

College Physics II

Lab 7: Resistors

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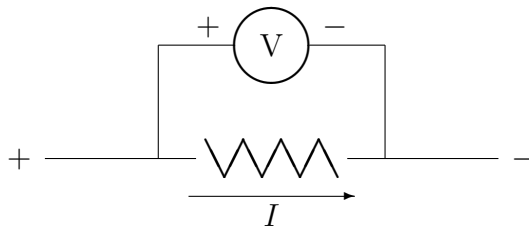
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Introduction

You will use a voltmeter to measure potential difference (also called voltage, V (in units of volts, V)) and an ammeter to measure current, I (in units of amperes, A) in some simple circuits. The lab consists of two parts:

1. Measuring the current through a single resistor for increasing amounts of voltage,
2. Analyzing a *current divider* circuit.

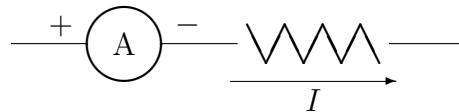
Voltmeters and ammeters are sensitive instruments; please use them carefully and correctly. Before you connect or reconnect any circuit elements you should turn down the power supply.



The voltmeter measures the potential difference, or voltage, between two points in a circuit. The voltmeter must go *across* the element to be measured.

GOAL

Voltmeters have a very high resistance and little current goes through them. Voltmeters have a positive input (usually red) and a negative or “common” input (usually black). The positive input should be connected to the point in the circuit which is at a higher potential. If this is not the case the meter will read backwards. For digital voltmeters this is not a problem and the display will just show a minus sign, but if the voltmeter has a moving needle, it may try to move backwards and can be damaged. In that case, you should turn up the voltage of the power supply slowly to see which way the needle moves before it moves too far.



The ammeter measures the current through a part of a circuit. In order to use it we must break the circuit and insert the ammeter into the circuit at that point so that all the current flows through the ammeter. Like the voltmeter it also has positive (red) and negative or “common” (black) terminals. The current should flow into the ammeter through the positive input and out through the negative one. Current flows from positive (high voltage) to negative (low voltage). In other words, it flows in the direction a positive charge would go.

Often, voltmeters and ammeters have a choice of ranges. Unless specifically told to do otherwise, always start with the highest (least sensitive) range (the range that goes up to the highest voltage or amperage), and go down to a lower (more sensitive) range only if you see that you are getting a small or negligible signal using the higher range. This way, you prevent sending too large a signal when you are on a low range, which could damage the meter.

Goal

In the first part, you will graphically study the resistance of a resistor by measuring current through the resistor as a function of voltage. You will see that, for small voltages, a graph of current versus voltage is a straight line, and the slope of that line is $1/R$, where R is what we call the resistance of

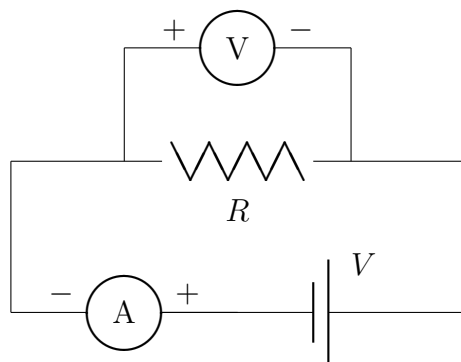
ACTIVITY 1: OHM'S LAW

the resistor, in units of V/A (volts per ampere) or Ω (ohms). When this is the case, the resistor is said to obey Ohm's Law. If a resistor obeys Ohm's Law, it means the resistance of that resistor is constant, regardless of the amount of current passing through it. At higher currents, the resistor may smoke and burn. In addition, the graph of current versus voltage may not be a straight line, in which case the resistor does *not* obey Ohm's Law. The point of this part is to show you that Ohm's Law only holds under certain conditions.

