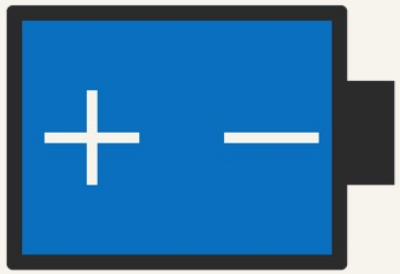
ELECTRICITY 2 · CURRENT, P.D., POWER & RESISTANCE

Current, Power & Resistance



The four quantities every circuit question is built from.

Higher Physics

Starter

2008 Higher Physics

Scan the code and answer these:

Q15

Section A · uncertainty (measurements)

Show your working, not just the letter.

Scan for the paper

Marking scheme

PART 1

Charge and current

Current is not a thing that sits in a wire. It is a rate — how much charge goes past, every second.

By the end of this part…

1. I can state what electric current is.
2. I can use the relationship between charge, current and time.
3. I can rearrange it to find charge, current or time.

What current actually is

- Charge is measured in coulombs. Current is measured in amperes.
- A current of 1 ampere means 1 coulomb of charge passes a point every second.
- So current is the rate of flow of charge — charge divided by time.

Charge, current and time

JOTTER NOTES

$$Q = It$$

Q	I	t
charge in coulombs (C)	current in amperes (A)	time in seconds (s)

JOTTER NOTES

Charge and current

Electric current is the rate of flow of charge — how much charge goes past a point each second.

A current of one ampere means one coulomb of charge passes every second.

The time in this relationship is always in seconds, so convert minutes before you substitute.

Worked example — charge from current

A current of $3.0\ \text{A}$ flows for $40\ \text{s}$.

Calculate the charge that passes.

$\text{I} = 3.0\ \text{A}$

$\text{t} = 40\ \text{s}$

$\text{Q} = ?$

$Q = It$

$\text{Q} = 3.0 \times 40$

$\underline{\text{Q} = 120\ \text{C}}$

Watch Out — seconds, every time

THE MISTAKE

- Substituting a time given in minutes
- Mixing up charge and current

THE CORRECT ANSWER

- Convert to seconds before substituting.
- Charge is coulombs; current is coulombs per second.

Show Me: charge and current

SHOW ME BOARDS

1. State what is meant by an electric current of $1\ \text{ampere}$.

2. A current of $2.0\ \text{A}$ flows for $60\ \text{s}$. Calculate the charge passed.

3. A charge of $60\ \text{C}$ passes in $20\ \text{s}$. Calculate the current.

4. A charge of $240\ \text{C}$ is moved by a current of $2.0\ \text{A}$. Calculate the time taken.

5. A current of $0.50\ \text{A}$ flows for $2.0\ \text{minutes}$. Calculate the charge passed.

Task

Work through the charge and current questions.
Convert every time to seconds before you substitute.

Scholar: quizzes 3.2.1 - 3.2.2

Starter

Revised Higher Specimen

Scan the code and answer these:

Q4

Section A · uncertainty (% uncertainties)

Show your working, not just the letter.

Scan for the paper

Marking scheme

PART 2

Ohm's law and resistance

One relationship ties the three quantities together — and almost every circuit question starts by using it.

By the end of this part…

1. I can state what resistance is.
2. I can use V = IR to find potential difference, current or resistance.
3. I can apply it to one component or to a whole circuit.

Resistance

- Resistance is how strongly a component opposes the current through it.
- It is measured in ohms. A bigger resistance means a smaller current for the same potential difference.
- Potential difference, current and resistance are linked by one relationship.

V = IR

JOTTER NOTES

$$V = IR$$

V	I	R
potential difference in volts (V)	current in amperes (A)	resistance in ohms (Ω)

JOTTER NOTES

Ohm's law

Resistance is a measure of how strongly a component opposes the current in it.

The potential difference across a component equals the current in it multiplied by its resistance.

You can use this for one component on its own, or for a whole circuit — as long as the values all belong to the same thing.

Worked example — finding a resistance

The potential difference across a resistor is $12\ \text{V}$ and the current in it is $3.0\ \text{A}$. Calculate its resistance.

$\text{V} = 12\ \text{V}$

$\text{I} = 3.0\ \text{A}$

$\text{R} = ?$

$V = IR$

$R = V/I$

$\text{R} = 12 \ / \ 3.0$

$\underline{\text{R} = 4.0\ \Omega}$

Watch Out — keep to one component

THE MISTAKE

- Using the supply voltage with one resistor's resistance
- Mixing values from different parts of a circuit

THE CORRECT ANSWER

- V, I and R must all belong to the same component.
- Label which resistor each value belongs to.

