Freely falling objects always have the same downward acceleration

It may seem a little confusing to think of something that is moving upward, like the ball in the example, as having a downward acceleration. Thinking of this motion as motion with a positive velocity and a negative acceleration may help. The downward acceleration is the same when an object is moving up, when it is at rest at the top of its path, and when it is moving down. The only things changing are the position and the magnitude and direction of the velocity.

When an object is thrown up in the air, it has a positive velocity and a negative acceleration. From **Table 3** in Section 2, we see that this means the object is slowing down as it rises in the air. From the example of the ball and from everyday experience, we know that this makes sense. The object continues to move upward but with a smaller and smaller speed. In the photograph of the ball, this decrease in speed is shown by the smaller and smaller displacements as the ball moves up to the top of its path.

At the top of its path, the object's velocity has decreased until it is zero. Although it is impossible to see this because it happens so quickly, the object is actually at rest at the instant it reaches its peak position. Even though the velocity is zero at this instant, the acceleration is still $-9.81\ m/s^2$.

When the object begins moving down, it has a negative velocity and its acceleration is still negative. From **Table 3,** we see that a negative acceleration and a negative velocity indicate an object that is speeding up. In fact, this is what happens when objects undergo free-fall acceleration. Objects that are falling toward Earth move faster and faster as they fall. In the photograph of the ball in **Figure 15** (on the previous page), this increase in speed is shown by the greater and greater displacements between the images as the ball falls.

Knowing the free-fall acceleration makes it easy to calculate the velocity, time, and displacement of many different motions using the equations for constantly accelerated motion. Because the acceleration is the same throughout the entire motion, you can analyze the motion of a freely falling object during any time interval.

Quick Lab

Time Interval of Free Fall

MATERIALS LIST

- **meterstick or ruler**

SAFETY

Avoid eye injury; do not swing metersticks.

Your reaction time affects your performance in all kinds of activities—from sports to driving to catching something that you drop. Your reaction time is the time interval between an event and your response to it.

Determine your reaction time by having a friend hold a meterstick vertically between the thumb and index finger of your open hand. The meterstick should be held so that the zero mark is between your fingers with the 1 cm mark above it.

You should not be touching the meterstick, and your catching hand must be resting on a table. Without warning you, your friend should release the meterstick so that it falls between your thumb and your finger. Catch the meterstick as quickly as you can. You can calculate your reaction time from the free-fall acceleration and the distance the meterstick has fallen through your grasp.