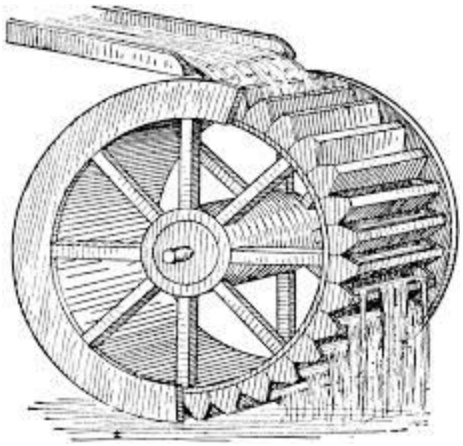
EE 1301: IoT

Quick Lesson

An Introduction to Electrical Circuits

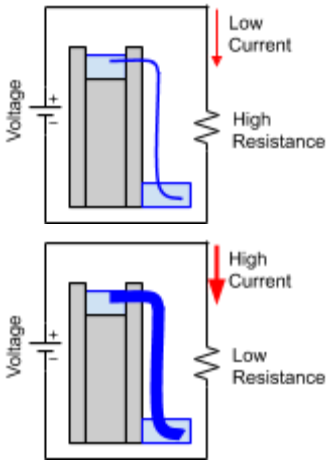
Electrical Current - The Water Analogy



The flow of electricity can be thought of as similar to water. When water flows over a water wheel it does work. The water flows from a high height to a low height and in the process turns the water wheel (releasing work or energy).

With electricity we use different words to describe these effects. Flowing "water" is known as current, "height" is known as voltage. Current wants to flow from a high voltage to a low voltage. In doing so it does work or releases energy into a load.

In electrical circuits there are several types of loads. The most basic is called a resistor. A resistor allows the current to flow from high to low voltage, but "resists" the flow. A resistor with a high resistance can be thought of as a very narrow water wheel (or pipe) and only lets a small amount of water through. A resistor with a low resistance would be similar to wide water while (or pipe.)

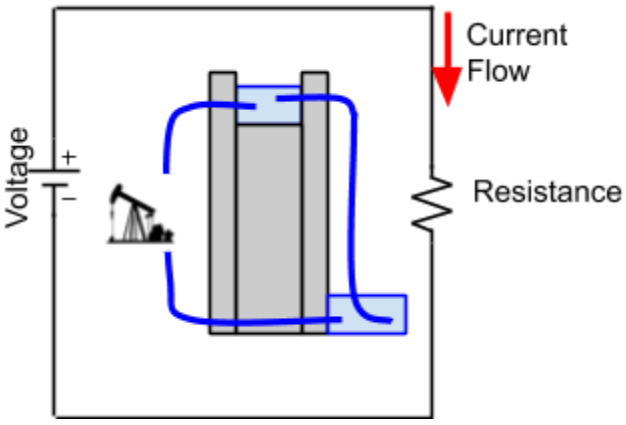


Like water, electrical current can flow through the same pipe at a higher or lower rate depending on the voltage at the source. In electrical circuits this relationship is called Ohm's Law, which says the current that flows (I) is based on the voltage (V) divided by the resistance (R).

Ohm's Law

$$I = \frac{V}{R}$$

Voltage sources



In the water analogy, the concept of the height of the water is used to illustrate the force (gravity) that causes the water to flow. How the water gets to the top of the stream was not discussed. In nature, the water that is provided by a stream or lake is refilled by rain.

In the case of an electrical circuit the high voltage is provided by a voltage source. A voltage source can be thought of as a pump. This pump moves the used current from a low voltage to a high voltage. The simplest voltage source is a battery. Obviously, pumping water uphill takes energy and thus batteries only act like a voltage source when they are charged.

Voltage is measured in the unit of Volts. A higher voltage infers the ability to do more work, but is potentially still limited by a high resistance.

NOTE: Electric circuits are very sensitive to too much voltage and may fail if more than 1.2x the designed voltage is applied. An alkaline battery has a voltage of 1.5V, NiMH batteries are around 1.2V, and LiPo batteries are 3.7V. The power supply pins on many devices operate at 3.3V or 5V. Be very careful not to connect a 5V pin to a 3.3V pin.

