Circle your lab day and time.

		Mon	Tue	Wed	Thu	Fri
Your name:	______________	Mon	Tue	Wed	Thu	Fri
TA name:	______________	8-10	10-12	12-2	2-4	4-6

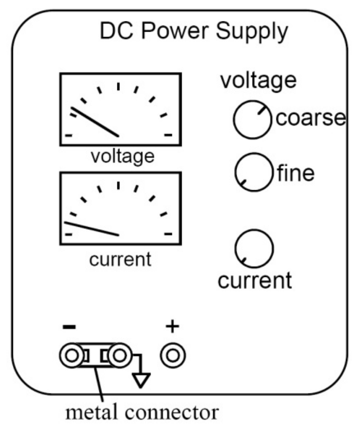
Lab 5: Real DC Circuits

INTRODUCTION

The field of electronics has revolutionized the way we live and what we do. We can find circuits everywhere – from our cell phones, digital watches, calculators, televisions, computers, etc. Understanding how these things work is interesting in their own right, but from this we can figure out how to do more practical things, like design and install our own car stereo system or make sure that we *do not* electrocute ourselves.

In this lab, we will first look at a few simple DC circuits that will give us an idea of how these things work in the first place (**DC** stands for *direct current*, as opposed to **AC**, which stands for *alternating current*; AC/DC is a rock band from Australia). We will learn how to use a DC power supply and an electrician's best friend: a digital multimeter (DMM).

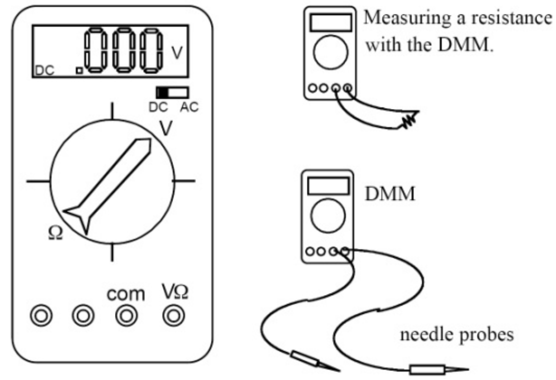
PRECAUTIONS & NOTES



The two instruments you will use in this lab are a DC power supply and a digital multimeter. The **DC power supply** produces a constant voltage, which can be adjusted anywhere from 0 to 30 volts with the voltage knobs (coarse and fine) on the front panel. **Make sure the switch under "coarse" is on "high."** The power supply has three output terminals: plus (red), minus (black), and ground (green). The ground terminal is always at zero volts. In this experiment, the ground and minus terminals are tied together by a metal connector so the minus terminal is also at zero volts.

Both the current and voltage produced by the power supply can be read on the meters on the front panel. Also on the front panel is a current-limit knob, which can be adjusted to limit the maximum output current, to prevent damage to sensitive circuit elements. In this lab, the current knob has been set and clamped in place so the power supply cannot produce more than about 0.6 A current.

The hand-held **digital multimeter (DMM)** is a wonderful little device which can be used to measure the voltage difference between any two points in a circuit, the current through a circuit, and the resistance of any circuit component(s). In this lab, you will use the DMM to measure both resistance and DC voltage differences. There are 2 wires attached to the DMM. One of the two wires always goes to the COM (common) terminal. To measure either the voltage difference or the resistance, the second wire is attached to the "VΩ" (volts & ohms) input. In this lab, *all your measurements will be DC*, so the DC/AC switch (upper right) should always be in the DC position. The DMM has an alarm and it rings if you have wires plugged into positions which conflict with the central knob's position. The 2 wires attached to the DMM are called "needle probes." You can quickly measure the difference in voltage between any two points in a circuit by touching the points with the needle probes.



The digital multimeter measures resistance using Ohm's Law. That is, it uses an internal battery to send current through the device under test and measures the resulting potential difference. The resistance is then the measured potential difference divided by the current that is flowing through the device. The meter displays the result of this calculation. Since the meter is supplying current to the device under test when a resistance is being measured, you must disconnect the resistance you are testing from any other devices, such as power supplies. ***Never try to measure the resistance of a resistor or light bulb while it is still in a circuit.*** At the very least, leaving a resistance in a circuit when you try to measure its value will give an erroneous reading since the current from the meter will flow through other parts of the circuit in addition to through the device you are testing. If a power supply or battery is present in the circuit, it will add additional currents and make the computed resistance incorrect; ***these additional currents can damage the meter.***

PART I: MEASURING RESISTANCE WITH THE DMM

At your table, you should have 5 resistors: one 15 Ω, one 40 Ω, one 1500 Ω, and two 3000 Ω resistors. These values are given by the manufacturer and are *approximate* – the actual values may differ by up to ±10%. Each resistor is mounted in a double-banana plug connector. Carefully measure the resistance of each resistor with your DMM and record your measured resistances in the table to the right. Be sure that the meter probes make a good contact with the resistors.

