Solutions

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

2.1

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

(b) velocity is a vector, so it has a direction; speed is a scalar, so it has none

2.2

(a) $3.0\text{ km} + 5.0\text{ km} = \mathbf{8.0}\text{ km}$

(b) the displacements are at right angles, so use Pythagoras

$$\sqrt{(3.0\text{ km})^2 + (5.0\text{ km})^2} = \mathbf{5.8}\text{ km}$$

(c) opposite side north, adjacent side east

$$\tan\theta = \frac{5.0\text{ km}}{3.0\text{ km}} \Rightarrow \theta = \mathbf{59}^\circ$$

north of east

(d) time $= 25 \times 60\text{ s} = 1500\text{ s}$ and distance $= 8000\text{ m}$

$$\text{average speed} = \frac{8000\text{ m}}{1500\text{ s}} = \mathbf{5.3}\text{ m s}^{-1}$$

(e) use the displacement, not the distance

$$\text{average velocity} = \frac{5830\text{ m}}{1500\text{ s}} = \mathbf{3.9}\text{ m s}^{-1}$$

2.3

(a) multiply by 1000 and divide by 3600

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

(b) in one hour the car travels $25\text{ m} \times 3600 = 90\,000\text{ m} = 90\text{ km}$, so the speed is $\mathbf{90}\text{ km h}^{-1}$

2.4

(a) velocity = gradient

$$v = \frac{8.0\text{ m} - 0}{10\text{ s} - 0} = \mathbf{0.80}\text{ m s}^{-1}$$

(b) the line is flat, so the displacement does not change: the train is **at rest**

(c) gradient of the line from 16 s to 20 s

$$v = \frac{2.0\text{ m} - 8.0\text{ m}}{20\text{ s} - 16\text{ s}} = \mathbf{-1.5}\text{ m s}^{-1}$$

- the minus sign means the train moves back towards its start

2.5

(a) the tangent passes through (1.5 s, 0) and (4.5 s, 9.0 m)

$$v = \frac{9.0\text{ m} - 0}{4.5\text{ s} - 1.5\text{ s}} = \mathbf{3.0}\text{ m s}^{-1}$$

(b) the curve gets **steeper**: its gradient, the velocity, increases with time

3.1 B

- distance $= 2.5 \times 400\text{ m} = 1000\text{ m}$

$$\text{average speed} = \frac{1000\text{ m}}{300\text{ s}} = 3.3\text{ m s}^{-1}$$

- after 2.5 laps the runner is half a lap from the start, so the displacement is one diameter

$$d = \frac{400\text{ m}}{\pi} = 127\text{ m}, \qquad \text{average velocity} = \frac{127\text{ m}}{300\text{ s}} = \mathbf{0.42}\text{ m s}^{-1}$$

- **A** is true only after whole laps; **C** swaps them; **D** uses the distance twice

3.2 A

- time for each part

$$t_1 = \frac{12\text{ km}}{40\text{ km h}^{-1}} = 0.30\text{ h}, \qquad t_2 = \frac{12\text{ km}}{60\text{ km h}^{-1}} = 0.20\text{ h}$$

- average speed = total distance ÷ total time

$$\frac{24\text{ km}}{0.50\text{ h}} = 48\text{ km h}^{-1} = \frac{48 \times 1000\text{ m}}{3600\text{ s}} = \mathbf{13}\text{ m s}^{-1}$$

- **B** averages the two speeds, but the bus spends longer at the lower speed; **C** and **D** forget to change the units

3.3

(a)

- the displacement increases, so the car moves forwards
- the gradient decreases to zero, so the car slows down and stops at $t = 10$ s

(b)

- tangent drawn at $t = 4.0$ s
- gradient from a large triangle, for example through (0, 16 m) and (8.0 s, 112 m)

$$v = \frac{112\text{ m} - 16\text{ m}}{8.0\text{ s} - 0} = \mathbf{12}\text{ m s}^{-1}$$

(accept 11 to 13)

(c) average velocity = displacement ÷ time

$$\frac{100\ \text{m}}{10\ \text{s}} = \mathbf{10}\ \text{m s}^{-1}$$

(d) (b) is the velocity at one instant; (c) is the total displacement divided by the total time