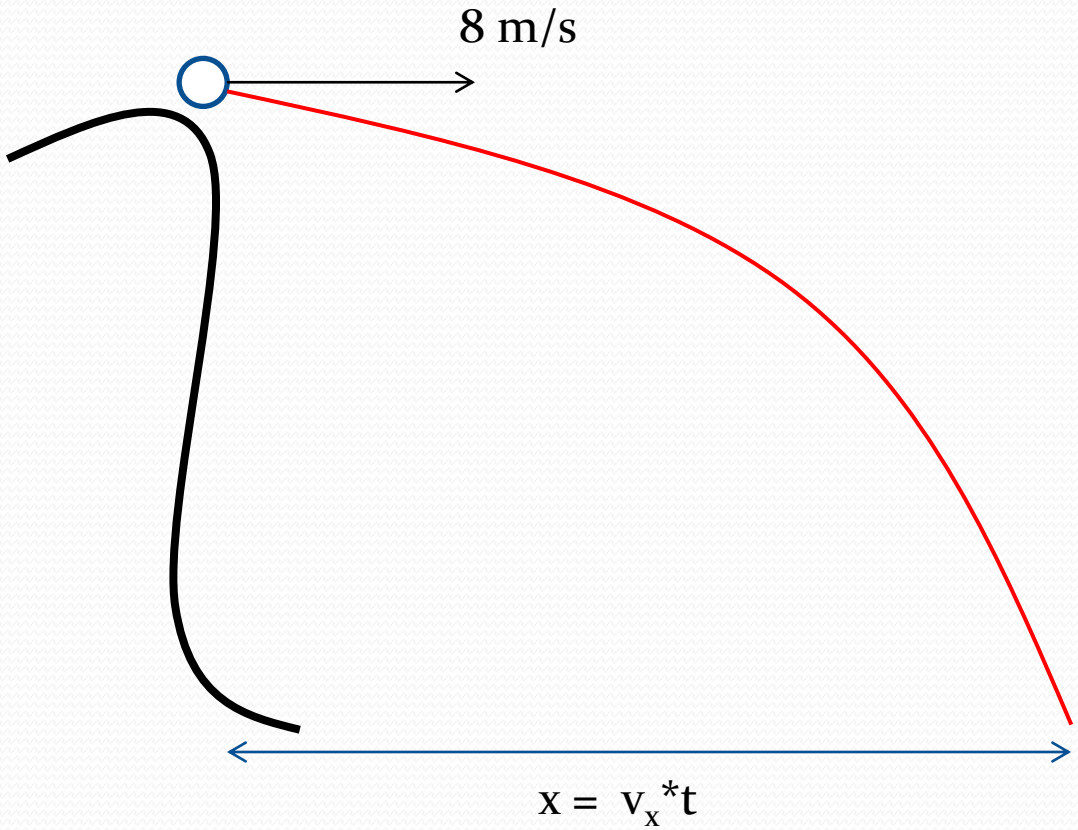
Projectile Practice Problems

Solutions

1. An object is projected horizontally at 8.0 m/s from the top of a 122.5 m cliff. How far from the base of the cliff will the object strike the ground?



1. An object is projected horizontally at 8.0 m/s from the top of a 122.5 m cliff. How far from the base of the cliff will the object strike the ground?

Step 1: Determine how long the object was in the air.

Use the equation d = ½ at² and solve for time.

Rearrange the equation into

$$d = \frac{1}{2}at^2$$

$$2d = at^2$$

$$\frac{2d}{a} = t^2$$

$$\sqrt{\frac{2d}{a}} = t$$

Our shortcut equation for finding the time an object hits the ground from a height of "d".

1. An object is projected horizontally at 8.0 m/s from the top of a 122.5 m cliff. How far from the base of the cliff will the object strike the ground?

Step 2: Substitute in the values for d and a and solve for t.

$$t = \sqrt{\frac{2d}{a}}$$

$$t = \sqrt{\frac{2(122.5)}{10}}$$

$$t = 5 \text{ sec}$$

1. An object is projected horizontally at 8.0 m/s from the top of a 122.5 m cliff. How far from the base of the cliff will the object strike the ground?

Step 3: Use the horizontal displacement equation $x = v_x t$ to solve for the displacement from the base of the cliff the object landed.

$x = 8 \times 5$

$x = 40$ meters

8.0 m/s → given

5 seconds → solved in step 2

2. An arrow is shot at 30.0° angle with the horizontal. It has a velocity of 49 m/s.

a. How high will it go?

b. What is horizontal displacement of the arrow?

