Exercise walk-through

Resistance and resistivity ▪ 9.3

eXercise

You must be able to

- define **resistance** and state **Ohm's law**
- sketch the I–V graphs of a **metal wire**, a **filament lamp** and a **diode**
- use $R = \rho L/A$, getting A from a **diameter** ($A = \pi d^2/4$)
- describe the **circuit and steps** to measure the resistivity of a wire

Method — Resistance and Ohm's law

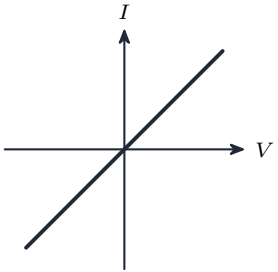
$$R = \frac{V}{I}\ (\Omega).$$

Ohm's law: for a metal at constant temperature, $I \propto V$, so R is constant (a straight-line I–V graph).

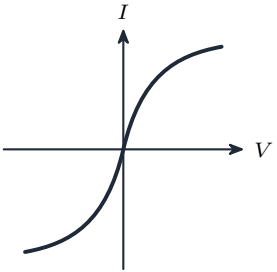
Method — I–V characteristics

A **filament lamp**'s resistance **rises** as current increases: more current heats the filament, raising its temperature and resistance, so the graph flattens.

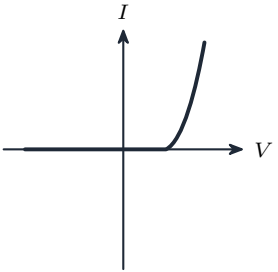
Method — I–V characteristics



ohmic conductor



filament lamp



diode

Method — Resistivity, LDR, thermistor

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

An **LDR**'s resistance **falls** as light gets brighter; a **thermistor**'s resistance **falls** as temperature rises.

Method — Measuring resistivity

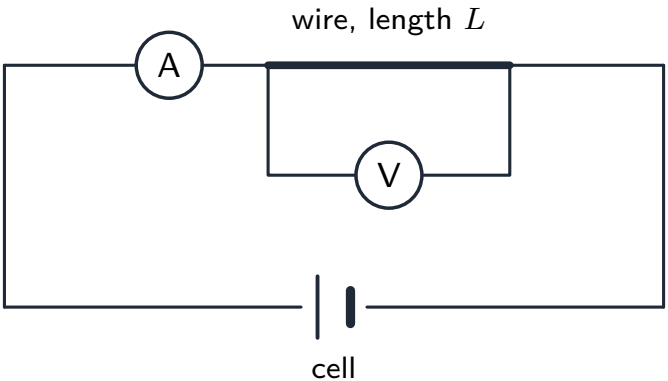
A very common experiment: find ρ for a wire. Connect an **ammeter in series** with the wire and a **voltmeter across** it:

1. Read V and $I \to$ resistance $R = V/I$.
2. Measure the **diameter** $d \to$ area $A = \pi d^2/4$ (use the radius $d/2$).
3. Measure the length $L \to \rho = \dfrac{RA}{L}$.

Worked example. $V = 1.5$ V, $I = 0.45$ A $\to$ $R = 3.33\ \Omega$. Diameter $d = 0.40$ mm $\to$ $A = \pi(0.20 \times 10^{-3})^2 = 1.26 \times 10^{-7}$ m^2. Length $L = 0.80$ m:

$$\rho = \frac{RA}{L} = \frac{(3.33)(1.26 \times 10^{-7})}{0.80} = 5.2 \times 10^{-7}\ \Omega\,\text{m}.$$

Method — Measuring resistivity



Practice 2.1 ▪ 1 mark

Define **resistance**.

Solution 2.1

Worked steps

Resistance $= \dfrac{\text{p.d.}}{\text{current}}$ $(R = V/I)$ B1.

Practice 2.2 ▪ 1 mark

State **Ohm's law**.

Solution 2.2

Worked steps

The current is **proportional** to the p.d. (at constant temperature) B1.

Practice 2.3 ▪ 2 marks

A component has 6.0 V across it and 0.30 A through it. Find its **resistance**.

Solution 2.3

Method: Measuring resistivity

Worked steps

$R = V/I = 6.0/0.30 = 20\ \Omega$ M1 A1.

Practice 2.4 ▪ 2 marks

A wire has diameter 0.50 mm. Calculate its cross-sectional **area** in m^2.

Solution 2.4

Method: Measuring resistivity

Worked steps

$$A = \frac{\pi d^2}{4} = \frac{\pi(0.50 \times 10^{-3})^2}{4} = 2.0 \times 10^{-7}\ \text{m}^2$$ M1 A1.

Practice 2.5 ▪ 1 mark

State what happens to a **thermistor's** resistance as its temperature **rises**.

Solution 2.5

Method: Resistivity, LDR, thermistor

Worked steps

It **decreases** B1.

Exam-style 3.1 ▪ 1 mark

Which component has a **straight-line** I–V graph through the origin?

A a filament lamp

B a diode

C a metal wire at constant temperature

D a thermistor

Solution 3.1

Method: I–V characteristics

A a filament lamp

B a diode

C a metal wire at constant temperature ✓

D a thermistor

Worked steps

C — a metal wire at constant temperature.

Exam-style 3.2 ▪ 2 marks

Explain why the **resistance** of a filament lamp **increases** as the current increases.

Solution 3.2

Method: I–V characteristics

Worked steps

A larger current **heats** the filament, raising its temperature B1; a hotter metal has a **higher resistance** (the ions vibrate more and impede the electrons) B1.

Exam-style 3.3 ▪ 2 marks

A student measures the resistivity of a metal wire.

(a) Draw a circuit, using an ammeter and a voltmeter, to measure the **resistance** of the wire.

(b) The readings are $V = 1.5$ V and $I = 0.45$ A; the wire has length 0.80 m and diameter 0.40 mm. Calculate the **resistivity** of the metal.

Solution 3.3

Method: Measuring resistivity

Worked steps

(b) $R = V/I = 1.5/0.45 = 3.33\ \Omega$ M1; $A = \dfrac{\pi d^2}{4} = \dfrac{\pi(0.40 \times 10^{-3})^2}{4} = 1.26 \times 10^{-7}\ \text{m}^2$ M1; $\rho = \dfrac{RA}{L} = \dfrac{(3.33)(1.26 \times 10^{-7})}{0.80}$ M1 $= 5.2 \times 10^{-7}\ \Omega\,\text{m}$ A1.

Exam-style 3.4 ▪ 1 mark

State what happens to the resistance of an **LDR** as the light intensity **increases**.

Solution 3.4

Worked steps

It **decreases** B1.