

Exercise walk-through

1.3

The Language of Science

GAC Science

Method — Key knowledge: a quantity needs its definition, unit and sensible reported precision

Units identify the scale used for a physical quantity. Conversions preserve the quantity while changing its numerical representation. Average speed is distance travelled divided by elapsed time. **Precision** concerns closeness of repeated measurements, while **accuracy** concerns closeness to a suitable reference or true value. Close repeats do not prove accuracy. Report digits supported by the measurements and avoid claiming uncertainty that was not established.

Method — Source A: text or task brief

Fictional trolley record: total travelled distance 3.60 m; elapsed time 48.0 s. The written task assumes these supplied values and asks for average speed. Three repeated timer readings for a separate fixed event are 10.1 s, 10.1 s and 10.2 s. A suitable independent reference measures that event as 12.0 s. A separate paper square has side length 10.0 cm. Use $1 \text{ m} = 100 \text{ cm}$ and $1 \text{ m}^2 = 10,000 \text{ cm}^2$. No uncertainty budget or acceleration measurements are supplied.

Method — Source B: response or review record

Student notes: “Average speed = time divided by distance = 13.3 m/s. Ten centimetres is 0.010 m, so the square area is 0.010 m². The three timer readings are close, therefore accurate. Every calculated result should show eight decimal places. The trolley’s average speed proves it travelled at a constant speed.”

Method — Worked example: write the equation before the conversion and substitution

Known: distance 3.60 m and elapsed time 48.0 s. Why divide distance by time?
Average speed is the distance travelled per unit time.

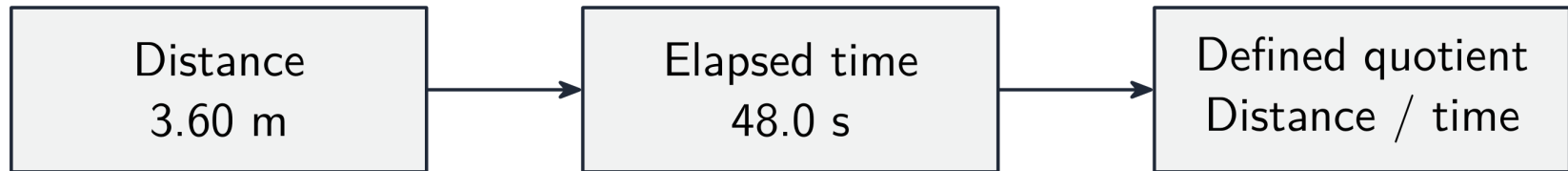
$$v_{\text{avg}} = \frac{d}{t}$$

$$v_{\text{avg}} = \frac{3.60 \text{ m}}{48.0 \text{ s}} = 0.0750 \frac{\text{m}}{\text{s}}$$

This is an average for the whole interval. It does not state the speed at every moment.

Method — Worked example: write the equation before the conversion and substitution

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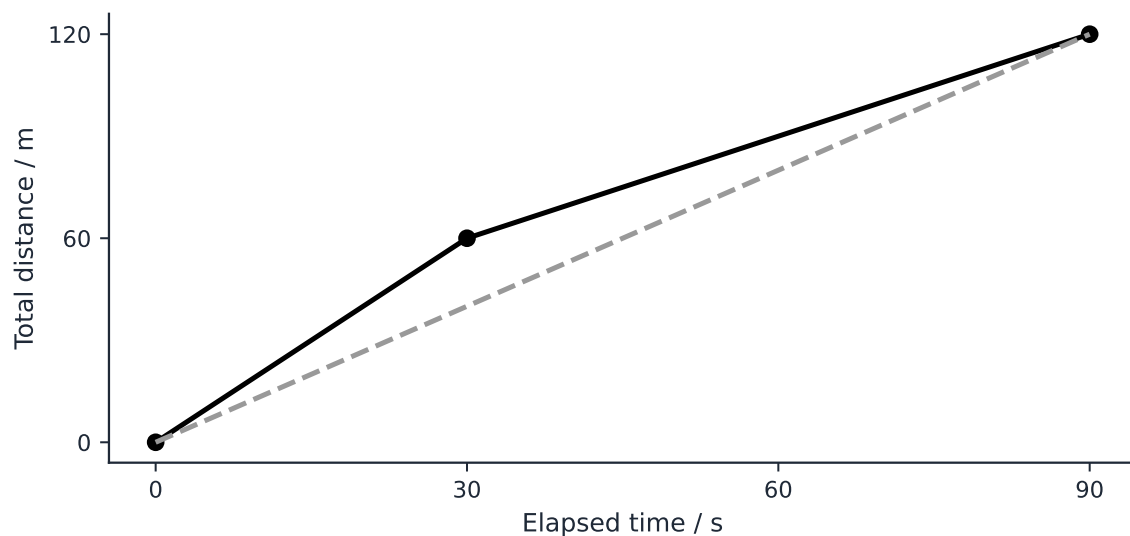


