Motion Equation Questions 2: Displacement ***SOLUTIONS***

1.

(a) $s = ?\quad t = 3.8\text{ s}\quad v_0 = 1.5\text{ ms}^{-1}\quad a = 0\text{ ms}^{-2}$

$$\begin{aligned} s &= v_0 t \\ &= 1.5 \times 3.8 \\ &= 5.7\text{ m} \end{aligned}$$

(b) $s = ?\quad v_0 = 9\text{ ms}^{-1}\quad v = 0\text{ ms}^{-1}\quad a = -9.8\text{ ms}^{-2}$

$$\begin{aligned} v^2 &= v_0^{\,2} + 2as \\ \therefore s &= \frac{v^2 - v_0^{\,2}}{2a} \\ &= \frac{0^2 - 9^2}{2(-9.8)} \\ &= 4\text{ m} \end{aligned}$$

2.

(a) $s = ?\quad t = 10.3\text{ s}\quad v_0 = 0\text{ ms}^{-1}\quad a = -9.8\text{ ms}^{-2}$

$$\begin{aligned} s &= v_0 t + \tfrac{1}{2}at^2 \\ &= \tfrac{1}{2}at^2 \\ &= \tfrac{1}{2} \times -9.8 \times 10.3^2 \\ &= 520\text{ m} \end{aligned}$$

(b) It would take the same amount of time. Horizontal and vertical components of velocity don't affect each other.

(c) $s = ?\quad t = 10.3\text{ s}\quad v_0 = 21.6\text{ ms}^{-1}\quad a = 0\text{ ms}^{-2}$

$$\begin{aligned} s &= v_0 t + \tfrac{1}{2}at^2 \\ &= v_0 t \\ &= 21.6 \times 10.3 \\ &= 222\text{ m} \end{aligned}$$

(d) Higher launch means more time to fall. Horizontal velocity is constant so $s_H \propto t$

3.

(a) $v_{0_H} = v_0 \cos\theta = 32\cos 41° = 24\text{ ms}^{-1}$

$v_{0_V} = v_0 \sin\theta = 32\sin 41° = 21\text{ ms}^{-1}$

(b) The vertical component is used to calculate the time of flight.

(c) Vertical first:

$s = 0\text{ m}\quad v_0 = 21\text{ ms}^{-1}\quad a = -9.8\text{ ms}^{-2}\quad t = ?$

$$\begin{aligned} s &= v_0 t + \tfrac{1}{2}at^2 \\ 0 &= t\left(v_0 + \tfrac{1}{2}at\right) \\ \therefore v_0 + \tfrac{1}{2}at &= 0 \quad \text{or} \quad t = 0 \\ \therefore t &= \frac{-v_0}{\tfrac{1}{2}a} = \frac{-21}{\tfrac{1}{2} \times -9.8} = 4.3\text{ s} \end{aligned}$$

Then horizontal:

$s = ?\quad t = 4.3\text{ s}\quad v_0 = 24\text{ ms}^{-1}\quad a = 0\text{ ms}^{-2}$

$$\begin{aligned} s &= v_0 t + \tfrac{1}{2}at^2 \\ &= v_0 t \\ &= 24 \times 4.3 \\ &= 100\text{ m (2 s.f.)} \end{aligned}$$