Show Me: Ohm's law

SHOW ME BOARDS

1. State what is meant by the resistance of a component.
2. A resistor carries $0.25\ \text{A}$ and has resistance $48\ \Omega$. Calculate the p.d. across it.
3. A $45\ \Omega$ resistor has $9.0\ \text{V}$ across it. Calculate the current in it.
4. A component carries $2.0\ \text{A}$ with $10\ \text{V}$ across it. Calculate its resistance.
5. State and justify what happens to the current if the resistance is doubled and the p.d. is unchanged.

Task

Work through the Ohm's law questions. Label every value with the component it belongs to.

Scholar: quizzes 3.2.3 - 3.2.4

Starter

2014 Higher Physics

Scan the code and answer these:

Q21

Section A · uncertainty (reaction time)

Show your working, not just the letter.

Scan for the paper

Marking scheme

PART 3

Series and parallel

Two ways to wire resistors together, and two completely different rules for adding them up.

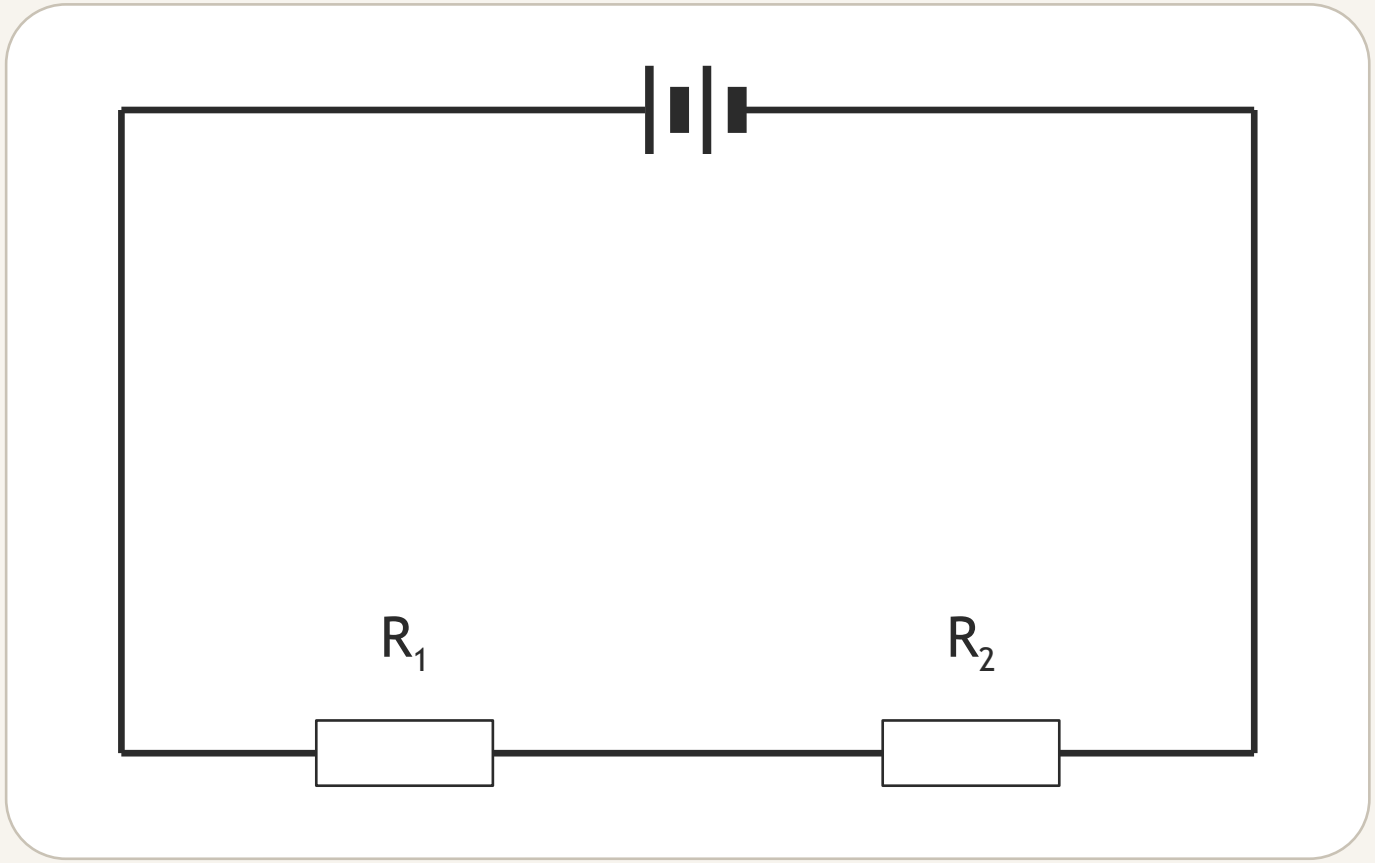
By the end of this part…

1. I can find the total resistance of resistors in series.
2. I can find the total resistance of resistors in parallel.
3. I can work out the total resistance of a mixed circuit.

