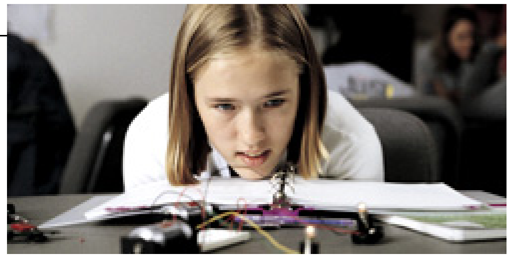
Session 4

Getting a Charge From Electricity

Engineering Fundamentals



In This Session:

A) Basic Electrical Concepts in a Flash (20 minutes)
- Student Handout

B) Turn it On and Off (60 Minutes)
- Student Handout
- Student Reading

C) Short Circuits (20 Minutes)
- Student Handout

D) Light-Emitting Diodes (50 Minutes)
- Student Handout

Home Improvement
- Student Handout

In this session, the students work in pairs to explore electricity basics. These pairs can remain the same throughout the session or change with each activity. *4A: Basic Electrical Concepts in a Flash* reviews simple circuitry using a common household item: a flashlight. You may find that some students have built circuits before, and this is a review. The goal is to prepare them for any electrical circuitry that they may need to incorporate into their own projects later. An extension to this activity involves looking inside a dissected lightbulb that is prepared in advance. This can be done with a demonstration, in small groups, or may be skipped if you don't have enough time.

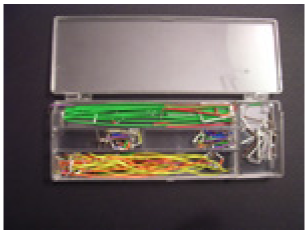
In *4B: Turn It On and Off*, students learn the differences between a simple, series, and parallel circuit. Here, they are introduced to using breadboards. They wire circuits on the breadboards with switches and buzzers (optional). In *4C: Short Circuits*, students learn about short circuits and the relationship between resistance and the current. An optional activity teaches them how to prevent a short circuit by making a fuse. In *4D: Light-Emitting Diodes*, students make their favorite numbers light up with an LED display. With each activity in this session, the students learn different electrical symbols and use the symbols in drawing diagrams. *Electric House Hunt*, the Home Improvement activity, entails having the students look at their own house from an electrical perspective.

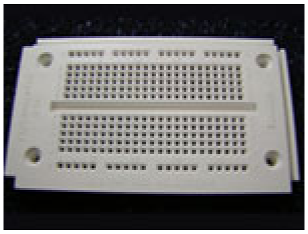
Supplies

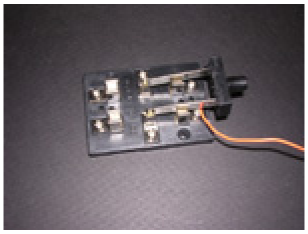
For Each Pair of Students
- 1 flashlight with batteries (preferably "D" size)
- 1 wire kit
- 1 wire cutters
- 1 breadboard (experimenter socket)
- 1 switch (knife switch)
- 1 mini buzzer (3VDC)
- 1 small screwdriver
- 1 rectangular piece of aluminum foil about 1 inch by 2 inches (2.5 cm x 5 cm)
- 1 LED number display (0.3 inches (8mm) LED number display)

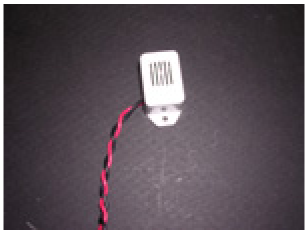
Session 4, Getting a Charge From Electricity (continued)

- 1 blinking 2.8 volt LED
- Gloves for each student
- Safety goggles for each student


Wire kit


Breadboard


Switch


Mini buzzer

Two Per Pair of Students

- Screw-base lamps (2.47 volts
- Miniature lamp holders (for E-10 screw-base lamp with screw terminals)
- "D" size batteries (may be taken from flashlights)
- "D" size battery holders


Bulbs and bulb holders


"D" size batteries and holder

For Demonstration

- A few household clear lightbulbs

Getting a Charge From Electricity

Key Concepts: Session 4

In Session 4, students get a hands-on experience with wiring **electrical circuits** of various kinds and purposes in order to better understand how electrical devices work.

Key Concepts
All matter is electrical. Every atom of matter has a positive nucleus surrounded by negatively charged electrons. Depending on the material, electrons are somewhat free to move. Electricity is the result of the stationary and moving charges of protons and electrons. Sometimes electrons can be rubbed from one surface to another where they build up as static electricity; this accumulated electric charge releases as a spark, as when you separate a sweater from socks that have tumbled in the dryer. An electrical charge can also move through matter such as metal wires. The flow of charge is electric current.

Circuit
A circuit is a complete path for electrons to flow through. The electrons flow from the negative terminal of a battery through wires connected to devices that convert electric energy into other forms such as light or sound components. A circuit must have a complete path for the electricity to begin flowing from the negative terminal to the positive terminal of a battery.

Conductor
A conductor is a material (usually a metal, such as copper) that allows electrical current to pass easily through. This is opposed to an insulator (such as plastic coating around wires), which prevents the flow of electricity through it.

Series Circuit
A series circuit is wired with only one path for the current to flow through all the devices in a row and back to the starting point. The same current flows through each part of a series circuit. If the circuit is broken at any point then no current will flow. For example, if this circuit were a string of light bulbs, and one burned out, the remaining bulbs would also turn off.

Parallel Circuit
A parallel circuit is one that has two or more paths for the electricity to flow. It is like a river that has been divided up into smaller streams, but all the streams come back to the same point to form the river once again. For example, if the loads in a circuit were light bulbs and one burned out, the other bulbs would remain lit. Current continues to flow to the other light bulbs because there is still a complete circuit from the negative to positive terminals of the battery.

Measuring Electricity
Volts, amps, and watts measure electricity. Volts measure the "pressure" under which electricity flows. Amps measure the amount of electric current. Watts measure the amount of work done by a certain amount of current at a certain pressure or voltage. The relationship of these measurements can be thought of as water in a hose. Turning on the faucet supplies the force, which is like the voltage. The amount of water moving through the hose is like the electrical current, known as amperage. You would use lots of water that comes out really hard (like a lot of volts) to wash off a muddy car. You would use less water that comes out more slowly (like

Key Concepts Session 4 (continued)

less volts) to fill a glass. The total water used in each would be like measuring the watts or power needed. A multimeter is an instrument that can be used to measure voltage, resistance, or current across an element in an electrical circuit.

1 watt = 1 amp multiplied by 1 volt
1 amp = 1 watt divided by 1 volt

Ohm's Law
Ohm's Law is the relationship between current, voltage, and resistance. It was named after the German physicist George Simon Ohm (1787-1854). He determined that:

Current (amps) = Voltage (volts) / Resistance (Ohms)

This relationship is used in designing any electric device, such as a toaster. In the U.S., electricity is supplied to household outlets at 110 volts. As with any heating element that gets hot when current flows, a toaster has high resistance of 10 ohms. Using Ohm's law and dividing voltage (110 volts) by resistance (10 ohms), a toaster needs 11 amps of current flowing through it. (This is way above the amount of current that the "D" cell batteries used in this session can supply—1.5 amps.)

Breadboard
The electronic breadboard provides a quick means for temporarily connecting circuits. A breadboard has numerous holes into which wires attached to electrical components may be inserted. The holes are conductive sockets, some of which are connected internally. A breadboard is set up with rows and columns. The two long sets of holes along the outside (called channels) are connected. Within each of the two columns down the center of the breadboard, there are two sets of five holes. Each set of five holes in the middle of the board is connected, but the sets of holes are not connected to each other. It is easiest to use 22-gauge wire when wiring a breadboard. It is helpful to get as many colors of insulated wire as possible. The different colors help with organization—it is easier to see what goes where, and different colored wires can be used for different purposes.

Short Circuit and Fuses
In your standard household outlet, there is a wire that brings the electricity. This is called the hot wire. There is another wire, called the neutral wire, that allows the electric current to flow back. A third opportunity to carry electricity is called the "ground." It is either a bare wire or a metal wrapping for the other two wires. The metal wrapping is called sheathing. It usually doesn't carry electricity. Its sole purpose is to carry electricity during an emergency back to the ground. If a hot wire becomes loose at some metal electrical box (such as an outlet box, a switch box, or a junction box, where several wires meet and are connected), and touches the box that is grounded, the electricity will be able to flow with no resistance. This is called a short

Key Concepts Session 4 (continued)

circuit and will often result in more electricity flowing than the wires are supposed to permit. The wires may become very hot, and if the box is shaken, then sparks may fly where the wire touches the box. This could potentially start a fire. To prevent this from happening, a special kind of switch called a circuit breaker or fuse will trip or blow, and no electricity will flow to the circuit. The circuit breaker or fuse is a safety device that stops the flow of electricity before it enters the hot wire.

