10.1 Practical circuits

Name: ______________ Class: __________ Date: ____________ **Total: 13 marks**

Objective

Build the skills to answer exam questions on **practical circuits** —e.m.f., p.d., and internal resistance.

You must be able to:

- define **e.m.f.** and distinguish it from **p.d.**
- explain **internal resistance** and use $V = \varepsilon - Ir$
- describe how to measure internal resistance

1 Worked examples

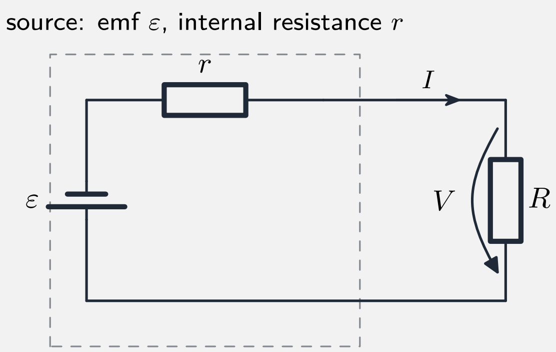
Study these first. Each one shows the method for a question type used later —follow the steps and you can do the Practice and Exam-style questions yourself.

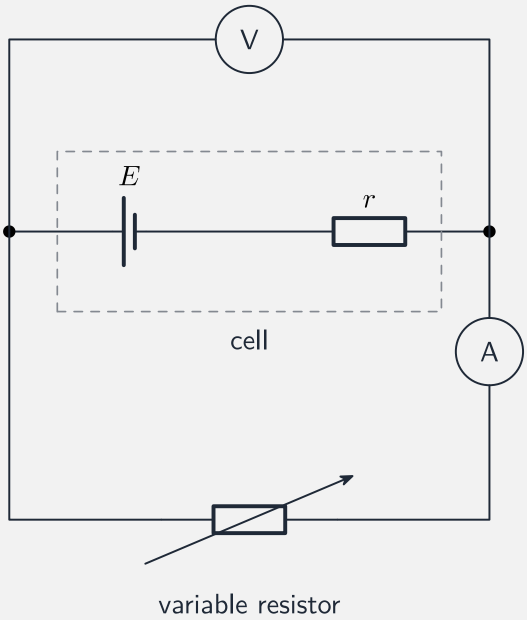
■ e.m.f. and p.d.

e.m.f. ε = energy given to each coulomb by the source (in driving it round the whole circuit). **p.d.** = energy transferred from electrical form by each coulomb in a component. Both in volts.

■ Internal resistance

A real cell has **internal resistance** r. When current flows, Ir is ”lost” inside it, so the **terminal p.d.** is:





Internal resistance in a practical cell

$$V = \varepsilon - Ir.$$

- $I = 0$ (open circuit): $V = \varepsilon$;
- larger current → smaller terminal p.d.

Worked example. $\varepsilon = 1.5$ V, $r = 0.50\ \Omega$, $R = 2.5\ \Omega$: $I = \dfrac{\varepsilon}{R+r} = \dfrac{1.5}{3.0} = 0.50$ A; $V = \varepsilon - Ir = 1.5 - 0.25 = 1.25$ V.

To **measure** r: vary R, plot V against I —the intercept is ε and the gradient is $-r$.

2 Practice

Now apply the methods above.

2.1 Define the **e.m.f.** of a source. [1]

2.2 Write the equation linking **terminal p.d.**, e.m.f., current and internal resistance. [1]

2.3 State the terminal p.d. of a cell when **no current** flows. [1]

2.4 State **one** cause of a cell's internal resistance. [1]

3 Exam-style questions

3.1 A cell of e.m.f. 1.5 V and internal resistance 0.50 Ω is connected to a 2.5 Ω resistor. Calculate (a) the current, (b) the terminal p.d. [4]

3.2 As the current drawn from a cell **increases**, the terminal p.d.: [1]

- **A** increases
- **B** decreases
- **C** stays the same
- **D** becomes equal to the e.m.f.

3.3 Explain, in terms of **energy**, the difference between e.m.f. and p.d. [2]

3.4 Describe how a graph can be used to find the **internal resistance** of a cell. [2]

4 Go further

You are now ready for the real exam questions on this subtopic. Open the **10.1 Practical circuits** past-paper sheet in the Library, or try these in **Practice mode**:

- 9702/21 N25 —Q5 (e.m.f. and internal resistance)
- 9702/23 J25 —Q7 (internal resistance, calculation)
- 9702/21 N24 —Q7 (practical circuit, calculation)
- 9702/12 J25 —Q35 (internal resistance, multiple choice)
- 9702/11 J25 —Q37 (practical circuits, multiple choice)

Solutions

2.1 The **energy transferred per unit charge** by the source in driving charge **around the complete circuit**.

2.2 $V = \varepsilon - Ir$.

2.3 Equal to the **e.m.f.** ε.

2.4 Any one: the resistance of the **electrolyte** in a cell; the resistance of the **wire windings** in a generator.

3.1 (a) $I = \dfrac{\varepsilon}{R + r} = \dfrac{1.5}{2.5 + 0.50} = \dfrac{1.5}{3.0} = 0.50$ A. (b) $V = \varepsilon - Ir = 1.5 - (0.50)(0.50) =$ 1.25 V. *(Or $V = IR = 0.50 \times 2.5 = 1.25$ V.)*

3.2 **B** —decreases (more Ir is lost internally).

3.3 **e.m.f.** is energy put **into** the circuit per coulomb by the source; **p.d.** is energy taken **out** of the electrical form per coulomb in a component.

3.4 Vary the external resistance and measure V and I; plot V against I —the magnitude of the **gradient** is r (and the intercept is ε).