step five: Check the compass you have made with one of the compasses in the kit. The two should both be pointing in nearly the same direction. NOTE: Do not place them too near to each other or the fields will interfere with each other.

Build an electromagnet

Magnets exist naturally. Lodestones or magnetite are naturally magnetic. However, we can also make magnets. All electrical fields have an associated magnetic field, so "artificial" magnets can be made using electricity. If an electrical current is passed through a coil of wire, the coil acts like a temporary magnet and is able to magnetize a bar of iron; the more loops made with the wire the stronger the magnetic field. Let's build one.

Step one: Wrap wire around the nail covering three fourths of the nail's surface area.

Step two: Insert the battery into the battery holder and attach each end of the wire into the Fahnestock clips.

Do not hold the wire to the battery with your hands. The connection between the wire and battery will become hot and may burn you.

Important: Do not hold the wire to the battery with your hands. The connection between the wire and battery will become hot and may burn you. It is suggested to hold the assembly as shown to avoid a mild burn.

Step three: Bring one end of the nail near a compass.

Step four: Observe the effect that the nail has on the compass. The nail has been transformed into a bar magnet or electromagnet. The magnet only exists when the current is flowing from the battery.

Step five: Test how many paperclips or thumbtacks the electromagnet will attract.

Step six: If time allows, repeat steps 1-5, increasing the number of wire wraps and compare the difference.

Q: What are some examples of electromagnetic uses?
A: Junkyards use huge electromagnets to lift large masses of metal. Power locks use electromagnets known as solenoids. A new type of space craft is currently being proposed that would be propelled through space by electro-magnetism.

Static Electricity

We are going to talk about static electricity. Before we describe what it is, let's talk about what it does.

Q: How you can tell if static electricity is around you?
A: *Encourage students to describe any experiences they may have had with static electricity such as their hair standing on end after they have brushed it a lot, or clothes clinging to their body when they have been dried in a dryer without conditioner, or shocking themselves when they shuffle across a carpet and touch a doorknob.*

Q: How is static electricity different from an electric current?
A: Static electricity is electrons that are transferred from one place to another rather than flowing in a current. If some of the electrons are transferred from one object to another by vigorous rubbing and separation, the other object becomes negatively charged while the object that loses electrons becomes positively charged. Remember, electrons are negatively charged particles. An electric field is set up around each object.

Unlike charges – one negative and one positive always attract each other; and like charges – both negative or both positive always repel each other. Rubbing or brushing creates a charge and, therefore, an electric field. The field affects objects nearby, producing an unlike charge in them, and the unlike charges are drawn together.

Generate Static Electricity Using Balloons

Give each student a balloon.

Step one: Blow up your balloon and tie off the end.

Give them time, helping those who need it.

Step two: Rub the balloon back and forth several time on your sleeve, pant leg, or hair and then touch the balloon to your hair.

Q: What happens when you do this?
A: The electrons come off your clothing onto the balloon and make it positively charged. The balloon then attracts your hair when it comes close to it because your hair is negatively charged. You need to rub the balloon on a synthetic material to create static electricity. Cotton

clothing or hair with conditioner will not give the desired results. Materials that are good generators of static are polar fleece, nylon, and polyester.

Static electricity will also pick up small particles.

Step four: Hold your static charged balloon over a pile of small bits of paper and observe how many pieces the balloon attracts.

Generate Static Electricity Using Scotch Tape

Step One: Take two strips of tape and place the non-adhesive sides together to show how they repel each other.

Q: What is happening with the tape?
A: The two pieces repel or push away from each other. When you pull the Scotch tape off of the roll, the piece that is torn off loses electrons, thus both pieces have a positive charge and repel each other.

Step Two: Give each student two strips of Scotch tape about 2-3 inches long and stick one on the index finger of the right hand, the other on the index finger of the left hand. Encourage the students to observe hot the two pieces of tape repel each other due to the positive charges on both pieces of tape.

Q: What do you think will happen to the charges when we run a flame between the two pieces of Scotch tape?
A: *Answers will vary.*

Adult volunteer only: Using a lighter, run a flame from top to bottom 3-4 inches from the opening created by the two pieces of tape.

Q: What's happening? What's causing it to happen?
A: The strips of tape start coming together. The open flame creates heat that generates positive and negative charges. As the gas molecules generated by the heat get near the tape, opposite charges are attracted to the tape

and neutralize the charge, causing the two tape pieces to be neutral and stop repelling one another.

Distribute memory devices

This is a memory device, which is what is made at Micron Technology. This device goes into computers, printers, cell phones, digital cameras, and many other applications that we use every day. Static electricity can ruin these devices while they are being fabricated because the device itself is made up of millions of electrical circuits. In order to avoid "killing" the device, our team members wear special garments that help ground the static they produce through movement.

