Introduction:

The objective of the lab was to compare the attributes of several conductors, and to determine their properties. Ohm's law was used to determine the resistance of each circuit component and to confirm whether each was ohmic or non-ohmic. Ohmic resistors had a constant value for resistance regardless of the potential difference applied across the circuit, while non-ohmic resistors have a resistance that changes based on the voltage across it. Current (***i***, in units of Amperes), potential difference or voltage (**V** in units of Volts), and resistance (**R**, in units of Ohms) can be related to one another by the equation **V=*i*R**. The values for resistance were determined mathematically and graphically while current and voltage were found using digital multimeters. The slopes of the current vs voltage graphs can be used as a way to determine the behavior of the resistance value of the various components. The value for resistance is inversely proportional to the slope of each graph.

It was predicted that the 1KΩ and 22Ω resistor would behave ohmically, and the lightbulb and LED would be non-ohmic. This prediction was made based on the assumption that the resistors being designed for the purpose of having a known resistance would behave predictably, whereas the lightbulb and LED would likely behave differently.

Procedure:

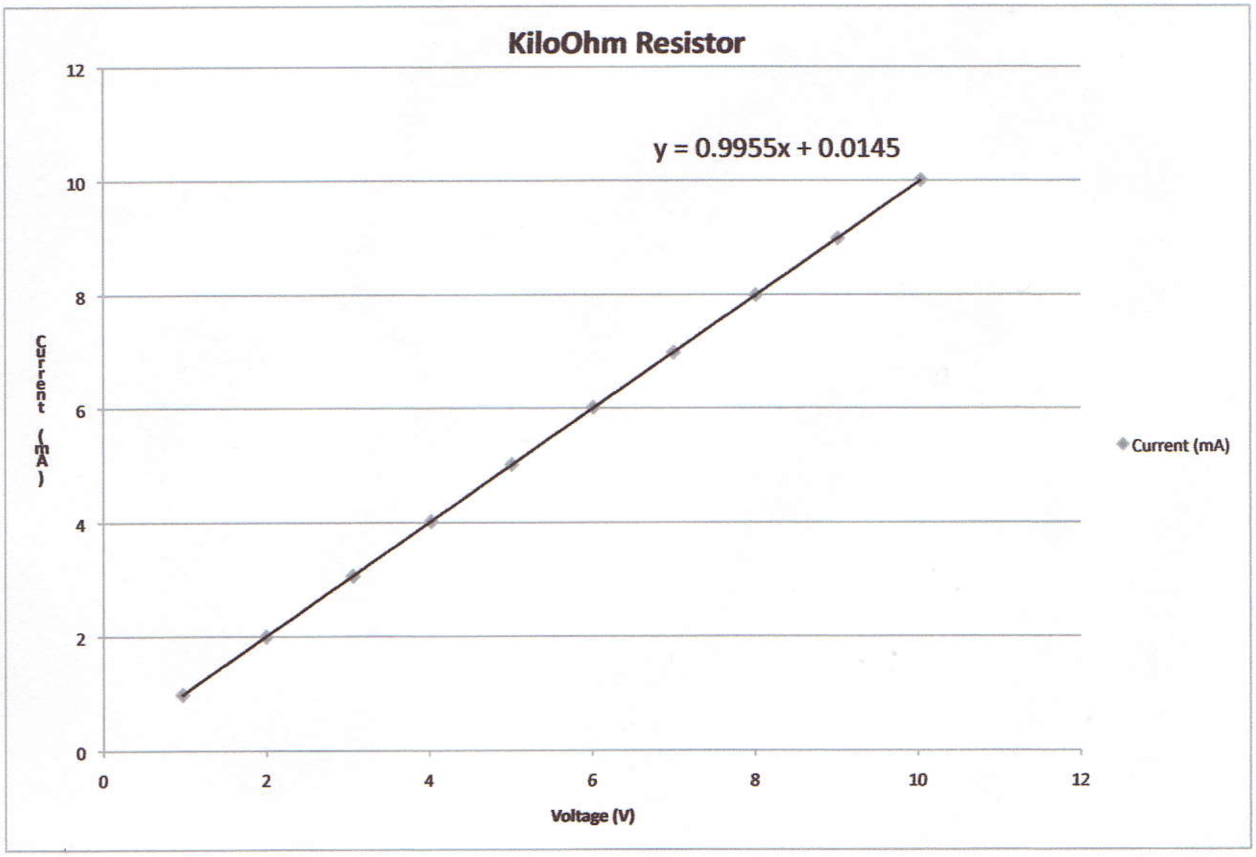
The circuits for each section of the lab consisted of a power supply with adjustable voltage linked to various circuit components with insulated copper wires. Four different components were used as resistors throughout the lab, including a 1KΩ resistor, a 22Ω resistor, a 6.3V light bulb, and a diode. The two resistors were wired in using a breadboard, while the bulb and the diode were linked directly to the wires. The multimeter set up to measure current was inserted into the circuit in series with the resistor, and the multimeter measuring voltage was hooked into the breadboard in such a way that it was in parallel with the resistor.