Switches
The lever you flip is attached to a metal piece that can move so that it makes a break in the circuit, preventing electricity from flowing through until you flip it back.

Diodes
Diodes are small one-way valves for electrical current. Diodes permit current flow in one direction and not in the opposite direction. A diode has two electrodes, called the anode and the cathode.

LED
LEDs, or light-emitting diodes, are diodes that emit light of one form or another. They are used as indicator devices. For example, an LED may light to indicate that a machine is on. They are useful because they have a low power requirement, are highly efficient, and have a long life. They come in several sizes and colors. An LED consists of two elements of processed material called P-type semiconductors and N-type semiconductors. These two elements are placed in direct contact, forming a region called the P-N junction. Integrated circuits (ICs) are complex circuits inside one simple package. LED displays are packages of many LEDs arranged in a pattern. The most familiar, and the one used in Session 4, is the 7-segment display for showing numbers (0-9). This is available in two versions: common anodes with all the LED anodes connected together and common cathodes with all the cathodes connected together. An LED passes current only when the cathode is negative with respect to the anode.

More About Electricity
Electricity Online, library.thinkquest.org*.
This Web site includes thorough lessons with animated demonstrations for student understanding of the theory and practical applications of electricity.

Rapid Electronics, www.rapidelectronics.co.uk*.
This is a good place to see pictures of electronic components.

Science Hobbyist, www.amasci.com/elect/elefaq.html*.
Find answers to frequently asked electricity questions at this site.

Institute of Electrical and Electronic Engineering, www.ieee.org/organizations/eab/precollege*.
This is a pre-college education site.

Session 4, Activity A

Basic Electrical Concepts in a Flash

Goal
Become familiar with electronic basics (a simple circuit) and what an electrical engineer does.

Outcome
Students can make and diagram a basic circuit.

Description
Students deconstruct a flashlight in order to learn how to build and diagram a simple circuit.

Supplies
For Each Pair of Students

- Flashlight with batteries (preferably "D" size), wire kit
- Gloves
- Safety goggles

Optional lightbulb dissection (for the facilitator): a few household clear lightbulbs, wire cutters

Safety Guidelines
Each student should have gloves and safety goggles to be worn throughout Session 4.

Preparation
For optional bulb dissection: Prepare a few dissected bulbs to hand out for observation. Using the wire cutters, make little snips around the base of the bulb. Cut all the way around the base just above the ceramic insulator and carefully pull the base off.

Procedures
Debrief Home Improvement

Discuss the materials that students found in their homes from the Home Improvement in Session 3.

Introduce Session

Explain that the purpose of this session is to help students learn basic electricity and electronics, something they may need in their designs.

A Flashlight

A flashlight offers an excellent tool to begin exploring electrical engineering concepts. Begin by discussing the purposes of a flashlight. Ask students to consider how these needs are met by

4A: Basic Electrical Concepts in a Flash (continued)

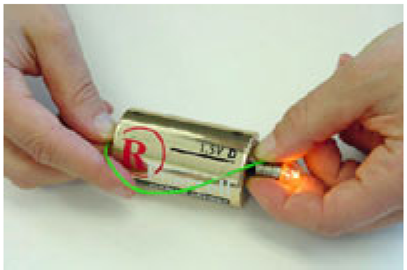
the design of a flashlight. Discuss the difference between necessary (such as the bulb) and useful (such as protective cover over bulb) parts of a flashlight.

A Circuit

1. Distribute one flashlight to each pair of students. Have students look at the flashlight and consider how it works.

2. Instruct students to take the flashlight apart to see how it works. Have them take out the bulb and batteries.

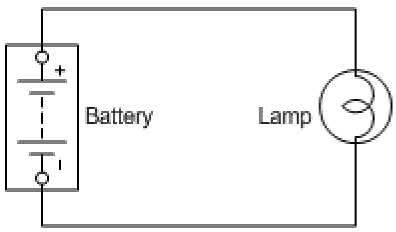
3. Hand out one wire to each group. Explain that they should make the lightbulb light using only one battery, the bulb, and the wire.



Circuitry Diagramming

1. Introduce the symbols for wire, battery, and lamp (see handout).

2. Ask the students to draw a diagram using the symbols of how they made their bulb light.

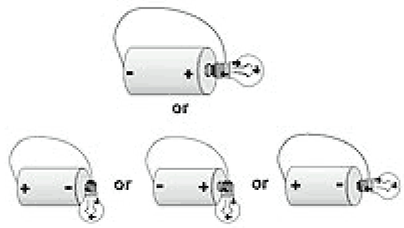


Simple circuit

3. Discuss what was necessary to light the bulb. (The wire had to go from one end of the battery to either the side or bottom of the bulb. Whichever bulb part, side or bottom, wasn't touching the wire had to touch the other end of the battery.)

4A: Basic Electrical Concepts in a Flash (continued)

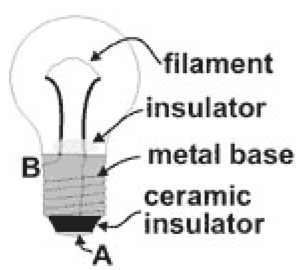
4. Explain that this is called a "circuit," which must have a source of electrons (battery) and a way for the electrons to flow from and back to that source. An easy way to understand a circuit is to think of it as a "circle." Define simple circuit: A combination of elements or components that are connected to provide paths for electrical current flow to perform some useful function.



5. Define an electric current: subatomic particles called electrons flowing through wires and electronic components. It is similar to the flow of water through pipes. Just as water is pushed through pipes by a pump, electric current is pushed through wires by a battery. In an electric current, like charges repel and unlike attract. That is, two negatives will repel each other; a negative and a positive will attract each other.

Optional Extension Activity: Bulb Dissection Demonstration

1. Distribute dissected lightbulbs. Have the students look inside the dissected bulb. In many bulbs, it is possible to see how one end of the filament is connected to the bottom of the bulb (A) and is connected to the side (B). In some bulbs, however, you may only be able to see the weld mark on the side of the bulb.



2. Looking inside the bulb, discuss how the bulb works. The current from the battery flows from one side of the metal side through the wire up to the filament. The filament is a very thin piece of wire that produces light and heat when an electrical current runs through it. The filament goes back down through the insulator (the little glass ball that holds the two wires apart) and down to the bottom of the bulb.

4A: Basic Electrical Concepts in a Flash (continued)

Wrap Up
Have students share their diagrams and discuss what challenges they faced when making a circuit.

Ask them if any ideas for design opportunities (needs, problems, or improvements) occurred to them today. They can add these to their list.

Optional: Read and discuss *4A Reading: What Do Engineers Do?*

Follow With
In *4B: Turn It On and Off*, students gain an understanding of the different types of circuits.

Basic Electrical Concepts in a Flash

Handout: Session 4, Activity A

Who invented the flashlight? It all started with an idea to light up a flower pot. Joshua Lionel Crown invented a flower pot that would light up when a button was pressed. However, it didn't sell. In 1898, he sold the idea to his salesman, Conrad Hubart, a Russian immigrant. Hubart took parts of the flower pot idea and turned them into an "electric hand torch." Because the bulbs and the batteries weren't very powerful, the torch gave only a "flash" of light. The company became the American Ever-Ready Company. Although Hubart arrived from Russia with no money, he died in 1928 with an estate worth over $15 million. Ever since then the company has kept going and going and going...

Directions

You should have a flashlight and some wire in front of you. A flashlight is a great way to understand how a simple circuit works. Take the flashlight apart and try to make the lightbulb light with a battery and a wire. This is called a simple circuit. Do the following activities and record your results in your design notebook.

Symbols

1. Draw a diagram of the circuit to show how you made the bulb light. Use the symbols above.

2. What additional features do you think would make a flashlight better or more useful? What would this flashlight look like? (Draw a sketch.)

What Do Engineers Do?