NOTE:

v_x = horizontal velocity

$v_x = V_i (\cos \theta)$

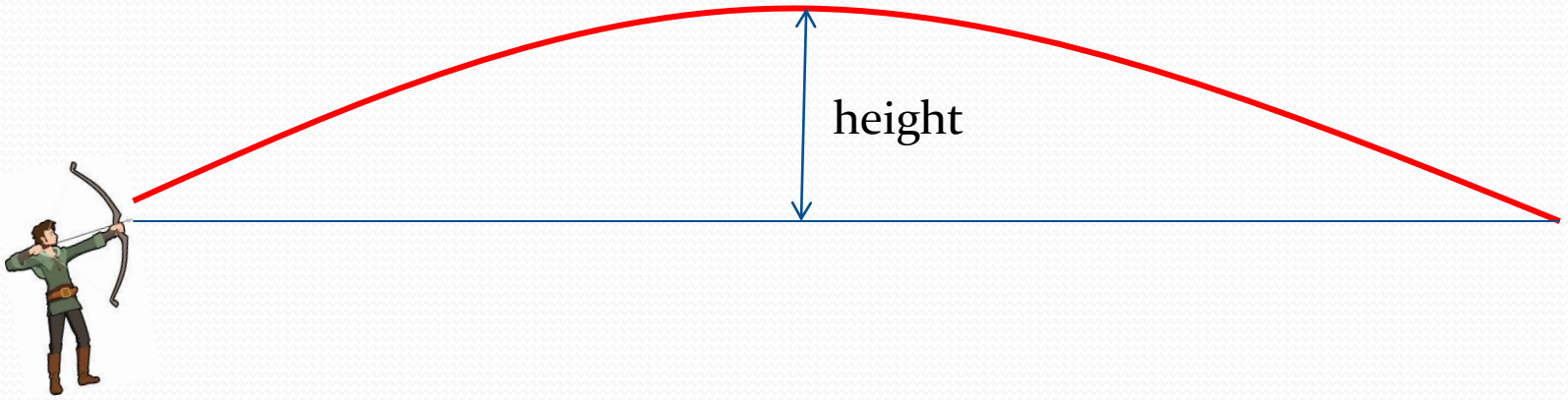
$v_y = V_i (\sin \theta)$

θ = angle of the velocity

2. An arrow is shot at 30.0° angle with the horizontal. It has a velocity of 49 m/s (a vertical velocity of 24.5 m/s and horizontal velocity = 42.4 m/s)

a. How high will it go?

b. What horizontal distance will the arrow travel? (relative to its original height)



2. An arrow is shot at 30.0° angle with the horizontal. It has a velocity of 49 m/s (a vertical velocity of 24.5 m/s and horizontal velocity = 42.4 m/s)

a. How high will it go?

Step 1: Determine the time it takes for the arrow to reach it peak. Use the equation

$v_f = v_i + at$

and the orientation of up is positive and down is negative

2. An arrow is shot at 30.0° angle with the horizontal. It has a velocity of 49 m/s (a vertical velocity of 24.5 m/s and horizontal velocity = 42.4 m/s)

a. How high will it go?

Step 2: Substitute in the values for v_i and a

$$v_f = v_i + at \qquad v_f - v_i = at \qquad \frac{v_f - v_i}{a} = t$$

$$since\ v_f = 0$$

Total flight time: $\boldsymbol{t = 2 \times \frac{-v_i}{a} = 2 \times \frac{-24.5}{-10} =}$

4.9 *seconds*

2. An arrow is shot at 30.0° angle with the horizontal. It has a velocity of 49 m/s (a vertical velocity of 24.5 m/s and horizontal velocity = 42.4 m/s)

a. How high will it go?

Step 3: To determine the height, use the equation

$$d = v_i t + \tfrac{1}{2} a t^2$$

$$d = (24.5)2.45 + \tfrac{1}{2} (-10)(2.45)^2$$

$$d = 30.0125 \text{ meters}$$

2. An arrow is shot at 30.0° angle with the horizontal. It has a velocity of 49 m/s (a vertical velocity of 24.5 m/s and horizontal velocity = 42.4 m/s)

a. How high will it go?

