9.3.8: Acceleration Due to Gravity

This Parachutist maximizes air resistance in order to limit the acceleration of the fall

Figure 2.7.1

In the absence of air resistance, all objects fall toward the Earth with the same acceleration. Parachutists, like the one from the U.S. Army Parachute Team shown above, make maximum use of air resistance in order to limit the acceleration of the fall.

Acceleration Due to Gravity

One of the most common examples of uniformly accelerated motion is that an object allowed to drop will fall vertically to the Earth due to gravity. In treating falling objects as uniformly accelerated motion, we must ignore air resistance. Galileo's original statement about the motion of falling objects is:

> *At a given location on the Earth and in the absence of air resistance, all objects fall with the same uniform acceleration.*

We call this **acceleration due to gravity** on the Earth and we give it the symbol g. The value of *g* is 9.81 m/s^2 in the downward direction. All of the equations involving constant acceleration can be used for falling bodies but we insert "-g" wherever "a" appeared and the value of g is always 9.81 m/s^2.

The equations for objects in free-fall are as follows:

$$v_f = v_i - gt$$
$$d = v_i t - \frac{1}{2} g t^2$$
$$v_f^2 = v_i^2 - 2(y_f - y_i)$$

In the absence of air resistance, is the cliff diver's acceleration 9.81 m/s^2 in the simulation below? How do you know? What information can you derive from the graphs?

Example: A rock is dropped from a tower 70.0 m tall. How far will the rock have fallen after 1.00 s, 2.00 s, and 3.00 s? Assume the displacement is negative downward.

Solution: We are looking for displacement and we have time and acceleration. Therefore, we can use $d = -\frac{1}{2} g t^2$.

Displacement after 1.00 s: $-(1/2)(9.81 \mathrm{m/s^2})(1.00\mathrm{s})^2 = -4.91\mathrm{m}$

Displacement after 2.00 s: $-(1/2)(9.81 \mathrm{m/s^2})(2.00\mathrm{s})^2 = -19.6\mathrm{m}$

Displacement after 3.00 s: $-(1/2)(9.81 \mathrm{m/s^2})(3.00\mathrm{s})^2 = -44.1\mathrm{m}$

Example: A stone is dropped from the top of a cliff. It is hits the ground after 5.5 s. How tall is the cliff?

Solution:

$$d = v_i t - \frac{1}{2} g t^2 = (0\mathrm{m/s})(5.5\mathrm{s}) - \frac{1}{2}(9.81\mathrm{m/s^2})(5.5\mathrm{s})^2 = 150\mathrm{m}$$

Further explore the acceleration of a model rocket due to gravity in the simulation below. Can you use the graphs to determine when the rocket is speeding up or slowing down?

Summary

- At any given location on the Earth and in the absence of air resistance, all objects fall with the same uniform acceleration.
- We call this acceleration the acceleration due to gravity on the Earth and we give it the symbol g.
- The value of *g* is 9.81 m/s^2.
- The equations for objects in free-fall are as follows:

$$v_f = v_i - gt$$
$$d = v_i t - \frac{1}{2} g t^2$$
$$v_f^2 = v_i^2 - 2(y_f - y_i)$$

Review

1. A baseball is thrown vertically into the air with a speed of 24.7 m/s.
    1. How high does it go?

2. How long does the round trip up and down require?
2. A salmon jumps up a waterfall 2.4 m high. With what minimum speed did the salmon leave the water below to reach the top?
3. A kangaroo jumps to a vertical height of 2.8 m. How long will it be in the air before returning to Earth?

Explore More

This video offers a discussion and demonstration of the acceleration due to gravity.

1. What is the gravitational acceleration given in the video? Why does it differ from that given in this text?
2. Why does the ball travel further in later time intervals than in the earlier ones?

Additional Resources

PLIX: Play, Learn, Interact, eXplore: Jumping Buses

Real World Application: Jumping Buses

Video:

Study Guide: Motion Study Guide
