Description: Conceptual questions about projectile motion and some easy calculations.

Constants | Periodic Table

Learning Goal:

To understand the basic concepts of projectile motion.

Projectile motion may seem rather complex at first. However, by breaking it down into *components*, you will find that it is really no different than the one-dimensional motions that you have already studied.

One of the most often-used techniques in physics is to divide two- and three-dimensional quantities into components. For instance, in projectile motion, a particle has some initial velocity $\vec{v}$. In general, this velocity can point in any direction on the *xy* plane and can have any magnitude. To make a problem more manageable, it is common to break up such a quantity into its *x* component (v_x) and its *y* component (v_y).

Consider a particle with initial velocity $\vec{v}$ that has magnitude 12.0 $\mathrm{m/s}$ and is directed 60.0 $\mathrm{degrees}$ above the negative *x* axis.

Part A

What is the *x* component v_x of $\vec{v}$?

Express your answer in meters per second.

ANSWER:

v_x = -6.00 $\mathrm{m/s}$

Part B

What is the *y* component v_y of $\vec{v}$?

Express your answer in meters per second.

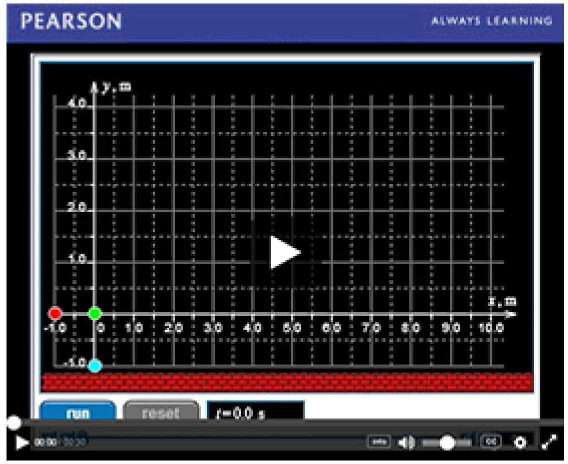
ANSWER:

v_y = 10.4 $\mathrm{m/s}$

Breaking up the velocities into components is particularly useful when the components do not affect each other. Eventually, you will learn about situations in which the components of velocity do affect one another, but for now you will only be looking at problems where they do not. So, if there is acceleration in the *x* direction but not in the *y* direction, then the *x* component of the velocity will change, but the *y* component of the velocity will not.

Part C

Click on the image below to launch the video: Projectile Motion. Once you have watched the entire video, answer the graded follow-up questions. You can watch the video again at any point.



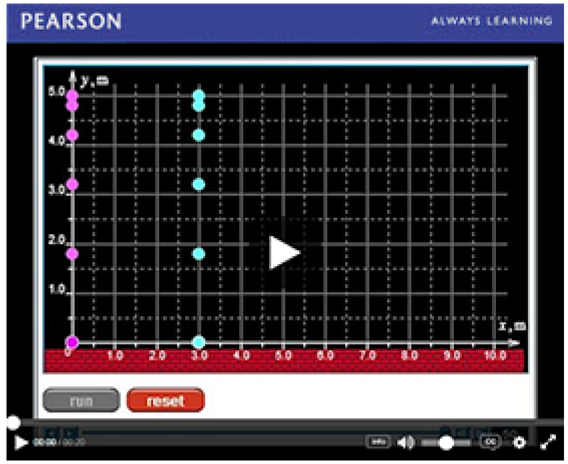
The motion diagram for a projectile is displayed, as are the motion diagrams for each component. The *x*-component motion diagram is what you would get if you shone a spotlight down on the particle as it moved and recorded the motion of its shadow. Similarly, if you shone a spotlight to the left and recorded the particle's shadow, you would get the motion diagram for its *y* component. How would you describe the two motion diagrams for the components?

ANSWER:

- Both the vertical and horizontal components exhibit motion with constant nonzero acceleration.
- The vertical component exhibits motion with constant nonzero acceleration, whereas the horizontal component exhibits constant-velocity motion.
- The vertical component exhibits constant-velocity motion, whereas the horizontal component exhibits motion with constant nonzero acceleration.
- Both the vertical and horizontal components exhibit motion with constant velocity.

As you can see, the two components of the motion obey their own independent kinematic laws. For the vertical component, there is an acceleration downward with magnitude $g = 10\ \mathrm{m/s^2}$. Thus, you can calculate the vertical position of the particle at any time using the standard kinematic equation $y = y_0 + v_0 t + (1/2)at^2$. Similarly, there is no acceleration in the horizontal direction, so the horizontal position of the particle is given by the standard kinematic equation $x = x_0 + v_0 t$.

Now, consider a variation on this problem in which two balls are simultaneously dropped from a height of 5.0 m. Click on the image below to launch the second video: Projectile Motion. Once you have watched the entire video, answer the graded follow-up questions. You can watch the video again at any point.



Part D

How long t_g does it take for the balls to reach the ground? Use 10 $\mathrm{m/s^2}$ for the magnitude of the acceleration due to gravity.

Express your answer in seconds to two significant figures.

View Available Hint(s) (1)

ANSWER:

t_g = 1.0 s

This situation, which you have dealt with before (motion under the constant acceleration of gravity), is actually a special case of projectile motion. Think of this as projectile motion where the horizontal component of the initial velocity is zero.

Part E

Imagine the ball on the left is given a nonzero initial speed in the horizontal direction, while the ball on the right continues to fall with zero initial velocity. What horizontal speed v_x must the ball on the left start with so that it hits the ground at the same position as the ball on the right? Remember that when the two balls are released, they are starting at a horizontal distance of 3.0 m apart.

Express your answer in meters per second to two significant figures.

View Available Hint(s) (1)

ANSWER:

$v_x =$ 3.0 $\mathrm{m/s}$