projectile motion

the curved path that an object follows when thrown, launched, or otherwise projected near the surface of Earth

In this section, we will focus on the form of two-dimensional motion called **projectile motion.** Objects that are thrown or launched into the air and are subject to gravity are called *projectiles.* Some examples of projectiles are softballs, footballs, and arrows when they are projected through the air. Even a long jumper can be considered a projectile.

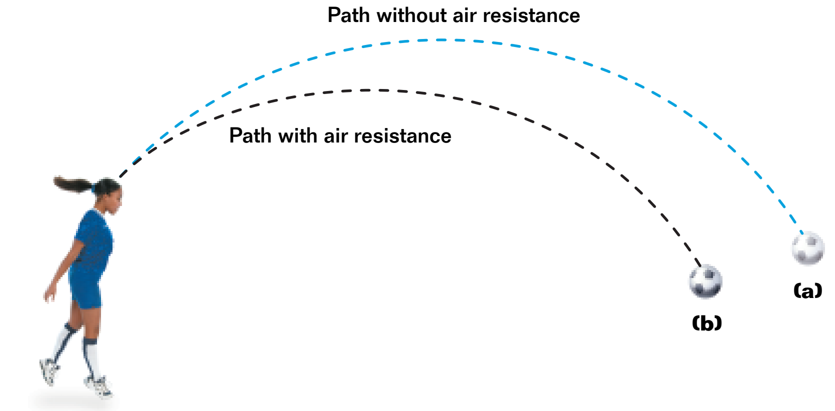

Figure 15
(a) Without air resistance, the soccer ball would travel along a parabola. **(b)** With air resistance, the soccer ball would travel along a shorter path.

Projectiles follow parabolic trajectories

The path of a projectile is a curve called a *parabola,* as shown in **Figure 15(a).** Many people mistakenly believe that projectiles eventually fall straight down in much the same way that a cartoon character does after running off a cliff. But if an object has an initial horizontal velocity in any given time interval, there will be horizontal motion throughout the flight of the projectile. *Note that for the purposes of samples and exercises in this book, the horizontal velocity of the projectile will be considered constant.* This velocity would not be constant if we accounted for air resistance. With air resistance, a projectile slows down as it collides with air particles, as shown in **Figure 15(b).**

Projectile motion is free fall with an initial horizontal velocity

To understand the motion a projectile undergoes, first examine **Figure 16.** The red ball was dropped at the same instant the yellow ball was launched horizontally. If air resistance is disregarded, both balls hit the ground at the same time.

By examining each ball's position in relation to the horizontal lines and to one another, we see that the two balls fall at the same rate. This may seem impossible because one is given an initial velocity and the other begins from rest. But if the motion is analyzed one component at a time, it makes sense.

First, consider the red ball that falls straight down. It has no motion in the horizontal direction. In the vertical direction, it starts from rest ($v_{y,i} = 0$ m/s) and proceeds in free fall. Thus, the kinematic equations from the chapter "Motion in One Dimension" can be applied to analyze the vertical motion of the falling ball, as shown on the next page. Note that on Earth's surface the acceleration (a_y) will equal $-g$ (-9.81 m/s^2) because the only vertical component of acceleration is free-fall acceleration. Note also that Δy is negative.

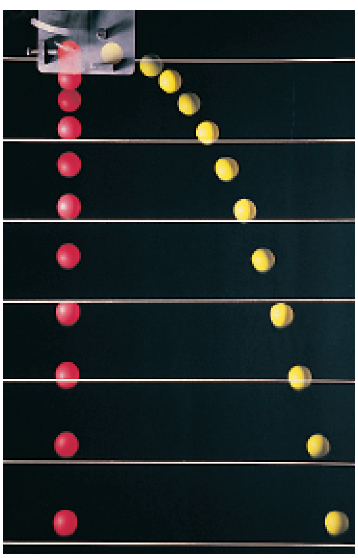

Figure 16
This is a strobe photograph of two table-tennis balls released at the same time. Even though the yellow ball is given an initial horizontal velocity and the red ball is simply dropped, both balls fall at the same rate.