Constant Acceleration Formulae

SCAN ME

REVISE THIS TOPIC

1 A car moves along a straight horizontal road passing through points A, B and C.

At $t = 0$, the car passes point A with a velocity of 6 ms^{-1} then accelerates uniformly at 1.5 ms^{-2} for 8 seconds before reaching point B. The car then maintains a constant velocity until it reaches point C.

(a) Find the velocity of the car when $t = 8$ **(2)**

(b) Find the distance between points A and B. **(2)**

The distance between points B and C is 135 m.

(c) Find the time taken for the car to travel from point A to point C. **(2)**

(a) $s = s$ $\quad v = u + at$

$u = 6$ $\quad v = 6 + 1.5(8)$

$v = v$ $\quad v = \mathbf{18\ ms^{-1}}$

$a = 1.5$

$t = 8$

(b) $s = s$ $\quad s = \frac{1}{2}(u + v)t$

$u = 6$ $\quad s = \frac{1}{2}(6 + 18) \times 8$

$v = 18$ $\quad s = \mathbf{96\ m}$

$a = 1.5$

$t = 8$

(c) $s = 135$ $\quad s = ut + \frac{1}{2}at^2$

$u = 18$ $\quad 135 = 18t + \frac{1}{2}(0)t^2$

$v = 18$ $\quad 135 = 18t$

$a = 0$ $\quad t = 7.5$ s

$t = t$

Total time = 8 + 7.5

= **15.5 seconds**

(Total for Question 1 is 6 marks)

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2 A cyclist travels along a straight horizontal road between points C and D.

In the model of the motion, the cyclist starts from rest at point C when $t = 0$, then moves with a constant acceleration of 1.2 ms^{-2}. When $t = 9$, the cyclist arrives at point D.

(a) Find the velocity of the cyclist when they reach point D. **(2)**

(b) Find the distance between points C and D. **(2)**

(c) Find the time taken to reach the midpoint of C and D. **(3)**

(a) $s = s$	(b) $s = s$	(c) $s = 24.3$ [48.6 ÷ 2]
$u = 0$	$u = 0$	$u = 0$
$v = v$	$v = 10.8$	$v = v$
$a = 1.2$	$a = 1.2$	$a = 1.2$
$t = 9$	$t = 9$	$t = t$ $\quad s = ut + \frac{1}{2}at^2$
		$24.3 = (0)t + \frac{1}{2}(1.2)t^2$
$v = u + at$	$s = \frac{1}{2}(u + v)t$	$24.3 = 0.6t^2$
$v = 0 + 1.2(9)$	$s = \frac{1}{2}(0 + 10.8) \times 9$	$t^2 = 40.5$
$v = \mathbf{10.8\ ms^{-1}}$	$s = \mathbf{48.6\ m}$	$t = \mathbf{6.36\ seconds}$

(Total for Question 2 is 7 marks)

3 A train travels along a straight horizontal track with uniform acceleration for 30 seconds.

When $t = 4$, the velocity of the train is 18 ms^{-1}
When $t = 24$, the velocity of the train is 34 ms^{-1}

(a) Find the acceleration of the train. **(2)**

(b) Find the velocity of the train when $t = 0$ **(2)**

(c) Find the distance travelled by the train in the 30 second journey. **(3)**

(a) $a = \frac{\text{change in velocity}}{\text{change in time}}$	(b) $s = s$	(c) $s = s$
	$u = u$	$u = 14.8$
	$v = 34$	$v = v$
$a = \frac{34 - 18}{24 - 4} = \mathbf{0.8\ ms^{-2}}$	$a = 0.8$	$a = 0.8$
	$t = 24$	$t = 30$
	$v = u + at$	$s = ut + \frac{1}{2}at^2$
	$34 = u + 0.8(24)$	$s = 14.8(30) + \frac{1}{2}(0.8)(30)^2$
	$u = \mathbf{14.8\ ms^{-1}}$	$s = \mathbf{804\ m}$

(Total for Question 3 is 7 marks)

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4 A cyclist travels along a straight horizontal road.

In the model of the motion, the cyclist is travelling at 9 ms^{-1} when they apply the brakes, causing them to decelerate uniformly. The cyclist comes to rest after travelling 27 m with the brakes applied.

(a) Find the acceleration of the cyclist whilst they are braking. **(2)**

(b) Find the time taken to come to rest whilst they are braking. **(2)**

(a) $s = 27$	$v^2 = u^2 + 2as$	(b) $s = 27$	$v = u + at$
$u = 9$	$0^2 = 9^2 + 2a(27)$	$u = 9$	$0 = 9 - 1.5t$
$v = 0$	$-54a = 81$	$v = 0$	$1.5t = 9$
$a = a$	$a = \mathbf{-1.5\ ms^{-2}}$	$a = -1.5$	$t = \mathbf{6\ seconds}$
$t = t$		$t = t$	

(Total for Question 4 is 4 marks)

5 A bus travels along a straight horizontal road.

In the model of the motion, the bus accelerates uniformly from a velocity of 8.5 ms^{-1} to a velocity of 16.5 ms^{-1}, in 5 seconds. The bus then maintains a constant velocity of 16.5 ms^{-1} for a further 15 seconds.

