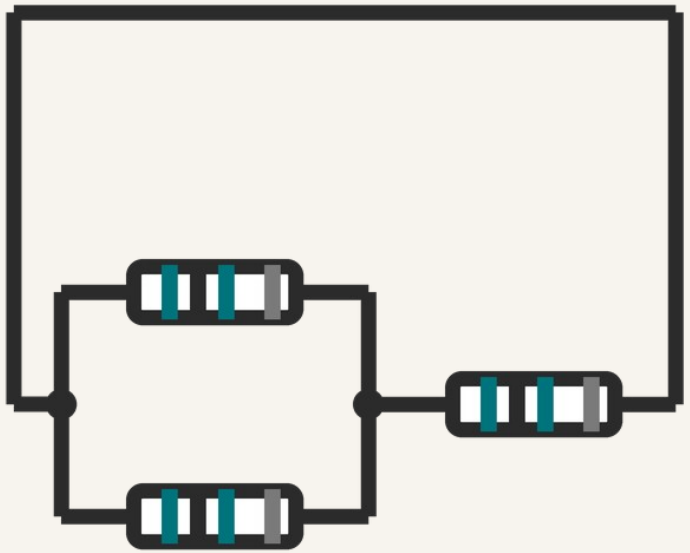
BOOKLET 1 · ELECTRICITY — CIRCUITS

Combining Resistors 2



Branches of different values, and circuits that mix series with parallel.

N5 Physics and Electronics (S3)

Daily Review

Booklet p.11-12 — Combining Resistors 1

1. Write the relationship for resistors in series.

2. Three 100 Ω resistors are in series. Find R_T.

3. Four 200 Ω resistors are in parallel. Find R_T.

4. Is a parallel total bigger or smaller than one branch?

5. Where do the two probes go to measure a total resistance?

PART 1

Different Values

The easy rule only worked because every branch was the same.

By the end of this part…

1. I can predict the total resistance of parallel branches of different values
2. I can measure that total resistance with an ohmmeter
3. I can solve problems involving total resistance in a parallel circuit

Why the easy rule fails

Booklet p.13

- Equal branches take equal shares of the current.
- Unequal branches do not — the smaller resistance takes more.
- So every branch has to be counted separately, one at a time.

The relationship

Booklet p.13 — branches of different values

$$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \cdots$$

R_T

the total resistance of the combination, in ohms (Ω)

R_1, R_2

the separate branches, in ohms (Ω)

Worked example 1

Two branches of different values

Find the total resistance of a 470 Ω and a 220 Ω resistor in parallel.

$R_1 = 470\ \Omega$

$R_2 = 220\ \Omega$

$R_T = ?$

$$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2}$$

$$\frac{1}{R_T} = \frac{1}{470} + \frac{1}{220}$$

$$\frac{1}{R_T} = 0.006673$$

$$\underline{R_T = 149.9\ \Omega}$$

Watch out

THE MISTAKE

- Stopping at $1/R_T$ = 0.006673
- Adding 470 + 220 for a parallel pair
- An answer bigger than one of the branches

THE CORRECT ANSWER

- Invert it — R_T = 149.9 Ω
- Add the reciprocals, then invert
- Always less than the smallest branch — check it

Task 1 — name the three rules

Booklet p.13

Three relationships are printed with a blank beside each.
Write in the word that finishes the sentence.

Booklet p.13, Task 1

Task 1 — Answers

ANSWERS

Booklet p.13 — the three relationships

	The blank	When you use it
1	series	resistors one after another
2	parallel	branches, all the same value
3	parallel	branches, different values

Show me — different values in parallel

SHOW ME BOARDS

1. A 10 Ω and a 15 Ω resistor in parallel. Find R_T.
2. A 20 Ω and a 30 Ω resistor in parallel. Find R_T.
3. A 6 Ω and a 3 Ω resistor in parallel. Find R_T.
4. A 100 Ω and a 400 Ω resistor in parallel. Find R_T.
5. A 2 Ω, a 3 Ω and a 6 Ω resistor in parallel. Find R_T.

Show me — different values in parallel

SHOW ME BOARDS

EXTRA PRACTICE

1. A 12 Ω and a 4 Ω resistor in parallel. Find R_T.
2. A 40 Ω and a 60 Ω resistor in parallel. Find R_T.
3. A 200 Ω and a 50 Ω resistor in parallel. Find R_T.
4. A 5 Ω and a 20 Ω resistor in parallel. Find R_T.
5. A 30 Ω, a 20 Ω and a 12 Ω resistor in parallel. Find R_T.

Daily Review

Booklet p.13 — different values in parallel

1. Write the relationship for parallel branches of different values.

2. Two 10 Ω resistors in parallel. Find R_T.

3. A 30 Ω and a 15 Ω resistor in parallel. Find R_T.

4. What must you do to $1/R_T$ at the end of the calculation?

5. Can the total be bigger than the smallest branch?

PART 2

Combination Circuits

Series and parallel in the same circuit. Take it one block at a time.