Reading: Session 4, Activity A

Engineers help to design and manufacture just about everything—from the tallest skyscrapers to the smallest computer chips, from cars to space shuttles, from miracle fabrics to artificial heart valves. Even though their efforts are all around us, the work of engineers can seem like a mystery to those outside the profession.

"You grow up knowing what teachers and doctors and lawyers do. But unless your parents happen to be engineers, you probably don't have a clue what their work involves," says a woman who grew up to be a successful environmental engineer.

What do engineers really do? Let's take a look.

Types of Engineering: The "Big Four"
In the most general terms, engineers are problem-solvers. They apply the concepts of mathematics and science to solving real-world challenges.

The engineering profession includes many different disciplines. In fact, engineering may offer more career options than any other profession. Engineers are a diverse group, contributing to projects that improve the quality of life on every continent. A background in engineering can also lead to a career in law, education, medicine, or public policy.

Here's a look at four of the largest categories within the profession: chemical engineering, civil engineering, electrical and computer engineering, and mechanical engineering.

Chemical Engineering
Take a walk through your grocery store, pharmacy, or paint store, and you'll see hundreds of examples of what chemical engineers create. Chemical engineers combine the science of chemistry with the principles of engineering to produce better plastics, fuels, fibers, semiconductors, medicines, building materials, cosmetics, and much more. Their know-how has helped to develop reduced-calorie sweeteners, lead-free paint, fibers that can withstand the heat of forest fires, and thousands of other products.

Chemical engineers work in a variety of settings, from research laboratories to food-processing plants to pharmaceutical companies. They tackle challenges relating to agriculture, environmental pollution, and energy production. Sometimes they even work at the molecular level to create brand-new synthetic materials.

Interested in the field of chemical engineering? Visit the American Institute of Chemical Engineers (AIChE) (www.aiche.org*) to learn how a chemical engineering background can prepare you for a career in manufacturing, research, biomedicine, quality control, law, sales and marketing, and related fields.

Civil Engineering
Civil engineers help to create the building blocks of modern society. From dams and highways to bridges and buildings, the products of civil engineering are all around us. Civil engineers

4A Reading: What Do Engineers Do? (continued)

belong to one of the oldest and largest branches of engineering. They use cutting-edge technologies and advanced materials to solve challenges in new ways.

A background in civil engineering opens the door to a variety of career options. According to the American Society of Civil Engineers, areas of focus include construction engineering, environmental engineering, geotechnical engineering, structural engineering, as well as transportation, urban planning, and water resources.

Interested in the field of civil engineering? Visit the American Society of Civil Engineers (ASCE), (www.asce.org*.)Also visit Manufacturing Is Cool!,(www.manufacturingiscool.com/cgi-bin/mfgcoolhtml.pl?/home.html*,) a K-12 site developed by the Society of Manufacturing Engineers which offers curriculum, displays, and resources.

Electrical and Computer Engineering
Electrical engineering has been one of the fastest-growing fields in recent decades, as breakthroughs in technology have led to rapid advancements in computing, medical imaging, telecommunications, fiber optics, and related fields.

Electrical engineers work with electricity in all its forms, from tiny electrons to large-scale magnetic fields. They apply scientific knowledge of electricity, magnetism, and light to solving problems that relate to cell phones, computer software, electronic music, radio and television broadcasting, air and space travel, and a wide range of other areas. According to the Institute of Electrical and Electronics Engineers, a background in electrical or computer engineering can lead to a career in aerospace, bioengineering, telecommunications, power, semiconductors, manufacturing, transportation, or related fields.

Electrical engineers often work in teams with other specialists to develop sophisticated devices such as lasers to use in medical treatments, or robots that can perform complex operations in space. In addition to technical expertise, engineers contribute problem-solving skills and interpersonal communications to successful team projects.

To find out more about the fields relating to electrical engineering, visit the Institute of Electrical and Electronics Engineers (IEEE), (www.ieee.org*.)

Mechanical Engineering
Mechanical engineers turn energy into power and motion. What does that mean? "Anything that moves or uses power, there's a mechanical engineer involved in designing it," explains a member of this large branch of engineering.

Mechanical engineers work in all areas of manufacturing, designing automobiles or sporting goods, water treatment facilities or ocean-going ships. In a field like biomechanics, their expertise can improve the quality of life by designing artificial joints or mechanical heart valves.

Interested in the field of mechanical engineering? Find out more about mechanical engineering from the American Society of Mechanical Engineers (ASME), (www.asme.org*).

4A Reading: What Do Engineers Do? (continued)

Other Engineering Disciplines

Aeronautical and Aerospace Engineering
Aircraft, space vehicles, satellites, missiles, and rockets are some of the projects that are developed by aeronautical and aerospace engineers. They get involved in testing new materials, engines, body shapes, and structures that increase speed and strength of a flying vehicle.

Aerospace engineers work in commercial aviation, national defense, and space exploration. Some engineers work in labs testing aircraft, while others investigate system failures such as crashes to determine the cause and prevent future accidents. They are specialists in fields such as aerodynamics, propulsion, navigation, flight testing, and more.

Agricultural Engineering
Agricultural engineers work with farmers, agricultural businesses, and conservation organizations to develop solutions to problems relating to the use and conservation of land, rivers, and forests. They look for solutions to problems such as soil erosion. They also develop new ways of harvesting crops and improving livestock and crop production.

Agricultural engineers also design and build equipment, machinery, and buildings that are important in the production and processing of food, fiber, and timber. For example, they might design specialized greenhouses to protect and grow exotic plants such as orchids.

For more information about agricultural engineering, visit the American Society of Agricultural Engineers, (www.asae.org*.)

Biomedical Engineering
Biomedical engineers, or bioengineers, use engineering principles to solve complex medical problems in health care and medical services. They work with doctors and medical scientists to develop and apply the latest technologies, such as microcomputers, electronics, and lasers.

Biomedical engineers might develop biomaterials to speed tissue repair in burn victims, or design medical devices that aid doctors in surgery. They might help to build bionic legs, arms, or hands to improve the lives of accident victims.

The biomedical field is changing rapidly as new technologies emerge. Bioengineers work in hospitals, government agencies, medical device companies, research labs, universities, and corporations. Many biomedical engineers have degrees in chemical or electrical engineering, and some go to medical school.

To find out more about biomedical engineering, visit the Biomedical Engineering Society (BMES), (www.bmes.org*.)

Environmental Engineering
Environmental engineers develop methods to solve problems related to the environment. They assist with the development of water distribution systems, recycling methods, sewage treatment

plants, and other pollution prevention and control systems. Environmental engineers often conduct hazardous-waste management evaluations to offer solutions for treatment and containment of hazardous waste. Environmental engineers work locally and globally. They study and attempt to minimize the effects of acid rain, global warming, automobile emissions, and ozone depletion.

To learn more about the work of environmental engineers, visit the American Academy of Environmental Engineers, (www.aaee.net*.)

Industrial Engineering
Industrial engineers make things work better, more safely, and more economical. They often work in manufacturing—dealing with design and management, quality control, and the human factors of engineering. They are problem-solvers who analyze and evaluate methods of production and ways to improve the methods. Based on their evaluation, they may determine how a company should allocate its resources.

Interested in the field of industrial engineering? To find out more, visit the Institute of Industrial engineers, (www.iienet.org*.)

Materials Engineering
Materials engineers work with plastics, metals, ceramics, semiconductors, and composites to make products. They develop new materials from raw materials and improve upon existing materials. Whether it's creating higher performance skis or a biodegradable coffee cup, materials engineers can be found applying their expertise.

Materials engineers specializing in metals are metallurgical engineers, while those specializing in ceramics are ceramic engineers. Metallurgical engineers extract and refine metals from ores, process metals into products, and improve upon metalworking processes. Ceramic engineers develop ceramic materials and the processes for making ceramic materials into useful products. Ceramic engineers work on products as diverse as glassware, automobile and aircraft engine components, fiber-optic communication lines, tile, and electric insulators.

Mining Engineering
Mining engineers figure out how to get valuable resources out of the ground. Along with geologists, they locate, remove, and appraise minerals they find in the earth. Mining engineers plan, design, and operate profitable mines. They are also responsible for protecting and restoring the land during and after a mining project so that it may be used for other purposes.

For more information about mining engineering, visit the Society for Mining, Metallurgy, and Exploration Inc., (www.smenet.org*.)

Nuclear Engineering
Nuclear engineers research and develop methods and instruments that use nuclear energy and radiation. They may work at nuclear power plants and be responsible for the safe disposal of nuclear waste. Some nuclear engineers specialize in the development of nuclear power for

4A Reading: What Do Engineers Do? (continued)

spacecraft; others find industrial and medical uses for radioactive materials, such as equipment to diagnose and treat medical problems.

