

GCSE MATHS

Graphs in context

Long workbook

Questions on GCSE Maths topics, including challenges beyond typical exam questions.

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Topic recap

Distance and speed

A distance-time gradient gives speed when the distance axis measures distance along the route. A horizontal section means no change in distance.

Area and gradient

Under a speed-time graph, area gives distance. Its gradient gives acceleration. Match the time and speed units first.

Curved graphs

To estimate the gradient at a point on a curve, draw a tangent there. Estimate an area by dividing it into trapeziums.

Velocity

Velocity includes direction. Area above the time axis represents travel in the positive direction; area below represents travel back. Subtract these areas to find the change in position (displacement). Add them to find the total distance travelled.

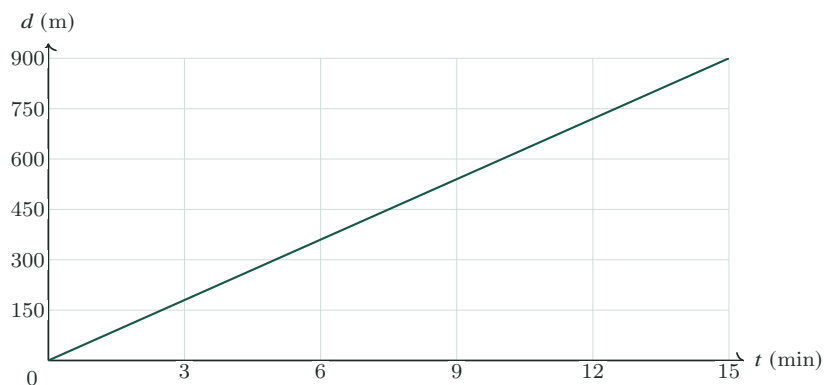
A calculator may be used. Give exact answers unless rounding is requested.

1. Distance-time graphs

Example Problem 1

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The distance-time graph shows a walker travelling at constant speed. Find the speed in metres per minute.



The idea

1. Divide the change in distance by the change in time.

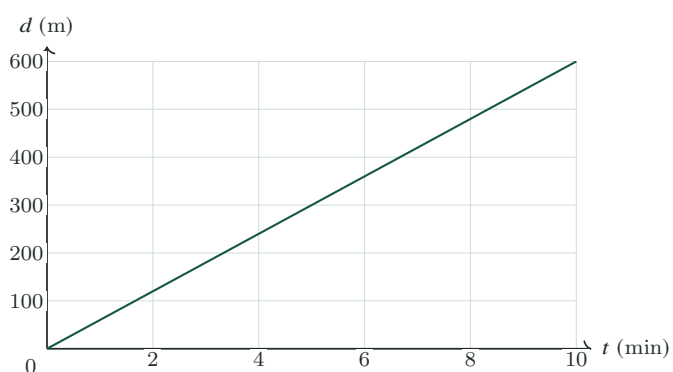
Worked Solution

$$v = 900/15 = 60 \text{ m/min}$$

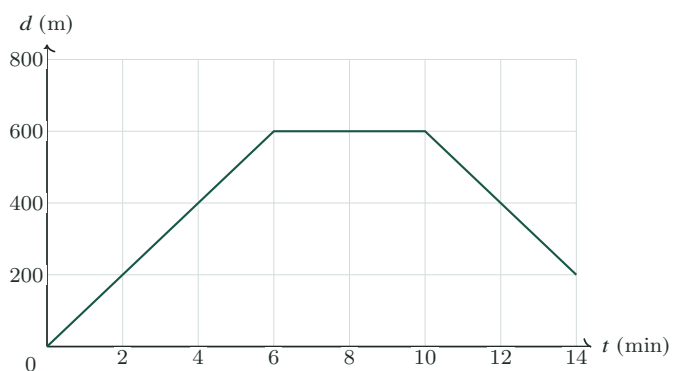
Use the units on the axes.

