The Other Constant-Acceleration Formulae

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

INDEPENDENT You do

A · Choose and use The dashed letter picks the formula.

1 A particle has constant acceleration 3 m s^{-2}. It passes A with velocity 2 m s^{-1}. Find its velocity at B, where AB = 10 m.

s	u	v	a	t
10	2	?	3	–

no t

$v^2 = 2^2 + 2 \times 3 \times 10 = 64 \Rightarrow v = 8$ m s^{-1} — $v^2 = u^2 + 2as$

2 A cyclist travelling at 10 m s^{-1} brakes and stops in 25 m. Assuming constant deceleration, find the deceleration.

s	u	v	a	t
25	10	0	?	–

no t

$0 = 10^2 + 2 \times a \times 25 \Rightarrow a = -2$ — $v^2 = u^2 + 2as$

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

3 A car passes a lamp post at 5 m s^{-1}. It accelerates uniformly and passes a sign 72 m further on, 8 s later. Find its acceleration.

s	u	v	a	t
72	5	–	?	8

no v

$72 = 5 \times 8 + \frac{1}{2} \times a \times 8^2 = 40 + 32a$ — $s = ut + \frac{1}{2}at^2$

$a = 1$ m s^{-2} — solve

4 A particle accelerates uniformly at 1.5 m s^{-2} for 8 s, reaching 20 m s^{-1}. How far does it travel in this time?

s	u	v	a	t
?	–	20	1.5	8

no u

$s = 20 \times 8 - \frac{1}{2} \times 1.5 \times 8^2 = 160 - 48 = 112$ m — $s = vt - \frac{1}{2}at^2$

5 A train passes one signal at 36 km h^{-1} and a second signal, 300 m further on, at 72 km h^{-1}. Its acceleration is constant. Find the acceleration.

$u = 10$, $v = 20$ (m s^{-1}) — km h^{-1} ÷ 3.6

$20^2 = 10^2 + 2 \times a \times 300 \Rightarrow 400 = 100 + 600a$ — $v^2 = u^2 + 2as$

$a = 0.5$ m s^{-2} — solve

B · Two steps and quadratics Collect a quadratic on one side; reject a negative time.

6 A puck slides across ice in a straight line. Its initial speed is 10 m s^{-1} and it slows down at a constant 0.4 m s^{-2}.
(a) Find the distance it slides before it stops.
(b) Find its speed when it has slid half of this distance.

(a) $0 = 10^2 - 2 \times 0.4 \times s \Rightarrow s = 125$ m — $v^2 = u^2 + 2as$

(b) $v^2 = 100 - 0.8 \times 62.5 = 50$ — s = 62.5

$v = \sqrt{50} = 7.07$ m s^{-1} — square root, 3 s.f.

7 A particle passes O with velocity 6 m s^{-1} and constant acceleration 2 m s^{-2}. Find the time it takes to travel 40 m, and its velocity then.

$40 = 6t + t^2 \Rightarrow t^2 + 6t - 40 = 0$ — $s = ut + \frac{1}{2}at^2$

$(t + 10)(t - 4) = 0 \Rightarrow t = 4$ s — factorise; t > 0

$v = 6 + 2 \times 4 = 14$ m s^{-1} — v = u + at

8 A particle passes O with velocity 7 m s^{-1} and constant acceleration 1.5 m s^{-2}. A point A is 50 m from O in its direction of motion.
(a) Find the time it takes to reach A.
(b) Find its speed at A.

(a) $50 = 7t + 0.75t^2 \Rightarrow 3t^2 + 28t - 200 = 0$ — $s = ut + \frac{1}{2}at^2$, × 4

$t = \dfrac{-28 + \sqrt{3184}}{6} = 4.74$ s — quadratic formula

(b) $v^2 = 7^2 + 2 \times 1.5 \times 50 = 199 \Rightarrow v = 14.1$ m s^{-1} — $v^2 = u^2 + 2as$

9 A particle has constant acceleration 2 m s^{-2}. It travels 52 m in 4 s.
(a) Find its initial velocity.
(b) Find its final velocity.

(a) $52 = 4u + \frac{1}{2} \times 2 \times 4^2 = 4u + 16 \Rightarrow u = 9$ m s^{-1} — $s = ut + \frac{1}{2}at^2$

(b) $v = 9 + 2 \times 4 = 17$ m s^{-1} — v = u + at

C · Reasoning No calculator.

10 Which formula would you use? Do not solve.
(a) You know u, v and s, and want a.
(b) You know u, a and t, and want s.
(c) You know v, a and t, and want s.

