The First Constant-Acceleration Formulae

Specification: AQA 7357: P1, Q1, Q3 · Edexcel 9MA0: 6.1, 7.1, 7.3

INDEPENDENT

You do

A · Using v = u + at

The letter you do not need here is s.

1 A particle moves in a straight line with constant acceleration 2.5 m s^{-2}. At $t = 0$ its velocity is 4 m s^{-1}. Find its velocity when $t = 8$.

s	u	v	a	t
–	4	?	2.5	8

s u v a t

$v = 4 + 2.5 \times 8 = 24$ m s^{-1} — v = u + at

2 A van moving at 18 m s^{-1} brakes and comes to rest with constant deceleration in 12 s. Modelling the van as a particle, find its deceleration.

s	u	v	a	t
–	18	0	?	12

comes to rest: v = 0

$0 = 18 + 12a \Rightarrow a = -1.5$ — v = u + at

Deceleration 1.5 m s^{-2} — a < 0: deceleration

3 A ball rolls down a slope with constant acceleration 1.2 m s^{-2}. After 5 s its velocity is 9 m s^{-1}. Find its velocity at the start.

s	u	v	a	t
–	?	9	1.2	5

s u v a t

$9 = u + 1.2 \times 5 \Rightarrow u = 3$ m s^{-1} — v = u + at

4 A cyclist accelerates uniformly from 2 m s^{-1} to 8 m s^{-1} at 0.75 m s^{-2}. How long does this take?

s	u	v	a	t
–	2	8	0.75	?

s u v a t

$8 = 2 + 0.75t \Rightarrow t = 8$ s — v = u + at

B · Using s = ½(u + v)t, and choosing the formula

The missing letter picks the formula. Change to m and s first.

5 A car accelerates uniformly from 6 m s^{-1} to 20 m s^{-1} in 9 s. Find the distance it travels.

s	u	v	a	t
?	6	20	–	9

no a

$s = ½(6 + 20) \times 9 = 117$ m — s = ½(u + v)t

6 A particle moves from A to B with constant acceleration, taking 6 s. The distance AB is 45 m and its velocity at B is 11 m s^{-1}.
(a) Find its velocity at A.
(b) Find its acceleration.

(a)

s	u	v	a	t
45	?	11	?	6

s u v a t

$45 = ½(u + 11) \times 6 = 3(u + 11) \Rightarrow u = 4$ m s^{-1} — s = ½(u + v)t

(b) $11 = 4 + 6a \Rightarrow a = 1.17$ m s^{-2} (3 s.f.) — v = u + at

7 A lorry travelling at 72 km h^{-1} brakes with constant deceleration and stops in 8 s.
(a) Find its deceleration.
(b) Find its braking distance.

72 km h^{-1} = 72 ÷ 3.6 = 20 m s^{-1} — km h^{-1} ÷ 3.6

(a) $0 = 20 + 8a \Rightarrow a = -2.5$: deceleration 2.5 m s^{-2} — v = u + at

(b) $s = ½(20 + 0) \times 8 = 80$ m — s = ½(u + v)t

8 A particle moves from P to Q with constant acceleration 0.4 m s^{-2}. Its velocity at P is 5 m s^{-1} and it takes 15 s.
(a) Find its velocity at Q.
(b) Find the distance PQ.

(a) $v = 5 + 0.4 \times 15 = 11$ m s^{-1} — v = u + at

(b) $s = ½(5 + 11) \times 15 = 120$ m — s = ½(u + v)t

9 A train passes a signal at 54 km h^{-1}. It then accelerates uniformly at 0.25 m s^{-2} for 2 minutes.
(a) Find its speed at the end, in km h^{-1}.
(b) Find the distance it travels, in km.

54 km h^{-1} = 15 m s^{-1}; 2 minutes = 120 s — units: m s^{-1} and s

(a) $v = 15 + 0.25 \times 120 = 45$ m s^{-1} — v = u + at

45 × 3.6 = 162 km h^{-1} — m s^{-1} × 3.6

(b) $s = ½(15 + 45) \times 120 = 3600$ m = 3.6 km — s = ½(u + v)t

C · Signs and turning round

No calculator. Positive direction: + ; against it: −.

10 The positive direction is from A to B. For each car, write down u, v and a, with signs.

(a) A car moving towards B speeds up from 4 m s^{-1} to 10 m s^{-1} in 3 s.

(b) A car moving towards B slows down from 10 m s^{-1} to 4 m s^{-1} in 3 s.

(c) A car moving towards A speeds up from 4 m s^{-1} to 10 m s^{-1} in 3 s.

(a) $u = 4, v = 10, a = 2$ — speeding up towards B

(b) $u = 10, v = 4, a = -2$ — slowing down: a < 0

(c) $u = -4, v = -10, a = -2$ — speeding up towards A

11 A particle passes O moving in the positive direction at 6 m s^{-1}. Its acceleration is a constant −2 m s^{-2}.

(a) Find its velocity when $t = 5$. What does the sign tell you?

