Name______________________________

EET 1150 Lab 6
Ohm's Law

EQUIPMENT and COMPONENTS

Digital Multimeter
Trainer with Breadboard
Resistors: 220 Ω, 1 kΩ, 1.2 kΩ, 2.2 kΩ, 3.3 kΩ, 4.7 kΩ, 6.8 kΩ
Red light-emitting diode (LED)

In this lab you'll use Ohm's Law to predict the currents through resistors, and then you'll measure the currents to see if your predictions are correct. You'll also build a circuit that causes a light-emitting diode (LED) to blink on and off, and you'll make measurements in that circuit.

COMPONENT VALUES

Get the resistors listed in Data Table A. Double-check the resistors' nominal values by reading their color codes, and record these color codes in the table. Using the multimeter, measure each resistor's resistance, and record your values in the table. **Remember to include the correct prefixes and units, and round your values to three significant digits.**

DATA TABLE A: Component Values

Nominal Value	Color Code	Measured Value	Percentage Error
220 Ω			
1 kΩ			
1.2 kΩ			
2.2 kΩ			
3.3 kΩ			
4.7 kΩ			
6.8 kΩ			

Also compute the percentage error for each resistor, using the equation from Lab 4 (repeated below). Since we're using resistors with 5% tolerances, **all of your resistors' percentage errors should be less than 5%**.

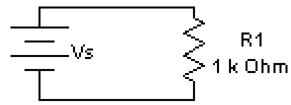
$$\text{Percentage error} = \frac{|\text{Nominal value} - \text{Measured value}|}{\text{Nominal value}} \times 100$$

OHM'S LAW

Ohm's Law says that the current through a resistor is directly proportional to the voltage across the resistor and inversely proportional to the resistor's resistance. This means that as you increase voltage, current should also increase. But as you increase resistance, current should decrease. In equation form, Ohm's Law lets you predict a resistor's current if you know its voltage drop and its resistance:

$$I = V/R$$

This equation should work for any resistor, whether it's in a very simple circuit or a very complicated circuit. Let's start by looking at the simplest possible circuit, which has a single resistor connected across a voltage source, as shown in the diagram below.



For each of the source voltages listed in the first column of Data Table B, use Ohm's Law to predict how much current will flow through a 1 kΩ resistor if that voltage is applied across it. Record your predictions in the table. Then build the circuit on a breadboard. Adjust the power supply to each of the voltages listed in Data Table B, and measure and record the current that flows. Compute and record percentage errors between your measured and predicted values, using the equation from Lab 4 (repeated below). All of your percentage errors should be less than 5%.

$$\text{Percentage error} = \frac{|\text{Predicted value} - \text{Measured value}|}{\text{Predicted value}} \times 100$$

DATA TABLE B: Current Through 1 kΩ Resistor

Voltage	Predicted Current	Measured Current	DMM Range Used	% Error
4 V				
6 V				
8 V				
10 V				
12 V				

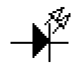
AN LED CIRCUIT

Now let's build a slightly more complicated circuit and see whether Ohm's law holds in it. This will be a series circuit that causes a light-emitting diode (LED) to light up.

Like a resistor, an LED has two terminals, or leads. But unlike a resistor, an LED's leads are not interchangeable. In other words, when you build a circuit containing an LED, the circuit will not operate correctly if you insert the LED backwards. The reason is that an LED allows current to flow in one direction only. The LED's two leads are given special names: one is called the **anode**, and the other is called the **cathode.**

If you look at your red LED, you will see that one of its leads is longer than the other. The longer lead is the anode, and the shorter lead is the cathode. Here's another way to identify which lead is which. The base of the LED's plastic "bulb" is circular most of the way around, but one side is flattened off. (It may be easier to feel this with your finger than to see it.) The lead on the flattened side is the cathode, and the other lead is the anode.

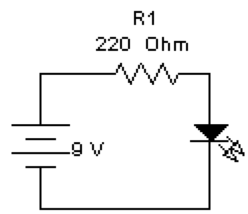
In schematic diagrams, the LED is represented by the symbol shown below.



In this symbol, the right-hand end is the cathode, and the left-hand end is the anode.

If you connect an LED to a voltage source with the anode toward the voltage source's positive terminal and the cathode toward the negative terminal, then current will flow. But if you reverse the connections, current will **not** flow.

