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/s²! It will not usually be stated – you will need to recognize the situation and realize that a = -9.81 m/s² 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

A ball takes 2.00 s to reach the water when dropped
 from bridge. Calculate the displacement of the ball.

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?

$$M = 8.0 \text{ Mg}$$

$$J = -6.5\text{ m}$$

$$V_{1} = 0$$

$$V_{2} = ?$$

$$a = \frac{V_{2} - V_{1}}{t}$$

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

$$t = 0.75\text{ s}$$

$$V_{2} - V_{1} = \text{ at}$$

$$V_{2} = \sqrt{1 + \text{ at}}$$

$$V_{2} = (-9.8 \text{ m/s}^{2})(0.75\text{ s})$$

$$\frac{V_{2} = -7.4 \text{ m/s}}{t}$$

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.

$$V_{1} = 0 \text{ m/s} \qquad d = V_{2}^{2} - V_{1}^{2}$$

$$d = ? \qquad 2a$$

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

$$Q = -9.8 \text{ m/s}^{2} \qquad 2(-9.8 \text{ m/s}^{2})$$

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

$$\partial_{0} \text{ He can jump from a height of } 7.3 \text{ m.}$$

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?

$$d = \frac{1}{2} \left(\frac{1}{2} \operatorname{at}^{2} \right) \left(\frac{1}{2} \operatorname{at}$$

- B) How much higher will the rocket rise after the engines shut off? (max height)
 - 1. Find V2 from part 1 -> This is V, in part2.

$$V_{2} = V_{1} + at$$

$$V_{2} = (15m/s^{2})(4.80s) = 72m/s$$

$$d = \frac{V_{2}^{2} - V_{1}^{2}}{2a} = \frac{0 - (72m/s)^{2}}{2(-9.8m/s^{2})} = 264m$$

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?

$$\begin{aligned}
\int \int t = \frac{V_2 - V_1}{a} = \frac{-18m|s - 18m|s}{-9.8m|s} \\
t = 3.7s \\
t = ? \\
a = -9.8m|s \\
V_2 = -18m|s \\
V_2 = 0 = (at max height) \\
a = -9.8m|s^2 \\
t_{up} = ? \\
t_{up} = ? \\
t_{up} = \frac{V_2 - V_1}{a} = \frac{0 - 18m|s}{-9.8m|s^2} \\
t_{up} = 2.85s \\
t_{up} = 2.85$$



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?

$$V_{i} = 15 m/s$$

 $a = -9.8 m/s^{2}$
 $d = 6.0 m$
 $t = ?$
 $V_{i} = 15.0 m/s$
 $V_{2} = ?$

$$V_{2}^{2} = V_{1}^{2} + 2ad$$

$$V_{2}^{2} = (15m|s)^{2} + 2(-9.8m|s^{2})(6.0m)$$

$$V_{2}^{2} = 107.4m^{2}|s^{2}$$

$$V_{2}^{2} = \pm \sqrt{107.4m^{2}}/s^{2}$$

$$V_{2}^{2} = -10.36m|s(-b|cheraught)$$

$$t = \frac{V_{2} - V_{1}}{2} = -\frac{10.36m|s - 15m|s}{-9}$$

$$= +2.68$$