

Practical graphs errors and evidence

AQA GCSE Combined Science Trilogy 8464 and Separate Physics 8463 | Papers 1 and 2 | Both tiers

Suggested: 35–40 minutes + 15–20 minutes review | 27 parts | 52 marks

Skills practised and specification contexts

Both courses: WS 2.2, 2.6, 2.7 and WS 3.1–3.7: measurements, graphs and evidence
 8463 4.2.1.3 / 8464 6.2.1.3: resistance from current and potential difference
 8463 4.5.3 / 8464 6.5.3: spring compression, proportionality and $F = kx$
 8463 4.3.1.1 / 8464 6.3.1.1: density and displacement measurements
 8463 4.1.1.3 / 8464 6.1.1.3: specific heat capacity and thermal measurements

A school laboratory reviews test data for a model delivery trolley: its spring buffer, chassis material and parcel-heater circuit. Decide which measurements and conclusions can be trusted, and how the tests should be improved.

Use a calculator, ruler and equations sheet. Show working and units. All data are original practice data. Figure 2 is a trainee's draft with deliberate errors. This worksheet is not a product-safety certificate or a substitute for practical work.

1 Zero checks on the heater circuit

A digital ammeter has adjacent display values of 0.23 A and 0.24 A. When disconnected, it reads +0.04 A. Assume this same positive offset is added to every current reading. The voltmeter is correctly zeroed.

1(a) State the resolution of the ammeter display. **[1 mark]**

1(b) Name the error shown by the disconnected ammeter. **[1 mark]**

1(c) During a test, 4.0 V is measured across the heater and the ammeter reads 0.24 A. Correct the current reading, then calculate the heater's resistance using $R = V / I$. **[2 marks]**

1(d) Twenty repeated readings have a mean of 0.24 A. Has taking this mean removed the zero error? Explain. **[1 mark]**



2 Which spring readings can be used

The trolley's spring buffer is compressed slowly using known forces. Compression is the decrease from its unloaded length. The same operator makes three measurements at each force using the same apparatus. Table 1 gives compression in mm.

Table 1

Force / N	Trial 1 / mm	Trial 2 / mm	Trial 3 / mm
0	0.0	0.0	0.0
1	4.8	5.0	5.2
2	9.8	10.0	10.2
3	14.8	15.0	15.2
4	19.8	29.8	20.2
5	24.8	25.0	25.2

2(a) Identify the independent variable and the dependent variable in the spring test. **[2 marks]**

2(b) Identify the reading that appears anomalous. Use the other repeats at the same force as evidence. **[2 marks]**

2(c) What should the operator do before deciding to exclude this reading from the mean? **[1 mark]**

2(d) A check confirms that the pointer slipped during the 29.8 mm reading. A replacement reading is 20.0 mm. Calculate the mean at 4 N using 19.8, 20.0 and 20.2 mm. **[1 mark]**

2(e) Calculate the mean compression at 1 N and at 5 N from Table 1. **[2 marks]**

2(f) The pointer vibrates after each load is changed. Suggest an improvement to the reading procedure and explain why it helps. **[2 marks]**

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3 Presenting the spring evidence

Use the checked means in Table 2, even if your earlier means differ. The spring remains within its limit of proportionality.

Table 2

Force / N	0	1	2	3	4	5
Mean compression / mm	0	5.0	10.0	15.0	20.0	25.0

3(a) Plot mean compression against force on Figure 1. Choose and label the axes with units, use suitable linear scales, plot all six points and draw a line of best fit. **[5 marks]**

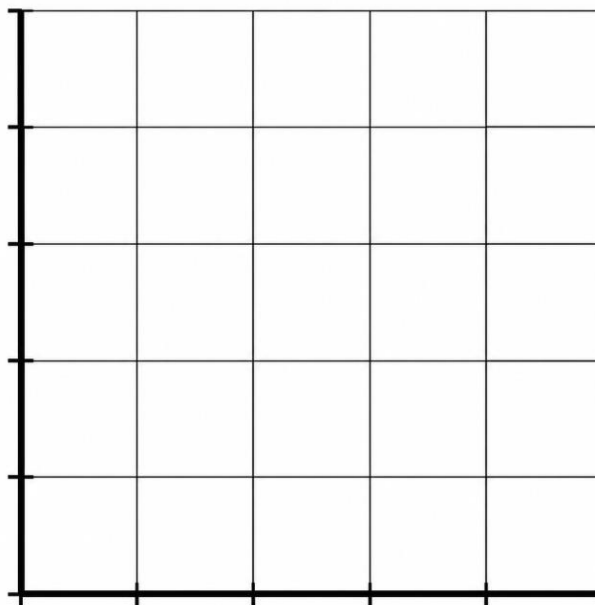


Figure 1

3(b) Use your best-fit line to determine the spring constant in N/m. Use $F = ke$; remember that compression e must be in metres. **[2 marks]**

3(c) Use your graph to estimate the compression at 2.5 N. **[1 mark]**

3(d) Does your graph support direct proportionality between compression and force over the tested range? Give graph evidence. **[2 marks]**

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4 Criticising the trainee graph

The same spring has an unloaded length of 50 mm. Its loaded lengths are 50, 45, 40, 35, 30 and 25 mm at forces of 0, 1, 2, 3, 4 and 5 N. Figure 2 shows these six data crosses and the trainee's attempted best-fit line. The scale numbers and crosses are correct; the draft contains errors. Use the data crosses, not the attempted line, for readings.