Manufacturer Value	Actual Value
15 Ω	
40 Ω	
1500 Ω	
3000 Ω	
3000 Ω	

You should also have two light bulbs at your table. Use the DMM to measure the resistance of each light bulb filament and record your results. (The DMM uses a very small current to measure the resistance. The light bulb probably will not glow during the test, so that you are measuring the "cold" resistance of the lamp. **The resistance of a light bulb varies with its temperature and will be different when the lamp is lit**.)

First Light Bulb	Second Light Bulb

What is the resistance of other things around you? Explore the benchtop, yourself, your lab partner, your lab book, etc. Pure water is a poor conductor of electricity and has a high resistance. However, the resistance of your skin will be much lower when it is wet because perspiration, drinking water, and etc. include dissolved salt and other minerals. Are these consistent with how well you thought these materials conduct electricity?

Item	Measured Resistance

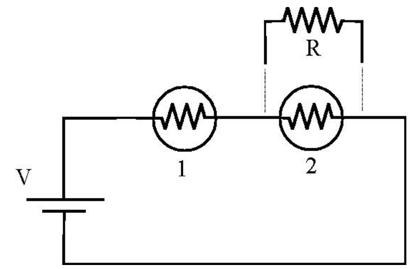
With your lab group, create **four** different resistor combinations using the 5 resistors and 2 light bulbs – use the various elements (at least four elements) *both* in series and in parallel.

- First just **draw** a diagram of each combination.
- Then *predict the* ***equivalent resistance*** of that combo without actually measuring it.
- Finally, actually build the four combinations and measure the resistance of each one.

	Equivalent Resistance	
Drawings of Resistor Combinations	**Predicted**	**Measured**

Do your measurements match your predictions? Why or why not?

PART II: CIRCUIT BEHAVIOR



Now that you understand how to use the DMM, you will build a circuit and investigate its behavior. Construct the circuit shown here, consisting of two light bulbs in series with the power supply. (The resistor R will be added later). Slowly increase the voltage until the bulbs are glowing, but not too brightly.

1. *Predict* what will happen to the brightness of each of the bulbs when you place a (R = 40 Ω) resistor in parallel with bulb #2 as shown in the schematic. Your group should come to consensus on your predictions before doing the experiment!

	Your Prediction
Bulb 1	
Bulb 2	

2. Now go ahead and add in the R = 40 Ω resistor, and describe in your own words what happened and why. (If it doesn't match your predictions, try to make sense of what is happening!)

3. Before using a voltmeter to check, rank the potential difference across the four elements (power supply, bulb 1, bulb 2, and resistor R) from smallest to largest. Some elements might be equal...for instance, you might predict $V_{bulb\ 1} = V_{bulb2} < V_{resistor} = V_{power\ supply}$ (…except that one is not right :-). Justify/explain your reasoning.

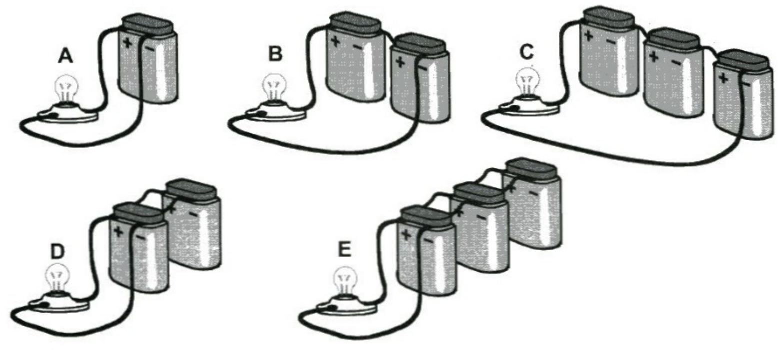
4. Measure the voltage drop across the four elements (fill in the table) and then verify that they match your predictions from above. If they don't match, try to make sense of what is going on with your group. (Note: Yes, you should use the DMM to measure the voltage difference across the terminals of the power supply because the meter on the power supply is not as accurate as the DMM.)

	Measured Voltage Difference
bulb 1	
bulb 2	
resistor	
power supply	

5. Pick a "complete path" around your circuit (that includes the power supply) and use your measured voltage differences to calculate the sum of these differences. Explain why the sum should be zero. If it is not zero, explain what you think is going on.

PART III: MULTIPLE BATTERIES

- In the figure shown, *predict* the order of light bulb brightness, from dimmest to brightest.



brightest
dimmest

- Draw the equivalent circuit diagram for each of the circuits A – E in the boxes below.
- For each of the five circuits *predict* the voltage difference across the bulb, assuming each battery has voltage of 6 V, and write your prediction in the boxes.

A.	B.	C.
Predicted ΔV =	Predicted ΔV =	Predicted ΔV =
Measured ΔV =	Measured ΔV =	

D.	E.
Predicted ΔV =	Predicted ΔV =
Measured ΔV =	

Now put together batteries in these configurations: **A, B, and D**. Be sure that you connect the positive and negative terminals as shown in the figures. (Can you explain why this is important and what will happen if you do not do this?) ***Do not connect a light bulb***.

- Measure the voltages across the terminals where you would connect the light bulb and record them in the appropriate boxes.

- Do the measured voltages match your predictions? If not, explain what is happening.