The current through each "resistor" was recorded for various voltages. The 1K Ω resistor's values were measured at 1V increments, while the 22 Ω resistor's and lightbulb's values were recorded at 0.5V intervals. The current through the LED was recorded at a variety of voltages both to determine the potential difference required to turn it on, as well as the changes in its resistance based on varying current and voltage values. Current vs. voltage graphs (voltage on the x-axis, current on the y) were plotted for each circuit element to determine the behavior of the components.

Data:

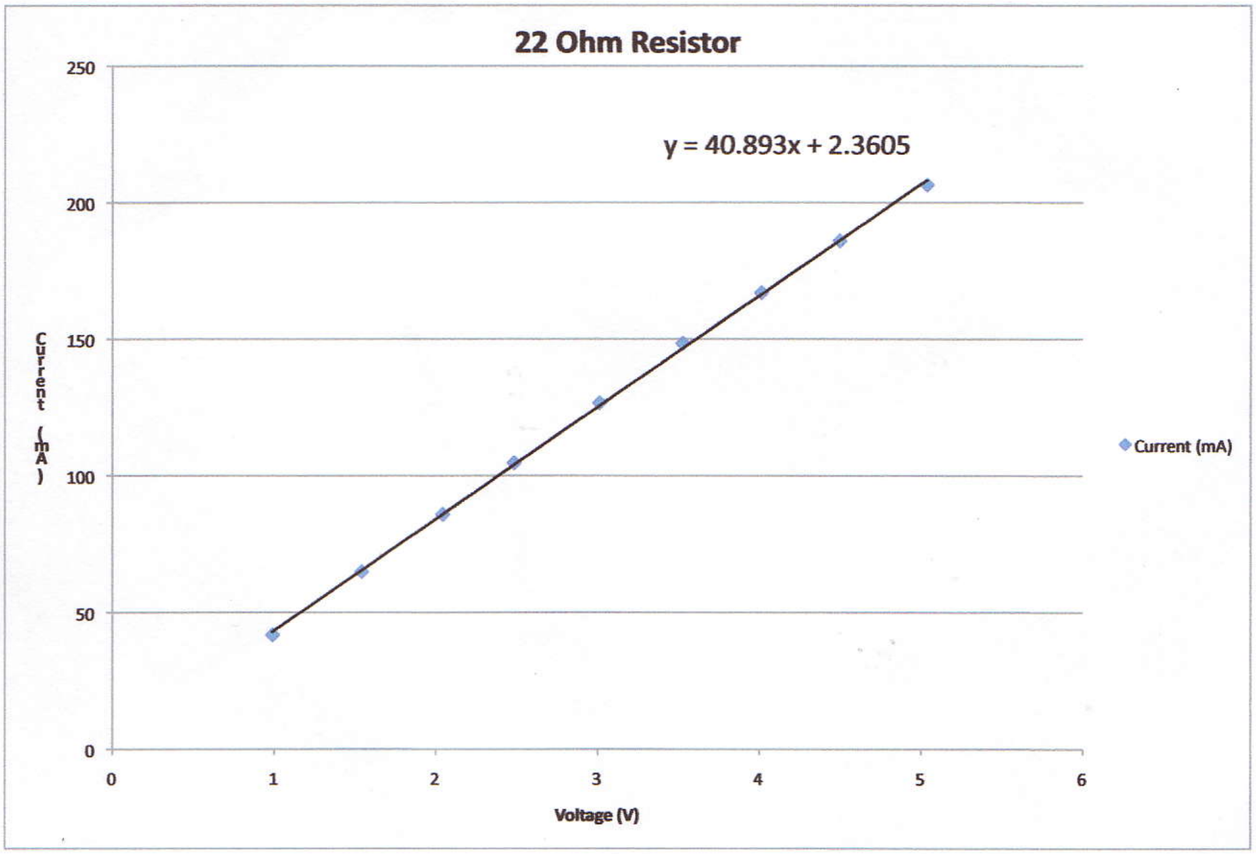
KiloOhm Resistor

Voltage (V)	Current (mA)	Expected Current (mA)	Percent Difference
0.968	0.98	0.968	1.24%
1.996	2	1.996	0.20%
3.064	3.06	3.064	0.13%
4.025	4.02	4.025	0.12%
5.014	5.01	5.014	0.08%
6.015	6.01	6.015	0.08%
7	6.98	7	0.29%
8.01	7.99	8.01	0.25%
9.02	8.99	9.02	0.33%
10.04	10.01	10.04	0.30%



