A-LEVEL PHYSICS • HOLIDAY HOMEWORK

10 D.C. circuits – Part 1

Name: _____ Class: _____ Date: _____

Vocabulary

Write each word three times.

English	**Write it 3 times** (English)		
series			
parallel			
electromotive force			
internal resistance			
Kirchhoff's first law			
junction			
Kirchhoff's second law			
potential divider			

Recall

At IGCSE you built and measured circuits. Bring this with you:

- You used $V = IR$ and added resistors in **series** and **parallel** .
- Current is the same all the way round a single loop.

At AS we treat real cells, two circuit laws, and a useful circuit called the potential divider.

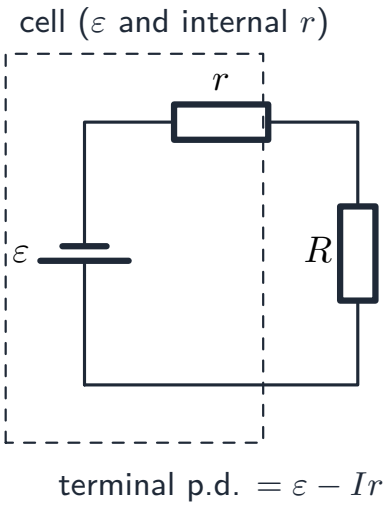
New ideas

1 E.m.f. and internal resistance

The **electromotive force** ε of a cell is the energy it gives each unit of charge. A real cell also has some **internal resistance** r, so when a current I flows the voltage you can use across the terminals is less:

$$V = \varepsilon - Ir.$$

Worked example. A cell with $\varepsilon = 12$ V and $r = 0.50\ \Omega$ supplies 2.0 A: $V = 12 - (2.0)(0.50) = 11$ V.

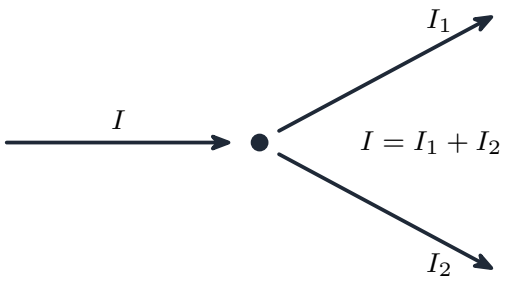


Watch out: the terminal voltage V is always *less* than the e.m.f. ε once current flows, because some energy is lost across the internal resistance r.

2 Kirchhoff's two laws

- **Kirchhoff's first law** (charge is conserved): the total current into a **junction** equals the total current out.
- **Kirchhoff's second law** (energy is conserved): around any loop, the sum of the e.m.f.s equals the sum of the voltage drops.

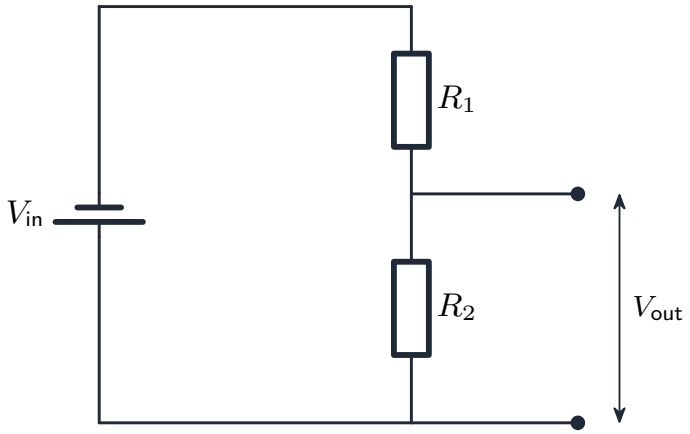
Worked example. 5.0 A flows into a junction and splits into two wires; one carries 2.0 A, so the other carries $5.0 - 2.0 = 3.0$ A.



■ 3 The potential divider

Two resistors in series share the supply voltage in proportion to their resistance. This is a **potential divider** . The voltage across R_2 is

$$V_{\text{out}} = \frac{R_2}{R_1 + R_2} V_{\text{in}}.$$



Worked example. $R_1 = 4.0\ \text{k}\Omega$, $R_2 = 2.0\ \text{k}\Omega$, $V_{\text{in}} = 9.0\ \text{V}$: $V_{\text{out}} = \dfrac{2.0}{6.0} \times 9.0 = 3.0\ \text{V}$.

Practice

10.1 A cell of e.m.f. 1.5 V and internal resistance 0.40 Ω supplies 0.50 A. Find the terminal voltage. [2]

10.2 At a junction, 3.0 A and 1.5 A flow in along two wires. Find the current flowing out along the third wire. [1]

10.3 Around a loop, a 9.0 V cell drives current through two resistors. One has 5.0 V across it. Use Kirchhoff's second law to find the voltage across the other. [2]

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10.4 A potential divider has $R_1 = 3.0\ \text{k}\Omega$ and $R_2 = 1.0\ \text{k}\Omega$ across a 12 V supply. Find the output voltage across R_2. [3]

10.5 In that potential divider, explain what happens to the output voltage across R_2 if R_2 is *increased*. [2]

10.6 Challenge. A potential divider uses a thermistor as R_1 and a fixed resistor as R_2. Explain what happens to the output voltage across R_2 as the temperature rises. [2]

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