OCR A A Level Motion Graphs solutions

Matching solutions and teaching prompts for the class review

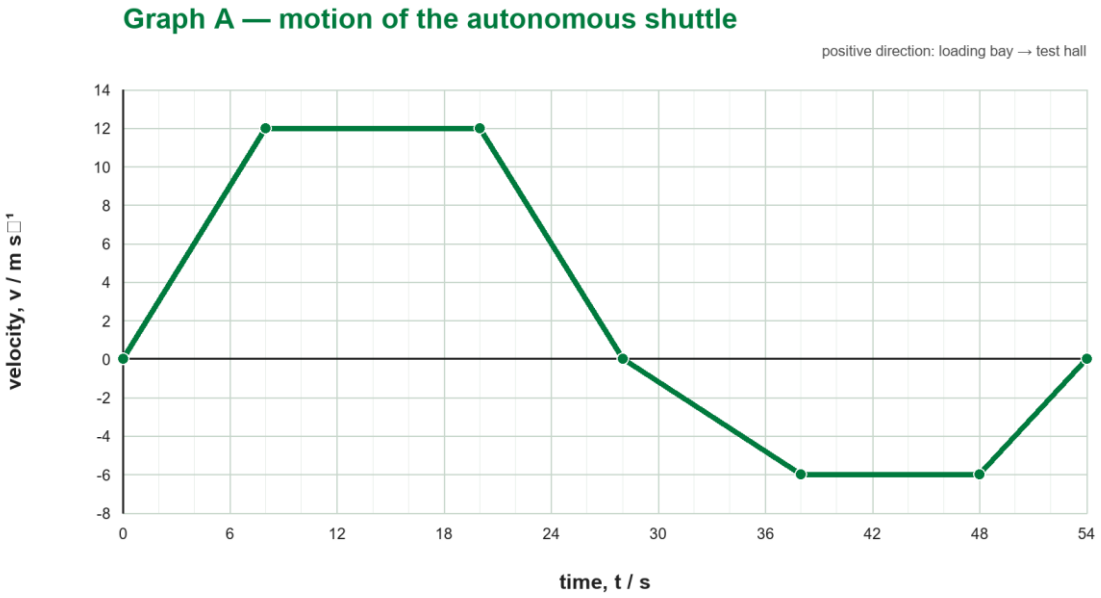
Specification points covered

- 3.1.1(a) Define and use displacement, instantaneous speed, average speed, velocity and acceleration.
- 3.1.1(b) Interpret graphical representations of displacement, speed, velocity and acceleration.
- 3.1.1(c) Use displacement–time graphs to determine velocity as the gradient.
- 3.1.1(d) Use velocity–time graphs to determine acceleration as the gradient and displacement as the area under the graph, including estimation for non-linear graphs.

Language focus for the review

A quantity can increase, decrease or stay the same. Its change can be linear or non-linear.
Use ‘velocity increases/decreases/stays the same’; use ‘acceleration is positive/negative/zero’ to describe the rate of change of velocity.
Avoid ‘the velocity is accelerating’, ‘the displacement accelerates’ and ‘the velocity is stationary’.

Graph A: velocity–time



The graph is repeated here so that numerical values and scales can be reviewed directly.

1. Graph A is a velocity–time graph. State what (i) its gradient and (ii) its signed area between the graph and the time axis represent. [2 marks]

Answer / mark points: (i) Gradient = acceleration. (ii) Signed area between the graph and the time axis = displacement.

Teacher prompt / common error: Keep acceleration and displacement distinct: gradient means rate of change; area means accumulated displacement.

Graph A: calculation and description

2. At t = 33 s, state the shuttle's (i) velocity and (ii) speed. [2 marks]

Answer / mark points: (i) Velocity = −3.0 m s^{-1}. (ii) Speed = 3.0 m s^{-1}.
Teacher prompt / common error: Probe the difference between a negative velocity (direction) and a positive speed (magnitude).

3. State the maximum speed reached on Graph A and the time interval during which it is reached. [2 marks]

Answer / mark points: Maximum speed = 12 m s^{-1}, reached from 8 s to 20 s.
Teacher prompt / common error: Maximum speed is the largest magnitude of velocity; here 12 m s^{-1} is larger than 6 m s^{-1}.

