# Experiment 19
# Series and Parallel Resistances

**Advanced Reading:**
What are Series and parallel circuits

**Equipment:**
1 universal circuit board
2 100Ω resistors
2 200Ω resistors
2 300Ω resistors
2 digital multimeters (DMM)
1 power supply
wire leads
6 jumpers

**Objective:**
The object of this lab is to study resistances in series and parallel and to observe and quantify the effect of an ammeter on a circuit.

**Theory:**

In the previous lab you made a circuit that contained one resistive element (i.e., a resistors or light bulb). In this experiment you will make circuits that contain more than one resistor.

The first type of circuit you will construct is called a **series** circuit. *In a series circuit the resistors (or some other resistive component) are connected so that* ***the current is the same through each resistor***. See Figure 19-1. For a series circuit the total equivalent resistance $R_{eq}$ in a circuit is given by:

$$R_{eq} = R_1 + R_2 + R_3 + ... + R_N = \sum_{i=1}^{N} R_i \qquad \text{Eq-1}$$

The next type of circuit you will make is a **parallel** circuit. Resistances are said to be connected in parallel when the potential difference applied across the combination is the same as the resulting potential difference

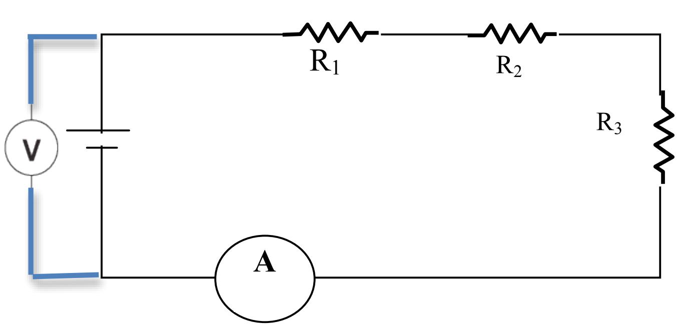


Figure 19-1__Series Circuit Schematic

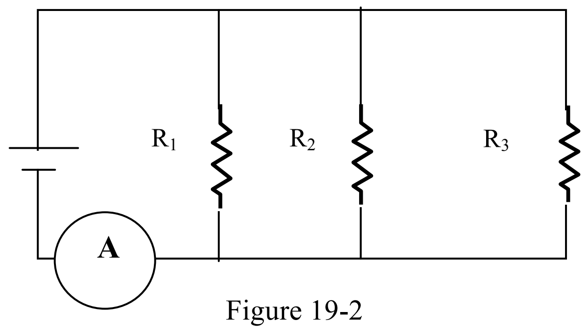


Figure 19-2
Parallel Circuit Schematic

across the individual resistances. ***In parallel circuits current can take more the one path***. See Figure 19-2. For a parallel circuit the total equivalent resistance $R_{eq}$ in a circuit is given by:

$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + ... + \frac{1}{R_N} = \sum_{i=1}^{N} \frac{1}{R_i} \qquad \text{Eq-2}$$

A secondary goal of this experiment is the measurement of the resistance of an ammeter. An ideal ammeter has zero resistance and does not affect the circuit being measured. All real ammeters have some resistance *(which is a function of the DMM setting)* and consequently will affect the circuit being measured.

**Procedure:**

**Part 1: Series Circuit**

1. Measure the resistance of your resistors and record these values. *Keep them separate since you have more than one resistor of each value.*

Using resistors and jumpers construct a series circuit with one 100Ω, 200Ω, 300Ω resistor, and an ammeter [DMM] on the circuit board. See fig. 19-1. *Note that there are 3! different ways to arrange 3 objects. The order is not important.*

2. Connect power supply (as in figure 19-1). Attach a voltmeter (DMM) so as to read the voltage differences across all the power supply when a current is flowing in the circuit. **Have your lab instructor approve the circuit before plugging in the power supply**.

3. Calculate a theoretical value of the equivalent resistance of the series circuit based on the measured resistances and record this value in your notebook as $\mathbf{R_{theory}}$ (series).

4. Plug in the power supply. Adjust the dial of the power supply until the potential difference V across the power supply is approximately 1.0 volt. *(This is the same as the potential difference as the resistors combined.)*

Record the current flow and the voltage drop. Repeat this process in one-volt increments up to 10 volts.

5. With the voltage across the power supply set at 10 volts, disconnect the voltmeter (DMM). Measure the potential differences across each individual resistor. Add the potential differences. Do they add up to the voltage across the power supply?

**Graph data**

6. Graph current vs. voltage, with current on the Y axis and voltage on the X axis. From this graph, determine the value of the equivalent resistance for this circuit by plotting the best-fit line. Calculate the percent difference between the value obtained from the slope of the graph to the theoretical value from step 3 above.

## Part 2: An Examination of the Resistance of an Ammeter

7. Disconnect the power supply. Next, replace the ammeter with a jumper (shunt) and measure the resistance of the circuit with the DMM. **Record this value in data table (this value is "$\mathbf{R_{eq}}$ without ammeter").**

8. Replace the jumper with the ammeter (set at 200 mA setting). **Measure $\mathbf{R_{eq}}$ of the circuit again and record the value in data table.** As you adjust the scale on the ammeter, record $\mathbf{R_{eq}}$ at the following ammeter scale settings: "20m"; "2m"; and "200μ". **Reset DMM to 200mA setting.**

**Part 3: Parallel Circuit**

9. Reconfigure the 3 resistors from the series circuit to a parallel circuit, i.e., connect one 100Ω, 200Ω, and 300Ω resistor in parallel with each other on the circuit board. You will need more jumpers to do so. See Figure 19-2. Using Eq-2 calculate $\mathbf{R_{theory}}$ (parallel).

