Name ______________________________

Atmospheric Sciences 360 Atmospheric Instrumentation:
Circuit Laboratory, an Introduction. You can write on the front and back of these pages as your report.

Purpose:
The purpose of this lab is to introduce you to the tools we will be using throughout the semester to measure voltages, resistances, diode voltage drops, etc. We also will introduce you to basic circuit components. Soon we will advance to more sophisticated tasks, so be sure you have a solid foundation with the basics.

Procedure: You will make observations and write about them. In responding to the questions you may wish to gather the data in class and analyze it later as homework, as you put together your report.

Materials: Proto-board for electronic layout, DC power supply, hand held digital volt meter, components collection (resistors, LED's, diodes, thermistors).

Reference:
We will make reference to the text "Getting Started in Electronics" by Forrest Mims. We will refer to pages in this text below.

1. Do it yourself resistor. Refer to pg 28.

Write a line parallel to the one below using a pencil, and go over that line several times to thicken the layer of graphite. Set your meter to the highest resistance setting. Measure the resistance along the line, with one probe on the left, and the other probe going from spot to spot on the right. Record the measured resistance values next to where you measured them. You may need to try several pencils to get measurable results.

____

Questions:

1. A. Estimate the resistance per unit length for the pencil line. Use this number to help you estimate the resistivity (resistance per unit length per unit area) of 'pencil lead'. You will need to somehow estimate the thickness of the pencil line.

1. B. What are resistors and what are they used for in electrical circuits?

Name ______________________________

2. Resistors.

Find the two types of resistors in your box. Refer to the color code given on page 29.

Questions:
2.A. What are the stated values of the resistors in your box?

Now place one resistor between the yellow and green posts, and measure the resistance value.
2.B.Is this value within the tolerance of the stated values? Repeat with the second resistor type.

Now make a series circuit with your two resistors on your proto-board, as shown on page 31.

2.C. What is your expected resistance value, and measured value.

Now make a parallel circuit with your two resistors on your proto-board, as shown on page 31.

2.D. What is your expected resistance value for the parallel circuit, and measured value.

3. Thermistors

A thermistor is an example of a transducer. [A **transducer** is a device, usually electrical, electronic, or electro-mechanical, that converts one type of energy to another for various purposes including measurement or information transfer. In a broader sense, a transducer is sometimes defined as any device that converts a signal from one form to another. see also http://en.wikipedia.org/wiki/Transducer.]

Find the thermistor in your box. Refer to pg 30 at the bottom for a brief description of the thermistor. Attach the thermistor between the green and yellow posts on your protoboard. Wait a minute and then measure and record the resistance value for your thermistor. Now carefully hold the thermistor between your thumb and forefinger and again measure and record the resistance.

Questions:
3.A. Make a crude graph estimating the two temperatures and the resistance values you measured. You will have to estimate room temperature and your body temperature for your graph.

3. B. Moisten the thermistor and waft air over it. Note any changes in resistance values, and interpret them in light of your results in 3.A.

Name ______________________________

Primer for the next section.
Carefully read pages 13-20 to understand the idea of voltage and current. Pay particular attention to pg 14 where Ohm's law is discussed. It is surprising how far you can go in electronics with just knowledge of this one concept.

4. Diodes

Read pages 44-46 to learn about diodes. Here we will consider both small signal diodes and light emitting diodes, as your kit contains both.

Questions:

4.A. Use your voltmeter and measure the forward voltage drop needed to turn on the small signal diode in your kit. The voltmeter has a dial setting that looks like a diode circuit element. When you get the orientation of the diode correct you will measure a positive voltage corresponding to the forward voltage drop. See pg 45 for a graph of the voltage current characteristics of the diode, and note that when you have a voltage across the diode

4.B. Consider now the LEDs in your kit. Make a table of values with columns including "LED description and body color", "Forward Voltage Drop". Comment on the relative forward voltage drop of the small signal diode and the LEDs.

5. More on Diodes And the First Step Towards an LED Sun Photometer

Construct a series circuit using your proto-board as follows. Start with the red post and connect it to the red + voltage line of terminals. Make it convenient to change the LEDs and do measurements on them. Have the instructor check your circuit before it is energized.

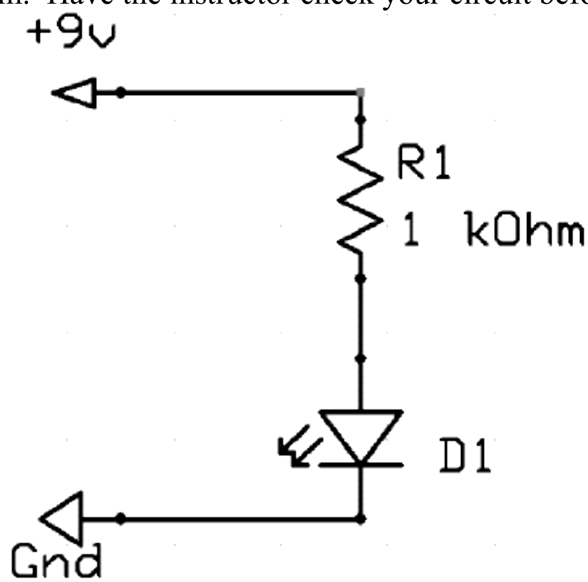

Figure 1. Series circuit used to test LEDs.

