

Exercise walk-through

10.2

Current and circuits (full B.5)

International Baccalaureate · IB Diploma · Physics · HL

Circuits · 3.1

Reasoning

Current is the same through components in series. Potential differences add around the series path. In parallel, branches share the same potential difference, while branch currents sum at a junction. Place an ammeter in series and a voltmeter in parallel. For an I-V investigation, change voltage in steps, reverse polarity when appropriate and limit current to reduce heating.

The cell loses terminal voltage

- 1 Set the model** A cell has emf 1.5 V , internal resistance $0.50\ \Omega$ and external resistance $7.5\ \Omega$.
- 2 Calculate** $I = 1.5 / (7.5 + 0.50) = 0.1875\text{ A}$. Terminal pd $V = IR = 1.406\text{ V}$, also $\varepsilon - Ir$.

Decision

Emf is energy supplied per charge. Some energy heats the internal resistance, so terminal pd is lower when the cell supplies current.

Exercises 2.1-2.3

2.1 State Ohm's law, and state the condition a metal conductor must meet for it to hold. [2]

2.2 Calculate the charge that passes a point when a current of 0.50 A flows for 2.0 minutes. [2]

2.3 A nichrome wire ($\rho = 1.1 \times 10^{-6} \Omega \text{ m}$) has length 2.0 m and cross-sectional area 0.10 mm^2 . Calculate its resistance. [3]

Exercises 2.1·2.3

2.1 State Ohm's law, and state the condition a metal conductor must meet for it to hold. [2]

2.1 Current is proportional to potential difference, $V = IR$; constant temperature – a metal at fixed temperature.

2.2 Calculate the charge that passes a point when a current of 0.50 A flows for 2.0 minutes. [2]

2.2 $\Delta q = I\Delta t = 0.50 \times 120 = 60 \text{ C}.$

2.3 A nichrome wire ($\rho = 1.1 \times 10^{-6} \text{ } \Omega \text{ m}$) has length 2.0 m and cross-sectional area 0.10 mm^2 . Calculate its resistance. [3]

2.3 $A = 0.10 \text{ mm}^2 = 1.0 \times 10^{-7} \text{ m}^2$; $R = \rho L/A = (1.1 \times 10^{-6} \times 2.0)/(1.0 \times 10^{-7}) = 22 \text{ } \Omega.$

Exercises 2.4·3.1

2.4 State how the resistance of a thermistor changes as temperature rises, and name one other component whose resistance changes with its environment. [2]

2.5 A $4.0\ \Omega$ resistor and a $12\ \Omega$ resistor are connected in parallel. Calculate the combined resistance. [2]

3.1 A cell of emf $6.0\ \text{V}$ and internal resistance $0.50\ \Omega$ is connected to a $5.5\ \Omega$ resistor. Calculate the current, the terminal potential difference, and the power dissipated inside the cell. [4]

Exercises 2.4·3.1

2.4 State how the resistance of a thermistor changes as temperature rises, and name one other component whose resistance changes with its environment. [2]

2.4 Falls as temperature rises; LDR – falls as light intensity rises.

2.5 A $4.0\ \Omega$ resistor and a $12\ \Omega$ resistor are connected in parallel. Calculate the combined resistance. [2]

2.5 $1/R_p = 1/4.0 + 1/12 = 0.333$, so $R_p = 3.0\ \Omega$.

3.1 A cell of emf $6.0\ \text{V}$ and internal resistance $0.50\ \Omega$ is connected to a $5.5\ \Omega$ resistor. Calculate the current, the terminal potential difference, and the power dissipated inside the cell. [4]

3.1 $I = 6.0/(5.5 + 0.50) = 1.0\ \text{A}$; terminal pd $= \varepsilon - Ir = 6.0 - 0.50 = 5.5\ \text{V}$; internal power $= I^2 r = 1.0^2 \times 0.50 = 0.50\ \text{W}$.

Exercises 3.2-3.4

3.2 A lamp is rated 12 V, 36 W. Calculate the current it draws at normal operation and its resistance then, and verify the power with a second power formula. [4]

3.3 Compare solar cells with chemical cells as energy sources for a circuit: give two advantages and two disadvantages of solar cells. [4]

3.4 A 12 V battery of negligible internal resistance is connected to a $2.0\ \Omega$ resistor in series with a parallel pair of $6.0\ \Omega$ and $3.0\ \Omega$. Calculate the total resistance, the battery current, and the potential difference across the parallel pair. [5]

Exercises 3.2-3.4

3.2 A lamp is rated 12 V, 36 W. Calculate the current it draws at normal operation and its resistance then, and verify the power with a second power formula. [4]

3.2 $I = P/V = 36/12 = 3.0$ A; $R = V/I = 12/3.0 = 4.0$ Ω ; check $P = I^2 R = 9.0 \times 4.0 = 36$ W – matches the rating.

3.3 Compare solar cells with chemical cells as energy sources for a circuit: give two advantages and two disadvantages of solar cells. [4]

3.3 Advantages: renewable energy source, no fuel consumed in use; no emissions while generating. Disadvantages: no output in darkness or low light – output varies with weather and time of day; manufacture requires energy and materials – finite cell lifetime and replacement cost.

3.4 A 12 V battery of negligible internal resistance is connected to a 2.0 Ω resistor in series with a parallel pair of 6.0 Ω and 3.0 Ω . Calculate the total resistance, the battery current, and the potential difference across the parallel pair. [5]

3.4 Parallel pair: $1/R_p = 1/6.0 + 1/3.0 = 0.50$, so $R_p = 2.0$ Ω ; total $R = 2.0 + 2.0 = 4.0$ Ω ; $I = 12/4.0 = 3.0$ A; pd across the pair $= IR_p = 3.0 \times 2.0 = 6.0$ V.