SCIENTIFIC EXPLORER

8+

28 AMAZING Experiments!

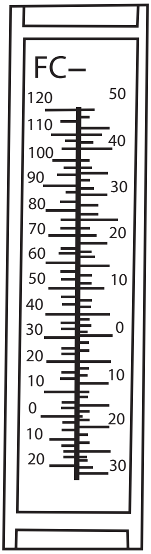
ELECTRIFIED ENERGY LAB

Instructions and More!

⚠ WARNING:
CHOKING HAZARD - Small parts.
Not for children under 3 years.

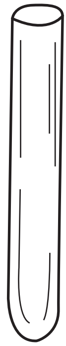
POOF-Slinky®

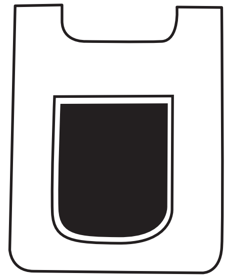
What's in Your Kit?



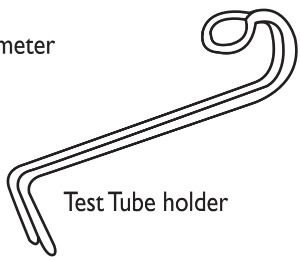
Graduation Card

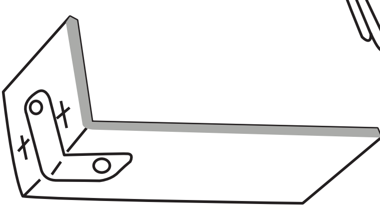

Thermometer


Test Tube

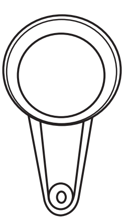

Heat Absorber Bag

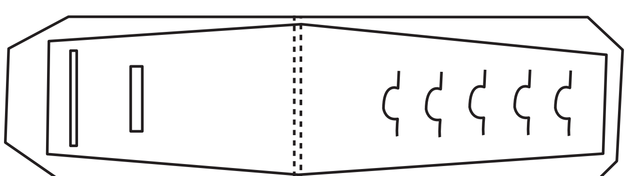

Piece of rubber

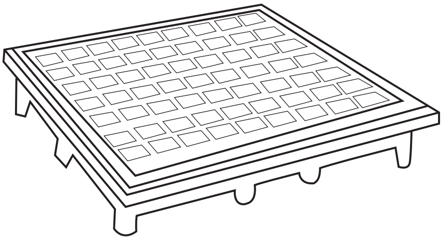

Test Tube holder


Test Tube stand

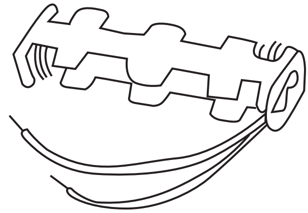

Solar Reflector


Magnifying glass
(lens)

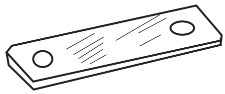

Cardboard bracket



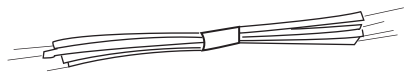
Circuit Board base



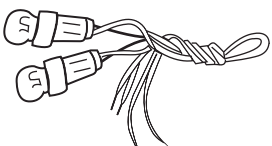
Battery holder



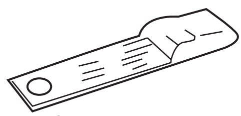
Brass strip



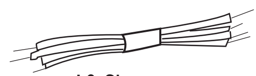
10 Long wires



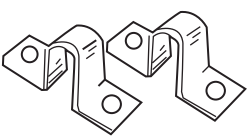
2 light bulbs with holders



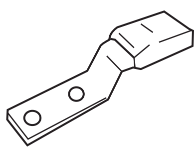
Switch connector



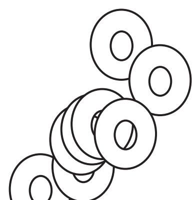
10 Short wires



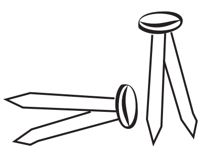
2 bulb holder clamps



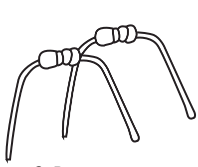
Morse code switch



22 Washers



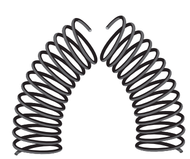
30 Brads (split connectors)



2 Resistors

Plastic jar with lid

Steel wool



21 Springs

It has been estimated that if every bit of the sunlight that falls on the earth in a single day could somehow be converted to useful energy forms, it would satisfy the energy needs of the world for 50 years. On the local level, enough sunlight falls on the roof of the average suburban home to supply three times as much energy as that home consumes. The energy is there-our challenge is to find ways to make use of it. Nature may be able to make use of solar energy, but can we?

What You'll Find in Your Kit:

- Graduation card
- Thermometer
- Test Tube
- Heat absorber bag
- Test tube stand
- Test tube holder
- Solar reflector
- Magnifying glass (lens)
- Cardboard bracket
- Morse code switch
- Switch connector
- 2 resistors
- Plastic jar with lid
- Piece of rubber
- Circuit board base
- Brass strip
- Battery holder
- 10 long wires
- 2 light bulbs with holders
- Switch
- 10 Short wires
- 2 holder clamps
- 22 Washers
- 30 Brads
- Steel wool
- 21 Springs

What You need to get or use:

- 4 "AA" batteries
- Scissors
- Ice Cubes
- Water
- 3 Transparent cups
- White & dark paper
- Clean glass, transparent saucer or plastic bag
- Plastic or cardboard carton
- Straw or eye dropper (optional)
- Salt
- Colored bowl
- Ink or dark food coloring
- Dark Feather
- Candle
- String
- 2 pencils
- Thread
- Tape
- Staples (optional)
- Paper cups (optional)
- Tea Bag
- Soap
- Uncooked egg
- White feather
- Mirror
- Felt tip pen
- Paper clips (optional)
- Stones or weight (optional)
- Bucket of water

WARNING: This kit contains experiments with electricity. All safety instructions should be followed carefully.
This kit is to be used with 1.5 volt AA batteries only. Under no circumstances should you use transformers, 9-volt batteries, or any other source of electricity!

WARNING:
Adult supervision is required for activities using the solar furnace/parabolic reflector in this kit. It collects and focuses sunlight very efficiently and will generate a great deal of heat.
Do not leave the reflector unattended, even if it is not currently in the sunlight. Remember, the sun travels throughout the day, and the reflector could be in the light in a few hours! Put the reflector away and under cover when not in use!
Several experiments involve cooking with the solar reflector. Do not eat or drink anything prepared this way, as the reflector may not have been cleaned properly between experiments!
The polished reflective coating on the reflector is very thin. Be careful not to scratch it! Handle it by the edges to avoid getting fingerprints on it. If it becomes dusty and you need to clean it, use a very soft cloth.

Finally, never shine the reflector on a living thing!

Activity #1 - Your Thermometer

What you need from kit:	What You need to get or use:
Thermometer Piece of rubber	Scissors

To begin, let's look at your thermometer. You've probably seen lots of thermometers before. There are many different types-the one enclosed in your kit is the most common type. It contains a bulb of liquid at one end and a long thin bore which runs up the center of the glass rod. When the liquid in the bulb gets warmer, it expands and moves up the bore. When it is cooled, it moves down.

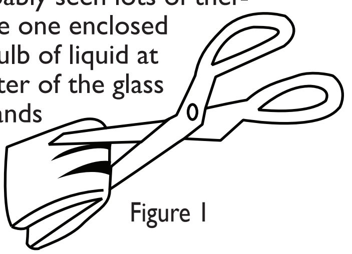


Figure 1

For most of your experiments, you are interested in whether the temperature goes up or down, not in knowing the exact temperature.

You will find a small piece of rubber with the thermometer. First, bend the rubber in half. With a pair of scissors, carefully cut two slits about 1/4 inch (.6 cm) apart and about the same length (see figure 1). Slide the thermometer through the slits (see figure 2). By sliding this rubber marker up or down the thermometer tube, you can mark the first temperature measured and see whether it rises or falls. The marker is made of rubber so that you can soak it in water when neccesary. This system will work for many of your experiments.

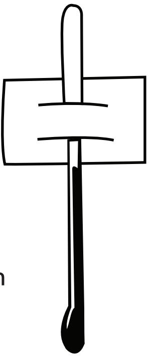


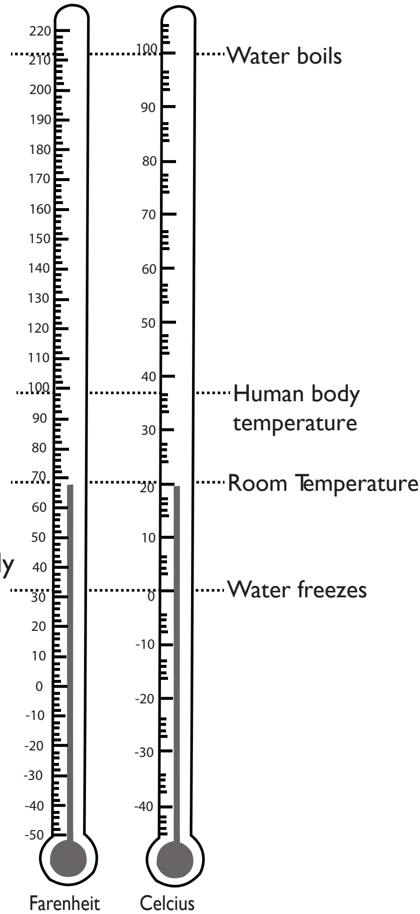
Figure 2

Activity #2 - Graduate Your Thermometer

What you need from kit:	What You need to get or use:	
Thermometer Graduation card	Cup Ice Cubes Water	Felt tip pen or piece of tape

The liquid in most thermometers is mercury, or, as in this one, colored alcohol. Scientists genrally use CENTIGRADE (also called CELSIUS) temperature scales, and so will we. On the next page there is a conversion table to Farenheit if you are more familiar with it.

If you dip a thermometer into liquids at 20° Celcius (C), the red column inside will reach a certain height. If you then put the thermometer in a liquid at 30° C (10° C warmer), the red column will rise further. Heat the liquid another 10°C (up to 40°C), and the column will rise exactly the same distance as it did from 20°C to 30°.



Examine your thermometer tube carefully. You will notice a small mark (like a horizontal scratch) about 2/3 up the glass rod. The liquid inside will reach that particular mark at exactly 20°C.

Now, put some ice cubes into a cup and leave them out for several minutes. When they start to melt, swirl the water continuously around the ice cubes. The temperature of this water is exactly 0°C.

Dip your thermometer into the ice water where the red column comes to rest. Use a fine pointed felt-tip marker or small piece of tape to mark it. This is your 0°C mark.

The graduation card enclosed may be useful, but, being made from paper, it can't be placed in water. Keeping in mind which of your marks represent which temperatures, you can hold the thermometer up to the graduated card to get a fairly accurate reading. Just line up your 20°C and 0°C marks on the thermometer with the same marks on the card. Remember to hold the thermometer by top end, not the bulb, so that your own body heat doesn't affect the reading!

Activity #3 - Converting Sunlight into Heat

What you need from kit:

Thermometer

What You need to get or use:

3 transparent cups
White and dark paper
Water
Clean glass, transparent saucer or plastic bag

The simplest and lowest technology approach to solar power is just putting things out in the sunlight to heat up. Energy efficient houses have been designed to do just that. Let's try to find out how effective that can be.

Take three transparent cups. They may be either glass or plastic, but they should be of the same size and material. Place one on a dark sheet of paper and two on white paper. Stand the three cups outdoors in bright sunlight. Pour an equal amount of cold water into each-about half a cupful should be enough. Measure the temperature of the water in each with the thermometer. Now, cover one of the cups standing on white paper with a sheet of clean glass, a transpaperent saucer, or even a plastic bag.