Resistors in series

JOTTER NOTES

One path. The same current goes through every resistor.



JOTTER NOTES

Resistors in series

In series there is only one path, so the current is the same everywhere in the circuit.

The supply voltage is shared between the resistors.

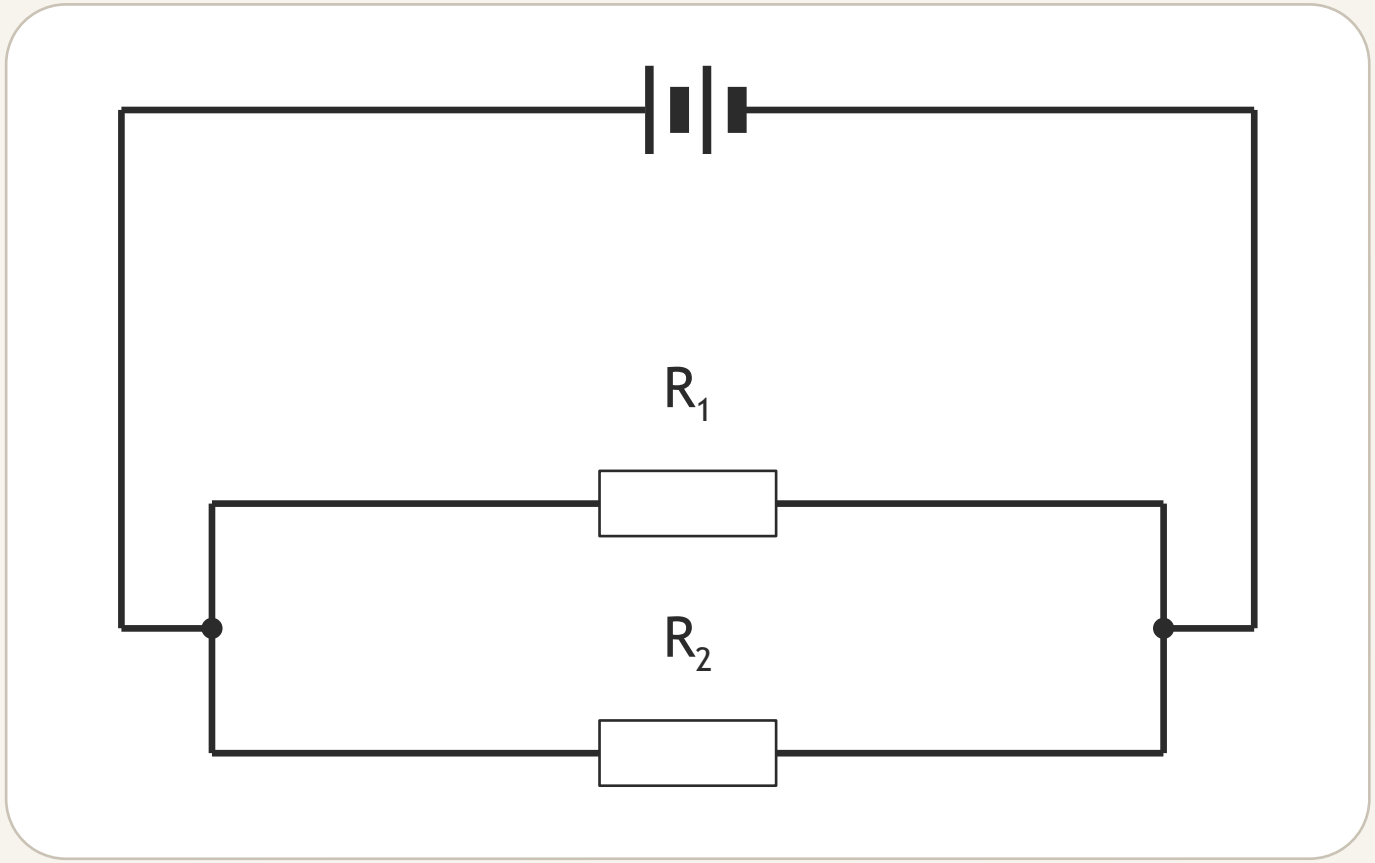
The total resistance is just the separate resistances added together, so adding a resistor in series always increases it.

$$R_T = R_1 + R_2 + R_3$$

Resistors in parallel

JOTTER NOTES

More than one path. The current splits between them.



JOTTER NOTES

Resistors in parallel

In parallel there is more than one path, so the current splits between the branches.

Every branch has the full supply voltage across it.