In the second part, you will make a number of measurements on a circuit, and you will also make some calculations involving that circuit. You will use resistors that can handle large currents and still obey Ohm's Law, so you may assume that Ohm's Law holds throughout this part of the lab. There is no "final result" for this part. It is meant to give you practice constructing a circuit, measuring voltage across different elements in a circuit, using Ohm's law, $V = IR$, and Kirchoff's two laws: the sum of the voltage drops along a section of a circuit must add to the total voltage drop from one end of that section to the other, and the sum of the currents going into a junction must equal the sum of the currents going out of that same junction.

Activity 1: Ohm's Law

Ohm's law states that the current through a resistor is proportional to the voltage across it, and that the resistance is a constant, regardless of the amount of current passing through the resistor. If the voltage is doubled, the current should also double. In this part you will measure the current through a single resistor for various voltages across the resistor, and make a graph of current versus voltage.



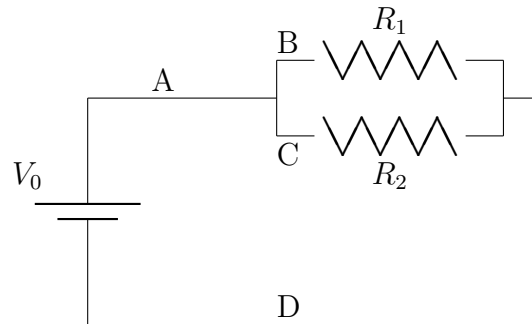
ACTIVITY 1: OHM'S LAW

1. Connect the circuit shown. I will give you a resistor, and tell you the ranges of V and I you will need to measure. Have me check the wiring and the settings before you plug in your equipment.
2. Before turning on the power supply, turn the voltage control knob all the way down and the current control knob all the way up. Turn on the power supply, and gradually turn up the voltage until a reading appears on both the voltmeter and the ammeter, and record both V and I . Increase the current in steps (I will tell you the size of the steps), recording V and I at each step. *Do not go to a higher voltage until you have recorded the data at the lower voltage!* Also, don't wait too long at one setting before moving on—that can cause the resistor to burn up too soon. Typically, at some point in this process, the resistor will be destroyed, producing smoke. Take data for a step or two beyond that point, and then you are done. Once the resistor is destroyed, you will be unable to go back and collect more data for that resistor.
3. Now make a graph of I (vertical or y -axis) versus V (horizontal or x -axis). With a very light pencil point, draw a smooth curve through all the data points (without obliterating the data points), and note at what voltage the curve can no longer be considered a straight line.
4. For the straight line region only, find the slope of I vs V . Take the inverse of the slope—this result is the experimentally determined resistance of the resistor over the region where it obeys Ohm's Law.
5. The power (energy per unit time) being dissipated in a resistor is equal to the current through the resistor times the voltage across the resistor. At what power does your resistor stop obeying Ohm's Law—that is, at what point does the resistance stop being a constant?

To hand in for activity 1

- Graph of I versus V for your resistor, showing where it does and where it doesn't obey Ohm's Law.
- The nominal resistance of your resistor, the experimentally determined resistance of your resistor, and power at which your resistor stops obeying Ohm's Law.

Activity 2: The Current Divider



1. The simple circuit shown containing two resistors in parallel and a battery is called a current divider circuit. Set up such a circuit with two resistors: one $20\ \Omega$ and one $44\ \Omega$. Set V_0 to about 5 V.
2. Use the meters to measure the current at points A, B, C and D in the circuit—how are I_A , I_B , I_C , and I_D related?
3. Measure the voltage supplied by the source, across R_1 , and across R_2 . How are V_s , V_1 , and V_2 related?
4. How are V_1 and I_B related, and what does Ohm's Law predict? How are V_2 and I_C related, and what does Ohm's Law predict?
5. What does our circuit theory predict for the ratio I_B/I_C ? Explain. Do your data support those predictions?
6. Why is the circuit called a current divider?
7. Devise a circuit that could be called a *voltage* divider, and draw a circuit diagram showing what it would look like.

To hand in for activity 2

- Data, relations used, and results all organized in a table.
- Answers to all the questions asked.