(a) $v^2 = u^2 + 2as$ — no t

(b) $s = ut + \frac{1}{2}at^2$ — no v

(c) $s = vt - \frac{1}{2}at^2$ — no u

11 A particle passes O moving in the positive direction at 4 m s^{-1}. Its acceleration is a constant -2 m s^{-2}.
(a) Show that it never reaches the point 5 m from O in the positive direction.
(b) Find the greatest distance it reaches from O in that direction.

(a) $v^2 = 4^2 + 2 \times (-2) \times 5 = 16 - 20 = -4$ — $v^2 = u^2 + 2as$
$v^2 < 0$ is impossible, so it never gets there. — $v^2 < 0$: never reached

(b) $0 = 16 - 4s \Rightarrow s = 4$ m — $v = 0$: furthest point

12 True or false? Explain each answer.
(a) $v^2 = u^2 + 2as$ can be used to find the time taken.
(b) A car that slows down from 10 m s^{-1} to 5 m s^{-1} covers the same distance as one that speeds up from 5 m s^{-1} to 10 m s^{-1} with the same size of acceleration.
(c) Both solutions of a quadratic in t always give a sensible time.

(a) False: it has no t in it. — no t

(b) True: $2|a|s = 10^2 - 5^2$ in both cases. — $v^2 - u^2 = 2as$

(c) False: a negative t is before the start, so it is rejected. — reject $t < 0$

D · Derive and simultaneous equations Number your equations; say what you substitute.

13 Use $v = u + at$ and $s = ut + \frac{1}{2}at^2$ to show that $s = vt - \frac{1}{2}at^2$.

$u = v - at$ — make u the subject
$s = (v - at)t + \frac{1}{2}at^2 = vt - at^2 + \frac{1}{2}at^2$ — substitute, expand
$s = vt - \frac{1}{2}at^2$ — collect at^2 terms

14 A car moves along a straight road with constant acceleration. It passes A, B and C in that order. AB = 60 m and BC = 165 m. Its speed at B is 8 m s^{-1} and at C is 14 m s^{-1}.
(a) Find its acceleration.
(b) Find its speed at A.
(c) Find the time it takes from A to C.

(a) B to C: $14^2 = 8^2 + 2a \times 165 \Rightarrow 132 = 330a \Rightarrow a = 0.4$ m s^{-2} — $v^2 = u^2 + 2as$

(b) A to B: $8^2 = u^2 + 2 \times 0.4 \times 60 \Rightarrow u^2 = 16 \Rightarrow u = 4$ m s^{-1} — $v^2 = u^2 + 2as$

(c) $t = (14 - 4) \div 0.4 = 25$ s — $v = u + at$

15 A runner moves along a straight path with constant deceleration. She passes P, Q and R. It takes her 4 s to run from P to Q and another 4 s from Q to R. PQ = 24 m and QR = 16 m. Find her deceleration and her speed at P.

P to Q: $24 = 4u + 8a \Rightarrow u + 2a = 6$ (1) — $s = ut + \frac{1}{2}at^2$
P to R: $40 = 8u + 32a \Rightarrow u + 4a = 5$ (2) — P to R: $t = 8$
(2) − (1): $2a = -1 \Rightarrow a = -0.5$; $u = 7$ — simultaneous equations
Deceleration 0.5 m s^{-2}; speed at P 7 m s^{-1} — $a < 0$: deceleration

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

16 A particle moves along a straight line with constant acceleration. It passes the points A, B and C in that order, with velocities 5 m s^{-1}, 13 m s^{-1} and 29 m s^{-1}. It takes t_1 seconds to move from A to B and t_2 seconds to move from B to C.

(a) Show that $t_1 : t_2 = 1 : 2$. [3 marks]

The particle takes 24 s to move from A to C.

(b) Find the acceleration of the particle and the distance AB. [3 marks]

(c) Find the distance BC. [2 marks]

(a) $13 = 5 + at_1 \Rightarrow t_1 = 8 \div a$ **M1** — v = u + at

$29 = 13 + at_2 \Rightarrow t_2 = 16 \div a$ **M1** — B to C: u = 13

$t_1 : t_2 = 8 : 16 = 1 : 2$ **A1** — ratio: a cancels

(b) $24 \div a = 24 \Rightarrow a = 1$ m s^{-2} **M1 A1** — $t_1 + t_2 = 24$

AB $= \frac{1}{2}(5 + 13) \times 8 = 72$ m **A1** — $s = \frac{1}{2}(u + v)t$

(c) $29^2 = 13^2 + 2 \times 1 \times s \Rightarrow s = 336$ m **M1 A1** — $v^2 = u^2 + 2as$