

ELECTRIC CIRCUITS

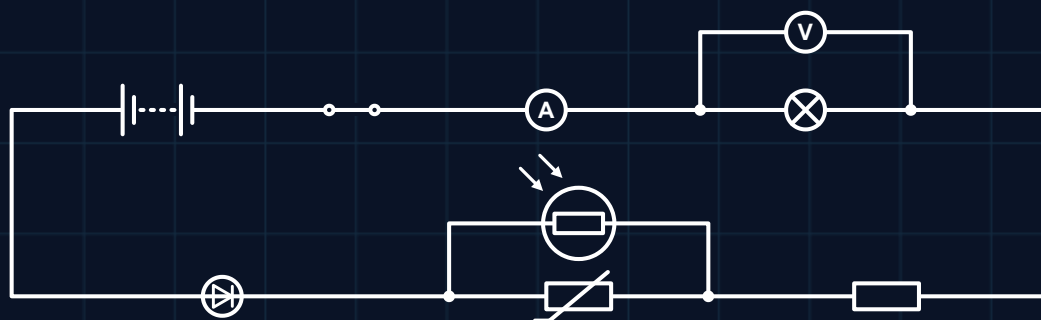
LESSON 06 SERIES AND PARALLEL CIRCUITS

When one bulb in your kitchen blows, why don't all the other lights in the house go out?

IN THIS LESSON YOU WILL

- tell series and parallel circuits apart
- use the rules for current and p.d. in each
- calculate total resistance in series
- explain why adding a parallel branch lowers the total resistance

ANSWER EDITION FOR TEACHERS AND SELF-MARKING



NAME

CLASS

TEACHER

TARGET GRADE

HOW THIS BOOKLET WORKS

This is the booklet for **Lesson 6** of the Electric Circuits unit. It builds on the lessons before it; the “Do now” questions and the quick answers at the back help you check what you remember. Keep it: it is your classwork book *and* your revision guide.



DO NOW

Quick questions from earlier lessons. Remembering again is what makes it stick.



LEARN IT

The explanation, diagrams and worked examples. Read this again when you revise.



TRY IT

Practice that builds up: first with support, then on your own.



LAB

Record measurements from a virtual lab or a required practical.



EXAM CORNER

An AQA-style question with a tip on how the marks are given.



REVISE IT

Summary, cover-and-answer questions and an “I can” check to colour in.



Revising at home? (1) Read the Learn it pages. (2) Cover them and answer the “Cover the page” questions in Revise it. (3) Check with the quick answers at the back.

THE ROUTE THROUGH THE UNIT (THIS LESSON IS HIGHLIGHTED)

01 Complete circuits and symbols

03 Potential difference

05 Resistance of a wire RP

07 Resistors in series and parallel RP

09 Investigating I–V characteristics RP

11 Power and energy transfer

02 Current and charge

04 Resistance and $V = IR$

06 **Series and parallel circuits**

Current, p.d. and resistance rules for series and parallel circuits

08 I–V graphs

10 Thermistors, LDRs and sensors

12 Mains, safety and the National Grid

SERIES AND PARALLEL CIRCUITS

AQA Combined 6.2.2; Physics 4.2.2

BIG QUESTION When one bulb in your kitchen blows, why don't all the other lights in the house go out?

BY THE END YOU CAN

- tell series and parallel circuits apart
- use the rules for current and p.d. in each
- calculate total resistance in series
- explain why adding a parallel branch lowers the total resistance

series

parallel

branch

junction

total resistance



RETRIEVE

DO NOW

From earlier lessons. No notes!

1

0.50 A flows through a 12 Ω resistor. Calculate the p.d.

$$V = 0.50 \times 12 = 6.0 \text{ V}$$

2

How does the resistance of a wire depend on its length?

Directly proportional.

3

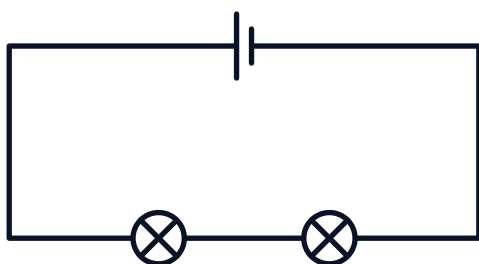
What is the unit of p.d., and what does it mean?

Volt; joules per coulomb.