Have students try on booties. Demonstrate how the grounding strap goes between the sock and shoe to ground the static charge.

Lemon Battery

The "Lemon Battery Data Sheet" Appendix A may be used for the experiments in this section.

Hold up an alkaline battery.

Q: How does a battery work?
A: Within a battery; a chemical reaction takes place between an electrolyte (such as a liquid acid or dry chemical) and electrodes. The electrodes are two different conducting materials, such as copper or zinc. Atoms from one conductor travel through the acid to the other conductor, releasing electrons. When all the mobile atoms have been transferred, and no additional electrons may be released, the battery is "dead."

Q: How many volts of electricity does a D cell battery generate?
A: 1.5 volts of electricity.

Measure the voltage of the alkaline D cell battery. The voltage measurement should be close to 1.5 volts if the battery is good.

Build a Lemon Battery

We are going to build a wet-cell battery like those used in cars, but the acid for our battery will be lemon juice.

It is recommended that an adult volunteer perform steps 1-3 when lemons are used for multiple station rotations. This prevents the lemons from becoming mush. Students can take turns attaching the wires between the electrodes and taking voltage (V) measurements.

Step one: Press down on the lemon and roll it on the table to get the juices flowing inside.

Step two: Insert the zinc electrode (nail) into the lemon so that approximately half of the electrode is still protruding out.

Step three: Insert the copper electrode in the same manner 3-5 centimeters from the zinc electrode. Ensure that the two are not touching.

Step four: Attach alligator clips to each electrode and then connect the alligator clips to the multi-meter.

Step five: Measure the voltage of the lemon battery.

The lemon battery voltage should measure approximately 0.90 volts.

Have the students compare the voltage of the lemon battery and the alkaline battery. Calculate the difference between the two.

Q: The voltage difference of the lemon battery and the alkaline battery is just a little over half a volt. Which battery do you think will last longer and why?
A: The alkaline battery will last longer because it is able to produce more moving electrons. The lemon battery can only produce voltage from 2 electrodes (the zinc and the copper). When the zinc electrode has plated the surface area of the copper electrode, the electrons will stop flowing.

Extension: Build a Series and Parallel Circuit Using a Lemon Battery

Q: How many kinds of circuits are there?
A: There are three kinds of circuits.

Q: Who knows what they are?
A: Simple, series, and parallel.

If students are unfamiliar with series and parallel circuits, ask the question below after you have built the two circuits.

Q: What is the difference between a series and parallel circuit?
A: In a series circuit, electricity has only one path to travel. In a parallel circuit, there is more than one path through which electricity can follow.

Coach students to build a series and a parallel circuit.

Build a Series Circuit

If you have just built a simple circuit, begin with step four and simply add on to your simple circuit. Three total alligator clips are used to wire the series circuit.

Step one: Press down on the lemon and roll it on the table to get the juices flowing inside.

Step two: Insert the zinc electrode (nail) into the lemon so that approximately half of the electrode is still protruding out.

Step three: Insert the copper electrode in the same manner 3-5 centimeters from the zinc electrode. Ensure that the two are not touching.

Step four: Add a second lemon and repeat steps 1-3.

Step five: Using an alligator clip, connect the zinc electrode in the first and second lemons with the copper electrode.

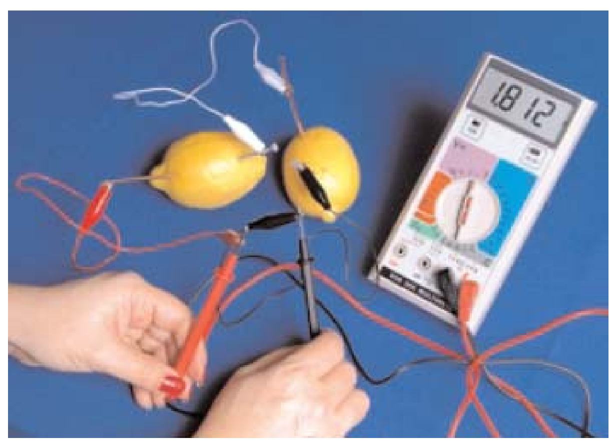
Step six: Attach an alligator clip to the copper electrode in the first lemon and connect the other end of the alligator clip to the multi-meter.

Step seven: Attach the third alligator clip to the zinc nail in the second lemon and connect the other end of the alligator clip to the remaining probe on the multimeter.

Have students use their fingers (held 1-2 inches above the wire) to trace the path of the series circuit.

