Pylab 2 - Voltage and Current through a Resistor and Potentiometer

Chris Compierchio

October 9, 2020

Abstract:

The purpose of this lab was to find the resistance across a resistor and a potentiometer using wires, a breadboard, and two multimeters. The resistances of the resistor and potentiometer were both measured and calculated and then compared for analysis. It turns out the calculations performed were very accurate compared to the measurements taken.

Introduction:

The resistance across a resistor and a potentiometer were both measured using a multimeter and then calculated using Ohm's Law ($I = (1/R)V$) as well as the curvefit() function in python. The calculated and measured resistance values were compared for analysis in order to investigate the accuracy of Ohm's Law.

Equipment:

- Two Multimeters - used to measure current, voltage, and resistance.
- Breadboard - used to add the loads to the circuit
- Wires - used to build the circuit
- Power Supply - used to supply power to the circuit

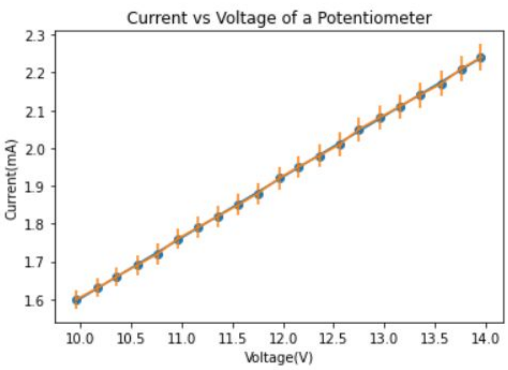
Using the equipment listed above, a circuit connecting the power supply and the resistor/potentiometer was constructed in series. One multimeter was connected in series to measure current and the other was connected parallel to the loads to measure voltage.

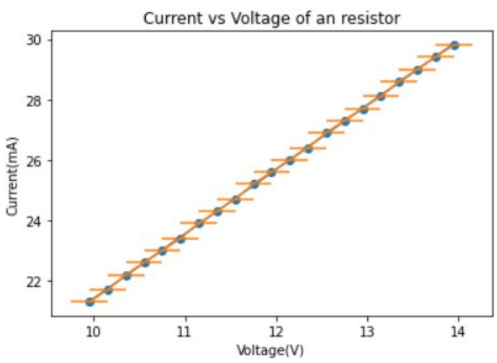
Procedure:

The first step was to set up the circuit. This was done exactly how it was described in the 'Equipment' section. Next, the voltage was changed from a starting value of 10.000V to 14.000V using increments of 0.200V. Each voltage was measured and each corresponding current was also measured and recorded in a table along with their uncertainties (See Appendix A). Once the experiment was complete, the resistance was measured across the resistor and potentiometer to get a theoretical value to compare the results. These values were then loaded into a python program where they were plotted with a curvefit() function and error bars. These values were also used to calculate the average resistance and the chi-squared values for both the resistor and the potentiometer (see Results).

Results:

As mentioned in the process above, several voltage and current readings were recorded in order to plot the following graphs:





The plots above show the expected linear relationship between current and voltage.

From the slope of the graphs, the resistance of the potentiometer and the resistor were both calculated using the slope from the Ohm's Law equation (see Introduction):

$$m = \frac{1}{R_r} \Rightarrow R_r = \frac{1}{m} = \frac{1}{2.1 \pm 0.2} = 0.47k\Omega \pm 0.04k\Omega$$

$$m = \frac{1}{R_p} \Rightarrow R_p = \frac{1}{m} = \frac{1}{0.16 \pm 0.03} = 6.21k\Omega \pm 0.03k\Omega$$

The chi-squared value was then calculated for the resistor and potentiometer values using the following formula:

$$\chi^2 = \frac{1}{N-n} \sum_{i=1}^{N} \left(\frac{y_i - y(x_i)}{\sigma_i}\right)^2$$

Where: N = number of observation
n = number of parameters
y_i = current values
x_i = voltage values
σ_i = the error in the current values

The resulting values for chi-squared were 0.023 for the resistor and 0.063 for the potentiometer.

<u>Discussion:</u>

As expected both resistance values that were calculated were within the range of the measured values of $0.466k\Omega \pm 0.001k\Omega$ for the resistor and $6.22k\Omega \pm 0.01k\Omega$ for the potentiometer. With the results as accurate as they are, there are still some errors to analyze.

