

What is Electricity?

Although this is a programming class, not a Physics or Electrical Engineering class, we will be working directly with sensitive electrical components, so we need to understand a little bit about how they operate. Plus, computers are electrical devices, and knowing something about how they operate will give you some insight into why some things are done the way they are in various programming environments.

To understand electricity you need to think small, at the atomic level. All matter is made up of atoms, and atoms themselves are made up of various subcomponents. Specifically *protons, neutrons & electrons*. As you might guess from the name, we are interested in the electrons. The protons and neutrons make up the nucleus of the atom, while the electrons orbit around the nucleus. It is the movement of these orbiting electrons from one atom to another that constitutes the flow of electric charge — which is electricity.

But what does it mean to flow? And why do these electrons move? If you have any familiarity with electricity or electrical devices, you have probably seen or heard mention of the terms '*positive*', often labeled **+**, and '*negative*', often labeled **-**. Electrons represent a **-**, or negative charge, and Protons represent a **+** or positive charge. Neutrons, as the root word of their name implies, are neutral and carry no charge. As in magnetism (electricity and magnetism are closely related) opposites attract, and likes repel. This force to attract or repel is called electrostatic force, and if enough of it can be introduced to the electrons on the outermost orbits of an atom (called valence electrons), they can leave the atom entirely. Since atoms are generally tightly packed, this force will usually send it into the orbital range of a neighboring atom. But now that atom will have too many electrons, and the repulsive force between it and the other electrons will cause another electron to be pushed out of orbit.... and so on down the line. This is electric current.

Conductivity

Different material is comprised of different atoms, and different atoms have a varying number of protons and electrons. Some combinations more readily lose electrons from orbit than others. They are called **conductors**. Common examples of good conductors are copper, gold & silver, though generally most metals are good conductors. Those which do not give up their electrons as readily are considered **insulators**.

Conductivity isn't absolute though, different materials have different levels of conductance. For example tap water is a better conductor than free air, but not as good as aluminum, which isn't as good as copper or gold. A conductor's propensity for conducting is measured in Siemens, but the measure of the difficulty in passing a current, resistance, which is measured in Ohms, is more commonly used.

There are also semiconductors, materials whose conducting properties can be externally changed in some way. We'll look into them in a future section.

Flow

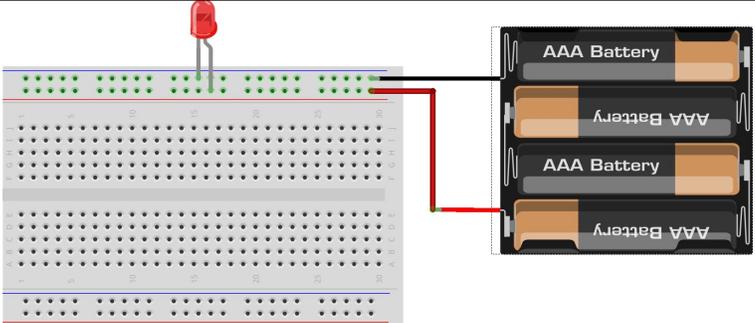
Electrical current doesn't just flow in any arbitrary direction though, it needs to follow the attract-repel patterns throughout the conducting material. What this means is that the conductor must physically connect from a positively charged point to a negatively charged one. *This completed connection is called a circuit.*

There are various ways to generate these positively and negatively charged points that make up a current source, however the details of this is outside of the scope of this class. For the next few experiments we will use batteries as the source of our electrical current, and they generate their electrical potential via a chemical reaction. Later, we will use power from the computer via the USB port.

We just learned that it is the negatively charged electrons which will actually be moving toward the positively charged atoms — from the negative side of the battery to the positive side in our case. This is called '*The Electron Flow*' model. Unfortunately, when the study of electricity was in its infancy, it was thought that electricity actually flowed from areas with an excess of 'electrical fluid' (i.e. positive) to areas with a deficit (i.e. negative). So many descriptions of current flow illustrate a move from **+** to **-**, in the vast majority of basic DC circuits, the actual flow makes no difference. It was an illustrious American inventor with a printing press, Benjamin Franklin, who coined these terms and the 'electrical fluid' concept, and while it was not 100% accurate, it advanced research significantly at the time.

Experiment: LED & Battery

In the simple experiment below, we are simply going to connect our power source to our breadboard, which is a matrix of conductors, and briefly connect an LED. Once the LED lights, remove power from the circuit as quickly as possible. Check the appendix if you need to review how the various pins on the breadboard are connected to each other. If a component, battery, or wire begins to get hot, immediately turn off and disconnect the battery pack. If it is not obvious what happened, ask for help.

Components		Wiring Diagram
✓ Battery Pack ✓ Breadboard ✓ Any single-color LED		 <p style="text-align: right;">fritzing</p>
Connection Instructions		
<p>Connect your battery pack as shown, so that the red wire goes to one of the horizontal slots on the red line side of the breadboard, and the black wire goes to one on the blue side. Be sure your battery pack's switch is in the OFF position.</p> <p>Then plug the LEDs two legs one each into a red and a blue line slot. Flip the power switch of the battery pack to the ON position. If the LED lights, <i>immediately</i> flip the switch back to the OFF position. If it does not illuminate, rotate the LED such that the leg that was in the red slot now is in the blue and visa-versa, then again briefly power on the pack to see if it illuminates.</p>		
Sketch(es)	N/A	
Analysis Questions		
<p>Does the LED get warm when illuminated? Why do you think the LED would be damaged if left connected for more than an instant?</p>		
Programming Tasks		
— —		
Related Material		
<p>From the Sparkfun T3 Series:</p> <p>What is Voltage What is Electric Current</p> <p>Other:</p> <p>Electrical Resistance and conductance Conventional Versus Electron Flow</p>		