Measure the temperature of the water in each cup after 10 minutes, 30 minutes and 1 hour. What differences did you find?

In order to make sense of the results, you must know that:
a) A dark background generally absorbs more heat than a light background.
b) Glass or plastic absorbs a small quantity of the sun's rays.
c) Covering the cup slows or stops the evaporation of water.
d) When water evaporates, some heat is lost since it is used to facilitate the evaporation. This is why we sweat-it cools us down!

Activity #4 - Solar Heater

What you need from kit:

Heat absorber bag
Thermometer

What You need to get or use:

Plastic or cardboard carton
Straw or eye dropper (optional)

Find a small cardboard or plastic carton that is just slightly larger than the "heat absorber bag" enclosed in this kit.

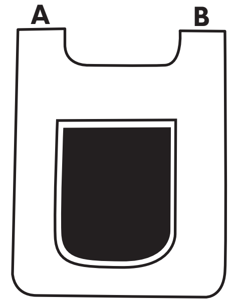
Fill the bag with cold water through the water inlet marked "A" in the diagram on next page. This is best done with a straw or an eye dropper, if you have one.

Fit the heat absorber bag in the mouth of the cardboard carton, with the clear side facing out and the back, black side of the bag facing into the carton. You may have to tape it in place. Leave inlet A unblocked.

Put this "solar heater" where it is facing the sun. As the day goes on, turn it to keep it facing the sun directly.

Measure the temperature every hour by carefully inserting your thermometer into Inlet A. Take the temperature at both the top of the bag (near the inlet) and the bottom. What happens?

Warmer water, like warmer air, rises. As the sun heats the water, the warmer water rises to the top of the bag, and the cooler water sinks down.



A commercial hot water tank is very similar to your bag. A water tank is placed above the heater and a pipe from the bottom of the tank is connected to inlet A and from the top of the tank to outlet B.

As the water is heated, it rises through outlet B and up the pipe to the top of the tank. As water rises from the heater to the tank, it pulls in colder water from the bottom of the tank through inlet A to be heated.

Does the water get warm enough to use around the house? How large of a solar heater would you have to have to be useful in everday life.

Activity #5 - Solar Heater & Reflected Light

What you need from kit:	What You need to get or use:
Heat absorber bag Thermometer	Plastic or cardboard carton Straw or eye dropper (optional) Mirror

Perform Activity 4 again, exactly as you did before, but this time take a mirror and stand it at a distance and angle from the solar heater in such a way that the mirror reflects additional sunlight onto the solar heater. One way to do this would be to keep the mirror lower than the heater and angled up to face it.

The heater will now absorb the direct sunlight as it did before, and, in addition, it will receive extra reflected energy from the mirror. How much additional heat can you obtain this way? Would this be a practical way to make a larger-scale solar heater more effcient?

Activity #6 - The Solar Pond

What you need from kit:	What You need to get or use:
Thermometer	Colored bowl Water Ink or Dark food coloring Salt

At the Southern tip of Israel, near the town of Eilat, is a small lake. At first glance, there seems to be nothing remarkable about the lake. The water is warm and salty and not particularly clean. However, this lake attracts scientists from all over the world because it is a "solar pond" and if current research proves succesful, this small lake may make a major contribution toward slowing the world's energy shortage.

If the sun shines on a pool of water, the top layer becomes slightly hotter as warmer water usually rises to the top. But hot water evaporates faster than cold, and when water evaporates, it uses up heat.

In an ordinary pool, the sun shines on the water which adds heat. When the water evaporates, it loses heat. Eventually, a balance is reached where any additional heat causes additional evaporation and the pool stays a constant temperature.

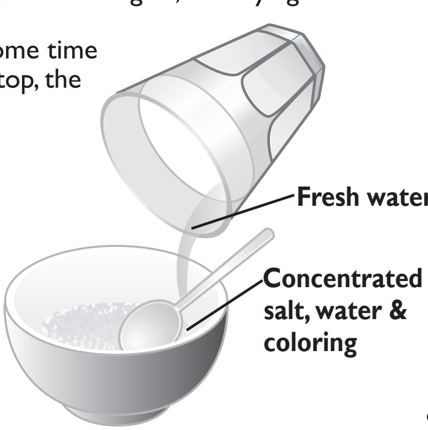
The solar pond in Eilat is different. Because of an underground salt water well, the water at the bottom is much more salty than at the top. Salty water is heavier than fresh water, so it does not rise to the top to float over the fresh water, even when warm.

Bathing is now strictly prohibited in this pond. Swimmers, diving to the bottom of that lake, were badly scalded before the scientific facts relating to this pond were known. Today, scientists are investigating the possibility of building human-made solar pools in order to make use of this solar energy trapped in the salt water layer.

You can test this idea. Find a colored bowl (not white). Fill it up one-third of the way with water and stir in as much salt as will dissolve. If you have some ink or dark food coloring, add a few drops of color to this salt solution.

You may want to do this next part in the sunlight, where you will need to leave the bowl when you are done. Carefully and slowly, add another one-third bowl of fresh water. Pour it very slowly down one side of the bowl, using a spoon to direct the flow. It is important to prevent the two liquids from mixing. If the fresh and salt water mix, don't panic! Stop pouring, and tip out some of the mixed water. Add more salt until you have salt water again, and try again.

Let your solar pond stand in the sun for some time and then measure the temperature at the top, the middle, and the bottom of the bowl.



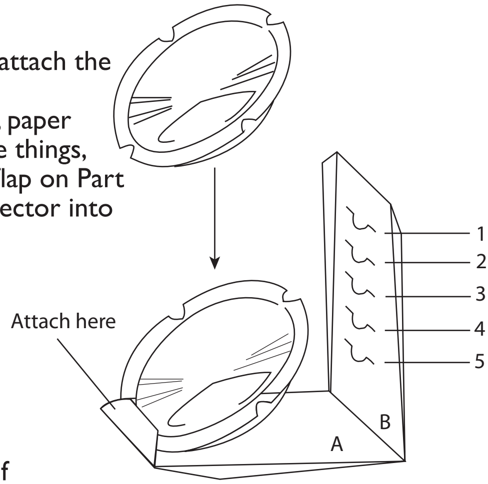
Activity #7 - Assembling the Solar Reflector

What you need from kit:

Solar reflector
Cardboard bracket
Test tube holder
Test tube stand
Test tube

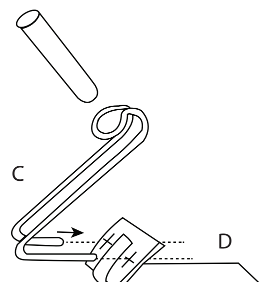
What You need to get or use:

Staples, paper clips or tape (optional)
Stones or weight (optional)

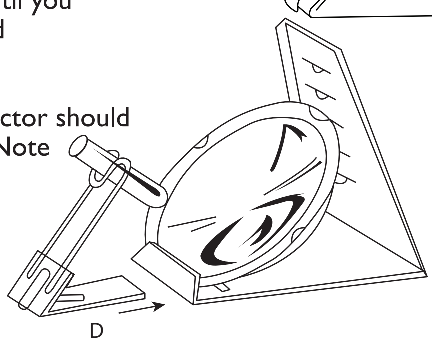


Take the parabolic solar reflector and attach the lower half to part A of the cardboard bracket. This can be done with staples, paper clips, or tape. If you have none of these things, carefully make a slit in the cardboard flap on Part A and insert the lower part of the reflector into the slit.

Part B of the cardboard bracket has 5 slits. Insert the top of the reflector into one of these slits. You want the reflector to be at the angle facing the sun that will gather the most energy. Therefore, you should use slit No. 1 if the sun is low in the sky, or slit No. 5 if you perform these experiments toward noon and the sun is high in the sky. Whether you use slit No. 1,2,3,4 or 5 depends on the position of the sun. You will have to experiment before you decide which to use. Once you have decided, turn the assembled reflector to face the sun.

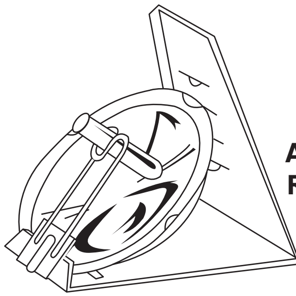


Next, take the wire test-tube holder (part C) and insert this into the two holes of the stand (part D). Insert the test tube into the assembled test tube holder. Finally, slip the tongue of the cardboard stand (D) into the slits provided in the base of the bracket (part A). Move the stand right and left until you think that the focal point of the reflected sunlight is within the test tube.



The drawing of the assembled solar reflector should make these assembly instructions clear. Note that you need the test tube holder for some of the experiments, but not all. The cardboard bracket is useful for every experiment with the parabolic solar reflector.

NOTE: On a windy day, place some stones or any other suitable weight into the bracket under the reflector, to prevent it from being blown away!



Assembled Solar Reflector

Activity #8 - Focal Point

SAFETY NOTE: Remember to follow all of the safety precautions listed at the front of these instructions while using the reflector! All of the reflector experiments should be done with adult supervision.

What you need from kit:

Solar reflector from Activity #7

What You need to get or use:

Blank white paper

The focal point of a perfectly shaped parabolic reflector of this type should be about 2.5 inches (6 cm) above the deepest point on the reflector. However, the reflector is made of thin, metal-coated plastic. It is likely to bend slightly. Even the slightest distortion can change the position of the focal point. (F.P.)

Place your solar reflector in the sunlight. Remove the test tube and its holder. Get a small sheet of blank white paper and slowly move it towards the reflector. As the sheet approaches the focal point, you will begin to see a circular bright spot on it. The closer you get, the smaller the spot becomes. At the focal point, it is quite small. Our solar reflector will be the most effective here, at the focal point.

What happens as you move the paper closer to the reflector than its focal point?

Activity #9 - Burning a Feather

What you need from kit:

Solar reflector

What You need to get or use:

Dark Feather
White Feather

Find a small, dark, bird feather and bring it to the focal point of the reflector. As you near this point, the feather may start to shrivel and smoke. It is easy to burn a dark feather. If you can find a white one, try the same experiment. What happens?

Activity #10 - Singeing a Piece of Rubber

What you need from kit:

Solar reflector
Piece of rubber

Try the same experiment with the dark piece of rubber you are using with your thermometer. As you approach the focal point of the parabolic reflector with the piece of rubber, the rubber begins to smoke and smell.

Activity #11 - Brewing Tea

What you need from kit:

Solar reflector
Test tube holder
Test tube

What You need to get or use:

Tea bag
Water

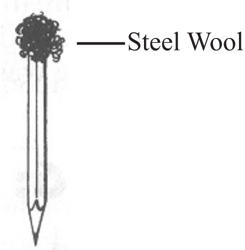
Fill the test tube halfway with cold water and attach it to the test tube holder. Measure the temperature of the water and then place the holder and test tube into the solar reflector in direct sunlight for 5 minutes. Measure the temperature again. How big was the rise in temperature? Add a tea bag and drink some tea!

Activity #12 - Melting Wax

What you need from kit:	What You need to get or use:
Solar reflector Steel wool	Candle Hot water Soap Pencil

Insert a small candle (like a birhday candle) into the test tube and fit it into your solar reflector. Does the candle melt? How long does it take? Did you use a dark or light colored candle? Given what you have found in other experiments, do you think it might make a difference?

WARNING: With this experiment, you have probably dirtied the test tube with melted wax. This will be difficult to clean! You need soap, hot water, and a test tube cleaner. You can make your own test-tube cleaner by wrapping a little steel wool around a pencil (see diagram).



Activity #13 - Frying an Egg White

What you need from kit:	What You need to get or use:
Solar reflector	Uncooked egg white

For this experiment, you will need an uncooked egg. You will need to separate the white from the yolk. Here's one way to do that. When you crack the shell, separate it into two halves and pour the egg back and forth between the halves, over a bowl. As you pour, the white should slide out over the shell and down into the bowl, eventually leaving you with just yolk in one of the shell halves. Keep the yolk for the next experiment, and pour some of the egg white into the test tube. Set it up in your solar reflector. Can you cook the egg white? How long does it take? Remember DO NOT eat the results!

