

Resistance practical: wire length and networks

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

Worked answers | Both qualifications and tiers | 28 parts | 44 marks

Specification points covered

8463 4.2.1.1 / 8464 6.2.1.1: circuit symbols and meter positions
8463 4.2.1.3 / 8464 6.2.1.3: $V = IR$; resistance practical (RP3 / RP15)
8463 4.2.2 / 8464 6.2.2: series and parallel resistor combinations

A model-railway workshop investigates unreliable lighting on a display. First, it tests how wire length affects resistance. Then it uses fixed resistors to model alternative lamp networks. These are two separate investigations; the test wire is not assumed to be the same material as the display leads.

Original PhysicsUK practice, not an official AQA resource. 28 parts, 44 marks. Both strands of RP3/RP15 are practised. Credit equivalent valid methods. Network resistance is inferred from measured total V and I , not a reciprocal formula. Fixed resistors model the layout, not the temperature-dependent resistance of real filament lamps. Read voltmeters as drawing negligible current.

1 Choosing a fair wire test

The team will compare different lengths of one uniform resistance wire. Its material and thickness are not changed.

1(a) A short test section has a p.d. of 1.2 V and a current of 0.30 A. Calculate its resistance. **[1 mark]**

Answer / mark points: $R = V / I = 1.2 / 0.30 = 4.0 \, \Omega$. [1] Use the p.d. across the same section whose current is measured.

1(b) A trainee proposes using a thicker wire for every longer length. Explain why this would not test the effect of length fairly. **[2 marks]**

Answer / mark points: The wire thickness / cross-sectional area would also change and can affect resistance. [1]

Any change in resistance could not be attributed to length alone. [1] Use the same material and thickness throughout.



2 Checking the measuring circuit

Figure 1 shows the wire test. P and Q are the contact points. Close the switch only while taking readings; the supply can be adjusted to keep the current low. Treat the meters as ideal.

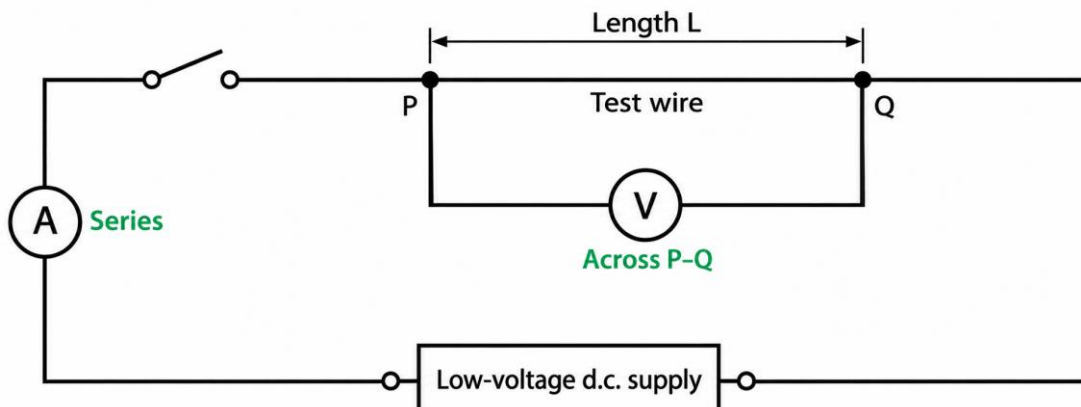


Figure 1

2(a) Describe how the ammeter is connected relative to the test wire. [1 mark]

Answer / mark points: In series with the test-wire circuit / in the main loop before or after the P–Q section. [1] It is not connected across the wire.

2(b) Describe exactly where the two voltmeter leads must connect. [1 mark]

Answer / mark points: One to P and one to Q, in parallel across the measured test-wire section. [1] Not across an ammeter or some different length.

2(c) Explain why leaving the switch closed for a long time could make the length investigation unfair. [2 marks]

Answer / mark points: Current can heat the wire, increasing its temperature. [1] Its resistance can then change because of temperature as well as length. [1] “It gets hot” alone does not explain the effect on the investigation.

