Introduction

The purpose of this lab is to test whether several conductors act as Ohmic or Non-Ohmic conductors. We will test a 1 kΩ resistor, 33 Ω resistor, 6.3 V light bulb, and a Light Emitting Diode (LED). The ohm (Ω) is the SI unit of electrical resistance, named after German physicist Georg Simon Ohm who discovered that certain resistors have a constant value for resistance and exhibit a linear proportion to voltage ([V] measured in Volts) divided by the current ([i] measured in Amperes), expressed as:

$$R = \frac{V}{i}$$

In order to accomplish this, we will be using a power supply (preferably current limiting), 1 kΩ resistor, 33 Ω resistor, 6.3 V light bulb, LED, breadboard, wires, and two digital multimeters to measure the current and voltage.

By hooking the conductors up to a circuit and measuring voltage and current, we can test their resistances. We predict that the two resistors will act as Ohmic conductors and the two bulbs will act as Non-Ohmic conductors

Procedure

Part 1A: 1kΩ Resistor

First, we assembled a simple circuit on the breadboard using the 1 kΩ resistor connected to two digital multimeters. Then we measured our theoretical resistance through the circuit using the multimeter's resistance reader. After setting the multimeters to measure both current and voltage, we adjusted the power supply so that the voltage across the resistor is about 1.0 V and measured the current. We then proceeded to increment the voltage in intervals of 1.0 V until we reached 10.0 V, measuring the current each time. When we reached 10 V, we observed the current for roughly 30 seconds and noticed no change in current. This tells us that there was no significant change in temperature or the resistance would have changed (1A.d). We also tried changing the polarity of the resistor by swapping the potential difference but observed no change (1A.e).

Part 1B: 33 Ω Resistor

For Part 1B, we swapped out our 1 kΩ resistor with a 33 Ω resistor and measured the theoretical resistance. Then we measured current by starting our voltage on 0.5 V and used increments of only 0.5 V until we reached 3.0 V. We observed the current at 3.0 V for roughly 30 seconds and noticed a decrease in current as the resistor heated up (1B.d). After allowing the resistor to heat up, we reduced the voltage down to 1.0 V and measured the current a second time and found a different value. We will discuss this in our conclusion.

Part 2A: 6.3 V Light Bulb

For Part 2A, we swapped out our 33 Ω resistor with a 6.3 V light bulb and measured our theoretical resistance. We started our current measurements at 0.5 V and incremented it another 0.5 V and attempted to reach 5.0 V. Before increasing the voltage we limited our current through the power supply but still managed to burn a fuse during the experiment. We recommend that you be very careful when increasing the voltage across a multimeter with a small amount of resistance. We only managed to make it to 3.5 V before the fuse burned.

Part 2B: Light Emitting Diode (LED)

For Part 2B, we swapped out our 6.3 V light bulb with an LED and a 1 kΩ resistor in series. We began by increasing the voltage to about 1.75 V and observed our current to be 0.11 Amps (2B.b). We then switched the polarity of the LED and noticed that current was not flowing through the new schema (2B.c). After correcting the polarity of the LED, we adjusted the voltage to 1.5 V and incremented it by 0.05 V and measured the current until we reached 2.0 V. For our LED, we measured the turn-on voltage to be roughly 1.75 V (2B.f).

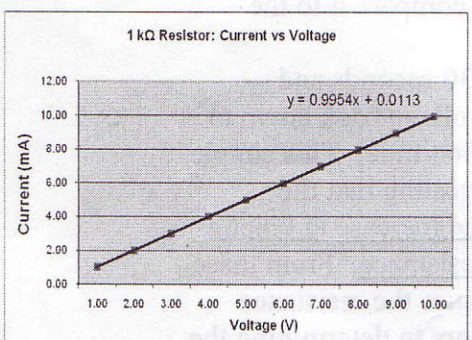
Data

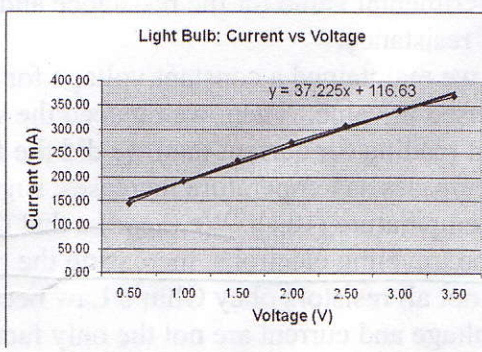
Resistor	Voltage (V)	Current (mA)	Resistance (Ω)	Theoretical Value (Ω)	
	1.00	1.01	990.10		1006.0
	2.00	2.00	1000.00		
	3.00	3.00	1000.00	Experimental Value (Ω)	
	4.00	3.99	1002.51		1004.6
1 kΩ	5.00	4.99	1002.00		
	6.00	5.98	1003.51	Percent Error (%)	
	7.00	6.98	1002.87		0.14
	8.00	7.97	1003.76		
	9.00	8.97	1003.34		
	10.00	9.97	1003.01		