1 Distance-time graphs

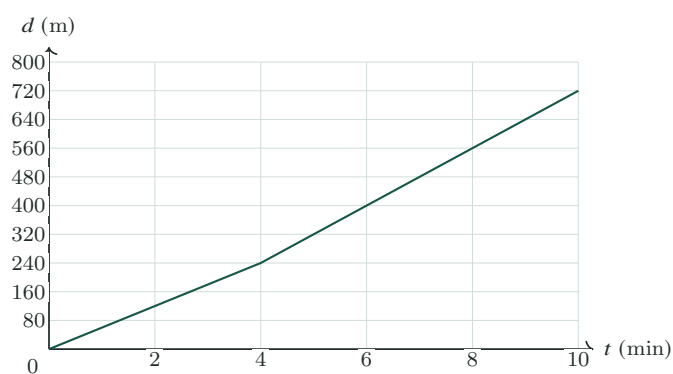
- Q1** The graph shows a walker's distance from home. Write down the distance from home after 5 minutes. *



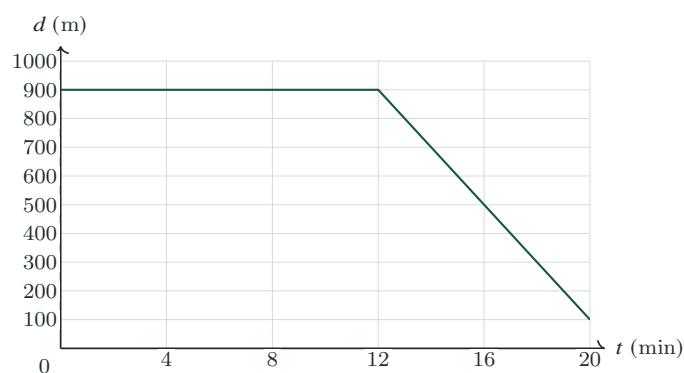
- Q2** The graph shows a cyclist's distance from home. (a) For how long is the cyclist stationary? **
(b) How far from home is the cyclist at the end?



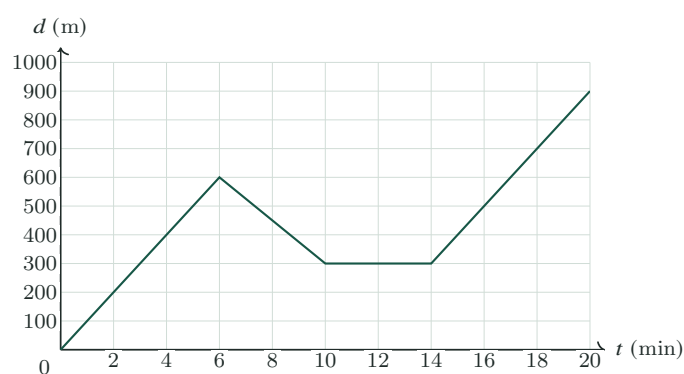
- Q3** The graph shows a runner's distance from home. Find the speed between 4 and 10 minutes, in metres per minute. **



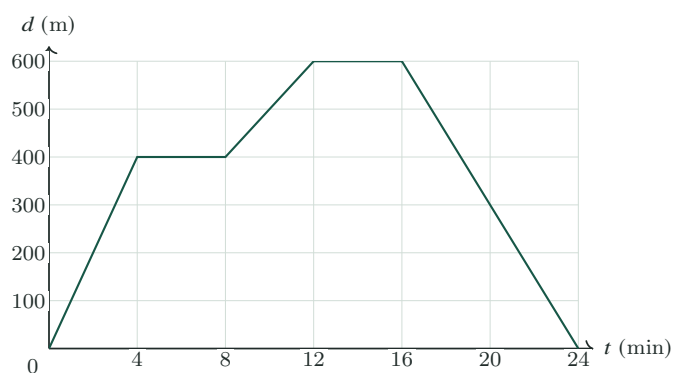
- Q4** The graph shows a walker's distance from home during part of a journey. Calculate the distance from home after 18 minutes. ***



- Q5** The graph shows a cyclist's distance from home. Find (a) the total distance travelled; (b) the average speed for the whole journey, including the stop. ***



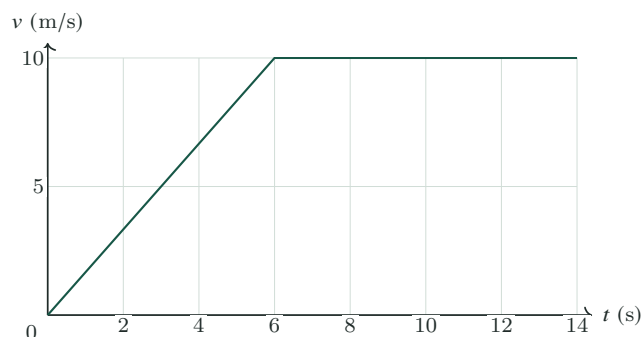
- Q6** The graph shows a walker's distance from home. Find the average speed for the whole journey, including both stops. ***



2. Speed-time graphs

Example Problem 2

A car accelerates uniformly from rest to 10 m/s in 6 s, then keeps that speed for 8 s. Find the distance travelled.



