Physics 405   NAME_____

Lab 1: DIGITAL MULTIMETERS

The purpose of this experiment is to become familiar with the standard digital multimeter (DMM) and use it to measure voltage, current, and resistance. Another indirect purpose is to show (using this instrument as an example) how one can adopt a critical attitude toward the functions of measuring instruments, understanding their sensitivity, precision and manner in which they interact with the system being measured.

Required equipment (see lab assistant): 2 multimeters, one light bulb (6V, l A), one LED (light emitting diode), one 330   resistor, two other resistors (about 100 to 1000 ohms), a photosensitive resistor, a voltage supply, test leads, and clips or connectors.

The multimeters that we will use take measurements and display the result as a 3 or 4 digit number. Older multimeters often used analog meters that incorporated a deflected needle. Most multimeters are capable of making at least three types of measurements: voltage (labeled V), current (labeled A), and resistance (labeled   ). In addition, one of our multimeters can measure capacitance (labeled C) and inductance (labeled L). Occasionally multimeters are also referred to as digital voltmeters, DVM.

We will be using one of three different digital multimeters. Most of the multimeters are turned on by either depressing a power button or by rotating the function knob from "off" to a specific function. Most meters are battery operated. The AC/DC function switch determines whether the meter measures the constant or unchanging part of the voltage or current (DC mode) or the alternating voltage or current is monitored (AC mode). A battery represents a DC power supply and the electrical wall outlet represents an AC supply. For this experiment the AC/DC switch should be set for DC operation.

The measuring function is determined by rotating the large knob to the correct region. For our multimeters it is necessary to set the range of the display. The numbers on the multimeter dial determine the maximum value that can be displayed. The range should be chosen to be just slightly larger than the expected voltage to be measured. For example, if the voltage of a 9V battery was being measured, the 20V scale would give the best precision, while the 2V setting would lead to an error. The error display is sometimes given by a 1 or -1 or some abnormal reading. Some DMM have an autoscale capability and, thus, automatically set the optimal range for you.

It is also necessary to connect the test leads to the appropriate connector holes. The COM connector is used for almost all functions. Connect the black test lead here. Then connect the red lead to the V or   connector for voltage and resistance functions, or connect the red lead to the "A" connector for current measurements. If there are two "A" connectors, connect the lead to the high current port for the light bulb measurement in this lab, or to the 300mA connector for the resistor measurements.

Always make sure to turn the voltmeter off when you are done to conserve the battery.

l. Voltage Measurements

a) Press the "ON" Button. Be sure that the DC/AC button sets the meter to DC.

b)   Press the Volts Button or turn to a voltage value (example: 2V means maximum voltages within the range -2V to 2V will be displayed. Typically, begin with high ranges and then decrease the range to get higher precision results during measurements.)

c) If necessary, select the 200 V range button to prepare for part d.

Figure 1.

Power Supply

DMM

Schematic
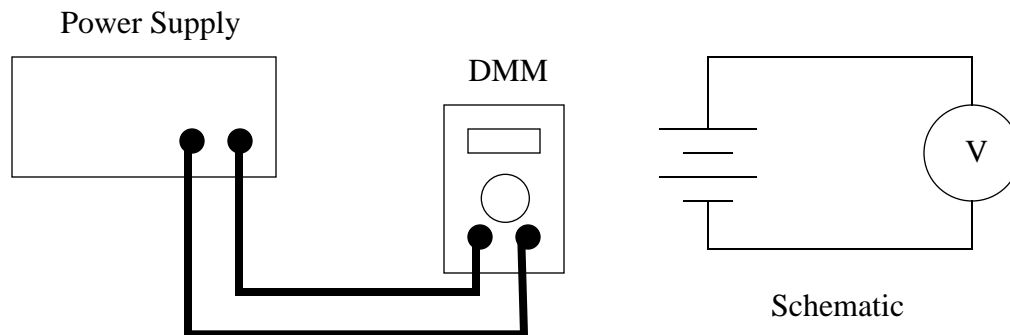
d) Assemble the circuit shown in Figure 1. Plug in the low-voltage power supply, set the voltage control to minimum, and turn the power on. Take voltage readings with the DMM. Observe that the voltage varies from zero to a maximum of about 25 V as you turn the voltage control knob. Reverse the wires. Notice that the sign of the voltage changes. Select other voltage ranges on the meter to see how the measurement is effected. Finally, return the power supply knob to zero volts.