Petroleum Engineering
Petroleum engineers are found wherever there is oil, working to remove oil from the ground. Petroleum engineers might be involved in drilling or developing oil fields. They might also ensure that the oil drilling process is safe, economical, and environmentally friendly.

To learn more about the field of petroleum engineering, visit the Society of Petroleum Engineers, (www.spe.org*.)

Systems Engineering
Systems engineers are like team captains who are responsible for bringing all the pieces of an engineering project together and making them work harmoniously, while still meeting performance and cost goals, and keeping on schedule. Systems engineering takes an interdiscipli0nary approach to a project, from concept to production to operation. Systems engineers consider both the business and technical needs of a project.

Sources

- Discover Engineering www.discoverengineering.org/home.asp*
- Engineer Girl! The National Academies—National Academy of Engineering www.engineergirl.org/nae/cwe/egcars.nsf/webviews/Careers+By+Engineering+Field?OpenDocument&count=50000
- Baine, Celeste, *Is There an Engineer Inside You? A Comprehensive Guide to Career Decisions in Engineering,* 2d ed. Ruston, LA: Bonamy Publishing, 2001.

Session 4, Activity B

Turn It On and Off

Goal
Understand series and parallel circuits using a breadboard.

Outcome
Participants learn how to use a breadboard to wire series and parallel circuits. They are also able to wire a switch to the circuit.

Description
Apply principles of a basic circuit to wire more complicated series and parallel circuits on a breadboard. Then apply this knowledge to wiring a switch. Wiring a buzzer is optional.

Supplies
For each pair of students: 1 breadboard, 2 batteries ("D" size), 2 battery holders (should have 2 wires attached), 2 screw-base lamps, 2 lamp holders, 1 wire kit, 1 small screwdriver, 1 knife switch, 1 buzzer (optional)

Preparation

1. In addition to the materials already distributed to each pair in *4A: Basic Electrical Concepts in a Flash*, now give each pair a breadboard with battery and bulb holders, another lamp, a switch, and a buzzer (for optional activity). In advance, attach a piece of wire 3-4 inches (7.5-9 cm) in length to each terminal of the battery holder. (You may need screwdrivers for this.)

2. Familiarize yourself with wire. Wire is measured in gauge which refers to the size of the wire. The higher the gauge number, the thinner the wire. The lower the gauge number, the thicker the wire and the more amps capacity it has to carry current further from the electrical source. This activity uses 22-gauge wire that is stripped 0.25” and bent 90 degrees. You may need to strip the wire if your wire is not pre-stripped. Use a wire stripper to strip insulation from wire and a wire cutter if wire needs to be shortened.

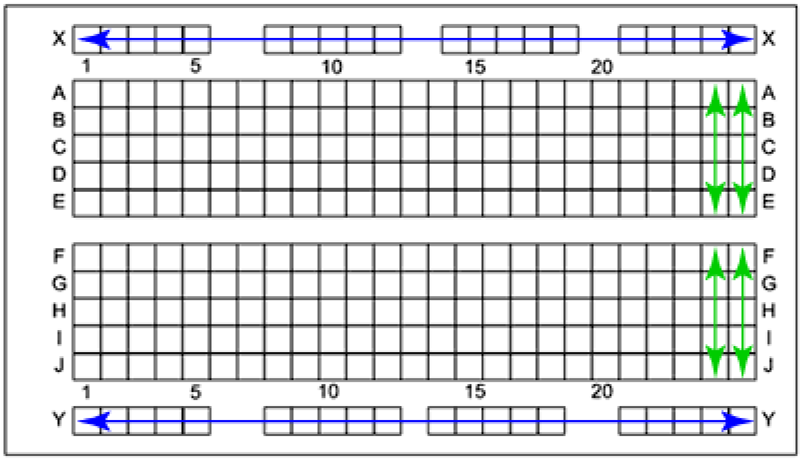
Procedures
Introduce Breadboards

1. Distribute breadboards and explain what a breadboard is. Explain that the purpose of the breadboard is to provide a flexible way to test circuits using a grid of pre-wired circuits. Electrical engineers use them to experiment with circuits before soldering them permanently to a circuit board.

2. Show how a breadboard is arranged: The two long sets of holes (called channels), labeled X and Y on the diagram, are connected horizontally. The power supply is connected to these rows. The other rows of holes (A-J) are connected vertically in blocks of five, (A-E) and (F-J) on the diagram. Each block of five holes is not connected to each other across the center between rows E and F. To make connections you only need to

4B: Turn It On and Off (continued)

stick the uninsulated ends of the wires into a set of holes. Underneath the plastic cover are little metal pieces that hold the wires and allow current to flow through them. Take off the plastic cover to demonstrate this.



Breadboard

Build a Simple Circuit

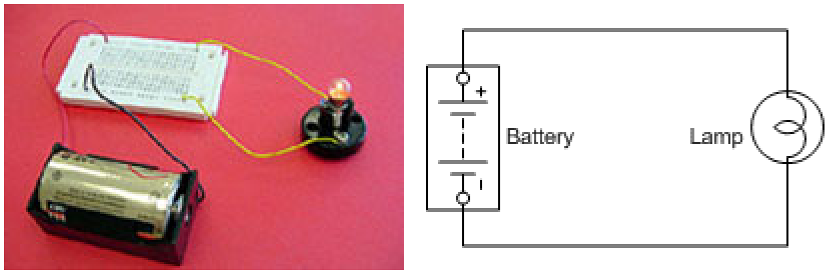
1. Instruct the students to begin wiring a simple circuit with one battery (in battery holder) and one bulb (in bulb holder) to explore how the breadboard works.

2. Insert the end of one of the battery wires into one of the holes in row X.

3. Insert the other battery wire into one of the holes in row Y. Ask if this is a complete circuit. *(No, the holes in the two rows are not connected to each other.)*

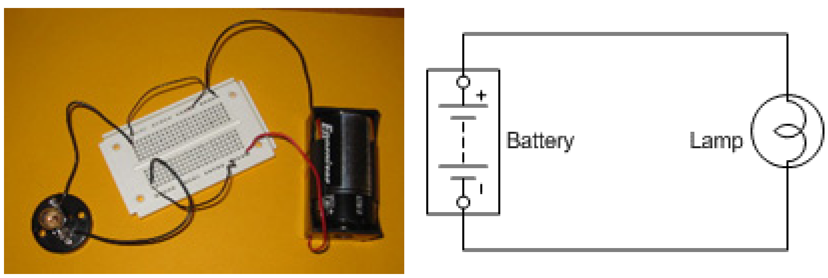
4. Insert one of the wires from the bulb holder into row X and the other into row Y. *(The bulb will now light because current is flowing from the battery through the channel to the lamp and back to the battery—a complete circuit.)* To understand how the breadboard is arranged, instruct students to move the wires around, testing which connections produce a complete circuit.

4B: Turn It On and Off (continued)



Simple circuit

5. Challenge students to wire the breadboard to light the bulb using two additional wires so that the lightbulb is not plugged into the power channels (rows X and Y).



Simple circuit

6. Explain that the bulb lights because electricity travels around the circuit in a circle.

Build a Series Circuit

1. Define series circuit: A circuit that contains only one possible path for electron flow supplied by a common voltage source.

2. Instruct the students that they will now build a series circuit with two batteries and two bulbs.

3. To build a series circuit, explain that they will need two batteries and two bulbs. Tell them to identify the positive (cathode) and negative (anode) terminals of the battery.

4. For the first battery, have them attach the positive wire to channel X on the breadboard. Next, tell them to attach the negative wire to any set of five holes in the middle of the board.

5. For the second battery, instruct them to attach the negative wire to channel Y on the breadboard. Next, tell them to attach the positive wire to the same set as with battery

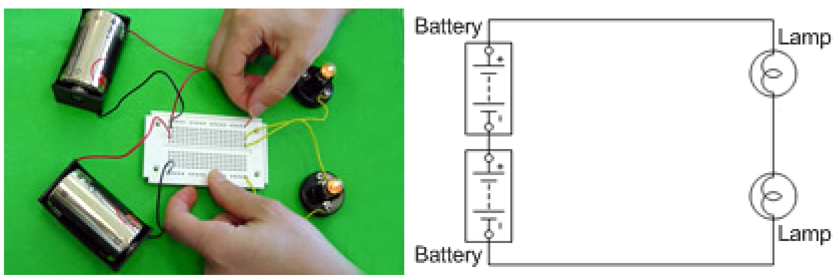
one.

