SAMPLE PROBLEM D

Projectiles Launched Horizontally

PROBLEM

The Royal Gorge Bridge in Colorado rises 321 m above the Arkansas River. Suppose you kick a rock horizontally off the bridge. The magnitude of the rock's horizontal displacement is 45.0 m. Find the speed at which the rock was kicked.

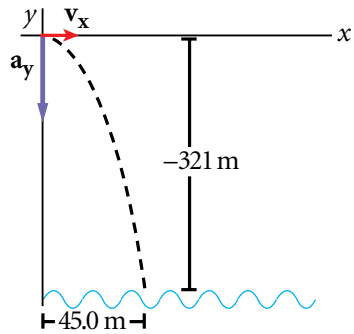
SOLUTION

1. DEFINE

Given: $\Delta y = -321 \text{ m}$ $\Delta x = 45.0 \text{ m}$ $a_y = -g = -9.81 \text{ m/s}^2$

Unknown: $v_i = v_x = ?$

Diagram: The initial velocity vector of the rock has only a horizontal component. Choose the coordinate system oriented so that the positive y direction points upward and the positive x direction points to the right.



2. PLAN

Choose an equation or situation:

Because air resistance can be neglected, the rock's horizontal velocity remains constant.

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

Because there is no initial vertical velocity, the following equation applies.

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

Rearrange the equations to isolate the unknowns:

Note that the time interval is the same for the vertical and horizontal displacements, so the second equation can be rearranged to solve for Δt.

$$\Delta t = \sqrt{\frac{2\Delta y}{a_y}}$$

Next rearrange the first equation for v_x, and substitute the above value of Δt into the new equation.

$$v_x = \frac{\Delta x}{\Delta t} = \left(\sqrt{\frac{a_y}{2\Delta y}} \right) \Delta x$$

3. CALCULATE

Substitute the values into the equation and solve:

$$v_x = \sqrt{\frac{-9.81 \text{ m/s}^2}{(2)(-321 \text{ m})}} (45.0 \text{ m}) = \boxed{5.56 \text{ m/s}}$$

TIP *The value for v_x can be either positive or negative because of the square root. Because the direction was not asked for, use the positive root.*

4. EVALUATE

To check your work, estimate the value of the time interval for Δx and solve for Δy. If v_x is about 5.5 m/s and $\Delta x = 45$ m, $\Delta t \approx 8$ s. If you use an approximate value of 10 m/s^2 for g, $\Delta y \approx -320$ m, almost identical to the given value.