

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 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

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

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

3.2 A

- time for each part

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

- average speed = total distance $\div$ 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 $t = 10 \text{ s}$

(b)

- tangent drawn at $t = 4.0 \text{ s}$
- 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 $\div$ 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