Solutions

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

2.1

(a) the gradient is the **acceleration**

(b) the area is the **displacement**

2.2

(a) gradient of the first line

$$a = \frac{2.0 \text{ m s}^{-1} - 0}{2.0 \text{ s}} = \mathbf{1.0} \text{ m s}^{\mathbf{-2}}$$

(b) $v = 0$ at $t = \mathbf{0}$, $\mathbf{8.0}$ s and $\mathbf{14}$ s

(c) going up, the area above the axis is a trapezium (or two triangles and a rectangle)

$$\tfrac{1}{2}(8.0 \text{ s} + 4.0 \text{ s})(2.0 \text{ m s}^{-1}) = 12 \text{ m}$$

- coming down, the area below the axis

$$\tfrac{1}{2}(6.0 \text{ s} + 2.0 \text{ s})(2.0 \text{ m s}^{-1}) = 8.0 \text{ m}$$

- total distance $= 12 \text{ m} + 8.0 \text{ m} = \mathbf{20}$ m

(d) displacement $= 12 \text{ m} - 8.0 \text{ m} = \mathbf{4.0}$ m above the starting point

2.3

(a) change in velocity = area under the acceleration–time graph

$$\Delta v = 2.0 \text{ m s}^{-2} \times 4.0 \text{ s} = \mathbf{8.0} \text{ m s}^{\mathbf{-1}}$$

(b) $5.0 \text{ m s}^{-1} + 8.0 \text{ m s}^{-1} = 13 \text{ m s}^{-1}$ at 4.0 s; the acceleration is then zero, so at 6.0 s the velocity is still $\mathbf{13}$ m s$^{\mathbf{-1}}$

(c)

- a straight line from $(0,\ 5.0 \text{ m s}^{-1})$ to $(4.0 \text{ s},\ 13 \text{ m s}^{-1})$
- then a horizontal line at 13 m s^{-1} to 8.0 s, with the axes labelled v / m s^{-1} and t / s

2.4

(a) tangent drawn at $t = 4.0$ s, for example through $(0,\ 8.8 \text{ m s}^{-1})$ and $(8.0 \text{ s},\ 0)$

$$a = \frac{0 - 8.8 \text{ m s}^{-1}}{8.0 \text{ s} - 0} = \mathbf{-1.1} \text{ m s}^{\mathbf{-2}}$$

(accept -1.0 to -1.2)

(b) about 21 squares are at least half under the curve, and each is worth $1 \text{ s} \times 2 \text{ m s}^{-1} = 2$ m

$$\text{distance} \approx 21 \times 2 \text{ m} = \mathbf{42} \text{ m}$$

(accept 40 m to 44 m)

3.1 C

- the curve in **C** gets steeper, so the velocity increases from zero, which matches a velocity line rising from the origin
- **A**: a straight displacement line means a constant velocity, not an increasing one
- **B**: a curve that gets steeper cannot have a constant velocity
- **D**: a curve that gets flatter means the velocity is decreasing

3.2 A

- the gradient is $-2.0\ \text{m s}^{-2}$, so $v = 0$ at $t = 4.0\ \text{s}$
- area above the axis and area below it

$$\tfrac{1}{2}(4.0\ \text{s})(8.0\ \text{m s}^{-1}) = 16\ \text{m}, \qquad \tfrac{1}{2}(2.0\ \text{s})(-4.0\ \text{m s}^{-1}) = -4.0\ \text{m}$$

- displacement $= 16\ \text{m} - 4.0\ \text{m} = \mathbf{12}\ \text{m}$
- **B** is the distance; **C** treats the whole graph as one triangle; **D** ignores the minus sign

3.3

(a) acceleration is the **rate of change of velocity**

(b) the gradients are

$$\frac{3.0\ \text{m s}^{-1}}{2.0\ \text{s}} = 1.5\ \text{m s}^{-2} \quad \text{and} \quad \frac{-1.5\ \text{m s}^{-1} - 3.0\ \text{m s}^{-1}}{9.0\ \text{s} - 6.0\ \text{s}} = -1.5\ \text{m s}^{-2}$$

- magnitude: **the same**
- direction: **opposite**

(c) the acceleration is the gradient of the straight line from 6.0 s to 9.0 s, which includes 8.0 s

$$a = \frac{-1.5\ \text{m s}^{-1} - 3.0\ \text{m s}^{-1}}{9.0\ \text{s} - 6.0\ \text{s}} = \mathbf{-1.5}\ \text{m s}^{\mathbf{-2}}$$

- it is not zero: the velocity is zero for an instant, but it is still changing

(d) the car moves forwards until $v = 0$, so the greatest displacement is at $t = \mathbf{8.0}$ s

- displacement = area under the line from 0 to 8.0 s

$$\tfrac{1}{2}(2.0\ \text{s})(3.0\ \text{m s}^{-1}) + (4.0\ \text{s})(3.0\ \text{m s}^{-1}) + \tfrac{1}{2}(2.0\ \text{s})(3.0\ \text{m s}^{-1}) = \mathbf{18}\ \text{m}$$

(e) area below the axis from 8.0 s to 10.0 s

$$\tfrac{1}{2}(1.0\ \text{s})(-1.5\ \text{m s}^{-1}) + (1.0\ \text{s})(-1.5\ \text{m s}^{-1}) = -2.25\ \text{m}$$

- displacement $= 18\ \text{m} - 2.25\ \text{m} = \mathbf{16}\ \text{m}$

(f)

- axes labelled s / m and t / s; a curve getting steeper to 3.0 m at 2.0 s, then a straight line to 15 m at 6.0 s
- a curve getting flatter to a maximum of 18 m at 8.0 s, flat at the top
- the displacement then decreasing, to about 16 m at 10.0 s