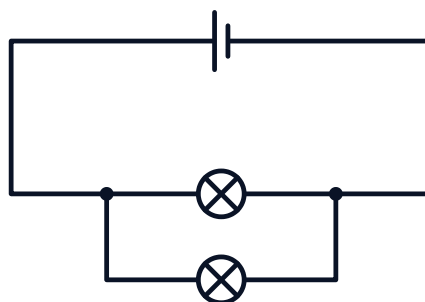


EXPLAIN

TWO WAYS TO CONNECT



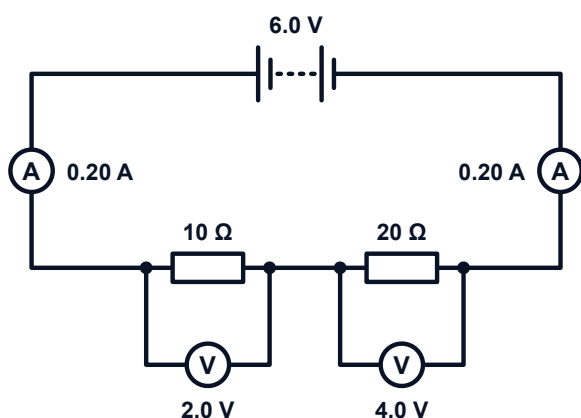
Series: one loop.



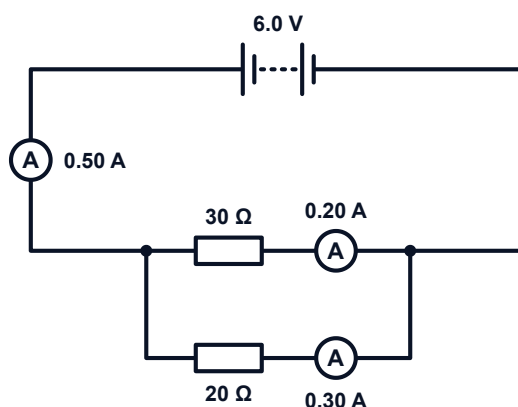
Parallel: two branches.

In **series** there is one loop. In **parallel** the current splits at a **junction** into separate **branches**, and each branch makes its own loop through the cell.

	SERIES (ONE LOOP)	PARALLEL (BRANCHES)
Current	the same everywhere	splits at a junction; branch currents add up to the supply current
p.d.	shared : component p.d.s add up to the supply p.d.	the same across each branch as across the supply
Resistance	adds : $R_{\text{total}} = R_1 + R_2$	total is less than the smallest branch resistance
One lamp breaks	all the lamps go out	the other branches keep working



Series: the same current everywhere; $2.0 \text{ V} + 4.0 \text{ V} = 6.0 \text{ V}$.



each branch has 6.0 V across it

Parallel: $0.20 \text{ A} + 0.30 \text{ A} = 0.50 \text{ A}$ from the battery.

$$R_{\text{total}} = R_1 + R_2$$

total resistance of components in series

all resistances in ohms (Ω)

Adding a resistor in series always increases the total resistance.

WORKED EXAMPLE

A $5.0\ \Omega$ and a $7.0\ \Omega$ resistor are in series with a $6.0\ \text{V}$ battery. Find the total resistance, the current and the p.d. across each resistor.

TOTAL R $5.0 + 7.0 = 12\ \Omega$

CURRENT $I = V \div R = 6.0 \div 12 = 0.50\ \text{A}$

P.D. $5\ \Omega$ $V = IR = 0.50 \times 5.0 = 2.5\ \text{V}$

P.D. $7\ \Omega$ $V = 0.50 \times 7.0 = 3.5\ \text{V}$

CHECK $2.5\ \text{V} + 3.5\ \text{V} = 6.0\ \text{V} \checkmark$

YOUR TURN

A $2.0\ \Omega$ and a $6.0\ \Omega$ resistor are in series with a $12\ \text{V}$ battery. Find the same four things.

TOTAL R $8.0\ \Omega$

CURRENT $I = 12 \div 8.0 = 1.5\ \text{A}$

P.D. $2\ \Omega$ $1.5 \times 2.0 = 3.0\ \text{V}$

P.D. $6\ \Omega$ $1.5 \times 6.0 = 9.0\ \text{V}$

CHECK $3.0 + 9.0 = 12\ \text{V} \checkmark$

WHY DOES A PARALLEL BRANCH LOWER THE RESISTANCE?

Think of supermarket checkouts. Opening a second checkout does not slow down the first one: it gives shoppers *another route*, so more people get through each minute. A parallel branch is another route for charge. The supply current goes up at the same p.d., so the total resistance ($V \div I$) goes down.

