

Motion graphs 2 comparing journeys

AQA GCSE Combined Trilogy 8464 and Separate Physics 8463 | Foundation and Higher | Paper 2

53 marks per path | 34 printed parts / 64 printed marks | Do not attempt both replacements

Specification points covered

8463 4.5.6.1.1 / 8464 6.5.4.1.1: distance and displacement
 8463 4.5.6.1.2–4.5.6.1.3 / 8464 6.5.4.1.2–6.5.4.1.3: speed and velocity
 8463 4.5.6.1.4 / 8464 6.5.4.1.4: distance–time gradients; tangents in Section 7 only
 8463 4.5.6.1.5 / 8464 6.5.4.1.5: acceleration; velocity–time areas in Section 7 only

Hospital robots make deliveries. Compare each campus-route, corridor and reversing test independently.

Original PhysicsUK practice, not an official AQA resource. Common: 23 parts / 42 marks. Foundation Section 6: 6 parts / 11 marks OR Higher Section 7: 5 parts / 11 marks. Each path totals 53 marks. Tangents and velocity–time areas are Higher-only. Timing is estimated and untrials.

1 Comparing the full campus routes

Table 1: both go from the depot to the same point 200 m due east. Route lengths include turns; times include stops.

Table 1

Robot	Full route length / m	Full mission time / s
A	280	200
B	320	160

1(a) For robot A's full mission, state the distance travelled and its displacement from the depot. **[2 marks]**

Answer / mark points: Distance travelled = 280 m. [1] Displacement = 200 m due east. [1]
 Displacement needs magnitude and direction; the route length is not the displacement.

1(b) Calculate A's average speed for the full mission in Table 1. **[1 mark]**

Answer / mark points: Average speed = total distance / total time = $280 / 200 = 1.4 \text{ m s}^{-1}$. [1]

1(c) Calculate B's average speed for its full mission. **[1 mark]**

Answer / mark points: Average speed = $320 / 160 = 2.0 \text{ m s}^{-1}$. [1]

1(d) A trainee says B has a larger displacement because its route is longer. Explain the error. **[2 marks]**

Answer / mark points: Both robots have the same start and finish, so both displacements are 200 m east. [1] Displacement depends on the straight start-to-finish change and its direction, not the length of the route taken. [1]



2 Reading the corridor trial

Figure 1 is a NEW trial along the same straight corridor, due east from the same start. A is solid and B dashed. Both are timed from the same instant. The collection point is 120 m along the corridor; B's plotted record ends at 140 s.

