Solutions

Each answer shows the steps, then the **result**.

2.1

- substitute $v = u + at$ into $s = \frac{1}{2}(u+v)t$

$$s = \tfrac{1}{2}(u + u + at)t = \tfrac{1}{2}(2u + at)t$$

- multiply out the bracket: $s = ut + \frac{1}{2}at^2$

2.2

(a) the acceleration is constant; the motion is in a straight line

(b) the object starts from rest, so $u = 0$

2.3

(a) no s, so $v = u + at = 2.0\text{ m s}^{-1} + (1.5\text{ m s}^{-2})(4.0\text{ s}) = \mathbf{8.0}\text{ m s}^{-1}$

(b) no t, so use $v^2 = u^2 + 2as$

$$a = \frac{v^2 - u^2}{2s} = \frac{(12\text{ m s}^{-1})^2}{2 \times 18\text{ m}} = \mathbf{4.0}\text{ m s}^{-2}$$

(c) no a, so use $s = \frac{1}{2}(u+v)t$

$$s = \tfrac{1}{2}(5.0\text{ m s}^{-1} + 15\text{ m s}^{-1})(4.0\text{ s}) = \mathbf{40}\text{ m}$$

(d) no t, so use $v^2 = u^2 + 2as$

$$v^2 = (3.0\text{ m s}^{-1})^2 + 2(2.0\text{ m s}^{-2})(10\text{ m}) = 49\text{ m}^2\text{ s}^{-2} \Rightarrow v = \mathbf{7.0}\text{ m s}^{-1}$$

2.4

(a) the speed is constant during the reaction time: $(25\text{ m s}^{-1})(0.60\text{ s}) = \mathbf{15}\text{ m}$

(b) $u = 25\text{ m s}^{-1}$, $v = 0$, $a = -6.25\text{ m s}^{-2}$; use $v^2 = u^2 + 2as$

$$s = \frac{0 - (25\text{ m s}^{-1})^2}{2(-6.25\text{ m s}^{-2})} = \mathbf{50}\text{ m}$$

(c) $15\text{ m} + 50\text{ m} = \mathbf{65}\text{ m}$

2.5

(a) at the top $v = 0$

$$t = \frac{v-u}{a} = \frac{0 - 6.0\text{ m s}^{-1}}{-1.5\text{ m s}^{-2}} = \mathbf{4.0}\text{ s}$$

(b) at the top $v = 0$; use $v^2 = u^2 + 2as$

$$s = \frac{0 - (6.0\text{ m s}^{-1})^2}{2(-1.5\text{ m s}^{-2})} = \mathbf{12}\text{ m}$$

(c) $s = ut + \frac{1}{2}at^2$ with $s = 10$, $u = 6.0$, $a = -1.5$ (values in m and s)

$$10 = 6.0t - 0.75t^2 \quad \Rightarrow \quad 0.75t^2 - 6.0t + 10 = 0$$

- use the quadratic formula

$$t = \frac{6.0 \pm \sqrt{36 - 30}}{1.5}$$

- $t = \mathbf{2.4}$ s (going up) and $t = \mathbf{5.6}$ s (coming back down)

3.1 B

- $u = 5.0\text{ m s}^{-1}$, $t = 4.0\text{ s}$, $s = 44\text{ m}$; there is no v, so use $s = ut + \frac{1}{2}at^2$

$$44\text{ m} = (5.0\text{ m s}^{-1})(4.0\text{ s}) + \tfrac{1}{2}a(4.0\text{ s})^2 \Rightarrow a = \frac{24\text{ m}}{8.0\text{ s}^2} = \mathbf{3.0}\text{ m s}^{-2}$$

- **A** leaves out the $\frac{1}{2}$; **C** leaves out ut; **D** subtracts u from the average speed but does not divide by the time

3.2 B

- top speed: $(1.2\text{ m s}^{-2})(2.5\text{ s}) = 3.0\text{ m s}^{-1}$
- distance = area under the velocity–time graph

$$\tfrac{1}{2}(2.5\text{ s})(3.0\text{ m s}^{-1}) + (6.0\text{ s})(3.0\text{ m s}^{-1}) + \tfrac{1}{2}(2.0\text{ s})(3.0\text{ m s}^{-1}) = \mathbf{25}\text{ m}$$

- **A** is the steady stage only; **C** halves only one of the two sloping stages; **D** uses the top speed for the whole 10.5 s

3.3

(a)

$$t = \frac{v-u}{a} = \frac{30\text{ m s}^{-1} - 0}{2.5\text{ m s}^{-2}} = \mathbf{12}\text{ s}$$

(b) no a needed once t is known

$$s = \tfrac{1}{2}(u+v)t = \tfrac{1}{2}(0 + 30\text{ m s}^{-1})(12\text{ s}) = \mathbf{180}\text{ m}$$

(c) the van has been moving for $3.0\text{ s} + 12\text{ s} = 15\text{ s}$

$$s_{\text{van}} = (16\text{ m s}^{-1})(15\text{ s}) = 240\text{ m}$$

- 240 m is more than 180 m, so the van is still ahead

(d) the gap at 15 s is $240\text{ m} - 180\text{ m} = 60\text{ m}$

- the police car closes the gap at $30\text{ m s}^{-1} - 16\text{ m s}^{-1} = 14\text{ m s}^{-1}$

$$\frac{60\text{ m}}{14\text{ m s}^{-1}} = 4.3\text{ s} \quad \Rightarrow \quad t = 15\text{ s} + 4.3\text{ s} = \mathbf{19}\text{ s}$$

(e)

- van: a horizontal line at 16 m s^{-1} from $t = 0$

- police car: zero until 3.0 s, a straight line up to 30 m s^{-1} at 15 s, then horizontal to about 19 s

3.4

(a)

- from $v = u + at$, $t = (v - u)/a$
- substitute into $s = \frac{1}{2}(u + v)t$

$$s = \frac{(u+v)(v-u)}{2a} = \frac{v^2 - u^2}{2a}$$

- so $2as = v^2 - u^2$, which gives $v^2 = u^2 + 2as$

(b) $u = 0$

$$a = \frac{v^2}{2s} = \frac{(9.0\ \text{m s}^{-1})^2}{2 \times 18\ \text{m}} = \mathbf{2.3}\ \text{m s}^{\mathbf{-2}}$$

(c) the equation is true only when the acceleration is constant