Displacement–Time Graphs

Specification: AQA 7357: P1, Q1, Q2 · Edexcel 9MA0: 6.1, 7.1, 7.2

INDEPENDENT

You do

A · Velocity from a gradient

Gradient = change in displacement ÷ change in time.

1 A displacement–time graph is a straight line from $(0, 0)$ to $(8, 36)$, with s in metres and t in seconds. Find the velocity.

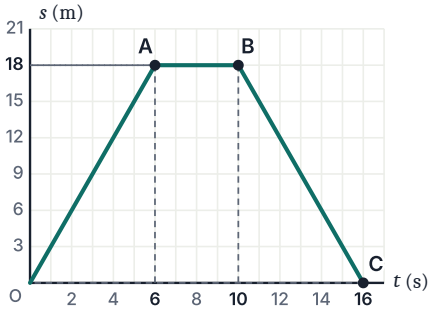
$36 \div 8 = 4.5$ m s^{-1} — gradient = velocity

2 A displacement–time graph is a straight line from $(0, 50)$ to $(10, 20)$ (s in m, t in s). Find the velocity and the speed.

Velocity $= (20 - 50) \div 10 = -3$ m s^{-1} — gradient = velocity

Speed $= 3$ m s^{-1} — speed: size of velocity

3 The graph shows the displacement of a robot from its charger. Find its velocity on each stage OA, AB and BC.



OA: $18 \div 6 = 3$ m s^{-1} — gradient = velocity

AB: 0 m s^{-1} — flat: at rest

BC: $-18 \div 6 = -3$ m s^{-1} — negative: back towards O

4 A displacement–time graph is a straight line from $(0, 0)$ to $(2.5, 4)$, with s in km and t in minutes. Find the velocity in m s^{-1}.

4 km = 4000 m, 2.5 minutes = 150 s — convert to m and s

$4000 \div 150 = 26.7$ m s^{-1} — gradient, 3 s.f.

5 The displacement of a particle is given by $s = 7 - 2t$ (s in m, t in s). Find its velocity and describe its motion.

Straight line, gradient -2 — gradient of s = 7 − 2t

Velocity -2 m s^{-1}: it starts 7 m from O and moves in the negative direction at 2 m s^{-1}.

in context

B · Average velocity and average speed

Displacement for velocity, distance for speed.

6 A jogger runs 400 m along a straight path in 160 s, then walks back to the start in 240 s.

(a) Find her average velocity.

(b) Find her average speed.

(a) Displacement 0 m, so average velocity 0 m s^{-1} — back at the start

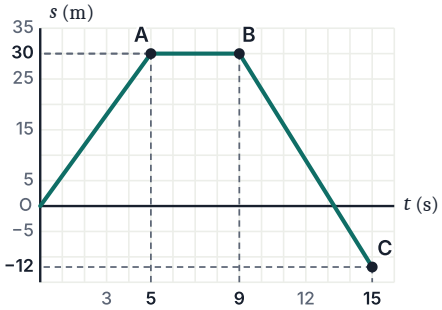
(b) $800 \div 400 = 2$ m s^{-1} — total distance ÷ total time

7 The graph shows the displacement of a scooter from a lamp post.

(a) Find the total distance travelled.

(b) Find the average velocity.

(c) Find the average speed.



(a) $30 + 42 = 72$ m — add every stage

(b) $-12 \div 15 = -0.8$ m s^{-1} — displacement ÷ time

(c) $72 \div 15 = 4.8$ m s^{-1} — distance ÷ time

8 A bus travels 12 km in 15 minutes, stops for 5 minutes, then travels a further 8 km in 10 minutes, all in the same direction. Find its average speed in km h^{-1} and in m s^{-1}.

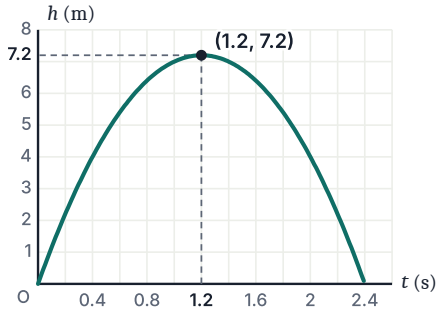
20 km in 30 minutes = ½ hour — total distance, total time

$20 \div \frac{1}{2} = 40$ km h^{-1} — distance ÷ time

$40 \div 3.6 = 11.1$ m s^{-1} — ÷ 3.6, 3 s.f.

C · Reasoning No calculator. Explain in words.

10 A ball is thrown straight up. The graph shows its height h metres after t seconds.
(a) Write down the greatest height and when it happens.
(b) Write down the velocity at that moment.
(c) Describe the motion before and after this moment.



