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SOLUTIONS
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Linear motion 2 solutions

AQA AS 7407 and first-year A Level 7408 | OCR A AS H156 and A Level H556

Matching solutions and teaching prompts for the class review

Specification points covered

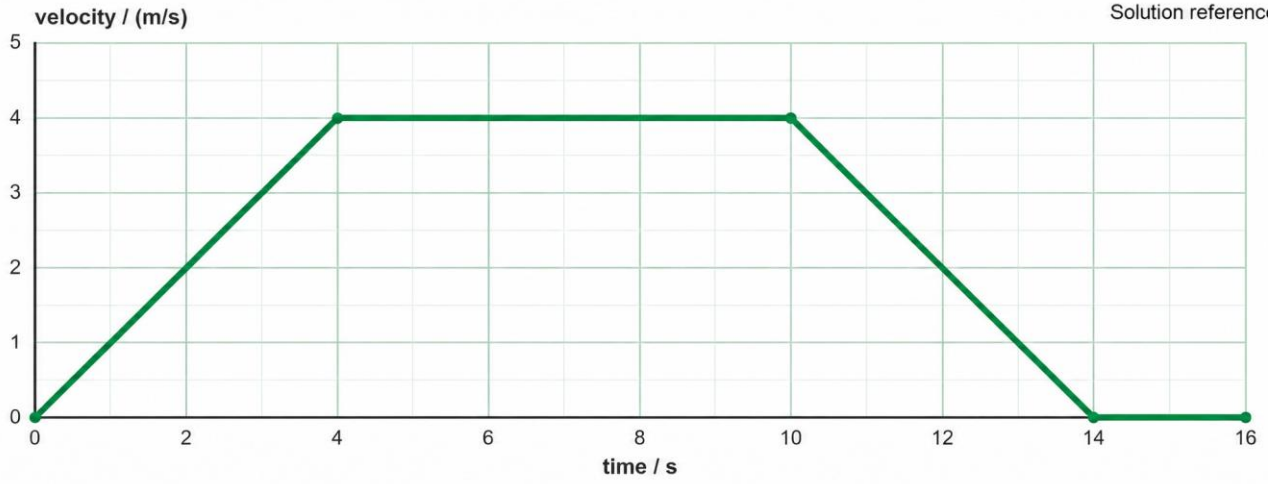
AQA 7407 / 7408: 3.4.1.3 selected motion skills — graphical gradients and signed areas, acceleration–time graphs, journey comparisons and the constant-acceleration condition for SUVAT.
OCR A H156 / H556: 3.1.1(a)–(d); 3.1.2(a)(i) — displacement, velocity, acceleration, graphical motion and the constant-acceleration condition. No free-fall practical is assessed here.

Graph language and review focus
Use gradients and signed areas to interpret a logistics trial. Name the quantity, say whether it increases, decreases or stays constant, and identify linear changes.
36 marks. Acceleration–time area is change in velocity; velocity–time area is displacement. Accept equivalent valid methods and consistent consequential work.

A Delivery cart velocity and acceleration

Context
A robotic delivery cart moves east along a straight warehouse aisle. East is the positive direction.

Solution reference



1. State the velocity of the delivery cart at t = 2.0 s. [1 mark]

Answer / mark points: 2.0 m s^{-1} east. [1]

Teacher prompt / common error: Read velocity, not gradient, at the specified time.

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2. From t = 0 to t = 4.0 s, describe the cart's velocity and acceleration. Use precise scientific language. [2 marks]

Answer / mark points: Velocity increases linearly from 0 to +4.0 m s^{-1}. [1] Acceleration is constant and positive. [1]

