Exercise walk-through

Potential difference and power ▪ 9.2

eXercise

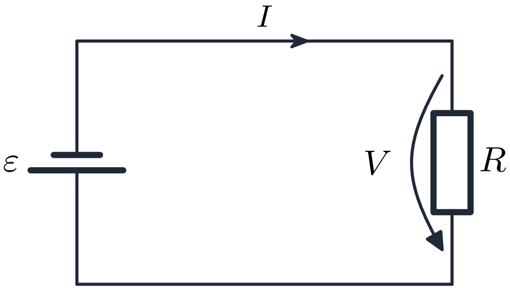
You must be able to

- define **potential difference** and use $V = W/Q$
- distinguish **e.m.f.** from **p.d.**
- use $P = VI = I^2R = V^2/R$

Method — Potential difference and e.m.f.

Potential difference is the energy transferred **per unit charge**: $V = W/Q$ (unit $\mathrm{V} = \mathrm{J\ C^{-1}}$).
e.m.f. is the energy given **to** each coulomb by the source; **p.d.** is the energy given **up** by each coulomb in a component. Same formula, opposite direction of energy transfer.

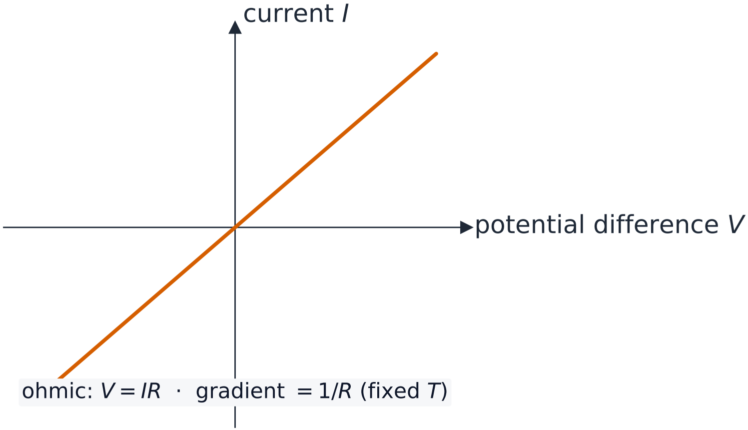
Method — Potential difference and e.m.f.



p.d. V: energy given *up* by each coulomb

emf ε: energy given *to* each coulomb

Method — Potential difference and e.m.f.



The I-V graph of an ohmic conductor

Method — Power

$$P = \frac{W}{t} = VI = I^2 R = \frac{V^2}{R}.$$

Pick the form with the quantities you know. Energy: $E = Pt$.

Worked example. A kettle "2.4 kW, 240 V": $I = P/V = 10$ A; $R = V^2/P = 24\ \Omega$.

Practice 2.1 ▪ 1 mark

Define **potential difference**.

Solution 2.1

Method: Potential difference and e.m.f.

Worked steps

The **energy transferred per unit charge** as charge passes through a component ($V = W/Q$) **B1**.

Practice 2.2 ▪ 1 mark

State the difference between **e.m.f.** and **p.d.**

Solution 2.2

Worked steps

e.m.f. is energy given **to** each coulomb by the source; **p.d.** is energy given **up** by each coulomb in a component **B1**.

Practice 2.3 ▪ 2 marks

Write the **three** forms of the electrical power equation.

Solution 2.3

Worked steps

$P = VI$, $P = I^2R$, $P = V^2/R$ **B1** **B1** *for two, for all three.*

Practice 2.4 ▪ 1 mark

A 12 V supply drives a current of 2.0 A. Find the **power**.

Solution 2.4

Method: Potential difference and e.m.f.

Worked steps

$P = VI = 12 \times 2.0 = 24$ W B1.

Exam-style 3.1 ▪ 1 mark

A lamp has 240 V across it and a current of 0.50 A. Its power is:

A 120 W

B 480 W

C 0.50 W

D 240 W

Solution 3.1

Method: Potential difference and e.m.f.

A 120 W ✓

B 480 W

C 0.50 W

D 240 W

Worked steps

A — $P = VI = 240 \times 0.50 = 120$ W.

Exam-style 3.2 ▪ 4 marks

A kettle is marked "2.4 kW, 240 V". Calculate (a) the current it draws, (b) its resistance.

Solution 3.2

Worked steps

(a) $I = P/V = 2400/240 = 10$ A **M1** **A1**. (b) $R = V^2/P = 240^2/2400 = 24\ \Omega$ **M1** **A1**.

Exam-style 3.3 ▪ 2 marks

A $10\ \Omega$ and a $20\ \Omega$ resistor are each connected, separately, across the **same** 12 V supply. State which dissipates **more power**, and why.

Solution 3.3

Method: Potential difference and e.m.f.

Worked steps

The $10\ \Omega$ resistor B1; at the same voltage $P = V^2/R$, so the **smaller** resistance gives the **larger** power B1.

Exam-style 3.4 ▪ 2 marks

A 60 W lamp runs for 5.0 minutes. Calculate the **energy** transferred.

Solution 3.4

Method: Potential difference and e.m.f.

Worked steps

$E = Pt = 60 \times (5.0 \times 60) = 60 \times 300 = 1.8 \times 10^4$ J **M1** **A1**.

Exam-style 3.5 ▪ 1 mark

A battery of negligible internal resistance supplies 9.0 V to a circuit that splits into two parallel branches. The **upper** branch contains a $150\ \Omega$ resistor in series with an unknown resistor R. The **lower** branch contains a $360\ \Omega$ resistor in series with a $540\ \Omega$ resistor. The battery delivers a total current of 0.040 A.

(a) **Define** the electric potential difference across a component.
(b) **Determine** the charge that passes through the battery in 3.0 minutes.
(c) **Calculate** the current I_2 in the **lower** branch.
(d) **Calculate** the current I_1 in the **upper** branch.
(e) **Determine** the resistance R.
(f) **Determine** the total power delivered by the battery, and the power dissipated in the $150\ \Omega$ resistor.

Solution 3.5

Method: Potential difference and e.m.f.

Worked steps

(a) The **energy transferred** to the component **per unit charge** passing through it **B1**.

(b) $Q = It = 0.040 \times 3.0 \times 60$ **M1** $= 7.2$ C **A1**.

(c) The lower branch has the full 9.0 V across $360 + 540 = 900\ \Omega$ **M1**, so $I_2 = \dfrac{9.0}{900} = 0.010$ A **A1**.

(d) The branch currents add to the battery current: $I_1 = 0.040 - 0.010 = 0.030$ A **A1**.

(e) The upper branch also has 9.0 V across it, so its total resistance is $\dfrac{9.0}{0.030} = 300\ \Omega$

Solution 3.5

M1; $R = 300 - 150 = 150\ \Omega$ A1.
(f) $P_{\text{total}} = VI = 9.0 \times 0.040 = 0.36$ W M1; in the $150\ \Omega$ resistor $P = I_1^2 R = (0.030)^2 \times 150$ M1 $= 0.135$ W A1. (Use the **branch** current there, not the battery current — the commonest slip.)