

Motion graphs

AQA GCSE Physics 8463 and Combined Science Trilogy 8464 | Paper 2 | Tier pathways below

Worked solutions and teaching prompts | 47 marks per pathway

Specification points covered

8463 4.5.6.1.1-1.3 / 8464 6.5.4.1.1-1.3: distance, displacement, speed and velocity

8463 4.5.6.1.4 / 8464 6.5.4.1.4: distance-time graphs; tangents are Higher only

8463 4.5.6.1.5 / 8464 6.5.4.1.5: acceleration and velocity-time graphs; areas are Higher only

A delivery robot carries parcels between collection points along a straight lane. Its team checks recorded journeys and a speed limit near pedestrians. The graph tests are separate; do not combine their data.

Questions 1-3 are shared. Foundation then completes 4 (30 parts); Higher then completes 5 (29 parts). Each route has 47 marks, not the 58 across both alternatives. Allow equivalent methods and meaningful follow-through. This is an original PhysicsUK resource, not an official AQA mark scheme.

1 Checking the journey

1(a) State how velocity differs from speed. **[1 mark]**

Answer / mark points: Velocity includes direction as well as speed. [1] Speed has magnitude only.

Teacher prompt: Do not define velocity as acceleration or as simply a faster speed.

1(b) In one journey the robot moves 15 m east, then 20 m west, then 5 m east. Calculate its total distance travelled and its final displacement. **[2 marks]**

Answer / mark points: Total distance = $15 + 20 + 5 = 40$ m. [1]

Taking east positive, displacement = $15 - 20 + 5 = 0$ m. [1] It finishes at its starting point; no direction is needed for zero displacement.

Teacher prompt: Distance adds path lengths. Displacement compares final and initial positions.

1(c) Two separate deliveries each cover 12 m at constant speed. Calculate the time at 1.5 m s^{-1} , then the time at 2.0 m s^{-1} . **[2 marks]**

Answer / mark points: $t = \text{distance} / \text{speed}$. First: $12 / 1.5 = 8.0$ s. [1]

Second: $12 / 2.0 = 6.0$ s. [1]

1(d) Near pedestrians the speed limit is 1.5 m s^{-1} . In a test the robot covers 12 m in 5.0 s. Calculate its average speed and decide whether it could have stayed within the limit throughout. **[2 marks]**

Answer / mark points: Average speed = $12 / 5.0 = 2.4 \text{ m s}^{-1}$. [1] No: the average is above 1.5 m s^{-1} , so the speed must exceed the limit at some time. [1]

Teacher prompt: An average below a limit would not, by itself, prove that every instantaneous speed was below it.

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2 Distance travelled during a delivery

Figure 1 records total distance travelled, not position. The robot moves east from 0-10 s, west from 20-30 s, then east from 30-40 s.