Predict whether the series circuit will produce more voltage than the single circuit (initial lemon battery).

Q: How much voltage does the lemon battery produce when it is wired in series?
A: Approximately 1.8 volts.



Have students record the voltage generated by the series circuit.

Q: Why does the series circuit generate more voltage than the single circuit?
A: There is more electron movement when you have two lemons than when you have just one.

Q: What is an example of a series circuit in everyday life?
A: Some strands of Christmas lights are wired as a series circuit.

Q: What happens when the strand of lights is missing one light bulb?
A: The entire strand won't work because the electricity only has one path to travel and the current stops flowing when it hits the gap in the path caused by the missing light. It is for this reason that series circuits are not often used in everyday electrical applications.

Build a Parallel Circuit

If you have just built a series circuit, begin with step four and simply rewire your series circuit. The materials from the series circuit can be reused and then added onto. Four total alligator clips are used to wire the circuit in parallel.

Step one: Press down on the lemon and roll it on the table to get the juices flowing inside.

Step two: Insert the zinc electrode (nail) into the lemon so that approximately half of the electrode is still protruding out.

Step three: Insert the copper electrode in the same manner 3-5 centimeters from the zinc electrode. Ensure that the two are not touching.

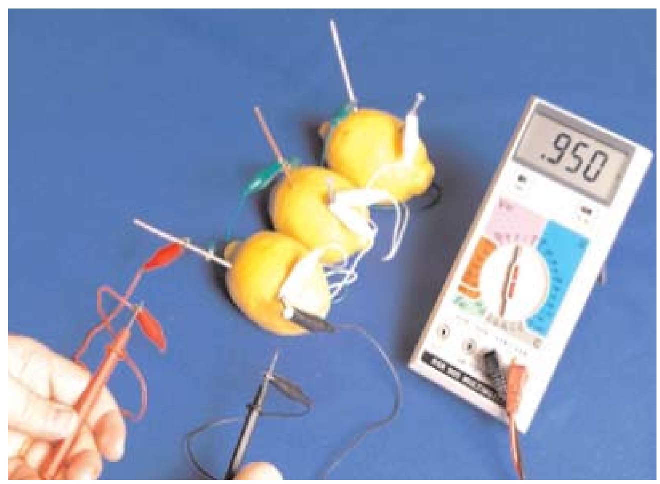
Step four: Add a second lemon and repeat steps 1-3.

Step five: Using an alligator clip, connect the copper electrode in the first lemon to the copper electrode in the second lemon.

Step six: Using another alligator clip, connect the zinc electrode in the first lemon to the zinc electrode in the second lemon.

Step seven: Attach the third alligator clip between the copper electrode of the second lemon and one probe of the multi-meter.

Step eight: Attach the fourth alligator clip between the zinc electrode of the second lemon and the remaining probe on the multi-meter.



Have students use their fingers (held 1-2 inches above the wire) to trace the path of the parallel circuit.

Predict whether the parallel circuit will generate more voltage than the series circuit and support your prediction with an explanation.

Q: How much voltage does the lemon battery that is wired in parallel generate?
A: 0.8 to 1.0 volts

Have students record the voltage generated by the parallel circuit.

The parallel circuit generates about the same voltage as the single circuit we initially built, but the circuit that is wired in parallel has the potential to increase the amount of electrical current that is generated without increasing the voltage. Each lemon has a limited number of electrons that can move. When we put the lemons in parallel (side by side) then there are twice as many electrons available to move, thus increasing the potential current that can be generated.

Q: Why does the parallel circuit generate less voltage than the series circuit?
A: In series, the voltages are additive. In parallel, the voltages are unaffected, but the current capability is increased.

Q: What are some examples of when parallel and series circuits are used?
A: Your house is wired in parallel. When you have two different lamps plugged into the same electrical outlet and turn one on, they do not both illuminate. Only the lamp that you turned on will light up. This is because your house is wired in parallel. If your home were wired in series and you turned on one light your whole house would light up!

Q: What do you think would happen if we added more lemons in series?
A: The voltage would increase.

Q: In parallel?
A: The current would increase but the voltage would not.

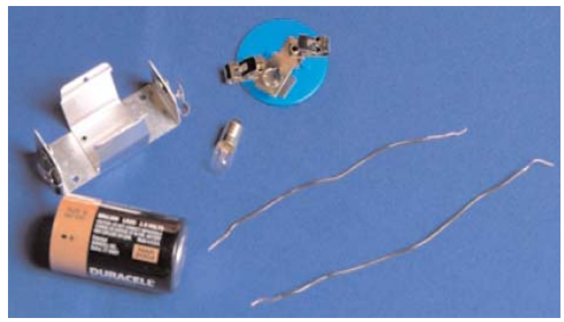
Q: What mathematic principle could we use to make an educated guess about what would happen without wiring more lemons?
A: Multiplication skills.