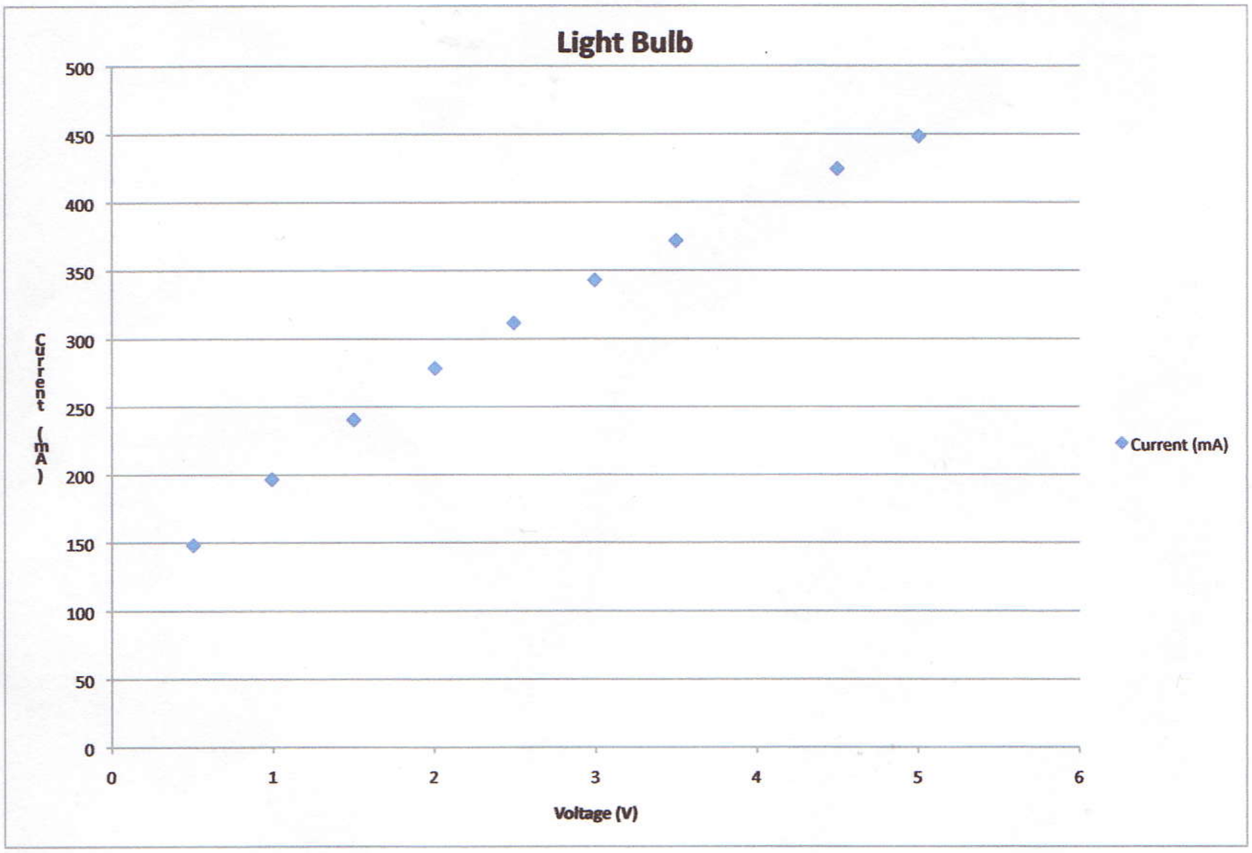
22 Ohm Resistor

Voltage (V)	Current (mA)	Expected Current (mA)	Percent Difference
0.991	41.7	45.05	7.43%
1.542	64.92	70.09	7.38%
2.044	85.9	92.91	7.54%
2.485	104.6	112.95	7.40%
3.012	126.5	136.91	7.60%
3.527	148.4	160.32	7.43%