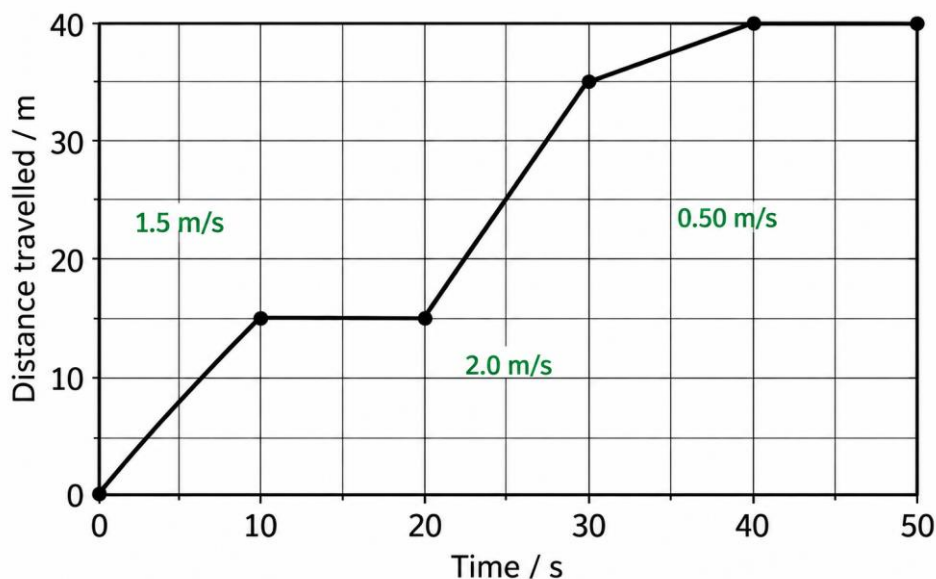


Figure 1

2(a) Use Figure 1 to read the distance travelled by 5.0 s. **[1 mark]**

Answer / mark points: 7.5 m. [1] Accept 7.0-8.0 m for a clear graph reading.

2(b) Read the distance travelled by 25 s. **[1 mark]**

Answer / mark points: 25 m. [1] It is halfway between 15 m at 20 s and 35 m at 30 s.

2(c) State both time intervals when the robot is stationary. **[1 mark]**

Answer / mark points: 10-20 s and 40-50 s. [1 for both] Total distance does not increase during either interval.

2(d) Calculate the speed from 0-10 s using the gradient. **[1 mark]**

Answer / mark points: Speed = $(15 - 0) / (10 - 0) = 1.5 \text{ m s}^{-1}$. [1]

Teacher prompt: Use change in distance divided by change in time.

2(e) Calculate the speed from 20-30 s. **[1 mark]**

Answer / mark points: Speed = $(35 - 15) / (30 - 20) = 20 / 10 = 2.0 \text{ m s}^{-1}$. [1]

Teacher prompt: 35 / 30 is an average from the origin, not the speed of this section.

2(f) Calculate the speed from 30-40 s. **[1 mark]**

Answer / mark points: Speed = $(40 - 35) / (40 - 30) = 5 / 10 = 0.50 \text{ m s}^{-1}$. [1]



2 Distance travelled during a delivery continued

2(g) Calculate the average speed over the full 50 s. Explain why the stopped time must be included. [2 marks]

Answer / mark points: Average speed = total distance / total elapsed time = $40 / 50 = 0.80 \text{ m s}^{-1}$.

[1] The full journey lasts 50 s, including its stops; excluding them would answer a different question.

[1]

2(h) State the interval with the greatest speed and explain which graph feature shows this. [2 marks]

Answer / mark points: 20-30 s. [1] This section has the greatest gradient, not the greatest graph height. [1]

Teacher prompt: At 40-50 s the graph is highest but the robot is stationary.

2(i) A pupil expects the line to fall from 20-30 s because the robot moves west. Explain why the total-distance graph still rises. [2 marks]

Answer / mark points: Travelling west still adds to the total distance travelled. [1] The vertical axis is accumulated distance, not position or signed displacement, so its value increases during this movement. [1]

3 A new straight run

Figure 2 is a different test, with east positive. The robot moves only east or is stationary. The final section is missing: from 20-24 s its velocity stays at 1.0 m s^{-1} .

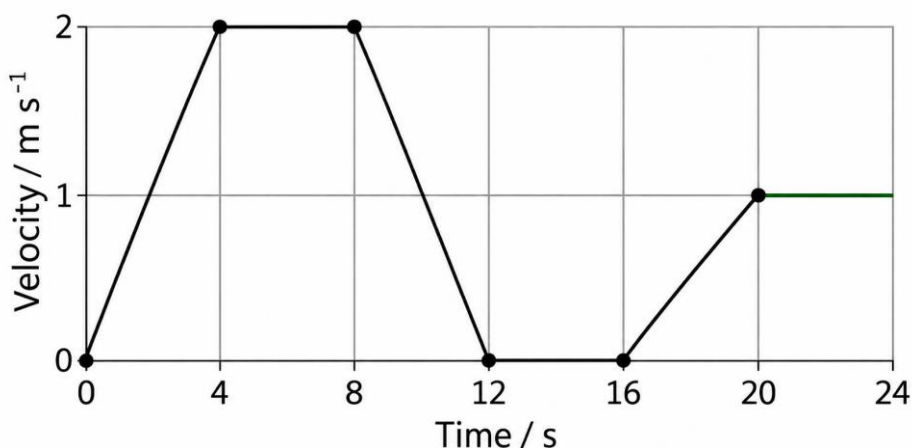


Figure 2

3(a) Complete Figure 2 for 20-24 s by drawing directly on the graph. [1 mark]