6. For the first bulb, they should now plug one wire into channel X on the breadboard. Then they should plug the other wire into one of the five sets of holes in the middle of the board—and make sure it is not plugged into one of the sets of five holes that the batteries are plugged into.

7. Have them take the second bulb and plug one wire into channel Y on the breadboard. Now direct them to take the second wire and plug it into the same set of five holes that the other bulb is connected to. Both bulbs should now light!

8. Explain that the two bulbs and battery are now wired in a "series circuit." Remove the wire from one bulb and see that the other bulb goes out. Describe how increasing the number of bulbs reduces their brightness in a series circuit. Some students may remember old-fashioned Christmas lights in which one bulb burning out turns out all of the lights on the string.

9. Instruct the students to make a diagram of a series circuit using the symbols.



Series circuit

Build a Parallel Circuit

1. Define parallel circuit: Circuit that contains two or more paths for electron flow supplied by a common voltage source.

2. Explain that students will now make a parallel circuit with two batteries and two bulbs, keeping the two batteries wired as before in the series circuit.

3. Instruct them to remove the two bulbs from the breadboard from the previous steps.

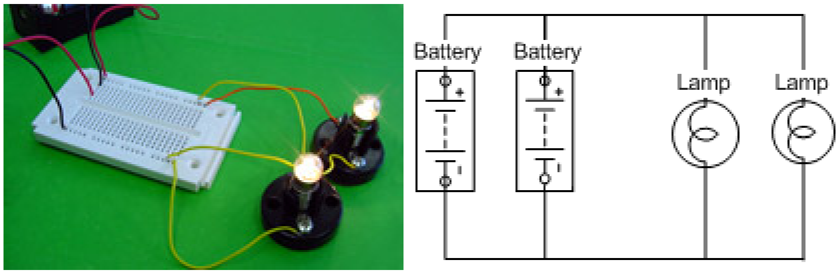
4. Direct them to take the first bulb and plug one wire into channel X on the breadboard and plug the second wire into channel Y. Now the bulb should light! Have them repeat this step for the second bulb. Both bulbs should now light!

4B: Turn It On and Off (continued)

5. Have them remove one wire from one of the bulbs and note that the other bulb remains lit. This is a parallel circuit. Tell them to repeat this for the other bulb.

6. Explain that parallel circuits are the types of circuits that are found in a house. Obviously, when you turn off your lamp, it doesn't turn off your TV. Connecting bulbs in parallel allows each to shine equally brightly.

7. Tell them to make a diagram of a parallel circuit using the symbols.



Parallel circuit

Add a Switch

1. Have the students look at the flashlights and ask what the purpose of a switch is. *(It breaks and connects circuits.)* Explain that the switch can be used to interrupt the circuit without removing a wire.

2. Essentially, students will be wiring a simple circuit and adding a switch. It is preferable to try to let them do this on their own—through inquiry. However, if they are struggling, you may give "hints" along the way to help them. Encourage students to "plan" the circuit design. They should study the switch and think about wiring it so it works.

3. First, have students wire the switch by attaching wires to the terminals of the switch (total of four wires).

4. Now tell them to wire a simple circuit.

5. Instruct them to remove the bulb wire from row X and place it in one of the sets of five holes in the middle of the board (rows A-E). They should then take another wire and insert one end in row X. Then, they should insert the other end of that wire into one of the sets of five holes in the middle of the breadboard (rows A-E). Have them make sure it is a different row than the one that the bulb wire is plugged into.

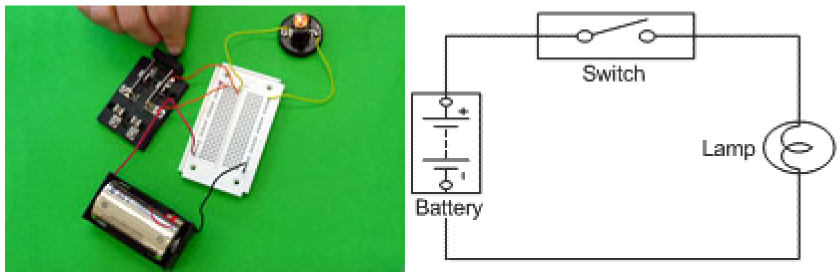
6. Have them take one of the switch wires and insert it into the same set of five holes in the middle of the breadboard as the bulb wire.

7. At this point, direct them to take the second switch wire and place it in the same row of five holes in the middle of the breadboard as the short wire (as in step 4).

4B: Turn It On and Off (continued)

8. Tell them to open and close the switch to turn the bulb on and off.

9. Show the students the symbol for switch (on their handout) and have them draw the diagram with the symbols.

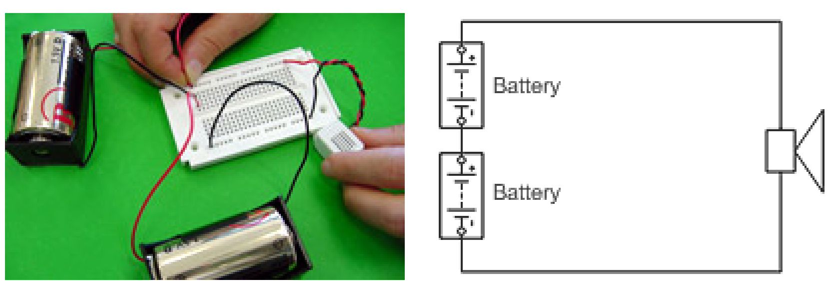


Wiring a switch

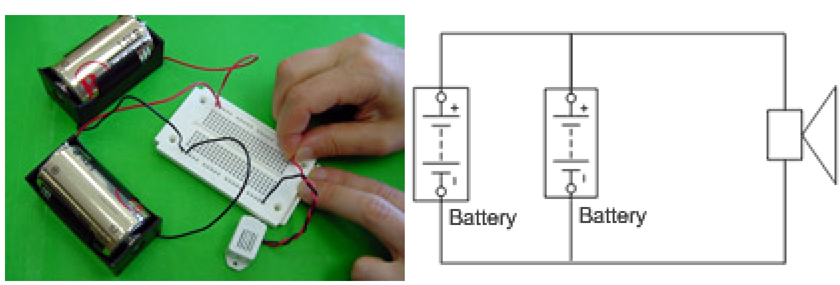
Optional: Add a Buzzer

1. Discuss doorbells and ask students how they think a doorbell works. Discuss the purpose and function of a doorbell. Ask them what electrical components they think doorbells have.

2. Ask them to show you how to wire a buzzer on the breadboard. Use the procedures from the previous activities to wire a parallel circuit and then a series circuit, but replace the light bulb with a buzzer.



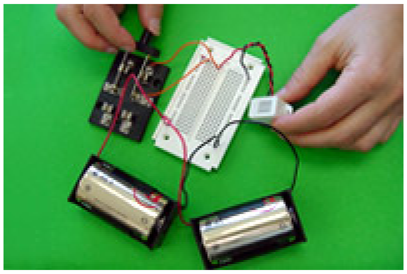
Series circuit with buzzer

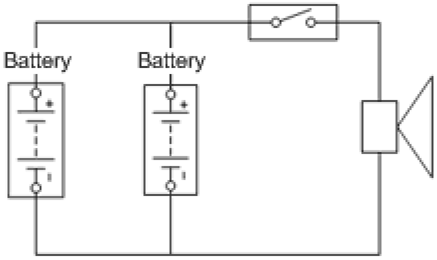


Parallel circuit with buzzer

4B: Turn It On and Off (continued)

3. Challenge the participants to use two batteries, a light, a switch, and a buzzer.





Parallel circuit with buzzer and switch

4. Show them the symbol for speaker (see handout) and have them draw a diagram with all the symbols.

Wrap Up

Discuss the differences between a simple, series, and parallel circuit. Explain that parallel circuits are the most common.

Read *4B: Meet a Computer Engineer*. A computer engineer is one type of electrical engineer.

Follow With

In the next activity, *4C: Short Circuits*, students learn more about basic electrical concepts.

