

Motion Equation Solutions

NOTE: There are often other ways of finding the answer.

1. Find the displacement after 2.0 seconds of an object thrown straight up into the air at 10ms^{-1}

$$v_0 = 10 \text{ ms}^{-1} \quad t = 2.0 \text{ s} \quad a = -9.8 \text{ ms}^{-2} \quad s = ?$$

$$\begin{aligned} s &= v_0 t + \frac{1}{2} a t^2 \\ &= 10 \times 2.0 + \frac{1}{2} (-9.8)(2.0^2) \\ &= 20 - 19.6 \\ &= 0.4 \end{aligned}$$

The object's displacement is 0.40 m upwards (2 s.f.)

2. An object is in motion along a flat horizontal plane at 5.2ms^{-1} . How far does it travel in 2.5 seconds?

$$v_0 = 5.2 \text{ ms}^{-1} \quad t = 2.5 \text{ s} \quad a = 0 \text{ ms}^{-2} \quad s = ?$$

$$\begin{aligned} s &= v_0 t \quad (\text{since there is no acceleration}) \\ &= 5.2 \times 2.5 \\ &= 13 \end{aligned}$$

The object has travelled a distance of 13 m (2 s.f.)

3. Find the velocity of an object 1.5 seconds after it is dropped in midair.

$$v_0 = 0 \text{ ms}^{-1} \quad t = 1.5 \text{ s} \quad a = -9.8 \text{ ms}^{-2} \quad v = ?$$

$$\begin{aligned} v &= v_0 + at \\ &= 0 + (-9.8)(1.5) \\ &= -14.7 \end{aligned}$$

The object's velocity is 15 ms^{-1} downwards (2 s.f.)

4. An object is thrown straight up at 17ms^{-1} . Calculate its velocity after 3.1 seconds.

$$v_0 = 17 \text{ ms}^{-1} \quad t = 3.1 \text{ s} \quad a = -9.8 \text{ ms}^{-2} \quad v = ?$$

$$\begin{aligned} v &= v_0 + at \\ &= 17 + (-9.8)(3.1) \\ &= -13.38 \end{aligned}$$

The object's velocity is 13 ms^{-1} downwards (2 s.f.)

5. Find the displacement of the object in part 4.

$$v_0 = 17 \text{ ms}^{-1} \quad t = 3.1 \text{ s} \quad a = -9.8 \text{ ms}^{-2} \quad v = 13 \text{ ms}^{-1} \quad s = ?$$

$$\begin{aligned} s &= v_0 t + \frac{1}{2} a t^2 \\ &= 17 \times 3.1 + \frac{1}{2} (-9.8)(3.1^2) \\ &= 5.611 \end{aligned}$$

The object's displacement is 5.6 m upwards (2 s.f.)

6. Find the maximum height of an object launched straight up from ground level at 16ms^{-1} .

$$v_0 = 16 \text{ ms}^{-1} \quad a = -9.8 \text{ ms}^{-2} \quad v = 0 \text{ ms}^{-1} \quad s = ?$$

$$\begin{aligned} v^2 &= v_0^2 + 2as \\ \therefore 2as &= v^2 - v_0^2 \\ \therefore s &= \frac{v^2 - v_0^2}{2a} \\ &= \frac{(0^2) - (16^2)}{2(-9.8)} \\ &= \frac{-256}{-19.6} \\ &= 13.06 \end{aligned}$$

The object's maximum height is 13 m (2 s.f.)

7. Find the time of flight of an object dropped from 10m above the ground.

$$s = -10 \text{ m} \quad v_0 = 0 \text{ ms}^{-1} \quad a = -9.8 \text{ ms}^{-2} \quad t = ?$$

$$s = v_0 t + \frac{1}{2} a t^2$$

$$\therefore s = \frac{1}{2} a t^2 \quad (\text{since } v_0 = 0)$$

$$\therefore t^2 = \frac{s}{\frac{1}{2} a}$$

$$\therefore t = \sqrt{\frac{s}{\frac{1}{2} a}}$$

$$= \sqrt{\frac{-10}{\frac{1}{2}(-9.8)}}$$

$$= 1.429$$

The object's time of flight is 1.4 s (2 s.f.)

8. An object thrown up at 4.8 ms^{-1} falls to the ground 2m below the starting height. What was the speed of the object just as it hit the ground?

$$s = -2 \text{ m} \quad v_0 = 4.8 \text{ ms}^{-1} \quad a = -9.8 \text{ ms}^{-2} \quad v = ?$$

$$v^2 = v_0^2 + 2as$$

$$v = \sqrt{v_0^2 + 2as}$$

$$= \sqrt{4.8^2 + 2(-9.8)(-2)}$$

$$= 7.89$$

The object's speed is 7.9 ms^{-1} (2 s.f.)

9. Find the time of flight of the object in part 8.

$$s = -2 \text{ m} \quad v_0 = 4.8 \text{ ms}^{-1} \quad a = -9.8 \text{ ms}^{-2} \quad v = -7.9 \text{ ms}^{-1} \quad t = ?$$

$$v = v_0 + at$$

$$\therefore at = v - v_0$$

$$\therefore t = \frac{v - v_0}{a}$$

$$= \frac{-7.9 - 4.8}{-9.8}$$

$$= 1.29$$

The object's time of flight was 1.3 s (2 s.f.)

10. Find the maximum height of the object in parts 8 and 9.

$$v_0 = 4.8 \text{ ms}^{-1} \quad a = -9.8 \text{ ms}^{-2} \quad v = 0 \text{ ms}^{-1} \quad s = ?$$

$$v^2 = v_0^2 + 2as$$

$$\therefore 2as = v^2 - v_0^2$$

$$\therefore s = \frac{v^2 - v_0^2}{2a}$$

$$= \frac{(0^2) - (4.8^2)}{2(-9.8)}$$

$$= 1.176$$

The object's maximum height was 1.2 m (2 s.f.)