

2.2 Current, resistance and potential difference

Name: _____ Class: _____ Date: _____

Total: 23 marks

KEY WORDS resistance

Objective

Use $V = IR$ in every direction, read resistance from a graph, and describe or evaluate the RP3 resistance-of-a-wire investigation with its controls and errors. Original questions for spec statement 4.2.1.3 and required practical 3.

1 Key knowledge and worked examples

$$V = IR$$

Quantity	Symbol	Unit
potential difference	V	volts, V
current	I	amperes, A
resistance	R	ohms, Ω

The **greater the resistance**, the **smaller the current** for a given potential difference. Choose the rearrangement before substituting:

Wanted	Rearranged form
V	$V = IR$
I	$I = V/R$
R	$R = V/I$

Worked example. A vending machine measures a coin's resistance by passing 0.0075 A at 0.45 V. Find R .

$$R = \frac{V}{I} = \frac{0.45 \text{ V}}{0.0075 \text{ A}} = 60 \Omega$$

Worked example (graph read). A graph of V against I for a wire is a straight line through the origin. At $I = 0.40 \text{ A}$ the line shows $V = 1.8 \text{ V}$.

$$R = \frac{V}{I} = \frac{1.8 \text{ V}}{0.40 \text{ A}} = 4.5 \Omega$$

- A straight line through the origin means resistance is **constant**: the wire obeys Ohm's law at constant temperature.

RP3: how the resistance of a wire depends on its length.

Method: tape resistance wire (nichrome or constantan) along a metre rule; fix one crocodile clip; place the second clip at a chosen length; measure length between the actual contact points and record it, ammeter reading and voltmeter reading; calculate $R = V/I$; repeat for a range of lengths; plot R against length.

Method and analysis points:

- **Graph:** for the same material, cross-sectional area and temperature, a straight line through the origin supports resistance being **directly proportional to length**.
- **Zero error:** check the measured length between the actual contact points. A non-zero intercept can also involve contact or lead resistance; investigate its cause before applying any correction, rather than automatically subtracting it.
- **Keep the wire cool:** use a low potential difference and switch off between readings; the wire's temperature must stay constant because heating changes the resistance (the current makes it climb).
- **Repeats:** take repeats at each length and use means to reduce random error.
- Variables: independent = length; dependent = resistance (from V and I); controls = material, thickness (cross-sectional area), temperature.

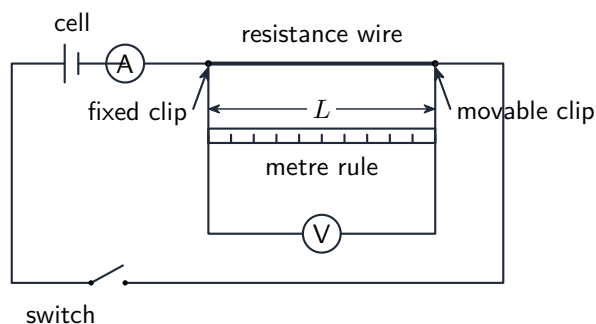
2 Practice

2.1 A 6.0 V battery drives a current of 0.50 A through a resistor. Calculate the resistance. [2]

2.2 A $48\ \Omega$ heating element runs from a 230 V supply. Calculate the current. [2]

2.3 In RP3 a student halves the length of the same uniform wire, keeping its temperature and the potential difference across the selected length constant. State and explain what happens to (a) the resistance and (b) the current. [3]

Move the clip to change the length; keep the current small.



3 Exam-style questions

3.1 A student investigates how the resistance of a wire depends on its length at constant temperature.

- (a) Describe a method the student could use to collect the data needed to plot a graph of resistance against length. [6]
- (b) The graph is a straight line through the origin. State the relationship it shows. [1]
- (c) Give one reason why the student should use a low potential difference. [1]

3.2 A cell of potential difference 1.50 V is used in the wire investigation. A student says “the 1.50 V cell is not an electrical hazard in this investigation”.

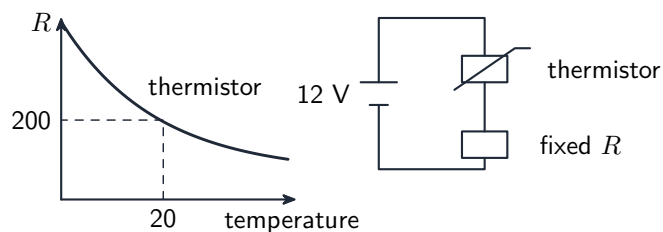
Explain why the student is correct. [2]

3.3 A thermistor in a thermostat circuit has the resistance–temperature graph shown.

At $20\text{ }^{\circ}\text{C}$ the graph shows $200\text{ }\Omega$. The thermistor is connected in series with a 12 V supply and a fixed resistor.

(a) The circuit is designed so the thermistor has 7.0 V across it at $20\text{ }^{\circ}\text{C}$. Show that the fixed resistor is about $140\text{ }\Omega$. [3]

(b) The room warms to $30\text{ }^{\circ}\text{C}$ and the thermistor's resistance falls to $140\text{ }\Omega$. Calculate the new potential difference across the fixed resistor. [3]



Solutions

2.1

$$R = \frac{V}{I} = \frac{6.0 \text{ V}}{0.50 \text{ A}} = \mathbf{12 \text{ } \Omega}$$

(method 1, answer with unit 1.)

2.2

$$I = \frac{V}{R} = \frac{230 \text{ V}}{48 \text{ } \Omega} = \mathbf{4.8 \text{ A}} \text{ (2 s.f.)}$$

(method 1, answer with unit 1.)

2.3 (a) The resistance halves: resistance is directly proportional to length. (b) The current doubles: the same potential difference now drives current through half the resistance, since $I = V/R$ and R halved.

3.1 (a) Indicative content: tape the resistance wire along a metre rule; fix one crocodile clip and a second clip at a chosen length; measure the length between their actual contact points with the rule; read the ammeter (series) and voltmeter (parallel across the wire); calculate $R = V/I$; repeat for a range of lengths; repeat readings and take means; switch off between readings to keep temperature constant; plot resistance against length. Level 3 (5–6): full method in a logical order, both meters placed correctly, $R = V/I$ used, and at least one accuracy step. Level 2 (3–4): most steps present with a gap or unclear order. Level 1 (1–2): isolated relevant steps. (b) Resistance is directly proportional to length. (c) To keep the current small so the wire does not heat up – its temperature (and so resistance) must stay constant.

3.2 The potential difference is very low, so there is no risk of electric shock (the supply cannot push a dangerous current through a person).

3.3 (a) Known: series circuit, so the same current flows through both; the supply's 12 V is shared.

- Thermistor share 7.0 V leaves the resistor $12 - 7.0 = 5.0 \text{ V}$ (C1).

$$I = \frac{7.0 \text{ V}}{200 \text{ } \Omega} = 0.035 \text{ A} \quad R = \frac{5.0 \text{ V}}{0.035 \text{ A}} = 143 \text{ } \Omega \approx 140 \text{ } \Omega \checkmark$$

(current C1, resistance A1 – statement shown.) (b) Now the two resistances are equal (140 Ω and 140 Ω).

$$I = \frac{12 \text{ V}}{280 \text{ } \Omega} = 0.043 \text{ A} \quad \Rightarrow \quad V_{\text{resistor}} = IR = 0.043 \times 140 = \mathbf{6.0 \text{ V}}$$

(total resistance C1, substitution C1, answer A1 – equal resistances share the supply equally.)