

11.5 Compound Direct Current Circuits

Name: _____ Class: _____ Date: _____

Total: 11 marks

Objective

Build the skills to answer exam questions on **compound direct current circuits**.

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

1 Worked examples

Study these first. Each one shows the method for a question type used later.

■ 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.

■ Real battery

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

$$V = \varepsilon - Ir.$$

■ 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.

2 Practice

2.1 A battery of emf 9.0 V and internal resistance 1.0 Ω drives 2.0 A. Find the terminal voltage. [2]

2.2 Two $8.0\ \Omega$ resistors in parallel are in series with a $4.0\ \Omega$ resistor. Find the total resistance. [2]

2.3 State the difference between the emf and the terminal voltage of a battery. [1]

3 Exam-style questions

3.1 A real battery is modelled as an ideal emf in series with [1]

- **A** a capacitor
 - **B** an internal resistance
 - **C** an inductor
 - **D** nothing
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3.2 The terminal voltage of a battery under load is [1]

- **A** greater than the emf
 - **B** less than the emf
 - **C** equal to zero
 - **D** infinite
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3.3 A $12\ \text{V}$ battery of internal resistance $0.50\ \Omega$ is connected to a $5.5\ \Omega$ resistor.

(a) Find the current. [2]

(b) Find the terminal voltage. [2]

4 Go further

- work through the **11.5 Compound Direct Current Circuits** lesson on the **Learn** page;
- read the **Electric Circuits** section of the AP Physics C: E&M handout on the **Know** page.

Solutions

2.1 $V = \varepsilon - Ir = 9.0 - 2.0(1.0) = 7.0 \text{ V}.$

2.2 parallel pair: $\frac{8.0}{2} = 4.0 \text{ } \Omega$; then $4.0 + 4.0 = 8.0 \text{ } \Omega.$

2.3 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.

3.1 B.

3.2 B.

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