# **Safety and Equipment**

- No special safety precautions are necessary for this lab.
- Computer with PASCO Capstone, PASCO 850 Universal Interface
- Multimeter with probes or banana leads.
- Banana-to-alligator wires for PASCO 850 Universal Interface
- (4) Alligator wires .
- (2) Light Bulbs in holders.
- (3) Large Ceramic Resistors: 100 Ω, 50 Ω, 50 Ω

# Introduction

There are two primary ways to connect devices in an electrical circuit: in parallel and in series.

*In series*, two resistors have only one point of connection to each other. They form one continuous path for the current. Therefore, the same current flows through each resistor. Because there is only one passage for the current in series configuration, the resistances of the individual resistors sum up into the total resistance of the configuration.

The potential difference across an individual resistor depends on the value of the resistance: the greater the resistance the greater the voltage measured across that resistor. Each resistor participating in series configuration "drops" part of the total potential. The individual voltage drops should add up to the total voltage of the entire configuration.

$$V_{\text{series}} = V_1 + V_2 + \cdots$$



**Figure 1.** Resistors in series. The voltmeter in this figure is measuring the voltage across  $R_1$  only. A voltmeter carries no current, so it doesn't interfere with the series nature of the circuit.

*In parallel*, each resistor is connected to the others at two points. The result is that the same potential difference exists across each resistor. Each resistor then forms a separate pathway for the current. Therefore, there are multiple passages for the current in parallel configuration, and different current flows through each resistor. Since the potential drop across every resistor in parallel configuration is the same, the current flowing through an individual resistor depends on the value of the resistance: the greater the resistance the smaller the current measured through that resistor. Because there are multiple passages for the current in parallel configuration, the current flowing in and out of the configuration.

 $I_{\text{parallel}} = I_1 + I_2 + \cdots$ 



Figure 2. Resistors is parallel. Note that the resistors are connected to each other at two points.

### **Objective:**

• To compare the current and voltage distribution in parallel and series circuits.

# Part #1. The Brightness of the Light Bulbs in Series and Parallel.

- 1. Open the "DC Power Supply Set Up" file provided with the lab instructions. (It's the same Capstone file that was used for the Ohm's Law lab.)
- 2. In PASCO Capstone, set the Voltage to 6.0 V and connect banana plugs to corresponding terminals
- 3. One at a time, construct three different circuits:
  - one single bulb
  - two bulbs in series
  - two bulbs in parallel
- 4. Asses the brightness of an individual light bulb in each circuit (single bulb, series, parallel).
- 5. Based the fact that the brightness of a bulb is a good gauge of the current through that particular, rank the circuits by the amount of current through each bulb. Describe and discuss this ranking in the abstract.

#### Part #2. Series Circuit Measurements

- 1. Connect two resistors,  $R_1 = 100 \Omega$  and  $R_2 = 50 \Omega$ , in series and use Multimeter set as an Ohmmeter to measure the equivalent resistance of the configuration (refer to Lab #2 Part 1).
- 2. Compare the measured value with the calculated value. The series equivalent resistance is calculated by:  $R_{eq} = R_1 + R_2$

Description	Value
$R_{eq.measured}\left(\Omega ight)$	
$R_{eq.calculated}(\Omega)$	
% Diff	

**Table 1.1.** Series resistance of  $R_1$  and  $R_2$ , both measured and calculated.

- 3. Set the voltage of the Power Supply to 6.0 V.
- 4. Construct a circuit that consists of two resistors, 50  $\Omega$  and 100  $\Omega$ , connected in series and the power supply.
- 5. Set up the Multimeter as a Voltmeter. Measure the terminal voltage of the loaded circuit and the voltage across each resistor (refer to Lab #2 part 3).
- 6. Set up the Multimeter as an Ammeter. Measure the current through each resistor and the current through the power supply (refer to Lab #2 part 2).
  - Note: If you don't know what current to expect, try the 10 A scale first. If the value is less than 0.1 A, then switch to the mA scale (and change which terminal you are plugged into on the meter.)

Device	Voltage Across (V)	Current Through (A)
Power Supply		
$R_1(100\Omega)$		
$R_2(50\Omega)$		

**Table 1.2.** Voltages and currents in the series circuit consisting of just  $R_1$  and  $R_2$ .

- 7. State the mathematical relationship between the currents (Hint:  $I_{ps} = ...$ ) and the relationship between the potential differences (Hint:  $V_{ps} = ...$ ).
- 8. Compare the ratio of the voltages across the resistors  $(V_1/V_2)$  with the ratio of the resistances  $(R_1/R_2)$ .
- 9. Predict how the current and voltage distribution will change if another  $50\Omega$  resistor is added in series to the others. Check your prediction and report the new values of the current and voltage. Explain the result.

