Honors Physics: Freefall

Freefall

Any time an object is moving while influenced only by gravity and nothing else, it is in **freefall.**

The term “freefall” is a bit misleading, because it implies that the object is falling down. If you throw a ball upward, it is in freefall both on the way up and the way down, because gravity is the only influence on it.

We’ll ignore air resistance in this class

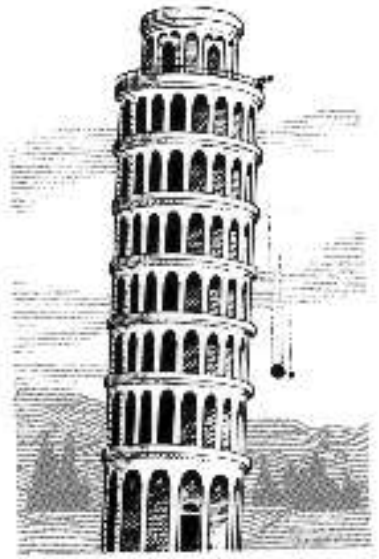
Freefall video

How do you know that the two objects have the same freefall acceleration, based on what you saw?

Freefall

Whenever an object is in freefall, it is being accelerated at 9.81 m/s^2. This value applies to all freefalling objects, whether they are large or small.

According to stories, Galileo Galilei dropped lead weights of different sizes off of the Leaning Tower of Pisa to prove this. It might be a myth, but Galileo did a lot of kinematics experiments in his lab.

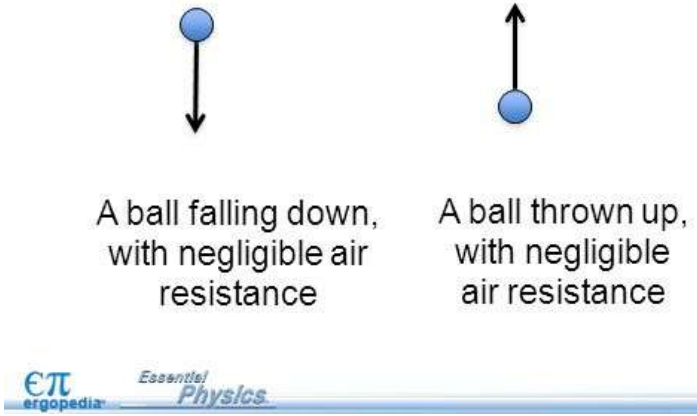


Freefall Discussion

Discuss these questions and come to conclusions.

In the image to the right,

1) For the ball falling down, what is the direction of the velocity? What is the direction of the acceleration?
2) For the ball thrown upward, what is the direction of the velocity? What is the direction of the acceleration?



Freefall calculations

You can use that value of 9.81 m/s^2 as the acceleration for any freefalling object. Since gravity points downward (always) we place a negative sign on this value in kinematics calculations to show direction.

We use the value 9.81 m/s^2 so often in physics, it is given its own letter to represent it - g for gravity.

In physics, g=9.81 m/s^2

In kinematics calculations we use -9.81 for acceleration

$$a = \frac{v_f - v_i}{t}$$

$$x = \left(\frac{v_i + v_f}{2}\right)t$$

$$x = v_i t + \frac{1}{2}at^2$$

$$v_f^2 = v_i^2 + 2ax$$

Freefall calculations

Example problem 1:

A rock is dropped from the top of a 20 meter tall cliff. How long will it take to hit the ground?

Step 1 - what information are we given?

Since it was dropped, that means it started from rest, so v_i=0. We know that the distance (x) is -20 meters (negative because it is falling downward). Because it is in freefall was can use the value -9.81 m/s^2 as acceleration (a).

$$a = \frac{v_f - v_i}{t}$$

$$x = \left(\frac{v_i + v_f}{2}\right)t$$

$$x = v_i t + \frac{1}{2}at^2$$

$$v_f^2 = v_i^2 + 2ax$$

Freefall calculations

Example problem 1:

A rock is dropped from the top of a 20 meter tall cliff. How long will it take to hit the ground?

Step 2 - what are we solving for?

We are trying to find how long it would take, which is time (t).

Step 3 - which equation has v_i, x, a, and t in it?

The third one down the list!

$$a = \frac{v_f - v_i}{t}$$

$$x = \left(\frac{v_i + v_f}{2}\right) t$$

$$x = v_i t + \frac{1}{2} a t^2$$

$$v_f^2 = v_i^2 + 2ax$$

Freefall calculations

Example problem 1:

A rock is dropped from the top of a 20 meter tall cliff. How long will it take to hit the ground?

Step 4 - substitute numbers and solve

$x=v_it + ½at^2$

$-20 = 0(t)+ ½(-9.81)t^2$ *note that zero times t is zero, so the first term is gone*

$-20 = -4.905t^2$

$t^2 = 4.08$

$t = 2.02$ *seconds*

$$a = \frac{v_f - v_i}{t}$$

$$x = \left(\frac{v_i + v_f}{2}\right)t$$

$$x = v_i t + \frac{1}{2}at^2$$

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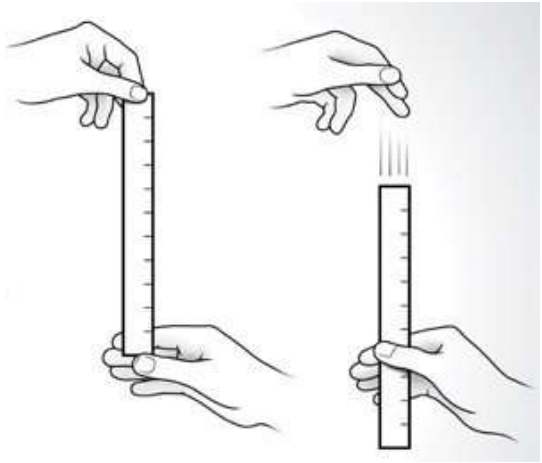
Freefall mini-lab

Have a friend or lab partner hold a ruler vertically with the 0 mark at the bottom. Place your thumb and forefinger on either side of the bottom end of the ruler.

Without any warning, the person holding the ruler lets it go. You try and catch the ruler as quickly as you can.

Look at where your fingers are holding the ruler. That is the distance the ruler fell. Convert the distance to meters. Use it in a kinematics problem to calculate your reaction time.



Freefall key words

Whenever an object is dropped from rest, $v_i = 0$

Whenever an object is in freefall, $a = -9.81\ m/s^2$

Whenever an object is thrown upward into the air, the initial speed v_i is not zero, it is the speed at which the ball was thrown.

Whenever an object is thrown upward, at its highest point $v_f = 0$.

Freefall Calculation Practice

Use the accelerated motion kinematics equations to calculate answers

1) A child drops a penny down a well. It takes the penny 3 seconds to hit bottom. How deep is the well?
2) On the 4th of July, a firework is launched up into the air with an unknown initial speed. The firework stops at a height of 75 meters. What is the initial speed of the firework when it was launched?
3) Using the firework information from the previous problem, how high up in the air was the firework when it was moving at half of its launch speed?

$$a = \frac{v_f - v_i}{t}$$

$$x = \left(\frac{v_i + v_f}{2}\right)t$$

$$x = v_i t + \frac{1}{2}at^2$$

$$v_f^2 = v_i^2 + 2ax$$