

Resistance, I–V characteristics and circuit practicals

AQA GCSE Physics 8463 and Combined Science Trilogy 8464 | Paper 1 | Both tiers

Worked solutions and teaching prompts | 28 parts | 52 marks

Specification points covered

Circuit symbols and $V = IR$: 8463 4.2.1.1/4.2.1.3; 8464 6.2.1.1/6.2.1.3
Component I–V behaviour, thermistors and LDRs: 8463 4.2.1.4; 8464 6.2.1.4
Series and parallel resistance: 8463 4.2.2; 8464 6.2.2 (selected content)
Wire length at constant temperature and resistor combinations: 8463 RP3; 8464 RP15
Resistor, filament lamp and diode I–V investigations: 8463 RP4; 8464 RP16

A technician refurbishes a low-voltage museum display. The display needs connecting wires, an indicator lamp and sensors that control its lights and cooling fan. Use test measurements to choose components and plan reliable checks. Each numbered question is a separate test.

Shared Separate/Trilogy content, both tiers. Accept equivalent methods and sensible follow-through. Suggested timing is not classroom-tested. The six-mark method is assessed holistically. This original PhysicsUK resource is not an official AQA paper or mark scheme.

1 A quick component check

1(a) State the SI unit of electrical resistance, including its symbol. **[1 mark]**

Answer / mark points: Ohm, Ω . [1] Both name and symbol are required.

1(b) At 3.0 V, a display component carries 0.25 A. Calculate its resistance. **[1 mark]**

Answer / mark points: $R = V / I = 3.0 / 0.25 = 12 \Omega$. [1]



2 How much connecting wire?

The technician tests different contact separations along one uniform wire. Length means the distance along the wire between the contacts. The wire temperature is kept constant. Table 1 gives idealised paired readings.

Table 1

Length / cm	Potential difference / V	Current / A
20	1.0	0.40
40	2.0	0.40
60	3.0	0.40
80	4.0	0.40

2(a) Calculate the resistance of the 20 cm length of wire in Table 1. **[1 mark]**

Answer / mark points: $R = 1.0 / 0.40 = 2.5 \, \Omega$. [1]

2(b) Calculate the resistance of the 40 cm length of wire. **[1 mark]**

Answer / mark points: $R = 2.0 / 0.40 = 5.0 \, \Omega$. [1]

2(c) Calculate the resistance of the 60 cm length of wire. **[1 mark]**

Answer / mark points: $R = 3.0 / 0.40 = 7.5 \, \Omega$. [1]

2(d) Calculate the resistance of the 80 cm length of wire. **[1 mark]**

Answer / mark points: $R = 4.0 / 0.40 = 10 \, \Omega$. [1]



2 How much connecting wire? continued

2(e) Plot your four resistance values against length on Figure 1. Draw a straight line of best fit, extending it to the origin. **[3 marks]**

Answer / mark points: Correct points: (20 cm, 2.5 Ω), (40 cm, 5.0 Ω), (60 cm, 7.5 Ω), (80 cm, 10 Ω). [1 for any two correct points; 2 for all four]
A single straight best-fit line through the points and the origin. [1] Allow plotting within half a small division. Figure 1 shows the completed plot.

Teacher prompt: Axes are already labelled. The origin is appropriate for these stated idealised data, not automatically for every real experiment.

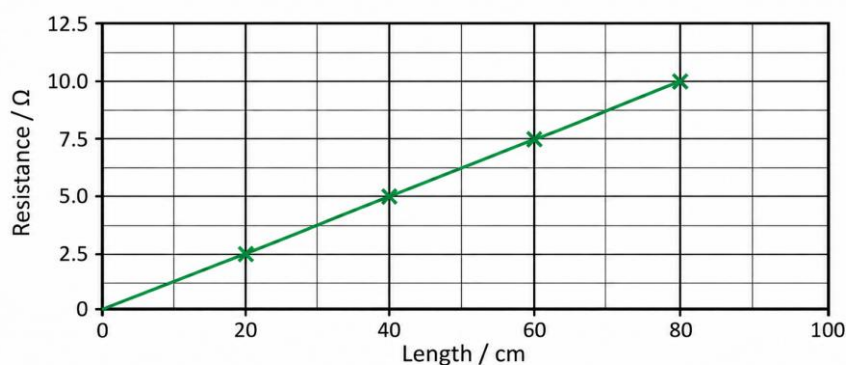


Figure 1

2(f) Describe the relationship between wire length and resistance. Support your answer using the results. **[2 marks]**

Answer / mark points: Resistance is directly proportional to length under these controlled conditions. [1] For example, doubling length from 20 cm to 40 cm doubles resistance from 2.5 Ω to 5.0 Ω . [1] Accept another correct ratio comparison or a straight line through the origin as evidence.