Conductors vs. Insulators

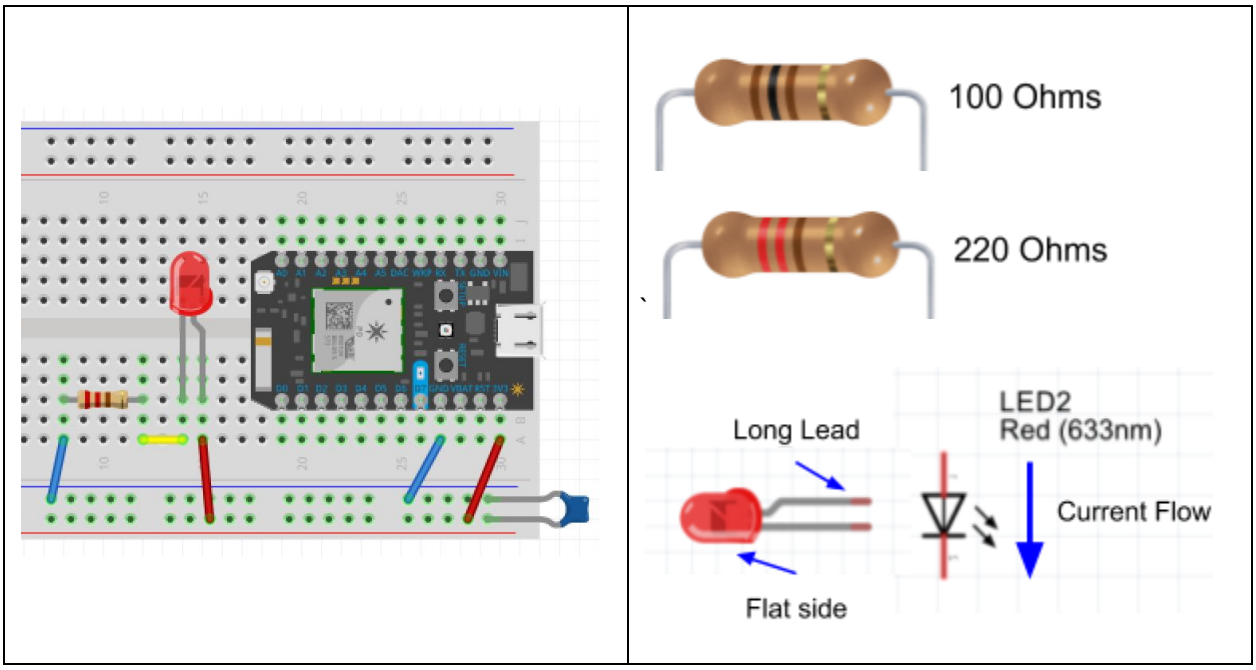
An interesting place where the analogy with water breaks down is the case where a pipe is broken. Electrical circuits must have a completed circuit for current to flow. If the wire or pipe breaks, current will not flow at all. Essentially this is because current, unlike water, cannot flow through the air. It must flow through a (generally) solid material. Not all solid materials allow current to flow. The materials through which electrical current can flow are called conductors, for example a copper wire or the steel frame of a car. Materials through which no electrical current can flow are called insulators, for example air and rubber. An insulator has a high resistance (so high we usually neglect it) and a conductor has a very low resistance (so low we usually neglect it.)

LED example

For many a physical example is worth more than text and graphics. Get out your Photon, breadboard, wires, an LED, and a couple resistors!

In the case of an LED, the brightness of the LED is determined by the current that flows through it. The more current, the brighter the light emitted.

1.) Start by wiring up an 3.3V supply of your Particle Photon to a resistor and an LED, start with a 220 Ohm resistor as shown below.



2.) Power up your Photon and watch the LED
3.) Now power down your Photon
4.) Replace the 220 Ohm resistor with a 100 Ohm resistor
5.) Power up the Photon and hopefully the LED gets brighter! (approximately 2x brighter)

Resistor Color Code

The resistors we will be using in this lab are identified by a color code. There is a very good section on resistor color codes on Wikipedia.
https://en.wikipedia.org/wiki/Electronic_color_code

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Resistor Color Code Table and Text from Wikipedia
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