Overview

Today we'll be learning about the basics of electrical circuits and how two different electrical components behave: resistors and lightbulbs. Resistors are one of the most basic components in a circuit and are used to limit and control current flow. Lightbulbs behave like resistors in some cases, but their main difference is that they can convert electrical energy into light.

Theory

One of the most important relationships for analyzing electrical circuits is Ohm's law. Ohm's law can be explained in several ways, but we're going to interpret it as a definition for resistance.

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

If there are multiple resistors, there are two fundamental ways to connect them in a circuit. One way is to connect them in series so the current flows through one resistor at a time. In this case, the total, or *equivalent*, resistance of the circuit is the sum of the individual resistors.

$$R_{eq} = R_1 + R_2 + \cdots$$

$$Diagram: Resistors\ in\ Series$$

The other way to connect the resistors is in parallel. In this case, the current is divided amongst the resistors. This time, the total resistance is not simply the sum of the individual resistances. The total resistance is equal to the reciprocal of the sum of the reciprocals of the individual resistors.

$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \cdots$$

$$R_{eq} = \left(\frac{1}{R_1} + \frac{1}{R_2} + \cdots\right)^{-1}$$

$$Diagram: Resistors\ in\ Parallel$$

With more than two resistors, it's possible to mix series and parallel connections. In this case, it's necessary to go through several steps to simplify the circuit and find the total resistance.

$$Diagram: Complex\ Circuit$$

The lab manual mentions that Ohm's law only works for ohmic devices. An ohmic device is anything whose resistance is the ratio of the voltage and current across it. The resistors used in lab behave as ohmic devices, but the bulbs will only behave ohmicly over a certain range.

For ohmic devices, a graph of voltage vs. current will be a straight line. The slope of that line is the resistance of the device.

Procedure

Setup

Begin by preparing Graphical Analysis and the current and voltage probes. Set Graphical Analysis to display voltage on the y-axis and current on the x-axis. Connect the current probe in series with the power supply and the voltage probe in parallel with the power supply.

Demo: Example Setup

Resistive Devices

The next step is to create plots of data for five different resistive devices.

- One resistor
- A different resistor
- Resistors in series
- Resistors in parallel
- One of the bulbs

Use a range of 0 to 5 volts for the resistors when collecting the data. A schematic diagram also needs to be made for each circuit setup.

Diagram: Schematic Symbols

Diagram: One Resistor Schematic Example

Bulb Box

In the last part of the lab, several different circuits are made from the three lightbulbs. Observations need to be made on the brightness of the bulbs for each configuration. Use the same voltage from the power supply for each setup.