Solutions

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

2.1

- they reach the floor **at the same time**
- both start with zero vertical velocity, fall the same height and have the same acceleration g; the horizontal velocity of Y does not change its vertical motion

2.2

(a) horizontal 12 m s^{-1} (the drone's velocity) and vertical 0

(b) vertical motion from rest, down positive

$$t = \sqrt{\frac{2 \times 45 \text{ m}}{9.81 \text{ m s}^{-2}}} = \mathbf{3.0} \text{ s}$$

(c) (12 m s^{-1})(3.03 s) = **36** m

(d) $v_\text{V} = (9.81 \text{ m s}^{-2})(3.03 \text{ s}) = 29.7 \text{ m s}^{-1}$

$$v = \sqrt{(12 \text{ m s}^{-1})^2 + (29.7 \text{ m s}^{-1})^2} = \mathbf{32} \text{ m s}^{-1}$$

2.3

(a) resolve

$$u_\text{H} = (18 \text{ m s}^{-1}) \cos 35° = \mathbf{14.7} \text{ m s}^{-1}, \qquad u_\text{V} = (18 \text{ m s}^{-1}) \sin 35° = \mathbf{10.3} \text{ m s}^{-1}$$

(b) at the top $v_\text{V} = 0$

$$t = \frac{0 - 10.3 \text{ m s}^{-1}}{-9.81 \text{ m s}^{-2}} = \mathbf{1.05} \text{ s}$$

(c) use $v^2 = u^2 + 2as$ vertically

$$H = \frac{0 - (10.3 \text{ m s}^{-1})^2}{2(-9.81 \text{ m s}^{-2})} = \mathbf{5.4} \text{ m}$$

(d) time of flight = 2 × 1.05 s = 2.10 s

$$R = (14.7 \text{ m s}^{-1})(2.10 \text{ s}) = \mathbf{31} \text{ m}$$

2.4

- horizontal component: a horizontal line at 14.7 m s^{-1} from 0 to 2.1 s
- vertical component: a straight line from +10.3 m s^{-1} at $t = 0$
- through zero at 1.05 s to −10.3 m s^{-1} at 2.1 s, with both lines labelled

3.1 D

- at the top the vertical component is zero, but the horizontal component is not, so the velocity is horizontal
- the acceleration is g downwards during the whole flight, including at the top
- **A** and **B** forget the horizontal velocity; **C** thinks the acceleration stops at the top

3.2 B

- vertical motion from rest gives the time

$$t = \sqrt{\frac{2 \times 20 \text{ m}}{9.81 \text{ m s}^{-2}}} = 2.02 \text{ s}$$

- horizontal motion gives the speed

$$u = \frac{30 \text{ m}}{2.02 \text{ s}} = \mathbf{15} \text{ m s}^{-1}$$

- **A** doubles the time; **C** is the vertical speed on landing; **D** leaves out the 2 in $s = \frac{1}{2}at^2$

3.3

(a) resolve

$$u_\text{H} = (9.0 \text{ m s}^{-1}) \cos 30° = \mathbf{7.8} \text{ m s}^{-1}, \qquad u_\text{V} = (9.0 \text{ m s}^{-1}) \sin 30° = \mathbf{4.5} \text{ m s}^{-1}$$

(b) rise above the machine, with $v_\text{V} = 0$ at the top

$$\frac{0 - (4.5 \text{ m s}^{-1})^2}{2(-9.81 \text{ m s}^{-2})} = 1.03 \text{ m}$$

- height above the ground $= 1.03 \text{ m} + 1.2 \text{ m} = \mathbf{2.2}$ m

(c) up positive: $s = -1.2$ m, $u = +4.5$ m s^{-1}, $a = -9.81$ m s^{-2}

$$-1.2 = 4.5t - 4.905t^2 \quad \Rightarrow \quad 4.905t^2 - 4.5t - 1.2 = 0$$

- quadratic formula, values in m and s

$$t = \frac{4.5 + \sqrt{20.25 + 23.5}}{9.81} = 1.13 \text{ s} \approx 1.1 \text{ s}$$

(d) $(7.8 \text{ m s}^{-1})(1.13 \text{ s}) = \mathbf{8.8}$ m

(e) $v_\text{V} = 4.5 \text{ m s}^{-1} + (-9.81 \text{ m s}^{-2})(1.13 \text{ s}) = -6.6 \text{ m s}^{-1}$

$$v = \sqrt{(7.8 \text{ m s}^{-1})^2 + (6.6 \text{ m s}^{-1})^2} = \mathbf{10} \text{ m s}^{-1}$$

- $\tan\theta = 6.6/7.8$, so the velocity is at **40°** below the horizontal

3.4

(a) vertical motion from rest

$$t = \sqrt{\frac{2 \times 0.80 \text{ m}}{9.81 \text{ m s}^{-2}}} = 0.404 \text{ s} \approx 0.40 \text{ s}$$

(b)

$$u = \frac{0.52\ \text{m}}{0.404\ \text{s}} = \mathbf{1.3}\ \text{m s}^{-1}$$

(c)

- it still takes **0.40** s
- the vertical motion is unchanged: zero vertical velocity at the start, the same height and the same g
- it lands **1.0** m from the table, because the horizontal distance is the horizontal speed multiplied by the same time