4. Calculate the acceleration during the first 8.0 s of the run. [2 marks]

Answer / mark points: $a = \Delta v / \Delta t = (12 - 0) / 8.0 = +1.5$ m s^{-2}.
Teacher prompt / common error: A positive gradient means positive acceleration; award the unit m s^{-2}.

5. During 28 s to 38 s, calculate the acceleration. Then describe the shuttle's direction of travel and what happens to its speed. [3 marks]

Answer / mark points: $a = \Delta v / \Delta t = [-6 - 0] / [38 - 28] = -0.60$ m s^{-2}. The shuttle travels in the negative direction and its speed increases from 0 to 6.0 m s^{-1}.
Teacher prompt / common error: Do not accept 'negative speed'. The negative sign identifies velocity direction; speed increases.

Graph A: areas and precise language

6. Describe the motion in each interval using the quantity–trend–linearity language: (a) 8–20 s, (b) 20–28 s and (c) 28–38 s. Do not say "the velocity is accelerating". [4 marks]

Answer / mark points: (a) 8–20 s: velocity stays the same at +12 m s^{-1}, so the shuttle has constant positive velocity. (b) 20–28 s: velocity decreases linearly from +12 m s^{-1} to 0; the shuttle slows down with constant negative acceleration. (c) 28–38 s: velocity decreases linearly from 0 to −6 m s^{-1}; it travels in the negative direction and its speed increases with constant negative acceleration.

Teacher prompt / common error: Insist on a quantity plus a trend. Do not accept 'the velocity is accelerating'; acceleration describes the change in velocity.

7. Use areas to calculate the shuttle's displacement from t = 0 s to t = 28 s. [3 marks]

Answer / mark points: Displacement = area = ½(8)(12) + (12)(12) + ½(8)(12) = 48 + 144 + 48 = +240 m.

Teacher prompt / common error: Credit clear subdivision into two triangles and a rectangle; the sign is positive above the time axis.

8. Calculate (i) the resultant displacement and (ii) the total distance travelled during the whole 54 s journey. [4 marks]

Answer / mark points: Positive displacement area = +240 m. Negative displacement area = −[½(10)(6) + (10)(6) + ½(6)(6)] = −108 m. Resultant displacement = +240 − 108 = +132 m. Total distance = 240 + 108 = 348 m.

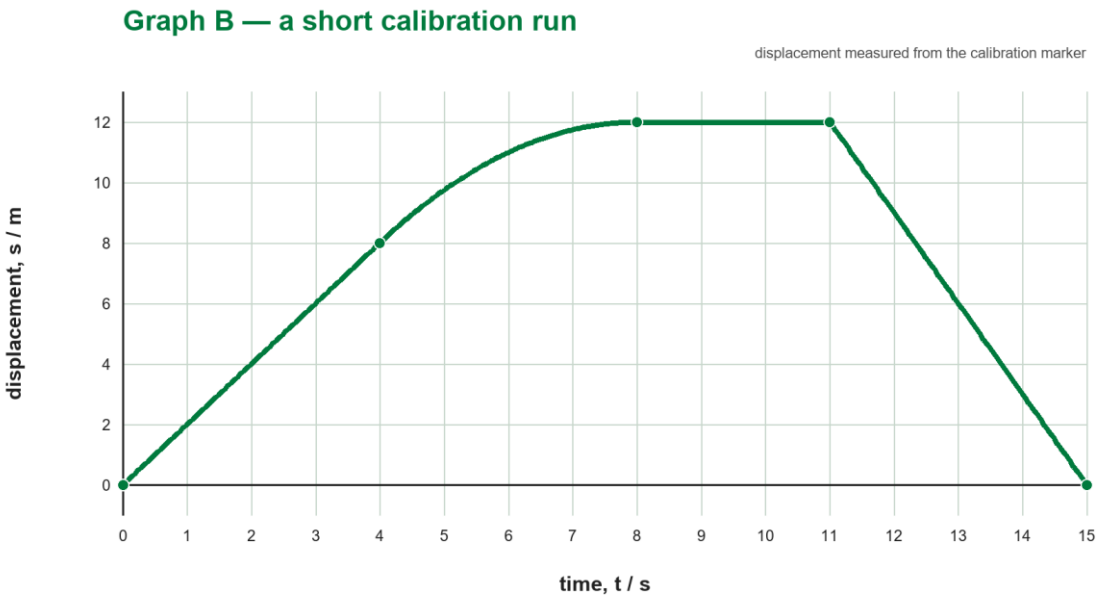
Teacher prompt / common error: Distance uses the magnitudes of all areas. Displacement retains the sign of each area.

