LAB 58: BATTERY AND LED

An LED should never be connected directly to a battery or it will be damaged. A current-limiting resistor must be attached to either leg to prevent this damage. The value of the resistor will depend on the battery that you use and the LED that you use. Be sure that when you purchase your LEDs, they are rated for a certain current and voltage (preferably in the range of 1.5 V so that a single battery may be used).

Calculate the value of the resistor to be used by determining how much current would flow through that resistor in the absence of the LED. For example, if you are using a 1.5 V battery and an LED rated at 10 mW, you would use Ohm's law to calculate the resistance needed.

$R = V/I$ or R = 1.5 V/.010 W = 150 Ohms

In this case, you would attach a 150 Ohm resistor to one of the LED's legs. Soldering is preferred, but twisting the legs together with electrical tape would also be acceptable.

Instruct students that they should not use any other type of battery to power the LED, or they could damage it or injure themselves if the wires overheat.

Students will create a circuit similar to the battery and lightbulb circuit and analyze it with a multimeter. They should see that the LED takes far less energy than a lightbulb.

Post-Lab Answers

1. Answers will vary but may include portable music devices, CD players, DVD players, computers, stereos, laptops, new car taillights, pocket lasers, remote controls, an optical mouse, a ball-type mouse, or toys.
2. Answers will vary, but the LED should have far lower power than the lightbulb.
3. Answers will vary. For example, if the power measured is 20 mW, it would take 50,000 hrs.
4. If a component gets hot, much of its energy is being converted to heat, and it is therefore inefficient. Lightbulbs get very hot; LEDs do not.

LAB 58: BATTERY AND LED

QUESTION

How do you connect an LED to a battery to get it to light up? What are the advantages of LEDs over light bulbs?

SAFETY

Do not connect the LED to more than the recommended voltage or it will get very hot and will be destroyed. Do not connect an LED without a resistor.

MATERIALS

D-cell battery, wires, LED (with current-limiting resistor), multimeter

PROCEDURE

An LED is a light-emitting diode. LEDs are common as little colored lights on computers, televisions, and other appliances. The lights on your computer, computer speakers, keyboard, monitor, and printer that tell you that the power is on are probably all LEDs. LEDs are different than lightbulbs in two main ways. First, they require far less power than a lightbulb does. You would be wasting a lot of electricity if you were to replace every LED in your house with a small lightbulb. Also, LEDs only work when electricity passes through them in the correct direction. A diode is a component that only allows electrons to flow in one direction. Diodes are commonly used for protection in circuits, and in combination with each other can be used to rectify the AC coming out of your wall (which is the first step in converting AC to DC to charge batteries and power small appliances). An LED is simply a diode that gives off light.

An LED normally has one leg (the metal pins sticking out of it) that is longer than the other. The legs will help you determine which way to hook it up in the circuit. Some LEDs also have one side of their body that is flat while the rest of the

body is round. LEDs are not meant to handle a lot of current, so a resistor must be connected to one of the legs to limit how much current flows through.

1. Using wires, connect the LED so that the longer leg is connected to the positive pole of the battery and the shorter leg is connected to the negative pole of the battery. Does it light up?
2. Now connect the LED so that the longer leg is connected to the negative pole of the battery and the shorter leg is connected to the positive pole of the battery. Does it light up?
3. Write a rule for connecting LEDs in a circuit.
4. Does the LED feel hot like a lightbulb?
5. Measure the voltage of your battery using the voltmeter.
   _____ V
6. Measure the current running through the LED when it is lit.
   _____ amps
7. Calculate the power running through the LED/battery/resistor circuit.
   _____ W
8. Calculate the resistance of the LED (remember to subtract the resistor).
   _____ ohms
9. Draw a schematic diagram of your circuit using the correct schematic symbols.

Post-Lab Questions

1. Name five things in your house that have LEDs in them.
2. How did the power of the LED compare to the power of the lightbulb in Lab 57: Battery and Lightbulb?
3. If electricity costs 15¢ per kWh, how long would you have to run this LED to cost 15¢? (A kWh is 1,000 W for 1 hr., or 1 W for 1,000 hrs., or 5 W for 200 hrs., etc.)
4. What does the temperature of the LED tell you about its efficiency?

Extension

Find out other ways that LEDs are used in your everyday life. You might be surprised to find out that a lot of inexpensive lasers use LEDs as their source of light.

LAB 59: THE ELECTRICAL SWITCH

This activity is inquiry-based in that students will perform the activity before they formally learn about how a switch works. They will use a multimeter to discover the different settings on a triple-throw switch. The teacher should show the students how to use their multimeters to perform a continuity test.

Switches are very simple and intuitive devices that will be easy for students to understand. In order to complete the circuit described in this activity, students should already know how to hook up an LED, a battery, and a lightbulb.