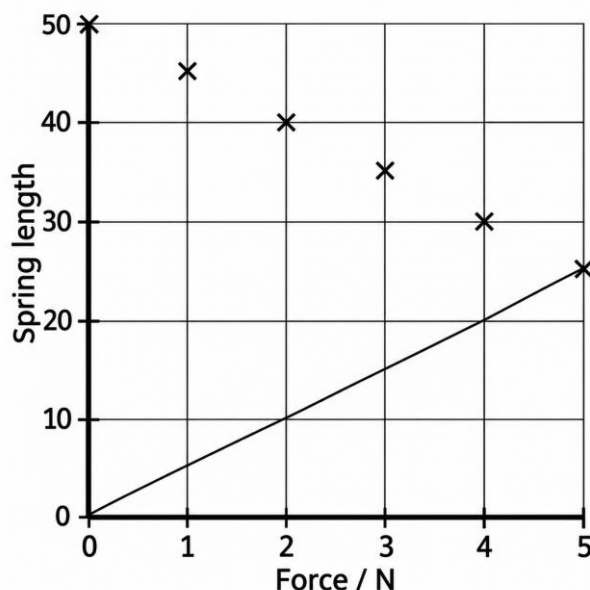


Figure 2

4(a) Identify the omission from the vertical-axis label in the trainee's graph. [1 mark]

4(b) Explain why the trainee's attempted best-fit line is unsuitable. Refer to the pattern of the data and to the no-force measurement. [2 marks]

4(c) Read the spring length at 3 N from the data cross. Use the unloaded length of 50 mm to calculate the compression at this force. [2 marks]

4(d) A constant +2 mm ruler offset changes the unloaded length from 50 mm to 52 mm and the loaded length from 45 mm to 47 mm. Calculate the recorded compression and explain whether this offset changes it. [2 marks]

4(e) The operator reads the ruler from a different viewing angle each time. Explain how this can increase variation, and state how to reduce this effect. [2 marks]

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5 Checking the chassis material

A solid, non-porous chassis sample is fully submerged without touching the cylinder scale. Its correctly measured mass is 54.0 g. The initial water volume is 30.0 cm³ and the final volume is 50.0 cm³. Use density = mass / volume; answers in g/cm³ are suitable here.

5(a) Calculate the sample's volume and density from the displacement measurements. [2 marks]

5(b) In a repeat test, an air bubble sticks to the sample, giving a final volume of 52.0 cm³ instead of 50.0 cm³. The initial volume is still 30.0 cm³. Calculate the density estimate and explain the direction of its error. [2 marks]

Table 3

Measurement set	Density estimates / g cm ⁻³
A before zero correction	3.09, 3.10, 3.11
A after zero correction	2.69, 2.70, 2.71
B with different equipment	2.68, 2.70, 2.72

5(c) Table 3 shows later density estimates. The accepted reference value is 2.70 g/cm³. Evaluate A's results before zero correction in terms of precision and accuracy. Use the data. [2 marks]

5(d) A check finds that A's empty balance shows a positive reading. State how A should correct this before weighing the sample, and explain why. [2 marks]

5(e) After A corrects the balance, operator B repeats the test using different equipment. Compare their results in Table 3. Which aspect of measurement quality does this check? [2 marks]



6 Evaluating the heater evidence

The parcel-heater test uses a metal block of mass 0.50 kg. A joulemeter records 3000 J supplied electrically to the heater. The block's measured temperature rises from 20.0 °C to 26.0 °C. For this evaluation, the mass, energy and temperature instruments are correctly calibrated; the block loses thermal energy to the surroundings. Use $E = mc\Delta\theta$ to analyse the estimate made by assuming all electrical energy heats the block.

6(a) Calculate the temperature rise and the estimated specific heat capacity of the block. **[2 marks]**

6(b) Explain why using all 3000 J as the energy gained by the block overestimates its specific heat capacity. **[2 marks]**

6(c) Two proposals are made: repeat the unchanged test ten times and average, or insulate the block and repeat under controlled conditions. Evaluate which better addresses the heat-loss bias. Explain the role of repeats and name one condition that should be matched for a fair comparison. **[4 marks]**

Review: choose one improvement and explain which limitation it addresses and why it helps.

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