Step 3: To determine the height, use the equation

$$v_f^2 = v_i^2 + 2ad$$

$$d = \frac{-v_i^2}{2a}$$ (our shortcut for finding max. height)

$$d = -24.5^2/(2 \times (-10)) = 30.0125 \text{ m}$$

2. An arrow is shot at 30.0° angle with the horizontal. It has a velocity of 49 m/s (a vertical velocity of 24.5 m/s and horizontal velocity = 42.4 m/s)

b. What horizontal distance will the arrow travel? (relative to its original height)

Step 1: Use the horizontal displacement equation

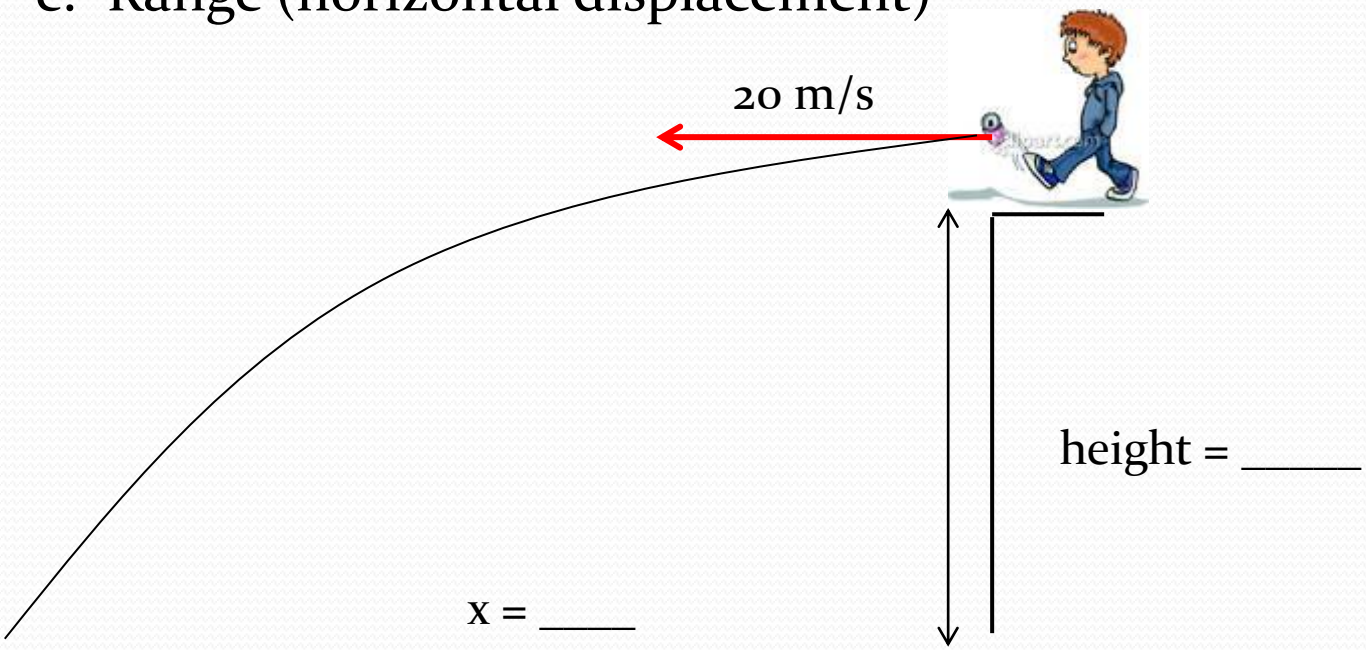
$x = v_x t$ ("t" here is total flight time)

$x = (42.4)(4.9)$ (total flight time = 2 · peaked time)

$x = 208$ meters

3. A person kicks a rock off a cliff horizontally with a speed of 20 m/s. It takes 7.0 seconds to hit the ground, find:

a. height of the cliff
b. final vertical velocity
c. Range (horizontal displacement)