(a) Find the acceleration of the bus during the first 5 seconds. **(2)**

(b) Find the total distance travelled by the bus during the 20 second period. **(4)**

(a) $a = \dfrac{\text{change in velocity}}{\text{change in time}}$

$a = \dfrac{16.5 - 8.5}{5}$

$a = \mathbf{1.6\ ms^{-2}}$

(b)

$s = s$	$s = s$
$u = 8.5$	$u = 16.5$
$v = 16.5$	$v = 16.5$
$a = 1.6$	$a = 0$
$t = 5$	$t = 15$
$s = ut + \frac{1}{2}at^2$	$s = ut + \frac{1}{2}at^2$
$s = 8.5(5) + \frac{1}{2}(1.6)(5)^2$	$s = 16.5(15) + \frac{1}{2}(0)(15)^2$
$s = 62.5$	$s = 247.5$

Total distance = 62.5 + 247.5 = **310 m**

(Total for Question 5 is 6 marks)

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6 A runner travels along a straight horizontal track.

In the model of the motion, the runner starts from rest when $t = 0$ before travelling with constant acceleration 1.6 ms^{-2}, until they reach a velocity of 6.4 ms^{-1}

The runner then maintains a constant velocity of 6.4 ms^{-1} until they have travelled a total distance of 500 m.

Show that it takes the runner more than 80 seconds to travel the distance of 500 m.

$s = s$	$s = ut + \frac{1}{2}at^2$	$s = 487.2$	$s = ut + \frac{1}{2}at^2$
$u = 0$	$s = 0(4) + \frac{1}{2}(1.6)(4)^2$	$u = 6.4$	$487.2 = 6.4t + \frac{1}{2}(0)t^2$
$v = 6.4$	$s = 12.8$ m	$v = 6.4$	$t = \frac{487.2}{6.4}$
$a = 1.6$		$a = 0$	
$t = t$	Distance remaining $= 500 - 12.8$	$t = t$	$t = 76.125$
	$= 487.2$ m		
$v = u + at$			
$6.4 = 0 + 1.6t$		Total time $= 4 + 76.125 = 80.125$ seconds	
$t = 4$ seconds		$80.125 > 80$	

(Total for Question 6 is 4 marks)

7 A motorcycle travels along a straight horizontal road between points A and B.

In the model of the motion, the motorcycle travels with constant acceleration between points A and B, passing point A with velocity 18 ms^{-1} and point B with velocity 32 ms^{-1}

Given that the distance between A and B is 125 m, find

(a) the acceleration of the motorcycle **(2)**

(b) the time taken for the motorcycle to travel between points A and B. **(2)**

(a)	$s = 125$	$v^2 = u^2 + 2as$	(b) $s = 125$	$v = u + at$
	$u = 18$	$32^2 = 18^2 + 2a(125)$	$u = 18$	$32 = 18 + 2.8t$
	$v = 32$	$1024 = 324 + 250a$	$v = 32$	$2.8t = 14$
	$a = a$	$250a = 700$	$a = 2.8$	$t =$ **5 seconds**
	$t = t$	$a =$ **2.8 ms^{-2}**	$t = t$	

(Total for Question 7 is 4 marks)

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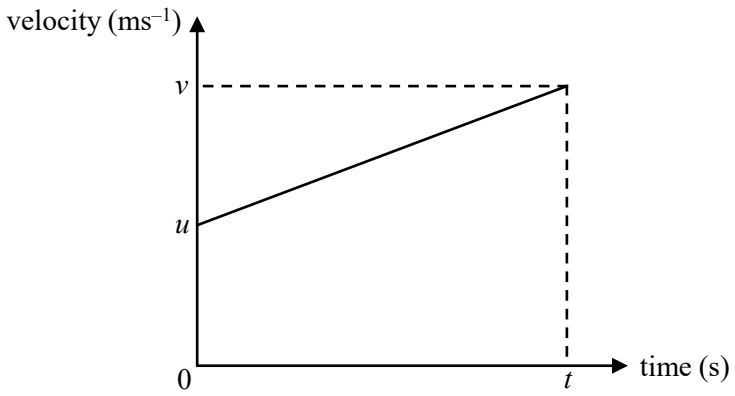


Figure 1

Figure 1 shows the velocity-time graph for the motion of the object travelling in a straight line for t seconds.