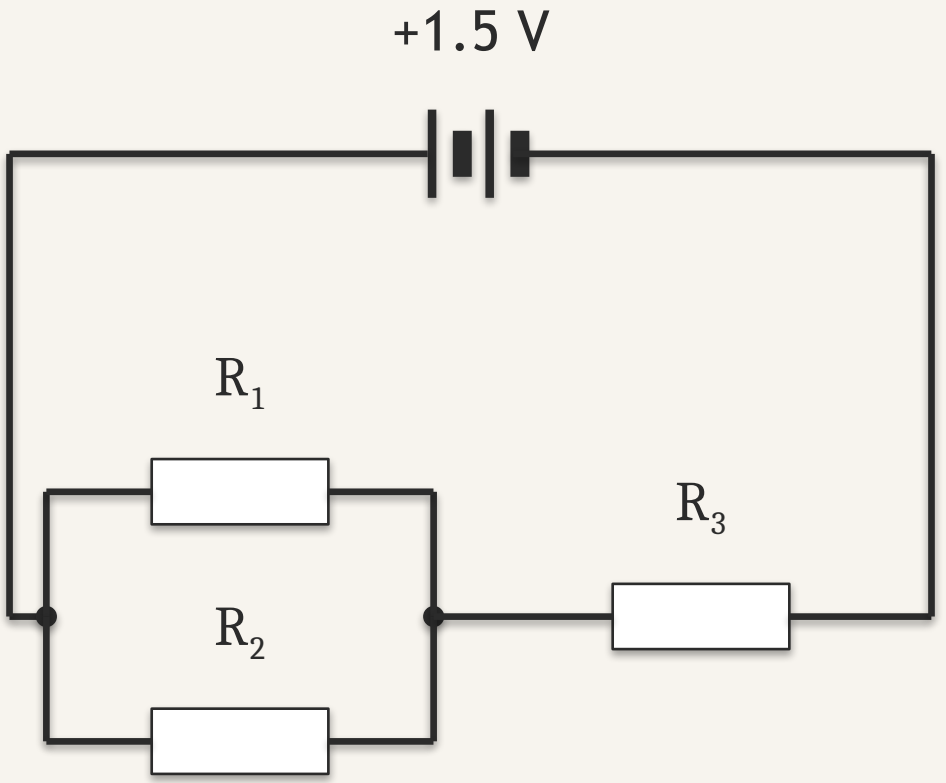
By the end of this part…

1. I can find the parallel block in a combination circuit
2. I can replace that block with a single resistance
3. I can solve problems involving total resistance in a combination circuit