2(d) The wire extends beyond both contacts. State which length should be measured and how to reduce a ruler-reading error. [2 marks]

Answer / mark points: Measure the wire length between P and Q / the actual contact points, not the full wire or free ends. [1] Place a ruler alongside the straight wire and read directly above the contacts to avoid parallax; accept correct zero alignment with a ruler datum. [1]



3 Processing the wire readings

Table 1 gives simplified, rounded practice data at constant temperature. The same wire is used throughout. The supply is adjusted for each length. Calculate each resistance separately; show working.

Table 1

Length / cm	P.d. / V	Current / A
20	0.40	0.20
40	0.80	0.20
60	1.20	0.20
80	1.60	0.20
100	2.00	0.20

3(a) Calculate the resistance of the 20 cm section. **[1 mark]**

Answer / mark points: $R = 0.40 / 0.20 = 2.0 \, \Omega$. [1]

3(b) Calculate the resistance of the 40 cm section. **[1 mark]**

Answer / mark points: $R = 0.80 / 0.20 = 4.0 \, \Omega$. [1]

3(c) Calculate the resistance of the 60 cm section. **[1 mark]**

Answer / mark points: $R = 1.20 / 0.20 = 6.0 \, \Omega$. [1]

3(d) Calculate the resistance of the 80 cm section. **[1 mark]**

Answer / mark points: $R = 1.60 / 0.20 = 8.0 \, \Omega$. [1]

3(e) Calculate the resistance of the 100 cm section. **[1 mark]**

Answer / mark points: $R = 2.00 / 0.20 = 10 \, \Omega$. [1]

3(f) At 60 cm, three repeat p.d. readings are 1.18 V, 1.20 V and 1.22 V. Current is 0.20 A for each reading. Calculate the mean p.d., then use it to calculate the resistance. **[2 marks]**

Answer / mark points: Mean p.d. = $(1.18 + 1.20 + 1.22) / 3 = 1.20 \, \text{V}$. [1]
 $R = 1.20 / 0.20 = 6.0 \, \Omega$. [1] Repeats do not by themselves remove a systematic contact or ruler error.



4 Using the resistance–length graph

Use your five resistances from Table 1. Each large grid square represents 20 cm horizontally and 2 Ω vertically.

4(a) Plot the five results from Table 1 on Figure 2 and draw a straight line of best fit. [3 marks]

Answer / mark points: Five points: (20, 2), (40, 4), (60, 6), (80, 8), (100, 10), with cm and Ω as on the axes. [2: all 5 correct; 1 for 3–4 correct]

One suitable straight best-fit line through the pattern, passing through the origin for these data. [1]

The supplied scales are already labelled; no marks for relabelling.