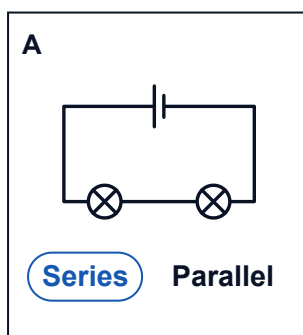
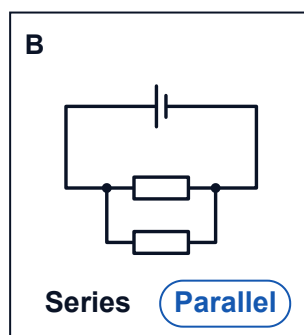
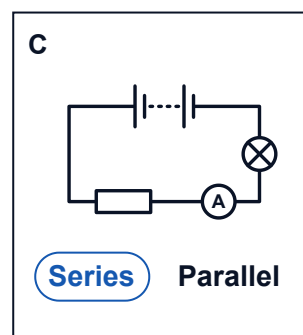
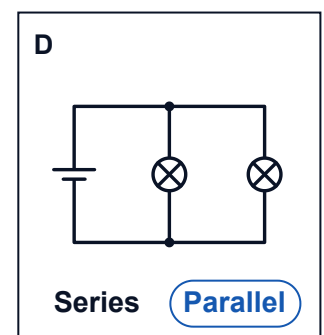
Where the model breaks: shoppers choose a queue; charge divides according to each branch's resistance.



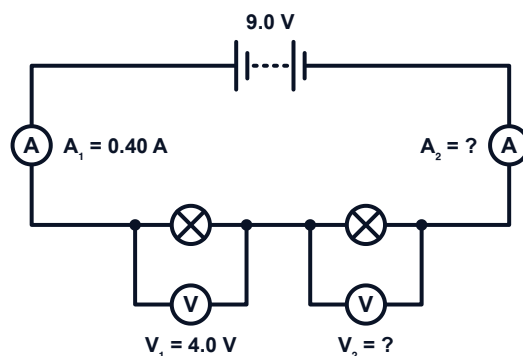
PRACTISE

TRY IT

1 Is each circuit series or parallel? Circle one.

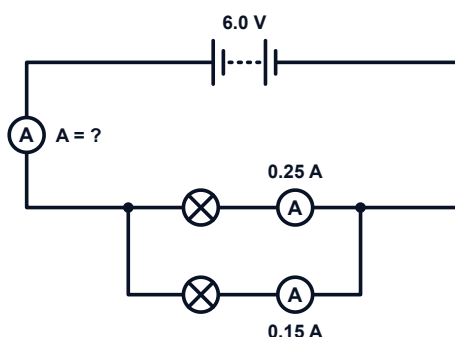


- 2 Series circuit: write down the readings on A_2 and V_2 . Give a reason for each.



$A_2 = 0.40 \text{ A}$ (same current everywhere in series). $V_2 = 9.0 - 4.0 = 5.0 \text{ V}$ (p.d.s add up to the supply p.d.).

- 3 Parallel circuit: what does ammeter A read? What is the p.d. across each lamp?



$A = 0.25 + 0.15 = 0.40 \text{ A}$. Each lamp has 6.0 V across it (the same as the supply).

- 4 **SUPPORTED** A 10Ω and a 20Ω resistor are in series with a 6.0 V battery. Calculate the total resistance and the current.

TOTAL R	$10 + 20 = 30 \Omega$	
EQUATION	$I = V \div R$	
SUBSTITUTE	$I = 6.0 \div 30$	
ANSWER	0.20 A	unit:

- 5 A 6.0Ω and a 12Ω resistor are connected in **parallel**. Which could be their total resistance?

☐ 18Ω

☐ 9.0Ω

☐ 6.0Ω

☒ 4.0Ω

Less than the smallest resistor (6.0Ω), so 4.0Ω .

- 6 Answer the big question. Give **two** reasons why the lights in a house are wired in parallel.

If one lamp breaks, the others stay on (each branch is its own loop). Each lamp gets the full supply p.d. Each light can be switched on and off on its own.



AQA-STYLE

EXAM CORNER

Write in full sentences. Show every step of a calculation.

Get the marks: Show the equation for each step. You can still get later marks with an earlier wrong answer if your method is right.

- 7 A $4.0\ \Omega$ resistor and an $8.0\ \Omega$ resistor are connected in series to a $9.0\ \text{V}$ battery. (a) Calculate the total resistance. (b) Calculate the current. (c) Calculate the p.d. across the $8.0\ \Omega$ resistor. **[5 marks]**

(a) $4.0 + 8.0 = 12\ \Omega$ (1). (b) $I = V \div R$ (1) $= 9.0 \div 12 = 0.75\ \text{A}$ (1). (c) $V = I R = 0.75 \times 8.0$

(1) $= 6.0\ \text{V}$ (1).



