Electric Circuits

Matthew Williams • Physics • May 20, 2026

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Circuit Symbols and Diagrams

Standard circuit diagrams use internationally recognised symbols. Key components and their symbols:

Component	Symbol description
Cell	Long line (positive) + short line (negative)
Battery	Multiple cell symbols in series
Switch	Gap that can be bridged
Resistor	Rectangle
Variable resistor	Rectangle with diagonal arrow
Lamp	Circle with cross
Ammeter	Circle labelled A
Voltmeter	Circle labelled V
Fuse	Rectangle with line through it
Diode	Triangle pointing to vertical line

Series Circuits

In a **series circuit**, components are connected end-to-end in a single loop:

- The same **current** flows through every component.
- The total **p.d.** of the supply equals the sum of the p.d.s across each component.
- The equivalent (total) resistance is the sum of all resistances:

$$R_s = R_1 + R_2 + R_3 + \dots$$

Removing or breaking any component breaks the entire circuit.

<ThemedImage

srcLight="/media/physics/circuit-series-light.png"

srcDark="/media/physics/circuit-series-dark.png"

alt="Series circuit diagram: a 6 V battery and switch connected in series with an ammeter (A) and three resistors R1 (2 ohm), R2 (5 ohm), and R3 (10 ohm) in a single loop; a voltmeter (V) is connected in parallel across R2"

caption="Series circuit: the ammeter sits in the main loop (same current everywhere); the voltmeter bridges across R2 only."

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Parallel Circuits

In a **parallel circuit**, components are connected across common junction points (they share the same two nodes):

- The **p.d.** across each branch is the same (equal to the supply p.d.).
- The total **current** from the supply equals the sum of currents through each branch.
- The equivalent resistance satisfies:

$$\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \dots$$

The equivalent resistance of a parallel combination is always **less** than the smallest individual resistance. Adding more parallel branches reduces the overall resistance.

<ThemedImage

srcLight="/media/physics/circuit-parallel-light.png"

srcDark="/media/physics/circuit-parallel-dark.png"

alt="Parallel circuit diagram: a 6 V battery with an ammeter (A) in the main line connects to two parallel branches, R1 (2 ohm) on top and R2 (5 ohm) below; a voltmeter (V) is connected across both branches"

caption="Parallel circuit: the ammeter measures total current from the supply; the voltmeter reads the common p.d. across both branches."

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Measuring Current and Voltage

Ammeters measure current and are connected **in series** with the component being measured (so the same current flows through both).

Voltmeters measure p.d. and are connected **in parallel** across the component (so they share the same two nodes). A voltmeter must have very high resistance so it does not divert significant current.

Series and parallel resistances (2019 Paper 02, Q5)

Three resistors of 2 Ω, 5 Ω and 10 Ω are connected first in series, then in parallel to a 6 V supply.

Series equivalent resistance:

$$R_s = 2 + 5 + 10 = 17\Omega$$

Parallel equivalent resistance:

$$\frac{1}{R_p} = \frac{1}{2} + \frac{1}{5} + \frac{1}{10}$$

$$\frac{1}{R_p} = \frac{5}{10} + \frac{2}{10} + \frac{1}{10}$$

$$\frac{1}{R_p} = \frac{8}{10}$$

$$R_p = \frac{10}{8}$$

$$R_p = 1.25\ \Omega$$

Total current from 6 V supply in parallel circuit:

$$I = \frac{V}{R_p}$$

$$I = \frac{6}{1.25}$$

$$I = 4.8\ \mathrm{A}$$

Cells: Primary and Secondary

Type	Description	Examples
Primary cell	Cannot be recharged, chemical energy converts to electrical energy until exhausted	Zinc-carbon, alkaline batteries
Secondary cell	Can be recharged by passing current through it in reverse	Lead-acid (car battery), lithium-ion (phones)

Cells connected in **series** add their EMFs. Cells connected in **parallel** keep the same EMF but can supply more current (longer life).

📝 **Exam Tip**

For parallel resistance calculations, find $1/R_p$
first by adding the reciprocals, then take the reciprocal of the total. A common error is forgetting to take the final reciprocal.

When two resistors are in parallel, the shortcut formula is: $Rp = \frac{R1R2}{R1+R_2}$.

An ammeter goes in series; a voltmeter goes in parallel. Getting this wrong in a diagram loses marks.