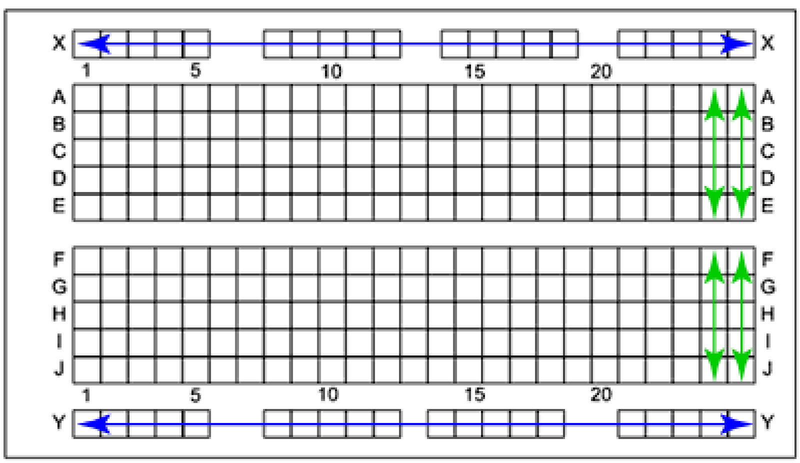
Turn It On and Off

Handout: Session 4, Activity B

You may find that you want to develop a prototype for a product that calls for the use of light or sound. If this is the case, you'll find that you need to wire some circuits. This activity will help familiarize you with the different types of circuits.

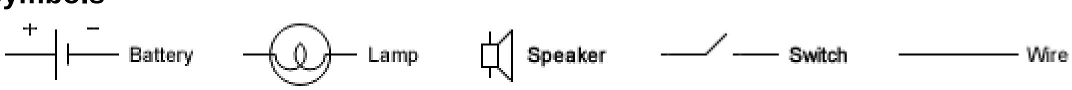
In this activity, you will be wiring on a breadboard. Electrical engineers use breadboads to test circuits before soldering them to a circuit board. The purpose of the breadboard is to provide a flexible way to wire circuits. Underneath the plastic cover are little metal pieces that hold wires and make connections between holes. You only need to stick ends of wire into the breadboard holes to make connections between electrical devices like lightbulbs and batteries.

A breadboard is arranged this way: The two long sets of holes (called channels), labeled X and Y on the diagram, are connected horizontally. The power supply is connected to these rows. The other row of holes (A-J) are connected vertically in blocks of five, (A-E) and (F-J) on the diagram. Each block of five holes is not connected to each other across the center between rows E and F.



Breadboard

Symbols



Directions for Wiring a Simple Circuit

1. Insert the end of one of the battery wires into one of the holes in row X.
2. Insert the other battery wire into one of the holes in row Y. Trace the flow of electricity. Is this a complete circuit?

4B Handout: Turn It On and Off (continued)

3. Insert one of the wires from the bulb holder into row X and the other into row Y. What happens? Trace the flow of electricity. Is this a complete circuit?

4. Explore how the breadboard circuitry is arranged. Move the wires to new holes and predict if the bulb will light or not. Trace the flow of electricity in each new arrangement.

5. Try to wire the breadboard to light the bulb using two additional wires so that the lightbulb is not plugged into the power channels (rows X and Y). Draw a diagram of this in your notebook.

Directions for a Series Circuit

1. To build a series circuit, you will need two batteries and two bulbs. Identify the positive (cathode) and negative (anode) terminals of the battery.

2. For the first battery, attach the positive wire to channel X on the breadboard. Next, attach the negative wire to any set of five holes in the middle of the board.

3. For the second battery, attach the negative wire to channel Y on the breadboard. Next, attach the positive to the same set as with battery one.

4. For the first bulb, plug one wire into channel X on the breadboard. Plug the other wire into one of the five sets of holes in the middle of the board—make sure it is not plugged into one of the sets of five holes that the batteries are plugged into.

5. Take the second bulb and plug one wire into channel Y on the breadboard. Plug the second wire into the same set of five holes that the other bulb is connected to. What happens?

6. Make a diagram of a series circuit in your notebook.

Directions for a Parallel Circuit

1. Remove the two bulbs from the breadboard from the previous steps, but keep the batteries wired as they were for a series circuit.

2. Take the first bulb and plug one wire into channel X on the breadboard and plug the second wire into channel Y. What happens? Now repeat this for the second bulb. What happens?

3. Remove one wire from one of the bulbs. What happens? What do you notice about the brightness of the bulb? This is a parallel circuit. Repeat this for the other bulb.

4. Make a diagram of a parallel circuit in your notebook.

Adding a Switch

If you decide to work on a project that requires some electronics, you may find that while you

4B Handout: Turn It On and Off (continued)

need a light or sound, you probably don't always want to have it on. Therefore, you'll need to learn to wire a switch. It should be easy now that you know how to wire a circuit.

1. Wire a simple circuit.
2. Be sure that the switch is wired and ready to go.
3. You will probably need to remove a wire and place it elsewhere—which wire is this? Remove it and place it where you think it should go.
4. How will you connect the bulb wire and the switch wire? (Hint: you may need to use a third wire that is not the bulb or switch wire.)
5. Where should the two switch wires go? Place them where you think they should go.
6. Try to open and close the switch to turn the bulb on and off. Does it work? If so, congratulations! You can now wire a switch. If not, keep trying!
7. Draw a diagram with symbols of a circuit with a switch in your notebook.

Wiring a Buzzer (Optional)
Ding dong! Ever wonder how a bell works? Here's your chance to wire a buzzer. It's easy now that you know how to wire circuits and a switch.

1. Wire a buzzer to the breadboard.
2. Now wire a light, switch, and buzzer with two batteries.
3. Draw a diagram using the symbols. You can use the speaker symbol for the buzzer.

Meet a Computer Engineer

Reading: Session 4, Activity B

May Tee
Computer Engineer
Portland, Oregon

A career in computer engineering has taken May Tee around the world, from the Pacific Northwest to New York to Italy. She has worked on everything from software applications for high fashion design to cutting-edge technical projects for the computer industry. Currently, as an engineer for Intel® Innovation in Education, she helps to develop online learning tools that teachers use with their students. What kind of student might be well-suited to her profession? "If you like fast change, new challenges, and being able to solve problems creatively," she says, "computer engineering could be the field for you."

An Unexpected Path

Tee grew up in Malaysia, dreaming of becoming an artist. She didn't see her first computer until she was in junior high school, and then was unimpressed. "The teacher did all this stuff to make the screen print out 'Hello.' I thought, that's it?" She was baffled by the whole idea of computer engineering. "I thought engineers only built concrete things, like bridges. But a computer screen is two-dimensional, not tangible. I had no clue what a computer engineer does."

Her high school teachers encouraged students to consider professions like medicine, law, or architecture. "In a developing country like Malaysia, those are the areas that are most needed," she says. Because she excelled in chemistry, she first planned to become a pharmacist. She came to the U.S. to start college and quickly changed gears. "Even though I was doing well in chemistry, I didn't like all the memorization. I only like the problem-solving part of chemistry." She explored other fields. "I took an accounting class, where I sat in the back row and fell asleep. When I wasn't sleeping, I was busy doing my homework for computer science. That class was much more interesting."

Tee says she was fortunate to have "a very good first instructor, so I fell in love with computer science. It takes a teacher who is knowledgeable in the field, and also good at teaching and explaining." Computer science can be hard to grasp at first, she admits, because the programming is hidden from what you see on the monitor. As she learned more about the field, she was attracted by "the problem-solving aspects. It's mathematical, logical. I used to play

4B Reading: Meet a Computer Engineer (continued)

chess, which takes step-by-step reasoning, so that's a thinking process I have."

After her first two years of college in Portland, attending both Portland Community College and Portland State University, she completed her degree in computer science at the University of Hawaii.

Launching Her Career
Tee graduated from college in 1996, when the technology sector was booming. The growth of the World Wide Web opened new opportunities, too, especially for a computer engineer with an eye for design and passion for visual art.

Her first engineering job, with Step Technologies in Portland, involved working on solutions using Microsoft software. She worked alongside veteran engineers, all with 10 to 15 years of experience. "I was the guinea pig, hired fresh out of college. They wanted to see what ideas some young blood would bring to an organization, and I was looking for someone to mentor me."

After three years there, she had a solid technical foundation and was ready for new challenges. "A lot of computer engineers have a creative side. They are photographers, artists, or musicians, something that's their passion." She followed her own passion and spent a few months in London studying art.

Back in the U.S., she took part in a complex project for Intel involving how users interface with computers. That let her bring together the technical side of how computers work with the graphic elements that affect the user's experience. "I could play with how things look on the screen, and saw how the right visual elements could help the user."

