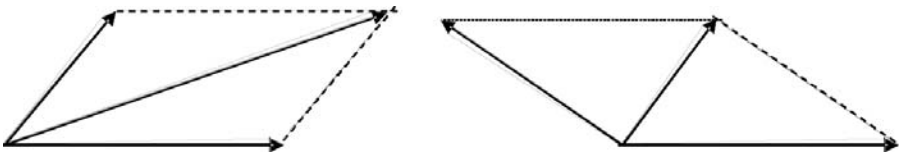
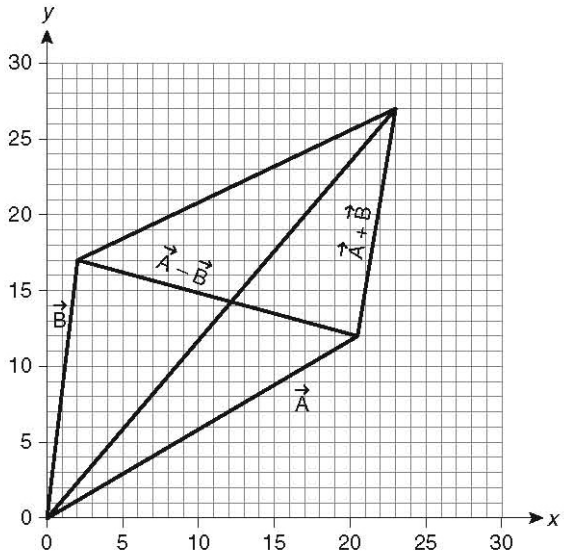
# Answers to Coursebook questions – Chapter 1.4

**1**



**2** **a**




Scale: 1 unit = 1 cm

$\vec{A} + \vec{B}$

length 18 cm

$F \approx 18$ units

$\theta \approx 49°$

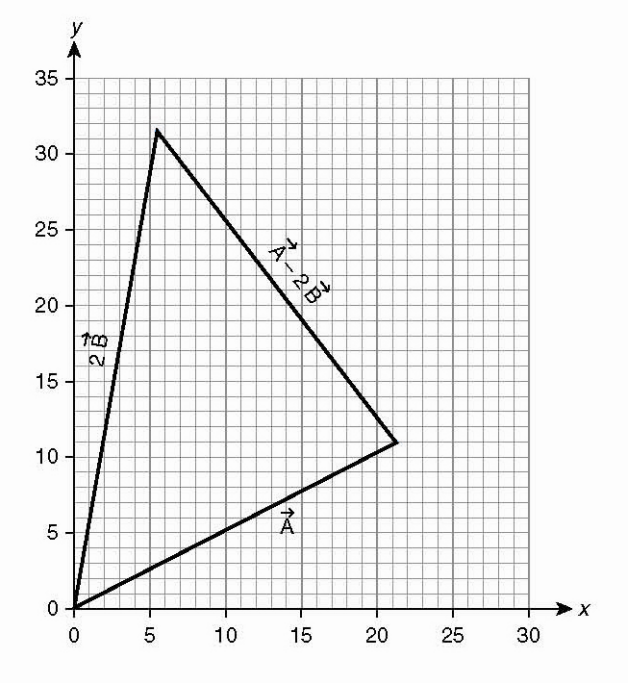
**b** $\vec{A} - \vec{B}$

length 9.5 cm

$F \approx 9.5$ units

$\theta \approx 11°$ below horizontal.

**c**




Scale: 1 unit = 1 cm

$\vec{A} - 2\vec{B}$

length 13 cm

$F \approx 13$ units

$\theta \approx 42°$ below horizontal.

**3** The components are:

$A_x = 12 \times \cos 30° = 10.39$ $\quad$ $B_x = 8.00 \times \cos 80° = 1.389$

$A_y = 12 \times \sin 30° = 6.00$ $\quad$ $B_y = 8.00 \times \sin 80° = 7.878$

**a** $(A + B)_x = 10.39 + 1.389 = 11.799$

$(A + B)_y = 6.00 + 7.878 = 13.878$

The vector $\vec{A} + \vec{B}$ has magnitude $\sqrt{11.799^2 + 13.878^2} = 18.2$ and is directed at an angle $\theta = \arctan\dfrac{13.878}{11.799} = 49.6°$ to the horizontal.

**b** $(A - B)_x = 10.39 - 1.389 = 9.001$

$(A - B)_y = 6.00 - 7.878 = -1.878$

The vector $\vec{A} - \vec{B}$ has magnitude $\sqrt{9.001^2 + 1.878^2} = 9.19$ and is directed at an angle $\theta = \arctan\left(-\dfrac{1.878}{9.001}\right) = -11.8°$ below the horizontal.

