Solutions

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

2.1

- scalar: size only; vector: size **and** direction
- distance **scalar**; force **vector**; temperature **scalar**; velocity **vector**; power **scalar**; acceleration **vector**

2.2

- the forces are perpendicular, so use Pythagoras

$$R = \sqrt{(3.0\ \mathrm{N})^2 + (4.0\ \mathrm{N})^2} = \sqrt{25\ \mathrm{N}^2} = \mathbf{5.0}\ \mathrm{N}$$

2.3

- horizontal is the adjacent side: $F\cos\theta$; vertical is the opposite side: $F\sin\theta$
- horizontal: $50\ \mathrm{N} \times \cos 30° = \mathbf{43}\ \mathrm{N}$
- vertical: $50\ \mathrm{N} \times \sin 30° = \mathbf{25}\ \mathrm{N}$

2.4

- $v_\mathrm{H} = v\cos\theta$, $v_\mathrm{V} = v\sin\theta$
- $v_\mathrm{H} = 20\ \mathrm{m\ s^{-1}} \times \cos 60° = \mathbf{10}\ \mathrm{m\ s^{-1}}$
- $v_\mathrm{V} = 20\ \mathrm{m\ s^{-1}} \times \sin 60° = \mathbf{17}\ \mathrm{m\ s^{-1}}$

2.5

- equal forces at 90°: Pythagoras, or $R = 2F\cos 45°$

$$R = \sqrt{(5.0\ \mathrm{N})^2 + (5.0\ \mathrm{N})^2} = \mathbf{7.1}\ \mathrm{N}$$

2.6

- take east and north as positive
- $\sum x = 6.0\ \mathrm{N} - 2.0\ \mathrm{N} = 4.0\ \mathrm{N}$ east; $\sum y = 5.0\ \mathrm{N}$ north

$$R = \sqrt{(4.0\ \mathrm{N})^2 + (5.0\ \mathrm{N})^2} = \mathbf{6.4}\ \mathrm{N}$$

$$\tan\theta = \frac{5.0\ \mathrm{N}}{4.0\ \mathrm{N}} \Rightarrow \theta = \mathbf{51}°\ \text{north of east}$$

3.1 C

- a vector needs a **direction** as well as a size
- **displacement** is "how far, and which way"
- **A**, **B**, **D** (energy, power, temperature) are scalars — *distance* is the scalar trap against displacement

3.2 A

- $\vec{X}$ east and $\vec{Y}$ north: tip-to-tail sum points **north-east**

- $\vec{X} - \vec{Y} = \vec{X} + (-\vec{Y})$: reverse $\vec{Y}$ to south, so the result points **south-east**
- **B** keeps $\vec{Y}$ pointing north when subtracting

3.3 B

- perpendicular forces: Pythagoras

$$R = \sqrt{(6.0\ \text{N})^2 + (8.0\ \text{N})^2} = \sqrt{100\ \text{N}^2} = \mathbf{10}\ \text{N}$$

- **A** is the difference; **C** is the sum; **D** is the product

3.4

(a) resolve at 40° to the horizontal

- $v_\text{H} = 15\ \text{m s}^{-1} \times \cos 40° = \mathbf{11}\ \text{m s}^{\mathbf{-1}}$
- $v_\text{V} = 15\ \text{m s}^{-1} \times \sin 40° = \mathbf{9.6}\ \text{m s}^{\mathbf{-1}}$

(b) the **horizontal** component stays constant

- no air resistance ⇒ no horizontal force ⇒ no horizontal acceleration

3.5

- two equal forces: $2\alpha = 80°$ so $\alpha = 40°$

$$R = 2F\cos\alpha = 2 \times 7.0\ \text{N} \times \cos 40° = \mathbf{10.7}\ \text{N}$$

3.6

(a)

- $v_\text{H} = 21\ \text{m s}^{-1} \times \cos 55° = \mathbf{12}\ \text{m s}^{\mathbf{-1}}$
- $v_\text{V} = 21\ \text{m s}^{-1} \times \sin 55° = \mathbf{17}\ \text{m s}^{\mathbf{-1}}$

(b) at the top, $v_\text{V} = 0$, so $t = v_\text{V}/g$

$$t = \frac{17.2\ \text{m s}^{-1}}{9.81\ \text{m s}^{-2}} = \mathbf{1.75}\ \text{s}$$

(c)

- **H**: horizontal straight line at $v = 12\ \text{m s}^{-1}$ across the whole grid, labelled H
- **V**: straight line of negative gradient, labelled V
- starts at $+17\ \text{m s}^{-1}$ and ends at $-17\ \text{m s}^{-1}$
- crosses $v = 0$ at $t = 1.75$ s

(d) just before landing, $v_\text{H} = 12\ \text{m s}^{-1}$ and $v_\text{V} = -17\ \text{m s}^{-1}$

$$v = \sqrt{(12\ \text{m s}^{-1})^2 + (17\ \text{m s}^{-1})^2} = \mathbf{21}\ \text{m s}^{\mathbf{-1}}$$

$$\tan\theta = \frac{17\ \text{m s}^{-1}}{12\ \text{m s}^{-1}} \Rightarrow \theta = \mathbf{55}°\ \text{below the horizontal}$$

(e) air resistance is negligible, so there is **no horizontal force** and therefore no horizontal acceleration