

Resistance and how Ohm linked v, i and r

Grade 8 science (Year 9 · Class 8) · Lesson

Quick answer: Ohm's law says that the current through an ohmic conductor is proportional to the potential difference across it, so $V = I \times R$. Resistance R, measured in ohms (Ω), tells you how strongly a component opposes current. A straight I-V graph through the origin shows constant resistance.

Level: Grade 8 science (Year 9 · Class 8) · **Curriculum:** MS-PS2-3

What is electrical resistance?

When charge flows through a wire, the charged particles bump into the atoms of the metal and lose some of their energy. This opposition to current is called resistance. A thin pencil lead resists the flow a lot, while a thick copper wire resists it very little. Components made to resist current on purpose are called resistors.

Definition**Resistance** (symbol R) measures how strongly a component opposes the flow of electric current. Its unit is the **ohm** (symbol Ω). A bigger resistance gives a smaller current for the same voltage.

How does Ohm's law link voltage, current and resistance?

Georg Ohm found that, for many conductors at a steady temperature, the current is directly proportional to the potential difference across them. Doubling the voltage doubles the current. Some textbooks write the potential difference as U instead of V.

Key law

Ohm's law: for an ohmic conductor at constant temperature, the current through it is directly proportional to the potential difference across it, so the resistance stays constant.

Formula

$V = I \times R$, so $I = V \div R$ and $R = V \div I$

V is the potential difference in volts (V), I is the current in amperes (A), and R is the resistance in ohms (Ω).

Quantity	Symbol	Unit	Measured with
Potential difference	V	volt (V)	Voltmeter, in parallel
Current	I	ampere (A)	Ammeter, in series
Resistance	R	ohm (Ω)	Calculated from $V \div I$

Worked example

Kofi in Accra connects a $12\ \Omega$ resistor to a $6.0\ \text{V}$ battery. Find the current.

$$I = V \div R = 6.0\ \text{V} \div 12\ \Omega = \mathbf{0.50\ \text{A}}.$$

Worked example

Mei in Singapore measures $0.15\ \text{A}$ through a resistor when the voltmeter reads $4.5\ \text{V}$. Find the resistance.

$$R = V \div I = 4.5\ \text{V} \div 0.15\ \text{A} = \mathbf{30\ \Omega}.$$

Worked example

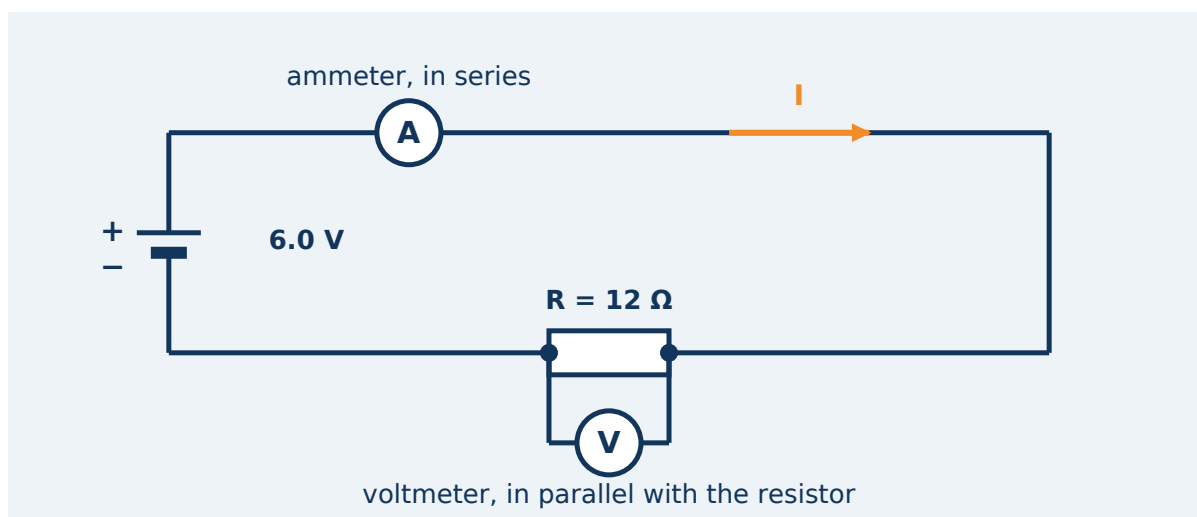
A $470\ \Omega$ resistor carries a current of $20\ \text{mA}$. Find the potential difference.