Name ______________________________

Questions:
5.A. Energize your circuit after having it ok'd by the instructor. Make a table of values for your various LEDs as follows. "LED Description", "LED light emission color", "Voltage across the source" (This is given as 9 Volts in the schematic, and is measured from the + terminal to the ground terminal.) "Voltage across R" "Calculated current in the circuit." The calculated current is just the voltage across R divided by the resistance value.

5.B. Pick your favorite LED, perhaps one you would like to make a sun photometer out of, and one different than your near neighbors. Take your proto-board over to the spectrometer and measure the spectrum of light emitted by your diode. Save this spectrum as a data file and plot it in yoru final report for this part of course.

6. Here is something you should do during the course of the semester. You will need to bring in a comb, and to wash your hair before class so that you can put a lot of static charge on the comb by using it on a dry day in Reno.

Static electricity. We will take a look at electric fields from static electricity by growing an ice cloud in the freezer (breath into it to add water vapor and water droplets that grow from it, then use the pop gun to homogeneously nucleate ice crystals that will grow at the expense of the water droplets), illuminating it with the spotlight, place a comb through your hair, and put it in the vicinity of the ice cloud, to notice how the electric field tends to orient the ice crystals.

Question:
6.A. Describe what you see.

Name ______________________________

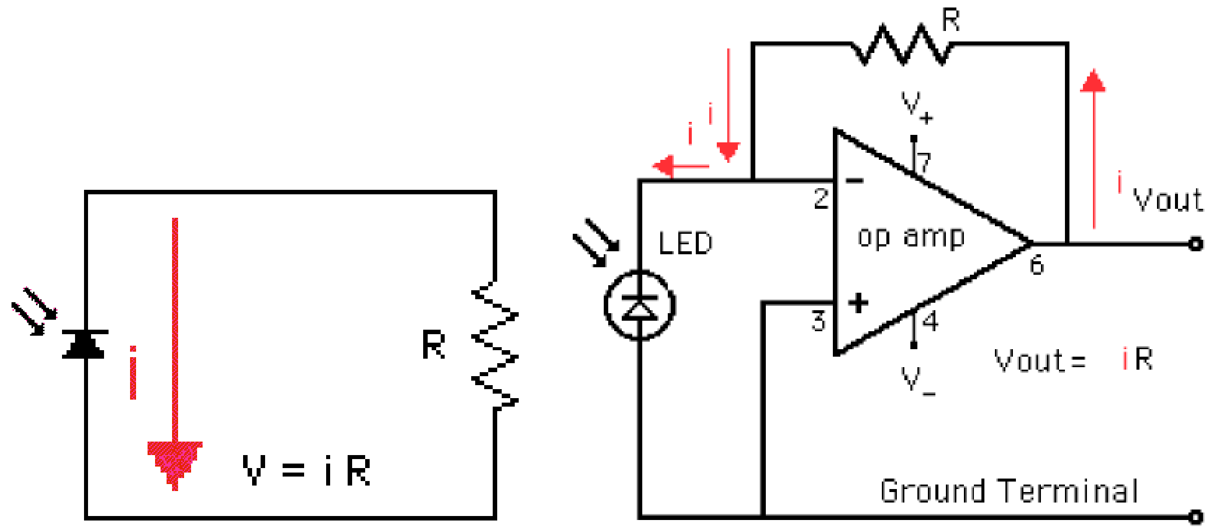

Figure 2. Circuit Schematics for LED current to voltage converters. The one on the left is the simplest form, and one simply measures the voltage across R to obtain the current. The time constant of the circuit on the right is much faster than that of the one on the left.

