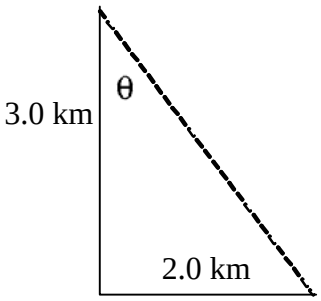
Answers to Coursebook questions – Chapter 2.1

1 $v = \dfrac{3000.0}{5.00}\dfrac{\text{km}}{\text{h}} = \dfrac{3000.0\times10^3}{5.00\times60\times60}\,\text{m s}^{-1} = 167\,\text{m s}^{-1}$.

2 Distance travelled in first 1.5 h is $s = vt = 70\times1.5 = 105$ km. Remaining distance is 15 km and must be covered in 1.0 h, so average speed must be $v = \dfrac{15}{1.0}\dfrac{\text{km}}{\text{h}} = 15\,\text{km h}^{-1}$.

3 **a** A distance of 5.0 km is covered in 3.0 h, so the average speed is $v = \dfrac{5.0}{3.0}\dfrac{\text{km}}{\text{h}} = 1.7\,\text{km h}^{-1}$.

b The magnitude of the displacement is $\sqrt{2.0^2 + 3.0^2} = 3.61$ km. The magnitude of the average velocity is then $v = \dfrac{3.61}{3.0}\dfrac{\text{km}}{\text{h}} = 1.2\,\text{km h}^{-1}$. The direction is determined by the angle θ, which is $\tan^{-1}\dfrac{2}{3} = 34°$.



4 The velocity is initially constant and negative, so the displacement graph will be a straight line with negative slope. The velocity is then constant and positive, so the displacement graph is a straight line with positive slope. See answers on page 790 in *Physics for the IB Diploma*.

5 **a** The area under the graph is the change in displacement. At t = 8 s the area is 80 m and so the displacement is 88 m.

b The area from t = 0 to t = 12 s is $80 - 20 = 60$ m and so the displacement is 68 m.

c The distance travelled is 80 + 20 = 100 m and so the average speed is $v = \dfrac{100}{12}\,\text{m s}^{-1} = 8.3\,\text{m s}^{-1}$. The change in displacement is 60 m, and so the average velocity is $v = \dfrac{60}{12}\,\text{m s}^{-1} = 5.0\,\text{m s}^{-1}$.

6 The relative speed of the cyclists is $v = 35\ \text{km h}^{-1}$. They will then meet in a time of $v = \frac{70}{35} = 2.0\ \text{h}$.

a The common displacement is $s = 15 \times 2.0 = 30\ \text{km}$.

b The fly will travel a distance of $s = 30 \times 2.0 = 60\ \text{km}$.

7 **a** $d = vt$

b $\vec{r} = \vec{d}_1 + ... + \vec{d}_N$, where $|\vec{d}_i| = d$.

Then, $r^2 = \vec{r} \bullet \vec{r} = (\vec{d}_1 + ... + \vec{d}_N) \bullet (\vec{d}_1 + ... + \vec{d}_N) = \sum_{i=1}^{N} d^2 + \sum_{i \neq j=1}^{N} d^2 \cos\theta_{ij}$, where θ_{ij} is the angle between vectors $\vec{d}_i, \vec{d}_j$.

On average, $\sum_{i \neq j=1}^{N} d^2 \cos\theta_{ij} = d^2 \sum_{i \neq j=1}^{N} \cos\theta_{ij} = 0$ since the angles are random. Thus, $r^2 = \sum_{i=1}^{N} d^2 = Nd^2$ and so $r = d\sqrt{N}$.

8 **a** $\vec{v}_{B|A} = \vec{v}_B - \vec{v}_A = -50 - 80 = -130\ \text{km h}^{-1}$.

b $\vec{v}_{A|B} = \vec{v}_A - \vec{v}_B = 80 - (-50) = +130\ \text{km h}^{-1}$.

9 **a** $\vec{v}_{B|A} = 1.0 = \vec{v}_B - \vec{v}_A = \vec{v}_B - (-3.0) \Rightarrow \vec{v}_B = -2.0\ \text{m s}^{-1}$.

b $\vec{v}_{C|A} = -2.0 = \vec{v}_C - \vec{v}_A = \vec{v}_C - (-3.0) \Rightarrow \vec{v}_C = -5.0\ \text{m s}^{-1}$.

10 $\vec{v}_{B|A} = \vec{v}_B - \vec{v}_A = 4.0 - (-4.0) = +8.0\ \text{m s}^{-1}$.

11 We must find the slopes of the graphs.

a $v = \frac{10 - 0}{11 - 5.0}\ \text{m s}^{-1} = 1.7\ \text{m s}^{-1}$

b $v = \frac{0 - 30}{4.8 - 0}\ \text{m s}^{-1} = -6.2\ \text{m s}^{-1}$.

12 **a** The distance travelled is 80 m. The average speed is then $v = \frac{80}{20}\ \text{m s}^{-1} = 4.0\ \text{m s}^{-1}$.

b The displacement is zero and so the average velocity is zero.