$$\text{Convert first: } 20\ \text{mA} = 0.020\ \text{A}. \quad V = I \times R = 0.020\ \text{A} \times 470\ \Omega = \mathbf{9.4\ \text{V}}.$$

Watch the prefixes: $1\ \text{k}\Omega = 1000\ \Omega$ and $1\ \text{mA} = 0.001\ \text{A}$. Convert to ohms and amperes before you substitute.

How do you measure resistance?

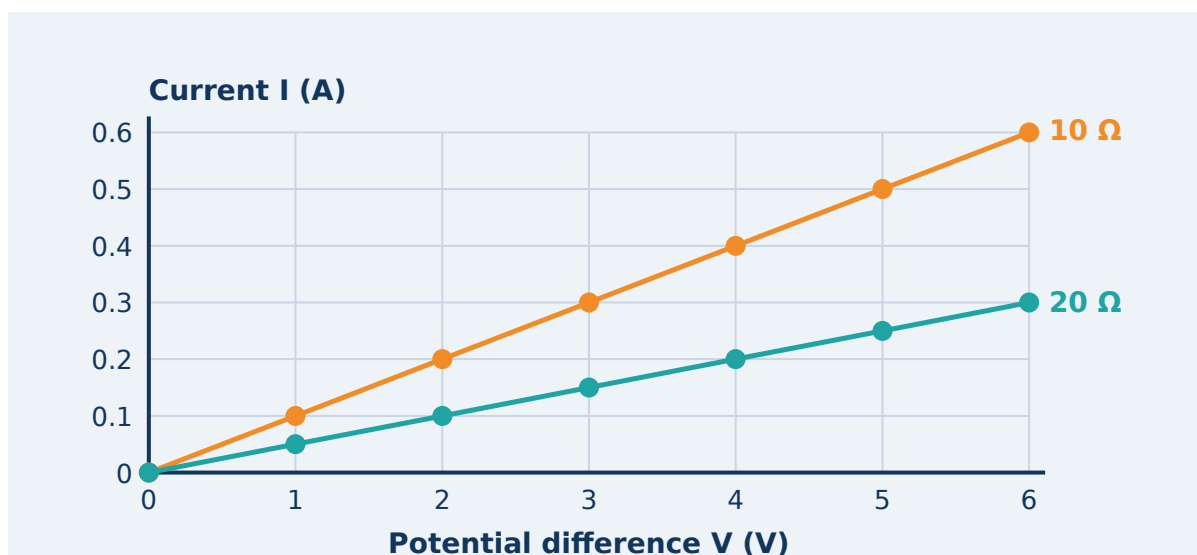
Connect an ammeter in series with the component and a voltmeter across it. Read both, then calculate $R = V \div I$. A variable resistor lets you change the current so you can take several readings.



An ammeter in series and a voltmeter in parallel measure V and I .

What does an I-V graph show?

An I-V graph plots current against potential difference. For an ohmic resistor the points lie on a straight line through the origin. The steeper the line, the smaller the resistance, because a larger current flows for each volt. The gradient of the line is $1 \div R$.



