Meet the Multimeter

Stephanie Alarcón & Christalee Bieber, The Hacktory

Multimeters are helpful tools to help figure out what's going on in your circuit. Today's workshop will go over how to use the basic multimeter modes, introduce you to some basic electricity concepts, and give you a pile of electronics to test out your skills.

Basic Settings on the Multimeter

The multimeter can be set to measure voltage (V), current (A), resistance (Ω), and continuity. Most also have settings for alternating current (~) and direct current (⎓). We'll start by testing a few simple items. What results do you expect to see when you check:

- battery (note the + and - terminals)
- resistor (note that this is non-directional)
- LED (note that this is directional)

Before we can measure current, we need to set up a circuit. Use the alligator clips or conductive dough to connect the positive (+) terminal of the battery to the resistor, then to the long leg of the LED, then to the negative (-) terminal of the battery. Next, disconnect either the LED or the resistor and measure the current in the circuit. How would you measure the current flowing through the resistor **and** the LED?

Basics of Electricity & Circuits

Making sense of the your multimeter measurements will be easier if you can compare it against an understanding of how the circuit should be working. This doesn't require calculating every current exactly, but a labeled sketch & some intuition about the relative values of voltages and currents is a good place to start. Here's some key concepts to keep in mind:

- A **voltage** source like a battery gives electrons the energy to do work, running a motor, light, or heater.
- The flow of electrons through a circuit is the **current**.
- Circuit elements designed to use or dissipate power are called loads; the **resistance** R is equal to the voltage V divided by the current I. (**Ohm's Law**)
- In a closed circuit loop, the total voltage drop over all the resistors has to equal the total voltage source. (**Kirchoff's Voltage Law**)

- In a circuit junction, the total current coming in has to equal the total current flow out. (**Kirchoff's Current Law**)
- **DC** comes from batteries, and provides a steady voltage until the batteries die. **AC** comes from wall outlets, and provides a time-varying voltage: 60 Hz in the US, and 50 Hz in Europe.

Practice Time

We have some equipment from around the house that we can explore with the multimeter. If you brought your own circuit, let's take a look! (Note: If you take something apart, you must put it back together, even if it doesn't work - so please keep track of your screws!)

1. Use your continuity check to test the audio cables and other power cords.
2. Plug a wall-wart into the power strip and test the output voltage and current.
3. Set up a circuit with a resistor and an LED, and test the current across each component. What happens to the LED, and why?
4. Open up a device to look at the circuit board inside. Can you identify any components? Are they surface-mount or through-hole?

Basic Safety

Working with electricity does have some hazards. Here's some tips on how to keep yourself, your electronics, and your multimeter safe.

High voltage or high current, or a combination of both due to unexpected low resistance, pose the highest danger to you and your electronics. Unplug any circuit you're working on, and if there are capacitors in the mix, short-circuit across them to make sure they're discharged. Try not to run electricity through your body; a current as low as 100mA can disrupt your heartbeat and kill you. Wearing rubber-soled shoes can increase your body's resistance and prevent the current from reaching ground. Circuits running off batteries typically don't have enough voltage to be dangerous, but wall outlets and power lines definitely do.

Short circuits can cause sparks or excessive heat build-up, which can damage components or start a fire. Know the current and voltage limitations for your components and don't exceed them. Use your eyes, ears, and nose to notice these problems before they get out of control.

Most multimeters have fuses to avoid burning out the board when you run too much current through them or accidentally test voltage while in current mode. One way to prevent this is to always leave your meter in voltage mode. If you don't know what voltage or resistance you're measuring, it's safest to start at the highest setting and step down until you get a reading.

Some electrical components can get quite hot, including resistors, lightbulbs, and soldering irons. Keep a first-aid kit handy.

Common Multimeter Problems

- measuring a resistor in a circuit or with the power on
- measuring current in parallel rather than in series or with the power off
- measuring voltage in series rather than in parallel or with the
- having your meter in the wrong mode, or set to the wrong magnitude
- blown fuse or low battery

Resources

- Adafruit Multimeter Tutorial: http://learn.adafruit.com/multimeters/overview
- Sparkfun Multimeter Tutorial: https://learn.sparkfun.com/tutorials/how-to-use-a-multimeter/introduction
- Multimeters used in this workshop: https://www.sparkfun.com/products/9141