The method

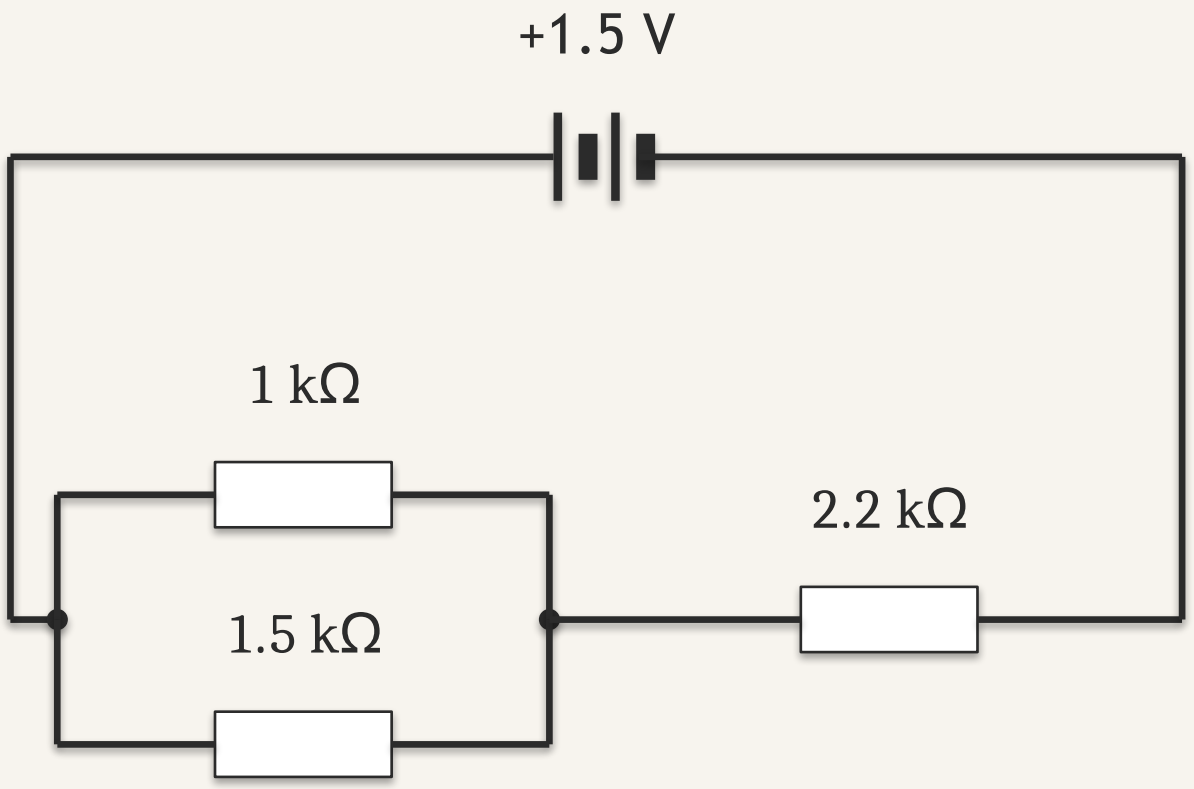
Booklet p.13

- Find the parallel block and work it out on its own.
- Replace the whole block with one resistance.
- Add that to whatever is in series with it.



The booklet's worked example

Booklet p.13 — the circuit



Step 1 — the parallel block

Booklet p.13

Calculate the resistance of the 1 kΩ and 1.5 kΩ parallel block.

$R_1 = 1000\ \Omega$

$R_2 = 1500\ \Omega$

$R_P = ?$

$$\frac{1}{R_P} = \frac{1}{R_1} + \frac{1}{R_2}$$

$$\frac{1}{R_P} = \frac{1}{1000} + \frac{1}{1500}$$

$$\frac{1}{R_P} = 0.001667$$

$$\underline{R_P = 600\ \Omega}$$

Step 2 — add the series resistor

Booklet p.14

The 600 Ω block is in series with the 2.2 kΩ resistor.

Calculate the total resistance of the whole circuit.

$R_P = 600\ \Omega$

$R_3 = 2200\ \Omega$

$R_T = ?$

$$R_T = R_P + R_3$$

$R_T = 600 + 2200$

$\underline{R_T = 2800\ \Omega = 2.8\ k\Omega}$

Task 2 — four circuits

Booklet p.14

Four combination circuits.
Work out the parallel block first, then finish.

Booklet p.14, Task 2

Task 2 — Answers, circuits 1 and 2

ANSWERS

Booklet p.14

	Step 1 — the parallel block	Step 2 — the series part
1	100 Ω with 200 Ω: 66.7 Ω	66.7 + 750 = 817 Ω
2	3.5 kΩ with 1.5 kΩ: 1050 Ω	1050 + 10 000 = 11 050 Ω

That is 817 Ω and 11.05 kΩ.

Task 2 — Answers, circuits 3 and 4

ANSWERS

Booklet p.14

	Step 1 — the series pair	Step 2 — the parallel block
3	1.0 kΩ + 2.2 kΩ = 3.2 kΩ	3.2 kΩ with 1.5 kΩ: 1.02 kΩ
4	7.5 kΩ + 2.2 kΩ = 9.7 kΩ	9.7 kΩ with 750 Ω: 696 Ω

Here the series pair comes first, then the parallel block.

Task 3 — more practice

Booklet p.15

Work the Yellow Book resistance questions.
Then sit the check test and mark it yourself.

Booklet p.15, Task 3
Yellow Books p.42-44
N5 Electricity CT 4 — Practical Circuits

Checkpoint

1. Write the relationship for parallel branches of different values.

2. A 12 Ω and a 6 Ω resistor are in parallel. Find R_T.

3. In a combination circuit, which part do you work out first, and why?

LOOKING AHEAD

Review and Test Prep

Everything in Booklet 1, and the practice test.

Plenary

1. Write the relationship for different values in parallel.
2. A 20 Ω and a 5 Ω resistor in parallel. Find R_T.
3. What is the last step of a parallel calculation?
4. Two 40 Ω resistors in parallel, then 30 Ω in series. Find R_T.
5. Why is a parallel total always less than its smallest branch?

Plenary

EXTRA PRACTICE

1. A 3 Ω and a 6 Ω resistor in parallel. Find R_T.
2. Two 100 Ω resistors in parallel, then 50 Ω in series. Find R_T.
3. Which block do you work out first in a combination circuit?
4. Two 24 Ω resistors in parallel. Find R_T.
5. Give 2800 Ω in kilohms.

Extension

1. A 6 Ω, a 12 Ω and a 4 Ω resistor, all in parallel. Find R_T.
2. A 10 Ω resistor in series with two 20 Ω resistors that are in parallel with each other. Find R_T.
3. You have three 30 Ω resistors. List every total you can make using all three of them.

Extension

EXTRA PRACTICE

1. A 5 Ω and a 20 Ω resistor in parallel, then 6 Ω in series. Find R_T.
2. Two resistors in parallel give 8 Ω. One of them is 24 Ω. Find the other.
3. Explain why putting anything in parallel with a 10 Ω resistor can never give more than 10 Ω.

Exam practice

Past-paper questions on this topic

1. 2024 Paper 1 — questions 11, 12 and 13
2. 2022 Paper 1 — questions 12, 13 and 14