2. Current Measurements

a)   Connect one of the resistors coded with yellow-orange-orange in the circuit as shown in Figure 2. Use a 0-500 µA current meter in series with the resistor as shown. Starting with zero voltage on the power supply, take data measurements and plot a graph of currents at the various settings as a function of the volts at the corresponding points. An example data table and plot are shown below (The resistor is not the same as yours). Do not exceed full scale on the current meter.

Voltage	Current
0 V	0 µA
5 V	51 µA
10V	105 µA
15V	145 µA
20V	198 µA
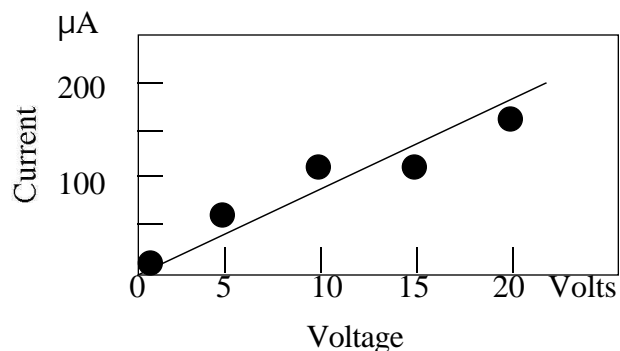
(Answer the following questions.) Do your data points lie on a straight line?
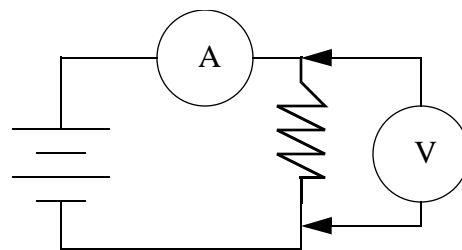

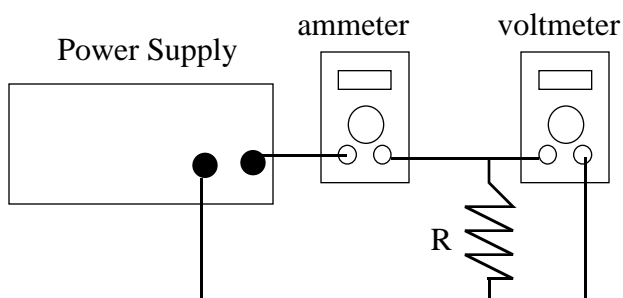What does this suggest to you?

How would explain any deviation from a straight line?

How might you improve the precision of your measurements?

From the best straight line through the data points, determine the resistance R = V/ I, which is the reciprocal of the slope of the line (Slope =   Y/ X.)

R = _____.   (From calculation of slope.)

Figure 2.

:Schematic

b)   Remove the resistor from the circuit. Switch to the Ohms " " function on the DMM. Connect the leads directly to the ends of the "free" resistor.
The resistance is _____.

Compare this measured value with the value of the resistance determined from the slope in part 2a. Reverse the resistor, changing its leads, end for end.   Are the values the same?

3. Resistance of a Tungsten Filament

To determine the resistance of a tungsten filament, assemble the circuit shown in Figure 3. Use a DMM to measure the voltage across the lamp and 0- 1 A ammeter to measure the current. Start with 0 Volts, and do not exceed one ampere.

Figure 3.
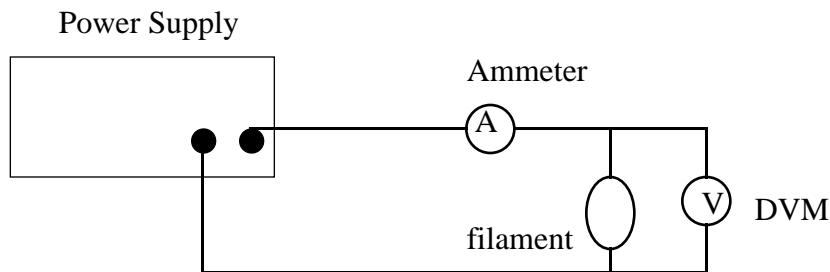
Using a tungsten-filament light bulb, measure current through the ammeter versus voltage across the bulb (reading of the DMM). If the voltage across the bulb exceeds 8V, the bulb will burnout. Make about 8 measurements between 0V and 6V.