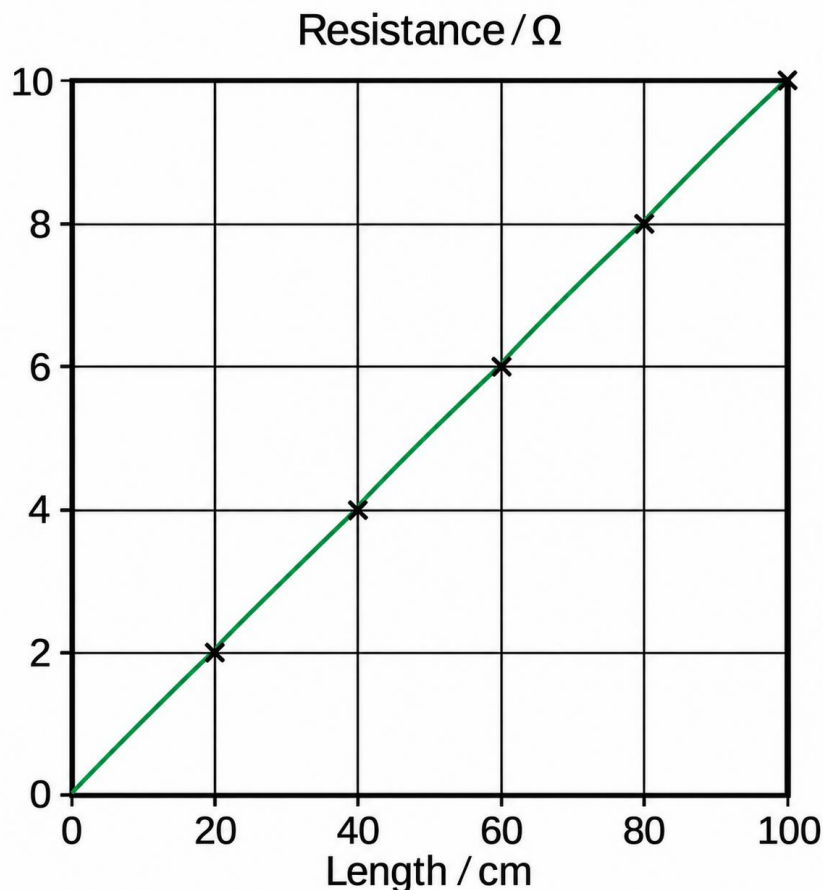


Figure 2

4(b) Describe the relationship shown by these results and give graphical evidence for your answer. [2 marks]

Answer / mark points: Resistance is directly proportional to wire length for this wire at constant temperature. [1]

The graph is a straight line through the origin / doubling length doubles resistance, with a correct data pair. [1] "Both increase" alone is insufficient.

4(c) Use the graph to estimate the resistance of a 70 cm section of this same wire at the same temperature. [1 mark]

Answer / mark points: Approximately 7.0 Ω . [1] Accept 6.8–7.2 Ω from a reasonable hand-drawn line. This is interpolation between 60 and 80 cm, not a prediction for a different wire.



5 Planning and evaluating the wire test

Build a six-mark-style method in parts (a)–(c). Write a usable procedure, not just a list of apparatus. A ruler, two crocodile contacts and the Figure 1 circuit are available.

5(a) Describe how to set and measure a range of wire lengths while controlling the wire itself. **[2 marks]**

Answer / mark points: Use one uniform wire of the same material and thickness; fix one contact and move the other to select at least five lengths. [1]
Measure each length between the contacts using a ruler alongside the straight wire, with a consistent datum and eye position. [1]

5(b) Describe which readings to take at each length and how to obtain reliable resistance values from them. **[2 marks]**

Answer / mark points: At each length close the switch briefly and record current in the series ammeter and p.d. from the voltmeter across the contacts. [1]
Calculate $R = V / I$ for that length; repeat each measurement and calculate a mean resistance (or mean V at the same I). [1] Do not average measurements from different lengths.

5(c) Describe how to keep the test near constant temperature and how to display the results to test the relationship. **[2 marks]**

Answer / mark points: Use a low current and disconnect between readings, allowing the wire to cool before measuring again. [1]
Plot resistance on the vertical axis against measured length on the horizontal axis; use the best-fit pattern to test proportionality. [1] Low supply voltage does not remove all heating risks.

5(d) Later, the 80 cm section gives 1.92 V at 0.20 A. Calculate its resistance. **[1 mark]**

Answer / mark points: $R = 1.92 / 0.20 = 9.6 \, \Omega$. [1] This exceeds the original $8.0 \, \Omega$ result.

5(e) A trainee says this result proves that the wire was hotter. Explain why the conclusion is too strong and suggest a useful check. **[2 marks]**

Answer / mark points: A higher calculated resistance is consistent with warming, but could also follow a poor contact / wrong effective length / meter error; one result does not prove the cause. [1]
Check contacts and length, let the wire cool and repeat with a low current; compare repeated results before deciding. [1] Do not delete a reading merely because it disagrees.



6 Testing two network layouts

Replace the test wire between P and Q in Figure 1 with each network in Figure 3; keep the meters in place. P and Q now mark the whole network. Each fixed resistor is $20\ \Omega$. These resistors model wiring layouts, not changing lamp temperatures. Keep the measured p.d. across P–Q at $4.0\ \text{V}$ in every test. Table 2 gives total-current readings.