The idea

1. Use a triangle for acceleration and a rectangle for constant speed.

Worked Solution

$$A_1 = \frac{1}{2}(6)(10) = 30 \text{ m}$$

Triangle area.

$$A_2 = 8(10) = 80 \text{ m}$$

Rectangle area.

$$d = 30 + 80 = 110 \text{ m}$$

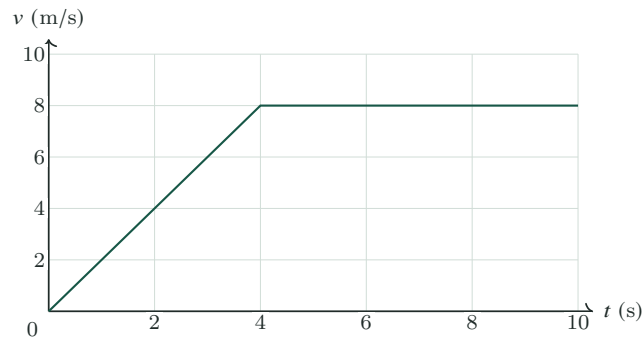
Add the two distances.

2. Speed-time graphs

Example Problem 3

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A cyclist accelerates uniformly from rest to 8 m/s in 4 s, then continues at 8 m/s. Find the time at which the cyclist has travelled 44 m.



The idea

1. Find the distance covered while accelerating. Divide the remaining distance by the constant speed, then add the acceleration time.

Worked Solution

$$d_1 = \frac{1}{2}(4)(8) = 16 \text{ m}$$

The first triangle gives the distance in the first four seconds.

$$d_2 = 44 - 16 = 28 \text{ m}$$

Find the remaining distance.

$$t_2 = 28/8 = 3.5 \text{ s}$$

Divide by the constant speed.

$$t = 4 + 3.5 = 7.5 \text{ s}$$

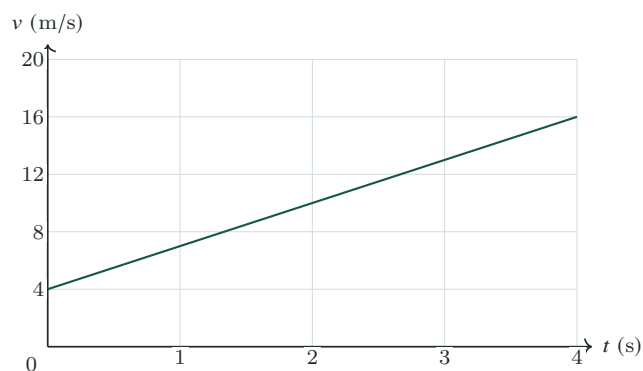
Measure time from the start.

2 Speed-time graphs

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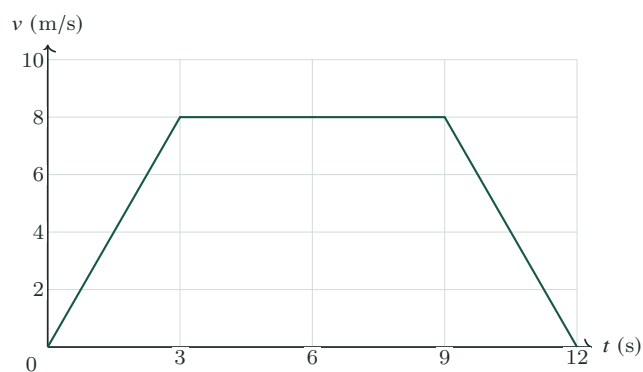
Q7 The speed–time graph shows a car accelerating. Find its acceleration in the first 4 seconds.