Activity #14 - Frying the Yolk

What you need from kit:	What You need to get or use:
Solar reflector	Uncooked egg yolk

Now it's yolk's turn to be fried. Does cooking the yolk take more or less time than cooking the egg white? Remember: DO NOT EAT THE RESULTS!

Activity #15 - The Focal Point of your Lens

What you need from kit:

Lens
This booklet

The lens enclosed in your kit is a 20 mm diameter double convex converging lens with a focal point of 35 mm. What does all of that mean? Well, the most important part is that it is a converging lens. That means that light shining through it is focused to a single point. In this case, that focal point is 35 millimeters (almost an inch and a half) away.

Hold your lens right over any letter "E" in Energy on the cover of this booklet. Slowly pull it away from the page. As you increase the distance from the lens to the letter E, the letter seems to grow and grow until a point is reached, past which the image blurs! This is the Focal Point. Try to measure whether it really is 35 mm.

Activity #16 - Concentrating Heat with Your Lens

What you need from kit:

Lens
Thermometer

In a normally-lit room, place the bulb of your thermometer at the Focal Point of the lens. Note the temperature at the start of the experiment and again after 5 minutes. Was there any noticeable change?

Now take your lens and thermometer outside into direct sunlight. Again, place the bulb of the thermometer into the Focal Point of the lens. Note the temperature at the start of experiment and see how long it takes your thermometer to almost reach the top (120°F). <u>Be sure to remove the thermometer before it gets to that temperature</u>.

Activity #17 - Charring Paper

What you need from kit:

Lens

What You need to get or use:

Blank white piece of paper
Dark colored piece of paper
Bucket of water for safety

ADULT SUPERVISION REQUIRED-Have bucket of water handy in case of fire.

Place your lens in bright sunlight, with a blank white piece of paper at its focal point. Can you char (blacken) the paper?
If the sun is bright enough, you may be able to char it. It will char easiest right on the edge of the paper.

The white paper reflects most of the sunlight and solar heat. Even though the solar heat is concentrated at a small point, the paper barely, if at all, reaches its burning point.

Replace the white piece of paper with a dark colored, matte (not shiny) paper. Does it char easier? Be careful not to actually set it afire! The dark colored paper absorbs most of the energy, and easily reaches its burning point.

Activity #18 - Making a Circuit

What you need from kit:

Battery holder
Circuit Board base
Light bulb with holder
Bulb holder clamp
5 brads
3 Washers
3 Springs
Switch

What You need to get or use:

Tape
4 "AA" betteries

1. Put Parts into a Bowl
Open the plastic envelopes that hold the parts to your kit. Empty the parts into a bowl.

2. Put Fresh Batteries into the Battery Holder
Insert 4 fresh "AA" batteries into the battery holder. Look carefully at the information printed on the holder to find which way the batteries should point. After you have the batteries in place, check to make sure that they were inserted correctly. The flat end of each battery rests against a spring. Batteries on one side of the holder point in the opposite direction from batteries on the other side.

BATTERY WARNING:
- Do not mix alkaline, standard (carbon-zinc) and rechargeable batteries (nickel hydride).
- Do not mix old and new batteries.
- Non-rechargeable batteries are not to be recharged.
- Rechargeable batteries are to be removed from the appliance before being charged (if removable).
- Rechargeable batteries are only to be charged under adult supervision (if removable).
- Exhausted batteries are to be removed.
- The supply terminals are not to be short circuited.
- Only batteries of the same or equivalent type as recommended are to be used.
- Batteries are to be inserted with the correct polarity.

3. Put the Battery Holder onto the Circuit Board

Get some tape and stick the battery holder to the top of the circuit board. Figure 1.

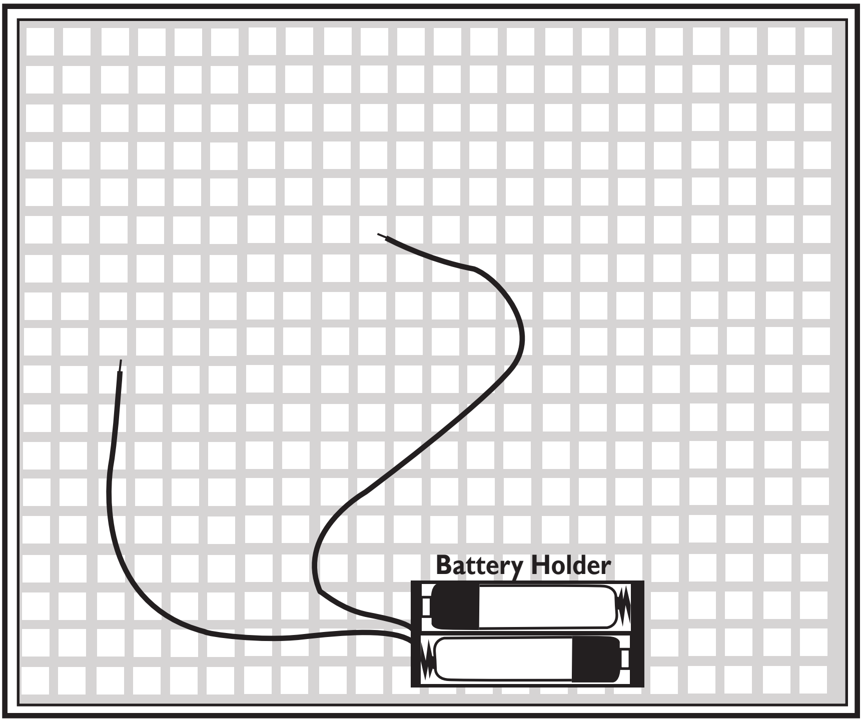


Figure 1

Be sure that the battery wires are in the position shown in the drawing before you stick the holder onto the circuit board.

4. Put a Bulb onto the Board

Take a bulb holder and insert a bulb into it. If the bulb is already in place, make sure it is inserted all the way.

Put a bulb holder clamp over the bulb holder. Attach the clamp and the bulb holder onto the circuit board with two brads (split pins.) The bulb should go onto the board in the place shown in the drawing. (Figure 2) The exact position isn't important.

Reach under the board and spread the legs of the brads so that they hold the bulb holder and bulb firmly in place.

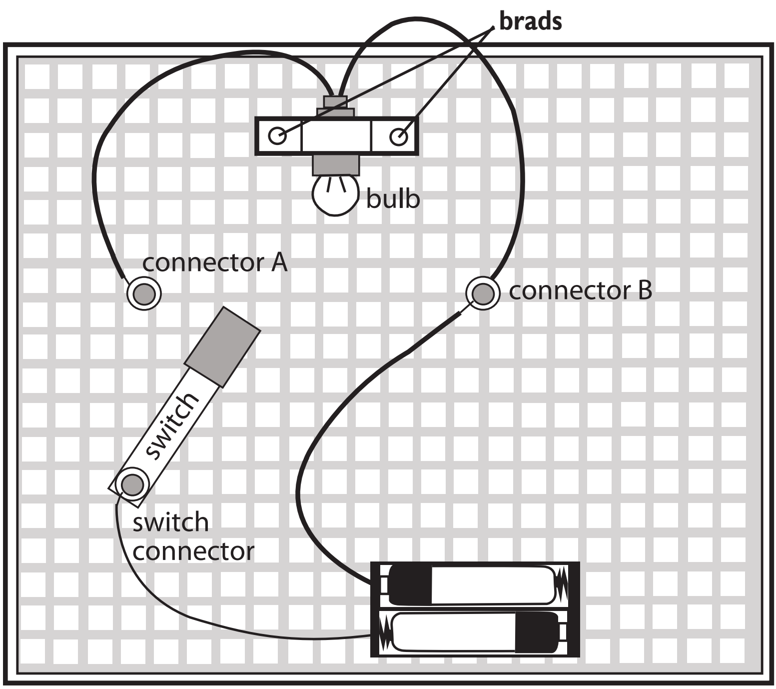
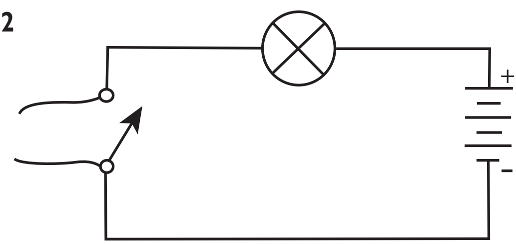


Figure 2



5. Put Two Connectors onto the Board

Take a brad. Slip a washer and then a spring onto it, as shown in the drawing (Figure 3a). Make sure the washer goes on first.

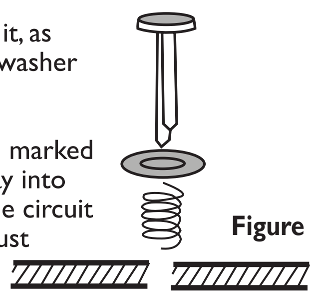


Figure 3a

Put the brad into the board about in the position marked Connector A in Fig. 2. Push it about 2/3 of the way into the board. Hold it at this position, reach under the circuit board, and spread the legs of the brad. You have just made a temporary connector. You should be able to push the washer down away from the head of the brad, and the spring should push it back up again when you let go.

Make a another temporary connector the same way and put it into the board at the position marked Connector B.

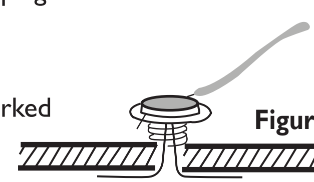


Figure 3b

6. Put a Switch onto the Board
Take the flat switch and attach it to the board with a temporary connector. To do this, first slip a washer onto a brad, then slip a spring onto it, then slip the brad through the hole in the switch. Put the brad into the fifth hole below Connector A, push it about 2/3 of the way onto the board, and spread the legs of the brad. This is your Switch Connector. (See Figure 3c)

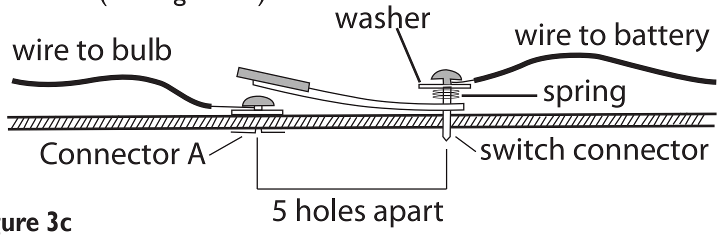


Figure 3c

Test your connection. You should be able to swing the switch around the brad and touch Connector A with it.

7. Check the Underside of the Board
This is a very important step! Turn the circuit board over and look at the legs of all the brads. <u>The legs of the brads must never touch each other!</u> If two legs are touching, turn the brads so that the legs do NOT touch. You'll learn why later.

8. Slip the Wires into the Connectors
Push down on the washer of Connector A. Slip the tip of the nearest wire from the light bulb between the washer and the head of the brad. Be sure that just the wire goes in, not the insulation covering it. When you let go, the spring should hold the tip of the wire in place. (Figure 3b)

Put the other bulb wire into Connector B.

Also, put a battery wire into Connector B.

Put the other battery wire into the Switch Connector. Your circuit is now complete. Check it against the drawing of Figure 2.

9. Turn Your Light On and Off
Move the switch so that it touches Connector A. This is the ON position of your switch. Your light bulb should light up! (If it doesn't check your connections. One of them is probably loose. Or check to make sure your bulb is inserted all the way into the battery holder.)

Move the switch away from the connector. The light goes off. This is the Off position of your switch.