SUMMARY

- Series: **same current**; p.d.s **add up**; $R_{\text{total}} = R_1 + R_2$.
- Parallel: **same p.d.** across each branch; branch currents **add up**.
- Adding a branch in parallel **lowers** the total resistance: there is another path, so more current flows.
- Houses are wired in parallel.

COVER THE PAGE AND ANSWER

1 In series, what is the same everywhere?

2 In parallel, what is the same for each branch?

3 Total resistance of $3\ \Omega$ and $5\ \Omega$ in series?

4 Branch currents $0.2\ \text{A}$ and $0.3\ \text{A}$. Supply current?

I CAN...

tell series and parallel circuits apart



use the current and p.d. rules in series and parallel



calculate total resistance, current and p.d.s in a series circuit



explain why parallel branches reduce the total resistance



EQUATION TOOLKIT

The equations you have met so far. You will meet these one at a time. Learn each equation **in words** as well as symbols: AQA gives you an equation sheet in the exam (it does not include $R_{\text{total}} = R_1 + R_2$), but knowing the equations by heart makes every question faster.

$$Q = I t$$

Lesson 2

charge flow = current × time

C, A, s

Rearranged: $I = Q \div t$ and $t = Q \div I$

$$E = Q V$$

Lesson 3

energy transferred = charge ×
p.d.

J, C, V

Rearranged: $V = E \div Q$ and $Q = E \div V$

$$V = I R$$

Lesson 4

p.d. = current × resistance

V, A, Ω

Rearranged: $I = V \div R$ and $R = V \div I$

$$R_{\text{total}} = R_1 + R_2$$

Lesson 6

total resistance in series

Ω

Rearranged: (series only)

FOUR STEPS FOR EVERY CALCULATION

1

Write down what you know, with units.
Convert units first
(minutes → seconds,
kW → W, mA → A).

2

Write the equation you will use, in symbols.

3

Substitute the numbers, then rearrange if needed.

4

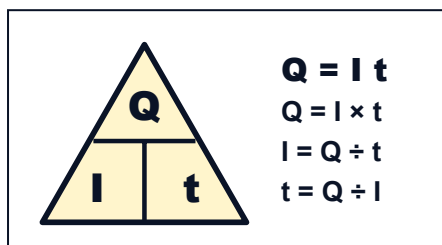
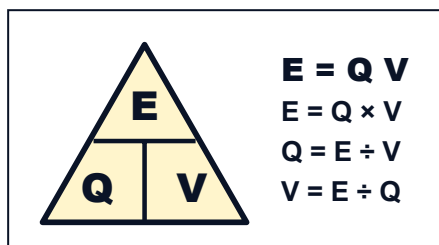
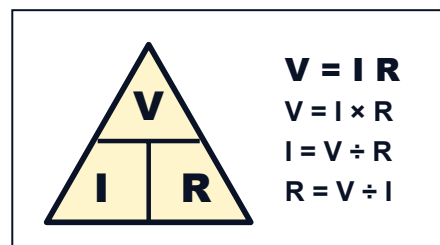
Give the answer with a unit. Ask: is it sensible?

CONVERT	HOW	EXAMPLE
minutes → seconds	× 60	3.0 min = 180 s
hours → seconds	× 3600	2.0 h = 7200 s
milliamps (mA) → amps (A)	÷ 1000	250 mA = 0.25 A
kilowatts (kW) → watts (W); kilohms (k Ω) → ohms (Ω)	× 1000	2.2 kW = 2200 W
kilovolts (kV) → volts (V)	× 1000	400 kV = 400 000 V

■ EQUATION TRIANGLES: HELP WITH REARRANGING

- 1 Cover the quantity you want to find.
- 2 The two left **side by side**? **Multiply** them.
- 3 One **above** the other? **Divide** the top by the bottom.

Example: to find I from $Q = I t$, cover I . Q is above t , so $I = Q \div t$. Triangles only help with rearranging: you still need to learn each equation.



CHECK YOURSELF

QUICK ANSWERS

Answers to the “Do now” and “Cover the page” questions, so you can check yourself when revising. Answers to the longer questions are in your teacher's answer edition.

DO NOW

1. $V = 0.50 \times 12 = 6.0 \text{ V}$
2. Directly proportional.
3. Volt; joules per coulomb.

COVER THE PAGE

1. The current.
2. The p.d.
3. 8Ω
4. 0.5 A