(b) Find its displacement from O when $t = 5$.

(c) Find the distance it travels in the 5 seconds.

(a) $v = 6 + (-2) \times 5 = -4$ m s^{-1}: moving back towards O — v < 0: turned round

(b) $s = \frac{1}{2}(6 + (-4)) \times 5 = 5$ m — s = ½(u + v)t

(c) At rest when $t = 3$: $s = \frac{1}{2}(6 + 0) \times 3 = 9$ — v = 0: at rest

Back 9 − 5 = 4: distance 9 + 4 = 13 m — out + back

12 True or false? Explain each answer.

(a) A particle moving in the positive direction decelerates at 3 m s^{-2}, so $a = -3$.

(b) If v is negative, the particle is slowing down.

(c) $s = \frac{1}{2}(u + v)t$ always gives the distance travelled.

(a) True: the acceleration is against the motion. — deceleration: a < 0

(b) False: it is moving in the negative direction. It may be speeding up (Q10(c)). — sign = direction

(c) False: it gives the displacement. They are equal only if the particle does not turn round. — s is displacement

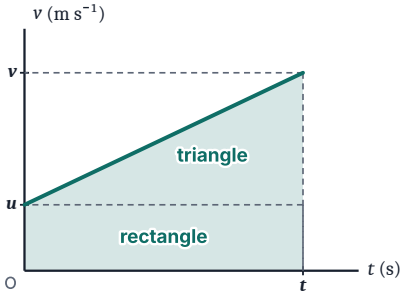
D · Derive and show that

Quote the graph fact you use at each step.

13 A particle accelerates uniformly from u to v in t seconds. The area under its velocity–time graph is split into a rectangle and a triangle.

(a) Use the gradient to show that $v - u = at$.

(b) Use the rectangle and the triangle to show that $s = \frac{1}{2}(u + v)t$.



(a) Gradient $= \frac{v - u}{t} = a \Rightarrow v - u = at$ — gradient = acceleration

(b) Rectangle ut; triangle $\frac{1}{2}t(v - u)$ — area of each part

$s = ut + \frac{1}{2}vt - \frac{1}{2}ut = \frac{1}{2}ut + \frac{1}{2}vt$ — expand, collect

$s = \frac{1}{2}(u + v)t$ — factorise

14 A car accelerates uniformly from u m s^{-1} to $3u$ m s^{-1} in T seconds. It travels d metres.

(a) Show that $d = 2uT$.

(b) Find its acceleration in terms of u and T.

(a) $d = \frac{1}{2}(u + 3u)T = \frac{1}{2} \times 4u \times T$ — s = ½(u + v)t

$d = 2uT$ — simplify

(b) $3u = u + aT \Rightarrow a = \frac{2u}{T}$ — v = u + at

15 A particle starts from rest and accelerates uniformly at 1.6 m s^{-2} for 15 s. It then decelerates uniformly to rest in 10 s.
(a) Find its greatest speed.
(b) Find the total distance it travels.
(c) Find its deceleration.

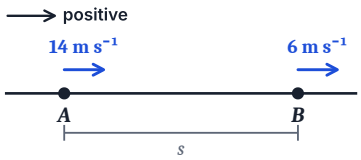
(a) $v = 0 + 1.6 \times 15 = 24$ m s^{-1} — from rest: u = 0

(b) Stage 1: $s = \frac{1}{2}(0 + 24) \times 15 = 180$ — s = ½(u + v)t
Stage 2: $s = \frac{1}{2}(24 + 0) \times 10 = 120$; total 300 m — stage 2: u = 24

(c) $0 = 24 + 10a \Rightarrow a = -2.4$: deceleration 2.4 m s^{-2} — a < 0: deceleration

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

16 A particle P moves along a straight line with constant acceleration. At time $t = 0$ it passes a point A, moving towards a point B with velocity 14 m s^{-1}. At $t = 4$ it passes B, still moving in the same direction, with velocity 6 m s^{-1}.
(a) Find the acceleration of P. [2 marks]
(b) Find the distance AB. [2 marks]
(c) Find the time at which P is instantaneously at rest. [2 marks]
(d) Find the velocity of P when $t = 10$, and state the direction in which it is moving. [2 marks]



sketch; A to B positive

(a) $6 = 14 + 4a \Rightarrow a = -2$ m s^{-2} **M1 A1** — v = u + at

(b) $s = \frac{1}{2}(14 + 6) \times 4 = 40$ m **M1 A1** — s = ½(u + v)t

(c) $0 = 14 - 2t \Rightarrow t = 7$ s **M1 A1** — v = 0: at rest

(d) $v = 14 + (-2) \times 10 = -6$ m s^{-1} **A1** — v = u + at
Moving towards A (from B back to A) at 6 m s^{-1} **B1** — v < 0: towards A