

Current, resistance and potential difference

4.2.1.3 · Electricity · revision notes

How the current through a component depends on the potential difference across it and its resistance, and the equation $V = I R$. This is one of the most used equations in Paper 1.

The required practical on the resistance of a wire and of resistors in series and parallel is also assessed here.

Key facts

- $V = I R$: pd (V) = current (A) $\times$ resistance (Ω)
- Greater resistance $\rightarrow$ smaller current (for the same pd)
- Resistance of a wire $\propto$ length (at constant temperature)
- $I = V \div R$ and $R = V \div I$
- $1 \text{ k}\Omega = 1000 \Omega$; $1 \text{ mA} = 0.001 \text{ A}$
- Ammeter in series with the wire; voltmeter in parallel across it

Notes

Current, potential difference and resistance

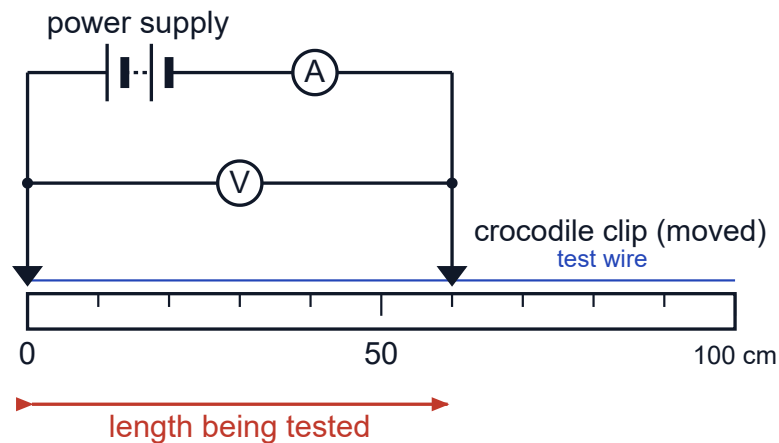
- The current through a component depends on the **potential difference** (pd) across it and on its **resistance**.
- For a given pd, the greater the resistance, the smaller the current.
- For a given resistance, the greater the pd, the greater the current.
- Potential difference is measured in **volts (V)** with a voltmeter. Resistance is measured in **ohms (Ω)**.
- AQA uses the term 'potential difference' (pd), so use it in your answers rather than 'voltage'.

The equation $V = I R$

- potential difference = current $\times$ resistance: $V = I R$ (V in volts, I in amps, R in ohms).
- Rearranged: $I = V \div R$ and $R = V \div I$.
- Convert first: $\text{k}\Omega \times 1000 = \Omega$ and $\text{mA} \div 1000 = \text{A}$.

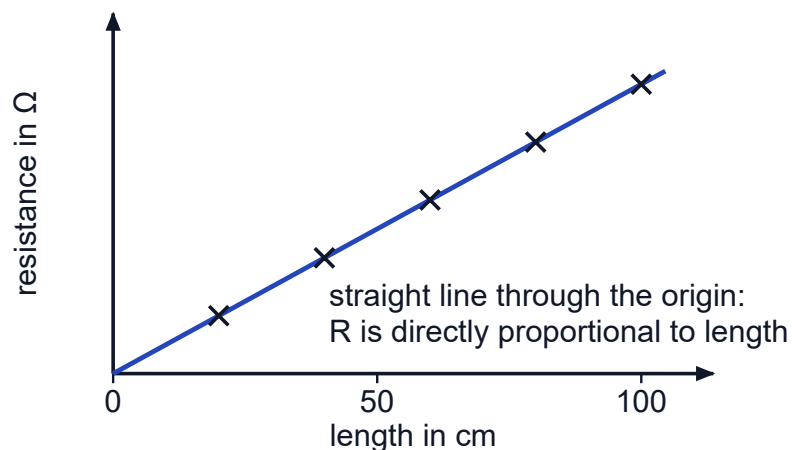
Required practical: resistance of a wire

- Fix a wire along a metre ruler. Connect it in series with an ammeter and a power supply, using crocodile clips, and connect a voltmeter in parallel across the length being tested.



Move one crocodile clip to change the length; $R = V \div I$.

- Measure the current and the pd for a range of lengths (e.g. 10 cm to 100 cm) and calculate $R = V \div I$ for each length.
- Keep the same wire (material and thickness) throughout, and keep the temperature constant: use a low current and switch off between readings, because a hotter wire has a higher resistance.
- Plot resistance (y-axis) against length (x-axis). For a uniform wire you get a straight line through the origin: resistance is **directly proportional** to length.



Resistance against length: straight line through (0, 0).

- The same circuit is used to find the resistance of resistors joined in series and in parallel: measure V and I for each combination and calculate $R = V \div I$.

How to answer each type of question

Calculate using $V = I R$

2 marks

Grade 4

1. Write $V = I R$ (or the rearranged form you need).
2. Substitute values in V , A and Ω .
3. Give the answer with its unit.

Example. The current through a resistor is 0.30 A. The resistance of the resistor is 40 Ω .
Calculate the potential difference across the resistor.

Model answer. $V = 0.30 \times 40$ (1)
 $V = 12 \text{ V}$ (1)

Don't lose marks

- ✗ Multiplying when you should divide: $I = V \div R$, not $V \times R$.
- ✗ Forgetting to convert $\text{k}\Omega$ to Ω or mA to A .
- ✗ Saying 'directly proportional' when the line does not go through the origin.
- ✗ Letting the wire heat up, which increases its resistance and spoils the results.
- ✗ Connecting the voltmeter across the power supply instead of across the wire being tested.

More tips

Memory tricks

- Formula triangle: V on top, I and R underneath.
- Sense check: 12 V across 4 Ω gives 3 A, not 48 A. More resistance should always mean less current.
- Directly proportional = straight line through the origin: double the length, double the resistance.

Exam technique

- $V = I R$ must be learned: it is not on the equation sheet.
- In method questions, name the equipment, say what you measure and how you calculate resistance, give the range of values and say how you keep the test fair.
- Show $R = V \div I$ working for each value. The method mark can be awarded even if you slip on the arithmetic.
- If a graph line misses the origin, suggest a systematic error, such as the crocodile clip not being exactly at the zero mark on the ruler.

What each grade needs

What you need to be able to do, from the first marks up to the top grade.

Grade 3

State the unit of resistance

Resistance is measured in ohms (Ω).

Grade 4

Describe how resistance affects current

For a given potential difference, the greater the resistance, the smaller the current.

Grade 4

Calculate pd using $V = I R$

Multiply the current in amps by the resistance in ohms to get the pd in volts.

Grade 5

Rearrange $V = I R$ for I or R

Use $I = V \div R$ and $R = V \div I$, converting $k\Omega$ and mA first.

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