

Ohm's law and component characteristics

Physics grades 9-10 (GCSE · IGCSE · O Level · Class 9-10) · Lesson

Quick answer: Current is the flow of charge in amperes, potential difference is the energy per coulomb in volts, and resistance in ohms is the opposition to current. They are linked by $V = I \times R$. I-V graphs show that resistors are ohmic, while lamps, diodes, thermistors and LDRs are not.

Level: Physics grades 9-10 (GCSE · IGCSE · O Level · Class 9-10) · **Curriculum:** GCSE P2, IGCSE 4.3

What are current, potential difference and resistance?

In a circuit three quantities work together. The battery pushes charge, the charge flows round the loop, and the wires and components make it harder or easier for the charge to pass.

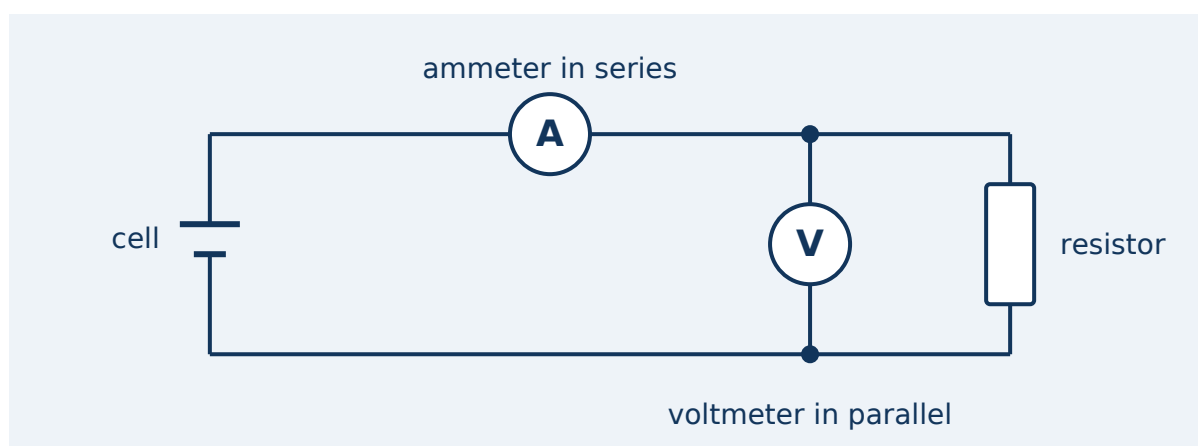
Definition

Current (I) is the rate of flow of charge, measured in amperes (A). **Potential difference (V)** is the energy transferred to or from each coulomb of charge, measured in volts (V): $1 \text{ V} = 1 \text{ J/C}$. **Resistance (R)** is how strongly a component opposes the current, measured in ohms (Ω).

Formula

$$V = I \times R$$

V = potential difference (V), I = current (A), R = resistance (Ω). Rearranged: $I = V \div R$ and $R = V \div I$. Energy transferred: $W = Q \times V$, with W in joules and Q in coulombs.



To find a resistance, the ammeter goes in series and the voltmeter goes across the component. Then $R = V \div I$.

The ammeter measures the current in the loop, so it is in series. The voltmeter measures the energy per coulomb across a component, so it connects in parallel. Divide the voltmeter reading by the ammeter reading to get the resistance.

Worked example 1

Aarav in Pune measures 2.4 V across a resistor while the ammeter reads 0.080 A. Calculate its resistance.

$$R = V \div I = 2.4 \div 0.080 = \mathbf{30\ \Omega}$$

Worked example 2

A motorbike battery in Lahore moves 45 C of charge through its lamps at 12 V. Calculate the energy transferred.

$$W = Q \times V = 45 \times 12 = \mathbf{540\ J}$$

What does Ohm's law say?

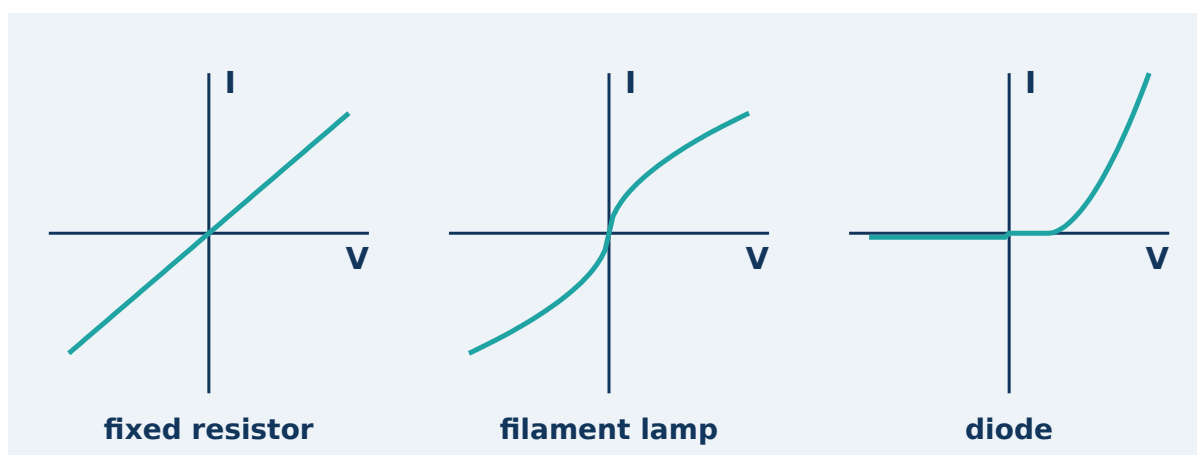
Key law

Ohm's law: for a component at constant temperature, the current is directly proportional to the potential difference. Such a component is called **ohmic**, and its resistance is constant.