2(g) The technician needs a 50 cm length of this wire. Use Figure 1 to estimate its resistance. **[1 mark]**

Answer / mark points: About 6.25 Ω . [1] Accept 6.0–6.5 Ω from an appropriate straight best-fit line; allow consistent follow-through from an otherwise valid pupil plot.

2(h) Apart from material, state one wire property that must stay the same. Describe one way to keep its temperature approximately constant during the measurements. **[2 marks]**

Answer / mark points: Keep diameter/cross-sectional area the same. [1] Use a small test current so heating is negligible, or switch off between brief readings and allow the wire to return to the same temperature. [1]

Teacher prompt: Use the distance between the electrical contacts as the tested length; keep the wire straight along a ruler.



3 Two replacement resistors

Each resistor is $30\ \Omega$. Table 2 gives the measured potential difference across the whole arrangement and the total current supplied to it, at constant temperature. Use the measurements, not a parallel-resistance formula.

Table 2

Arrangement	Measured readings
One $30\ \Omega$ resistor	6.0 V; 0.20 A
Two $30\ \Omega$ resistors in series	6.0 V; 0.10 A
Two $30\ \Omega$ resistors in parallel	6.0 V; 0.40 A

3(a) Calculate the resistance of the single-resistor arrangement using Table 2. **[1 mark]**

Answer / mark points: $R = 6.0 / 0.20 = 30\ \Omega$. [1]

3(b) Calculate the total resistance of the two-resistor series arrangement. **[1 mark]**

Answer / mark points: $R = 6.0 / 0.10 = 60\ \Omega$. [1]

3(c) Calculate the total resistance of the two-resistor parallel arrangement. **[1 mark]**

Answer / mark points: $R = 6.0 / 0.40 = 15\ \Omega$. [1]

3(d) Compare each two-resistor arrangement with the single resistor. Explain why one increases the total resistance and the other decreases it. **[2 marks]**

Answer / mark points: In series, both resistors are in the same current path and their resistances add: total resistance increases to $60\ \Omega$. [1] In parallel, there is an additional current path, so more total current flows at the same potential difference: total resistance decreases to $15\ \Omega$. [1]

Teacher prompt: Each mark requires its comparison and explanation. Do not add individual resistances for a parallel arrangement.

3(e) Where should the ammeter and voltmeter be connected to measure the total resistance of the parallel arrangement? **[2 marks]**

Answer / mark points: Ammeter in the supply path before the current splits or after it recombines, measuring total current. [1] Voltmeter in parallel across the two ends of the whole arrangement. [1]



4 Which component behaves like this?

Figure 2 contains qualitative I-against-V graphs. A is measured at constant temperature. The filament lamp in B reaches a steady temperature at each setting. The graphs have no numerical scale; use the stated readings for calculations.

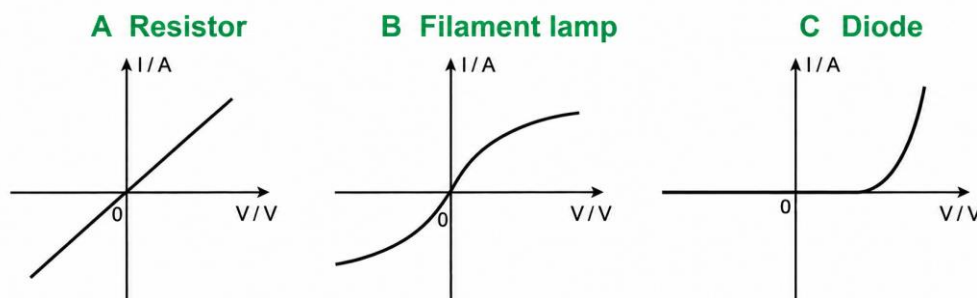


Figure 2

4(a) Identify the component represented by each graph A, B and C in Figure 2. **[3 marks]**

Answer / mark points: A: fixed resistor. [1] B: filament lamp. [1] C: diode. [1]

4(b) For A, state the relationship between current and potential difference. A second ohmic resistor gives a steeper straight line on the same axes. Compare its resistance with A. **[2 marks]**

Answer / mark points: Current is directly proportional to potential difference at constant temperature. [1] The second resistor has lower resistance. [1] A steeper I-against-V line means more current at the same potential difference, so V/I is smaller.