a. $t = 7$ seconds

$a = -10\ m/s^2$

$v_i = 0\ m/s$

$d = ?$

$d = v_i t + \frac{1}{2} a t^2$

$d = (0)(7) + \frac{1}{2}(-10)(7)^2$

$d = -5(49)$

$d = -245\ m \rightarrow$ height $= 245\ m$

b. $t = 7$ seconds

$a = 10\ m/s^2$

$v_i = 0\ m/s$

$v_f = ?$

$v_f = v_i + at$

$v_f = 0 + (-10)(7)$

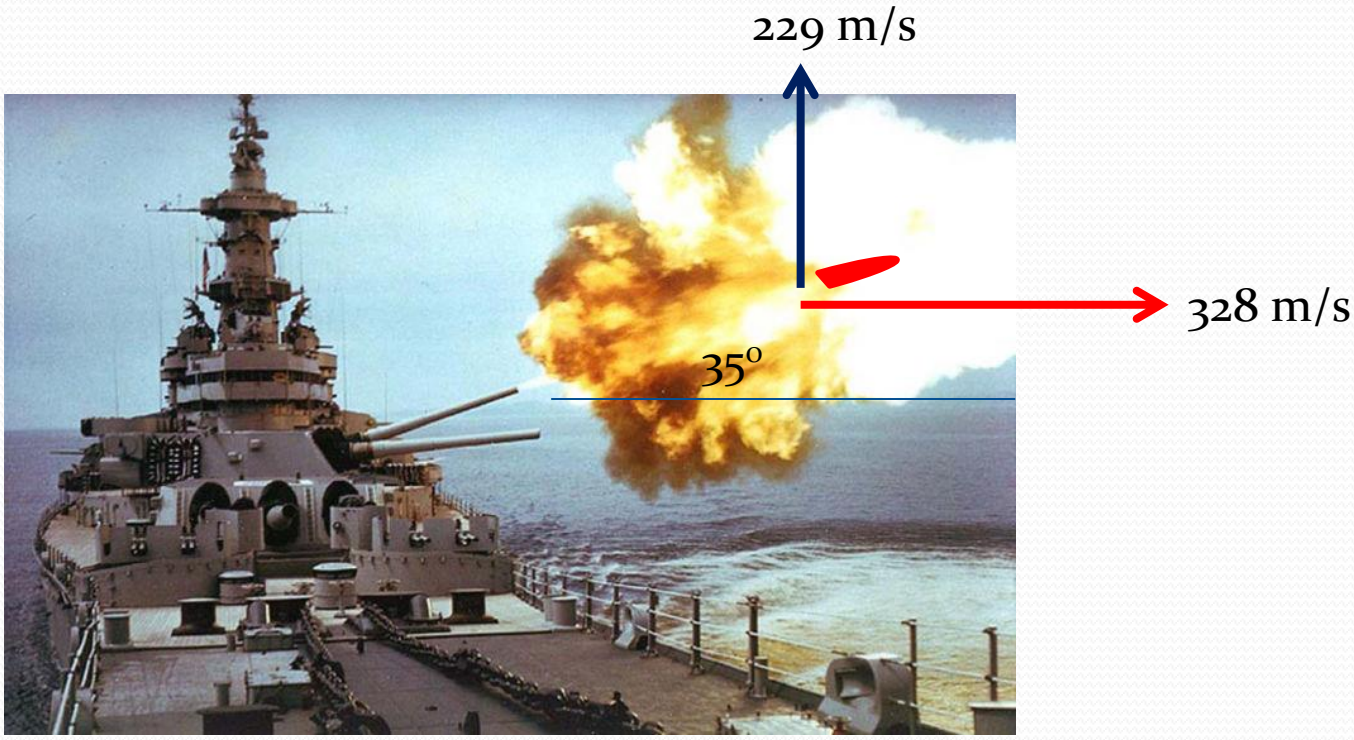
$v_f = -70\ m/s$

c. $x = v_{horizontal}\ t$

$= (20)(7)$

$= 140$ meters

4. A ship fires its guns with a speed of 400 m/s at an angle of 35° (328 m/s horizontally and 229 m/s vertically) with the horizontal. Find the range and maximum altitude.



To find the range,
we need total flight time.

Shortcut equation:

$$t = \frac{-2v_i}{a}$$

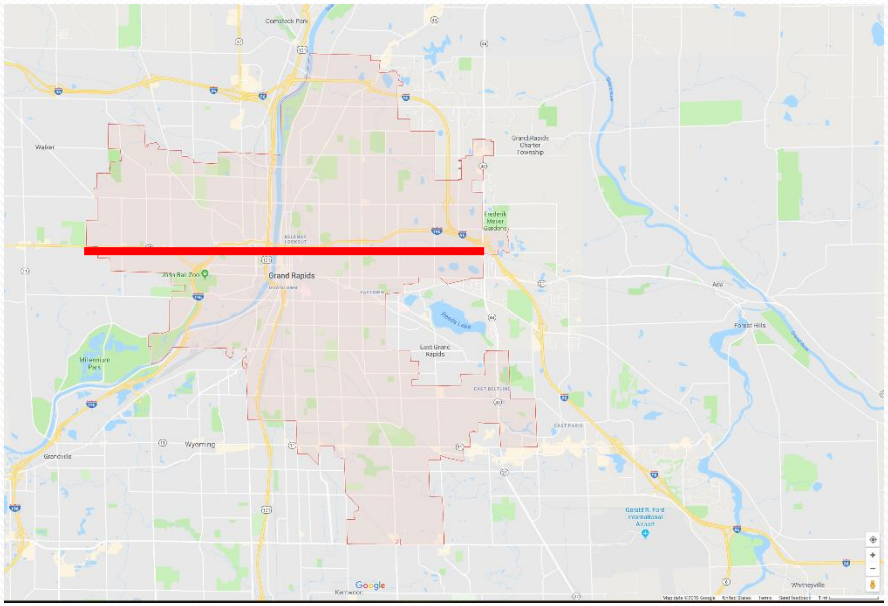
$$t = \frac{-2(229)}{-10}$$

$$t = 45.8\ seconds$$

Range = horizontal displacement: $x = v_x t$

$x = (328\ m/s)(45.8\ s) = 15022.4\ m = 15.0224\ km = 9.32\ miles$

Map of Grand Rapids

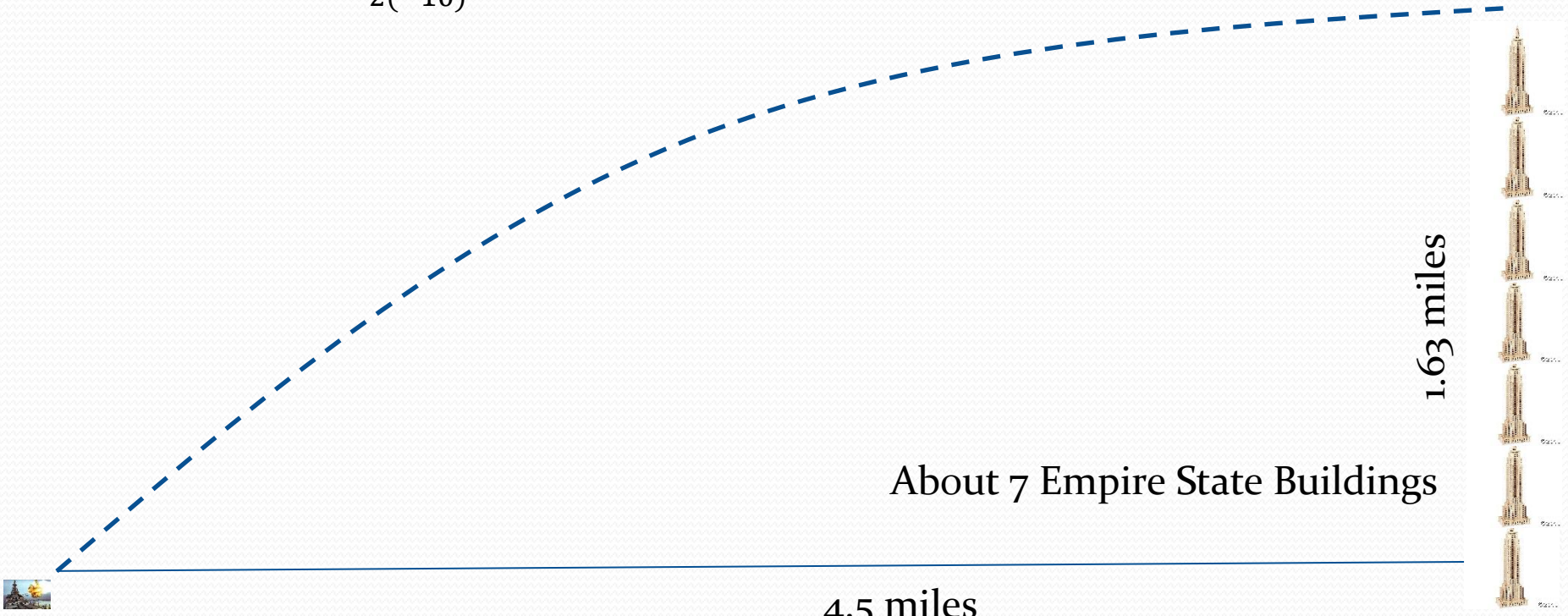


To determine the height, use the equation

$$v_f^2 = v_i^2 + 2ad$$

$d = \frac{-v_i^2}{2a}$(equation for max. height)

