# Experiment 14B: Electric Circuits

Ohm's Law - Series & parallel circuits (Version 1)

**EQUIPMENT**
1 Power Supply
*Circuit Boards*
*2 Light Bulbs*
*2 Multimeters*
*Connecting Wires & 1 jumper*

## Introduction

**Electrical current** is the movement of charges along a conductor or space. The path along which these charges (usually electrons) flow is called a **circuit**. In this lab, we'll explore the relationships between voltage, current, resistance, and power. We'll also see how these variables are affected by the layout of elements in a circuit.

In order for these charges to be pushed through the circuit, a **voltage,** measured in volts (V), must be applied. **Resistance** in the circuit**,** measured in ohms (Ω), slows the flow of electrons. Current, measured in amps (A), measures the amount of charge flowing through the circuit. **Ohm's Law** defines the relationship between voltage (V), current (I), and resistance (R) explicitly:

$$V = IR \quad \text{or} \quad I = \frac{V}{R}$$

**Since this equation is linear, plotting voltage vs. current should resemble a straight line with constant slope**. Electrical components that that follow this trend are called **Ohmic**. The resistance in some items, such as light bulbs, changes significantly as the temperature increases, so plotting V vs. I for these will NOT produce a straight line. These are **Non Ohmic** elements. You can still find the resistance at any one moment using Ohm's law, but that resistance will change as the voltage & consequently, the current increases and the object gets hotter.

When charges are moved, they carry the kinetic energy provided by the voltage source. In a typical conductor (e.g., copper) some of this energy is transferred to the lattice atoms by collisions. This process results in the production of heat. The rate of energy transfer is the **power**, measured in watts, and is proportional to the current and voltage. That is:

$$P = IV$$

The connection between components in a circuit affects how this voltage and current (and therefore power) is distributed.

If elements are connected in **series**, then same current flowing through the circuit MUST pass through each component one by one. The total voltage across the circuit is divided among the different components. Adding components increases the total circuit resistance, so (at a given voltage) less current flows through the circuit and total power for the circuit drops. This lower total power is also now divided among more elements, so power delivered to each component also drops.

If elements are connected in **parallel**, the current has multiple different paths across elements that allow it to go from the beginning of the circuit to the end. In this case, total voltage across the circuit is equal to the voltage across each path. Now, the current must be divided into each path. Adding new elements (in parallel) **decreases** the total resistance, so (for a given voltage) more current can flow to the circuit and the total power expended by the circuit increases.

An important part of this experiment and life in general is appreciating the difference between linear and nonlinear phenomena. The plot of a linear phenomena is a line & the plot of nonlinear is a not a line. **It will be shown in this experiment that some phenomena are linear in one part and then nonlinear in the other**. The behavior of a light bulb with increasing voltage is such an an example. At 'low' voltages (& currents), a light bulb is relatively linear resulting in very little resistive heating or light, and at higher voltages the resistance dramatically goes up resulting in large amount of heat and consequently radiated visible light.

# Procedure

<u>Note</u>: Please do not rearrange your meter setup or you will be unable to take data.

## A. Series Circuit (Data Table 1)

1. Set the multimeter that is connected in parallel with the power supply to 20 the DCV setting. This will be our voltmeter and will record our voltage across the circuit.
2. Set the multimeter that is in series between the power supply and our circuit to 200m under the DCA section. This will be our ammeter and will record current flowing into the circuit. **<u>Note</u>**: The "m" that follows 200 indicates that the reading here will be in milliAmps. You should convert this to Amps by dividing the reading by 1000.
3. You are to set up a series circuit consisting of two light bulbs connected in series. **See figure 14B-1 on l page 7 of procedure.**
4. Adjust the power supply until the voltmeter reads around 1V. **Record your voltage and current in Table 1**. Repeat this for 2V, 3V, 4V, 5V, 6V, 7V ,8V and 10V.
5. Before you turn off power supply, unplug one light bulb. What do you observe. **Replace light bulb and turn off power supply.**
6. Use Ohm's Law and the power equation to find the resistance and power dissipated through the resistor.
7. Using the Graphical Analysis program, create a plot of Voltage vs. Current. (You always plot Y vs. X, so voltage should be the Y values). **Use the linear fit button to find the slope of this graph from 1 volts to 4 volts. The plot should be reasonably linear in this range.**
8. Copy this graph to your data sheet. **<u>Note:</u>** Any graph you plot should include axis labels and units!
9. Be sure and show where you obtained slope on the copied plot.

