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Exercise 3:

Chosen wire resistivity of "lots", the highest setting available on the website.

The resistance of the ammeter in the circuit is, by design, much smaller than that of the resistant wire, so it can be assumed to be negligible (i.e., null). Ohm's law states $total\,resistance = \frac{total\,voltage}{current}$, so we can say $(\Sigma R) = r + R = \frac{(\Delta V_{BAT})}{(I)} \Rightarrow r = \frac{\Delta V_{BAT}}{I} - R$, where ΔV_{BAT} is the voltage of the circuit's power supply, I is the circuit's current, ΣR is the system's total resistance and R is the resistance of the known resistor. We can thus control R and manipulate ΔV_{BAT} to get I in order to calculate $\frac{\Delta V_{BAT}}{I}$. Then, we calculate r using $r = \frac{\Delta V_{BAT}}{I} - R$.

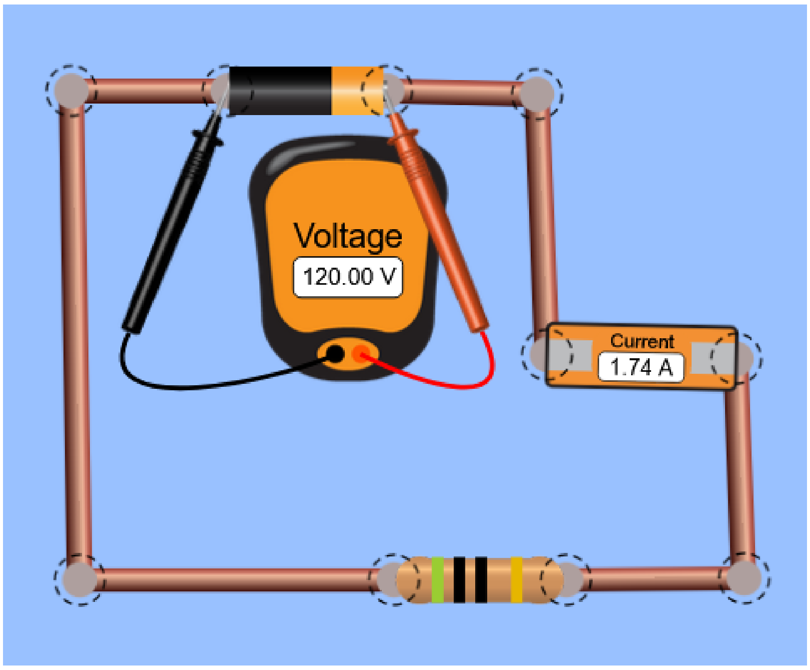

Figure 3.1: *Setup of the described experiment in a Series Circuit to measure the wire's resistance by a controlled voltage.*

By controlling R as $50 \pm 3\,\Omega$ ($u(R)$) determined using resistor's colour code visible in Figure 3.1, we can obtain the following values:

Table 3.2
Response of Series Circuit Voltage to the Manipulation of Current

Current of circuit (A)	Circuit Voltage (V)
0.13 ± 0.01	9.00 ± 0.02
0.32 ± 0.01	22.0 ± 0.03
0.72 ± 0.01	50.0 ± 0.05
1.16 ± 0.01	80.0 ± 0.06
1.45 ± 0.01	100 ± 0.07
1.74 ± 0.02	120 ± 0.08

The circuit's current and voltage uncertainties in Table 3.2 were determined using the methodology listed in the Keysight U1272 data sheet, assuming 300 V and 10 A settings. It is calculated by finding a percentage of the reading and summing it with a multiple of the device's tolerance. For example, for the current $0.32\,A$ we compute $u(0.32\,A) = 0.32\,A \times 0.3\% + 10 \times 0.001\,A = 0.01\,A$. Similarly, for the voltage, say, $22.0\,V$ we compute $u(22.0\,V) = 22.0\,V \times 0.05\% + 2 \times 0.01\,A = 0.03\,A$.

We can plot the data from Table 3.2 to determine the total resistance of the circuit:

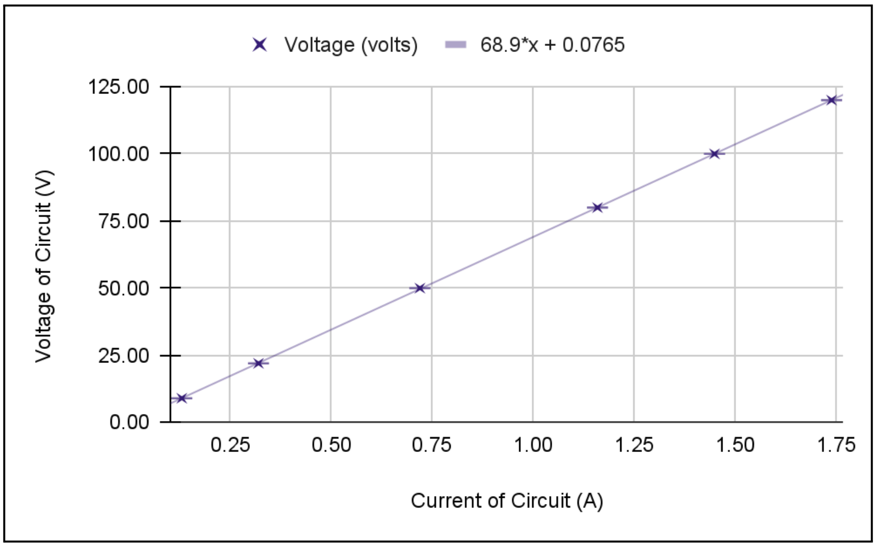

Figure 3.2 | *Current through a* $50 \pm 3\,\Omega$ *resistor connected in a series circuit for varied potential difference. Error bars represent uncertainties from a multimeter reading. Solid line is a least-squares fit to a line with best-fit slope 68.9.*

Since some data was measured to two significant digits, we will use $\frac{\Delta V_{BAT}}{I} = 69$ instead of 68.9 as the slope of the graph in Figure 3.2 says. so $\frac{\Delta V_{BAT}}{I} = 68.9 \pm 0.08\,\Omega$, where $u(\frac{\Delta V_{BAT}}{I})$ was calculated using the Google Sheets `LINEST` function.

Now that we have $\frac{\Delta V_{BAT}}{I}$, we can calculate $r = \frac{\Delta V_{BAT}}{I} - R = (69\,\Omega) - (50\,\Omega) = 19\,\Omega$, where $u(r) = \sqrt{\left(u\left(\frac{\Delta V_{BAT}}{I}\right)\right)^2 + (u(R))^2} = \sqrt{(0.08)^2 + (3)^2} = 3$. **Therefore, we can conclude that the wire's resistance,** r**, is** $19 \pm 3\,\Omega$. This final value is reasonable, as subjectively-speaking it is not an uncommon level of resistance.

This experiment was made with the assumption that the resistance of the wire is independent of its length, despite that not always being the case. So long as the fundamental structure of the circuit is the same, there is no intrinsic reason for the wires in Figure 3.1 to be arranged in the way that they were. Error may have occurred in reading as well by maintaining the $300V$ and $10A$ settings on the multimeter.