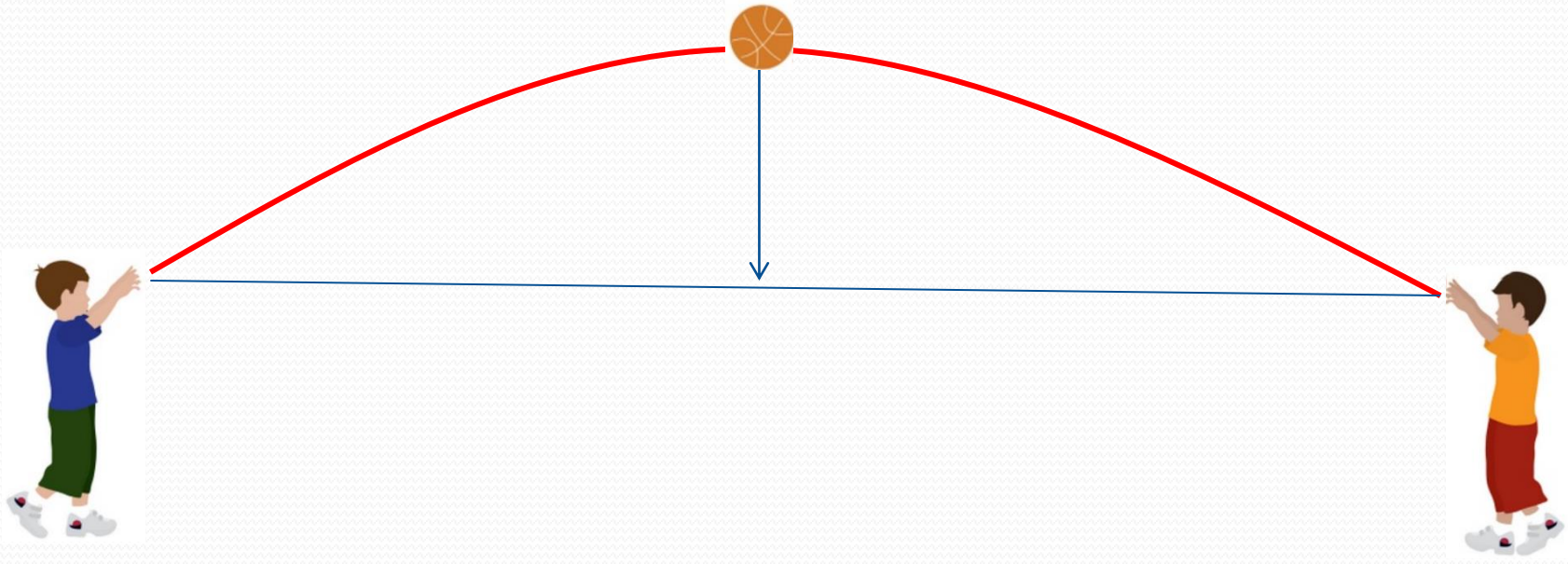
$d = \frac{-229^2}{2(-10)}$ = 2622.05 m = 2.62205 km = 1.63 miles



5. A basketball is held over head at a height of 2.4 m. The ball is lobbed to a teammate at 8 m/s at an angle of 40° (6.13 m/s horizontally and 5.14 m/s vertically). If the ball is caught at the same height it was tossed at, how far away is the teammate?

5. A basketball is held over head at a height of 2.4 m. The ball is lobbed to a teammate at 8 m/s at an angle of 40° (6.13 m/s horizontally and 5.14 m/s vertically). If the ball is caught at the same height it was tossed at, how far away is the teammate?

Type 2 problem, similar to the battleship problem.



To find the range, we need total flight time.

Shortcut equation:

$$t = \frac{-2v_i}{a}$$

$$t = \frac{-2(5.14)}{-10}$$

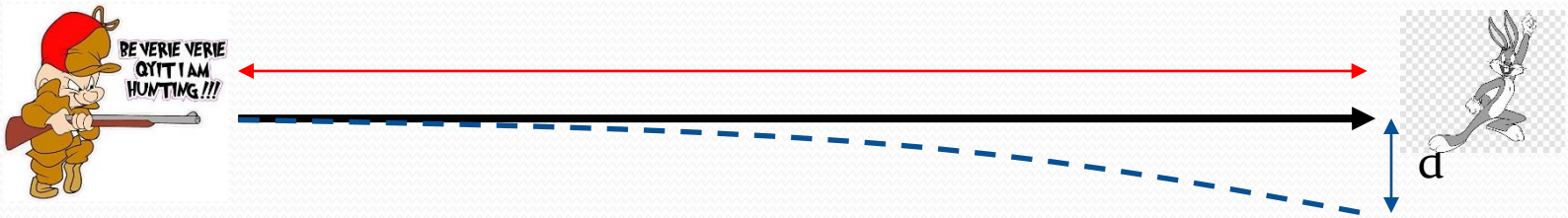
$$t = 1.028\ seconds$$

Range = horizontal displacement:

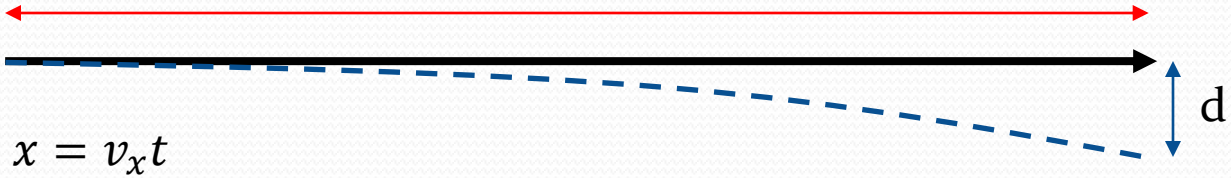
$$x = v_x t$$

$$x = (6.13\ m/s)(1.028\ s) = 6.3\ m$$

6. A hunter aims directly at a target (on the same level) 140 m away. If the bullet leaves the gun at a speed of 280 m/s, by how much will the bullet miss the target?



6. A hunter aims directly at a target (on the same level) 140 m away. If the bullet leaves the gun at a speed of 280 m/s, by how much will the bullet miss the target?



$x = v_x t$

$140 = (280)\, t$

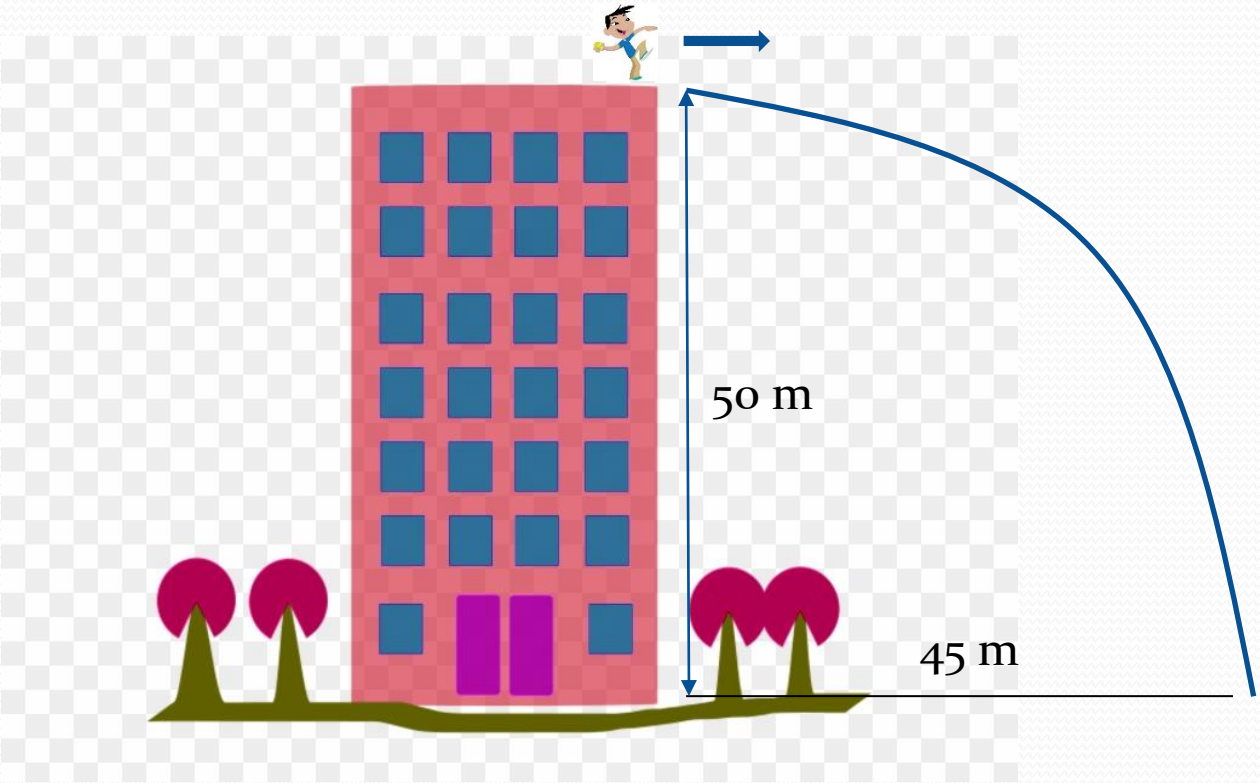
$t = \frac{140}{280} = 0.5\ seconds$

To find "d", we need to use the equation $d = v_i t + \frac{1}{2} a t^2$, where $v_i = 0$

$d = \frac{1}{2}\, a t^2$

$d = \frac{1}{2}\,(-10)(.5)^2 = -1.25$ m

7. A ball is thrown horizontally from the roof of a building 50 m tall and lands 45 m from the base. What was the ball's initial speed?