Adding a resistor in parallel gives the current another route, so the total resistance goes DOWN.

$$1/R_T = 1/R_1 + 1/R_2 + 1/R_3$$

JOTTER NOTES

The parallel trap

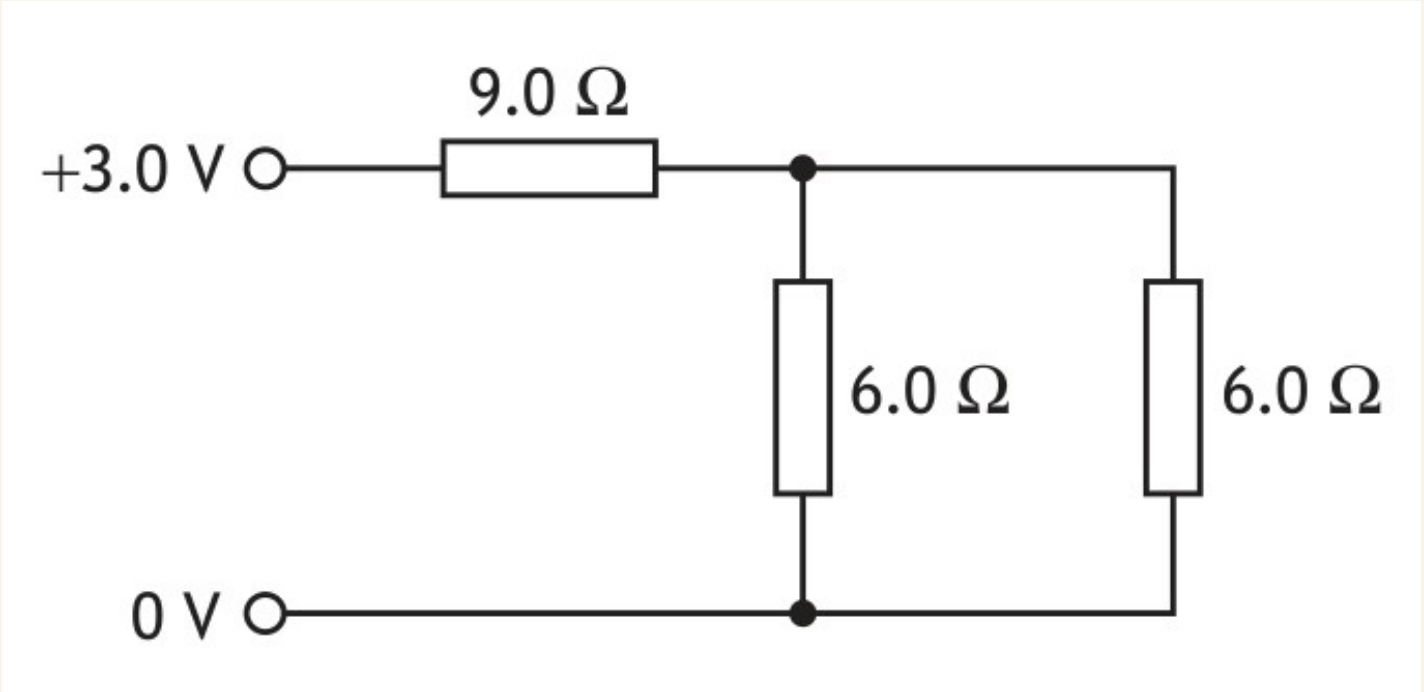
The parallel relationship gives you one over the total, not the total itself.

So the last step is always to turn that answer upside down.

A total parallel resistance is always smaller than the smallest single branch — if it is not, you have forgotten the last step.

A mixed circuit in an exam

One resistor in series with two more in parallel.



JOTTER NOTES

Working through a mixed circuit

Deal with the parallel group first, and replace it with its single total resistance.

Then the circuit is just resistors in series, and you add them.

Here the two six-ohm resistors in parallel come to three ohms, which in series with nine ohms gives twelve ohms altogether.

Worked example — resistors in parallel

Two 6.0 Ω resistors are connected in parallel.

Calculate the total resistance of the pair.

$R_1 = 6.0\ \Omega$

$R_2 = 6.0\ \Omega$

$R_T = ?$

$1/R_T = 1/R_1 + 1/R_2$

$1/R_T = 1/6.0 + 1/6.0$

$1/R_T = 0.333$

$\underline{R_T = 3.0\ \Omega}$

Watch Out — turn it back up the right way

THE MISTAKE

- Stopping at 1/R and calling it the answer
- Adding parallel resistors like series ones

THE CORRECT ANSWER

- The last step is to invert it.
- Parallel always gives LESS than the smallest branch.