Tee's next projects took her to New York to work for Prada, a leading fashion house, and then on to Italy to see how computers are used in all facets of the textile industry. She enjoyed taking on each new set of challenges, using her technical skills to create a better result. "I began working directly with the people who use the software, seeing how they behave and what works for them. I could see the kind of frustration people have if the software does not meet their needs."

Each new assignment has made Tee's work more satisfying. "I realize I can make a difference visually, and that helps people feel like this is a usable tool. I love that part-to communicate to people through the software. It makes my work interesting and satisfying."

Always Something New
Currently, in her role of developing interactive tools for online learning, Tee works with diverse colleagues. She attends meetings to talk with clients and understand the design requirements and instructional purpose for each tool. She meets with graphic designers who bring in

4B Reading: Meet a Computer Engineer (continued)

expertise about color, typefaces, animations, and other visual elements. Human factor engineers add another perspective, bringing an analysis of how well tools will work for intended users. And through the whole process, Tee collaborates with fellow computer engineers, figuring out the technical solutions that will make everything work smoothly on the World Wide Web. "You learn so much from all these other people," she says.

Tee says her career moves may not be typical for engineers, but the variety has kept her excited about computer engineering and learning new skills. "I love the constant stimulation. It's the right fit for me," she says. "The creative part of computer science lets me fulfill my desire to be able to solve problems creatively, like an artist.

Advice for Students
Tee advises students heading into computer engineering to seek out the best professors they can find. "Ask your classmates. They always know who the best teachers are." And she encourages students to learn all they can by interviewing engineers and arranging internships. "That's the best way to see all the different aspects of the field. It's not just sitting in front of the computer."

Session 4, Activity C

Short Circuits

Goal
Understand short circuits.

Outcome
Students wire a series and parallel circuit to understand short circuits.

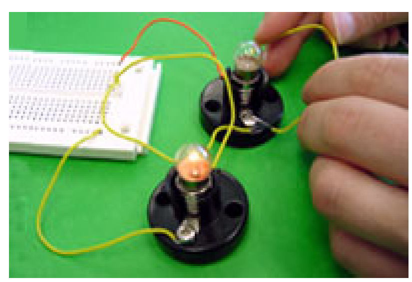
Description
See what causes a short circuit by understanding the relationship between resistance and the current.

Supplies
For each pair of students: 2 lamps, 2 "D" batteries, 1 wire kit, 2 lamp holders, 2 battery holders, 1 breadboard, 1 rectangular piece of aluminum foil about 1 inch by 2 inches (2.5 cm x 5 cm) (for optional fuse activity)

Preparation
Distribute materials to each pair.

Procedures
Put two pairs together. Explain that they are going to explore what happens in a short circuit. A short circuit is when electricity flows with no resistance and then more electricity flows than the wires are supposed to permit. The wires become very hot and sparks may fly. To prevent this from happening, a special kind of switch called a circuit breaker or fuse will trip or blow, and no electricity will flow to the current. This is a safety device that stops the flow of electricity before it enters the hot wire.

Wiring for a Short Circuit

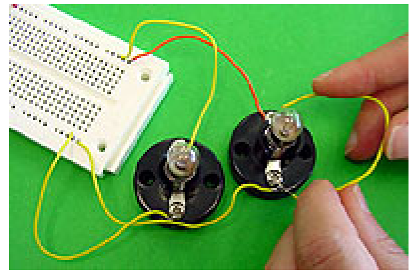


1. Instruct one pair in the group to make a series circuit with two bulbs and one battery.
2. Have everyone in the group look at the series circuit. Instruct the students to hold a wire *very briefly* so that one end touches one terminal on one side of the bulb holder and the other end touches the other terminal on the same holder. Ask what happens?
   (The other bulb gets very bright and the wire gets very hot.)
3. Explain that the bulb has resistance to the current flow. By replacing the lightbulb with the wire you are almost eliminating the resistance so the current increase is very large.

4C: Short Circuits (continued)

This large amount of current creates excessive heat that can burn out bulbs and melt wires.

4. Instruct the other pair to make a parallel circuit with two bulbs and one battery.



5. Repeat the same activity as in #2 with the parallel circuit. Ask what happens.
(Both bulbs go out.)

6. Explain that this is known as a short circuit. This means that the current in the wire across the "short" circuit is high because the resistance is so low. In a sense, it is easier for the current to flow through the wire than through the resistance of the bulb. The current flowing through the other lamp is too low to cause the bulb to light.

Optional: Fuses
Review what happened when parallel circuits were short circuited. *(The lights went out, and the wire got very hot.)* Explain that the more devices like lights, motors, or buzzers that are added to a parallel circuit, the more the current flows through the wires close to the battery. If the amount of current flowing through a wire increases, the wire gets hotter. If that happens, wire can get so hot that it starts a fire. Fuses are designed to burn and break the circuit before the wires get too hot.

Wiring a Fuse

1. Instruct the students to wire a parallel circuit with two batteries and two bulbs. Be sure everyone has wired a circuit in which both lights and batteries are wired in parallel. Have them refer to the wiring diagram on their handout. Tell them to ignore the fuse symbol for now.

2. Now have them change the wiring by moving one end of each bulb's wire from one power channel to the same inside block of holes (either A-E or F-J). They should then insert one end of a new a wire into the same block of holes in that channel and one end of another wire into the empty power channel. They should then touch the ends of those two wires together to test the circuits. The bulbs should light. Give the following instructions:

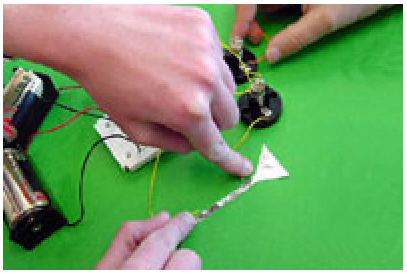
    A. Make a fuse by cutting a piece of aluminum foil (see handout for shape).

    B. Hold the two extra wires to the ends of the fuse (aluminum foil).

    C. Short out the circuit by holding another wire so that one end touches one terminal of one of the bulb holder and the other end touches the other terminal of that same bulb holder. Be very careful; you may see smoke!

4C: Short Circuits (continued)

D. Discuss what happened *(the fuse burned and broke the circuit)* and instruct students to write their observations and the reasons why they think it happened in their notebooks.



Wrap up
Discuss situations that would cause a short circuit; for example, a tree limb falling across a power line, a hair dryer that is plugged in falling into the bathtub, or a clothes dryer that is plugged into a circuit that cannot handle that much power.

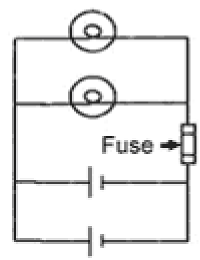
Follow with
In *4D: Light-Emitting Diodes*, students learn about LEDs and make numbers with LEDs.

Short Circuits

Handout: Session 4, Activity C

Imagine what happens when a tree falls across a power line, a hair dryer that's plugged in falls into the bathtub, or a clothes dryer is plugged into a circuit that can't handle that much power—a short circuit occurs. The current takes the easy route, the one with less resistance.

1. Your pair will join with another pair. One pair should make a series circuit with two bulbs and one battery.



2. Everyone in the group should look at the series circuit. Hold a wire *very briefly* so that one end touches one terminal on one side of the bulb holder and the other end touches the other terminal on the same holder. In your notebook, explain what happens.

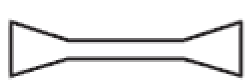
3. The other pair should make a parallel circuit with two bulbs and one battery. Repeat the same activity as above with the parallel circuit. Explain what happens.

Fuses (Optional Activity)
Have you ever had to change a fuse? If so, you probably know that fuses are designed to break a circuit before the wire gets too hot and catches on fire. In this activity, you'll see how a fuse works.

1. Wire a parallel circuit with two batteries and two bulbs. (Ignore the fuse symbol for now.)

2. Change the wiring by moving one end of each bulb's wire from one power channel to the same inside block of holes (either A-E or F-J). Then insert one end of a new a wire into the same block of holes in that channel and one end of another wire into the empty power channel. Now touch the ends of those two wires together to test the circuits. The bulbs should light.

   A. Make a fuse by cutting the shape below out of a piece of aluminum foil.



4C Handout: Short Circuits (continued)

B. Hold the two extra wires to the ends of the fuse (foil).

C. Short out the circuit by holding another wire so that one end touches one terminal of one of the bulb holders and the other end touches the other terminal of that same bulb holder. Be careful. You may see smoke!

