

11 Combining resistors and circuit rules

– Part 2

Name: _____ Class: _____ Date: _____

Vocabulary

Write each word three times.

English	Write it 3 times (English)
equivalent resistance	_____
Kirchhoff's junction rule	_____
Kirchhoff's loop rule	_____

Recall

In Part A you used $V = IR$ and $P = IV$ for single components. Now handle circuits with **several** resistors:

- Resistors in a line add up; resistors side by side share the current.
- Whatever current flows into a junction must flow out again.

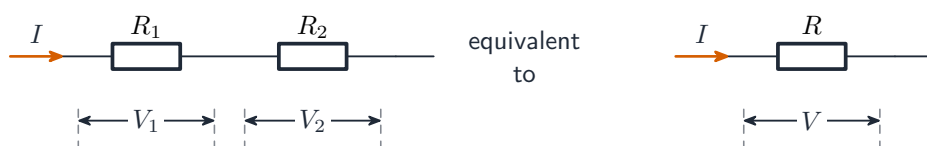
Each idea has a worked example before the Practice.

New ideas

■ 1 Combining resistors

Replace several resistors with one **equivalent resistance** _____ :

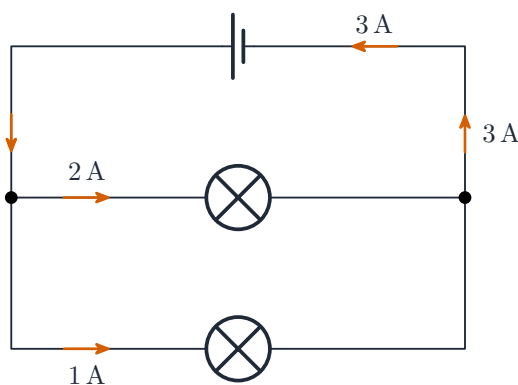
- **Series:** $R_{\text{eq}} = R_1 + R_2 + \cdots$ (they add).
- **Parallel:** $\frac{1}{R_{\text{eq}}} = \frac{1}{R_1} + \frac{1}{R_2} + \cdots$ (the total is **less** than the smallest one).



Worked example. A $4.0\ \Omega$ and a $12\ \Omega$ resistor in **parallel**: $\frac{1}{R_{\text{eq}}} = \frac{1}{4} + \frac{1}{12} = \frac{4}{12}$, so $R_{\text{eq}} = 3.0\ \Omega$ – smaller than either one.

■ 2 The junction rule

Kirchhoff's junction rule says the current flowing **into** a junction equals the current flowing **out** (charge is conserved).



at each junction: $3\ \text{A} = 2\ \text{A} + 1\ \text{A}$

Worked example. If $4.0\ \text{A}$ enters a junction and one branch carries $3.0\ \text{A}$, the other branch must carry $4.0 - 3.0 = 1.0\ \text{A}$.

■ 3 The loop rule

Kirchhoff's loop rule says that, going around any complete loop, the voltage gains (from the battery) and drops (across resistors) add up to **zero** (energy is conserved).

■ 4 Capacitor circuits

An **RC circuit** has a resistor and a capacitor. The capacitor charges up (or discharges) gradually, over a time set by $\tau = RC$. Right at the start it acts like a plain wire; once fully charged it blocks the current.

Watch out: putting resistors in **parallel** makes the total resistance **smaller** than the smallest one – because you have opened extra paths for the current. Series makes it larger.

Practice

Try these in order. The methods are all above.

2.1 Find the equivalent resistance of a $3.0\ \Omega$ and a $5.0\ \Omega$ resistor in **series**. [2]

2.2 Find the equivalent resistance of a $6.0\ \Omega$ and a $3.0\ \Omega$ resistor in **parallel**. [3]

2.3 A current of $5.0\ \text{A}$ enters a junction. One branch carries $2.0\ \text{A}$. Find the current in the other branch. [2]

2.4 State the two conservation ideas behind Kirchhoff's junction rule and loop rule. [2]

2.5 State whether the total resistance of two resistors in parallel is larger or smaller than the smallest resistor, and explain briefly. [2]