

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

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

2.3

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

2.4

- $v_H = v \cos \theta$, $v_V = v \sin \theta$
- $v_H = 20 \text{ m s}^{-1} \times \cos 60^\circ = \mathbf{10 \text{ m s}^{-1}}$
- $v_V = 20 \text{ m s}^{-1} \times \sin 60^\circ = \mathbf{17 \text{ m s}^{-1}}$

2.5

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

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

2.6

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

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

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

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

- $v_H = 15 \text{ m s}^{-1} \times \cos 40^\circ = \mathbf{11 \text{ m s}^{-1}}$
- $v_V = 15 \text{ m s}^{-1} \times \sin 40^\circ = \mathbf{9.6 \text{ m s}^{-1}}$

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

- no air resistance $\Rightarrow$ no horizontal force $\Rightarrow$ no horizontal acceleration

3.5

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

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

3.6

(a)

- $v_H = 21 \text{ m s}^{-1} \times \cos 55^\circ = \mathbf{12 \text{ m s}^{-1}}$
- $v_V = 21 \text{ m s}^{-1} \times \sin 55^\circ = \mathbf{17 \text{ m s}^{-1}}$

(b) at the top, $v_V = 0$, so $t = v_V/g$

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

(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 m s^{-1}
- crosses $v = 0$ at $t = 1.75 \text{ s}$

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

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

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

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