Resistivity

Theory: Resistivity, denoted by the Greek letter ρ (rho), is a material property that quantifies how strongly a given material opposes the flow of electric current.

Unlike resistance, which depends on the length and cross-sectional area of a wire, resistivity is an intrinsic property - it stays the same regardless of the shape or size of the material.

The relationship between resistivity and resistance is given by the equation:

$$\rho = \frac{RA}{L}$$

Where:

ρ is the resistivity (in Ω m)

R is the resistance

A is the cross-sectional area

L is the length

Typical values:

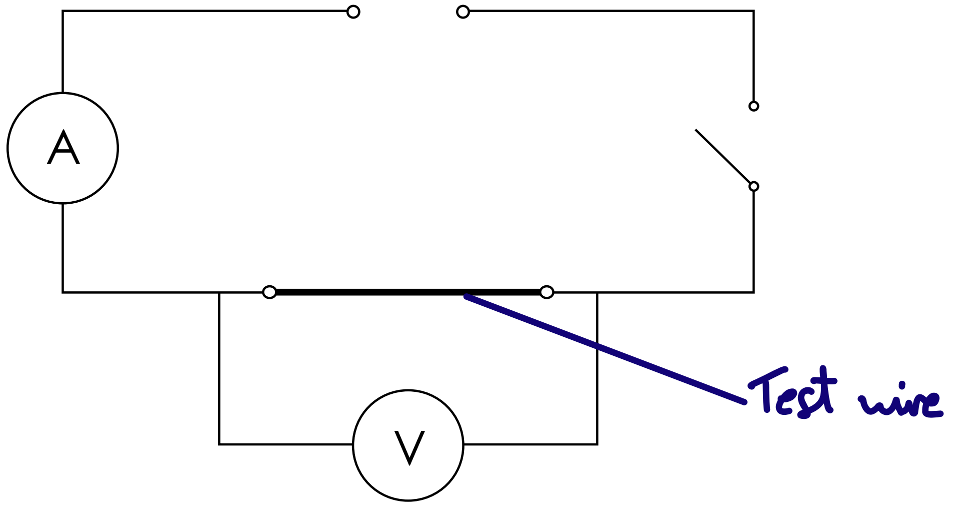
1.6×10^{-8} Ω m	Silver
1.7×10^{-8} Ω m	Copper
7.0×10^{-8} Ω m	Nickel
4.9×10^{-7} Ω m	Constantan (an alloy of copper and nickel)

Risks and Hazards

High temperatures: As the resistance of the wire is very low, a small potential difference will result in a big current that can cause a large heating effect in the wire.

Method 1. Resistance of a Length of Wire

To investigate the resistance of a length of wire, the following circuit can be set up:



This is often achieved with a sample of wire taped to a metre ruler. A crocodile clip is attached to one end at 0 mm. A second clip is attached to the other end and the length of wire read off the ruler. It is worth ensuring the wire is straight and not kinked, and the crocodile clips make a good connection in the correct place on the wire.

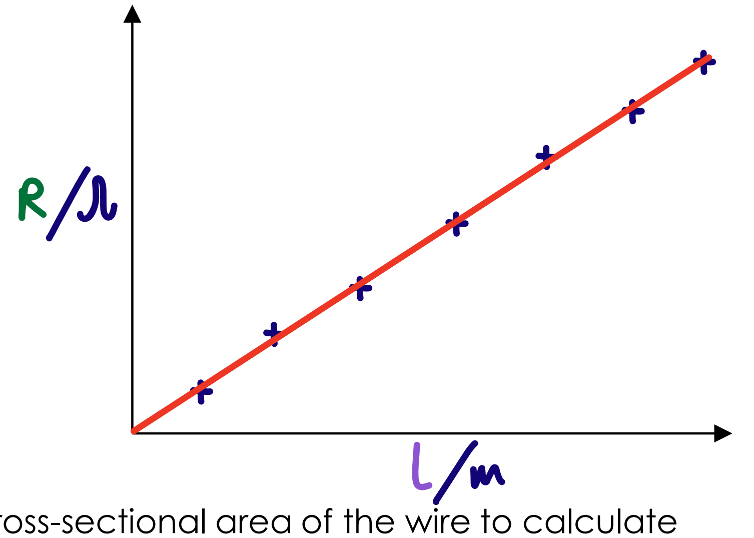
The circuit is connected for a short time to reduce any heating effects in the wire. The current in the wire, and potential difference across it, is recorded and used to calculate the resistance of the wire at that length.

