Experiment 19
Series and Parallel Resistances

Advanced Reading:
(Halliday, Resnick and Walker)
Chapter 27 section 27-5 thru 27-7

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

Objective:
The object of this lab is to study resistances in series and parallel.

Theory:
In the previous lab you made a circuit that contained one resistive element (resistors and a 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 are connected so that the current is the same through each device. See Figure 19-1. For a series circuit the total equivalent resistance $R_{eq}$ in a circuit is given by:

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

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

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

Procedure:

Part 1: Series Circuit

1. Construct a series circuit with one 100Ω, 200Ω, and 300Ω resistors on
the circuit board (see fig. 19-1) with the power supply and the ammeter connected in the appropriate places. (Note: There is more than one way to do this.)

2. Attach the voltmeter so as to read the voltage differences across all the resistances 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 circuit based on these resistances and record this value in your notebook.

4. Plug in the power supply. Adjust the dial of the power supply until the potential difference $\varepsilon$ across the resistors is approximately 1.00 volt. (This is the same as the potential difference across the power supply.) Record the current flow and the voltage drop. Repeat this process in 1 volt increments up to 12 volts.

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

6. Disconnect the power supply from the circuit and measure the resistance of the circuit with the ohmmeter setting of the DMM. Record this value.

**Part 2: Determine the Resistance of an Ammeter**

7. Leave the power supply disconnected. Measure $R_{eq}$ of the circuit (scale set to 2k-Ω). As you adjust the scale on the ammeter, record $R_{eq}$ at the following ammeter scale settings: "200µ"; "2m"; "20m"; and "200m".

8. 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. (hint: what does the slope of the line represent?) Calculate the percent difference between the value obtained from the slope of the graph to the ohmmeter value.

**Part 3: Parallel Circuit**

9. Connect one 100Ω, 200Ω, and 300Ω resistor in parallel with each other on the circuit board. See Figure 19-2. **Have your instructor check the circuit before plugging in the power supply.** After approval, plug in the power supply and plug the leads of the DMM into the banana-plug holders on top of the power supply.

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?

11. Disconnect the power supply from the circuit by pulling a banana-plug lead out of the power supply.
Measure the total resistance of the circuit with the ohmmeter as before.

12. Repeat steps 2 through 4 for this circuit. Graph current vs. voltage and determine the total equivalent resistance of the circuit.

13. Calculate the percent difference between the ohmmeter value and the value obtained from the slope of the best-fit line.

**Part 4: Combination of series and parallel**

14. Construct the circuit that appears in fig. 19-3. Calculate the total theoretical equivalent resistance of the circuit.

15. Repeat steps 2, 3, and 5 for this circuit. What is the percentage difference between the best-fit line value and the ohmmeter value for this circuit?

**Questions/Conclusions:**

1. Draw an equivalent circuit for each combination of resistors. (parts 1, 2, and 3). Show each step.

2. Why should the voltage drops (potential differences) across the resistors wired in parallel be the same?

3. Are the circuits in houses wired in parallel or series? What evidence do you have for your answer?

4. Consider two different series circuits consisting of a power supply and two resistors. One circuit has two 100 ohm resistors and the second circuit has two 10 megaohm resistors. You are to measure the voltage across one resistor in both circuits using a DMM with an internal resistance of 10MΩ. Calculate the equivalent resistance of both circuits once the DMM is connected. Draw two diagrams and show all work. Discuss whether the presence of the DMM affects either circuit.