4.013	167	182.41	8.45%
4.497	186	204.41	9.01%
5.037	206.4	228.95	9.85%
After Heat			
1.026	33.77		



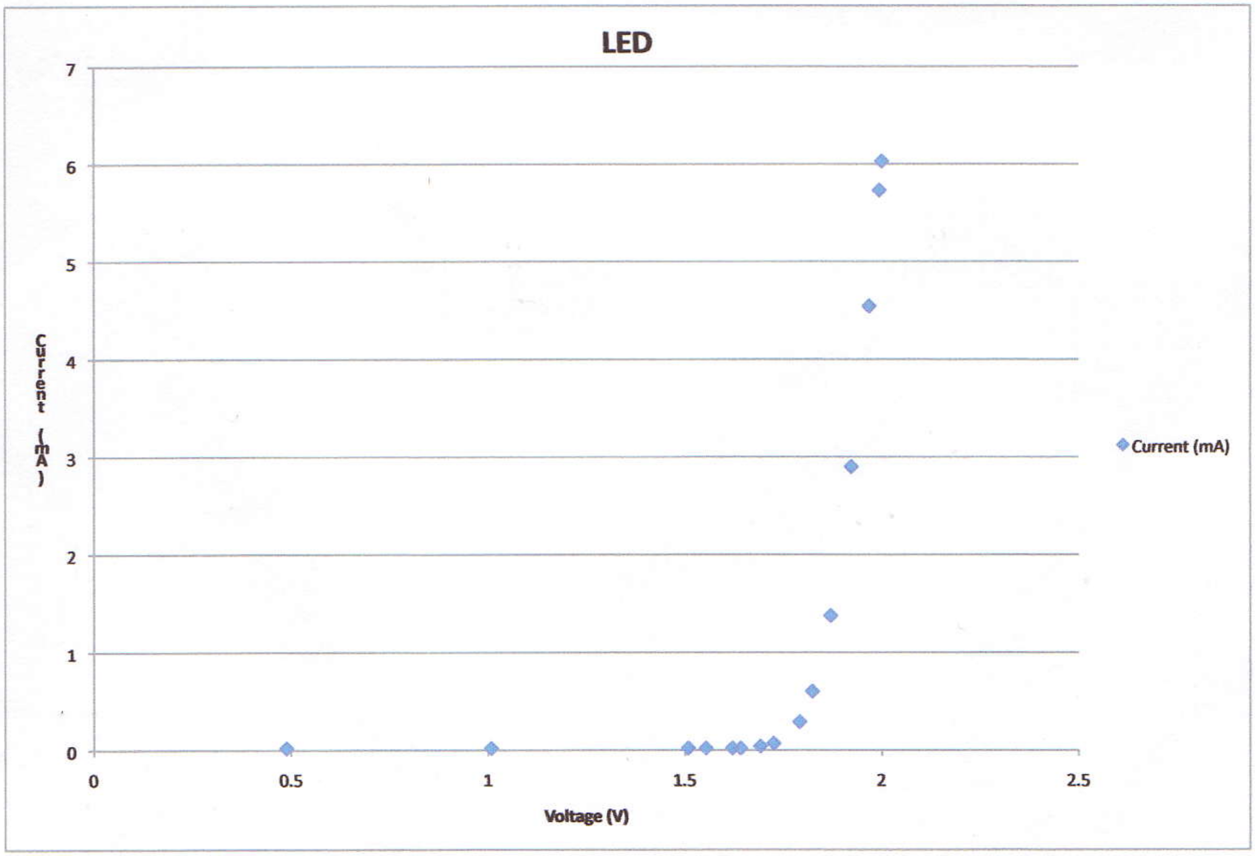
Lightbulb

Voltage (V)	Current (mA)
0.504	148.1
0.992	196.6
1.499	240.4
2.004	278.4
2.492	311.5
2.994	342.7
3.498	371.8
4.497	424.5
5.002	448.5



