

Section 2.7: Free Fall and Acceleration Due to Gravity

Remember:

- $a_g = -9.8 \text{ m/s}^2$

Any time you are working with objects moving freely through the air, they will always be accelerated downward at the rate of 9.81 m/s^2 ! It will not usually be stated – you will need to recognize the situation and realize that $a = -9.81 \text{ m/s}^2$ as an unstated given!

- Displacement is positive if it finishes above its initial position; if it finishes below its initial position, its displacement is negative.

Examples

1. A ball takes 2.00 s to reach the water when dropped ^{$v_i = 0$} from bridge. Calculate the displacement of the ball.

$$\begin{array}{l}
 t = 2.00 \text{ s} \\
 v_i = 0 \text{ m/s} \\
 a = -9.8 \text{ m/s}^2 \\
 d = ?
 \end{array}
 \qquad
 \begin{array}{l}
 d = v_i t + \frac{1}{2} a t^2 \\
 d = \frac{1}{2} (-9.8 \text{ m/s}^2) (2.00 \text{ s})^2 \\
 d = -19.6 \text{ m}
 \end{array}$$

2. An 8.0 kg object is dropped from a height of 6.5 m above the ground. What is the object's velocity after 0.75 s ?

$$\begin{array}{l}
 \cancel{m = 8.0 \text{ kg}} \\
 \cancel{\vec{d} = -6.5 \text{ m}} \\
 v_i = 0 \\
 v_2 = ? \\
 a = -9.8 \text{ m/s}^2 \\
 t = 0.75 \text{ s}
 \end{array}
 \qquad
 \begin{array}{l}
 \downarrow \\
 a = \frac{v_2 - v_1}{t} \\
 v_2 - v_1 = at \\
 v_2 = v_1 + at \\
 v_2 = (-9.8 \text{ m/s}^2)(0.75 \text{ s}) \\
 \underline{v_2 = -7.4 \text{ m/s}}
 \end{array}$$

3. An athlete in good physical condition can land on the ground at a speed of up to 12 m/s without injury. Calculate the maximum height from which he/she can jump without injury.

$$v_1 = 0 \text{ m/s}$$

$$d = ?$$

$$v_2 = 12 \text{ m/s}$$

$$a = -9.8 \text{ m/s}^2$$

$$d = \frac{v_2^2 - v_1^2}{2a}$$

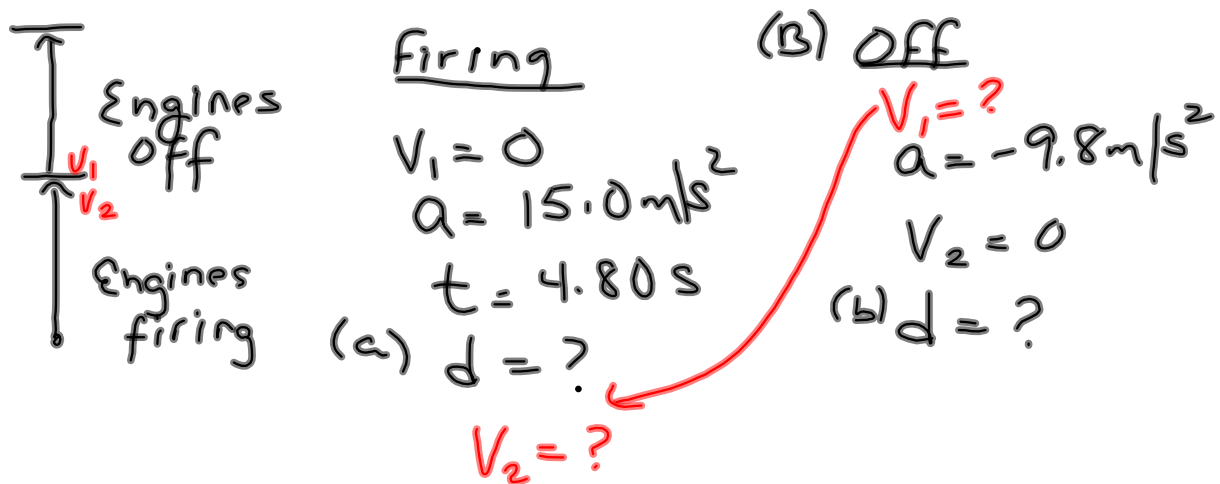
$$d = \frac{(-12 \text{ m/s})^2}{2(-9.8 \text{ m/s}^2)}$$

$$d = -7.3 \text{ m}$$

∴ He can jump from a height of 7.3 m.

4. A rocket is launched from rest with a uniform vertical acceleration of 15.0 m/s². After 4.80 s, the engines shut off.

A) To what height has the rocket risen in 4.80 s?



$$d = v_1 t + \frac{1}{2} a t^2$$

$$= \frac{1}{2} (15 \text{ m/s}^2) (4.80 \text{ s})^2$$

$$\underline{d = 173 \text{ m}}$$

B) How much higher will the rocket rise after the engines shut off? (max height)

1. Find V_2 from part 1 \rightarrow This is V_1 in part 2.

$$V_2 = V_1 + at$$

$$V_2 = (15 \text{ m/s}^2)(4.80 \text{ s}) = 72 \text{ m/s}$$

$$d = \frac{V_2^2 - V_1^2}{2a} = \frac{0 - (72 \text{ m/s})^2}{2(-9.8 \text{ m/s}^2)} = 264 \text{ m}$$

5. An object is thrown up into the air with a speed of 18 m/s.

A) How long will it take the ball to return to the same position?

B) What is the maximum height the ball will reach?

6. A ball is dropped from a helicopter from a height of 50.0 m. When the ball was dropped, the helicopter was moving upward with a velocity of 30.0 m/s. How long would it take the object to hit the ground?

7. Your friend is sitting on the roof of your house 6.0 m above your throwing arm as you stand on the ground. You toss a ball upward which bypasses your friend on the way up, but which he catches on the way down. If the ball leaves your hand at 15.0 m/s, how many seconds elapse before your friend catches it?