One important thing to note is the discrepancy between the power supply reading and the multimeter readings for voltage. The voltage reading on the power supply was always about 0.05mA above the reading on the multimeter used for voltage. This leaves a gap in the accuracy of the readings on top of the 0.75% error already provided with the power supply. The power supply also had an error of 0.25% per current reading[1].

Both the wires and the breadboard were also not "ideal" meaning that they do not conserve all of the electrical energy being supplied. Without getting into too much detail, the electrical energy is directly proportional to both current and voltage and due to energy being lost to heat, this could cause some error in terms of current and voltage measurements.

In terms of the chi-squared values, both were very small. A good chi-squared value is around 1 and since the values recorded were far less than 1, this means the data was almost too perfect and therefore the results were a lot more accurate than they should have been. This, of course, could be due to the error readings on the equipment. The manufacturer of the power supply gave an error of 0.75% and 0.25% for voltage and current

---

[1] *MULTIMETER (Digital)*, faraday.physics.utoronto.ca/specs/tegam130a.html.

respectively. My results suggest that these given values may have been too large for my specific power supply and therefore my results came out to be more accurate than they should have been.

Conclusion:

As expected, Ohm's Law turned out to be very accurate for the calculated resistance values when compared to the measure values.

Appendix A:

Measurements for Resistor		Measurements for Potentiometer	
Voltage(V)	Current(mA)	Voltage(V)	Current(mA)
9.95 ± 0.03	21.3 ± 0.2	9.96 ± 0.03	1.6 ± 0.01
10.15 ± 0.03	21.7 ± 0.2	10.17 ± 0.03	1.63 ± 0.01
10.35 ± 0.03	22.2 ± 0.2	10.36 ± 0.03	1.66 ± 0.01
10.55 ± 0.03	22.6 ± 0.2	10.56 ± 0.03	1.69 ± 0.01
10.75 ± 0.03	23.0 ± 0.2	10.76 ± 0.03	1.72 ± 0.01
10.95 ± 0.03	23.4 ± 0.2	10.96 ± 0.03	1.76 ± 0.01
11.15 ± 0.03	23.9 ± 0.2	11.16 ± 0.03	1.79 ± 0.01
11.35 ± 0.03	24.3 ± 0.2	11.36 ± 0.03	1.82 ± 0.01
11.55 ± 0.03	24.7 ± 0.2	11.56 ± 0.03	1.85 ± 0.01
11.75 ± 0.03	25.2 ± 0.2	11.75 ± 0.03	1.88 ± 0.01
11.95 ± 0.03	25.6 ± 0.2	11.96 ± 0.03	1.92 ± 0.01
12.15 ± 0.03	26.0 ± 0.2	12.15 ± 0.03	1.95 ± 0.01
12.35 ± 0.03	26.4 ± 0.2	12.36 ± 0.03	1.98 ± 0.01
12.55 ± 0.03	26.9 ± 0.2	12.56 ± 0.03	2.01 ± 0.02
12.75 ± 0.03	27.3 ± 0.2	12.75 ± 0.03	2.05 ± 0.02
12.95 ± 0.03	27.7 ± 0.2	12.95 ± 0.03	2.08 ± 0.02
13.15 ± 0.03	28.1 ± 0.2	13.15 ± 0.03	2.11 ± 0.02
13.35 ± 0.03	28.6 ± 0.2	13.35 ± 0.03	2.14 ± 0.02
13.55 ± 0.03	29.0 ± 0.2	13.56 ± 0.03	2.17 ± 0.02
13.75 ± 0.03	29.4 ± 0.2	13.76 ± 0.03	2.21 ± 0.02
13.95 ± 0.03	29.8 ± 0.2	13.95 ± 0.03	2.24 ± 0.02

References:

[1] *MULTIMETER (Digital), faraday.physics.utoronto.ca/specs/tegam130a.html.*

Questions

1. My linear fit did not pass through zero since my initial current (y-intercept) was not zero.
2. If forced through zero, my line of best fit still goes through the points as expected, however, my points become bunched up as they are much greater than zero.
3. For the resistor, the curvefit() function gave a value of $0.47k\Omega \pm 0.04k\Omega$ which agrees with the measured $0.466k\Omega \pm 0.001k\Omega$. For the potentiometer the function gave a value of $6.21k\Omega \pm 0.03k\Omega$ which agrees with the measured $6.22k\Omega \pm 0.01k\Omega$.
4. The chi-squared values calculated were about 0.023 and 0.063 for the resistor and potentiometer respectively. Both of these values are much less than 1 which tells me that my model is an over-fit. This is further explained in the discussion portion of the lab.