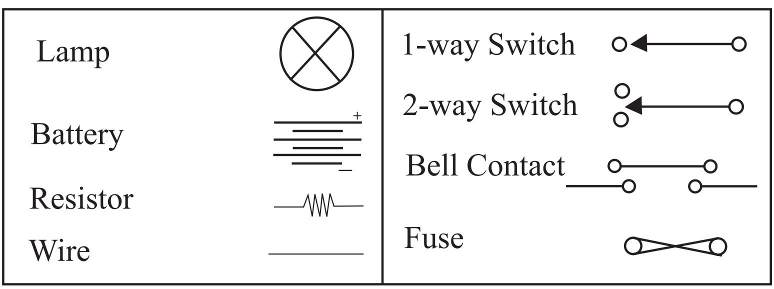
Always turn the switch Off when you finish an experiment. If you leave it on, the batteries will run down and some of the connections may get uncomfortably hot.

10. Look at the Circuit Diagram
Back on page 17, below the drawing of the setup you just made (Figure 2), is a simplified diagram of the same setup. It is called a circuit diagram.
A circuit diagram shows only the path of the electricity and the electrical devices in that path. It leaves out everything else. It doesn't show the circuit board, or all the connectors you put together, or all the twists and turns of the wire, or the holders for the different electrical devices.

Anybody who works with electrcity should learn how to read a circuit diagram. It's not hard. Look at the circuit diagram again. See if you can identify the symbols for:

- the batteries
- the bulb
- the switch, in an open position

Most important, compare the circuit diagram with the more complicated drawing above it. Notice how the circuit diagram gives you the same information about the electrical devices and the electrical circuit as the drawing does, only in a much simpler form.



WHAT YOUR EXPERIMENT SHOWED
What you just did is called making a circuit and breaking a circuit.

-When you moved the switch to the ON position, you made a circuit - a path along which electricity could flow. Electricity flowed out from the batteries, through all your connections, and back to the batteries again. And since the path of the electricity went through the bulb, the bulb lit up.

-When you moved your switch to the OFF position, you made a gap in the path. You broke the circuit. Electricity couldn't flow. And the light went off.

Every time you turn on something that runs by electricty, you are making a circuit. Every time you turn it off, you are breaking a circuit. This is true both with battery-powered toys and with the appliances in your house.

You usually can't see the circuit you are making and breaking. The electric wires are hidden inside an appliance or inside the walls of your house. But they are there. When you turn a switch on, you are making a circuit - either with batteries or with a far-away electric company as the power source. All your switch does is make the circuit or break the circuit.

Whenever an electrical device doesn't work when you turn it on, the most probable cause is a break in the circuit somewhere!

- Part of the device or the switch may be burned out, breaking the circuit.

OR

- An electrical connection may be loose somewhere, breaking the circuit.

If an electrician repairs the connection, the device usually works again.

Activity #19 - Short Circuits

What you need from kit:	
Circuit board	1 Short wire

1. Make a Temporary Short Circuit
Take your circuit board and move the switch to the On position. The light bulb lights up, of course.

Leave the switch in the On position. Take one of the short wires that come with your kit. Touch one end of the wire to Connector A and the other end to Connector B. You have made a short circuit. What happens?

Take the wire away. What happens?

Turn the switch to Off.

2. Make Another Short Circuit
With the switch in the Off position, slip one end of the wire into Connector A and the other end into Connector B. You have made a short circuit (Fig. 4).

Move the switch to the On position. What happens?

Keep the switch in the On position for 10 seconds, or while you count to 10 slowly. Then move the switch to the Off position.

Touch one of the connectors. Does the connector feel warm or cold?

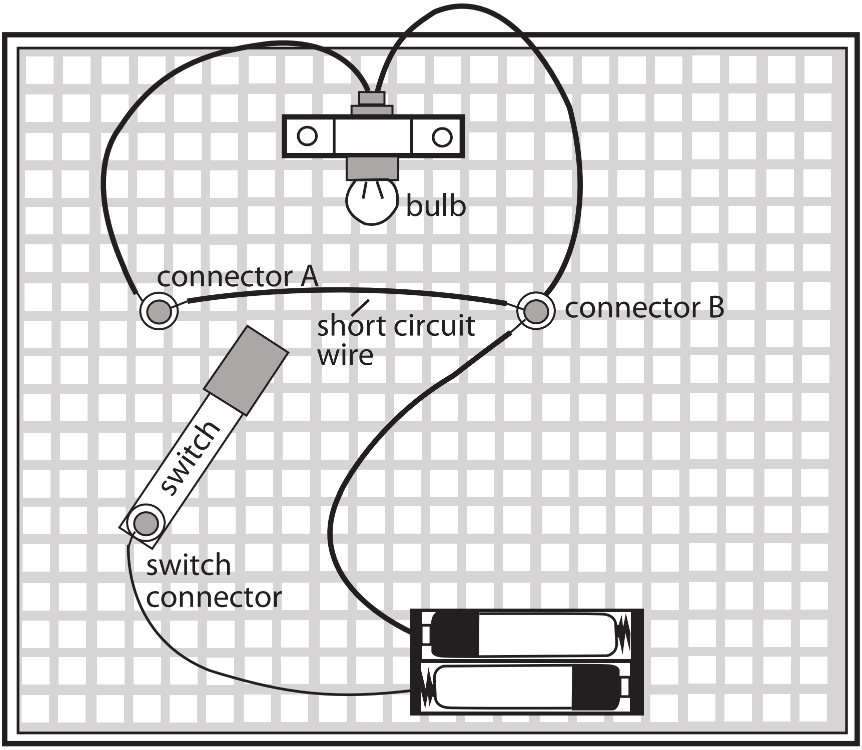
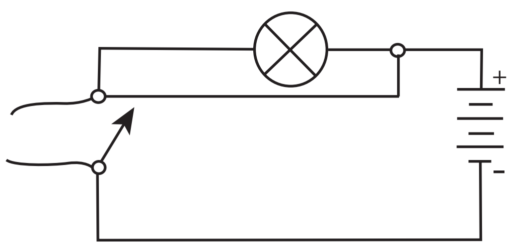


Figure 4



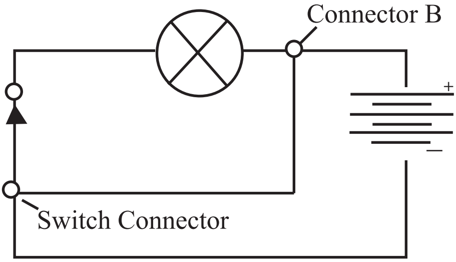
3. Make Other Short Circuits
Remove the short-circuit wire from Connectors A and B.

Move the switch to the On position. The light bulb lights.

Touch one end of the wire to Connector B and the other end to the Switch Connector - the brad at the end of the switch. What happens?

Touch one end of the wire to Connector A and the other end to the Switch connector. What happens?

Which experiment made a short circuit? Which did not? The circuit diagrams (Fig. 5) should show you.



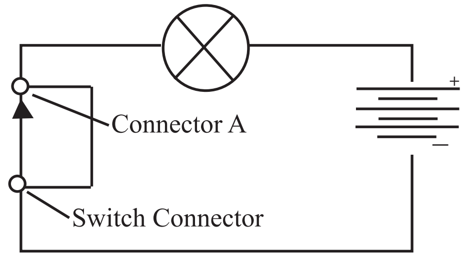


Figure 5

Short circuit - the wire bypasses the light bulb. The current does not work.

No Short circuit - the wire does not bypass the light bulb. It bypasses the switch, which will no longer break the circuit. The light bulb is always lit.

WHAT YOUR EXPERIMENT SHOWED

You made a short circuit in two different ways:

- you made a short circuit when you switched the light on, touched two connectors with the two ends of a wire, and the light went off.
- You made a short circuit when you attached a wire between two connectors, moved the switch to On, and the light didn't light

To understand what happened, you should understand that we use electricty to do work. Running an appliance is work. Even lighting a light bulb is work.

But electricty is lazy! If it can find a path to flow through without doing any work, it will.

When you make a short circuit, you are making a path for the electric current that it can follow without doing any work. So the current follows that path. And the light bulb doesn't light.

In a short circuit, the current flows out of the batteries with almost no resistance. The battery rapidly loses its charge and goes dead.

But even when electricity flows through a short circuit, it actually does a little work after all. It heats the wires and connectors that it flows through. They can get very hot. You felt this when you let electricty flow through a short circuit and then touched one of the connectors.

This is why a short circuit is dangerous! If a short occurs in an appliance or in the wiring in your home, the wires heat up. The short circuit can cause a fire.

In the last experiment, you learned that whenever an electrical device doesn't work when you turn it on, the most probable cause is a loose connection or some other break in the circuit somewhere. But if the problem isn't a break in the circuit, it may be a short circuit.

IF AN ELECTRICAL DEVICE DOESN'T WORK WHEN YOU TURN IT ON, TURN IT OFF AGAIN! GET SOMEONE TO UNPLUG IT! SHORT CIRCUITS ARE DANGEROUS!

You will learn how electricians protect against fire caused by short circuits later in this booklet.

Activity #20 - Testing Conductors & Insulators

What you need from kit:

Circuit board
Plastic jar with lid
2 brads
2 Long wires

What You need to get or use:

Salt
Water

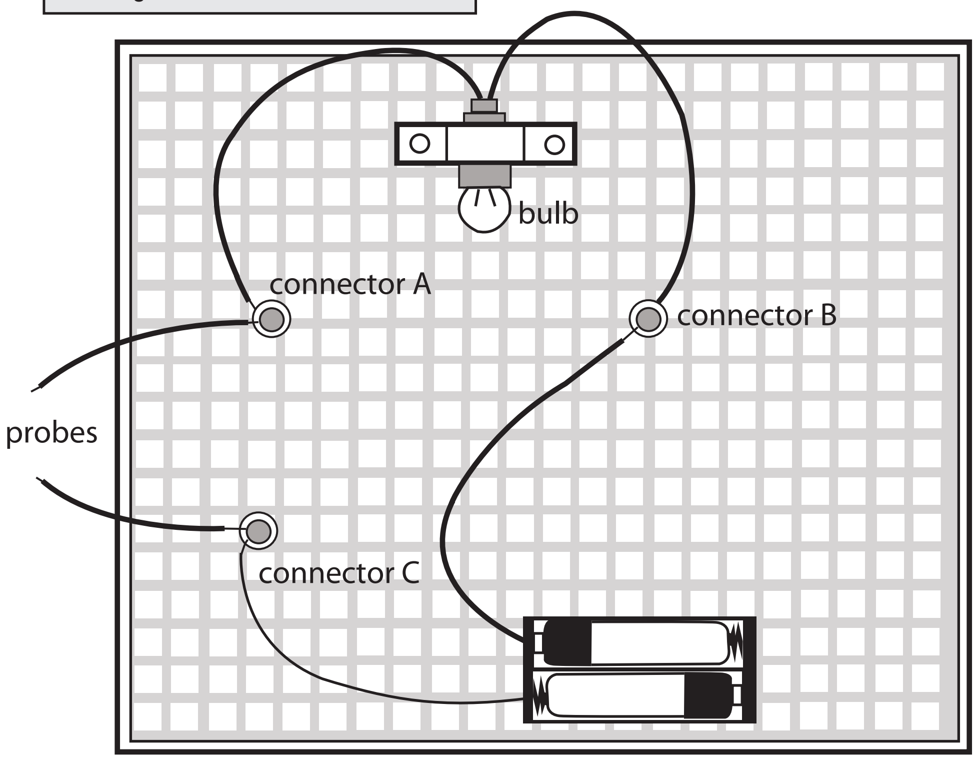
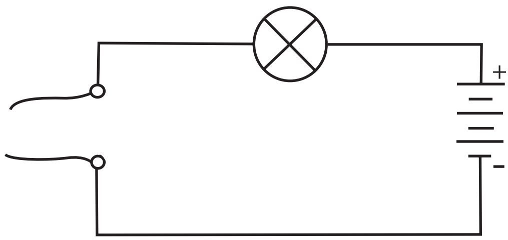


Figure 6



1. Make a Tester
You can make a tester (Figure 6) that you can use to test things to see if they are conductors or insulators.

