Rediscovering Ohm's Law

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Abstract: The relationship between the voltage (V) applied across a resistor (R) and the current (I) that flows through it is known as Ohm's law, and in this experiment we attempted to characterize it. We used a simple setup - a single resistor with a voltage applied across it by a DC power supply. The data showed a linear relationship between voltage and current, corresponding to the equation $V = kI$, with k=1 Ω.

Introduction

In this experiment, we examined how the current flowing through a resistor varies with the voltage applied across it. Current is defined as the rate of flow of charge per unit time, and the voltage applied is just the change in potential energy per unit charge between the two electrodes. Intuitively, we expected the current to increase with the voltage applied, but we wanted to precisely quantify this relationship.

Theory

In many cases, physical phenomena obey 'power laws'. We assume that Ohm's law is one such power law, and try to determine its form. We first plotted the raw data of current (I) vs. voltage (V) to see what the data looked like and whether there were any obvious trends, and then plotted a graph of ln(I) vs. ln(V) to determine the form of the power law connecting V and I. If a quantity $y(x)$ obeys the power law

$$y = ax^b$$

then taking the natural logarithm on both sides gives us

$$\ln(y) = \ln(a) + b\ln(x)$$

plotting $\ln(y)$ on the y-axis and $\ln(x)$ on the x-axis gives us the value of a and b from the y-intercept and the slope of the graph, respectively.

$$a = e^{(y\text{-intercept})}$$
$$b = slope$$

from which we can determine the form of the equation that describes the variable y as a function of the variable x.

Experimental Setup

Our experimental setup consists of a single 1-ohm resistor across which we applied a steady voltage using a DC power supply. The voltage applied and the current flowing through the resistor were displayed on the built-in voltmeter and ammeter on the power supply. We increased the voltage in 1 V increments and recorded pairs of current and voltage.

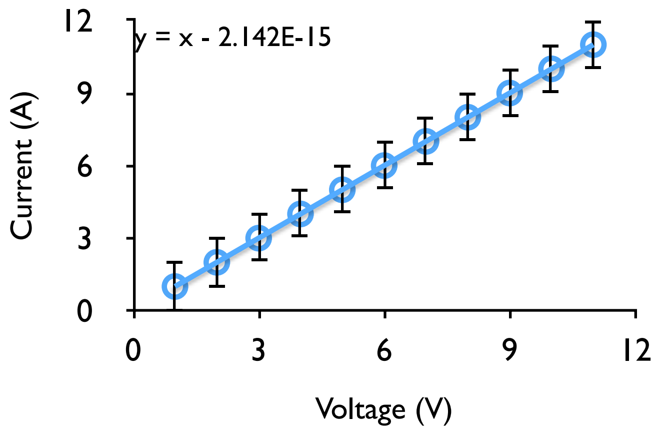

Fig. 1: Graph of Current vs Voltage. We see a linear relationship.

Results

Plotting the raw data of voltage vs current (Fig. 1), we see a fairly linear relationship, we can see that there is at first glance a linear relationship between voltage and current. To confirm this, we made a log-log plot as well, and saw that indeed, the slope of the graph is to a very good approximation, so the current is linearly proportional to the voltage applied. From the current vs voltage graph, we deduce that the form of Ohm's law is

$$V = kI$$

with the proportionality constant $k = 1\ \Omega$.

Conclusion

In conclusion, we see that there appears to be a linear relationship between the current flowing through a resistor and the voltage applied across it. The proportionality constant k is $1\ \Omega$, which is the value of the resistance of our resistor. It is possible that this is not an accident, and the proportionality constant depends on the resistance. This could be a potentially fruitful avenue of investigation - we could use different resistors and find out what the

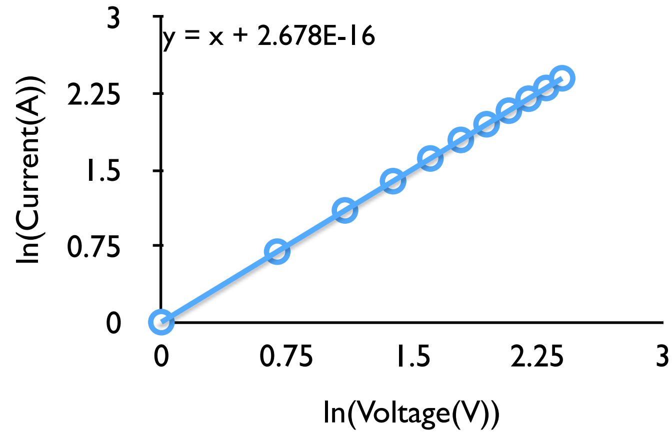

Fig. 2: log-log graph of Current vs Voltage. We see a linear trend with a slope of 1.

Table 1: Raw data of current vs voltage

Voltage (V)	Current (A)
1	1
2	2
3	3
4	4
5	5
6	6
7	7
8	8
9	9
10	10
11	11

relationship between the proportionality constant and the resistance is.

References

Physics 141 Laboratory Manual, Chambers.