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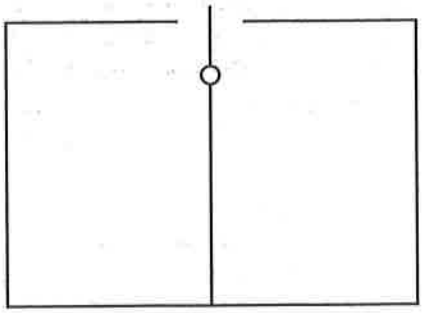
Post-Lab Answers

1. The triple pole switch works just like its diagram. When flipped to the left, two conductors touch and complete a circuit. In the middle, the conductors do not touch and the circuit is off. When flipped to the right, two different conductors touch and a different circuit is completed.
2. I would have an almost complete circuit on the left with one of the wires broken and an almost complete circuit on the right with the same wire broken. Touching the center wire to the left circuit would turn it on and touching the broken wire to the circuit on the right would make it work.



3. Answers will vary. Television, computer, radio—single throw (on/off). Forward/reverse—double throw. Car headlight switch (off, parking lights, headlights)—triple throw. Ceiling fan (off, high, medium, low)—quadruple throw.

LAB 59: THE ELECTRICAL SWITCH

QUESTION

How do electrical switches work?

SAFETY

Never leave a circuit connected too long, as it may get hot and destroy the battery.

MATERIALS

Triple-throw switch (left, center, right), wire, lightbulb, D-cell batteries, LED

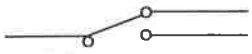
PROCEDURE

There are many types of switches in use in modern appliances. There are simple on/off switches that can be in the form of a push button or a light switch. There are low/medium/high switches like the one on a ceiling fan. There are forward, reverse, and stop switches like in a remote control car. Basically, a switch works by making contact between two conductors to complete a circuit. Switches are categorized by how many throws (settings) they have and how many sets of conductors (poles)—for example, SPST (Single Pole Single Throw) or DPDT (Double Pole Double Throw).

In this lab, you will use a switch with three throws, meaning that you can flip the switch to the left, center, or right. If the center position is "off," this is called a Double Throw Center Off switch. In this lab, you will use your multimeter to test your switch. You will use the "continuity" or "diode checking" feature on your meter if it's available. This setting beeps whenever you touch the probes to something that is a complete circuit. If you don't have a continuity setting on your meter, you can use resistance to do the same. When a switch is in the off position, the meter will read infinite resistance or "OL" (overload). When it is in the

on position, it will read nearly zero resistance. On your meter, look for either the sound symbol •))) or the diode symbol ▶|.

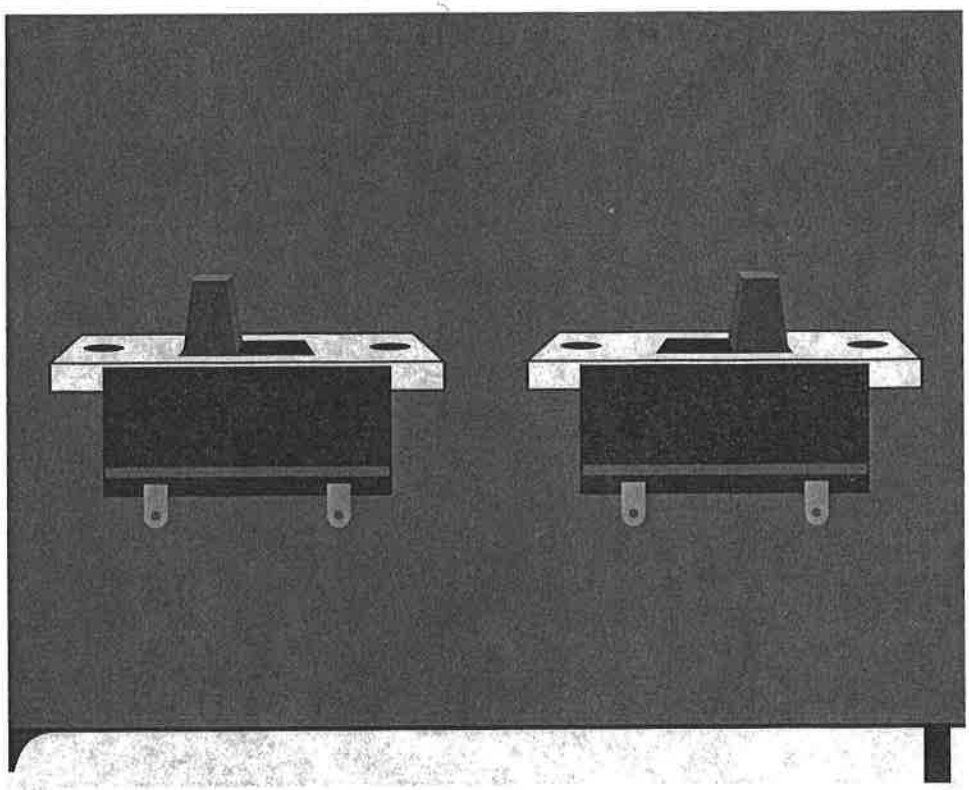
The schematic symbol for a double-throw switch (left/right) is