Teacher prompt: Gradient is $I/V = 1/R$ for this straight line. Do not say a steeper I-V line means greater resistance.

4(c) At 1.0 V the lamp carries 0.20 A; at 4.0 V it carries 0.50 A. Calculate its resistance at each setting. **[2 marks]**

Answer / mark points: At 1.0 V: $R = 1.0 / 0.20 = 5.0 \, \Omega$. [1]
At 4.0 V: $R = 4.0 / 0.50 = 8.0 \, \Omega$. [1]

4(d) Explain why the lamp resistance increases at the higher setting. Link this to graph B. **[2 marks]**

Answer / mark points: The filament temperature rises, increasing its resistance. [1] Current therefore increases less rapidly as potential difference increases, so the I-V curve becomes less steep rather than remaining a straight line. [1]

Teacher prompt: Current still increases; it is not directly proportional to potential difference. Avoid saying that current is used up.

4(e) A diode is in series with an indicator lamp. The battery connections are accidentally reversed, so the diode is reverse-biased. Explain why the lamp does not light. **[2 marks]**

Answer / mark points: A reverse-biased diode has very high resistance. [1] Current is negligible, so the lamp does not light. [1] This assumes the diode remains within its reverse-voltage rating.



5 Choosing sensors for the display

Table 3 gives measured sensor resistances. The fan controller needs a sensor that responds to temperature. The lighting controller turns the lights ON only when its sensor resistance is greater than 10 k Ω .

Table 3

Sensor	Condition	Resistance / k Ω
Thermistor	10 °C	10
Thermistor	25 °C	5.0
Thermistor	40 °C	2.5
LDR	Dark	20
LDR	Bright light	1.0

5(a) Choose the sensor for detecting a rising display temperature. Explain how its resistance changes as the temperature rises. **[2 marks]**

Answer / mark points: Choose the thermistor. [1] Its resistance decreases as temperature rises, for example from 10 k Ω at 10 °C to 2.5 k Ω at 40 °C. [1]

5(b) Choose the sensor for the lighting controller. Use both of its readings to show that the lights will be ON in the dark and OFF in bright light. **[2 marks]**

Answer / mark points: Choose the LDR: in the dark its 20 k Ω resistance exceeds 10 k Ω , so lights are ON. [1] In bright light its 1.0 k Ω resistance is below 10 k Ω , so lights are OFF. [1]

5(c) At 25 °C, the potential difference across the thermistor is 0.50 V. Calculate its current in mA. **[2 marks]**

Answer / mark points: $R = 5.0 \text{ k}\Omega = 5000 \text{ }\Omega$; $I = 0.50 / 5000 = 0.000100 \text{ A}$. [1 for correct SI calculation]
 $I = 0.100 \text{ mA}$. [1 for conversion]

Teacher prompt: Convert k Ω to Ω before using volts and amps. Multiply the final current in A by 1000 to obtain mA.

5(d) You have a waterproof thermistor probe, resistance meter, thermometer and warm-water bath. Describe how to investigate resistance between 15 °C and 45 °C. Make clear what is placed in the water and what is measured. **[4 marks]**

Answer / mark points: Immerse the waterproof thermistor probe in the water, with its leads connected to the resistance meter kept dry. [1] Measure the water temperature with the thermometer close to the probe. [1] Wait for a steady temperature and read the probe resistance from the meter. [1] Change the water temperature in steps, for example every 5 °C from 15 °C to 45 °C, and record paired temperature and resistance values each time. [1]

Teacher prompt: Keep the probe immersed and stir gently for uniform temperature. Repeat at stable temperatures; use a low-current resistance test to limit self-heating. Measure the probe, not the water. Use teacher-managed warm water, not boiling water; keep meter and supply dry.