A graph with the length of the wire on the x-axis is plotted against the resistance on the y-axis.

$$R = \frac{\rho L}{A}$$

$$R = \frac{\rho}{A} \cdot L$$

$$y = mx + c$$

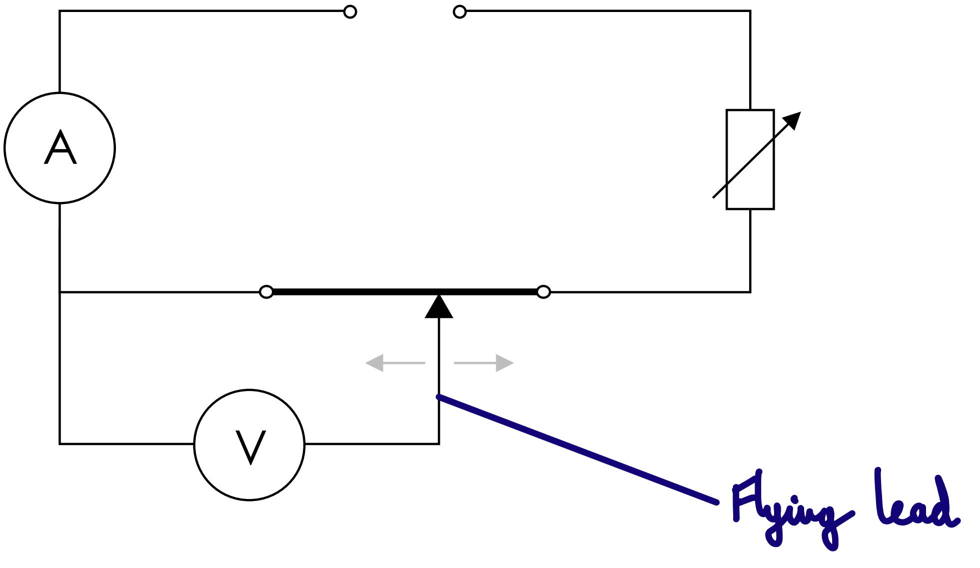


The gradient can be multiplied by the cross-sectional area of the wire to calculate the resistivity of the material the wire is made from.

$$\rho = \text{gradient} \times A$$

Method 2. Resistance of a Length of Wire

An alternative approach to measure resistivity is with the following circuit:



This still allows the resistance of various lengths of wires to be calculated, but it has a number of advantages compared to Method 1:

- A variable resistor is in series with the test wire. This can be adjusted until a low current (approximately 0.5 A) is set up in the circuit. With a constant current, the heating effect in the wire is constant so the wire will quickly reach an equilibrium position at a constant temperature, avoiding any effect of the wire increasing in length or other temperature effects.
- For this constant current, the potential difference is measured across different lengths of wire by attaching the 'flying lead' on the voltmeter to the desired length.

As before, a graph with the length of the wire on the x-axis is plotted against the resistance on the y-axis. The gradient can be multiplied by the cross-sectional area of the wire to calculate the resistivity of the material the wire is made from.

Teacher and Technician Notes

- Make sure that the circuit is only connected for a short time. With a low resistance, the current can be very high in the wire, which in turn causes a heating effect that affects the value of resistivity calculated.
- This practical provides an excellent opportunity for students to develop their skills using a micrometer to measure the small diameter of the wire, and reading the scale for distances less than 1 mm.

Suitable Equipment

Lascells Variable Power Supply

VTT12302915

A DC output of about 3.0 V works well for this practical.

SATZ Voltmeter

VTT12302845

Simple to use and easy to read. It is worth reminding your students to turn them off after use to prolong the battery life.

SATZ Ammeter

VTT12302838

A digital ammeter with a suitable range for currents up to 5 amps.

Constantan Wire

SWG 30 is a suitable diameter wire to be tested.