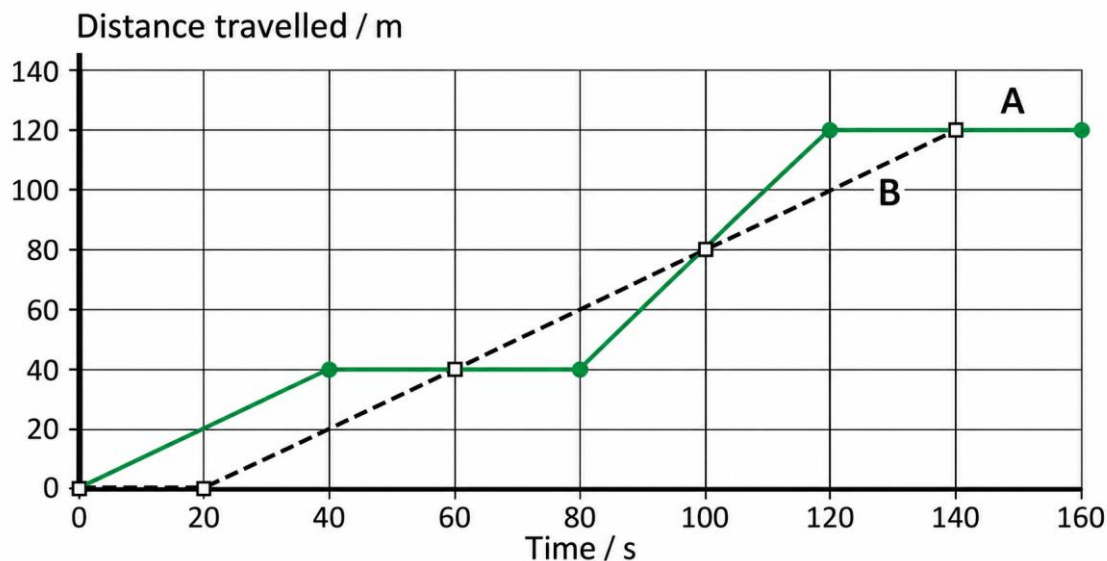


Figure 1

2(a) Calculate A's speed from 0 to 40 s in Figure 1. **[1 mark]**

Answer / mark points: Speed = $(40 - 0) / (40 - 0) = 1.0 \text{ m s}^{-1}$. [1]

2(b) Calculate A's speed from 80 to 120 s. **[1 mark]**

Answer / mark points: Speed = $(120 - 40) / (120 - 80) = 80 / 40 = 2.0 \text{ m s}^{-1}$. [1] Use changes in both quantities, not $120 / 120$.

2(c) Calculate B's speed while it is moving. **[1 mark]**

Answer / mark points: Speed = $(120 - 0) / (140 - 20) = 1.0 \text{ m s}^{-1}$. [1] The initial 20 s is a wait, not moving time.

2(d) Describe A's motion from 40 to 80 s and explain how the graph shows this. **[2 marks]**

Answer / mark points: A is stationary. [1] Its distance travelled remains constant at 40 m, so the distance–time gradient is zero. [1] Do not describe this as constant non-zero velocity.

2(e) At 90 s, which robot is farther along the corridor, and by how much? Use both graph readings. **[2 marks]**

Answer / mark points: A has travelled 60 m and B 70 m. [1 for both readings] B is 10 m farther along the corridor. [1]



3 Overtaking and the collection deadline

Continue using Figure 1 on the previous page, not Table 1. Both robots follow the same corridor in this trial, so equal distance travelled means the same position. A collection deadline is 130 s after timing starts.

3(a) Determine when B first catches A after leaving the start, and the distance from the start at that instant. **[2 marks]**

Answer / mark points: 60 s. [1] Both are 40 m from the start. [1] Ignore the shared initial point; B passes the stationary A here.

3(b) Determine when A subsequently overtakes B while both are moving, and their distance from the start. **[2 marks]**

Answer / mark points: 100 s. [1] Both are 80 m from the start. [1] A's line changes from below to above B's line here.

3(c) Can A and B each reach the 120 m collection point by the 130 s deadline? Support both decisions with arrival times. **[2 marks]**

Answer / mark points: A arrives at 120 s, before the deadline. [1] B arrives at 140 s, after the deadline. [1] Do not use where the lines end as A's arrival time.

3(d) Calculate A's average speed from the start of timing until arrival. Compare it with A's fastest moving-stage speed. **[2 marks]**

Answer / mark points: Overall average = $120 / 120 = 1.0 \text{ m s}^{-1}$. [1] This is lower than the fastest stage's 2.0 m s^{-1} because the overall time includes the 40 s stop and the slower stage. [1]

3(e) B is farther along at 90 s. Does this mean B is moving faster at that instant? Explain using the graph gradients. **[2 marks]**

Answer / mark points: No: A is moving at 2.0 m s^{-1} and B at 1.0 m s^{-1} , so A is faster. [1 for a correct comparison using both speeds] Current speed is the gradient, not the height of the distance–time line. [1]



4 Reading the reversing test

Figure 2 is a separate test of one robot. East is positive and west negative. A negative velocity gives direction, not a negative speed. Use signed change in velocity / elapsed time for acceleration.