Show Me: series and parallel

SHOW ME BOARDS

1. Three resistors of $10\ \Omega$, $20\ \Omega$ and $30\ \Omega$ are in series. Calculate the total resistance.

2. Two $20\ \Omega$ resistors are in parallel. Calculate the total resistance.

3. A $12\ \Omega$ and a $4.0\ \Omega$ resistor are in parallel. Calculate the total resistance.

4. State and justify what happens to the total resistance when a resistor is added in parallel.

5. A $9.0\ \Omega$ resistor is in series with two parallel $6.0\ \Omega$ resistors. Calculate the total resistance.

Task

Work through the series and parallel questions.
Redraw every mixed circuit with the parallel group replaced by one resistor.

Scholar: quizzes 3.2.5 - 3.2.6
Past papers: 2025 Q19, 2022 Q20

Past Paper Finder

Starter

2015 Higher Physics

Scan the code and answer these:

Q16

Section A · uncertainty (wavelength)

Show your working, not just the letter.

Scan for the paper

Marking scheme

PART 4

Electrical power

Three ways to write the same idea — and picking the right one saves you a step.

By the end of this part…

1. I can state what electrical power is.
2. I can use all three power relationships.
3. I can choose the one that fits the values I have been given.

What power is

- Power is the rate at which energy is transferred — joules per second, which is watts.
- In a circuit, energy is transferred whenever charge is pushed through a resistance.
- There are three ways of writing electrical power, and all three are on the relationships sheet.

P = IV

JOTTER NOTES

$$P = IV$$

P	I	V
power in watts (W)	current in amperes (A)	potential difference in volts (V)

The other two forms

JOTTER NOTES

$$P = I^2 R$$

P	I	R
power in watts (W)	current in amperes (A)	resistance in ohms (Ω)

And the third: $P = V^2 / R$, for when you have the voltage and the resistance.

JOTTER NOTES

The three power relationships

Power is the rate of transfer of energy, measured in watts.

Use the first form when you know the current and the voltage.

Use the second when you know the current and the resistance, and the third when you know the voltage and the resistance.

All three are on the relationships sheet — choose the one that fits the values you already have.

Worked example — choosing a power relationship

A resistor of 15 Ω carries a current of 2.0 A.

Calculate the power dissipated in it.

I = 2.0 A

R = 15 Ω

P = ?

$P = I^2 R$

$P = 2.0^2 \times 15$

$\underline{P = 60\ \text{W}}$

Watch Out — square only the right thing

THE MISTAKE

- Writing $P = IR^2$ instead of $P = I^2R$
- Squaring the resistance in $P = V^2/R$

THE CORRECT ANSWER

- It is the CURRENT that is squared.
- In the third form it is the VOLTAGE that is squared.

Show Me: power

SHOW ME BOARDS

1. A component carries $0.50\ \text{A}$ with $24\ \text{V}$ across it. Calculate the power.
2. A $6.0\ \Omega$ resistor has $12\ \text{V}$ across it. Calculate the power.
3. A $5.0\ \Omega$ resistor dissipates $45\ \text{W}$. Calculate the current in it.
4. A resistor with $24\ \text{V}$ across it dissipates $48\ \text{W}$. Calculate its resistance.
5. State which power relationship you would use given only the current and the resistance.

Task

Work through the power questions.
Write down which of the three relationships you chose, and why.

Scholar: quiz 3.2.7
Past papers: 2024 Q19, 2025 Q20

Past Paper Finder

Starter

2010 Higher Physics

Scan the code and answer these:

Q24

Section A · uncertainty (ball timing)

Show your working, not just the letter.

Scan for the paper

Marking scheme

PART 5

Potential dividers

Two resistors in series across a supply, and a tapping point between them — the circuit behind almost every sensor.

