VERTICAL MOTION OF A PROJECTILE THAT FALLS FROM REST

$$v_{y,f} = a_y \Delta t$$

$$v_{y,f}^2 = 2a_y \Delta y$$

$$\Delta y = \tfrac{1}{2} a_y (\Delta t)^2$$

Now consider the components of motion of the yellow ball that is launched in **Figure 16.** This ball undergoes the same horizontal displacement during each time interval. This means that the ball's horizontal velocity remains constant (if air resistance is assumed to be negligible). Thus, when the kinematic equations are used to analyze the horizontal motion of a projectile, the initial horizontal velocity is equal to the horizontal velocity throughout the projectile's flight. A projectile's horizontal motion is described by the following equation.

HORIZONTAL MOTION OF A PROJECTILE

$$v_x = v_{x,i} = \text{constant}$$

$$\Delta x = v_x \Delta t$$

Next consider the initial motion of the launched yellow ball in **Figure 16.** Despite having an initial horizontal velocity, the launched ball has no initial velocity in the vertical direction. Just like the red ball that falls straight down, the launched yellow ball is in free fall. The vertical motion of the launched yellow ball is described by the same free-fall equations. In any time interval, the launched ball undergoes the same vertical displacement as the ball that falls straight down. For this reason, both balls reach the ground at the same time.

To find the velocity of a projectile at any point during its flight, find the vector that has the known components. Specifically, use the Pythagorean theorem to find the magnitude of the velocity, and use the tangent function to find the direction of the velocity.

Did you know?

The greatest distance a regulation-size baseball has ever been thrown is 135.9 m, by Glen Gorbous in 1957.

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Quick Lab

Projectile Motion

MATERIALS LIST

- **2 identical balls**
- **slope or ramp**

SAFETY

Perform this experiment away from walls and furniture that can be damaged.

Roll a ball off a table. At the instant the rolling ball leaves the table, drop a second ball from the same height above the floor. Do the two balls hit the floor at the same time? Try varying the speed at which you roll the first ball off the table. Does varying the speed affect whether the two balls strike the ground at the same time? Next roll one of the balls down a slope. Drop the other ball from the base of the slope at the instant the first ball leaves the slope. Which of the balls hits the ground first in this situation?