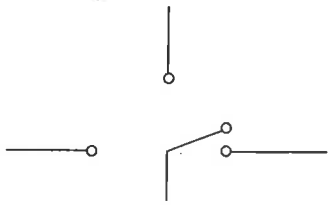
and it looks like Figure 59.1.

Figure 59.1

Double-Throw Switch (Notice the two "legs" on the bottom.)



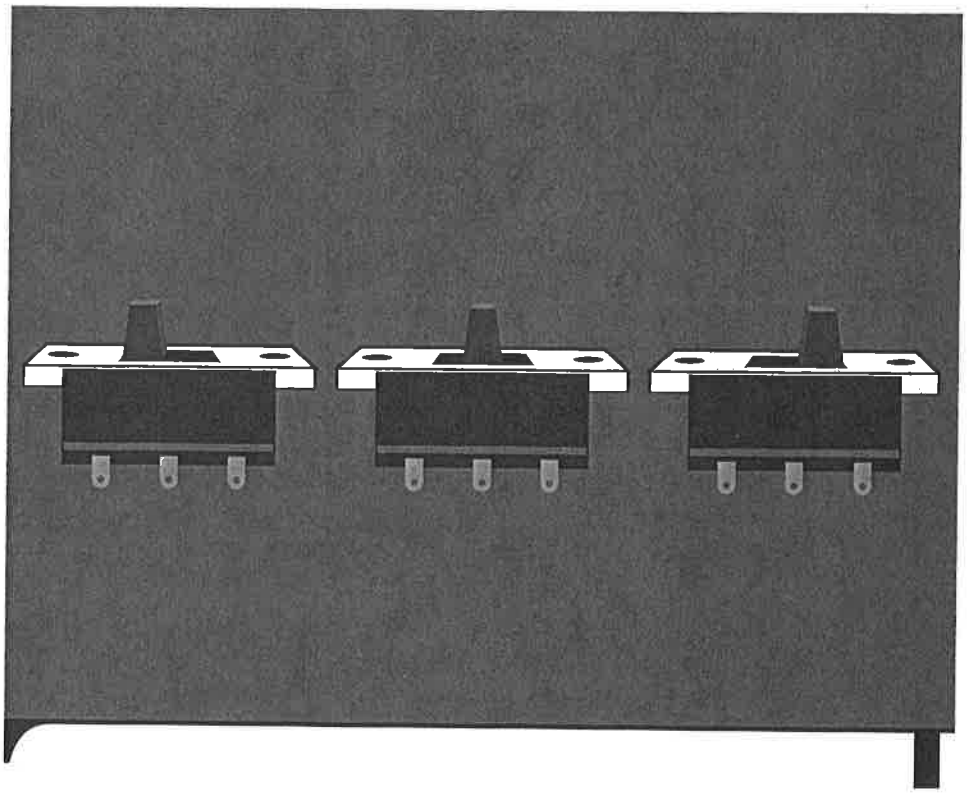
A triple-throw switch (left/middle/right) has the schematic symbol



in the open position and it looks like Figure 59.2.

Figure 59.2

Triple-Throw Switch (Notice the three "legs" on the bottom.)



1. Take your switch and mark one side so that you can keep the same side facing you the whole time. Put your meter either on continuity test, diode checker, or resistance and connect the black probe to the left lead and the red probe to the middle lead on the switch. Place the switch in each of the three positions and record whether the switch is continuous or not:

   Left yes/no Middle yes/no Right yes/no

2. Now put the probes on the middle and the right leads and repeat Step 1:

   Left yes/no Middle yes/no Right yes/no

3. Now put the probes on the left and right leads and repeat Step 1:

   Left yes/no Middle yes/no Right yes/no

4. Now connect a circuit that will allow you to move the switch to the left and an LED will light up. When you move it to the right, the lightbulb will light up. Draw a schematic diagram of your circuit. (Be sure that your LED has the resistor connected before starting.)

Post-Lab Questions

1. In your own words, explain how a triple-pole switch is used.
2. Explain how you could make a double-pole switch with just wires. Draw a diagram.
3. Find at least five things in your house that have switches in them and tell how many throws they are. Try to find different types of switches.

Extension

Draw a schematic to show how two double-throw switches could be used to control a light from either end of a hallway so that flipping either switch would change the status of the light. Build your circuit with a flashlight bulb and see if it works.