Lab 10

Internal Resistance of Batteries

Experimental Objectives

- In this experiment, we would like to consider the characteristics of a voltage source.

A voltage source, V, is anything that has a potential difference across two terminals: A liquid battery (such as in a car), a dry cell battery, a power plant (accessible through the wall socket), etc. An ideal voltage source, $\mathcal{E}$, will provide the same amount of voltage regardless of how much current is drawn from it. Physical voltage sources will approximate this to various degrees.

In order to determine how ideal a voltage source is, we will draw more and more current and measure how much voltage it is able to supply. If we attach a large resistance to the voltage source, then it will resist the current and we will only draw off a small current. If we attach a small resistance to the voltage source, then it will draw a large current.

Next week, you will consider the details of that relationship. Your resistors should already be ordered largest to smallest; don't worry about their actual values, but please try to keep them in order. Each of the resistors has multiple color bands on it. Please be diligent about recording the colors in order on each resistor. When you are finished with the lab, you should be able to sort them largest to smallest.

10.1 The Equipment

In the diagrams, A is an ammeter, which measures the current in amps (A), milliamps (mA), or microamps (μA). These measure the *current through* a wire and must be placed in series with the circuit element. Two circuit elements are "in series" if all of the current which goes through one also goes through the other. Current is the flow of charge (an amount of material); it does not diminish as it passes through the circuit elements.

In the diagrams, V is a voltmeter, which measures the voltage in volts (V). These measure the *voltage across* (the potential difference from before to after) a circuit element and must be placed in parallel with the circuit element. Two circuit elements are "in parallel" if the current gets split between one and the other. Voltage is related to the energy of the charges; it does diminish (or increase) as it passes through the circuit elements.

Figure 10.1.1 shows two configurations of ammeter and voltmeter. The small circles are the connections for the wires. In this lab, we are trying to measure the current drawn from the battery and the voltage output by the battery. On the left, the voltmeter is in parallel with the battery, but the ammeter is not in series with the battery. (V is correct, but I is too small.) On the right, the ammeter is in series with the battery, but the voltmeter is not in parallel with the battery. (I is correct, but V is too small.) You will be making a mistake either way, but hopefully neither is *too wrong.* For only your largest and smallest resistors, measure this both ways and see how large the effect is. (It is incorrect to use the voltage from one circuit and the current from the other.)

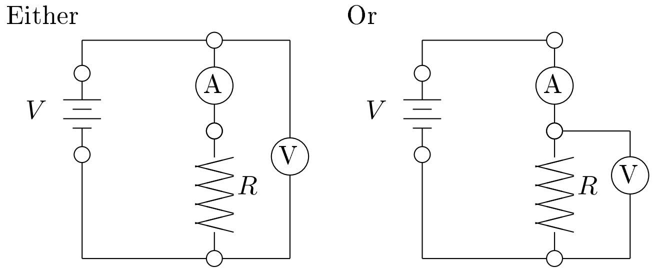

Figure 10.1.1: Measuring the voltage across "and" the current through a resistor.

10.2 The Experiment

You should consider (one at a time, of course) three voltage sources: a "good" dry-cell battery, a "bad" dry-cell battery, and a dc-power supply. To determine the characteristics of each battery, you will need to build the circuit in Figure 11.2.1 using some resistor, and then replace the resistor with 10 different resistance values, in order to vary the amount of current drawn. Measure the current (from the ammeter A) and the terminal voltage (from the voltmeter V) for each of these resistors. Figure out how the terminal voltage is related to the current drawn by graphing the voltage V versus the current I and considering the equation of the best trendline.

10.3 The Analysis

Comment on the following in your lab notebook, and use this information to enhance your analysis of the data.

1. Does the good battery provide a constant voltage? If so, tell the instructor to find smaller resistors for you. If not, try to figure out what is happening.
2. Discuss the units and the interpretation of the slope and intercept for each graph.
3. Compare the values of slope and intercept from the three graphs. It may be that they should not have the same value; but correlate the values to the voltage sources. If they have comparable voltages, then graph them on the same chart.

On your graph, extrapolate the trendline to determine what would happen if you had zero resistance. (***Do not*** actually use zero resistance; that would use up the battery "juice" ***very*** quickly.)

1. Which portion of the graph is large R and small R? How do you know?
2. In principle, if there were absolutely no resistance to the flow of current, how much current would flow?
3. Based on your graph, if you were to allow the resistance to be zero in the circuit, what would happen to the current? (This is called the "short-circuit current.")
4. Can you draw any conclusion about the resistance that is internal to the battery? (Be as quantitative as possible.)
5. Based on your graph, what characteristic distinguishes a "good" battery from a "bad" battery?

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