Network A



Network B

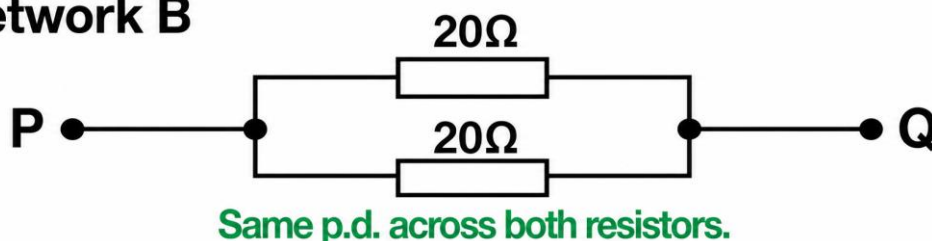


Figure 3

Table 2

Test	P.d. across test / V	Total current / A
One $20\ \Omega$ resistor	4.0	0.20
Network A	4.0	0.10
Network B	4.0	0.40

6(a) Use Table 2 to calculate the resistance of the single-resistor test. **[1 mark]**

Answer / mark points: $R = 4.0 / 0.20 = 20\ \Omega$. [1]

6(b) Use the measured total p.d. and current to calculate the resistance of Network A. **[1 mark]**

Answer / mark points: $R = 4.0 / 0.10 = 40\ \Omega$. [1] Also equals $20 + 20\ \Omega$ for these series resistors.

6(c) Use the measured total p.d. and current to calculate the resistance of Network B. **[1 mark]**

Answer / mark points: Measured network resistance = $4.0 / 0.40 = 10\ \Omega$. [1] This uses measurements of the whole network, not a parallel-combination formula.

6(d) In Network A, the current is $0.10\ \text{A}$ through each $20\ \Omega$ resistor. Calculate the p.d. across one resistor. **[1 mark]**

Answer / mark points: $V = IR = 0.10 \times 20 = 2.0\ \text{V}$. [1] Each has half the total p.d. because their resistances are equal.



7 Making a workshop recommendation

Use the Figure 3 layouts and Table 2. The supply maintains 4.0 V across each complete network. Assume the fixed resistors remain at constant temperature.

7(a) Explain why adding the second parallel resistor gives a lower measured total resistance than using one resistor alone. **[2 marks]**

Answer / mark points: It provides another conducting path, so total current increases at the same p.d. [1]
Since measured $R = V / I$, a larger total I at the same V gives a lower total resistance. [1] Each individual resistor is still 20 Ω .

7(b) The team wants each display lamp to receive the full supply p.d. and to stay on if the other lamp is removed. Which layout should it choose? Explain using the paths in the circuit. **[2 marks]**

Answer / mark points: The parallel layout, Network B: each branch is connected across the supply and receives the full p.d. [1]
Removing one lamp opens only that branch; the other still has a complete supply path. [1] With a suitable maintained supply, one lamp is not fed through the other.

7(c) Describe a fair measurement procedure to compare the resistance of one resistor, two in series and two in parallel. Include meter positions and how to process the readings. **[3 marks]**

Answer / mark points: With power off, use the same two fixed resistors to build the single, series and parallel cases; keep their temperature controlled and set the same measured p.d. for each comparison. [1]
Place the ammeter in the main supply path to measure total current and the voltmeter across the entire selected network / P–Q; check connections before powering. [1]
Record V and total I , calculate network $R = V / I$, and repeat to obtain means for comparison. [1]
Never put an ammeter directly across the supply.

7(d) In the parallel test, a trainee uses the 0.20 A current in just one branch with the 4.0 V across the network. They report 20 Ω for the whole network. Explain the error and state the correct total current to use. **[2 marks]**

Answer / mark points: That voltage and branch current calculate the resistance of one branch, not the whole network. [1]
Use the total current before the junction: $0.20 + 0.20 = 0.40$ A, giving 10 Ω . [1] Current is shared between paths, not used up.

Review and improve

Check meter placement and the measured P–Q section before accepting $R = V / I$. A written method is not practical completion. Timing is estimated and untrials.

Continue your physics journey

Videos, practice and support for your next step

www.physicsuk.co.uk