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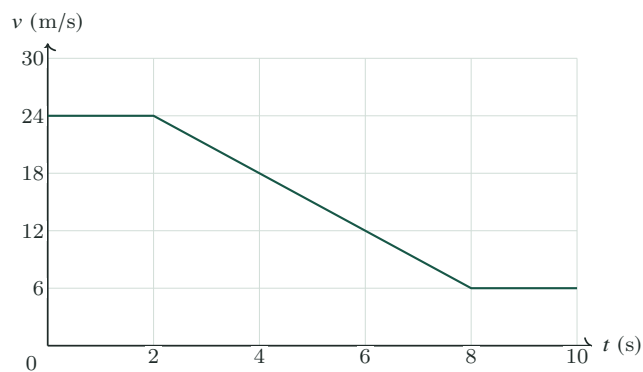


Q8 The speed–time graph shows a cyclist's journey. Find the distance travelled between 3 and 9 seconds.

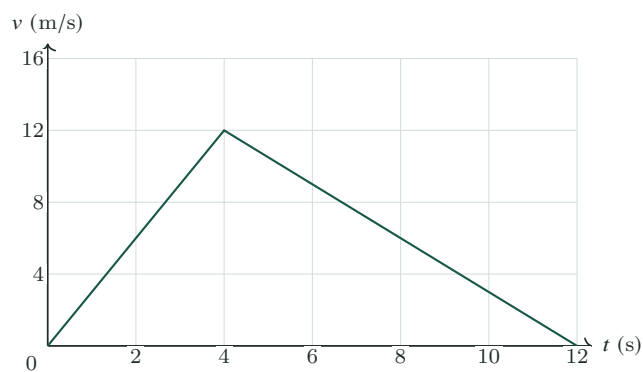
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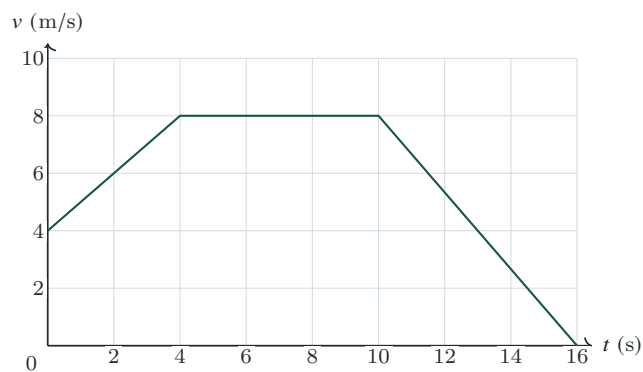
- Q9** The speed-time graph shows a car slowing down. Find the deceleration between 2 and 8 seconds. **



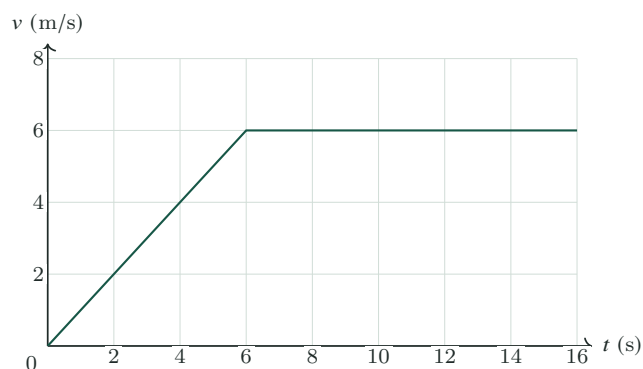
- Q10** The speed-time graph shows a journey. Find the total distance travelled. ***



- Q11** The speed-time graph shows a runner moving for 16 seconds. Find the average speed for these 16 seconds. ***



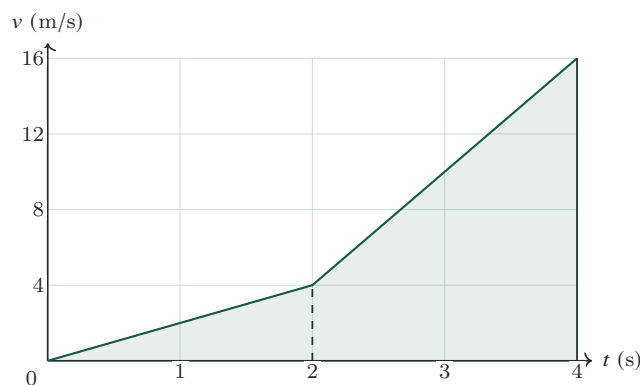
- Q12** The speed-time graph shows a cyclist's journey. Find the time at which the cyclist has travelled 54 m. ****



3. Curved graphs and estimates

Example Problem 4

Speed readings at 0, 2 and 4 seconds are 0, 4 and 16 m/s. Estimate the distance using two trapeziums.