6 Planning an I–V investigation

Figure 3 is a measurement circuit. The rectangle labelled test component marks the position of the resistor, lamp or diode being tested; it is not their individual circuit symbol. P and Q are meter positions. All tests use a low-voltage DC supply.

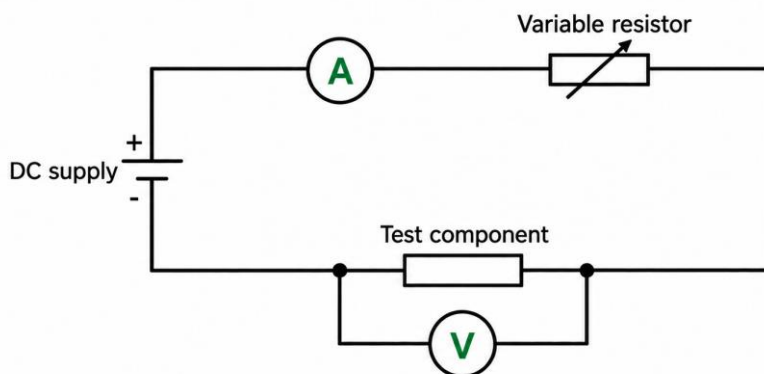


Figure 3

6(a) Identify the meter required at P and at Q. State how each is connected to the test component. **[2 marks]**

Answer / mark points: P: ammeter in series with the component. [1] Q: voltmeter in parallel across the component. [1] Each mark requires the correct meter and connection.

6(b) Describe how the technician can obtain several different positive potential differences across the test component. **[1 mark]**

Answer / mark points: Adjust the variable resistor or the adjustable DC supply to change the potential difference, checking the actual value on the voltmeter. [1]

6(c) Describe the change needed to investigate negative potential differences and reversed current through the component. **[1 mark]**

Answer / mark points: Switch off, reverse the DC supply connections and then switch on again. [1] Keep the meter connections in their original orientation so suitable digital meters show signed readings.

Teacher prompt: Reversing only the meter leads changes a displayed sign, not the direction of current through the component.



6 Planning an I–V investigation continued

6(d) Write a complete method to obtain an I–V graph for the display filament lamp from -4.0 V to $+4.0\text{ V}$. Use Figure 3 and develop your answers to (a)–(c) into an ordered method. Include a measurement range, intervals, paired readings, repeats and how to treat an unusual result. Explain how you would adapt the test for a fixed resistor and a diode. The lamp is rated at 4.0 V ; do not exceed any component rating. **[6 marks]**

Answer / mark points: Model method: replace the test component in Figure 3 with the lamp. Connect the ammeter in series and voltmeter across the lamp. Start with the supply at zero and a large variable resistance. Adjust until the voltmeter reads 0, 1, 2, 3 and 4 V. At each setting wait for the readings to settle and record both V and I. Switch off, reverse the supply connections, keep the meter orientation unchanged and repeat for -1 , -2 , -3 and -4 V . Repeat each setting under the same steady conditions and calculate a mean current. Recheck an unusual reading, including connections, rather than discarding it without evidence. Plot I vertically against V horizontally and draw a smooth curve. For a fixed resistor, use low currents/brief readings so its temperature remains approximately constant. For a diode, retain series current limiting, use smaller steps around the forward turn-on region and stay within its forward-current and reverse-voltage ratings. Holistic levels (not six automatic ticks): 5–6 marks: a coherent, functioning and usable signed-range method with paired readings and reliability checks; adaptations correctly distinguish constant resistor temperature from lamp warming and protect the diode. 3–4: a broadly workable method with some omissions in range, repeats, signed readings or adaptations. 1–2: isolated relevant steps, not a complete usable investigation. 0: no relevant content. Select the mark within the level for accuracy and completeness.

Teacher prompt: The lamp is allowed to warm to a steady temperature at each setting. Do not demand constant lamp temperature, a straight lamp graph or equal positive/negative current magnitudes from a diode. A series current-limiting resistor or current-limited supply is acceptable for the diode.

Review and improve

On an I-against-V graph, the gradient is I / V , not resistance. Use $R = V / I$ for a reading. Only an ohmic straight-line graph has a constant gradient equal to $1 / R$. Reverse the supply, not just the meter leads, to test reversed current. Keep the fixed resistor at constant temperature; allow a lamp to reach a steady temperature at each setting rather than pretending its temperature remains constant.

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