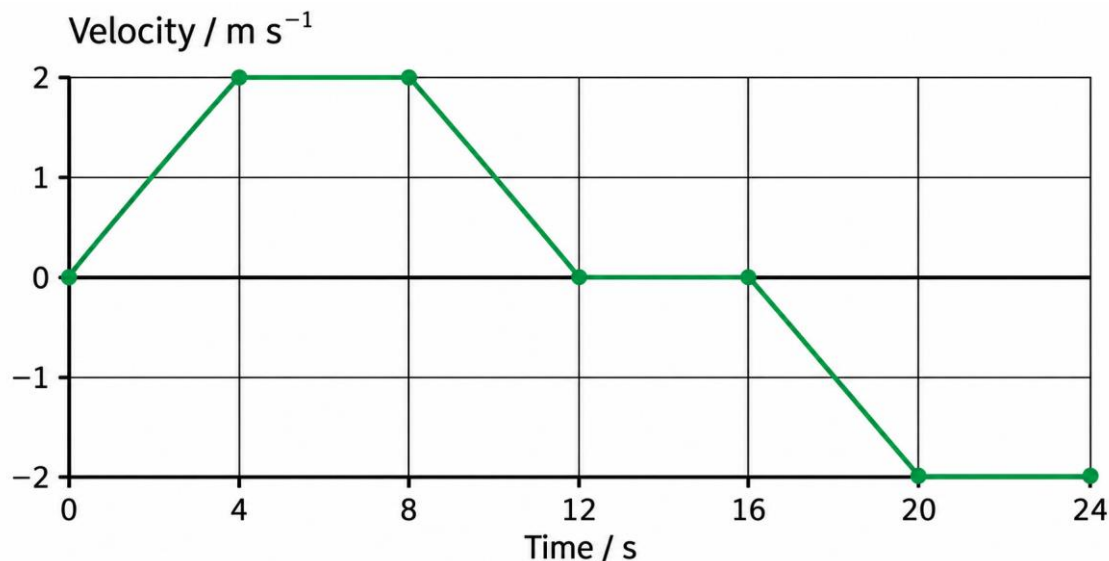


Figure 2

4(a) Read the robot's velocity at 18 s in Figure 2 and state its speed then. [2 marks]

Answer / mark points: Velocity = -1.0 m s^{-1} , or 1.0 m s^{-1} west. [1] Speed = 1.0 m s^{-1} . [1] Speed is the non-negative magnitude of velocity.

4(b) Calculate the acceleration from 0 to 4 s. [2 marks]

Answer / mark points: Change in velocity = $+2.0 - 0 = +2.0 \text{ m s}^{-1}$ over 4.0 s. [1]
Acceleration = $+2.0 / 4.0 = +0.50 \text{ m s}^{-2}$. [1]

4(c) Calculate the signed acceleration from 8 to 12 s. [2 marks]

Answer / mark points: Change in velocity = $0 - 2.0 = -2.0 \text{ m s}^{-1}$ over 4.0 s. [1]
Acceleration = $-2.0 / 4.0 = -0.50 \text{ m s}^{-2}$. [1] A deceleration magnitude of 0.50 alone does not supply the requested sign.

4(d) Describe how velocity and speed change from 16 to 20 s. Include the direction of motion. [2 marks]

Answer / mark points: Velocity decreases linearly from 0 to -2.0 m s^{-1} . [1] Speed increases from 0 to 2.0 m s^{-1} as the robot moves west. [1] Negative acceleration does not always mean slowing.

4(e) Describe the difference between the horizontal sections from 12 to 16 s and from 20 to 24 s. [2 marks]

Answer / mark points: 12–16 s: zero velocity, so stationary. [1] 20–24 s: constant velocity -2.0 m s^{-1} , so it moves west at a steady speed of 2.0 m s^{-1} . [1] Horizontal does not automatically mean stationary on a velocity–time graph.



5 Checking the explanations

Use Figure 2 where specified. The event log and full-route question below are separate from the graph tests.