Remove the brad that holds your switch in place and take the switch off the circuit board.

Put a temporary connector into the circuit board where the Switch Brad was. Follow the directions for making temporary connectors on page 6. This is Connector C.

Take two long wires. Slip an end of one wire into Connector A. Slip an end of the other wire into Connector C. These wires are called probes (Figure 6).

Test your tester by touching the ends of the two probes together. The light bulb should light up. If it doesn't, check your connections.

2. Test Common Objects
Test different things to see whether they are conductors or insulators. Just touch the ends of your probes to the object.

- If the bulb lights brightly, the object is a good conductor.
- If the bulb lights dimly, the object is a poor conductor.
- If the bulb doesn't light at all, the object is an insulator.

Use your tester to test each of the following items:

OBJECT	GOOD COND.	POOR COND.	INSULATOR
1. penny			
2. dime			
3. quarter			
4. piece of paper			
5. something wood			
6. something plastic			
7. metal spoon			
8. ceramic plate or cup			
9. key			
10. book			

WHAT YOUR EXPERIMENT SHOWED
You should have found that metal is a good conductor of electricity. The best conductors are silver, copper, gold, and aluminum. The most common conductors, used in electric wires, are copper and aluminum. They are used instead of silver and gold because they are much less expensive.

Paper, plastic, wood and ceramics are insulators.

2. Test Water
Take the small plastic jar and its lid. If the lid has no holes, make two small holes about 1/2 inch (1.5 cm) apart.

Push 2 brads through the holes in the lid.

Fill the jar about 3/4 full with water and snap the lid onto the jar. The legs of the brads should be in water.

Touch the ends of your probes to the brads (Figure 7). Look at the bulb. Does it light up? Is water a conductor or an insulator?

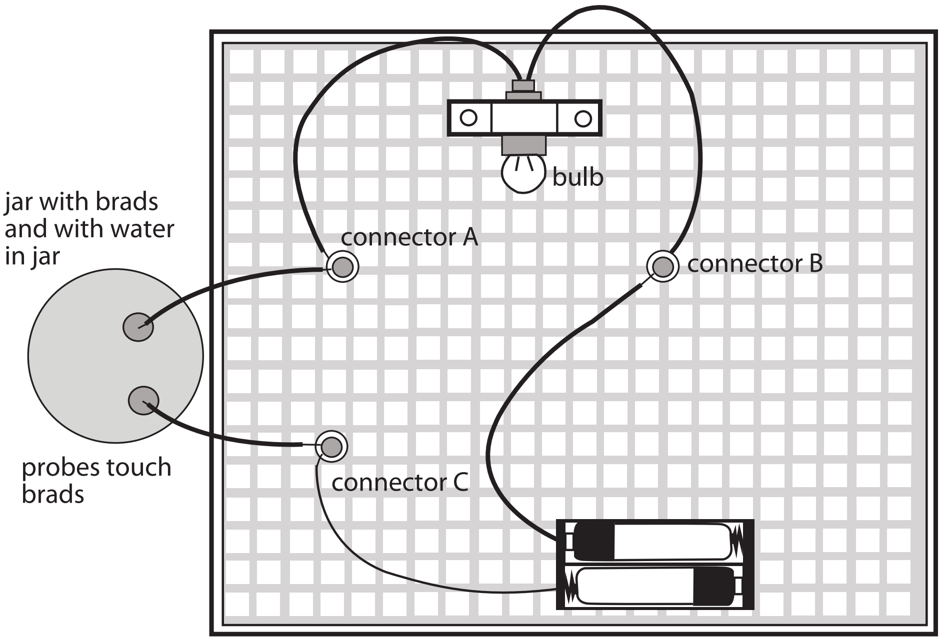


Figure 7

3. Test Salt Water
Take the lid off the jar. Add about half a teaspoon of salt to the water. Stir the water until most of the salt is dissolved.

Snap the lid back onto the jar.

Connect the ends of your probes to the brads. Look at the bulb again. Does it light up? Is salt water a conductor or an insulator?

You may wish to try other liquids, like salt water and vinegar. Are they conductors?

WHAT YOUR EXPERIMENT SHOWED
You should find that when you use plain water in the jar, the light bulb doesn't light. Plain water is a very poor conductor of electricity.

When you use salt water, (or vinegar, or lemon juice in the jar), the light bulb lit up, but not as brightly as when you used a metal conductor. Salt water, vinegar, and lemon juice are conductors though not as good as metal.

WARNING:
Batteries don't have much power. But the electric current in your home has a lot more power behind it! It CAN use water as a conductor! Never touch any electric wall switch or electric appliance when you or your hands are wet! The electricity in your home can injure or even kill you if it passes through your body.

Activity #21 - Making a Fuse

ADULT SUPERVISION REQUIRED FOR THIS ACTIVITY

What you need from kit:

Plastic jar with lid (from last experiment)
Steel wool
Circuit board (from last experiment)

1. Prepare the Fuse Jar
Empty out all the liquid from your jar. Dry the inside of the jar, and dry the brads too. Make sure there is no moisture in the jar or on the brads.

Get your piece of steel wool and pull a small tuft from it. Twist it so that it no longer feels fuzzy, but is like a single piece of thick, soft wire. Slip the ends into the legs of the brads in the jar lid, so that it forms a bridge between them.

Put the lid back on the jar and snap it shut firmly (Figure 8).

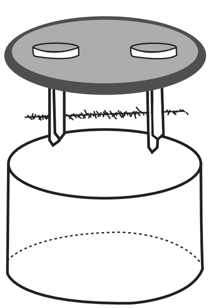


Figure 8

2. Prepare the Circuit Board
Remove Connector C and its probe from the circuit board. (Leave the other probe attached to Connector A.)

Put the switch back on the board the way you did in the first series of experiments - Making a Circuit.

Check your circuit by moving the switch to the On position. The light bulb should light up. Then move the switch back to Off.

Remove the light bulb wire from Connector A and connect it to a brad in the jar lid. (Place it between the legs of the brad.)

Connect the probe from Connector A to the other brad in the jar lid. Your circuit board should now look like the drawing (Fig.9)

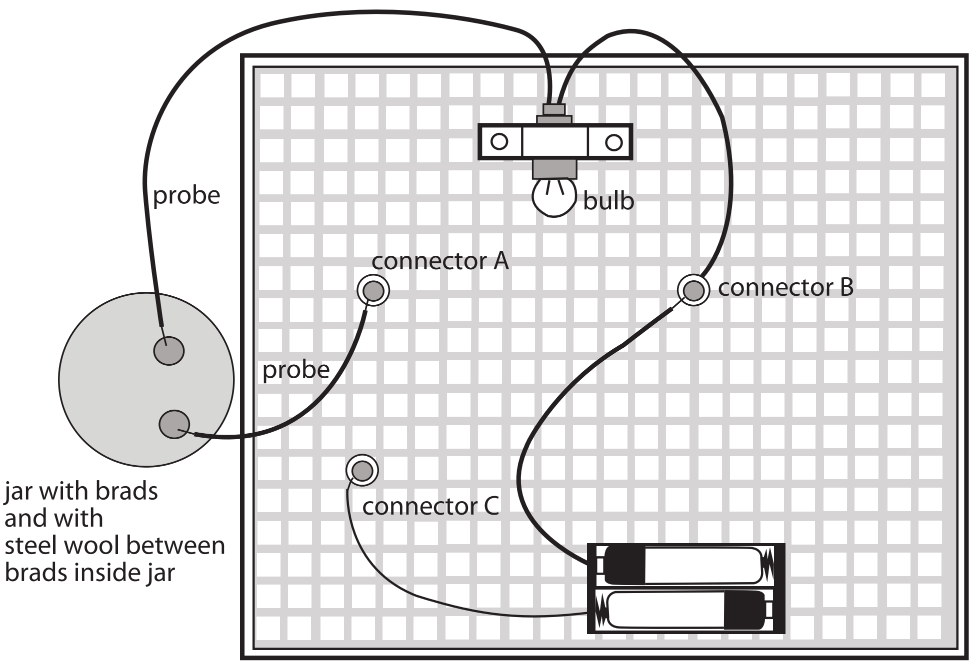
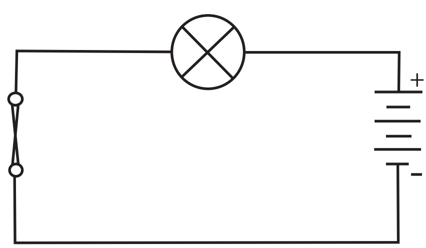


Figure 9



3. Test the Fuse
Move the switch to On. Keep it there. What happens?

WHAT YOUR EXPERIMENT SHOWED

When you switched the current on, the steel wool glowed brightly for a moment. Then it burned out. At the same time, the light bulb went off.

Whenever current passes through a conductor, it makes heat. You found this out in the second series of experiments. - Short Circuits. Some metals heat up so quickly and so much that they glow red and then white. They melt or vaporize if too strong a current is passed through them. This happened to the steel wool.

Somewhere in your home you have a box containing fuses (or automatic switches called circuit breakers that do the same job.) The fuses in the box are made of a short length of very thin wire in a glass or ceramic housing. There is a fuse or a circuit breaker in every circuit in your home. The fuse protects the circuit from overheating. This can happen for two reasons:

-Too many appliances are plugged into the circuit. They use too much current. The wires in the circuit heat up.

- The insulation on two electric wires that are close to each other wears through. The wires touch each other and a short circuit results.

In either case, the fuse heats up, too. The fuse blows before the electricity can cause a fire. Electricity stops flowing in the circuit, and a fire is prevented.

SOMETHING ELSE THAT YOUR EXPERIMENT SHOWED

When electricity passes through a wire, it heats the wire. If you choose the right kind of wire, it gets white hot and gives off light. You saw this when you made your fuse. It glowed for a moment before it burned out.

You not only made a fuse. You also made a light bulb!

Of course, your light bulb burned out in less than a second. Real light bulbs last longer. Here's why:

- Burning is the process of heating something until it combines with a gas in the air called oxygen.

- If the wire in the bulb has no oxygen around it, it won't burn.

- Bulb makers prevent bulbs from burning either by taking all the air out of the bulb or by putting in some other gas that doesn't burn.

Activity #22 - Electrolysis

ADULT SUPERVISION REQUIRED FOR THIS ACTIVITY

What you need from kit:

Plastic jar with lid (from Activity 20)
Circuit board

What You need to get or use:

Salt
Water

1. Set Up the Experiment
Set up Experiment #20 Testing Conductors again. This is the experiment where you passed an electric current through salt water.

You can use the same setup that you used for the fuse experiment - without the steel wool, of course. Just put the salt water in the jar and, when you are ready, close the switch.

Leave the switch On and keep the experiment running for 3 minutes.

2. Watch Carefully
Look through the side of the jar. The jar is made of a cloudy plastic, but you should notice the following:

- Nothing much happens for about a minute.
- After a minute or so, you will see a cloudy green-gray substance slowly forming in the water.
- This change takes place near only one of the brads.
- You can't see the next change, but if the jar were clear, you would notice tiny bubbles forming on the other brad.

WARNING: You have made a chemical in the salt water. Now it contains harmful chemicals. **DO NOT DRINK IT!**
Never drink or eat anything you use in an experiment or that is produced by an experiment! It may be poisonous!
Always wash your hands after doing experiments with chemicals!

3. Clean the Jar
After 3 minutes, remove the probes from the brad. Empty the stuff in the jar into the sink or toilet. Wash out the jar. Then wash your hands.

4. Look at the Brads
Notice any changes in the color of the brads. Did only one brad change color, or did both?

WHAT YOUR EXPERIMENT SHOWED
This is an easy experiment to do. But to understand what happened is not so easy.

Here's a quick explanation:

- The electricity caused chemical changes both in the salt water and in one of the brads.

- The greenish-gray sludge comes from a chemical combination of the metal in the brad with part of the salt in the water.