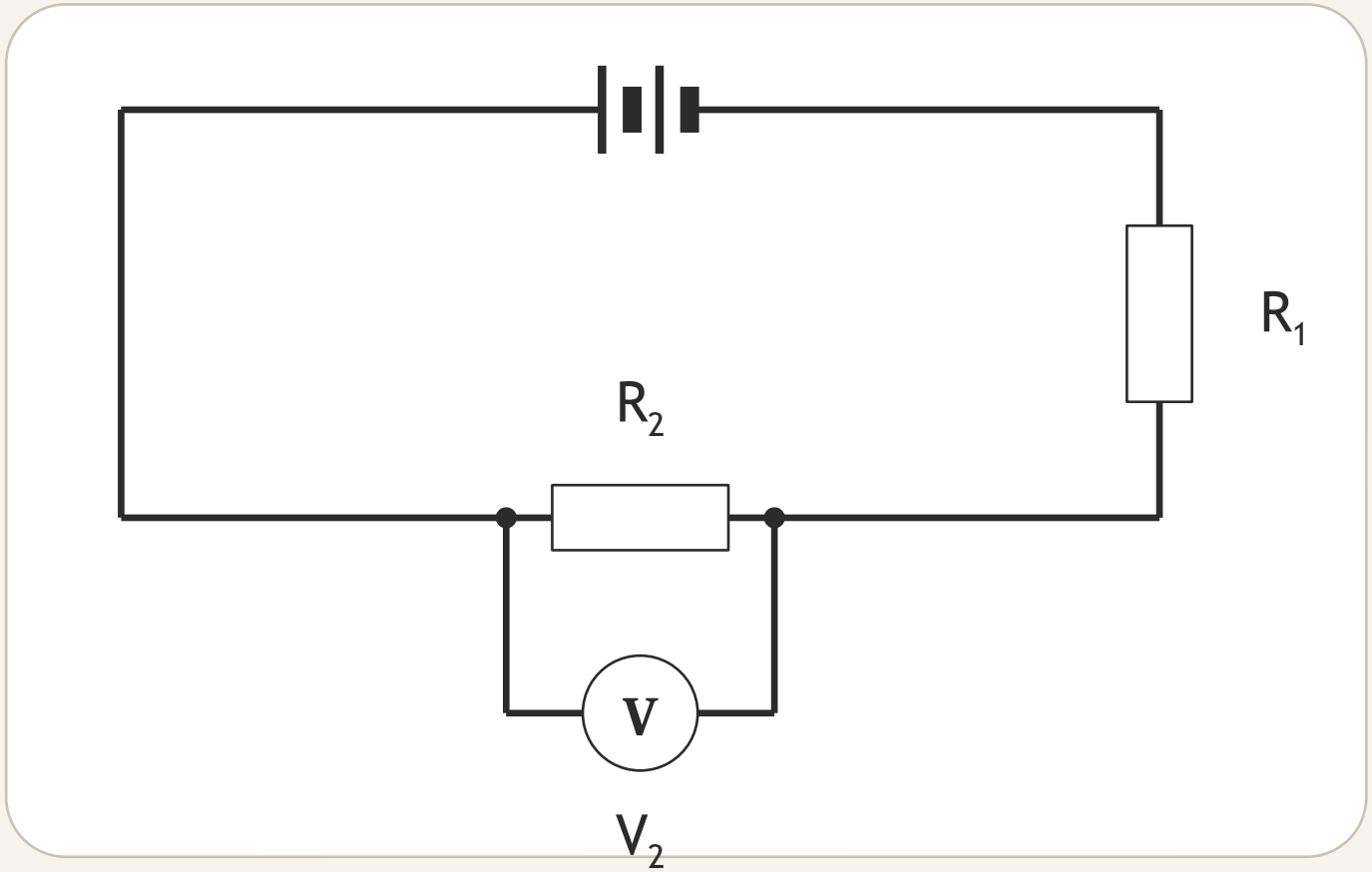
By the end of this part…

1. I can describe what a potential divider does.
2. I can calculate the output voltage of a potential divider.
3. I can use the ratio form to find a missing resistance.

The potential divider

JOTTER NOTES

Two resistors in series. The output is taken across one of them.



JOTTER NOTES

What a potential divider does

Two resistors in series share the supply voltage between them.

The bigger a resistor's share of the total resistance, the bigger its share of the voltage.

Taking the output across just one of them gives you a voltage smaller than the supply — which is the whole point.

The potential divider relationship

JOTTER NOTES

$$V_2 = R_2/(R_1 + R_2)\, V_s$$

V_2	R_2	R_1	V_s
output p.d. (V)	resistance across the output (Ω)	the other resistance (Ω)	supply p.d. (V)

The ratio form

JOTTER NOTES

$$V_1/V_2 = R_1/R_2$$

V_1	V_2	R_1	R_2
p.d. across R_1 (V)	p.d. across R_2 (V)	first resistance (Ω)	second resistance (Ω)

