**E8: Voltmeters, ammeters, and power supplies**

**Materials:**

ammeter, voltmeter, low-voltage power supply, bulbs, batteries, wires, switch, enthusiasm…

**Initial definitions and givens:**

**Ampere** (aka amp): a measure of the strength of an electrical current. In a 1-ampere current $6 \times 10^{18}$ electrons pass each second through a cross section of whatever the current is flowing through (wire, bulb, battery, whatever). One ampere is about the current that flows through a standard 100-watt light bulb.

**Volt:** a measure of the ability of a battery (or other power supply) to drive current through a circuit. Can be thought of as “electric pressure”.

**Ohm:** a measure of the resistance of a bulb or other part of a circuit. A 1-volt battery would drive a current of 1 ampere in a circuit whose resistance is 1 ohm.

**Ammeter:** a device that measures current. An ammeter measures the current passing through it, so it is wired in series. An ammeter has very low resistance.

**Voltmeter:** a device that measures voltage. A voltmeter measures the voltage, or number of volts, between two points, e.g., the two ends of a battery. If the two points are in a circuit, the voltmeter is wired in parallel to whatever connects the two points. A voltmeter has very high resistance.

**Initial Instructions and questions:**

Today we will learn to use analog voltmeters and ammeters. We will use them with batteries and bulbs first, but will replace the batteries with a power supply later. Using an ammeter instead of bulb brightness to measure the strength of a current will allow us to study circuits quantitatively. After we do some measurements we will try to restate some of our qualitative rules.

**Initial measurements** (sketch the circuits and write down all your measurements):

1) Use the voltmeter to measure the voltage between the two ends of a single battery, two batteries in series, three batteries in series, and two batteries in parallel.

2) Wire a circuit that containing two batteries and a bulb in series with a switch. Include an ammeter to measure the current in the circuit and a voltmeter to measure the voltage across the two batteries. Make measurements with and without the switch closed.

3) Wire a circuit with two batteries and two bulbs in series. Repeat the measurements.

4) Wire a circuit with two batteries in series with two bulbs in parallel. Place your ammeter in different parts of the circuit to measure the current in each part. Put switches in both parts of the parallel bulb circuit so either bulb or both bulbs can be included.

5) Replace the batteries with a power supply. You will repeat most of your measurements, but wait for instructions.