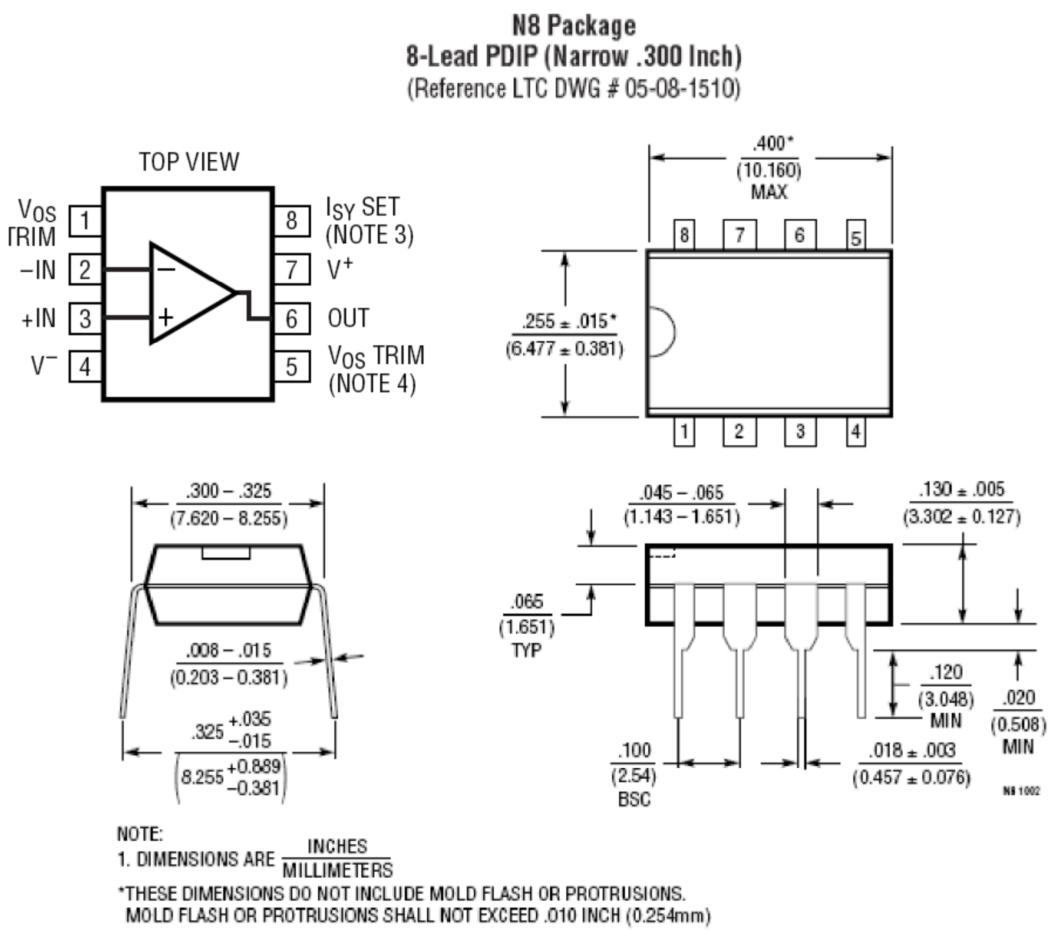

Figure 3. LT1006 Operational amplifier. Note carefully the pin assignments.

Name ____________________________

Figure 2 is a schematic for circuits that can be used to measure the current produced by a light emitting diode (LED). The LED is being used here as a photodiode that converts light into electrical energy. In theory, the voltage for each circuit should be the same, V=iR, where i is the current produced by the LED from the light incident upon it. This current is also known as a photocurrent. In practice, the notion of increasing R to have a larger voltage to measure in the circuit on the left doesn't exactly work because the input impedance of a voltmeter is around 10 MegOhm. The voltmeter's input resistance and the resister R are in a parallel circuit, so that if R is also equal to 10 MegOhm, the net resistance for the parallel combination is 5 MegOhm.

The circuit on the right in Figure 2 overcomes the limitation of the voltmeter input impedance by using an operational amplifier circuit (Op Amp for short). We can analyze this circuit using the two golden rules for the op amp.

OP AMP GOLDEN RULE 1: The voltage feedback from the output to the input does all it can to keep the voltage the same at the – and + terminals of the op amp. Thus in the circuit above since the + terminal is at ground voltage, so is the – terminal.
OP AMP GOLDEN RULE 2: No current flows into either the + or the – terminals at the inputs of the op amp. This rule is another way of saying that the input impedance of the op amp is very large. Thus in the circuit above, since no current flows into the – terminal, the current i from Vout flows through R, then through the diode, and to ground.

It is important to realize that the current is actually created by the LED itself. The complete circuit in the op amp circuit is given by Vout through R and through the LED to ground. The current created by the LED stimulates the current from Vout through R to the – terminal.

7. Construct each circuit. You can set the negative supply voltage at pin 4 in the op amp circuit to ground, for if you connect the LED with the polarity shown it will result in a positive voltage at the output. Notice carefully the pin assignments for the op amp in Figure 3, as referenced to the notch on the top of the op amp. Use a 10 Meg Ohm resistor for R, keeping in mind that the input resistance of the voltmeter will play a central role in the circuit on the left.

A. Carefully arrange the LED so that it has the same amount of light coming in for both circuits. What voltage do you measure in each circuit? Explain the reason for any difference in each case.

B. Do you agree with the current direction in the schematic on the left in Figure 1? If that current direction is correct you should notice that the lower part of R is at a higher voltage than the upper part.

C. Consider the light source in the schematic on the left in Figure 2 to be sunlight, and consider that this sunlight is converted to current with an efficiency of 30%. Assume that the resistance R is a hair dryer that needs 1,000 Watts to operate it. Assume that the sunlight has an irradiance of 1,000 Watts per square meters (a bit large, but good enough for the thoughts needed here). How large of a solar panel (large LED in the figure on the left in Figure 2) would you need to operate the hair dryer? Considering that you would need probably 10 times that amount of power for household use on the average, during peak usage, what size solar panel would you need for your house?