LED

Voltage (V)	Current (mA)
0.488	0.02
1.008	0.02
1.508	0.02
1.553	0.02
1.641	0.02
1.62	0.02
1.691	0.04
1.725	0.07
1.791	0.29
1.823	0.6
1.87	1.38
1.922	2.9
1.968	4.54
1.994	5.73
2	6.03



Data Analysis/Discussion:

Sample Calculations:

$$\text{Percent Difference} = \frac{\text{Theoretical} - \text{Experimental}}{\text{Theoretical}}(100\%) = \frac{.968A - .98A}{.98A}(100\%) = 7.43\%$$

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

$$\text{Slope of graphs} = \frac{\text{rise}}{\text{run}} = \frac{i}{V} = 1/R$$ → So Resistance is inversely proportional to the slope.

1KΩ Resistor:

The graph for the 1KΩ resistor indicates that it is ohmic, as it has the same resistance regardless of the voltage across it (resistance can be found through calculation, or by looking at the slope of the graph). When the voltage across the resistor was left at 10V for 30 seconds the current did not change, which indicates that there was not a significant increase in temperature, and that its resistance was unchanged. When the direction of the resistor was reversed there was no change in the behavior of the circuit, so we can assume that the polarity of the resistor does not effect its resistance.

22 Ω Resistor:

The 22 Ω resistor is also ohmic as its graph had a constant slope as well, indicating that its resistance remained reasonably constant. When the potential difference was increased to 10V for 30s the current through the resistor decreased over time, indicating that there was an increase in temperature within the resistor significant enough to increase its resistance. When the voltage was reduced to 1V the value did not agree with the previous one found because the resistor was still much hotter than it was previously, so it still had an increased resistance value. It cannot be determined that all resistors are ohmic all the time, however it would be reasonable to assume that resistors are ohmic as long as they remain at a constant temperature.

Lightbulb:

Judging by the lightbulb's graph, it is not ohmic, as the slope decreased dramatically, indicating that the resistance increased by a significant amount as the voltage increased. This was likely due to a dramatic increase in heat, which is known to increase resistance.

Light Emitting Diode (LED):

The LED only allows current to flow when the voltage across it has the correct polarity. Initially, there was no current flowing through it, as it was wired in the incorrect direction, but once it was reversed, current was allowed to flow. Additionally, the LED required a specific potential difference across it before it would allow the flow of current, which was determined to be somewhere around 1.69V. The diode was not ohmic, as the slope of its graph increased over time, indicating that its resistance was dropping as the voltage was increased.

Conclusion:

We can conclude that the hypotheses were confirmed, as the 1kΩ and 22Ω resistor were determined to be ohmic, while the lightbulb and LED were confirmed to be non-ohmic. Although the 22Ω resistor's resistance changed when its temperature increased significantly, it can still be considered ohmic as it has a constant value of resistance within a reasonable range of voltages. The 1kΩ resistor remained at a constant resistance even at a potential difference of 10V, indicating that it is designed to handle much larger voltages and would require a very large voltage to cause it to have a large increase in heat. From our experience we can also assume that standard resistors remain at constant resistance while at constant temperature. This may also be true for the lightbulb, however its current would have to be measured under various voltages while keeping its filament at a constant temperature to confirm it experimentally. The bulb was determined to be non-ohmic because its resistance changed by a experimentally significant amount every time the voltage was adjusted. Currently we don't have the background knowledge to explain the behavior of the LED, however we do now know that it only allows current to flow in one direction, and has a minimum voltage requirement to before current begins to flow. The diode also had decreased resistance as we increased the voltage across it, or reasons we do not have the knowledge to explain at this time. Aside from the effects of temperature there were no significant discrepancies in our data, and while it seems likely that there were errors that came from the nature of the setup, such as the resistance of the wires, and any error from the multimeters, these would have been the same for all portions of the lab making them have very little effect on our overall conclusions.