Device	Predicted Voltage (V)	Predicted Current (A)	Measured Voltage (V)	Measured Current (A)
Power Supply				
$R_1(100\Omega)$				
<i>R</i> <sub>2</sub> (50Ω)				
$R_3(50\Omega)$				

**Table 1.3.** Predicted and measured voltages and currents in the series circuit consisting of  $R_1$ ,  $R_2$ , and  $R_3$ .

#### Part #3. Parallel Circuit Measurements

1. Connect two resistors,  $R_1 = 100 \Omega$  and  $R_2 = 50 \Omega$ , in parallel and measure the equivalent resistance of the configuration. Compare the measured value with the calculated value. The parallel equivalent resistance is calculated by:  $R_{eq} = (R_1^{-1} + R_2^{-1})^{-1}$ 

Description	Value
$R_{eq.measured}\left(\Omega ight)$	
$R_{eq.calculated} \left( \Omega \right)$	
% Diff	

**Table 2.1.** Parallel resistance of  $R_1$  and  $R_2$ , both measured and calculated.

- 2. Construct a circuit that consists of two resistors,  $R_1$  and  $R_2$ , connected in parallel with the power supply.
- 3. Set up the Multimeter as a Voltmeter. Measure the voltage across the power supply and each resistor.
- 4. Set up the Multimeter as an Ammeter. Measure the current through each resistor and through the power supply. (Note: measuring the current through  $R_1$  from Figure 2 is tricky; ask the lab instructor to check your settings )

Device	Voltage Across (V)	Current Through (A)
Power Supply		
$R_1(100\Omega)$		
<i>R</i> <sub>2</sub> (50Ω)		

**Table 2.2.** Voltages and currents in the series circuit consisting of just  $R_1$  and  $R_2$ .

- 5. State the mathematical relationship between the currents (Hint:  $I_{ps} = ...$ ); state the mathematical relationship between the potential differences (Hint:  $V_{ps} = ...$ ).
- 6. Compare the ratio of the current through the resistors  $(I_1/I_2)$  with the ratio of the resistances  $(R_1/R_2)$ .
- 7. Predict how the current and voltage distribution changes if another 50  $\Omega$  resistor is added in parallel to the circuit. Check your prediction and report the new values of the current and voltage. Explain the result.

Device	Predicted Voltage (V)	Predicted Current (A)	Measured Voltage (V)	Measured Current (A)
Power Supply				
$R_1(100 Ω)$				
$R_2(50\Omega)$				
<i>R</i> <sub>3</sub> (50Ω)				

Table 2.3. Predicted and measured voltages and currents in the parallel circuit consisting of  $R_1$ ,  $R_2$ , and  $R_3$ .

#### Part #4. Mix-Configuration Circuit Measurements

1. Connect two resistors,  $R_1 = 100 \Omega$  and  $R_2 = 50 \Omega$ , in parallel and add  $R_3 = 50 \Omega$  in series to the first configuration. Calculate the expected resistance. Measure the equivalent resistance of the mix-configuration. (Hint: Since  $R_1$  and  $R_2$  are in parallel, use the parallel rule to find their combined resistance. Then since  $R_3$  is in series with the  $R_1/R_2$  pair, simply add  $R_3$  for the overall result.)

Description	Value
$R_{eq.measured}\left(\Omega ight)$	
$R_{eq.calculated} \left( \Omega \right)$	
% Diff	

**Table 3.1.** Parallel resistance of  $R_1$  and  $R_2$ , both measured and calculated.

- 2. Connect your combination to the power supply (red terminal of the power supply should be connected to  $R_1/R_2$  junction and black terminal of the power supply should be connected to  $R_3$ ).
- 3. Measure the current through each resistor and through the power supply; then measure the terminal voltage and the voltage across each resistor.

Device	Voltage Across (V)	Current Through (A)
Power Supply		
$R_1(100 Ω)$		
<i>R</i> <sub>2</sub> (50Ω)		
<i>R</i> <sub>3</sub> (50Ω)		

**Table 3.2.** Voltages and currents in the series circuit consisting of just  $R_1$  and  $R_2$ .

- 4. Mathematically state the relationship between the currents (Hint:  $I_{ps} = ...$ ); mathematically state the relationship between the potential differences (Hint:  $V_{ps} = ...$ ).
- 5. Compare the ratio of the current through the resistors  $(I_1/I_2)$  with the ratio of the resistances  $(R_1/R_2)$ .