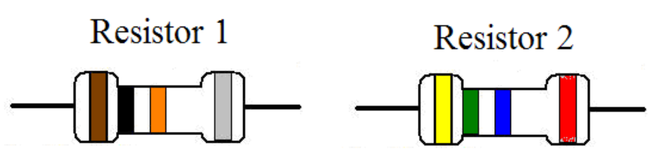
Experiment 3
Lab Activity

Pre-Lab Activity

Read the above sections, the laboratory activity and the post-lab before coming to the Laboratory. Study the Unit on the DC Power Supply and the Multimeter. Solve the following problems and submit your solutions to your instructor on the day of the lab activity for Experiment 3.

1. Find the resistance of a 2cm long cylindrical piece of carbon material that has a 0.5cm diameter.
2. What should be the length of a Gauge 40 (diameter = 0.007874cm) copper wire be for it to have the same resistance as that of Problem 1?
3. Use the resistor color code to find the resistance and tolerance of the following resistors.



Laboratory Activity

Required components:

Five 1kΩ resistors (**±10%** , ½ W or 1W)

Five 1kΩ resistors (±5% , ½ W)

One 47Ω resistor (±5% ½ W)

One 100Ω resistor (±5% ½ W)

One 1MΩ resistor (±5% ½ W)

1. Obtain five 1kΩ resistors, rated at ±5% and ½ W, from your lab instructor. Use the ohmmeter to measure the actual value of each resistor. Use alligator clip terminated test leads to connect the ohmmeter to the resistor.

2. Repeat Step 1 for a set of five 1kΩ resistors, rated at ±10%. (There is a typo in lab kits which 1% actually is 10%)

3. Set the +5V supply of the DC power supply to a *limit current* of 50mA. **Have your instructor verify your settings before you continue.** The supply will be used as a voltage source (CV mode). Obtain a 100Ω (½ W) resistor from your instructor and measure and record its actual value. Connect the output from the +5V supply to the 100Ω resistor (use alligator clip terminated test leads). **Never short the DC supply output**. Use the DC power supply display to set the voltage and monitor the supply current. Start the voltage at 0V and record the current meter reading. Repeat by increasing the voltage in increments of 1V and measuring the corresponding current. Stop when you reach a voltage of 4V.

4. Set the output of the +30V supply to 1V (while in *meter mode*). Set the *limit current* for the +30V supply to 25mA. **Have your instructor verify your settings before you continue**. Connect the 100Ω (½ W)

resistor that you used in Step 3 across the +30V supply terminals. Slowly increase the voltage in increments of 0.1V, until the DC power supply switches from CV to CC mode. At this point, record the value of the DC power supply voltage and current. Warning: You must not violate the condition $V_s < \sqrt{P_{max} R}$; therefore, make sure that the supply voltage never exceeds 7V, even if the DC power supply allows it.

5. In this Step, you will obtain data that will allow you to calculate the internal resistance, R_i, of the voltmeter. Turn off the +30V Channel. Set the +30V supply to (exactly) 8V. Obtain from your instructor a 1MΩ (½ W) resistor and measure and record its actual value. Replace the 100Ω resistor by the 1MΩ resistor. Configure the multimeter to measure DC voltage (press the "DCV" key). Connect the voltmeter *in series* with the resistor (use two sets of alligator clip terminated test leads to build the circuit). **Have your instructor verify your connections**. Press the "ON/OFF" key on the DC power supply so it goes into the *meter mode*. Record the voltage reading of the power supply. Record the reading of the voltmeter.

6. Starting from the setup in Step 5, reduce the +30 supply to 4V. Replace the 1MΩ resistor by a 100Ω resistor. Measure and record the actual value of the resistor before you connect it to the power supply. Set the multimeter to measure DC current (press the "DCI" key). Record the voltage reading of the power supply. Record the current reading of the ammeter.

