Basic Circuits

Overview: This lab will get you familiar with how to hook up a simple circuit so we can move to more complex stuff soon, like motors, switches, and remote controls. But first… the basics.

What to Learn: Remember when you scuffed along the carpet? You gathered up an electric charge in your body. That charge was static until you zapped someone else. The movement of electric charge is called electric current, and is measured in amperes (A). When electric current passes through a material, it does it by electrical conduction. There are different kinds of conduction, one of which is called *metallic conduction*, where electrons flow through a conductor, like metal.

Materials

- 2 AA batteries
- AA battery case
- 2 alligator wires
- LEDs

Safety Tip: I recommend using the super-cheap kind of batteries (usually labeled "Heavy Duty" or "Super Heavy Duty"), usually found at dollar stores. These types of batteries are carbon-zinc, which do not contain acid that can leak and expose you to toxic chemicals. When you short the circuits and overheats the batteries (which you should expect, by the way), it's not dangerous. Alkaline batteries (like Energizer and Duracell) will get super-hot and leak acid, so those aren't the ones you want to play with.

Lab Time

1. Following the video instructions, use the materials to wire up a simple circuit and get the LED to light up:
    a. Insert your batteries into the case. Flat side (minus) goes to the spring.
    b. Attach one alligator clip to each of the metal tips of the wires from the battery case. Make sure you've got a good metal-to-metal connection. You should now have two alligator clips attached to the battery pack.
    c. Attach the end of the alligator clips that's connected to the black wire (negative) from the battery case to the flat side of the LED. It doesn't matter what color the alligator clip wire is.
    d. Attach the other alligator clip that's connected to the red wire (positive) from the battery case to the longer LED wire. Again, it doesn't matter what color the alligator clip wire is.
    e. Your LED should light up!
2. Once your LED is illuminated, what happens if you take it out and insert it in the opposite way into the circuit? (Reverse the polarity.) Does it still work?
3. Troubleshooting a circuit that doesn't work:
    a. Batteries inserted into the case the wrong way? (Flat side of the battery should go to the metal spring inside the case.)
    b. LED is in the circuit the wrong way? Remember, LEDs are picky about plus and minus, meaning that it matters which way they are in the circuit. If you choose a bipolar LED, then you don't have to

worry about this one, since there are two LEDs, one in each direction, in one LED package which will illuminate no matter which way you have it in your circuit. LEDs are polarized.

c. Is there a metal-to-metal connection? You're not grabbing the plastic insulation, are you? Not even a tiny bit? Sometimes kids have the edge of the alligator clip lead propped up on the edge of the plastic insulation, which will make your connection not work.
d. Once in awhile, you'll get a bad alligator wire. There's an easy to check this: remove your alligator clip leads from the circuit and touch each of the metal tips from the battery pack wires to the LED wires. If the LED lights up, swap out your alligator clip lead wires for new ones and that should fix it.

Reading

When electric current passes through a material, it does so by electrical conduction. There are different kinds of conduction, such as metallic conduction, where electrons flow through a conductor, like metal, and also by electrolysis, where charged atoms called ions flow through liquids (we'll be getting to that later).

Although we can't see electricity flow through wires, you can certainly see, hear, and feel its effects: the light bulb flashing on, the hair dryer blowing, the heat generated by a hot wire, and so forth. In order to understand electricity, though, we're going to talk about water, because that's something that you already have experience with.

Electricity is like water going through a pipe. Imagine you have a big pipe connected in a circle, so it connects back to itself in a loop. The water needs a pump in order to move through the pipe. Electricity is like the water going through the pipe, and the battery is like the pump.

Now imagine breaking open your pipe to insert a waterwheel. Seal up the cracks and turn on your pump. Can you imagine what happens now? When the pump (battery) turns on, the water (electricity) flows through the pipe and turns the waterwheel. The waterwheel is like your motor or light bulb.

Suppose you add in a valve so you can turn the water on and off through your pipe. What is the valve like in your circuit? It's just like a switch in a circuit, because it interrupts the flow of electricity.

What would happen if you broke your pipe? Imagine you have a sledgehammer and you smashed open the pipe. Does it matter which side of the waterwheel you break it on? It does! If you break it before the waterwheel, the waterwheel won't turn. If you break it after the waterwheel, it might turn for a minute, but then it will stop because there's no more water going into the pump because you busted open the pipe, so the flow stops either way., That's what happens when you disconnect one of your wires in your circuit. No more electricity can flow.

Now imagine you've got a whole, complete pipe again. What would happen if we take out the pump, turn it around, and stick it back in again? The water goes the other way! What direction does the waterwheel go? It starts turning in the opposite direction also.

Some waterwheels are designed to go either forward or backward, while other waterwheels can only move forward due to the shape of their blades and how they were made. Some electrical components like buzzers and LEDs are polarized, meaning that they do not work backward. Other electrical components, like motors and light bulbs, do work forward and backward. When you work with circuits, if you find a component that doesn't work, try turning it around in the circuit to see if that fixes it.

If you look around the room, do you notice the different kinds of light bulbs you have? You might find a fluorescent bulb, an incandescent light bulb, a neon bulb an LED, or even a halogen lamp. What's the difference in how these produce light?

The incandescent light bulb uses a wire that glows when electric current runs through it. To keep the wire from burning itself up, the air is removed from the bulb and replaced with an inert gas. The wire is made from the element *tungsten*.

Neon bulbs light up because the electrical field excites the gas, which then gives off a pinkish-orange light.

A fluorescent tube is lined with white stuff called phosphor, which gives off light whenever it's struck by UV rays. The tube is filled with a gas that gives off UV rays when placed in an electrical field. When the bulb is brought close to a static charge, electrons rip through the tube and go out the other side. As they go through, they smack into the gas vapor which releases light rays (UV in a fluorescent tube) that hit the phosphor on the inside of the tube, which then emits light. Fluorescent lights, or any tube of gas from the noble gases column on the periodic table, like neon, will also glow in an electrically-charged field.

LED stands for "Light Emitting Diode." They don't have a filament so they don't get hot. They light up by the movement of electrons in a semiconductor material (more on this later), and they last a long time, like thousands of hours.

For halogen lamps, instead of creating a vacuum like with incandescent bulbs, they fill the bulb with a halogen gas so that the filament will burn brighter. It's not the gas that's illuminating, but rather the filament itself.

Exercises

1. What does LED stand for?
2. Does it matter which way you wire an LED in a circuit?
3. Does the longer wire on the LED connect to plus (red) or minus (black)?
4. Do you need to hook up batteries to make a neon bulb light up? Why or why not?
5. What's the difference between a light bulb and your LED?
6. What is the difference between a bolt of lightning and the electricity in your circuit?
7. What is the charge of an electron?

Answers to Exercises: Basic Circuits

1. What does LED stands for? (“Light Emitting Diode.”)
2. Does it matter which way you wire an LED in a circuit? (Yes, LEDs are polarized.)
3. Does the longer wire on the LED connect to plus (red) or minus (black)? (Longer lead is positive, and the flat side on the lens is negative.)
4. Do you need to hook up batteries to make a neon bulb light up? Why or why not? (No. The neon bulb (from *Lesson #7* will light up from static electricity. No batteries required. The neon lamp requires very little amps, but high voltage to illuminate, which you can get by charging yourself up. Simply hold one lead and scuff along the carpet and touch the other lead to your cat's nose. Or hold one lead and slide down a non-metal slide.)
5. What's the difference between a light bulb and your LED?
6. What is the difference between a bolt of lightning and the electricity in your circuit? (One one: quantity.)
7. What is the charge of an electron? (Negative)