Exercise walk-through

Compound Direct Current Circuits ▪ 11.5

eXercise

You must be able to

- reduce a network of **series and parallel** resistors to one equivalent resistance
- model a real battery as an **ideal emf 电动势** in series with an **internal resistance 内阻**
- distinguish a battery's **emf** from its **terminal voltage 端电压** under load
- find the current and voltage for each element

Method — Reducing a network

Combine resistors step by step: series add, parallel combine by $\frac{1}{R} = \sum \frac{1}{R_i}$, until one equivalent resistance remains.

Method — Real battery

A real battery is an ideal emf ε in series with an internal resistance r, so the **terminal voltage** under load is

$$V = \varepsilon - Ir.$$

Method — emf vs terminal voltage

The emf is the full “push”; the terminal voltage is what is left across the external circuit once Ir is lost inside.

Practice 2.1 ▪ 2 marks

A battery of emf 9.0 V and internal resistance $1.0\ \Omega$ drives 2.0 A. Find the terminal voltage.

Solution 2.1

Method: Real battery

Worked steps

$V = \varepsilon - Ir = 9.0 - 2.0(1.0) = 7.0$ V **M1** **A1**.

Practice 2.2 ▪ 2 marks

Two $8.0\ \Omega$ resistors in parallel are in series with a $4.0\ \Omega$ resistor. Find the total resistance.

Solution 2.2

Method: Reducing a network

Worked steps

parallel pair: $\dfrac{8.0}{2} = 4.0\ \Omega$; then $4.0 + 4.0 = 8.0\ \Omega$ M1 A1.

Practice 2.3 ▪ 1 mark

State the difference between the emf and the terminal voltage of a battery.

Solution 2.3

Method: Real battery

Worked steps

the emf is the total energy per charge supplied; the terminal voltage is the smaller potential difference across the external circuit once Ir is lost internally B1.

Exam-style 3.1 ▪ 1 mark

A real battery is modelled as an ideal emf in series with

A a capacitor

B an internal resistance

C an inductor

D nothing

Solution 3.1

Method: Real battery

A a capacitor

B an internal resistance ✓

C an inductor

D nothing

Worked steps

B.

Exam-style 3.2 ▪ 1 mark

The terminal voltage of a battery under load is

A greater than the emf

B less than the emf

C equal to zero

D infinite

Solution 3.2

Method: Real battery

A greater than the emf

B less than the emf ✓

C equal to zero

D infinite

Worked steps

B.

Exam-style 3.3 ▪ 2 marks

A 12 V battery of internal resistance $0.50\ \Omega$ is connected to a $5.5\ \Omega$ resistor.
(a) Find the current.
(b) Find the terminal voltage.

Solution 3.3

Method: Real battery

Worked steps

(a) $I = \dfrac{\varepsilon}{R+r} = \dfrac{12}{5.5+0.50} = 2.0$ A M1 A1. (b) $V = \varepsilon - Ir = 12 - 2.0(0.50) = 11$ V M1 A1.