

10 D.C. circuits – Part 2

Name: _____ Class: _____ Date: _____

Vocabulary

Write each word three times.

English	Write it 3 times (English)		
Series	_____	_____	_____
Parallel	_____	_____	_____
sensor	_____	_____	_____
thermistor	_____	_____	_____
light-dependent resistor	_____	_____	_____
terminal p.d.	_____	_____	_____

Recall

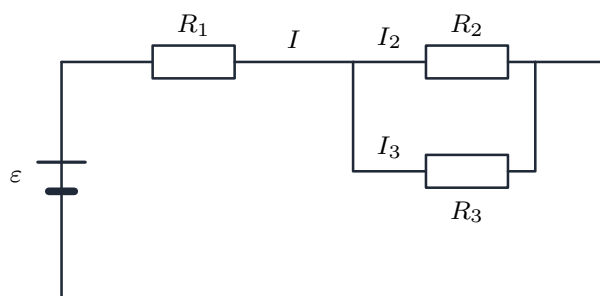
In **Part 1** you used e.m.f. and internal resistance ($V = \varepsilon - Ir$), Kirchhoff's two laws, and the potential divider. Part 2 adds combining resistors, using a divider to sense temperature or light, and measuring a cell's e.m.f. and internal resistance.

New ideas

Read these first. Each idea has a short worked example. Then do the Practice.

■ 1 Combining resistors

- **Series** (same current): $R = R_1 + R_2 + \dots$ – always bigger.
- **Parallel** (same p.d.): $\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \dots$ – always *smaller* than any single resistor (two equal $R \rightarrow R/2$).



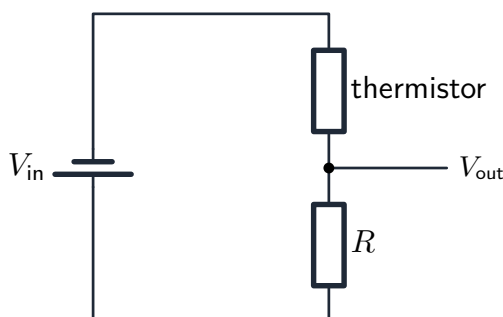
Worked example. A $4.0\ \Omega$ and a $12\ \Omega$ resistor in parallel: $\frac{1}{R} = \frac{1}{4.0} + \frac{1}{12} = \frac{3+1}{12} = \frac{1}{3}$, so $R = 3.0\ \Omega$.

■ 2 Sensor circuits

Put a **sensor** in a potential divider instead of a fixed resistor:

- a **thermistor** – its resistance falls as the temperature rises;
- a **light-dependent resistor** (LDR) – its resistance falls as the light gets brighter.

The divider's output voltage then changes with temperature or light, and can switch a heater or lamp on and off.



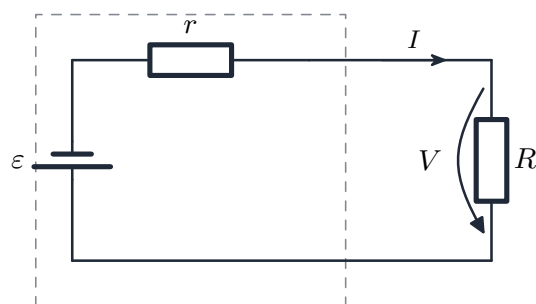
Worked example. In a thermistor-plus-fixed-resistor divider, a cold room gives the thermistor a high resistance; as it warms, that resistance falls and the output voltage shifts – enough to switch a fan on.

■ 3 Measuring e.m.f. and internal resistance

Connect a cell to a variable resistor and record the **terminal p.d.** V and current I as you change it. Plotting V against I gives the line $V = \varepsilon - Ir$:

- the y -intercept (at $I = 0$) is the e.m.f. ε ;
- the gradient is $-r$ (the internal resistance).

source: emf ε , internal resistance r



Worked example. A V – I line cuts the axis at $V = 1.5 \text{ V}$ (so $\varepsilon = 1.5 \text{ V}$) with a gradient of -0.50 V A^{-1} (so $r = 0.50 \text{ }\Omega$).

Watch out: resistors in parallel always give a total *smaller* than the smallest one – each extra path gives the current another way to flow.

Practice

10.1 Find the combined resistance of a $3.0 \text{ }\Omega$ and a $6.0 \text{ }\Omega$ resistor in **series**. [1]

10.2 Find the combined resistance of a $6.0 \text{ }\Omega$ and a $3.0 \text{ }\Omega$ resistor in **parallel**. [2]

10.3 State how the resistance of a thermistor changes as it gets warmer. [1]

10.4 When the terminal p.d. V is plotted against the current I for a cell, state what (a) the y -intercept and (b) the gradient represent. [2]

10.5 A cell of e.m.f. 1.5 V and internal resistance $0.50\ \Omega$ supplies a current of 0.60 A . Find the terminal p.d. [2]

10.6 Explain *why* adding a second resistor in parallel *lowers* the total resistance, even though you have added more resistor. [2]

10.7 Challenge. You have three identical $6.0\ \Omega$ resistors. State the largest and the smallest total resistance you can make using all three. [2]