Method — Worked application: Average the whole trip, not the two speeds

A separate invented journey covers 60 m in 30 s and then another 60 m in 60 s. Segment speeds are 2 and 1 m s⁻¹. Whole-trip average speed is total distance divided by total elapsed time: $v_{\text{avg}} = (60 + 60)/(30 + 60) = 4/3 \text{ m s}^{-1}$. The unweighted mean of the two speeds, 1.5 m s⁻¹, is wrong because the segments take different times. Include any stationary waiting time in the total if it belongs to the stated journey. The result still gives no claim about acceleration or instantaneous speed.

Method — Worked application: Average the whole trip, not the two speeds

Include any stationary waiting time in the total if it belongs to the stated journey.



Original diagram of the separate worked extension

Exercises 2.1-2.3

2.1 State the equation for average speed and its SI unit. [2]

2.2 Convert 10.0 cm to metres and calculate the square's area in m^2 . [2]

2.3 Calculate the trolley's average speed with a suitable number of significant figures. [3]

Exercises 2.1-2.3

2.1 State the equation for average speed and its SI unit. [2]

2.1

: average speed = travelled distance / elapsed time, $v_{\text{avg}} = d/t$.: metre per second, written m/s or as a stacked fraction.

2.2 Convert 10.0 cm to metres and calculate the square's area in m^2 . [2]

2.2

: $10.0/100 = 0.100 \text{ m}$.: area = $\text{side}^2 = (0.100 \text{ m})^2 = 0.0100 \text{ m}^2$. The student's area happens to have the right numerical size but their stated side length does not support it.

2.3 Calculate the trolley's average speed with a suitable number of significant figures.[3]

2.3

: $v_{\text{avg}} = d/t$.: $v_{\text{avg}} = 3.60/48.0 = 0.0750 \text{ m/s}$.: three significant figures match the supplied values; leading zeros are not significant.

Exercises 2.4·3.1

2.4 Explain what the repeated timer readings show about precision and accuracy. [3]

3.1 Evaluate the student notes with six corrections or limits. [6]

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2.4

: readings are close, indicating good repeat precision for this record.: they differ substantially from the supplied 12.0 s reference.: therefore close repeats do not establish accuracy; a systematic timing problem should be investigated.

3.1 Evaluate the student notes with six corrections or limits. [6]

3.1

each: speed uses distance/time, not the reverse; inverted quotient has units s/m, not m/s; 10.0 cm is 0.100 m; area conversion squares the length factor; precision differs from accuracy; average speed does not establish constant speed. Accept justified reporting precision instead of one of the distinct unit corrections.

Exercise 3.2

3.2 Write an 80–110-word corrected measurement note explaining the result and its limits. [8]

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3.2

Local analytic rubric, 8 ×: state distance/time definition; give 0.0750 m/s; use appropriate precision; correct length conversion; square the conversion for area; distinguish close repeats from accuracy; use independent reference; avoid constant-speed or invented-uncertainty claim; coherent truthful 80–110 word response. Example: “Average speed is travelled distance divided by elapsed time. The trolley’s supplied values give 0.0750 metres per second, reported to three significant figures. This interval average does not prove constant speed. A side of 10.0 centimetres equals 0.100 metres, so its square area is 0.0100 square metres. Length and area need different conversion factors. The repeated timer readings are close together, but they disagree with the supplied 12.0-second reference. They therefore show repeat precision without establishing accuracy. We should investigate the timing procedure rather than add unsupported decimal places or invent an uncertainty range.”

Exercise 3.3

3.3 A fictional journey covers 40 m in 20 s and 60 m in 60 s. Calculate its whole-trip average speed and explain why averaging the two segment speeds without weights gives a different answer. [4]

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3.3

Total distance = 100 m and time = 80 s; $v_{\text{avg}} = 100/80 = 1.25 \text{ m s}^{-1}$; segment speeds are 2 and 1 m s^{-1} ; their unequal durations require time weighting, so the simple mean 1.5 is inappropriate.