Answer / mark points: Draw a horizontal line from (20 s, 1.0 m s^{-1}) to (24 s, 1.0 m s^{-1}), as shown in green. [1]

3(b) State the velocity at 6.0 s, including direction. [1 mark]

Answer / mark points: 2.0 m s^{-1} east. [1] The velocity is positive and constant during 4-8 s.

3(c) Calculate the acceleration from 0-4.0 s. [1 mark]

Answer / mark points: $a = (2.0 - 0) / (4.0 - 0) = +0.50 \text{ m s}^{-2}$. [1]



3 A new straight run continued

3(d) Calculate the signed acceleration from 8-12 s. East is positive. [1 mark]

Answer / mark points: $a = (0 - 2.0) / (12 - 8) = -0.50 \text{ m s}^{-2}$. [1] Its direction is west; the robot is slowing while moving east.

Teacher prompt: The deceleration magnitude is 0.50 m s^{-2} , but the question asks for signed acceleration.

3(e) Describe the velocity and acceleration from 4-8 s. [2 marks]

Answer / mark points: Velocity stays constant at 2.0 m s^{-1} east. [1] Acceleration is zero because velocity does not change. [1]

3(f) State the time interval when the robot is stationary. [1 mark]

Answer / mark points: 12-16 s. [1] The velocity is zero throughout this interval.

3(g) Describe how velocity changes from 16-20 s and state whether acceleration is constant. [2 marks]

Answer / mark points: Velocity increases linearly from 0 to 1.0 m s^{-1} east. [1] Acceleration is constant and positive because the graph has a constant positive gradient (0.25 m s^{-2}). [1]

3(h) A trainee writes: the velocity is accelerating at 0.50 m s^{-2} from 0-4 s. Rewrite this using the correct quantities and language. [2 marks]

Answer / mark points: The velocity increases linearly from 0 to 2.0 m s^{-1} east. [1] The robot has a constant acceleration of $+0.50 \text{ m s}^{-2}$. [1] Accept equivalent precise wording.

Teacher prompt: A quantity increases, decreases or stays constant. The robot accelerates; its velocity does not accelerate.

3(i) A pupil says the falling line from 8-12 s means the robot is moving west. Explain the error. [2 marks]

Answer / mark points: Velocity remains positive until it reaches zero at 12 s, so the robot is moving east, not west. [1] A falling line shows decreasing velocity and negative acceleration; it does not mean negative velocity. [1]

3(j) Describe how a fixed camera, a metre scale and video timestamps could provide distance-time data for a straight eastward run. Explain how the data would show whether the speed is constant. [4 marks]

Answer / mark points: Put the scale along the lane in the same plane as the tracked robot marker; keep the camera fixed and viewing the lane side-on to minimise parallax. [1]
Read the marker position at several known timestamps, subtract the initial position to obtain distance travelled and record paired distances and elapsed times. [1]
Plot distance against time with labelled axes and suitable uniform scales. [1]
A straight rising line has constant gradient and hence constant speed; a changing gradient shows changing speed. [1]

Teacher prompt: Do not say constant speed because the line passes through the origin. This is motion measurement, not a complete required-practical claim.



4 Foundation practice and application

Foundation pathway: complete this question instead of Question 5. Table 1 is a new eastward test. Assume constant speed between each pair of adjacent readings.