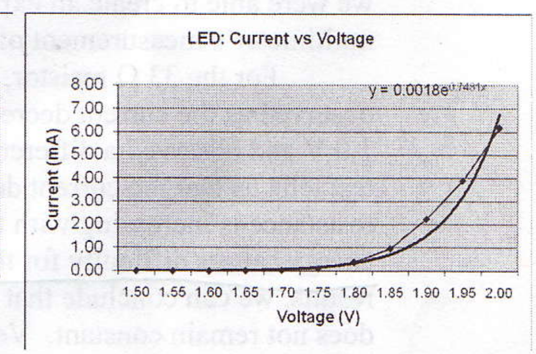
Resistor	Voltage (V)	Current (mA)	Resistance (Ω)	Theoretical Value (Ω)	
	0.50	14.68	33.99		34.4
	1.00	29.42	33.99		
33 Ω	1.50	44.15	34.02		
	2.00	58.73	34.05		
	2.50	73.30	34.11		
	3.00	87.80	34.17		

Conductor	Voltage (V)	Current (mA)	Resistance (Ω)	Theoretical Value (Ω)	
	0.50	143.90	3.47		1.3
	1.00	191.90	5.21		
	1.50	234.50	6.40	Experimental Value (Ω)	
Light Bulb	2.00	272.80	7.33		26.9
	2.50	307.60	8.13		
	3.00	339.30	8.84		
	3.50	368.70	9.49		

Conductor	Voltage (V)	Current (mA)	Resistance (kΩ)
	1.50	0.01	150.00
	1.55	0.01	155.00
	1.60	0.01	160.00
	1.65	0.02	82.50
	1.70	0.04	42.50
L.E.D.	1.75	0.11	15.91
	1.80	0.39	4.62
	1.85	0.98	1.89
	1.90	2.24	0.85
	1.95	3.90	0.50
	2.00	6.18	0.32







Data Analysis

In order to calculate the resistance, we used our measured voltage and current and solving for resistance with Ohm's Law.

$$R = \frac{V}{i} \rightarrow R[\Omega] = \frac{V[V]}{i[A]} \rightarrow R = \left(\frac{4.00V}{3.99mA}\right) x \left(\frac{1000mA}{1A}\right) = 1002.51\Omega$$

To calculate our experimental value of resistance, we took the slope of our Current vs Voltage graph and converted it into Ohms.

$$m = \frac{[mA]}{[V]} \rightarrow \Omega = \frac{[V]}{[A]} \rightarrow R = \frac{1}{(m)\,x\,\frac{(1A)}{(1000mA)}} \longrightarrow R = \frac{1}{(.995\,{}^{mA}\!/_{V})\,x\,\frac{(1A)}{(1000mA)}} = 1004.6\Omega$$

To test the difference between our theoretical resistance and our experimental resistance, we used the percent error equation.

$$PercentError = \left(\frac{Theoretical - Experimental}{Theoretical}\right) x(100\%) \longrightarrow PercentError = \left(\frac{1006.0\Omega - 1004.6\Omega}{1006.0\Omega}\right) x(100\%) = 0.14\%$$

Based on our results for the both resistors, we can assume they are Ohmic resistors because they had relatively constant values for resistance (1A.f). On the other hand, both the light bulb and the LED appeared to be Non-Ohmic because the resistance varied as we changed the voltage (2B.g). These results support our predictions with only a small amount of error. We propose that the limited accuracy of the digital multimeters, the resistance of the wire, and the temperature of the system contributed to our error.

Discussion/Conclusion

In the experiment, we created simple circuits to test the resistance of 4 conductors and discover whether they exhibited Ohmic or Non-Ohmic behaviors. For each circuit, we measured the theoretical resistance by using the multimeter and created a Current vs. Voltage graph by measuring the current at increasing values of voltage. By doing this, we were able to create an experimental value for the resistance and compare it to the multimeter's measurement of resistance.

For the 33 Ω resistor, we maintained a constant voltage for 30 seconds and observed as the current decreased in value. Then, we reduced the voltage back down to 1.0 V and observed a different reading for current than we did the first time. This simple test tells us that the current decreases as temperature increases, suggesting that the resistance is increasing with temperature (1B.e). We theorize that the increase in kinetic energy causes difficulty for the traveling electrons, increasing the resistance. From these results, we can conclude that not all resistors obey Ohm's Law because the resistance does not remain constant. Voltage and current are not the only factors in determining the resistance if the temperature rises above a certain value. However, if the temperature is moderate, we can use Ohm's Law for a reasonable calculation (1B.f).

For the light bulb, we observed a change in resistance for every change in voltage. Because of this, we could immediately tell the light bulb was Non-Ohmic. The filament in the light bulb does not have a constant resistance because it is heating up to extreme temperatures to emit heat and light into its surroundings (2A.d).

As a result of the experiment, we were able to prove our predictions. The resistors acted as Ohmic conductors (for moderate temperatures) while the light bulb and LED acted as Non-Ohmic conductors. The only problem we encountered was the burnt fuse while measuring the light bulb, which we could improve by limiting the current even lower. As far as our calculation errors, we expected that it was effected by the multimeter accuracy, the resistance in the wire, and the temperature of the system. Overall, Ohm's Law was proven to work for the resistors at moderate temperatures but not for all conductors.

sounds ~~like~~ similar to arithmetic errors, try error calculations or calculation of error.