Plot a graph of current as a function of voltage. Do the data points lie on a straight line? Calculate the resistance (V/ I) of the filament when is hot and glowing? What is it when it is cold and dark (near the zero Amp measurement)? The nominal operating temperature of an incandescent filament is 2575 K(Kelvins), which is over eight times room temperature (nominally 293 K). Do your measurements suggest that the resistance of the tungsten filament increases or decrease with temperature? Reverse the lamp connections. Do the properties change? Measure the bulb resistance with an ohmmeter. Discuss your results.

R_{hot} = _____ R_{cold} = _____

$R_{ohmmeter}$ = _____

4. Semiconducting Diode

Figure 4
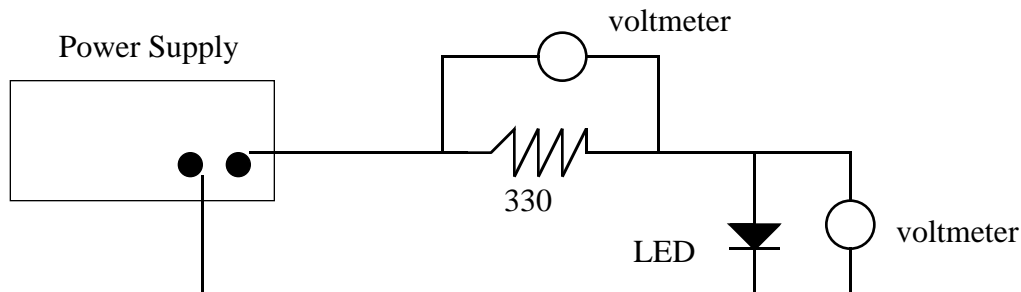
Connect the circuit as shown in Figure 4. Instead of using an ammeter, you will calculate the current using the voltage measurement and resistance value. If there are two DMM's available,

connect one across the 330 resistor and the other across the diode. Each should be set for DC volts, 20 Volts maximum. Ohm's law states that the voltage across a resistor is equal to the resistance times the current. Note that the same current flows through the LED as flows through the 330 resistor. If we solve for the Current, we see that

I = V(across 330) / R= V / 330

If the voltage across the resistor is 3.3 Volts, then I =3.3 / 330= 1/100 A =0.01A= l0 mA.
(If current is very small, reverse the diode connections.) Do not exceed 20 mA or 6 Volts across the diode. Make a data table and then plot the current in mA versus the voltage across the diode for about 6 to 8 data points. Reverse the diode's connections and repeat, not exceeding 20 mA or 6 Volts across the diode. Plot the data for the two polarities on the same graph, but use negative diode voltage values for the second data set. Place the origin at the center of the graph. What can you conclude about the properties of the device?

5. Resistors in Series and Parallel

Measure the resistance or each of two resistors using the ohmmeter function of the DVM. Record the measured values.

R1 = _____   R2 = _____

Connect them in series and measure the total resistance. Calculate the expected value from R1 and R2.

R (measured) = _____ R (calculated) =_____

Connect them in parallel and repeat.

R (measured) = _____ R (calculated) = _____

6. Dependence of Resistance on Material (Ignore for Oakbrook Class)

Measure the resistance of the thinnest copper wire on the large black mounting board

R = _____

Measure the resistance of the thin German silver wire on the game board.

R = _____

Note how the resistance changes with material type and dimensions. Commercial wires are usually copper, but occasionally aluminum, silver or even gold.

7. Resistance of a Photoresistor

Connect the ohmmeter to a photoresistor.   Observe how the resistance changes dramatically with illumination. Such a device is called a "transducer" --it changes one form of energy into another. For computers, these devices can become the sensing elements of the physical world. Similar devices are found in cameras.

R (dark) =_____ R (bright) = _____

Conclusion.

Hand in your data tables, the graphs and these sheets with a short description of the purpose of the experiment(s). The primary purpose of the experiment is to give you some hands-on experience with the electronic measuring equipment. Be sure to plot the points neatly on graph paper, connecting them with smooth curves. Label the graphs with a title and your name; label axes with quantity measured and units(e.g.,"Current, in microAmps"). Each graph should occupy at least l/4 of an 8 l/2 x 11 sheet. You may use one piece of paper for all the graphs. You may also use computer spreadsheets and graphing programs if they are available to you.