**c** $(A - 2B)_x = 10.39 - 2 \times 1.389 = 7.612$

$(A - 2B)_y = 6.00 - 2 \times 7.878 = -9.756$

The vector $\vec{A} - 2\vec{B}$ has magnitude $\sqrt{7.612^2 + 9.756^2} = 12.4$ and is directed at an angle $\theta = \arctan\left(-\dfrac{9.756}{7.612}\right) = -52.0°$ below the horizontal.

**4** The components of her change of displacement in each leg of the walk are:

$d_{1x} = -5.0$ km $\quad$ $d_{1y} = 0$

$d_{2x} = 0$ $\quad$ $d_{2y} = +3.0$ km

$d_{3x} = 2.0\cos 45° = 1.41$ km $\quad$ $d_{3y} = 2.0\sin 45° = 1.41$ km

Therefore her displacement from the starting point is

$d_x = -5.0 + 0 + 1.41 = -3.59$ km $\quad$ and $\quad$ $d_y = 0 + 3.0 + 1.41 = +4.41$ km

Her distance is the magnitude of the displacement vector, i.e. $d = \sqrt{3.59^2 + 4.41^2} = 5.69$ km

in a direction $\theta = 180° - \arctan\dfrac{4.41}{3.59} = 129°$.

(Notice that her position is in the second quadrant.)

**5** **a** $\sqrt{4.0^2 + 4.0^2} = 5.66$ cm in a direction $\theta = 180° + \arctan\frac{4.0}{4.0} = 225°$.

**b** $\sqrt{124^2 + 158^2} = 201$ km in a direction $\theta = \arctan\left(-\frac{158}{124}\right) = -52°$.

**c** $\sqrt{0^2 + 5.0^2} = 5.0$ m in a direction $\theta = 270°$ or $\theta = -90°$.

**d** $\sqrt{8.0^2 + 0^2} = 8.0$ N in a direction $\theta = 0°$.

**6** **a** $\sqrt{2.00^2 + 3.00^2} = 3.61$ at $\theta = \arctan\frac{3.00}{2.00} = 56.3°$.

**b** $\sqrt{2.00^2 + 5.00^2} = 5.39$ at $\theta = 180° - \arctan\frac{5.00}{2.00} = 112°$.

**c** $\sqrt{0^2 + 8.00^2} = 8.00$ at $\theta = 90°$

**d** $\sqrt{4.00^2 + 2.00^2} = 4.47$ at $\theta = \arctan\left(-\frac{2.00}{4.00}\right) = -26.6°$.

**e** $\sqrt{6.00^2 + 1.00^2} = 6.08$ at $\theta = \arctan\frac{1.00}{6.00} = 9.46°$.

**7** The vector $\vec{C}$ is given by $\vec{C} = \vec{B} - \vec{A}$. Its components are

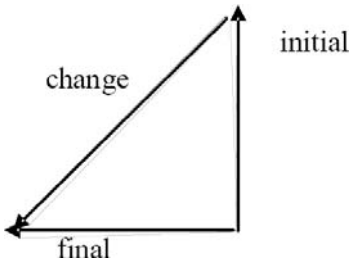
$C_x = -1.00 - 3.00 = -4.00$ cm $\quad C_y = 5.00 - 4.00 = +1.00$ cm

Hence the magnitude is $\sqrt{4.00^2 + 1.00^2} = 4.12$ in a direction $\theta = 180° - \arctan\frac{1}{4} = 166°$.

The vector is in the second quadrant.

**8** The change in displacement has components $\Delta r_x = 4 - 2 = 2$, $\Delta r_y = 8 - 2 = 6$.

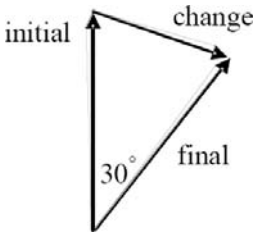
**9** A diagram is




The magnitude of the change in the velocity vector is $\sqrt{10^2 + 10^2} = 14.1$ m s$^{-1}$.

The vector makes an angle of 45° with the horizontal as shown in the diagram.

**10** A diagram is:




The other two angles of the triangle are each $\frac{1}{2}(180° - 30°) = 75°$.

Using the same rule we find:

$$\frac{\Delta p}{\sin 30°} = \frac{p}{\sin 75°} \quad \Rightarrow \quad \Delta p = p \times \frac{\sin 30°}{\sin 75°} = 0.518p \approx 0.52p$$

**11** **a** $(x_2 - x_1, y_2 - y_1)$

**b** $(x_1 - x_2, y_1 - y_2)$

**c** $\sqrt{x_1^2 + y_1^2}$

**12** The components of the velocity vector at the various points are:

A: $v_{Ax} = -4.0 \text{ m s}^{-1}$ $\quad v_{Ay} = 0$

B: $v_{Bx} = +4.0 \text{ m s}^{-1}$ $\quad v_{By} = 0$

C: $v_{Cx} = 0$ $\quad v_{Cy} = 4.0 \text{ m s}^{-1}$

**a** From A to B the change in the velocity vector has the components

$v_{Bx} - v_{Ax} = +4.0 - (-4.0) = 8.0 \text{ m s}^{-1}$ and $v_{By} - v_{Ay} = 0 - 0 = 0$.