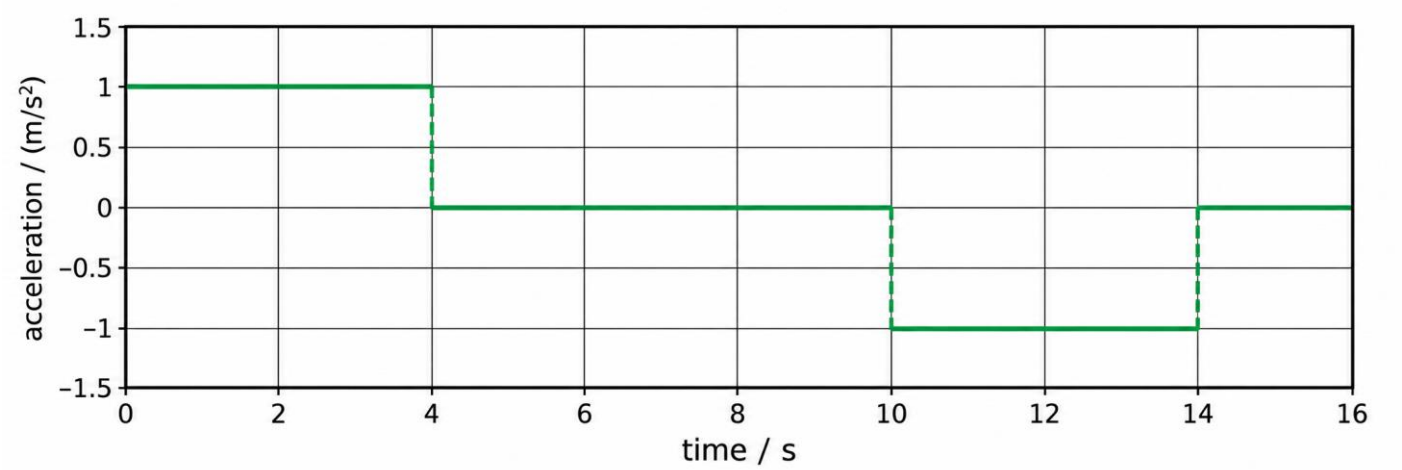
Teacher prompt / common error: Velocity increases; do not write that velocity accelerates.

A Acceleration graph and signed areas

3. Draw the delivery cart's acceleration–time graph on the axes provided, for the full 0–16 s run. Treat the changes between straight-line stages as instantaneous. [4 marks]

Answer / mark points: Acceleration is +1.0 m s^{-2} for 0–4 s [1], zero for 4–10 s [1], −1.0 m s^{-2} for 10–14 s [1] and zero for 14–16 s [1]. The solution graph shows these four intervals.

Teacher prompt / common error: Award one mark per correct horizontal level over the correct interval. Ignore treatment of the instantaneous boundaries. Dashed vertical joins are idealised jumps, not finite-duration intervals.



4. Calculate the acceleration of the cart from t = 10 s to t = 14 s. [1 mark]

Answer / mark points: $a = \Delta v/\Delta t = (0 - 4.0)/(14 - 10) = -1.0$ m s^{-2}. [1]

Teacher prompt / common error: Negative acceleration here reduces the positive velocity; it does not mean the cart travels west.

5. Calculate the displacement of the cart from t = 0 to t = 14 s. [3 marks]

Answer / mark points: Rising triangle: ½ × 4 × 4 = 8 m. [1] Rectangle: 6 × 4 = 24 m. [1] Falling triangle: ½ × 4 × 4 = 8 m, giving total displacement 8 + 24 + 8 = 40 m east. [1]

Teacher prompt / common error: Accept the equivalent trapezium method. The total is an area under a velocity–time graph, not a gradient.

6. Use the signed areas under your acceleration–time graph to determine the cart's final velocity at 16 s. Explain whether zero net area would mean that the cart travelled zero distance. [3 marks]

Answer / mark points: The non-zero signed acceleration–time areas are (+1.0 × 4) = +4.0 m s^{-1} and (−1.0 × 4) = −4.0 m s^{-1}. [1] Net change in velocity is zero; initial velocity is zero, so final velocity is zero. [1] Zero net change in velocity does not imply zero distance: the cart moves east before returning to rest. [1] Its distance is 40 m.

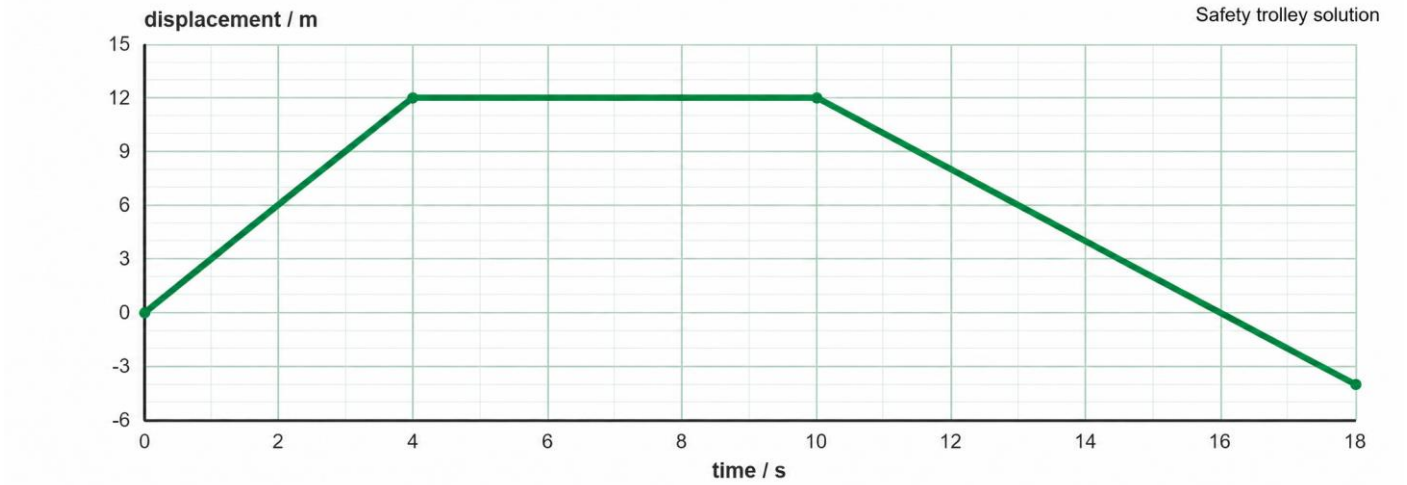
Teacher prompt / common error: An acceleration–time area is a change in velocity, not displacement or distance. Zero net area means equal initial and final velocities.