The idea

1. Each trapezium has width 2 seconds; its parallel sides are the two speed readings.

Worked Solution

$$A_1 = \frac{1}{2}(0 + 4)(2) = 4$$

First time interval.

$$A_2 = \frac{1}{2}(4 + 16)(2) = 20$$

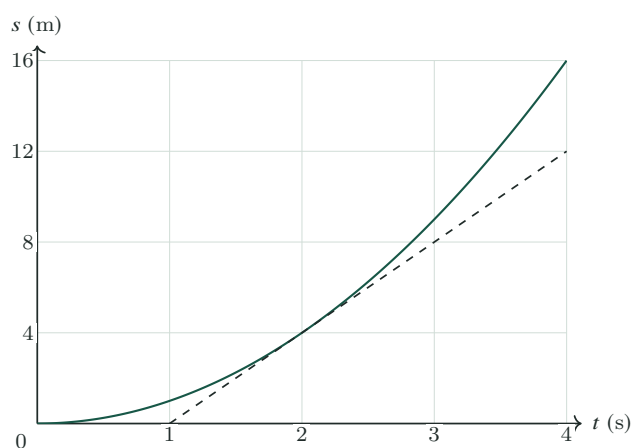
Second time interval.

$$d \approx 24 \text{ m}$$

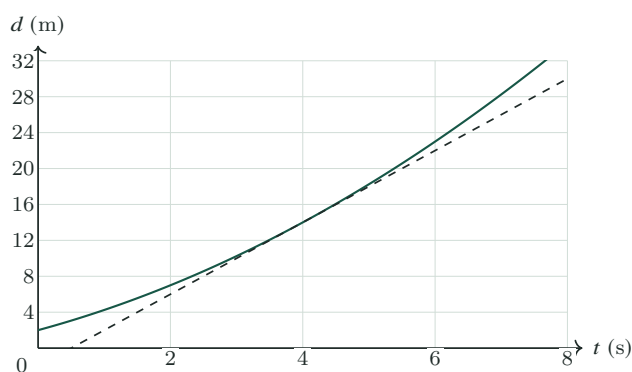
Add the estimates.

3 Curved graphs and estimates

- Q13** The solid curve shows distance in metres against time in seconds. The dashed tangent at $t = 2$ passes through $(1, 0)$ and $(3, 8)$. Estimate the speed at $t = 2$ seconds.

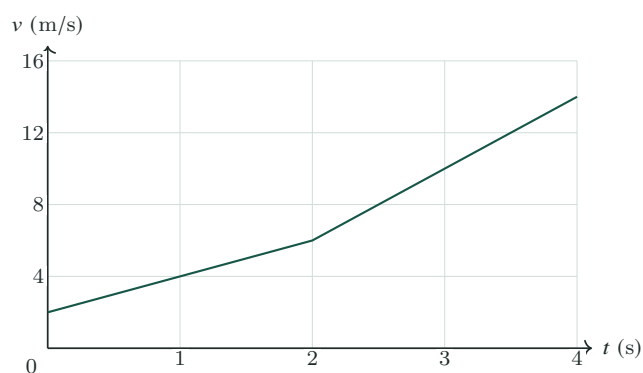


- Q14** The curve shows distance against time. The dashed tangent at $t = 4$ passes through $(2, 6)$ and $(6, 22)$. Estimate the speed at $t = 4$ seconds.

