Constant acceleration 9C

1 $a=3, u=2, t=6, v=?$

$v=u+at$
$=2+3\times 6=2+18=20$

The velocity of the particle at time t = 6 s is 20 m s^{-1}.

2 $u=10, v=0, t=16, a=?$

$v=u+at$

$0=10+a\times 16$
$a=-\frac{10}{16}=-0.625$

The deceleration of the car is 0.625 m s^{-1}.

3 $s=360, t=15, v=28, u=?$

$$s=\left(\frac{u+v}{2}\right)t$$
$$360=\frac{u+28}{2}\times 15$$
$$u=\frac{360\times 2}{15}-28$$
$$=20$$

The velocity of the car at the first sign post is 20 m s^{-1}.

4 a $a=0.5, u=3, t=12, v=?$

$v=u+at$
$=3+0.5\times 12=3+6=9$

The velocity of the cyclist at B is 9 m s^{-1}.

b $u=3, v=9, t=12, s=?$

$$s=\left(\frac{u+v}{2}\right)t$$
$$=\left(\frac{3+9}{2}\right)\times 12=6\times 12=72$$

The distance from A to B is 72 m s^{-1}.

5 a $s=24, t=6, v=5, u=?$

$$s=\left(\frac{u+v}{2}\right)t$$

5 a $24 = \left(\frac{u+5}{2}\right) \times 6$

$u = \frac{24 \times 2}{6} - 5 = 3$

The velocity of the particle at A is 3 m s^{-1}.

b $u = 3, v = 5, t = 6, a = ?$

$v = u + at$

$5 = 3 + 6a$

$a = \frac{5-3}{6} = \frac{1}{3} = 0.333$ (to 3 s.f.)

The acceleration of the particle is 0.333 m s^{-1}.

6 a $a = -1.2, t = 6, v = 2, u = ?$

$v = u + at$

$2 = u - 1.2 \times 6 = u - 7.2$

$u = 2 + 7.2 = 9.2$

The speed of the particle at A is 9.2 m s^{-1}.

b $u = 9.2, v = 2, t = 6, s = ?$

$s = \left(\frac{u+v}{2}\right)t = \left(\frac{9.2+2}{2}\right) \times 6 = 11.2 \times 3 = 33.6$

The distance from A to B is 33.6 m.

7 a $72 \text{ km h}^{-1} = 72 \times 1000 \text{ m h}^{-1} = \frac{72 \times 1000}{3600} \text{ m s}^{-1} = 20 \text{ m s}^{-1}$

$u = 20, a = -0.6, t = 25, v = ?$

$v = u + at = 20 - 0.6 \times 25 = 20 - 15 = 5 \text{ m s}^{-1}$

$5 \text{ m s}^{-1} = \frac{5 \times 3600}{1000} \text{ km h}^{-1} = 18 \text{ km h}^{-1}$

The speed of the train as it passes the second signal is 18 km h^{-1}

b $u = 20, v = 5, t = 25, s = ?$

$s = \left(\frac{u+v}{2}\right)t = \left(\frac{20+5}{2}\right) \times 25 = 12.5 \times 25 = 312.5$

The distance between the signals is 312.5 m.

8 a $a = -4, u = 32, v = 0, t = ?$

$$v = u + at$$
$$0 = 32 - 4t$$
$$t = \frac{32}{4} = 8$$

The time taken for the particle to move from *A* to *B* is 8 s.

b $u = 32, v = 0, t = 8, s = ?$

$$s = \left(\frac{u+v}{2}\right) t = \left(\frac{32+0}{2}\right) \times 8 = 16 \times 8 = 128$$

The time between *A* and *B* is 128 m.

9 a $u = 16,\ t = 40,\ v = 0,\ a = ?$

$$v = u + at$$
$$0 = 16 + 40a$$
$$a = \frac{-16}{40} = -0.4$$

The deceleration between *A* and *B* is 0.4 m s^{-2}.

b $u = 16, t = 40, v = 0,\ s = ?$

$$s = \left(\frac{u+v}{2}\right) t = \left(\frac{16+0}{2}\right) \times 40 = 8 \times 40 = 320$$

The distance from the bottom of the hill to the point where the skier comes to rest is 320 m.