JOTTER NOTES

Using the two forms

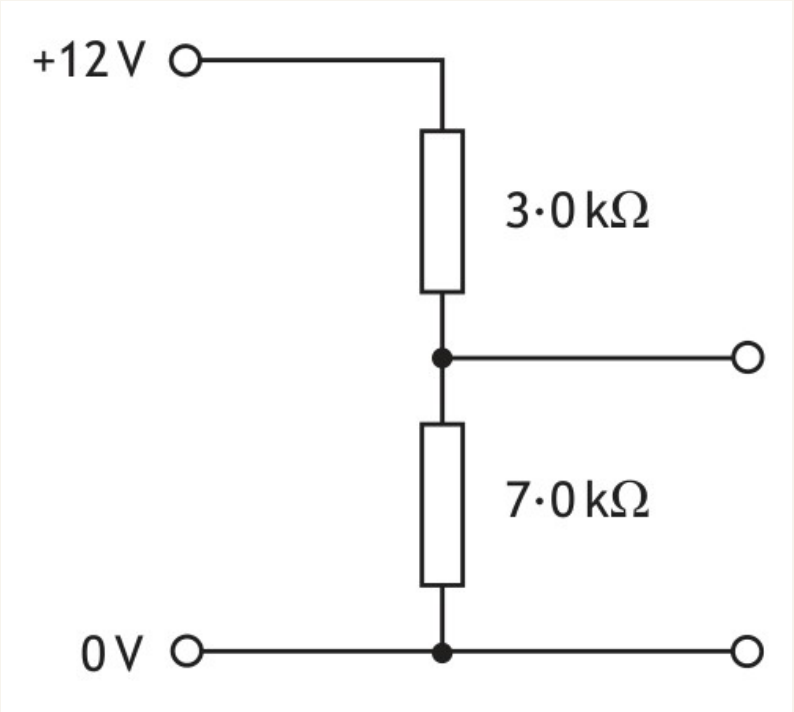
The first form gives you the output voltage straight away when you know both resistances and the supply.

The ratio form says the voltages are shared in the same proportion as the resistances.

Neither relationship has anything squared in it. Copy them from the relationships sheet rather than from memory.

A potential divider in an exam

A 3.0 kΩ and a 7.0 kΩ resistor across a 12 V supply.



JOTTER NOTES

Reading a divider circuit

The supply voltage sits across both resistors added together.

The output is taken from the point between the two resistors.

Here the seven-kilohm resistor is seven tenths of the total, so it takes seven tenths of the twelve volts.

Worked example — a potential divider

A 12 V supply is across an 8.0 Ω and a 4.0 Ω resistor in series. Calculate the p.d. across the 4.0 Ω resistor.

$V_s = 12\ V$

$R_1 = 8.0\ \Omega$

$R_2 = 4.0\ \Omega$

$V_2 = ?$

$$V_2 = R_2/(R_1 + R_2)\ V_s$$

$$V_2 = (4.0 / (8.0 + 4.0)) \times 12$$

$$V_2 = 0.333 \times 12$$

$$\underline{V_2 = 4.0\ V}$$

Watch Out — subscripts, not powers

THE MISTAKE

- Writing the ratio with squared terms
- Copying a relationship from memory

THE CORRECT ANSWER

- The 1 and 2 are LABELS, not powers.
- Copy it off the relationships sheet.

Show Me: potential dividers

SHOW ME BOARDS

1. A $12\ \text{V}$ supply is across a $6.0\ \Omega$ and a $3.0\ \Omega$ resistor in series. Calculate the p.d. across the $3.0\ \Omega$.
2. A $9.0\ \text{V}$ supply is across a $6.0\ \Omega$ and a $3.0\ \Omega$ resistor. Calculate the p.d. across the $3.0\ \Omega$.
3. A $5.0\ \text{V}$ supply is across a $3.3\ \text{k}\Omega$ and a $2.2\ \text{k}\Omega$ resistor. Calculate the output across the $2.2\ \text{k}\Omega$.
4. A $12\ \text{V}$ supply is across a $10\ \Omega$ and an unknown resistor. The output across the unknown is $4.0\ \text{V}$. Calculate it.
5. State and justify what happens to the output if the resistor across the output is increased.

Task

Work through the potential divider questions.
Copy each relationship from the sheet before you use it.