Circuits

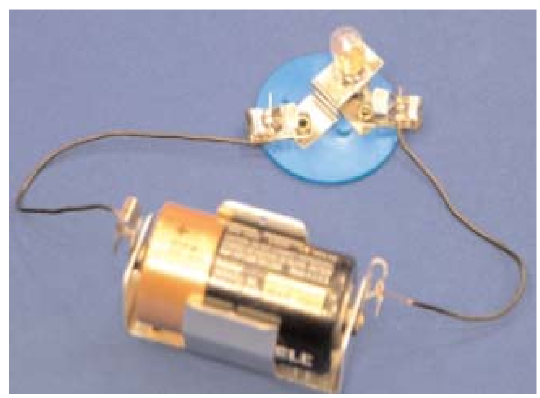
Build a simple circuit

Q: What is a simple circuit?
A: A complete path for electrons to travel from the negative side to the positive side of a battery. If the electric path along the wire is complete, the circuit is complete, and any device in the circuit will be turned on.

Divide the group into two teams. Give each team a set of materials: 1 D-cell battery, 1 bulb, 2 six-inch pieces of wire, 1 battery holder, and 1 bulb socket.



In teams, you are going to build a circuit and test it. If you are successful, the light bulb will illuminate. Take turns performing each step to involve everyone on your team. If the bulb does not illuminate, troubleshoot what the problem might be.

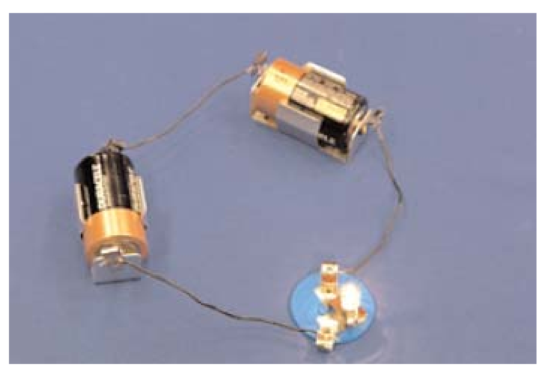


Step one: Insert the light bulb in the bulb socket.

Step two: Insert the battery in the battery holder.

Step three: Connect one wire end to the negative side of the battery holder and the other end to the bulb socket clip.

Step four: Connect one end of the second wire to the positive side of the battery holder and the other end to the remaining bulb socket clip.



Step five: Substitute the buzzer or small motor for the bulb socket.

Step six: Join teams and wire a series circuit and a parallel circuit by combining your materials. Is the bulb brighter, dimmer, or the same on the parallel circuit and the series circuit?

If time permits have one team build a parallel circuit and the other build a series circuit and compare the difference.

Troubleshooting:
Q: If the light does not illuminate, what can you check prior to assuming that the battery is dead?
A: Check that the wire path is making a good connection at all points. If so, check that the battery is good.

Lemon Battery Experiment Data Sheet

Name: ______________________________________

1. What is the voltage of the D cell battery? ______________________________________

2. Predict the number of volts that will be generated by the simple circuit lemon battery. ______ ______________________

3. What is the voltage generated by the simple circuit lemon battery? ______________________

Extension

5. What is the voltage generated when the lemon battery is wired in series using two lemons? ____________________________

6. What is the voltage generated when the lemon battery is wired in parallel using two lemons? __________________________________

7. Predict number of volts the parallel circuit will generate using two batteries. ______________ ________________

8. Predict the number of volts that will be generated by the series circuit using two batteries. __________________________________

9. Were your predictions accurate? Explain why or why not. _____________________________
____
____
____
____
____

Lemon Battery Experiment Answer Key

1. What is the voltage of the D cell battery? 1.5 volts

2. Predict the number of volts that will be generated by the simple circuit lemon battery.
   Answers will vary.

3. What is the voltage generated by the simple circuit lemon battery? Approximately 0.90 volts

Extension

4. What is the voltage generated when the lemon battery is wired in series using two lemons?
   Approximately 1.8 volts

5. What is the voltage generated when the lemon battery is wired in parallel using two lemons?
   O.8 to 1.0 volts

6. Predict number of volts the parallel circuit will generate using two batteries.
   Answers will vary.

7. Predict the number of volts that will be generated by the series circuit using two batteries.
   Answers will vary.

8. Were your predictions accurate? Explain why or why not.
   Answers will vary.