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B Safety trolley displacement and direction

Context

The safety trolley travels on the same straight aisle. East is positive. It returns past its starting point during the final section.



7. Use the graph to calculate the velocity of the safety trolley from t = 0 to t = 4.0 s. [1 mark]

Answer / mark points: $v = \Delta s/\Delta t = (12 - 0)/(4.0 - 0) = +3.0$ m s^{-1}. [1]

Teacher prompt / common error: The positive gradient represents eastward velocity.

8. From t = 4.0 s to t = 10 s, describe the trolley's displacement and velocity. [2 marks]

Answer / mark points: Displacement stays constant at +12 m. [1] Velocity is zero because the displacement–time gradient is zero. [1]

Teacher prompt / common error: The trolley is stationary 12 m east of the start, not back at the origin.

9. Use the graph to calculate the velocity of the safety trolley from t = 10 s to t = 18 s. [1 mark]

Answer / mark points: $v = (-4 - 12)/(18 - 10) = -16/8 = -2.0$ m s^{-1}. [1]

Teacher prompt / common error: Use change in displacement, including the negative final coordinate.

10. From t = 10 s to t = 18 s, describe the trolley's motion. Include the direction of travel. [2 marks]

Answer / mark points: Displacement decreases linearly. [1] The trolley travels west at constant velocity, −2.0 m s^{-1}. [1]

Teacher prompt / common error: It passes the origin at 16 s without reversing there. A downward displacement–time line does not mean it slows down.

11. Calculate the total distance travelled by the trolley from t = 0 to t = 18 s. [2 marks]

Answer / mark points: Eastward distance is 12 m and westward distance is 12 − (−4) = 16 m. [1] Total distance is 12 + 16 = 28 m. [1]

Teacher prompt / common error: Add positive distances. Final displacement is −4 m and is not the total distance.

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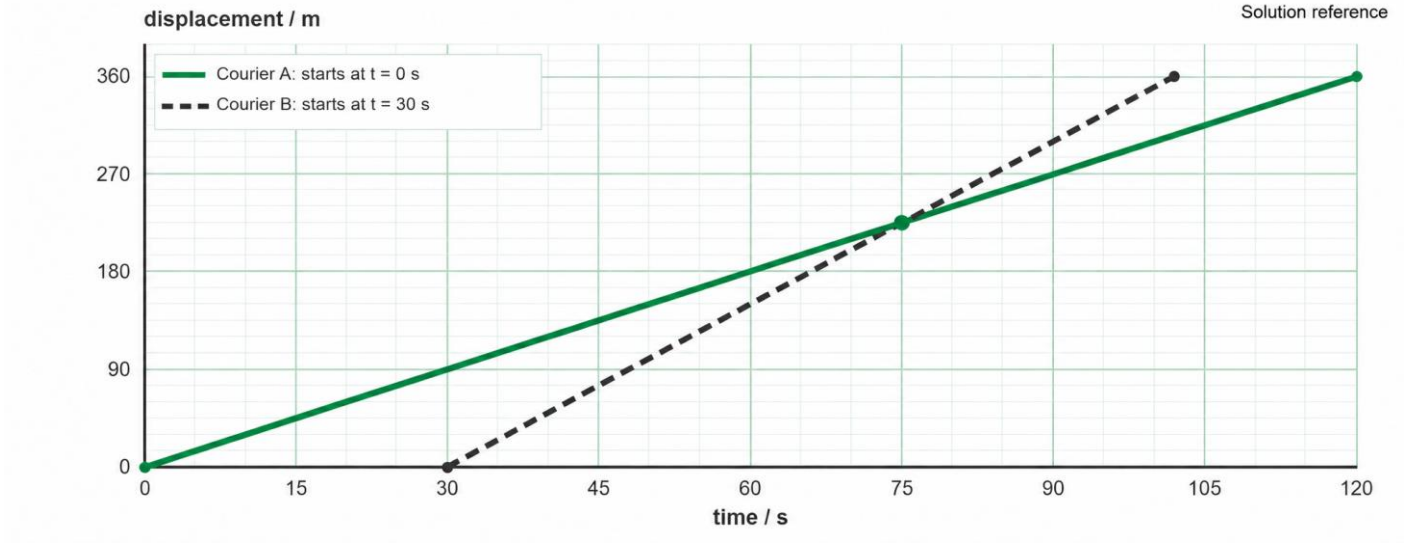
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C Courier journey comparisons

