Free Fall Acceleration

by

Nada Saab, Ph.D.

http://nhsaab.weebly.com

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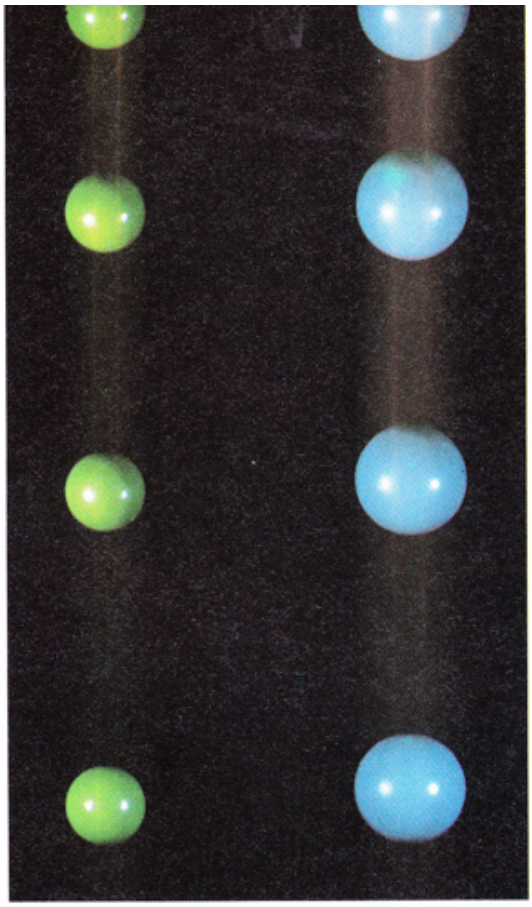
3.2. Free fall acceleration: (P2.2G)



The strobe photograph above shows two balls of different mass dropped at same instant.

- When air resistance is minimal, all freely falling objects have the same downwards acceleration.

- Acceleration due to gravity is approximately constant near the Earth's surface and has a value of $g = 9.8\ m/s^2$

Acceleration of Free Falling Objects

The equations derived for uniform acceleration in chapter 2 apply to freely falling objects. The three equations for free fall motion are:

$$\vec{v}_2 = \vec{v}_1 + \vec{g}\,\Delta t \qquad \text{Equation (1)}$$

$$\Delta d = \vec{v}_1 \Delta t + \frac{1}{2}\vec{g}\,(\Delta t)^2 \qquad \text{Equation (2)}$$

$$\vec{\Delta d} = \frac{(\vec{v}_2 + \vec{v}_1)}{2}\,\Delta t \qquad \text{Equation (3)}$$

v : Velocity down is negative

g : up is 9.8 m/s^2 , down is -9.8 m/s^2

<u>What to do?</u>

1- Open pages 88. Study sample problem. Do exercises 1, 2, 3, and 4. Show your work and submit.

2- When submitting, write the section number Example:

Section 3.2 (Free fall)

Sample Problems

1. A girl throws a rock straight down form a bridge at 15 m/s. How fast is ti going 3.0 s later?

We know from the question that

$$v_1 = 15 \text{ m/s[down]} = -15 \text{ m/s}$$
$$\Delta t = 3.0 \text{ s}$$

However, since the rock is in free fall, the instant it leaves the girl's hand we can also assume that:

$$a = g = 9.8 \text{m/s}^2\text{[down]} = -9.8 \text{ m/s}^2$$

To find the velocity of the rock, we use the equation

$$\begin{aligned} v_2 &= v_1 + a\Delta t \\ &= -15 \text{ m/s} + (-9.8 \text{ m/s}^2)\ (3.0 \text{ s}) \\ &= -15 \text{ m/s} + -29.4 \text{ m/s} \\ &= -44.4 \text{ m/s, or } 44 \text{ m/s[down]} \end{aligned}$$

Therefore, the rock acquires a velocity of 44 m/s [down] in 3.0s.

2. An egg drops through a hole in bottom of nest. How far does it fall in 1.0 s?

Assuming that the egg is in free fall after leaving the nest, we can state the following;

$$
\begin{aligned}
v_1 &= 0 \\
\Delta t &= 1.0 \text{ s} \\
a &= 9.8 \text{ m/s}^2\text{[down]} = -9.8 \text{ m/s}^2
\end{aligned}
$$

$$
\begin{aligned}
\Delta d &= v_1 \Delta t + \frac{1}{2} a(\Delta t)^2 \\
&= (0)\ (1.0 \text{ s}) + \left(\frac{1}{2}\right)(-9.8 \text{ m/s}^2)\ (1.0 \text{ s})^2 \\
&= -4.9 \text{ m, or } 4.9 \text{ m[down]}
\end{aligned}
$$

Therefore, the egg falls 4.9 m in 1.0 s.

3. A girl throws a baseball straight up at 15 m/s. What is the ball's velocity 2.0 s later?

$$
\begin{aligned}
v_1 &= 15 \text{ m/s[up]} = 15 \text{ m/s} \\
a &= 9.8 \text{ m/s}^2\text{[down]} = -9.8 \text{ m/s}^2 \\
\Delta t &= 2.0 \text{ s}
\end{aligned}
$$

$$
\begin{aligned}
v_2 &= v_1 + a\Delta t \\
&= 15 \text{ m/s} + (-9.8 \text{ m/s}^2)\ (2.0 \text{ s}) \\
&= 15 \text{ m/s} - 19.6 \text{ m/s} \\
&= -4.6 \text{ m/s}
\end{aligned}
$$

Practice

1. What velocity does a freely falling object after 4.0 s if it starts from rest?
2. A boy throws a rock into a deep well with a velocity of 10 m/s [down]. What is the velocity of the rock 2.5 s later?
3. A prankster drops a water-filled balloon from the balcony of a high-rise. How long does it take for the balloon to fall 44.1 m?
4. A girl uses a slingshot to fire a stone straight up at 24 m/s. What is the stone's velocity 3.0 s later? what is its displacement 3.0 s after it was fired.

Answers:

1. 39 m/s [down] hint: use equation (1)
2. 35 m/s [down] hint: use equation (1)
3. 3.0 s hint: use equation (2)
4. 5.4 m/s [down] hint: use equations (1) and (3)
   28m [up]