7. Use the function generator to generate the signal $v(t)$ = 2sin(2,000πt) Volt. Connect a 47Ω (5%, ½ W) resistor across the output terminal of the function generator (use BNC-to-clip test cables). **Use the scope (with the 10x probe) to verify the peak-to-peak value and frequency of the function generator output signal.** Adjust the function generator peak-to-peak value so that the scope reads (exactly) 4V peak-to-peak voltage. Set the multimeter to measure AC voltage and frequency (press the "Freq" key). Connect

the voltmeter across the resistor and record the displayed RMS value and frequency.

8. Repeat Step 7 for the voltage signal $v(t) = 1 + 2\sin(2{,}000\pi t)$ Volt. **Use the scope (with the 10x probe) to verify the peak-to-peak value and the "offset" of the waveform.** Adjust the function generator offset value so that the scope reads 1V for the "average" value of the signal. Set the voltmeter to the "AC" and "DC" mode. Record the reading of the voltmeter respectively.

9. **Sort all resistors and give them back to your instructor.**

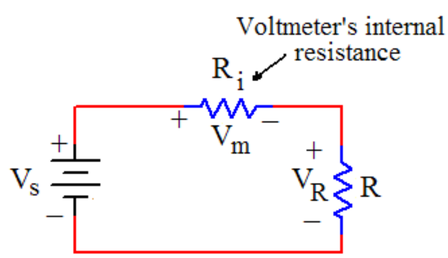
Post-Lab Activity

Write a technical report that discusses your observations and includes analysis and justifications of all steps in this activity. Tabulate and/or plot experimental data whenever possible. More specifically, your report should address the following points:

- Tabulate the measured resistance R_i and its corresponding error ε_i (in percent, relative to the nominal value) in Step 1. Are the errors consistent with the tolerance rating? Compute the average of the absolute value error: $\frac{1}{5}\sum_{i=1}^{5}|\varepsilon_i|$.
- Plot the *V-I* data you obtained from Step 3. Connect the data by a straight line. What is the slope of the line? What physical property does this slope represent?
- In Step 4, why does the DC power supply switch from CV to CC mode? Compare the measured supply current (at the instant of mode switching) to the 25mA limit current. What is the theoretical value of the voltage that causes the power supply to switch from the CV to the CC mode? Compare this theoretical value to the measured voltage. What is the largest current that the 100Ω (½ W) resistor can handle? What DC power supply voltage leads to such current value?

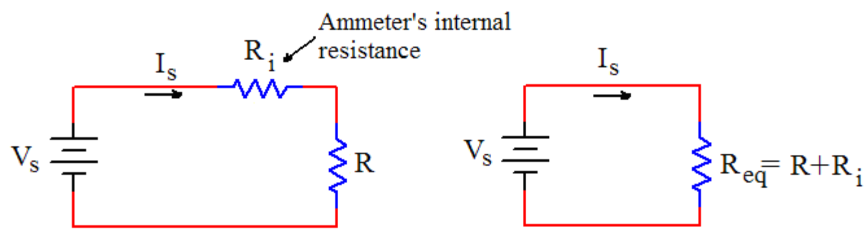
- Employ the results from Step 5 to demonstrate the existence of a voltmeter's (large) internal resistance. Find the value of this resistance using the following theoretical results.

  Theoretical analysis: The voltmeter's internal resistance (R_i) changes the power supply load from R to $R + R_i$, as shown in the figure below. In this (unusual) setting, the voltmeter reads the voltage drop across its internal resistance. The source voltage is split over the two resistors R and R_i. The voltage drop across R_i is equal to the voltage V_m across the voltmeter. V_m is given by the voltage division formula: $V_m = V_s R_i/(R + R_i)$. Solving for R_i we obtain: $R_i = V_m R/(V_s - V_m)$.



- Employ the results from Step 6 to demonstrate the existence of an ammeter's (small) internal resistance. Use the following theoretical results.

  Theoretical analysis: The ammeter's internal resistance (R_i) changes the power supply load from R to R_{eq}, as shown in the figure below. Using ohm's law, $V_s = I_s R_{eq} = I_s(R+R_i)$ or $R_i = V_s/I_s – R$. You can solve for R_i employing experimental data (V_s, the current reading of the ammeter and the measured value of R).



- Compute the theoretical RMS values for the voltage in Steps 7 and 8. Compare to the measured RMS values.