- The bubbles that form on the other brad are hydrogen gas, the lightest gas in the universe. The hydrogen came from splitting the water molecules; water is made of the gases hydrogen and oxygen.

You'll find a more complete explanation later in the book.

As you saw, in this experiment electric current brought about a chemical change. Using electricity to split molecules and make chemical changes is called electrolysis, which means "loosening or splitting with electricity".

Electrolysis was discovered very shortly after the invention of the battery. Today, electrolysis is often used by scientists to make or study new chemicals. It is also widely used to make the chemicals that are used in our factories and industries.

Another common use is to put a metal coating on an object. This is called electroplating. If you had used a silver salt instead of table salt in the water, the brad would have been plated with silver when you passed electricity through it.

Activity #23 - Light Bulb in Series and in Parallel

What you need from kit:

Circuit board
Light bulb with holder
Switch Connector

1. Experiment with Two Light Bulbs in Series
Add the second light bulb in your kit to your circuit board setup. You'll also need to insert a new connector, Connector C, between the bulbs. Follow the illustration and the circuit diagram (Fig. 10). Putting two light bulbs in a row like this is called putting them in series.

Turn the switch to On. What happens to the light bulbs?

Compare the brightness of each bulb in the series circuit to the brightness of one bulb alone. Do this by keeping the switch On and then touching one end of a wire to Connector B and the other end to Connector C. You have created a short circuit around Bulb 2. (An electrician would say that you "shorted out" Bulb 2.) The electricity bypasses Bulb 2 and goes through Bulb 1 only. Which is brighter - a single bulb in a circuit, or 2 bulbs in series?

With the switch still on, pull Bulb 2 from the series circuit. What happens?

Put Bulb 2 back in its socket and switch everything Off.

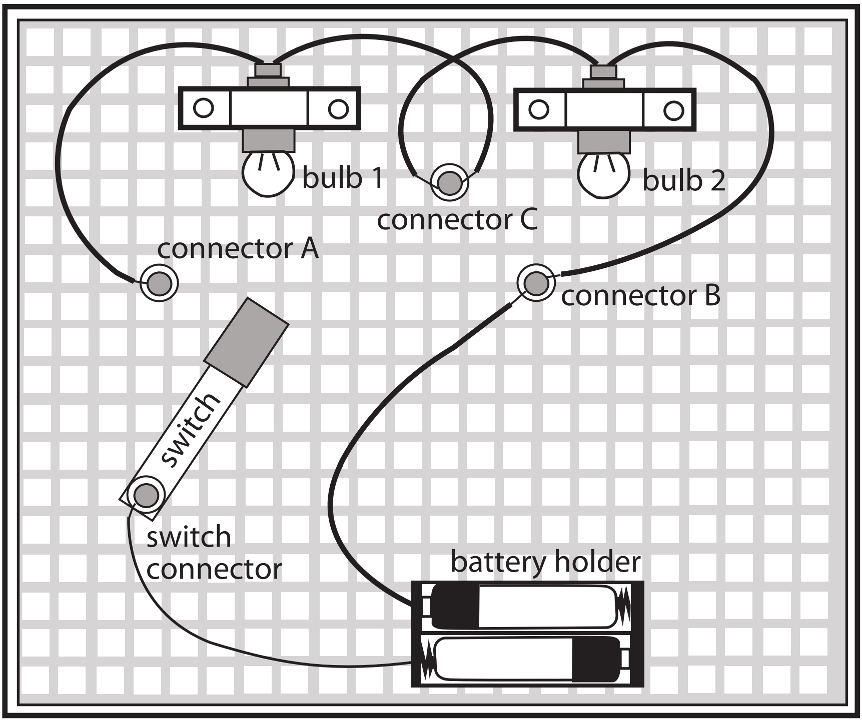
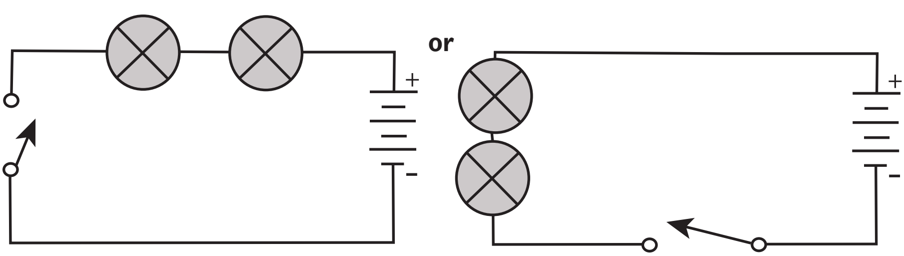


Figure 10



WHAT YOUR EXPERIMENT SHOWED

You should have found the following things about two bulbs wires in series:

- Two light bulbs in series are not as bright as one light bulb alone. This is because the "push" that the batteries give to the electric current remains the same, but now the current has to light up two bulbs.

- As you can see from the circuit diagram, if you remove a bulb, you break the circuit. And so the other bulb also goes out. It doesn't matter which one you remove. The other also goes out.

2. Experiment with 2 Light Bulbs in Parallel

Make a new setup with the 2 light bulbs. Take the wires ends out of Connector C and remove this connector. Put one wire into Connector A and the other into Connector B, exactly the way the diagram shows (Figure 11).

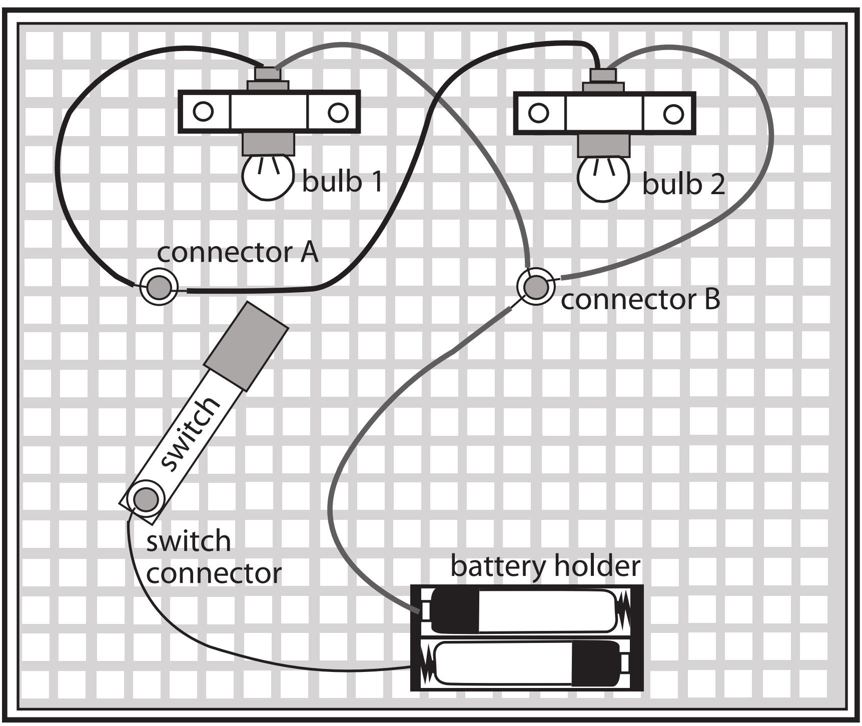
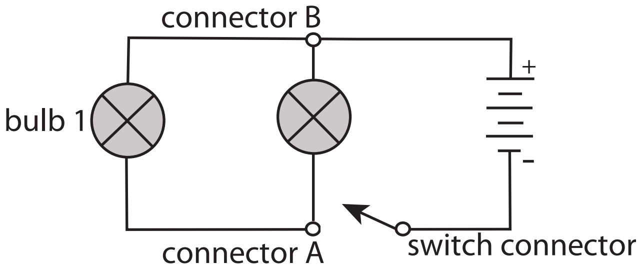


Figure 11



Putting two light bulbs side by side in a circuit like this is called wiring them in parallel.

Turn the switch On. What happens to the light bulbs?

Again, compare the brightness of each bulb in the parallel circuit to the brightness of one bulb alone. Do this by disconnecting both Bulb 2 wires from the connectors. Which is brighter - a single bulb in a circuit, or two bulbs in parallel? Which is brighter, two bulbs in parallel, or two bulbs in series?

Reconnect Bulb 2. With the switch on, pull Bulb 2 from the parallel circuit. What happens?

Put Bulb 2 back and switch everything Off.

WHAT YOUR EXPERIMENT SHOWED

Look carefully at your circuit board and at the circuit diagram. At first they may not look the same at all. But if you look at them carefully, you will understand how they show the same kind of circuit. The labeling on the circuit diagram should help you.

Notice that in a parallel circuit, the path of the electricity splits in two, and then join the two paths again. Some of the current goes in one path, through Bulb 1. The rest goes in the other path, through Bulb 2. This is very different from a series circuit, where there is only one path for the electricty to follow.

You should have noticed the following things about a parallel circuit:

-Bulbs wired in parallel are brighter than bulbs wired in series!

-When two light bulbs are wired in parallel, each bulb is nearly as bright as one bulb wired by itself. (Surprisingly, in a parallel circuit like this one, each of the branches draws the same amount of electricity as the one path of an ordinary circuit.)

- When you remove one bulb from one branch of a parallel circuit, the other branch of the circuit is not broken. So the other bulb stays lit. This is why appliances in your home are wired in parallel, not in series.

Some of the electricity in the circuit is wasted in heating up the wires and the connectors. If there were no waste, each light bulb in the parallel circuit would be just as bright as a single light bulb.

You don't get the extra brightness for free. The circuit is now lighting two bulbs at nearly full brightness, so it is using two times the amount of current as a circuit with only one bulb. The batteries will wear out more quickly.

3. Make a Two-Way Switch

With a small change in your parallel circuit, you can make a two-way switch. The switch will turn on either bulb, but not both at once.

Make a new temporary connector (Connector D) on the other side of the switch from Connector A. Take the wire from Bulb 2 out of Connector A and insert it in Connector D. Follow the diagram to make sure everything is correct (Fig. 12). And check under the circuit board to make sure the legs of the brads are not touching!

You now have a two-way switch.

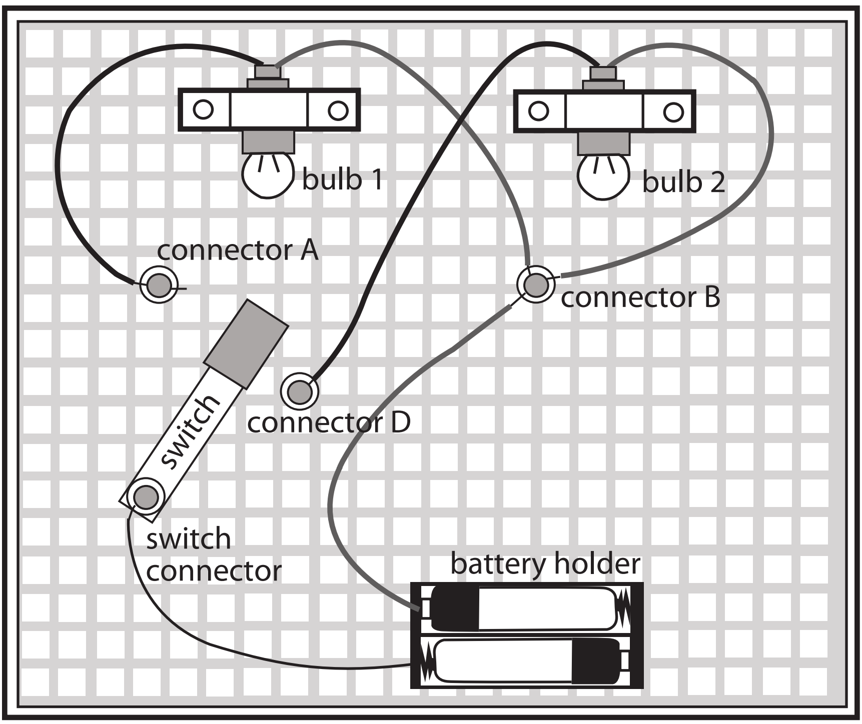
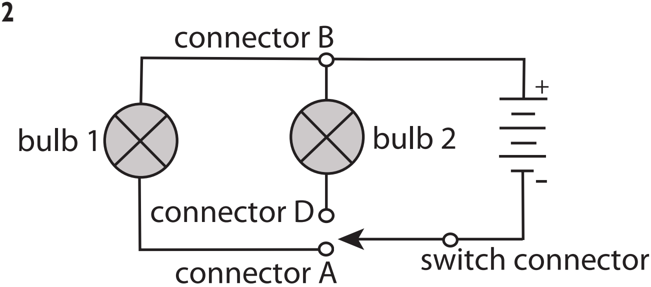


Figure 12



Activity #24 - Batteries in Series and in Parallel

What you need from kit:	What You need to get or use:
Bulb Brass strip Brad	2 "AA" Batteries

1. Make a Battery Tester
Remove one of the bulbs and holders from the circuit board.

Take the brass strip with the two holes in it. Put the end of a bulb wire into a hole and wrap the end around the brass strip so that it makes a good electrical contact.