A longer wire has more resistance because charge has further to go, and a thicker wire has less resistance because there is more room for charge to flow. Doubling the length doubles the resistance, and doubling the cross-sectional area halves it.

What do I-V graphs show?

An I-V characteristic graph plots current against potential difference for one component. Its shape tells you how the resistance behaves.



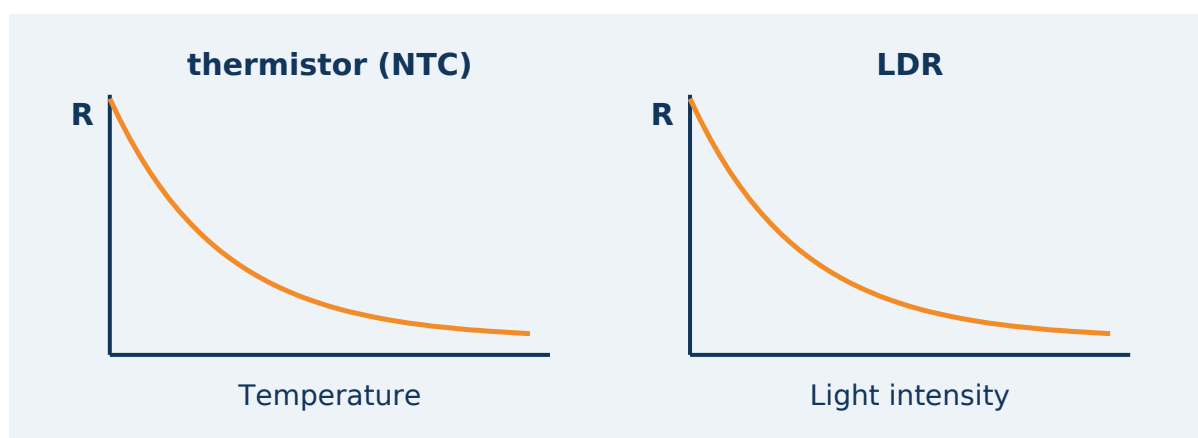
I-V characteristics. The resistor gives a straight line, the lamp flattens as it heats, and the diode conducts only in one direction.

Component	I-V graph	What happens to resistance
Fixed resistor	Straight line through the origin	Constant
Filament lamp	Curve that flattens	Increases as the filament gets hotter

Component	I-V graph	What happens to resistance
Diode	Zero in reverse, steep rise above about 0.6 V forward	Very high in reverse, low in forward
Thermistor (NTC)	Curve that steepens as it heats	Decreases as temperature rises
LDR	Steeper in brighter light	Decreases as light intensity rises

In the lamp, metal ions in the hot filament vibrate more and collide with moving electrons more often, so the resistance climbs. A diode acts as a one-way valve, so it is used to protect circuits and to convert alternating current to direct current.

How do thermistors and LDRs work?



Both sensors have resistance that falls as the thing they sense increases.

A thermistor (negative temperature coefficient, NTC) releases more charge carriers when heated, so its resistance falls. A light-dependent resistor (LDR) does the same in brighter light. Because the resistance changes, the current in a circuit changes, and that signal can switch on a fire alarm, a heater or a street lamp.

Worked example 3

A thermistor has resistance $2.0 \text{ k}\Omega$ and is connected across a 6.0 V supply. Calculate the current.

$R = 2000 \text{ }\Omega$. $I = V \div R = 6.0 \div 2000 = 0.0030 \text{ A} = \mathbf{3.0 \text{ mA}}$. If it gets hotter, R falls and the current rises.

Common mistake

Forgetting to convert $\text{k}\Omega$ to Ω or mA to A . A resistance of $2.0 \text{ k}\Omega$ is $2000 \text{ }\Omega$, and 3 mA is 0.003 A .

Lina's tip

Cover the quantity you want in the triangle V over $I \times R$: cover V to see $I \times R$, cover I to see $V \div R$, cover R to see $V \div I$.

Key points to remember

- $V = I \times R$; $R = V \div I$; $I = V \div R$.
- 1 volt = 1 joule per coulomb; energy $W = Q \times V$.
- Ohm's law: I is proportional to V at constant temperature.
- Filament lamp resistance rises with temperature; a diode conducts one way only.
- NTC thermistor and LDR resistances decrease with temperature and light respectively.

Ohm's law and component characteristics: frequently asked questions

What is Ohm's law?

For an ohmic component at constant temperature, current is directly proportional to potential difference, so $V = I \times R$ with a constant R . The I-V graph is a straight line through the origin.

What is the difference between current and potential difference?

Current is the flow of charge each second, measured in amperes. Potential difference is the energy given to or taken from each coulomb, measured in volts.

Why does the resistance of a filament lamp increase?

As the filament heats, the metal ions vibrate more and collide with electrons more often. This makes it harder for charge to flow, so the resistance rises.

What does a diode do?

A diode lets current pass in one direction only. In the reverse direction its resistance is very large, and in the forward direction it conducts above about 0.6 V.

How does a thermistor change with temperature?

The resistance of an NTC thermistor decreases as its temperature rises. This is used in thermostats and fire alarms.