This lab is a review, at a somewhat deeper level, of things that you have probably seen or heard in the freshman courses and labs. You will use Digital Multimeters (DMM) to study some simple circuit elements, their characteristics, and the behavior of some combinations of these. You will also get a sense of possible complications when you introduce measuring instruments into a circuit, since the measuring instrument is an additional component that can alter the properties of a circuit.

In any scientific work, record keeping is a basic requirement. It is important that you carefully record: (1) the instruments used; (2) the measurement configuration; (3) all raw data (in tables); and (4) preliminary analysis. Put items (1) and (2) in your notebook. You should arrange your data in well-designed tables. Don’t just write down numbers – include units (V or mV, mA or μA). If you are planning to do calculations on your data, include columns/rows in your tables in the appropriate places for recording these results.

For this Lab, and most other Labs, you will need the following:
- Variable DC power supply (PS) (12 or 15 V, 0.5 A)
- 2 DMMs (Digital MultiMeter)
- Resistors (kΩ range; one 10 Ω, 1 W), capacitors (10-100 μF)
- Flashlight bulb in holder, diode
- Jumper wires

I. The DMM (Digital MultiMeter) – Familiarize yourself with the buttons and controls of your DMMs. Set the DMMs to DC and to VOLTAGE measurement.

Power supply procedures for a circuit. (a) Before turning the power on, make sure that the voltage and current control knobs are set to the minimum. (b) Turn on the main switch. (c) Turn the current control knob to about half way to full on. (d) Now turn up the voltage to your set value.

1. Set the DVM to a high value, such as 100 V. Look at the other buttons to see what they do. Make sure that the input leads for the DMM are plugged into GND (ground or common) and V (voltage). Meters often have other input terminals. Look at the other terminals to see their functions.
2. Connect the DVM to the power supply (PS) and measure the voltage for various settings of the supply (turn the voltage control knob). Be careful - if the DMM is plugged in for measuring current or resistance you can blow a fuse, or worse.
   Make sure you turn the voltage controls all the way down (counter clockwise), then switch on the power supply, then turn the current control half way up (clockwise).
3. What are the minimum and maximum voltages from the PS? Make a voltage measurement with the meter set to AC. What do you find?
4. Next, make some resistance (R) measurements. Disconnect the DMM from the PS. Select a few resistors from the grey box. From the color code, find their nominal resistances and tolerances. Measure their resistances with the meter. Explore the different meter ranges and find the optimum range for these measurements. Are your measurements within the resistor tolerances?
II. Resistance – Here, you will investigate Ohm’s Law (V=IR) for a resistor.

ALWAYS SKETCH THE CIRCUIT IN YOUR NOTEBOOK BEFORE CONSTRUCTING IT.

1. Choose a resistor in the ~kΩ range. Measure R with the DMM and compare to the color-code value.
2. Measure the I-V (current-voltage) characteristics of the resistor. First, compute the maximum V for a given R, so that you do not exceed the resistor power rating \((P=V^2/R=1/4 \text{ W})\). Use two DMMs, one to measure voltage and one to measure current. Plot your results \((v \text{ on the x-axis})\) while you are taking the data. Use at least 5 measurements for both positive and negative voltage.

ALWAYS PLOT THE DATA AS YOU TAKE IT. REPLOT AFTER EVERY 3 DATA POINTS. THE PLOT WILL INDICATE WHERE YOU SHOULD FILL IN MORE POINTS.

3. Did the resistor show ohmic behavior?
4. Discuss the slope of the data.
5. Compare the computed V/I resistance to that measured with the digital resistance meter and that from the color code.
6. What is the power dissipated by the resistor at the highest voltage? Compare to the power rating?

III. I-V Characteristics – Use the same I-V (current-voltage) setup to measure the characteristics of:
(a) Light Bulb (Caution – bulb gets HOT; do not exceed 6 V or it will burn out);
(b) Standard 1-amp Si diode (1N400X, X=1-5) in series with a \(R=1 \text{ kΩ}\) current-limiting resistor.

Be sure to measure the voltage across the diode, not the resistor+diode.

Do not exceed the power ratings of the components – Search for the specifications to find the maximum allowable voltage and current for the diode. If you exceed the ratings of a diode or transistor for even a millisecond it will be destroyed.

1. Make an I-V plot \((V \text{ on x-axis})\) for the light bulb, taking data for both voltage polarities. Discuss I(V).
2. Plot the resistance \((V/I)\) as a function of voltage, R(V). Compare R at 0.1 V and 5 V and discuss.
3. For the standard diode, plot I-V, where V is the voltage across the diode. Discuss I(V).

Note that forward (positive) I and V directions are in the directions of the diode arrow.
4. What is the approximate voltage onset for the diode.
5. Also plot I-V for the diode using a log scale for the positive I-axis, and discuss.

Solder the five resistors shown in the configuration on the right. Measure the total R and compare to the computed R. Discuss.