Put the other bulb wire end between the legs of a brad. Wrap the wire end around the brad so that it, too, makes a good electrical contact.

Your tester is now complete. It should look like the one in the drawing (Fig. 13a).

2. Test with One Battery
Take a battery out of the battery holder. Place the flat bottom of the battery on the brass strip. Touch the bump on the top with the brad, the way the drawing shows (Figure 13b). What happens?

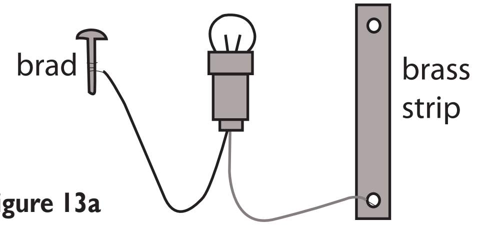


Figure 13a

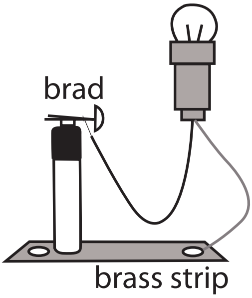


Figure 13b

Turn the battery upside down so that the bump is on the brass strip. Touch the flat end with the brad. What happens?

WHAT YOUR EXPERIMENT SHOWED
Using one battery gave a very weak glow to your light bulb.

Look at the side of the battery. It's marked 1.5 volts. Volts are the push that the battery gives to the electric current flowing through the bulb. 1.5 volts isn't much of a push.

A weak push means that not much electric current goes through the bulb, so it's not very bright.

Current, by the way, is measured in units called amperes, or amps for short. (They are named after André Ampère, an early scientist who studied electricity.)

-Batteries are marked with a "+" on top (where the bump is) and (sometimes) a "-" on or near the bottom. The top with the bump is called the positive end and the flat bottom is the negative end.

In a circuit, electricity flows from the negative end of the battery to the positive end.

When you turned your battery upside down, the electricity flowed the other way. But nothing new happened. In the circuits in this kit, it doesn't make any difference which way the electricity flows. (It does make a difference in some circuits - inside radios and TV sets, for example.)

3. Test Batteries in Series
Stack 2 batteries on the brass strip. You now have two batteries connected in series (Fig. 14). Hook it up like the diagram. What happens? How is the result different from your test with only one battery?

Turn both batteries upside down and test again. What happens?

Hold the two batteries so that the two flat ends are touching (negative to negative). Test again. What happens?

WHAT YOUR EXPERIMENT SHOWED

Stacking batteries in series adds voltage. So when you have 2 batteries in series sending electricity through the bulb, you have double the push that you have with only 1 battery. The batteries send twice as much current through the bulb, and it burns brighter.
Two 1.5 volt batteries in series equals 3 volts. (1.5 volts x 2 = 3 volts)

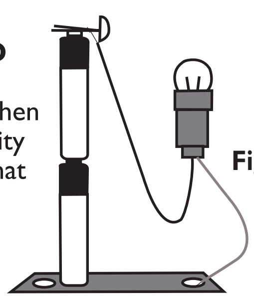


Figure 14

When you stack batteries in series, you have to stack them so that the positive end of one touches the negative end of the other. If you don't do this, you have the batteries trying to send electricity in opposite directions, and nothing happens.

4. Test Batteries in Parallel
Rest 2 batteries side by side on the brass strip and touch the top bumps of both of them with the brad. You now have 2 batteries in parallel. (Fig. 15). What happens? How does the light of the bulb compare to the light when the batteries are in series?

Turn 1 of the batteries upside down and test again. What happens?

3. Put the batteries back in the battery holder.

WHAT YOUR EXPERIMENT SHOWED

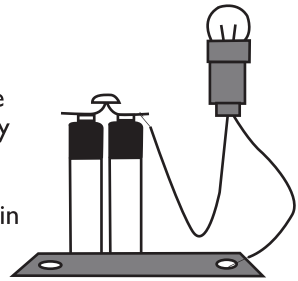


Figure 15

2 batteries in parallel don't give any more "push" to the current than 1 battery does. So the bulb didn't burn any brighter.

What's the advantage of batteries in parallel? Batteries in parallel last 2 times as long.

Now look at all you learned from your experiments with the battery tester!

Volts are the push that the battery gives to the electric current it puts out. Amperes or amps are the amount of current in a circuit.

Batteries in series add voltage-electrical push. The more batteries you put in series, the brighter the bulb shines.

Batteries in parallel don't add voltage. (But putting batteries in parallel makes them last twice as long.)

Batteries in series must be positive to negative. If you stack them positive to positive, or negative to negative, they don't work.

Current in a circuit moves from negative to positive.

Activity #25 - Resistance

What you need from kit:

Circuit board
Resistor
1 Short wire

1. Experiment with a Resistor and a Bulb in Series
Connect a resistor into the circuit in series with a light bulb. Follow the diagram carefully (Fig. 16). What happens to the light when you turn on the switch? Leave the switch on for only a few seconds, then turn it off.

Look carefully at the circuit diagrams. What is the symbol for a resistor?

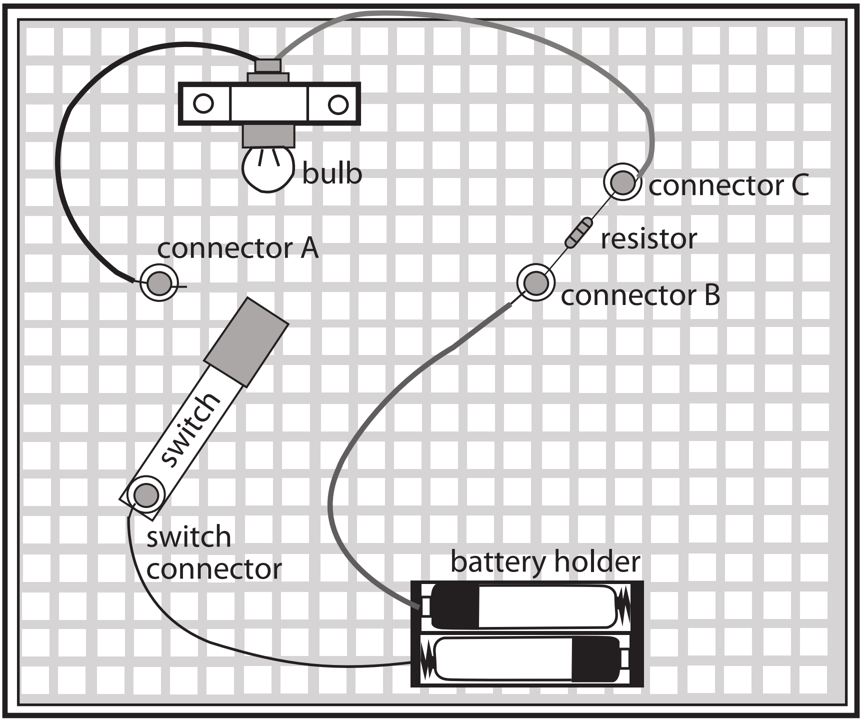
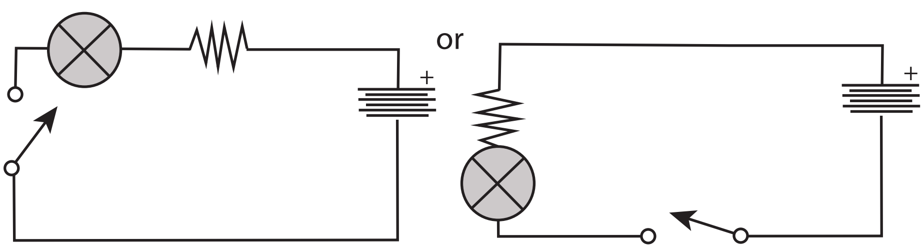


Figure 16



2. Experiment with a Resistor and a Bulb in Parallel
Connect a resistor into the circuit in parallel with the light bulb. Follow the diagram carefully (Fig. 17).

The wires from the resistor may not be long enough to reach between the two connectors the way the diagram shows. If you need to, take a short wire from your kit. Place it across one of the wires from the resistor and twist the two wires together. The combination should be long enough. Or move Connector B closer to A.

What happens to the bulb when you turn on the switch? Leave the switch on only a few seconds, then turn it off.

Very lightly, touch the resistor. What do you notice?

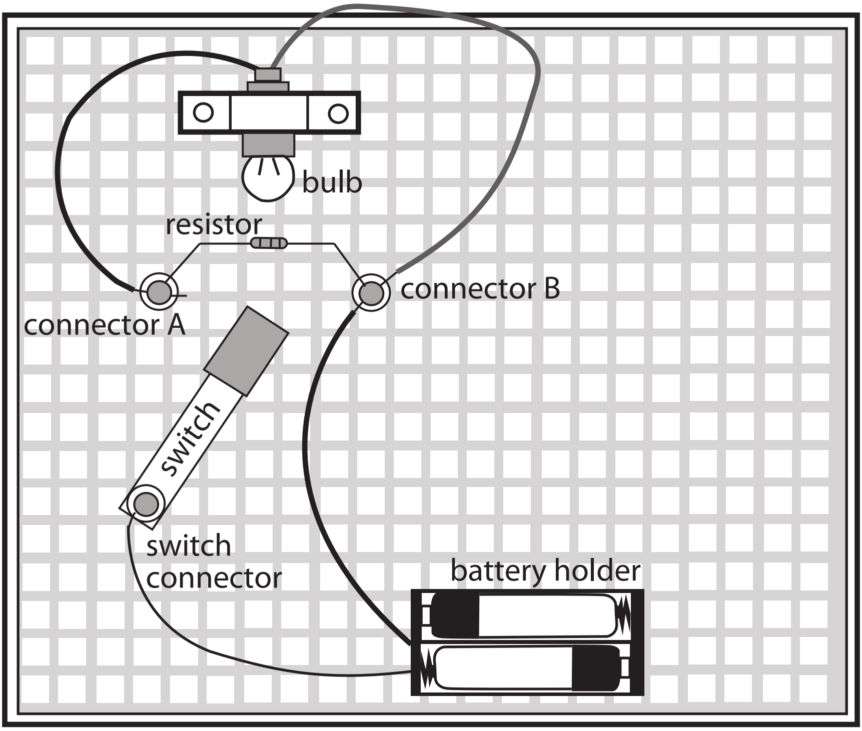
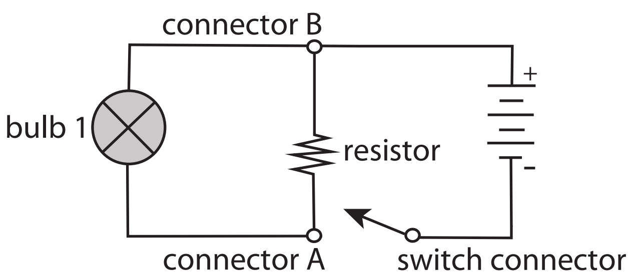


Figure 17



WHAT YOUR EXPERIMENT SHOWED

A resistor resists the flow of electricity.