5(a) Compare the signed accelerations from 8 to 12 s and from 16 to 20 s in Figure 2. Explain why the same acceleration sign has different effects on speed. **[3 marks]**

Answer / mark points: Both accelerations are -0.50 m s^{-2} . [1] From 8–12 s positive velocity approaches zero, so speed decreases. [1] From 16–20 s negative velocity moves farther from zero, so speed increases westwards. [1]

5(b) A separate event log records 20 m east followed by 8 m west along one corridor. Calculate total distance and final displacement from the start. **[2 marks]**

Answer / mark points: Total distance = $20 + 8 = 28 \text{ m}$. [1] Displacement = $20 - 8 = 12 \text{ m east}$. [1]
Do not subtract when calculating total path length.

5(c) On their different full campus routes, A and B have travelled equal distances at one time. Does this prove they are at the same place? Explain why this differs from the shared-corridor trial. **[2 marks]**

Answer / mark points: No: equal path lengths on different routes can end at different positions. [1]
In Figure 1 they share the same straight path and start, so equal outward distance does locate the same point; that condition does not hold for the different campus routes. [1]

5(d) Describe how technicians could obtain reliable distance–time measurements for a new corridor timetable test. **[2 marks]**

Answer / mark points: Use measured distance markers/a calibrated position system and a timer or time-stamped video with a clearly defined common start. [1] Repeat under comparable conditions, such as the same load and route, and compare repeat journey times/check unusual readings. [1]
Credit another workable linked measurement-and-repeat method.

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6 Foundation replacement

FOUNDATION PATH ONLY: complete this section instead of Section 7. Table 2 is a separate start-up test. Use interval-average speeds only; do not draw tangents or calculate velocity–time areas.

Table 2

Time / s	0	2	4	6	8
Distance travelled / m	0	1	4	9	16

6(a) FOUNDATION REPLACEMENT. A robot moves at a constant 1.5 m/s for 12 s. Calculate the distance travelled. **[1 mark]**

Answer / mark points: Distance = speed $\times$ time = $1.5 \times 12 = 18$ m. [1]

6(b) At a constant 1.2 m/s, how long does a robot take to cover 24 m? **[1 mark]**

Answer / mark points: Time = distance / speed = $24 / 1.2 = 20$ s. [1]

6(c) In a separate test, east is positive. Velocity decreases from +2.0 m/s to zero in 5.0 s. Calculate the signed acceleration. **[2 marks]**

Answer / mark points: Change in velocity = $0 - 2.0 = -2.0$ m s⁻¹. [1]
Acceleration = $-2.0 / 5.0 = -0.40$ m s⁻². [1]

6(d) Use Table 2 to calculate the average speed over 0–4 s and over 4–8 s. **[2 marks]**

Answer / mark points: 0–4 s: $(4 - 0) / 4 = 1.0$ m s⁻¹. [1] 4–8 s: $(16 - 4) / 4 = 3.0$ m s⁻¹. [1] These are interval averages, not instantaneous speeds.

6(e) Does Table 2 support constant speed over the whole test? Justify your answer using distances covered in equal time intervals. **[2 marks]**

Answer / mark points: No: for example, 0–2 s covers 1 m whereas 2–4 s covers 3 m, both in 2 s. [1 for a valid comparison] Different distances in equal times show changing/increasing speed. [1]

6(f) Return to the full missions in Table 1. Which robot can meet a 180 s dispatch deadline? State its time margin and explain why the shorter route is not automatically quicker. **[3 marks]**

Answer / mark points: B: 160 s meets the deadline; A's 200 s does not. [1] B's margin is $180 - 160 = 20$ s. [1] Arrival depends on average speed and stops as well as route length; B has the longer route but the greater average speed. [1]



7 Higher replacement

HIGHER TIER ONLY: complete this section instead of Section 6. Figure 3 is a separate start-up test. Draw a tangent for (a). For (c)–(e), return to Figure 2; east is positive.

