Objectives
1.) Verify Ohm’s and Kirchoff’s laws.
2.) Verify series and parallel equivalence, and the divider rules.
3.) Feel the power dissipation of a resistor as heat.

Check out from stockroom: (Should be on the bench already)
- Wire kit
- Two digital multimeters
- EE 1050 kit, optional, if available.

Parts to be supplied by the student: (Should be in the EE1050 kit)
These items may be bought from stockroom or may be in the EE 1050 kit.
- Two 390 Ω, 560 Ω, and 1 kΩ resistors, ¼ watt
- Proto-board and wires

Experiment
Resistor measurements
Use the bench-mounted digital multimeter as an ohmmeter to measure the resistance of each of the four resistors listed above. Record these values for use in later calculations.

Basic Laws
Build the circuit shown at right. Notice that the ammeter is in the bottom wire (negative return wire). For $V_s$, use a DC power supply.

Set the power supply output to about 10 volts (10 V). Set the digital multimeter on the bench to DC volts and connect it directly to the power supply terminals (red lead on top). Measure the voltage at the power supply. Move the meter connections to the resistor and measure the voltage across the resistor (red, lead on top). Are the two voltage measurements the same? We normally neglect the voltage drops across wires and ammeters, do you think that’s ok? Swap the voltmeter’s red (+) and black (-) lead connections at the resistor. What does the minus sign on the meter mean?

Record the current measured by the ammeter. Move the ammeter to the top wire of the circuit, as shown. Is the current the same in the top wire? Comment on Kirchoff’s current law (KCL).

Use Ohm’s law to calculate the resistance of your resistor. How does this compare to its measured value?
Calculate the power dissipated by the resistor. Is it within the resistor’s rating (≤1/4 watt)? Energy is power times time (E = Pt). If the resistor is dissipating power, what is happening to the energy? Carefully feel the resistor. Is it warm? If you can’t feel the heat, turn up the voltage to 15 or 20 V and try again. Now be careful, the resistor can get hot.

**Series circuit**

Wire any three of your resistors in series with your ammeter and connect them to the power supply (set at about 10 V). As you should whenever you make a new circuit, sketch the circuit in your notebook, showing all the pertinent values. Also label your resistors as $R_1$, $R_2$ and $R_3$. Measure (and of course record) the voltage across each element of your circuit, including your ammeter. Measure the voltage across $R_1$ and $R_2$ together (measure from the bottom of $R_2$ to the top of $R_1$ and call this voltage $V_{12}$). Measure the voltage across $R_2$ and $R_3$ together ($V_{23}$), and finally measure the voltage across all three resistors together ($V_{123}$). Use the concepts of Kirchoff’s voltage law (KVL), series equivalence, and the voltage divider rule to calculate several of the voltages that you’ve just measured. Comment on the agreement between theory and measurement.

Use Ohm’s law and your measurements to calculate the resistance of $R_1$ and $R_2$ together ($V_{12} / I$), and all three resistors together ( $V_{123} / I$). Comment on the agreement between these values and those you get from series equivalence calculations ($R_1 + R_2$, and $R_1 + R_2 + R_3$).

Use Ohm’s law to calculate the resistance of the ammeter. An ideal ammeter would have zero resistance, but our ammeter is not ideal. Keep this in mind as you do the following sections of this lab.

**Parallel circuit**

Build the circuit at right, using any three of your resistors in parallel. Ignore the “dotted” ammeters for now. Label your resistors as $R_1$, $R_2$ and $R_3$. Measure the voltage across the parallel resistors.

Record the ammeter reading. Move the ammeter into each of the different positions shown by the dotted outlines in the drawing above and record all the currents. Since current must flow through the ammeter for it to work, you will need to do some rewiring each time you move the ammeter. Admittedly, this is a pain in the neck but it is good practice. Be very careful with your wiring. Use the ohm’s law to calculate the currents $I_1$, $I_2$, and $I_3$. Add these to calculate the currents $I_{23}$, and $I_{123}$. Comment on the agreement between theory and measurement.

Use Ohm’s law and your measurements to calculate the resistance of $R_2$ and $R_3$ together ( $V / I_{23}$ ), and all three resistors together ( $V / I_{123}$ ). Recalculate these equivalent...
resistances using the formula for parallel resistors. Comment on the agreement between these values.

**Series-parallel circuit**
The resistors in the circuits you have made so far have been either all in series or all in parallel. In a series-parallel circuit some resistors are in series and some are in parallel at the same time. Design a series-parallel circuit using all four of your resistors. Make your circuit and connect it to the power supply. Make at least two voltage measurements and two current measurements. Use electrical theories to calculate expected values for each of these meter readings. Comment on the agreement between theory and measurement.

Use Ohm’s law and measurements to calculate the resistance of all the resistors together (the resistor network). Comment on the agreement between these values and those you get from equivalence calculations.

**Conclude**
Before you tear down your final circuit, call your lab instructor over to check you off. Be prepared to discuss your measurements, calculations, and conclusions and to show off your notebook.

Write a conclusion in your notebook. Make sure that you touch on each of the subjects in your objectives. Did this lab help you understand basic DC circuits?

Discuss the agreement of measurements and calculations. If you are concerned about disagreements, make some % error calculations. Usually your errors are smaller than they at first appear. Also remember that no measuring instrument is perfect and neither are parts.

Mention any problems that you encountered in this lab and how you overcame them.

This sort of check-off and conclusion will be required at the end of each lab, even if it’s not specifically asked for in the lab handout.