9. Explain why the total distance travelled is not equal to the magnitude of the resultant displacement for this journey. [2 marks]

Answer / mark points: The shuttle reverses direction at 28 s. Displacement is the signed/net change in position, whereas distance adds the size of every part of the journey.

Teacher prompt / common error: Direction change makes distance and displacement differ; distance is never reduced by moving back.

Graph B: displacement–time



Use gradient language throughout: the gradient of displacement–time is velocity.

10. State what the gradient of Graph B represents. [1 marks]

Answer / mark points: The gradient represents velocity (instantaneous velocity on a curved section).

Teacher prompt / common error: On a displacement–time graph, gradient is velocity — not acceleration.

11. Describe the motion in each interval on Graph B using precise graph language: (a) 0–4 s, (b) 4–8 s, (c) 8–11 s and (d) 11–15 s. [4 marks]

Answer / mark points: (a) 0–4 s: displacement increases linearly, so velocity is constant and positive. (b) 4–8 s: displacement increases non-linearly; the curve becomes less steep, so velocity decreases but remains positive. (c) 8–11 s: displacement stays the same, so velocity is zero and the shuttle is stationary. (d) 11–15 s: displacement decreases linearly, so velocity is constant and negative.

Teacher prompt / common error: Use increase, decrease or stay the same for displacement; then use the changing gradient to infer velocity.

12. Use gradients of the straight sections of Graph B to calculate the velocity in 0–4 s and in 11–15 s. Hence state the maximum speed in the calibration run. [3 marks]

Answer / mark points: 0–4 s: $v = \Delta s / \Delta t = (8 - 0) / (4 - 0) = +2.0$ m s^{-1}. 11–15 s: $v = (0 - 12) / (15 - 11) = -3.0$ m s^{-1}. Maximum speed = 3.0 m s^{-1}.

Teacher prompt / common error: A negative gradient gives negative velocity. Ask pupils to turn this into a positive speed only at the final step.

Graph B: calculation and precise language

13. At t = 6 s, the data logger gives an instantaneous velocity of +1.0 m s^{-1}. Explain why this is consistent with the 4–8 s part of Graph B and why this velocity is lower than during the first 4 s. [2 marks]

Answer / mark points: From 4 s to 8 s, displacement still increases but the curve becomes less steep, so its positive gradient (velocity) decreases. At 6 s, +1.0 m s^{-1} is therefore lower than the +2.0 m s^{-1} constant velocity from 0 s to 4 s.

Teacher prompt / common error: For a curve, the instantaneous velocity is its tangent gradient. The decreasing steepness is the key visual evidence.

14. Using Graph B, calculate (i) the total distance travelled and (ii) the resultant displacement from 0 s to 15 s. [2 marks]

Answer / mark points: Distance = 12 m out + 12 m back = 24 m. Resultant displacement = 0 m because the shuttle returns to the calibration marker.

Teacher prompt / common error: Returning to the start gives zero resultant displacement, not zero distance.

15. A pupil writes: "The displacement accelerates from 4 s to 8 s, then the velocity is stationary from 8 s to 11 s." Rewrite both parts so that the quantities and their changes are described correctly. [3 marks]

Answer / mark points: Corrected wording: 'From 4 s to 8 s, displacement increases non-linearly. Its gradient decreases, so velocity decreases.' 'From 8 s to 11 s, displacement stays the same; velocity is zero, so the shuttle is stationary.'

Teacher prompt / common error: Model the precise alternatives aloud: 'velocity is zero' and 'the shuttle is stationary', not 'the velocity is stationary'.

Closing discussion

Ask pupils to read one corrected description aloud using the sequence: quantity → trend → linear/non-linear → motion meaning.
Return to any answer that treats velocity and acceleration as interchangeable quantities.