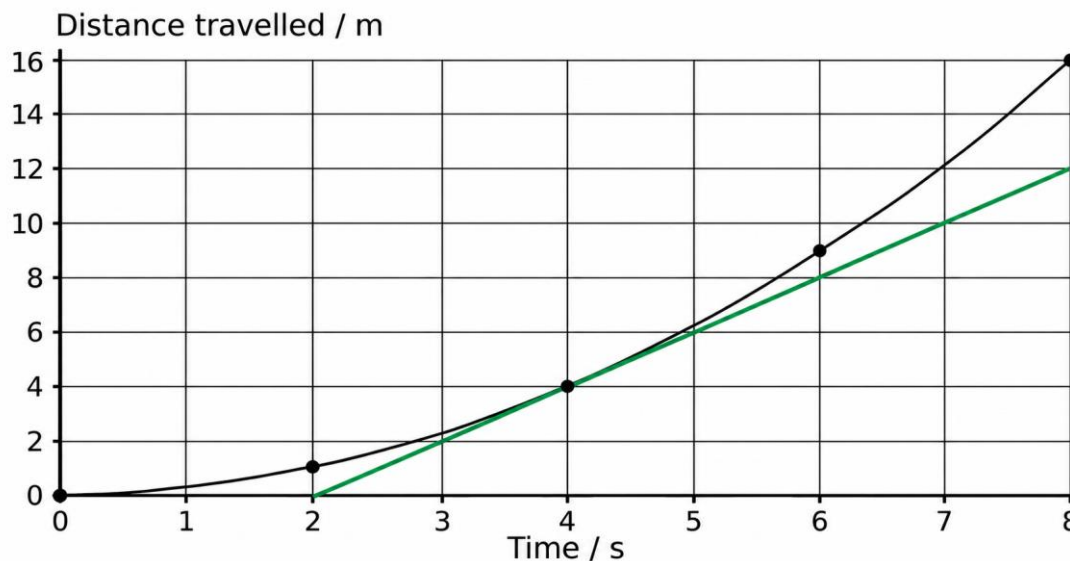


Figure 3

7(a) HIGHER REPLACEMENT. On Figure 3 draw a tangent at 4.0 s. Use a large gradient triangle to estimate the speed at that instant. **[3 marks]**

Answer / mark points: A tangent touching the curve at (4 s, 4 m), consistent with the local slope. [1] A large correct rise/run, for example $(12 - 0) / (8 - 2)$. [1] Speed $\approx 2.0 \text{ m s}^{-1}$. [1] Allow 1.8–2.2 m s^{-1} from a reasonable drawn tangent; no credit for a chord from the origin.

7(b) Compare that instantaneous speed with the average speed over the first 4.0 s. Explain the difference. **[2 marks]**

Answer / mark points: Average speed = $4 / 4 = 1.0 \text{ m s}^{-1}$. [1] The instantaneous speed of about 2.0 m s^{-1} is greater because the robot's speed has been increasing; the tangent is steeper than the origin-to-point chord. [1]

7(c) Use areas in Figure 2 to calculate the displacement from 0 to 12 s. **[2 marks]**

Answer / mark points: Positive areas = $\frac{1}{2} \times 4 \times 2 + 4 \times 2 + \frac{1}{2} \times 4 \times 2 = 4 + 8 + 4 \text{ m}$. [1 for correct area method] Displacement = +16 m, or 16 m east. [1]

7(d) Use Figure 2 to calculate the distance travelled west from 16 to 24 s. **[2 marks]**

Answer / mark points: Magnitude of negative area = $\frac{1}{2} \times 4 \times 2 + 4 \times 2 = 4 + 8$. [1] Distance west = 12 m. [1] Distance is not –12 m.

7(e) For the whole 0–24 s reversing test in Figure 2, calculate the final displacement and the total distance travelled. **[2 marks]**

Answer / mark points: Displacement = $16 - 12 = 4 \text{ m east}$. [1] Total distance = $16 + 12 = 28 \text{ m}$. [1] Allow consistent follow-through from (c)/(d); displacement uses signed areas, distance uses their magnitudes.

Review and improve

Use “velocity increases/decreases linearly” and distinguish speed from signed velocity. Never say “velocity is accelerating”. A horizontal distance–time line means stationary; a horizontal non-zero velocity–time line means constant velocity. Signed areas give displacement; magnitudes give total distance.

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