You felt one result of resistance:heat.

Another result can be light, for a light bulb is also a kind of resistor.

When a resistor is connected in series with a light bulb, the bulb loses brightness.

When a resistor is connected in parallel with a light bulb, however, the brightness of the light bulb is not dimmed. There is still a clear path for the current to take through the bulb without going through the resistor, and it does so.

But current also goes through the resistor when it is in parallel. You can feel it. It gets hot.

There are many things in your home that work because of resistance: toasters, lamps, heaters, even a dimmer switch.

Activity #26 - Sending Messages with Morse Code

What you need from kit:

Circuit board
Morse Code Switch

1. Put the Morse Code Switch onto the Circuit Board
Take the switch key off the circuit board.

Count 8 holes down from Connector A. Slip a brad through the end hole of the Morse Code Switch and into the 8th hole below Connector A. Do not spread its legs yet.

Slip a spring under the hole in the middle of your Morse Code Switch. Slip another brad through this hole, through the spring, and through the circuit board. Reach under the circuit board and spread the legs of this brad.

Slip the loose battery wire through the legs of the first brad-the one at the end of the key. Reach under the board and spread the legs of the brad. Your setup should look like the diagram. (Figure 18).

Check under the circuit board. Make sure there are no brads touching

Test your connection. You should be able to make the light blink on and off just by tapping the key.

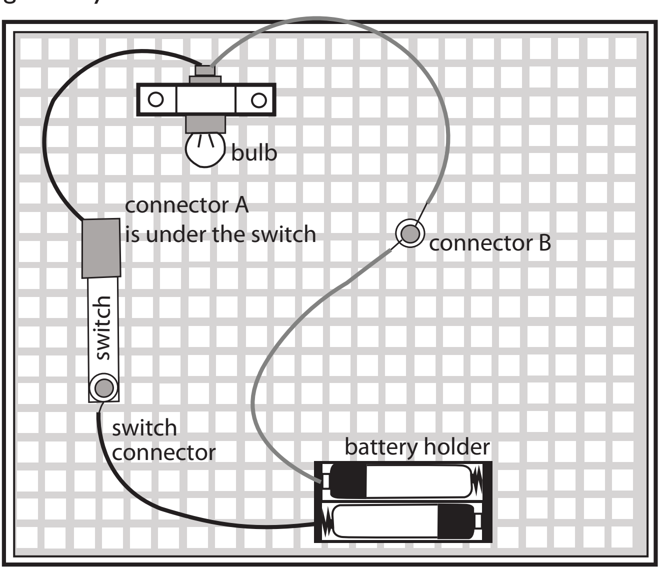
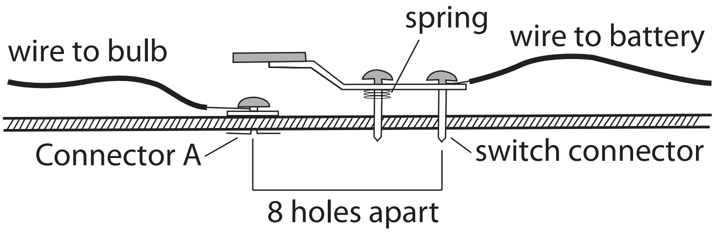


Figure 18



2. Send Messages in Morse Code
Morse Code uses two kinds of signals: very short ones (dots) and longer ones (dashes). Use a quick tap for a dot. Use a longer one for a dash. The complete code is shown below (Figure 19)

You may want to practice sending messages to a friend who is some distance away from you. Now and then, change places with your friend so that both of you can practice coding and sending meassages as well as receiving and decoding them.

Morse Code used to be used to send messages by telegraph and by wireless (radio). It isn't used much anymore, since radios can now send voices anywhere in the world.

International Morse Code Table

A	•—	N	—•	1	•————	Period (full stop) •—•—•—
B	—•••	O	———	2	••———	
C	—•—•	P	•——•	3	•••——	Question Mark (interrogation) ••——••
D	—••	Q	——•—	4	••••—	
E	•	R	•—•	5	•••••	Break —•••—
F	••—•	S	•••	6	—••••	Wait •—••
G	——•	T	—	7	——•••	End of Transmission •••—•—
H	••••	U	••—	8	———••	
I	••	V	•••—	9	————•	
J	•———	W	•——	10	—————	
K	—•—	X	—••—			
L	•—••	Y	—•——			
M	——	Z	——••			

Figure 19

Activity #27 - Making a Burgular Alarm

What you need from kit:

Circuit board

What You need to get or use:

Thread

You can use your circuit board to make a burgular alarm. It won't make a noise, but it will light up if anyone comes into a room where the circuit board is.

1. Set up your circuit board as shown in the drawing (Figure 20). Basically, this is just the first circuit you made in this kit, only without a switch key.

2. Get a length of very thin thread that's easy to break. Tie it around the brass strip and place the strip as shown in the diagram.

3. Test your alarm. Pull gently on the thread. The brass strip should be pulled into the contacts, and the light should light.

4. When everything tests OK, set up the alarm. Place it on the floor against the wall, near the door. Tape the end of the thread to the door so that when the door opens, the thread pulls the brass strip into the two contacts. You may want to put a weight on top of the circuit board so that the thread doesn't pull it across the floor when the doors opens. The thread breaks instead, but the light stays on.

5. Test your setup until it works the way you want it to.

Remember that this is really just a demonstration! If someone goes into the room and turns the alarm on, the batteries will run down unless you turn it off.

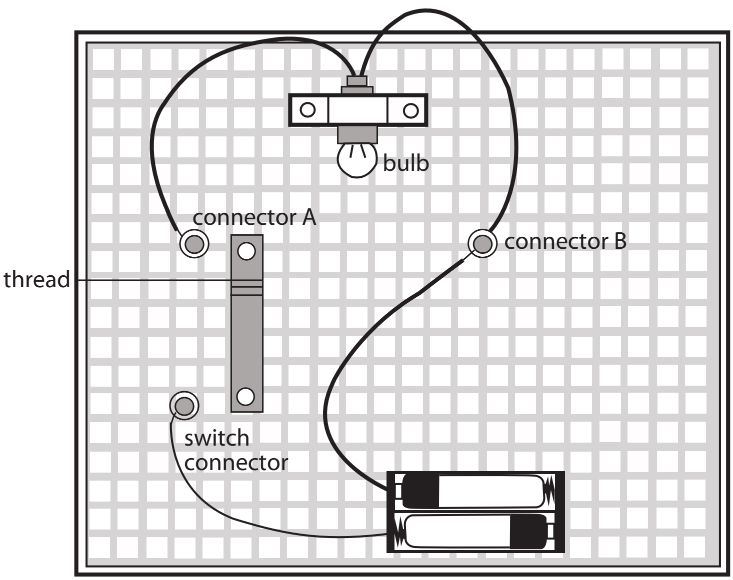
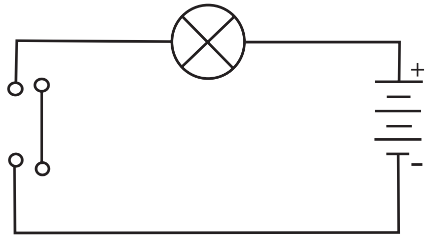


Figure 20



Activity #28 - Making a Puzzle Game

What you need from kit:

Circuit board

You can make an electric puzzle game with your circuit board. Just follow the directions below.

1. Set up your circuit board as shown in the drawing (Figure 21). The main part of the setup has five rows of two brads each. The brads don't need springs or washers.

2. Player 1 uses short wires to connect just one brad in every row. (Player 2 must not watch.) The last brad, one in Row 5, is connected to the battery wire, which is slipped under the circuit board through one of the holes. In the setup shown here, the brads that are connected are 1A, 2A, 3B, 4A and 5B. However, you can make your own setup.

3. Player 2 tries to guess which brad in each row is connected to the circuit. He or she uses the free bulb wire as a probe, touching one brad in each row with the tip of the wire. The bulb lights with each correct guess. The player's score is the number of correct guesses (out of 5).

4. Now Player 2 rewires the underside of the board, and Player 1 tries to guess.

5. The winner of the game is the player with the highest number of correct guesses.

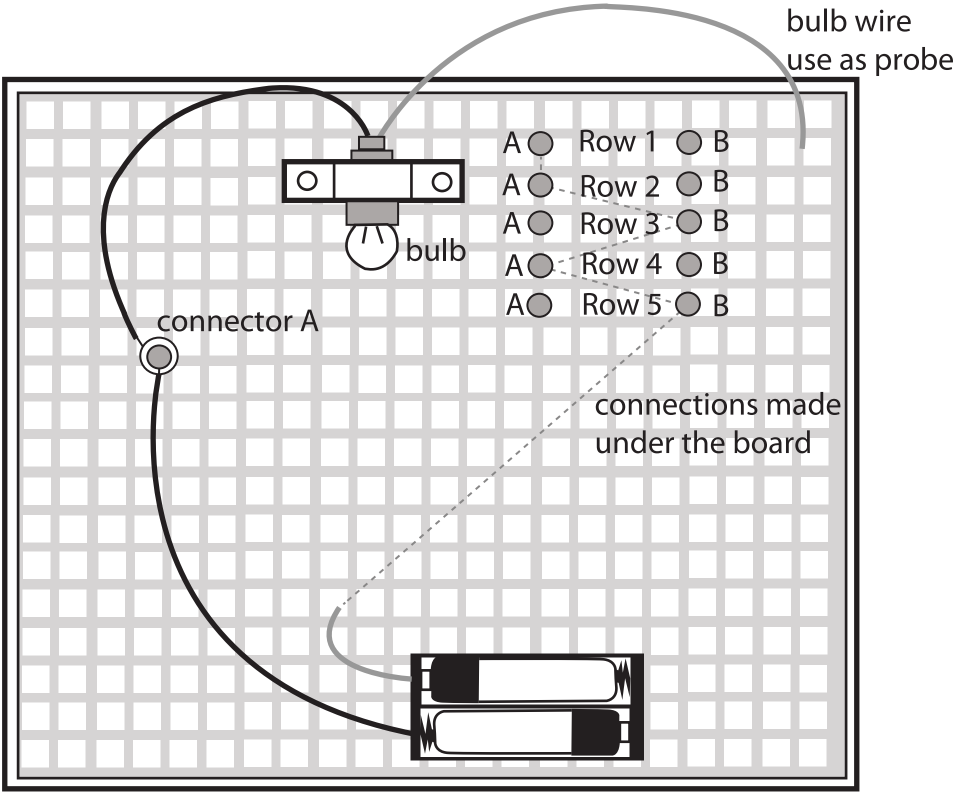
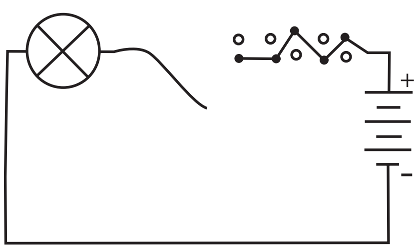


Figure 21



What is Electricity?

You probably know that everything in the world is made of tiny particles called atoms.

The outside of an atom is made up of a cloud of even tinier electrical particles called electrons.

In an electrical circuit, the voltage moves some of the electrons in the wire from atom to atom in the direction of the current flow. The negative end of the battery is "pushing" the electrons, and at the same time the positive end of the battery is attracting them.

Of course, if there's a break in the circuit, the electrons don't move and current doesn't flow.

Electric current flows fast. But the actual movement of the electrons is slow. Think of a long line of kids. The last one in line suddenly gives a push to the person in front of him or her. That person bumps into the next person, and so on all the way to the front of the line. The push traveled a long way, but nobody has really moved very far.

Lab Notes

Lab Notes

Lab Notes

Lab Notes

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