Lab 3 – Resistors in Series and Parallel

Safety and Equipment

- No special safety precautions are necessary for this lab.
- Multimeter with probes or banana leads.
- Light bulbs in light bulb holders.
- 100 Ω resistor, two 50 Ω resistors.
- Alligator wires.

Introduction

There are two different ways to connect resistors in an electrical circuit: in parallel and in series.

In series, two resistors have only one point of connection and 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 the potential. The individual voltage drops should add up to the total voltage of the entire configuration.

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

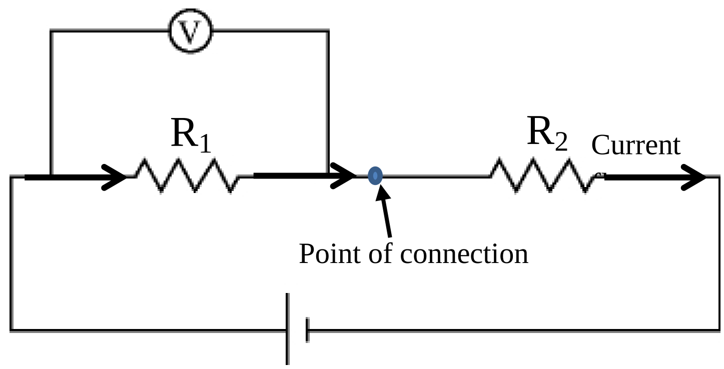

Figure 1. Resistors is series. The voltmeter in this figure is measuring the voltage across R_1 only.

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 currents trough the individual resistors should add up into the total current flowing in and out of the configuration.

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

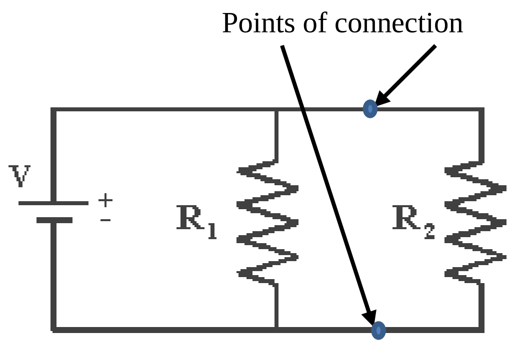

Figure 2. Resistors is parallel. Note that the resistors are connected to each other at two points.

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" file that is distributed with the Lab Instructions.
2. In PASCO Capstone, set the Voltage to 2.5 V and connect banana plugs to red & black banana 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 a light bulb in each circuit (single bulb, series, parallel).
5. Based on the assessment and 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 a bulb. Include 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
$R_{eq.measured}$ (Ω)	
$R_{eq.calculated}$ (Ω)	
% 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 V.
4. Construct a circuit that consists of two resistors, 50 Ω and 100 Ω, 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). **Never connect the ammeter "across" a resistor or the power supply.**

Device	Voltage Across (V)	Current Through (A)
Power Supply		
R_1(100Ω)		
R_2(50Ω)		

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 Ω 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(100Ω)				
R_2(50Ω)				
R_3(50Ω)				

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 Ω and R_2 = 50 Ω, 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
$R_{eq.measured}$ (Ω)	
$R_{eq.calculated}$ (Ω)	
% 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(100Ω)		
R_2(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 Ω 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(100Ω)				
R_2(50Ω)				
R_3(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 and R_2, in parallel and add R_3 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
$R_{eq.measured}$ (Ω)	
$R_{eq.calculated}$ (Ω)	
% 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(100Ω)		
R_2(50Ω)		
R_3(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).