Exercise 2.2.2 (Page 303/316)
Past papers: 2023 Q20, 2016 Q18

Past Paper Finder

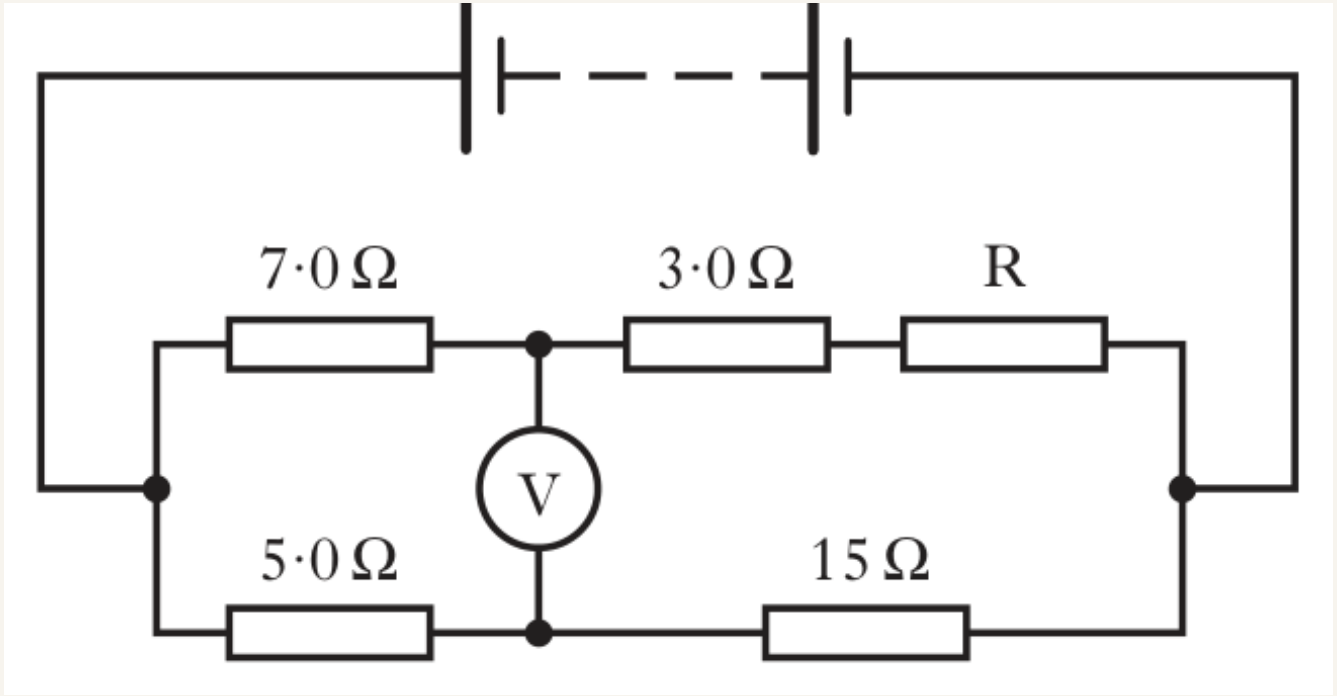
BEYOND THE COURSE

The Wheatstone bridge

Not on the Higher course any more — but the department still sets it, and it is only two potential dividers.

A Wheatstone bridge

Two potential dividers side by side, with a meter between them.



JOTTER NOTES

What a Wheatstone bridge is

A Wheatstone bridge is two potential dividers connected across the same supply.

A meter is connected between the two output points.

It reads the difference between the two output voltages.

When both dividers split the supply in the same ratio, that difference is zero.

A bridge reading zero is said to be balanced.

Show Me: the Wheatstone bridge

SHOW ME BOARDS

1. State what a Wheatstone bridge is made from.
2. State what the meter in a Wheatstone bridge measures.
3. State the condition for a Wheatstone bridge to be balanced.
4. A $12\ \text{V}$ supply is across a $7.0\ \Omega$ and a $5.0\ \Omega$ resistor. Calculate the p.d. across the $5.0\ \Omega$.
5. The other arm has $3.0\ \Omega$ and $15\ \Omega$. Calculate the p.d. across the $15\ \Omega$, then the meter reading.

Task

Work through the Wheatstone bridge question.
Treat each arm as a separate potential divider, then subtract.

Exercise 2.2.2 Q3 only (Page 303/316)

Checkpoint

1. State what is meant by an electric current of $1\ \text{ampere}$.

2. A $45\ \Omega$ resistor has $9.0\ \text{V}$ across it. Calculate the current.

3. Two $20\ \Omega$ resistors are in parallel. Calculate the total resistance, and explain why it is less than $20\ \Omega$.

4. A $6.0\ \Omega$ resistor has $12\ \text{V}$ across it. Calculate the power.

5. A $12\ \text{V}$ supply is across an $8.0\ \Omega$ and a $4.0\ \Omega$ resistor. Calculate the p.d. across the $4.0\ \Omega$.

Exam Practice

2025 Q19 — total resistance of a network.
2025 Q22 — finding a resistance from a circuit.
2024 Q18 — p.d. across one resistor of several.

Past papers, Section A

LOOKING AHEAD

Next: EMF & Internal Resistance

Why a real battery never quite delivers the voltage printed on the label.

Plenary

SHOW ME BOARDS

1. State the relationship between charge, current and time.
2. State what happens to the total resistance when a resistor is added in parallel, and why.
3. State the three relationships for electrical power.
4. A $5.0\ \Omega$ resistor dissipates $45\ \text{W}$. Calculate the current.
5. Explain how a potential divider produces an output smaller than the supply voltage.

Extension

SHOW ME BOARDS

1. Show that two equal resistors in parallel always give a total of half one of them.
2. A lamp is rated $60\ \mathrm{W}$ at $230\ \mathrm{V}$. Calculate its resistance in normal use, and explain why its cold resistance is lower.
3. A thermistor replaces one resistor in a divider. Explain how the output changes as it warms up.