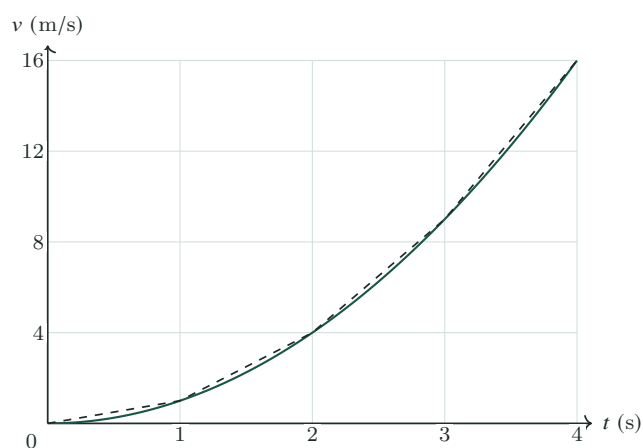


Q15 Speed readings at $t = 0, 1, 2, 3, 4$ s are 0, 1, 4, 9, 16 m/s. Estimate the distance using four trapeziums of width 1 s.

Q16 Speed readings at $t = 0, 2, 4$ seconds are 2, 6 and 14 m/s. Estimate the distance travelled using two trapeziums.



- Q17** The graph shows speed against time. The dashed lines form the tops of trapeziums used to estimate the distance travelled. Is this estimate too big or too small? Explain your answer.



- Q18** Four trapeziums estimate a distance of 22 m over 4 s. Use this to estimate the average speed.

4. Interpreting and combining graphs

Example Problem 5

A particle has velocity 3 m/s for 4 s , then -2 m/s for 3 s . Find (a) how far from its starting point it finishes; (b) the total distance travelled.

The idea

1. Subtract the return journey for the distance from the start. Add both journeys for the total distance travelled.

Worked Solution

(a) Distance from start $= 3(4) - 2(3) = 6 \text{ m}$

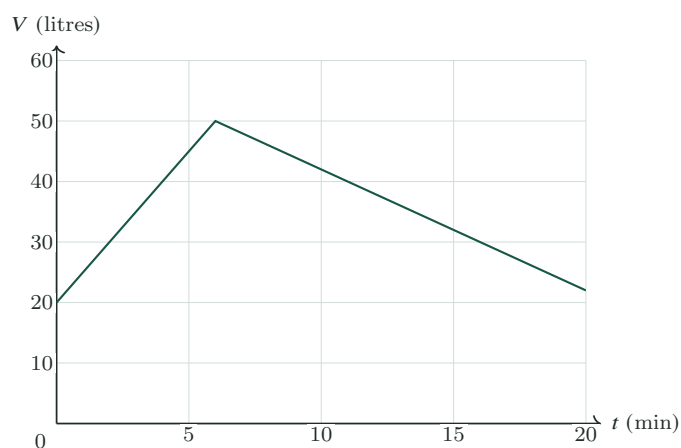
It travels 12 m forwards and 6 m back.

(b) Distance $= 3(4) + 2(3) = 18 \text{ m}$

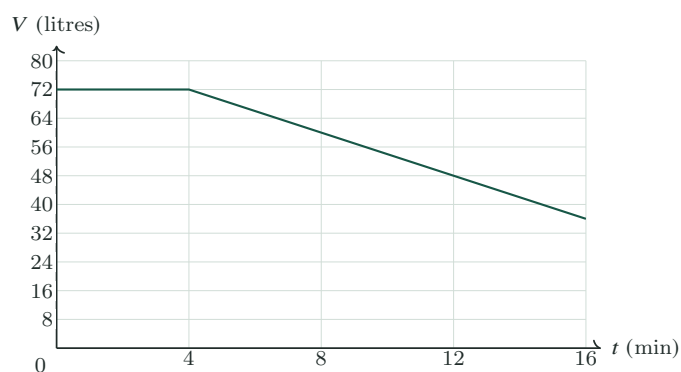
Count both legs as positive distances.