## B. Short Circuit

10. Turn voltage up to 8V. Take a jumper and plug it into one of the light bulbs. What do you observe? A jumper is a piece of wire- in this case it is the white component- although the wire is covered and not visible.

## C. Parallel Circuit

11. You are to set up a parallel circuit consisting of two light bulbs connected in parallel. **See figure 14B-2 on page 8 of procedure.**
12. Please note that when you unplug one of the light bulbs it must be replaced with a jumper to complete circuit. Repeat steps 4 through 9.

# Exp 14B: Current Data

Name: ______________________

Section: _____________________

**Table 14.1:Series Circuit**

| Voltage Applied (V) | Current (A) | Calculated Resistance (Ω) | Power Dissipated (W) |
|---|---|---|---|
| 0.00 | 0.000 | | 0.00 |
| 0.5 | | | |
| 1 | | | |
| 2 | | | |
| 3 | | | |
| 4 | | | |
| 5 | | | |
| 6 | | | |
| 8 | | | |
| 10 | | | |
| 12 | | | |

**Voltage vs. Current for Series Circuit**

Slope = Resistance = ____________

Find the slope of this graph from 1 volt to 4 volts by highlighting the region first & then click on slope icon from task bar. Click on this figure->

Table 14.1:Parallel Circuit

| **Voltage Applied (V)** | **Current (A)** | **Calculated Resistance (Ω)** | **Power Dissipated (W)** |
|---|---|---|---|
| 0.00 | 0.000 | | 0.00 |
| 0.5 | | | |
| 1 | | | |
| 2 | | | |
| 3 | | | |
| 4 | | | |
| 5 | | | |
| 6 | | | |
| 8 | | | |
| 10 | | | |

**Voltage vs. Current for Parallel Circuit**

Slope = Resistance = ___________

Find slope for same interval as Series circuit above.

# Postlab Questions

1. Ohm's Law predicts that any plot of voltage vs. current will produce a straight line with a slope that equals the resistance. Was your plot of voltage vs. current a straight line today? If you noticed that some part of the plotted data was not a straight line, why did this happen (for the light bulbs)?

2. What happened when you short circuited the one of the light bulbs in the series circuit? Explain this result.

3. Compare the power of both circuits when the power supply was set to 8V.

Which circuit (i.e., the series or parallel connection) had a higher current and therefore the higher power? How did this affect the brightness of the bulbs?

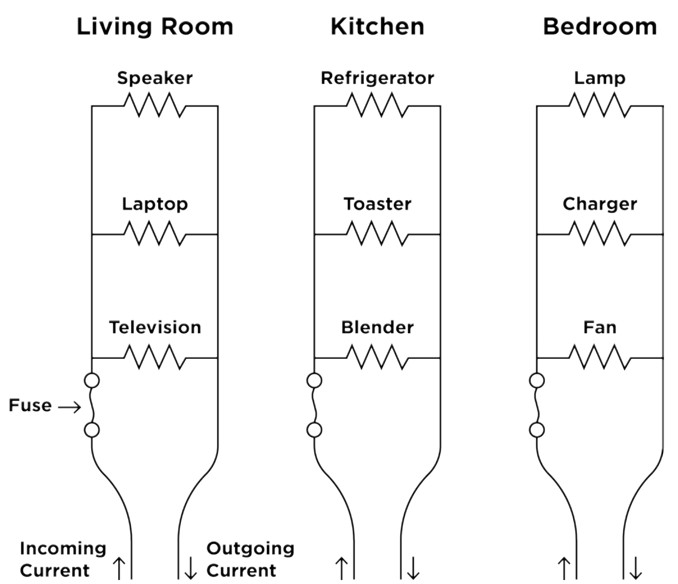
4. The voltmeter is set up in parallel with the power supply. Think about what happened when the (almost) zero resistance wire short circuited the light bulb. **Do you think the resistance of the voltmeter is very large or very small.** Hint: Ideally we do not want **ANY** current to flow through the voltmeter since this would 'mess up' our current reading.