Table 1

Time / s	0	2	4	6	8
Distance travelled / m	0	2	6	10	12

4(a) Use Table 1 to calculate the average speed from 0-4 s. **[1 mark]**

Answer / mark points: Average speed = $(6 - 0) / (4 - 0) = 1.5 \text{ m s}^{-1}$. [1]

4(b) Calculate the average speed from 4-8 s. **[1 mark]**

Answer / mark points: Average speed = $(12 - 6) / (8 - 4) = 1.5 \text{ m s}^{-1}$. [1]

4(c) Calculate the speed from 2-4 s and from 6-8 s. **[2 marks]**

Answer / mark points: 2-4 s: $(6 - 2) / (4 - 2) = 2.0 \text{ m s}^{-1}$. [1]
6-8 s: $(12 - 10) / (8 - 6) = 1.0 \text{ m s}^{-1}$. [1]

4(d) The lane speed limit is 1.8 m s^{-1} . Identify every interval in Table 1 that exceeds it and justify your answer. **[2 marks]**

Answer / mark points: 2-4 s and 4-6 s. [1 for both] Each has speed $4 / 2 = 2.0 \text{ m s}^{-1}$, greater than 1.8 m s^{-1} . [1]

4(e) After 8 s the robot has 6.0 m left to travel. Calculate the extra time at a constant 1.5 m s^{-1} . **[1 mark]**

Answer / mark points: Extra time = $6.0 / 1.5 = 4.0 \text{ s}$. [1]

4(f) A pupil says the equal average speeds in (a) and (b) prove that the speed was constant throughout 0-8 s. Explain why this conclusion is wrong. **[2 marks]**

Answer / mark points: Equal averages over long intervals do not establish constant speed within them. [1] The shorter intervals give different speeds, for example 2.0 m s^{-1} in 2-4 s and 1.0 m s^{-1} in 6-8 s. [1]

4(g) For another constant-speed run, each video position has the same measurement uncertainty. Timing is precise. Explain why using positions 2.0 s apart instead of 0.20 s apart can reduce the effect on the calculated speed. **[2 marks]**

Answer / mark points: The longer interval gives a larger measured distance change at the same speed. [1] The same position uncertainty is a smaller fraction of that distance change, so it has less effect on the calculated speed. [1]

Teacher prompt: This comparison assumes constant speed. A longer interval gives an average, not generally an instantaneous speed.

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5 Higher only areas and tangents

Higher pathway: complete this question instead of Question 4. Use the completed Figure 2 for parts (a)-(c). All velocities are non-negative, so graph area gives distance.

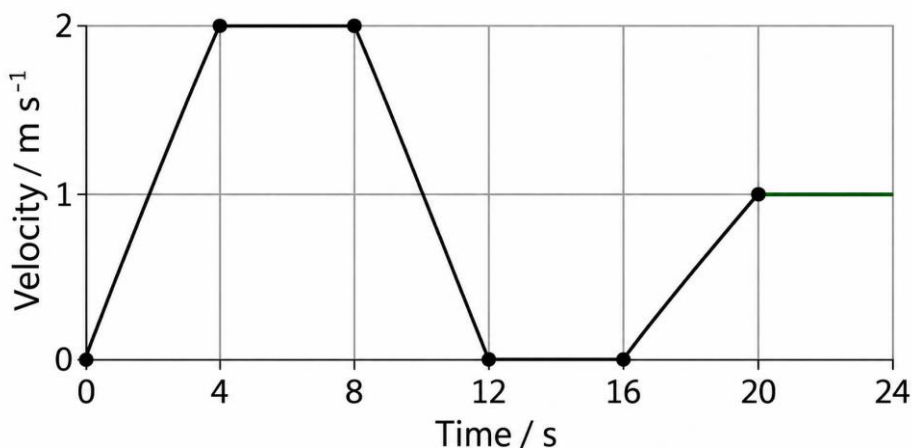


Figure 2

5(a) Higher only: calculate the distance travelled from 0-12 s using Figure 2. **[2 marks]**

Answer / mark points: Areas: first triangle = $0.5 \times 4 \times 2 = 4$ m; rectangle = $4 \times 2 = 8$ m; second triangle = $0.5 \times 4 \times 2 = 4$ m. [1 for correct component areas]
Distance = $4 + 8 + 4 = 16$ m. [1]

Teacher prompt: Do not multiply maximum velocity by the whole time; velocity is not constant throughout.

