

Measuring the Resistivity of a Wire

Student Worksheet

In this experiment you will be making measurements of voltage and current for a piece of metal wire, together with the physical dimensions of the wire, from which you will calculate the resistivity of the metal.

Theory

The resistance R of a component in a circuit is given by the equation

$$V = IR$$

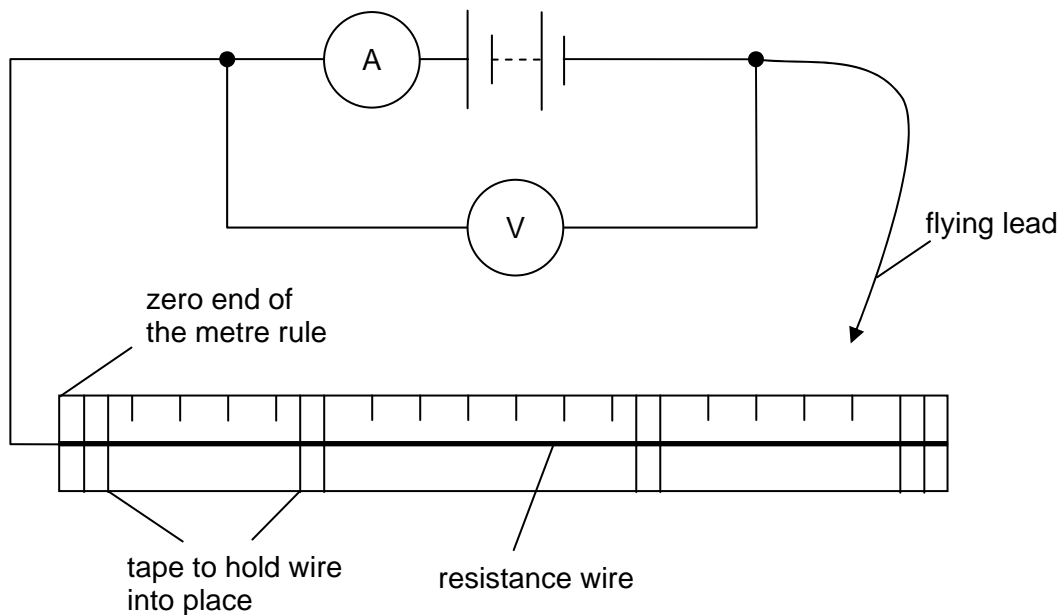
where V is the potential difference across the component and I is the current in the component.

The resistance of a wire is given by the equation

$$R = \rho l / A$$

where ρ is the resistivity of the metal from which the wire is made, l is the length of the wire and A is its cross-sectional area.

Using the circuit below, you will make measurements of current and voltage for different lengths of wire. You will plot a graph of resistance against length and from this you will calculate the resistivity.



Making measurements and observations

- 1 Use the micrometer screw gauge to measure the diameter d of the resistance wire in several places along the length. Each time you take a measurement at a new place, rotate the wire slightly.
- 2 Tape the wire to the metre rule so it cannot slip and the markings of the rule are visible.
- 3 Connect the circuit shown in the diagram above. The flying lead should have a bare conducting end and should be long enough to touch any part of the resistance wire.
- 4 Using the flying lead, make a contact with the resistance wire so that a length $l = 1.00$ m of resistance wire is in the circuit. Record the readings from the ammeter and the voltmeter. Disconnect the flying lead.
- 5 Repeat 4 until you have nine sets of readings where $0.10 \text{ m} \leq l \leq 1.00 \text{ m}$.

Recording and presenting your data

- 1 Your readings should be recorded in a table of results with columns for length l , potential difference V , current I and resistance R . Record the lengths in metres and the current in amperes.
- 2 Plot a graph of R (y -axis) against l (x -axis). Draw a line of best fit.

Analysing your data

- 1 Calculate an average value for the diameter d of the wire.
- 2 Calculate the cross-sectional area A of the wire using the equation

$$A = \frac{1}{4}\pi d^2.$$

- 3 Determine the gradient of your graph.
- 4 Use the equation

$$R = \rho l / A$$

and your answers to 2 and 3 to calculate a value for the resistivity ρ of the metal of the wire. Show your working.

Evaluation

- 1 Describe any limitations or problems that you encountered with the method used.
- 2 Suggest ways in which the accuracy of the measurements could be improved.
- 3 Look up the actual value for the resistivity of the metal of your wire. Compare your experimental value to the actual value and comment upon the accuracy of your experiment.

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Teaching Notes

Link to theory

19(h) recall and solve problems using $V = IR$

19(l) recall and solve problems using $R = \rho l/A$

Key learning objectives

- To gain experience in setting up electrical circuits from instructions and a circuit diagram.
- To gain experience in selecting the correct range on a digital multimeter.
- To gain experience in relating a formula to a graph in order to calculate the value of a constant.
- To reinforce learning about resistance and resistivity.

Notes

If students have not previously used digital multimeters, then it is worth spending some time discussing how to select the correct range. This is important as some multimeters have small internal fuses that are easily blown.

Some students may have difficulty relating the gradient of the graph to the equation and may need help and support with the analysis.

Students will be asked to look up the resistivity of the metal of their wire. It is useful to have a data book or internet access available (and to know the metal being used).

Expected results

material	resistivity / $\Omega \text{ m}$
constantan	4.7×10^{-7}
nichrome	1.5×10^{-6}
copper	1.7×10^{-8}
stainless steel	9.6×10^{-7}

Possible extension work

Different thickness of wire of the same material can be investigated to see if the resistivity is the same.

Students could also be asked to make resistors of a fixed value (e.g. 10Ω) from a piece of wire wrapped round a wooden dowel or pencil. They would need to calculate the length of wire needed and to check their results with an ammeter and a voltmeter.

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Technical Notes

Apparatus requirements

- 1 **Piece of resistance wire**, 110 cm long. This can be constantan wire (sometimes known as eureka wire) or nichrome wire, usually 28-32 swg. Other diameters and metals can be used as long as it is checked that a good set of results can be obtained beforehand.
- 2 **Two digital multimeters.**
- 3 **Low voltage power supply.** This can be a number of cells connected together in series if needed. A p.d. of about 3 V will suffice.
- 4 **Five connecting leads.** One of these should be at least 70 cm long.
- 5 **Crocodile clip.**
- 6 **Metre rule.**
- 7 **Tape** to fix the wire to the metre rule.
- 8 **Micrometer screw gauge.**

Notes

The resistance wire must be checked to ensure that it does not become too hot when 10 cm is connected across the terminals of the power supply. If it does become hot, the students should be warned at the start of the experiment. Depending on the resistance wire used, it may be necessary to instruct the students not to use small lengths of resistance wire in their circuit.