Let's see that this is true. Build the circuit shown below. **Note: the resistor plays a very important role here; it limits the current to a value that will not burn out the LED. If you connect the LED directly across the terminals of the voltage source, you will ruin the LED.**



Review Question

1. In this diagram, which of the LED's leads (anode or cathode) is connected to the voltage source's negative terminal?

If you built the circuit correctly, the LED should light up. Use a multimeter to measure the current flowing through the resistor, and record the value in the first row of Data Table C below.

Next, since we know the resistor's resistance and its current, we should be able to use Ohm's Law to predict its voltage. The form of Ohm's Law that we want is:

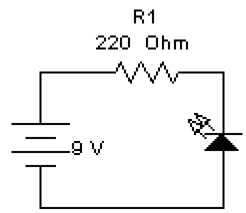
$$V = I \times R$$

Use this equation to predict the resistor's voltage, and enter your prediction in the data table. Then measure the voltage and compute the percentage error between your predicted and measured values. The error should be less than 5%.

Data Table C: LED Cathode Connected to Negative Terminal

Quantity	Predicted Value	Measured Value	% Error
Resistor current			
Resistor voltage			

Now turn the LED around. In other words, build the circuit shown below:



Review Question

2. In this diagram, which of the LED's leads (anode or cathode) is connected to the voltage source's negative terminal?

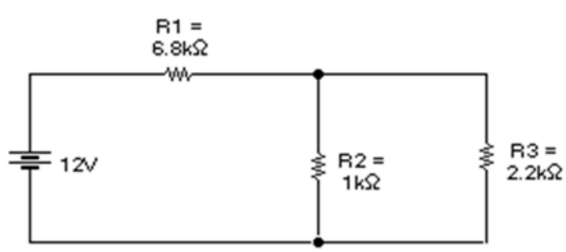
In this circuit, the LED should **not** light up. Measure the current flowing through the resistor, and record the value in the first row of Data Table D. As you did before, use Ohm's Law to predict the resistor's voltage, and then use the multimeter to measure this voltage.

Data Table D: LED Anode Connected to Negative Terminal

Quantity	Predicted Value	Measured Value
Resistor current		
Resistor voltage		

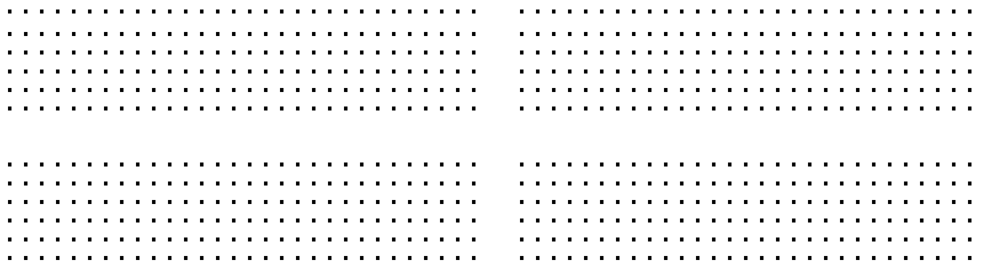
A SERIES-PARALLEL CIRCUIT

Now let's see whether Ohm's Law holds in more complicated circuits. Look at the schematic diagram below. It shows a series-parallel circuit containing three resistors and a power supply. In this circuit, the power supply is in series with resistor R_1, while R_2 and R_3 are in parallel with each other. So we do indeed have a combination of series components and parallel components.



It's important to be able to go from a schematic diagram to an actual layout of components on a breadboard. This can be difficult, because in many cases the actual circuit on the breadboard may not look much like the schematic diagram.

On the blank breadboard diagram below (top of next page), draw resistors (**in pencil)** showing how to build this circuit. Label the resistors as R1, R2, and R3. Also show the points where the + and – terminals of the power supply attach to the circuit.



Compare the two diagrams—the schematic diagram and your breadboard diagram—until you are convinced that they do in fact match each other. When you are convinced that they match, build the circuit in the Multisim program. As indicated in Data Table E (below), use Multisim to find the predicted values of R_T, V_1, V_2, V_3, and I_T. (Remember that R_T is the total resistance of the circuit, with the voltage source removed from the circuit, and I_T is the total current flowing through the voltage source.)