10 a $u = 2, v = 7, t = 20, a = ?$

$$v = u + at$$
$$7 = 2 + 20a$$
$$a = \frac{7-2}{20} = 0.25$$

The acceleration of the particle is 0.25 m s^{-2}.

b From *B* to *C*, $u = 7,\ v = 11,\ a = 0.25,\ t = ?$

$$v = u + at$$
$$11 = 7 + 0.25t$$
$$t = \frac{11-7}{0.25} = 16$$

10 b The time taken for the particle to move from B to C is 16 s.

c The time taken to move from A to C is (20 + 16) = 36 s

From A to C, $u = 2,\ v = 11,\ t = 36,\ s = ?$

$$s = \left(\frac{u+v}{2}\right)t = \left(\frac{2+11}{2}\right)\times 36 = 6.5\times 36 = 234$$

The distance between A and C is 234 m.

11 a From A to B, $a = 1.5,\ u = 1,\ t = 12,\ v = ?$

$$v = u + at = 1 + 1.5\times 12 = 1 + 18 = 19$$

The velocity of the particle at B is 19 m s^{-1}.

b From B to C, $u = 19,\ v = 43,\ t = 10,\ a = ?$

$$v = u + at$$
$$43 = 19 + 10a$$
$$a = \frac{43-19}{10} = 2.4$$

The acceleration from B to C is 2.4 m s^{-2}.

c The distance from A to B, $u = 1,\ v = 19,\ t = 12,\ s = ?$

$$s = \left(\frac{u+v}{2}\right)t = \left(\frac{1+19}{2}\right)\times 12 = 10\times 12 = 120$$

The distance from B to C, $u = 19,\ v = 43, t = 10,\ s = ?$

$$s = \left(\frac{u+v}{2}\right)t = \left(\frac{19+43}{2}\right)\times 10 = 31\times 10 = 310$$

The distance from A to C is (120 + 310) = 430 m.

12 a $u = 0,\ v = 5,\ t = 20,\ a = x$

$$v = u + at$$
$$5 = 0 + 20x$$
$$x = \tfrac{5}{20} = 0.25$$

b While accelerating, $u = 0,\ v = 5,\ t = 20,\ s = ?$

$$s = \left(\frac{u+v}{2}\right)t = \left(\frac{0+5}{2}\right)\times 20 = 2.5\times 20 = 50$$

12 b While decelerating, $u = 5$, $v = 0$, $a = -\frac{1}{2}$, $x = -0.125$, $t = ?$

$$v = u + at$$
$$0 = 5 - 0.125t$$
$$t = \frac{5}{0.125} = 40$$

Now, $u = 5$, $v = 0$, $t = 40$, $s = ?$

$$s = \left(\frac{u+v}{2}\right)t = \left(\frac{5+0}{2}\right)\times 40 = 2.5\times 40 = 100$$

The total distance travelled is the distance travelled while accelerating added to the distance travelled while decelerating = (50 + 100) = 150 m.

13 a From A to B

$$v = u + at$$
$$30 = 20 + at_1$$
$$at_1 = 10 \qquad (\mathbf{1})$$

From B to C

$$v = u + at$$
$$45 = 30 + at_2$$
$$at_2 = 15 \qquad (\mathbf{2})$$

Dividing (**1**) by (**2**),

$$\frac{at_1}{at_2} = \frac{10}{15}$$
$$\frac{t_1}{t_2} = \frac{2}{3} \quad \text{as required.}$$

b From the result in part **a**

$$t_2 = \tfrac{3}{2}t_1$$
$$t_1 + t_2 = t_1 + \tfrac{3}{2}t_1 = \tfrac{5}{2}t_1 = 50$$
$$t_1 = \tfrac{2}{5}\times 50 = 20$$

From A to B, $u = 20$, $v = 30$, $t = 20$, $s = ?$

$$s = \left(\frac{u+v}{2}\right)t = \left(\frac{20+30}{2}\right)\times 20 = 25\times 20 = 500$$

The distance from A to B is 500 m.

Challenge

a Distance s is the same for both particles: AB.

For the first particle: $u = 3$, $v = 5$, time taken is t seconds

$$s = \left(\frac{u+v}{2}\right)t = \left(\frac{3+5}{2}\right)t = 4t \qquad \textbf{(1)}$$

For the second particle: $u = 4$, $v = 8$, time taken is $(t - 1)$ seconds, because the particle starts 1 second later than the first and arrives at the same time)

$$s = \left(\frac{u+v}{2}\right)(t-1) = \left(\frac{4+8}{2}\right)(t-1) = 6(t-1) = 6t - 6 \qquad \textbf{(2)}$$

$4t = 6t - 6$ (**1**) and (**2**)

$t = 3$

The time for the first particle to get from A to B is 3 s.

b Substituting this value of t into equation (**1**):

$s = 4t = 4 \times 3 = 12$

The distance between A and B is 12 m.

[Check by substituting into equation (**2**): $s = 6t - 6 = 6 \times 3 - 6 = 12$]