Based upon your answer above about the  the resistance of the voltmeter what would happen if the voltmeter was set up in series with the circuit (i.e., connected in series with the light bulbs)?

5. The ammeter is set up in series with the circuit. Since this means the current HAS to flow through the ammeter, what must be the resistance of the ammeter in order to not impact the amount of current going into the circuit? **Do you think the resistance of the ammeter is very large of very small in order not to affect the current too much when it is connected to a circuit?**

Based on this, what would happen if the ammeter was connected in parallel with the circuit?

6. A fuse is a device that breaks if too much current is flowing through it. This is meant to prevent other elements in the circuit from melting during a current surge. Using this knowledge and the following diagram, do you think that the wiring in your house is in series, parallel, or a combination of both? Explain.



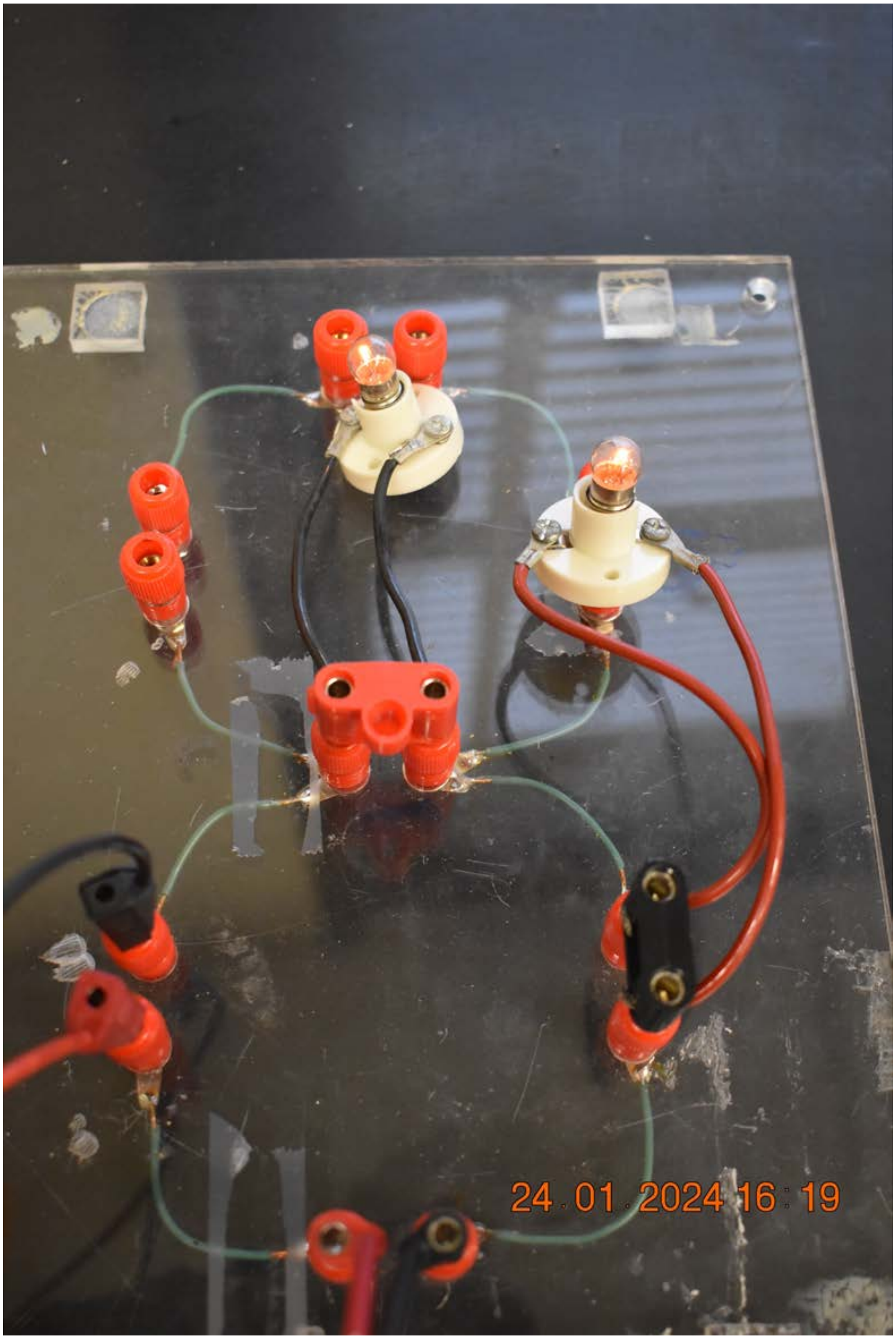



**Figure 14B-1 - Series circuit**

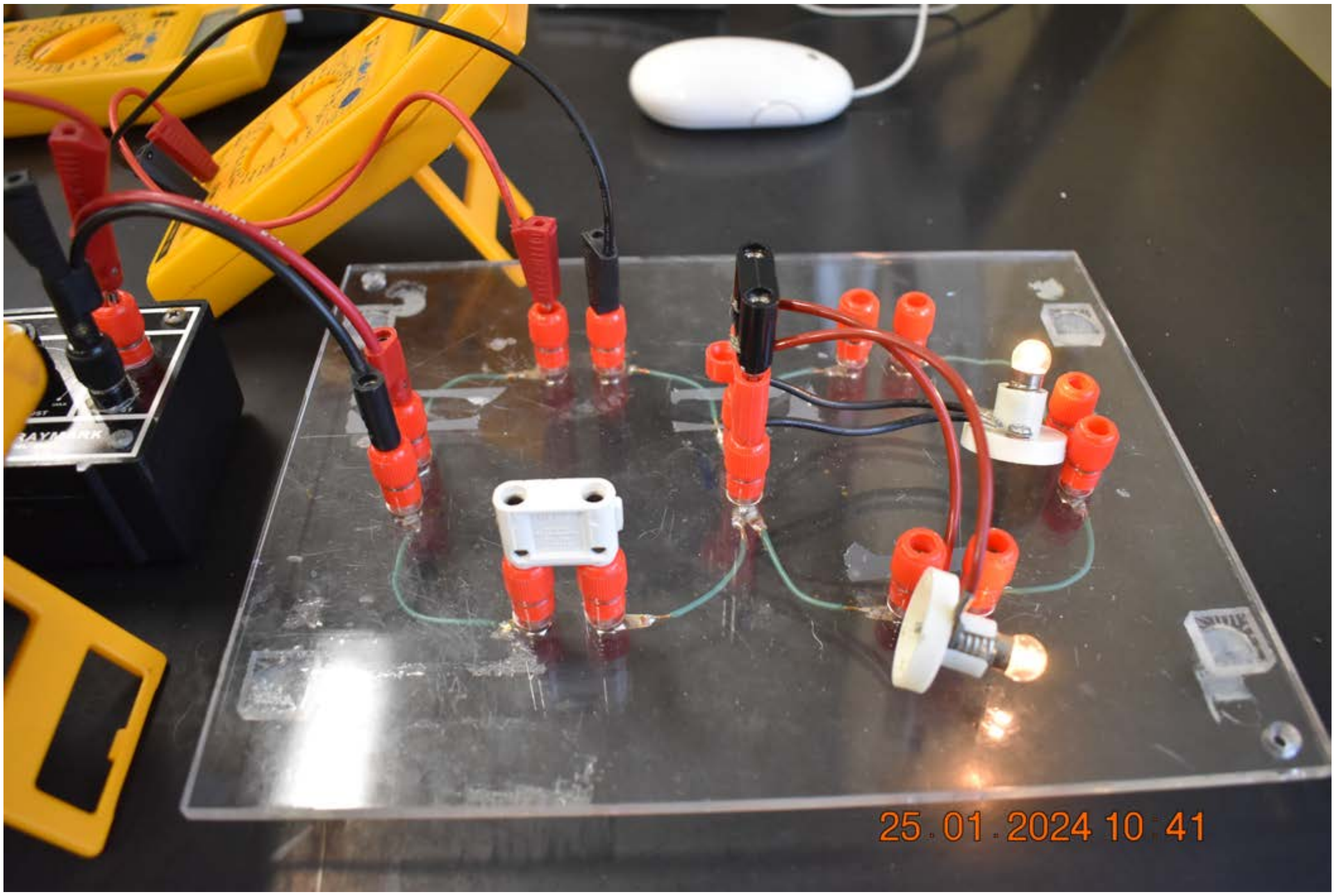



**Figure 14B-2 - Parallel circuit**