(a) 7.2 m at $t = 1.2$ s — top of the curve

(b) 0 m s^{-1} — gradient 0: at rest

(c) Before: moving up and slowing down (the curve gets less steep). — gradient falls to 0

After: moving down and speeding up (steeper, going down). — gradient negative, steeper

12 True or false? Explain each answer.
(a) If an object's average velocity is zero, it has not moved.
(b) An object's average speed is never less than the size of its average velocity.

(a) False: it can go out and come back. Displacement 0, distance not 0. — out and back

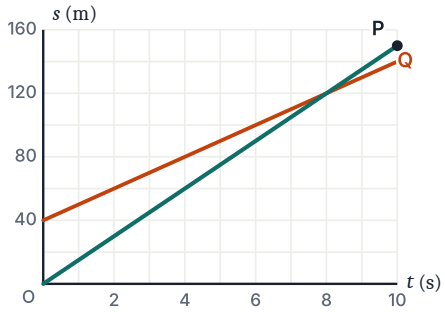
(b) True: distance is never less than the size of the displacement, and both are divided by the same time. — distance ≥ |displacement|

9 (a) Convert 72 km h^{-1} into m s^{-1}.
(b) Convert 12.5 m s^{-1} into km h^{-1}.

(a) $72 \div 3.6 = 20$ m s^{-1} — ÷ 3.6

(b) $12.5 \times 3.6 = 45$ km h^{-1} — × 3.6

11 The graph shows the displacements of two cars, P and Q, on a straight road.
(a) Which car is faster? Explain.
(b) When and where are they level?



(a) P: $150 \div 10 = 15$ m s^{-1}; Q: $100 \div 10 = 10$ m s^{-1} — gradient = velocity

P is faster: its line is steeper. — steeper: faster

(b) $15t = 40 + 10t$ — level: same s

$t = 8$ s, $s = 120$ m — solve; substitute

D · Unknowns and "show that" Set up an equation in the unknown.

13 A car travels a distance d metres along a straight road at 20 m s^{-1} and returns along the same road at 30 m s^{-1}. Show that its average speed for the whole trip is 24 m s^{-1}.

Times: $d \div 20$ and $d \div 30$ — time = distance ÷ speed
Total time $= 3d \div 60 + 2d \div 60 = d \div 12$ — common denominator
Average speed $= 2d \div (d \div 12) = 24$ m s^{-1} — total distance ÷ total time

14 A runner runs 300 m in a straight line at 6 m s^{-1}, rests for T seconds, then runs back to the start at 5 m s^{-1}. Her average speed for the whole journey is 4 m s^{-1}. Find T.

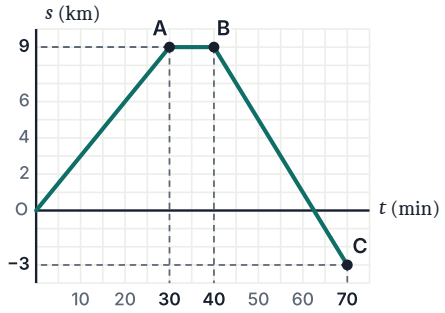
Times: $300 \div 6 = 50$, $300 \div 5 = 60$ — time = distance ÷ speed
$600 \div (110 + T) = 4$ — average speed
$110 + T = 150 \Rightarrow T = 40$ — solve

15 A robot moves along a straight line. Its displacement–time graph is two straight lines: from $(0, 0)$ to $(a, 24)$, then from $(a, 24)$ to $(18, 0)$ (s in m, t in s). It takes twice as long to come back as to go out. Find a and the velocity on each stage.

Time back $= 18 - a = 2a$ — back takes twice as long
$a = 6$ — solve
Out: $24 \div 6 = 4$ m s^{-1}; back: $-24 \div 12 = -2$ m s^{-1} — gradient = velocity

E · Exam-style question Show your method: marks are for working.

16 The graph shows a cyclist's displacement s km from home after t minutes on a straight road.
(a) Find her velocity on OA, in km h^{-1}. [2 marks]
(b) Find her velocity on BC, in m s^{-1}. [3 marks]
(c) Find her average speed for the whole journey, in km h^{-1}. [2 marks]
(d) Where is she at the end? How does the graph show this? [1 mark]



(a) $9 \div 0.5$ M1 — 30 min = 0.5 h
$= 18$ km h^{-1} A1 — gradient = velocity

(b) $(-3 - 9) \div 0.5 = -24$ km h^{-1} M1 — 30 min = 0.5 h
$-24 \div 3.6$ M1 — km h^{-1} ÷ 3.6
$= -6.67$ m s^{-1} A1 — 3 s.f.

(c) $(9 + 12) \div (70 \div 60) = 18$ km h^{-1} M1 A1 — distance ÷ time in hours

(d) 3 km from home, on the other side: the graph ends below the t-axis ($s = -3$). B1 — negative displacement