5(b) Higher only: calculate the total distance travelled from 0-24 s, including your completed graph section. **[2 marks]**

Answer / mark points: Extra areas: 12-16 s = 0 m; 16-20 s triangle = $0.5 \times 4 \times 1 = 2$ m; 20-24 s rectangle = $4 \times 1 = 4$ m. [1 for extra areas]
Total distance = $16 + 2 + 4 = 22$ m. [1]

5(c) Higher only: calculate the average speed over the 24 s run. **[1 mark]**

Answer / mark points: Average speed = $22 / 24 = 0.917$ m s⁻¹ (about 0.92 m s⁻¹). [1] Stationary time is included.



5 Higher only areas and tangents continued

Figure 3 shows a separate eastward test with a smooth increase in speed. Draw the tangent for part (d) directly on this graph.

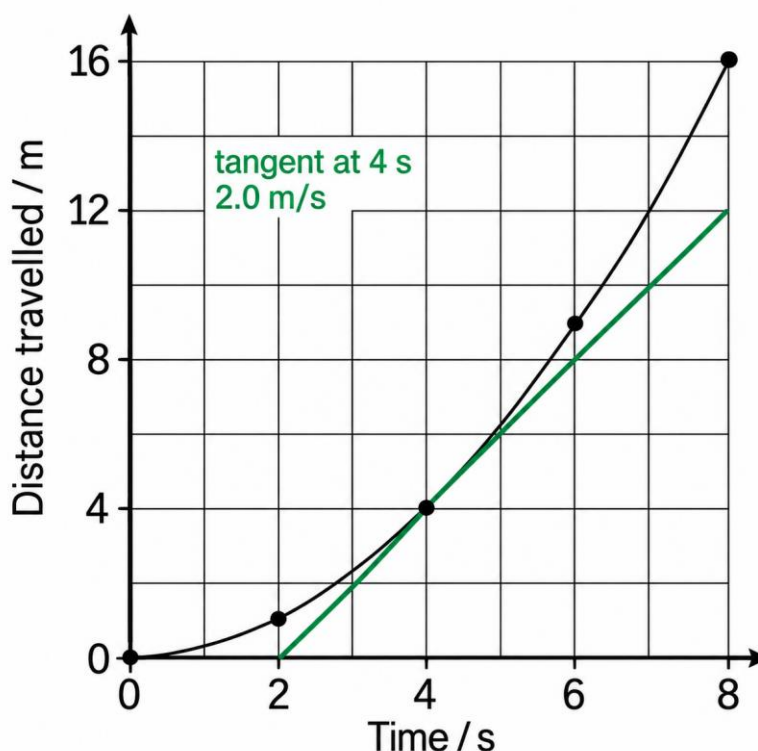


Figure 3

5(d) Higher only: draw a tangent to Figure 3 at 4.0 s. Use two widely separated points on your tangent to determine the instantaneous speed. **[2 marks]**

Answer / mark points: A straight tangent touches the curve at (4.0 s, 4.0 m) and follows its local gradient. [1]

For example, tangent points (2 s, 0 m) and (8 s, 12 m) give speed = $(12 - 0) / (8 - 2) = 2.0 \text{ m s}^{-1}$. [1]
Accept about 1.8–2.2 m s^{-1} from a sensibly drawn tangent and consistent gradient calculation.

Teacher prompt: Use points on the tangent, not two distant points on the curve. Do not require a tangent to cross the origin.

5(e) Higher only: describe how distance and speed change during the run in Figure 3. Refer to the curve and its gradient. **[2 marks]**

Answer / mark points: Distance increases non-linearly as time increases. [1] The gradient becomes steeper, so instantaneous speed increases. [1]

5(f) Higher only: calculate the average speed from 0–8 s in Figure 3. A pupil says its agreement with the speed at 4 s proves constant speed. Use the graph to evaluate this claim. **[2 marks]**

Answer / mark points: Average speed = $16 / 8 = 2.0 \text{ m s}^{-1}$. [1] The claim is wrong: the gradient changes, so speed changes despite the average matching the instantaneous speed at one time. [1]

Review and improve

Model the distinction between graph height and gradient, distance and displacement, and changing velocity versus constant acceleration. Only Higher uses graph areas and tangents.

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