Resistivity

Purpose

To determine the resistivity of the nickel-chromium alloy called Nichrome.

Introduction and Theory

At a given temperature, the resistance R of a conducting wire is related to its length L, its cross-sectional area A, and its electrical property, the resistivity, represented by the Greek letter ρ (rho):

$$R = \rho \frac{L}{A} \quad (1)$$

Resistivity, like density or specific heat, is a property of the material. Lower resistivity means it is a good conductor: for example, at room temperature, copper's resistivity is $1.7 \times 10^{-9}\ \Omega\ m^2/m$ or $1.7 \times 10^{-9}\ \Omega\ m$.

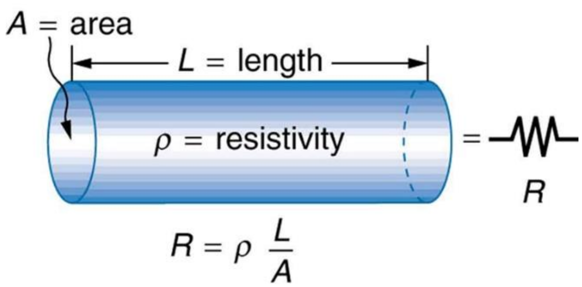

Figure 1: For a uniform cylindrical wire with cross-section area A, length L and resistivity ρ, the resistance R is given as above.
(Picture taken from: College Physics, Openstax, 2023.)

For the quantities in Eq. (1), the length L of the conducting wire can be measured directly. Assuming the cross-section of the wire is a circle with diameter d (or radius r), the cross-sectional area A is

$$A = \pi r^2 = \pi \left(\frac{d}{2}\right)^2$$

The resistance R can be found by the potential difference across the wire ΔV and current through the wire I (Ohm's Law):

$$R = \frac{\Delta V}{I}$$

In the prelab, we ask you to derive an equation to calculate the resistivity ρ from quantities L, d, and R.

Apparatus Draw a circuit diagram. List all other apparatus: Nichrome wire of two different diameters, wire leads, battery, voltmeter, ammeter, micrometer and metre stick *etc*. List any identifying numbers.

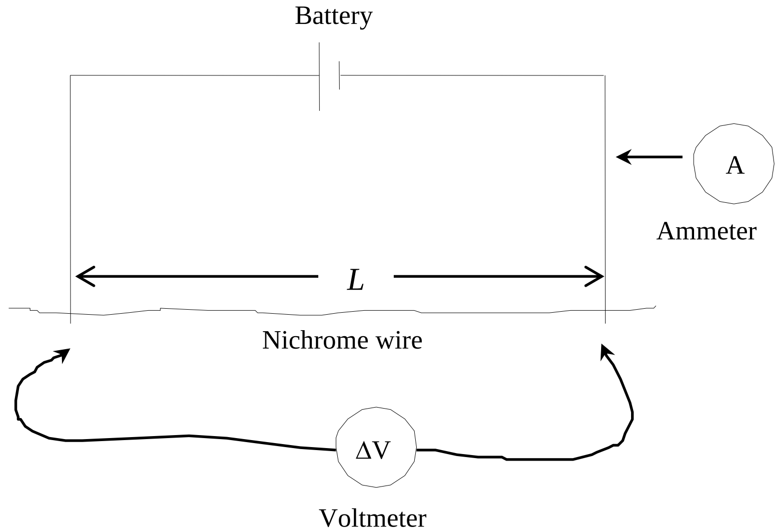

Figure 2: Measure the length and the resistance of a nichrome wire.

Data

You must set up two data tables: one for the diameter d measurement, and one for the others (length L, potential difference ΔV and current I). Each table should have two columns for the two wires.

Measure and record the diameter of one of the nichrome wires with the micrometer. <u>Please watch the video on Brightspace to see how to use the micrometer.</u> Be sure to make at least 3 readings and take the average. The micrometers we use usually have a negative zero reading, so your data must show the zero reading and the corrected average diameter, which is "average diameter − the zero-reading". Include the uncertainty, as usual.

Set up the circuit shown in Figure 2. Measure and record the length L. Note that L is the length between the two alligator clips and is <u>not</u> the total length of the wire, but it should be close. Once L is measured, you cannot change the position of the alligator clips anymore. Next, measure the potential difference ΔV across the wire and, separately, the current I through the wire. Note that the circuit has to be broken somewhere in order to insert the ammeter to measure the current.

Repeat for the other wire. Clearly state which data belongs to which wire.

Calculations

Calculate the resistances R of the two lengths of wire used.

Use the quantities L, d, R and the equation you derived earlier, to calculate the resistivity of each wire. The resistivities of the two wires should be approximately the same. If not, your most probable error is a mistake in measuring the diameter, most likely in reading or handling of the zero reading of the micrometer.

Calculate the percentage discrepancies between each of the two results and the reference value of $1.10 \times 10^{-6}\ \Omega\text{m}$. Also, calculate the percentage difference between the two wires.

Conclusions

State both resistivities in the correct format, and give the percentage differences with the reference value and between themselves.

Discussions

Are these percentage discrepancies too big, or are they acceptable? Let us compare the discrepancy to the data uncertainties, both in the percentage form. The voltage measurement, the current measurement, and the length and the diameter measurement all have uncertainties. Calculate their percentage uncertainties by taking the uncertainty over its value, multiplying by 100%. If the sum of these percentage uncertainties is larger than the percentage discrepancies, then we can take the discrepancies as acceptable. Which raw data has the largest percentage uncertainty?