Record your observations and explain what caused this to happen.

Session 4, Activity D

Light-Emitting Diodes

Goal
Learn about how light-emitting diodes (LEDs) work.

Outcome
Students learn how to wire an LED number display.

Description
Students explore wiring an LED number display. The number display uses eight LEDs to form numbers. Students experiment with different wiring combinations to light different LEDs in the display to make various numbers.

Supplies
For each pair of students: 1 blinking LED (2.8 volt) of various colors, 1 LED number display (0.3 inches LED number display), 1 breadboard, 1 wire kit, 2 batteries in battery holders, wire cutter/stripper

Preparation

1. Learn about LEDs.
   LEDs form the numbers on many digital clocks, tell you when your curling iron is on, send messages from your TV remote to your TV, and do many more things. There are all sorts of LEDs. Some emit infrared light (your remote control) and others produce light of different colors. The color is determined by the material used in the diode. As electrons move from the N-type material to the P-type material, electrons drop to a lower orbit and release energy. The distance the electrons have to drop depends on the material and determines the color of light.

2. Assemble materials and practice wiring the number display.
   Watch a short video clip that demonstrates how to make the LED display.

> View a Video
>
> Watch a short video clip that demonstrates how to make the LED display.
>
> To view the video, select a player and then click on your connection speed.
>
> Select a Player
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> Dialup High Speed

4D: Light-Emitting Diodes (continued)

Procedures
Introduction

1. Have students review the brief background information about LEDs on their handouts.

2. Lead a brief discussion about LEDs that students have seen in objects they use.

3. Distribute blinking LEDs and batteries and have students get a feel for how LEDs work by making them blink with a battery. They may need to use an extra wire to reach both sides of the battery since the LED leads are short, or they can use a breadboard.

4. Use the diagram on the handouts to explain how an LED works and why LEDs are used. LEDs have several advantages over conventional incandescent lamps. They don't have a filament that will burn out, so they last much longer. Additionally, the small plastic bulb is designed to be durable. LEDs also fit more easily into modern electronic circuits. But the main advantage is efficiency. In a conventional incandescent bulb, the light-production process involves generating a lot of heat (the filament must be warmed). LEDs generate much less heat. A much higher percentage of the electrical power is going directly to generating light, which cuts way down on the electricity demands.

Studying an LED Number Display

1. Distribute materials to each group. Have students study the LED number display and explain that there are eight LEDs arranged to form numbers when lit.

Wiring an LED Number Display

1. Power the breadboard by connecting two batteries in series to the power tracks.

2. Insert the LED number display so the pins on one side of the chip are in the E row and the other side are in the F row and the decimal point is at the bottom edge. If the display does not fit snugly on the breadboard, check to see that all pins are straight and press firmly.

3. Wire one cathode (referred to as a common cathode on the diagram) to the negative power track.

4. To light the different LED segments, experiment with connecting wires between the positive track to the different anodes.

5. Encourage students to take notes as they try different connections to light different segments.

4D: Light-Emitting Diodes (continued)

Wrap Up
Allow time for these electrical engineers to make a diagram with the LED symbol. Remind students to add to their list of design opportunities. They may be noticing problems with electronic devices.

Introduce the Home Improvement activity, *Electric House Hunt*, where students take a close look at their house to understand the electrical parts in a house.

Follow With
Session 5, *Making Machines*, introduces students to simple machines and mechanical engineering concepts.

Light-Emitting Diodes

Handout: Session 4, Activity D

What Is an LED?

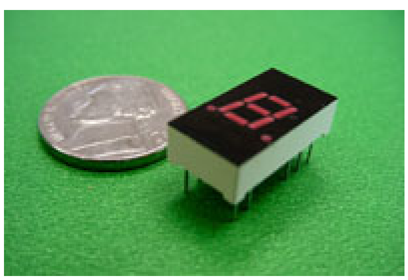
LED stands for "light-emitting diode." Basically, LEDs are tiny bulbs that fit easily into an electrical circuit. But unlike ordinary bulbs, they don't have a filament that will burn out, and they don't get very hot. They are illuminated solely by the movement of electrons in a semiconductor material. The light is emitted from the material used in the diode. Diodes are electrical components that allow the current to flow in only one direction. LEDs have an additional feature of lighting up when current is flowing through.

LEDs are everywhere—the numbers on digital clocks, the light on a curling iron or on the TV remote control perhaps. Collected together, they can even form images on a TV screen or illuminate a traffic light. Several LEDs are needed to display a number.

Try to make an LED light using a battery. What did you need to do?

Wiring an LED Number Display

In this activity you will experiment with different combinations of wiring to light up eight different LEDs that make up a number display. Study the LED Number Display chip and the information on the back of the packaging:



LED display (next to a U.S. nickel coin)

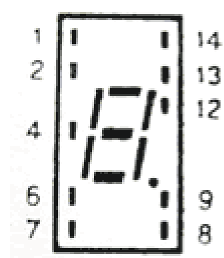


Diagram of pin location

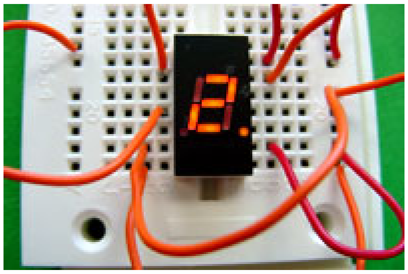
Table of Pin Designations

1. Anode F	14. Anode A
2. Anode G	13. Anode B
3. No Pin Cathode	12. Common Cathode
4. Common Cathode	11. No Pin
5. No Pin	10. No Pin
6. Anode E	9. Anode RHDP
7. Anode D	8. Anode C

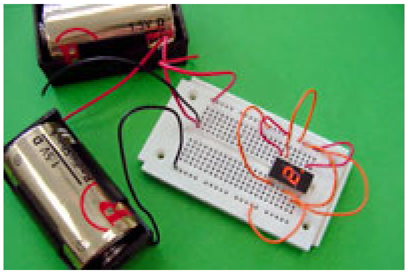
Follow the instructions below to light up the LED number display:

4D Handout: Light-Emitting Diodes (continued)

1. Power the breadboard by connecting two batteries in series to the power tracks.
2. Insert the LED number display so the pins on one side of the chip are in the E row and the other side are in the F row and the decimal point is at the bottom edge. If the display does not fit snugly on the breadboard, check to see that all pins are straight, aligned over holes, and press firmly.
3. Wire one cathode (referred to as a common cathode on the diagram) to the negative power track.

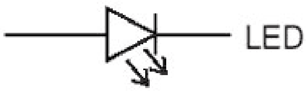


Close-up of LED number display with breadboard



LED number display circuit

4. To light the different LED segments, experiment with connecting wires between the positive track to the different anodes. Take notes on the results of your tests in your design notebook.
5. Try wiring the other cathode to the negative power track. Which wiring lights each segment? Did you figure out how to light up the right hand decimal point (RHDP)?
6. Now wire the necessary segments to display your favorite number.
7. Challenge: Can you wire a switch so that it displays your lucky number and then the lucky number of your partner? For example, one position of the switch will show the number "2" and the other position will show the number "6."
8. Bigger challenge: Wire a touch screen to display a number. How do you make a touch screen? How about using two pieces of aluminum foil arranged so that when you touch them in a particular place they complete a circuit? Take it from there!
9. Make a diagram of your circuit using an LED symbol.



Electrical House Hunt

Session 4, Home Improvement

Goal
Identify electrical units in the home.

Description
Students look at their homes from an electrical point of view by locating the circuit breakers, LEDs, and switches.

Procedures
Explain to students that they will be investigating the electrical units in their homes in order to identify the things they have learned about in this session. They will need to find out where the circuit breakers are, find 10 household items that use LEDs, and find 10 household items that have switches.

Next Day
Have students compare their lists with a partner.

Electrical House Hunt

Handout: Session 4, Home Improvement

Have you ever considered the electrical units in your house? We are all accustomed to flipping a switch to turn on the lights or pressing a button on a microwave, but have you thought about how these things work? Here's a chance to take an electrical hunt through your home. Record your findings in your design notebook.

1. Locate circuit breakers (these act like fuses to prevent fires from short circuits). Where are they located?

2. Find 10 household items that use LEDs and list them.

3. Find 10 household items that have switches