Then use Ohm's Law to predict the currents through the three resistors. (For example, to predict I_1, you divide your predicted value of V_1 by the resistance of resistor R_1.) If you wish, you can also use Multisim to double-check these three predicted currents.

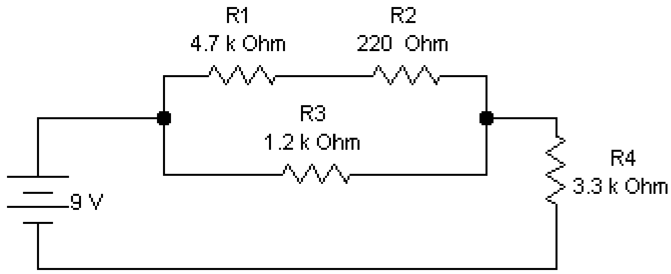
Then build the actual circuit on a breadboard, and measure the quantities. As always, be sure to **use the best range on the multimeter**, round all values to **three significant digits**, and include **units** with your values. Compute percentage errors, which should all be less than 5%.

Data Table E: A Series-Parallel Circuit

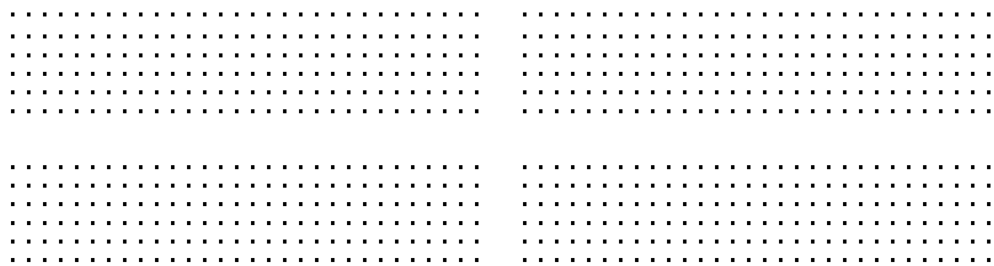
Quantity	Predicted Value	Measured Value	DMM Range Used	% Error
R_T	(Multisim)			
V_1	(Multisim)			
V_2	(Multisim)			
V_3	(Multisim)			
I_T	(Multisim)			
I_1	(Ohm's Law)			
I_2	(Ohm's Law)			
I_3	(Ohm's Law)			

ANOTHER SERIES-PARALLEL CIRCUIT

Below is the schematic diagram of another series-parallel circuit.



Draw resistors (**in pencil)** showing how to build this circuit. Label the resistors as R1, R2, and R3. Also show where the + and – terminals of the power supply attach to the circuit.



Study the two diagrams until you are sure that they match each other.

As indicated in Data Table F (below), use Multisim to find the predicted values of R_T, I_1, I_2, I_3, and I_T. Then use Ohm's Law to predict the voltages across the three resistors. Then build the circuit on a breadboard and measure the quantities. **Use the best DMM range**, round to **three significant digits**, and include **units**. Percentage errors should be less than 5%.

Data Table F: Series-Parallel Circuit #2

Quantity	Predicted Value	Measured Value	DMM Range Used	% Error
R_T	(Multisim)			
I_T	(Multisim)			
I_1	(Multisim)			
I_2	(Multisim)			
I_3	(Multisim)			
I_4	(Multisim)			
V_1	(Ohm's Law)			
V_2	(Ohm's Law)			
V_3	(Ohm's Law)			
V_4	(Ohm's Law)			

REVIEW QUESTIONS For all questions, show your calculation, round your answer to three significant digits, and express your answer in engineering notation using metric prefixes.

1. Suppose a current of 735 μA flows through a resistor with a voltage drop of 500 mV. What is the resistor's resistance?

2. Suppose a resistor has a resistance of 3.3 kΩ and a voltage drop of 15.3 V. How much current flows through the resistor?

3. Suppose a current of 1.55 mA flows through a resistor with color code red-violet-red. How much voltage would you expect to measure across the resistor?

4. If the resistor in the previous question has a gold tolerance band, what is the **largest** voltage that you could measure across the resistor if the resistor is within its tolerance range?

5. For the same resistor, what is the **smallest** voltage that you could measure across the resistor if the resistor is within its tolerance range?

*****END OF LAB 4*****