It has initial velocity u ms^{-1}, final velocity v ms^{-1}, and uniform acceleration a ms^{-2}

(a) Use the graph to show that $v = u + at$ **(3)**

(b) Use the graph to show that $s = \frac{1}{2}(u + v)t$ **(1)**

(a) gradient = $\dfrac{v - u}{t}$

Gradient of velocity-time graph = acceleration so

$a = \dfrac{v - u}{t}$

$at = v - u$

$at + u = v$

$v = u + at$

(b) area under graph = $\frac{1}{2}(u + v)t$

area under velocity-time graph = displacement so $s = \frac{1}{2}(u + v)t$

(Total for Question 8 is 4 marks)

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9 An object travels in a straight line with constant acceleration a ms^{-2} for t seconds.

It has initial velocity u ms^{-1} and final velocity v ms^{-1}

Given that $v = u + at$ and $s = \frac{1}{2}(u + v)t$ show that

(a) $s = ut + \frac{1}{2}at^2$ **(3)**

(b) $s = vt - \frac{1}{2}at^2$ **(3)**

(c) $v^2 = u^2 + 2as$ **(3)**

(a) $v = u + at$	(b) $v = u + at$	(c) $v = u + at$
	$u = v - at$	$t = \frac{v - u}{a}$
$s = \frac{1}{2}(u + v)t$		
$s = \frac{1}{2}(u + (u + at))t$	$s = \frac{1}{2}(u + v)t$	$s = \frac{1}{2}(u + v)t$
$s = \frac{1}{2}(2u + at)t$	$s = \frac{1}{2}((v - at) + v)t$	$s = \frac{1}{2}(u + v)(\frac{v - u}{a})$
$s = \frac{1}{2}(2ut + at^2)$	$s = \frac{1}{2}(2v - at)t$	$2as = (u + v)(v - u)$
$s = ut + \frac{1}{2}at^2$	$s = \frac{1}{2}(2vt - at^2)$	$2as = v^2 - u^2$
	$s = vt - \frac{1}{2}at^2$	$v^2 = u^2 + 2as$

(Total for Question 9 is 9 marks)

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10 A train travels along a straight horizontal track.

In the model of the motion, when $t = 0$ the train travels with uniform acceleration 0.3 ms^{-2} for T seconds, from an initial velocity of 15 ms^{-1} to a velocity of V ms^{-1}.

At time $t = T$ the train has travelled a total distance of 255 m.

Find the values of V and T.

$s = 255$	$V^2 = u^2 + 2as$	$19.4\ldots = 15 + 0.3T$
$u = 15$	$V^2 = 15^2 + 2(0.3)(255)$	$19.4\ldots - 15 = 0.3T$
$v = V$	$V^2 = 378$	$T =$ **14.8 s**
$a = 0.3$	$V =$ **19.4 ms^{-1}**	
$t = T$		

(Total for Question 10 is 4 marks)

11 A car travels along a straight horizontal road.

In the model of the motion,

- the car travels with constant acceleration
- when $t = 2$, the car has velocity 10 ms^{-1}
- when $t = 8$, the car has travelled a total distance of 104 m

Find the velocity of the car when $t = 9$

When $t = 2$, $v = 10$ When $t = 8$, $s = 104$

$s = s$	$v = u + at$	$s = 104$	$s = ut + \frac{1}{2}at^2$
$u = u$	$10 = u + a(2)$	$u = u$	$104 = u(8) + \frac{1}{2}a(8)^2$
$v = 10$	$10 = u + 2a$	$v = v$	$104 = 8u + 32a$
$a = a$	$[u + 2a = 10]$	$a = a$	$[8u + 32a = 104]$
$t = 2$		$t = 8$	

$u + 2a = 10$	Simultaneous equation.	$v = u + at$
$8u + 32a = 104$	Solution from calculator	$v = 7 + 1.5(9)$
	$u = 7$ $a = 1.5$ ms^{-2}	$v =$ **20.5 ms^{-1}**

(Total for Question 11 is 6 marks)

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12 A cyclist travels along a straight horizontal road between points A and B.

In the model of the motion, at $t = 0$ the cyclist passes point A, travelling at 12 ms^{-1} and then accelerates uniformly at 0.5 ms^{-2} for T seconds, reaching a velocity of V ms^{-1} when they pass point B.

The distance between A and B is D metres

In the final 2 seconds of the journey the cyclist travels a distance of 34 metres.

Find the values of V, T and D.

For final 2 seconds

$s = 34$	$s = vt - \frac{1}{2}at^2$
$u = u$	$34 = V(2) - \frac{1}{2}(0.5)(2)^2$
$v = V$	$34 = 2V - 1$
$a = 0.5$	$35 = 2V$
$t = 2$	$V =$ **17.5 ms^{-1}**

For whole journey

$s = D$		$s = ut + \frac{1}{2}at^2$
$u = 12$	$v = u + at$	$D = 12(11) + \frac{1}{2}(0.5)(11)^2$
$v = 17.5$	$17.5 = 12 + 0.5T$	$D =$ **162.25 m**
$a = 0.5$	$0.5T = 5.5$	
$t = T$	$T =$ **11 seconds**	

(Total for Question 12 is 6 marks)

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