4 Interpreting and combining graphs

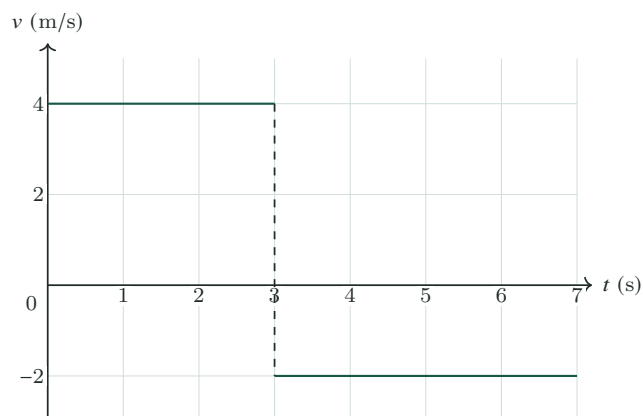
Q19 A tank starts with 20 litres and fills at 5 litres per minute. Write V in terms of t for the filling stage. ***



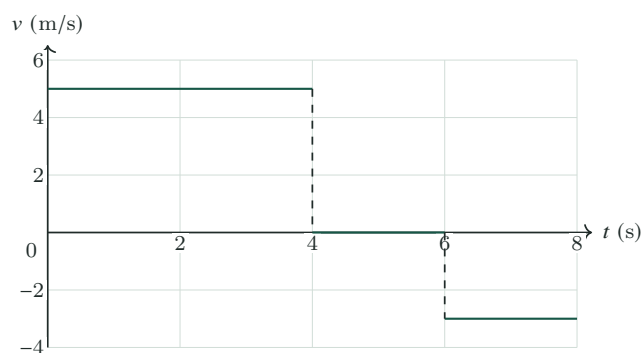
Q20 A tank holds 72 litres at $t = 4$ minutes. It then drains at the constant rate shown. Calculate the time t when it will be empty. ***



- Q21** A particle has velocity 4 m/s for 3 s , then -2 m/s for 4 s . How far from its starting point does it finish? ***

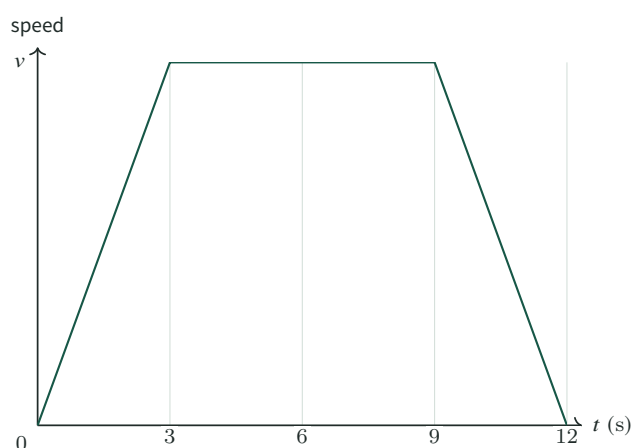


- Q22** The velocity-time graph shows a particle moving along a straight line. Find the total distance travelled in 8 seconds. ***



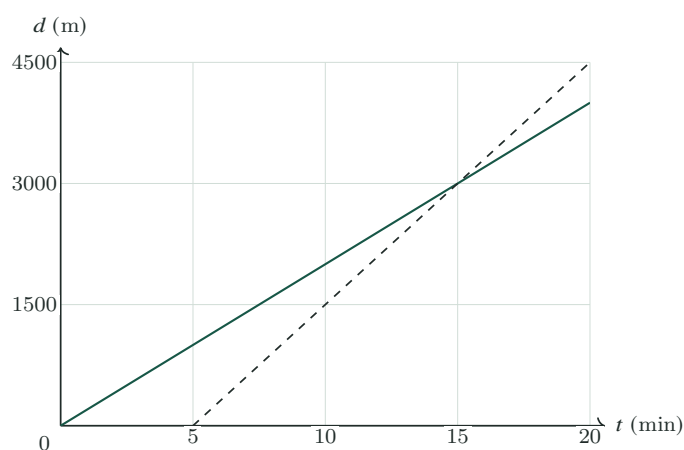
- Q23** A car accelerates uniformly from rest to v m/s in 3 s, stays at v for 6 s, then decelerates uniformly to rest in 3 s. It travels 126 m. Find v .

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- Q24** Cyclist A leaves home at $t = 0$ and travels at 200 m/min. Cyclist B leaves the same place 5 minutes later, following the same route at 300 m/min. At what time t does B catch A?

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Solving principles

1. Read the axes

State which quantity an area or gradient represents.

2. Split the graph

Calculate simple sections separately, then combine them.

3. Use elapsed time

Include stops when calculating average speed for the whole journey.

4. Interpret the sign

Negative velocity means motion in the opposite direction, not negative distance.