**b** From B to C the change in the velocity vector has the components

$v_{Cx} - v_{Bx} = 0 - 4.0 = -4.0 \text{ m s}^{-1}$ and $v_{Cy} - v_{By} = 4.0 - 0 = 4.0 \text{ m s}^{-1}$.

**c** From A to C the change in the velocity vector has the components

$v_{Cx} - v_{Ax} = 0 - (-4.0) = 4.0 \text{ m s}^{-1}$ and $v_{Cy} - v_{Ay} = 4.0 - 0 = 4.0 \text{ m s}^{-1}$.

The change in the vector from A to C is the sum of the change from A to B and the change from B to C.

**13** **a** The initial velocity is $+352 \text{ m s}^{-1}$ and the final velocity after the collision is $-352 \text{ m s}^{-1}$. The change in the velocity is therefore $-352 - 352 = -704 \text{ m s}^{-1}$.

**b** The speed is the same before and after the collision, so the change in speed is zero.

**14** **a** $A_x = -10.0\cos 40° = -7.66$ $A_y = -10.0\sin 40° = +6.43$

**b** $A_x = -10.0\cos 35° = -8.19$ $A_y = -10.0\sin 35° = -5.74$

**c** $A_x = +10.0\cos 68° = +3.75$ $A_y = -10.0\sin 68° = -9.27$

**d** $A_x = +10.0\cos(90° - 48°) = +7.43$ $A_y = -10.0\sin(90° - 48°) = -6.69$

**e** $A_x = -10.0\cos(90° - 30°) = -5.00$ $A_y = -10.0\sin(90° - 30°) = -8.66$

**15** The vector we want is $\vec{C} = -\left(\vec{A} + \vec{B}\right)$. The components of $\vec{A}$ and $\vec{B}$ are:

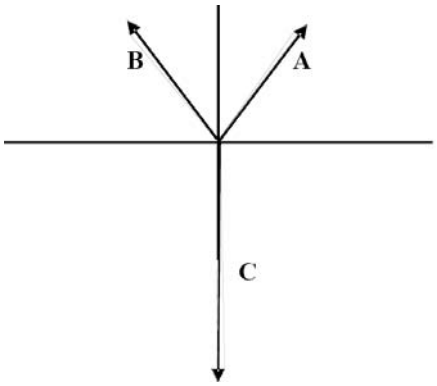
$A_x = 6.0\cos 60° = +3.0$ $A_y = 6.0\sin 60° = +5.20$

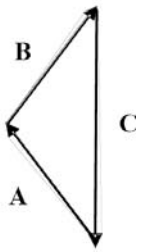
$B_x = 6.0\cos 120° = -3.0$ $B_y = 6.0\sin 120° = +5.20$

So,

$C_x = -(+3.0 - 3.0) = 0$ $C_y = -(+5.20 + 5.20) = -10.4$

The magnitude of vector $\vec{C}$ is therefore 10.4 and is directed along the negative *y*-axis.



**16** **a** $A_x = 12.0\cos 20° = +11.28$ and $A_y = 12.0\sin 20° = +4.10$.

$B_x = 14.0\cos 50° = +9.00$ and $B_y = 14.0\sin 50° = +10.72$.

The sum has the components:

$S_x = +11.28 + 9.00 = 20.28$ and $S_y = +4.10 + 10.72 = 14.82$.

The magnitude of the sum is $\sqrt{20.28^2 + 14.82^2} = 25.1$

and its direction is $\theta = \arctan\frac{14.82}{20.28} = 36.2°$.

**b** $A_x = 15.0\cos 15° = +14.49$ and $A_y = 15.0\sin 15° = +3.88$.

$B_x = 18.0\cos 105° = -4.66$ and $B_y = 18.0\sin 105° = +17.39$.

The sum has the components:

$S_x = +14.49 - 4.66 = 9.83$ and $S_y = +3.88 + 17.39 = 21.27$.

The magnitude of the sum is $\sqrt{9.83^2 + 21.27^2} = 23.4$ and its direction is $\theta = \arctan\frac{21.27}{9.83} = 65.2°$.

**c** $A_x = 20.0\cos 40° = +15.32$ and $A_y = 20.0\sin 40° = +12.86$.

$B_x = 15.0\cos 310° = +9.64$ and $B_y = 15.0\sin 310° = -11.49$.

The sum has components:

$S_x = +15.32 + 9.64 = 24.96$ and $S_y = +12.86 - 11.49 = +1.37$.

The magnitude of the sum is $\sqrt{24.96^2 + 1.37^2} = 25.0$ and its direction is $\theta = \arctan\frac{1.37}{24.96} = 3.14°$.