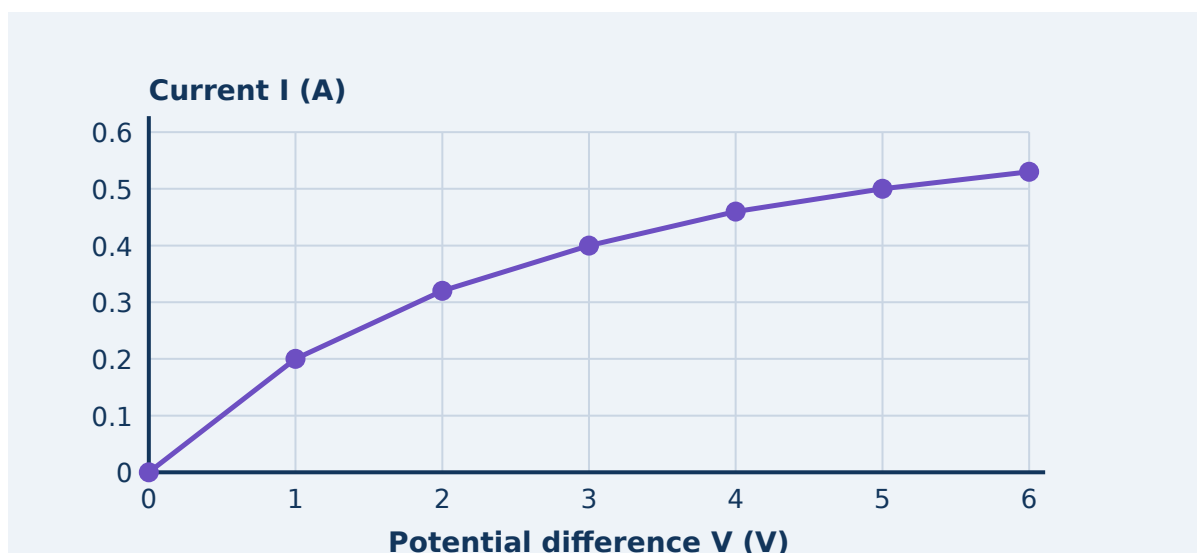
I-V lines for two ohmic resistors.

Common mistake

Many students think resistance goes up when the voltage goes up. For an ohmic resistor, R stays the same. Doubling V doubles I , so $V \div I$ does not change. Do not mix up the steep line (low R) with high resistance.

What makes a component not obey Ohm's law?

A filament lamp gets very hot as current flows. Its metal atoms vibrate more, so the particles collide more often and the resistance rises. The I-V graph therefore bends over, and the lamp is called non-ohmic.



The curve of a filament lamp shows its resistance rising with temperature.

For a lamp at 6.0 V and 0.53 A, $R = 6.0 \div 0.53 = 11 \, \Omega$. At 1.0 V and 0.20 A, $R = 1.0 \div 0.20 = 5.0 \, \Omega$. The same lamp has two different resistances.

What affects the resistance of a wire?

Change to the wire	Effect on resistance
Longer wire	Increases (doubling length doubles R)
Thicker wire	Decreases (doubling area halves R)
Different metal	Copper is low; nichrome is high
Higher temperature	Increases for a metal wire

Lina's tip

Write $V = I \times R$ at the top, then cover the quantity you need with your finger. If you cover V you see $I \times R$, and if you cover I you see V over R.

Key points to remember

- Resistance R is measured in ohms (Ω).
- Ohm's law: $V = I \times R$, so $I = V \div R$ and $R = V \div I$.
- Use an ammeter in series and a voltmeter in parallel.
- An ohmic resistor gives a straight I-V line through the origin.
- A filament lamp is non-ohmic: its resistance rises as it heats up.

Resistance and how Ohm linked V, I and R: frequently asked questions

What is Ohm's law in simple words?

For an ohmic conductor at constant temperature, the current is proportional to the potential difference. Doubling the voltage doubles the current, and $V = I \times R$.

What is one ohm?

One ohm is the resistance that allows a current of one ampere when the potential difference is one volt. Larger values use kilohms (k Ω) and megohms (M Ω).

Why is an ammeter connected in series?

It must carry the same current as the component, so the current has to pass through it. A voltmeter goes in parallel because it compares the energy per charge across two points.

Why does a lamp not obey Ohm's law?

The lamp filament heats up as the current rises, so its resistance increases. The I-V graph bends instead of being a straight line.

How can you reduce the resistance of a wire?

Use a shorter wire, a thicker wire, a metal with lower resistance such as copper, or keep it cooler.