10. Adjust the dial on the power supply until the DMM reads approximately 1.0 volt. Record this voltage. Now measure the voltage difference across the 100Ω resistor and record this voltage. Do the same for the 200Ω and the 300Ω resistors. Are the values the same? Do they add to 1.0?

11. Measure current vs. potential as before (i.e., from one to 10 volts). Graph current vs. voltage on the same plot as the series graph and using slope determine the total (equivalent) resistance of the circuit.

12. Calculate the percent difference between the plot from step 11 above to the theoretical value $\mathbf{R_{theory}}$ (parallel) from step 9. They should be very close (but not necessarily the same). Why not?

## Part 4: Combination of series and parallel

13. Construct the circuit that appears in figure 19-3. Calculate the total theoretical (equivalent) resistance of the circuit, i.e., $\mathbf{R_{theory}}$ (combination).

14. Repeat step 11 for this circuit. What is the percentage difference between the best-fit line value and the theoretical value $\mathbf{R_{theory}}$ (combination) for this circuit?

**All three plots should be graphed on one graph.**

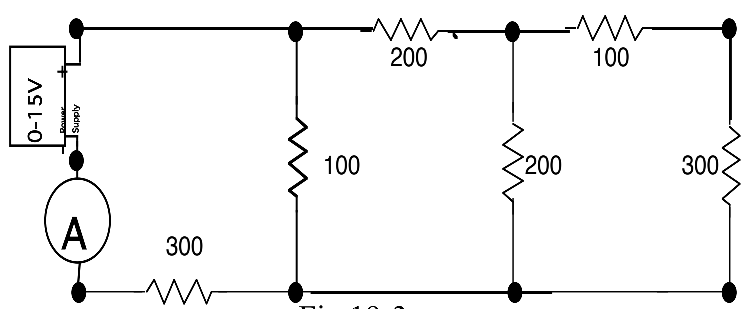


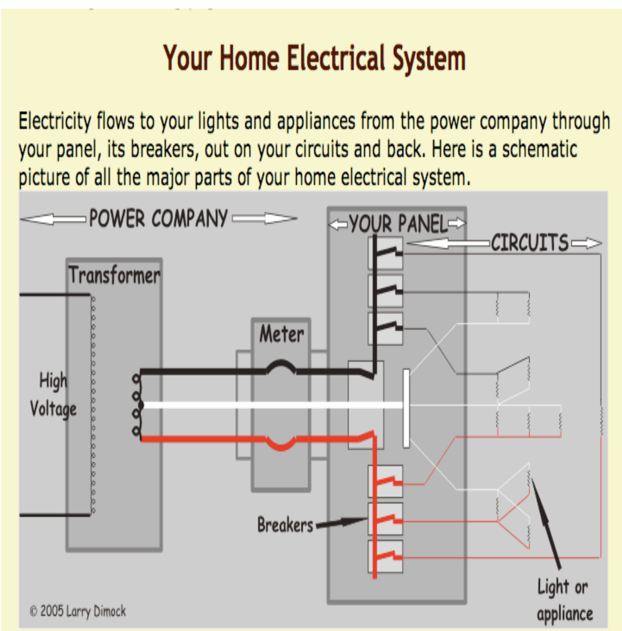

Fig 19-3
Combination circuit

15. Disconnect the power supply from the circuit by pulling both banana-plug leads out of the power supply. **Measure the total resistance of the circuit with the ohmmeter.** This value should be close to both theoretical value and plotted value. **Reconnect the power supply.**

## Post lab Questions:

1. What is the definition of equivalent resistance (of a circuit)? What is the definition of an electrical circuit breaker? What is the definition of a 'circuit breaker" used in stock market or commodity trading?

2. Using the figure below, answer the following: Are the houses wired in parallel, series, or both? *Be sure and consider the* ***circuit breakers*** *in the fuse box ('your panel' in diagram) and* ***room circuits*** *("see light or appliance" in diagram*. Explain your answer.




3. Show how you determined the equivalent resistance of the circuit used in part 3 of the lab (the combination circuit). You are to use the **DMM measured resistances** of your resistors (e.g, if your 100 ohm resistor was 98.5 ohms use 98.5 ohms). Show work for each part. *You will need to draw a different circuit diagram for each time you combine two resistors. See Example 28.9 of text.* **Your diagrams should be hand drawn.**

4. Based upon the results of your measurements in part 2 of the experiment, what can you say about the resistance of an ammeter (DMM) when you put the DMM in the 20A and/or the 2A setting compared to the 200mA?

5. Two light bulbs of resistance R are connected first in series with to a constant voltage supply of voltage V and then reconfigured and are connected in parallel to the same constant voltage power supply.

Which arrangement produces the brighter light (i.e., which arrangement uses more power and why)? SHOW ALL WORK.