Context

Two bicycle couriers travel from the same gate to a marker 360 m away. Courier A starts at t = 0 s. Courier B starts at t = 30 s.

Solution reference



12. At t = 30 s, calculate how far ahead of Courier B Courier A is. [1 mark]

Answer / mark points: Courier A is at 3.0 × 30 = 90 m while B is at the gate, so A is 90 m ahead. [1]
Teacher prompt / common error: Both positions must refer to the same clock time.

13. Use the graph to determine (i) the time at which Courier B overtakes Courier A and (ii) their displacement then. [2 marks]

Answer / mark points: The lines intersect at t = 75 s [1] and displacement 225 m. [1]
Teacher prompt / common error: The intersection has equal displacement and equal clock time, not equal velocity.

14. Each courier reaches the marker at a displacement of 360 m. Determine the time each courier spends moving from the gate to the marker. [2 marks]

Answer / mark points: A spends 120 s moving. [1] B arrives at clock time 102 s but starts at 30 s, so spends 102 − 30 = 72 s moving. [1]
Teacher prompt / common error: Elapsed journey time must be measured from that courier's own start.

15. Calculate the gradient of each courier's displacement-time line. State what each gradient represents. [2 marks]

Answer / mark points: A: gradient = 360/120 = 3.0 m s^{-1}, its constant eastward velocity. [1] B: gradient = 360/(102 − 30) = 5.0 m s^{-1}, its constant eastward velocity. [1]
Teacher prompt / common error: Each mark requires the numerical gradient with units and its velocity interpretation. Use an interval on the relevant line.

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C Journey decisions and model limits

16. Explain why Courier B overtakes Courier A even though Courier B starts later. [2 marks]

Answer / mark points: B has the steeper displacement–time line and therefore the greater velocity. [1] Its displacement increases more rapidly, so it closes A's initial lead and then passes A. [1]

Teacher prompt / common error: A later start does not prevent overtaking when the later traveller has a greater velocity.

17. A trainee applies one constant-acceleration SUVAT equation to the cart's whole 0–14 s run. Because it starts and finishes at rest, the trainee uses a = 0 and concludes that its displacement is zero. Explain why this reasoning is invalid. [2 marks]

Answer / mark points: A constant-acceleration SUVAT equation requires acceleration to stay constant over the interval, but the graph has different gradients in different stages. [1] Zero average acceleration only means equal initial and final velocities; it does not imply rest throughout or zero displacement. [1]

Teacher prompt / common error: SUVAT may be used separately on a constant-acceleration interval. Here the cart starts and finishes at rest but moves 40 m between those events.

18. In a separate courier trial, A and B initially follow the velocities and start times in the graph. At t = 60 s, A stops for 10 s and then resumes its original velocity. B continues unchanged. Ignore the short stopping and restarting transitions. Determine whether B overtakes A while A is stationary. Find the clock time and displacement of this event. [3 marks]

Answer / mark points: At 60 s A is at 3.0 × 60 = 180 m and B at 5.0 × (60 − 30) = 150 m, leaving a 30 m gap. [1] B takes 30/5.0 = 6.0 s to close this gap while A is stationary. [1] Overtaking occurs at clock time 66 s and displacement 180 m, before A restarts at 70 s, so yes. [1]

Teacher prompt / common error: Check that the calculated event lies in the 60–70 s stationary interval. Do not use the original 75 s intersection after changing A's journey.

Review: distinguish clock time from elapsed time, distance from displacement, and zero net change in velocity from no motion.

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