Determine how long it takes to hit the ground.

$$t = \sqrt{\frac{2d}{a}} = \sqrt{\frac{2(-50)}{-10}} = 3.16\ seconds$$

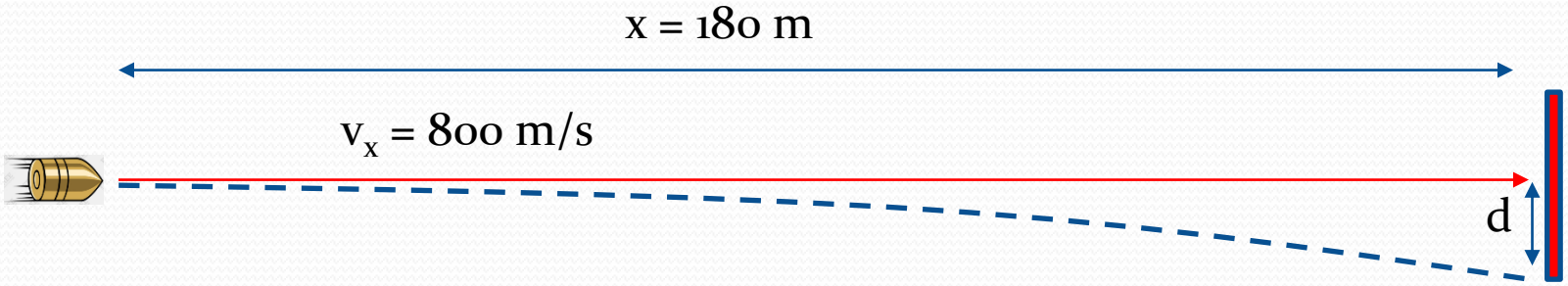
Using horizontal displacement equation $x = v_x t$ to find the original horizontal velocity.

$$x = v_x t$$

$$45 = v_x(3.16)$$

$$v_x = \frac{45}{3.16} = 14.2\ m/s$$

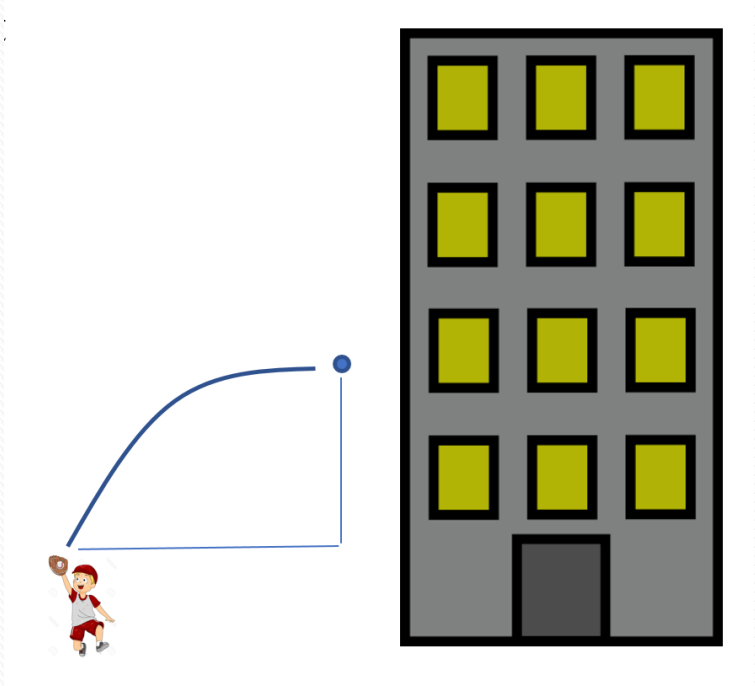
8. A bullet traveling 800 m/s horizontally hits a target 180 m away. How far does the bullet fall before it hits the target?



$$x = v_x t$$
$$180 = 800t$$
$$t = \frac{180}{800} = 0.225s$$

$$d = \frac{1}{2}at^2$$
$$d = \frac{1}{2}(-10)(0.225)^2$$
$$d = -0.25m$$

9. A student threw a ball horizontally out of a window 8 m above the ground. It was caught by another student who was 10.0 m away. What was the initial velocity of the ball?

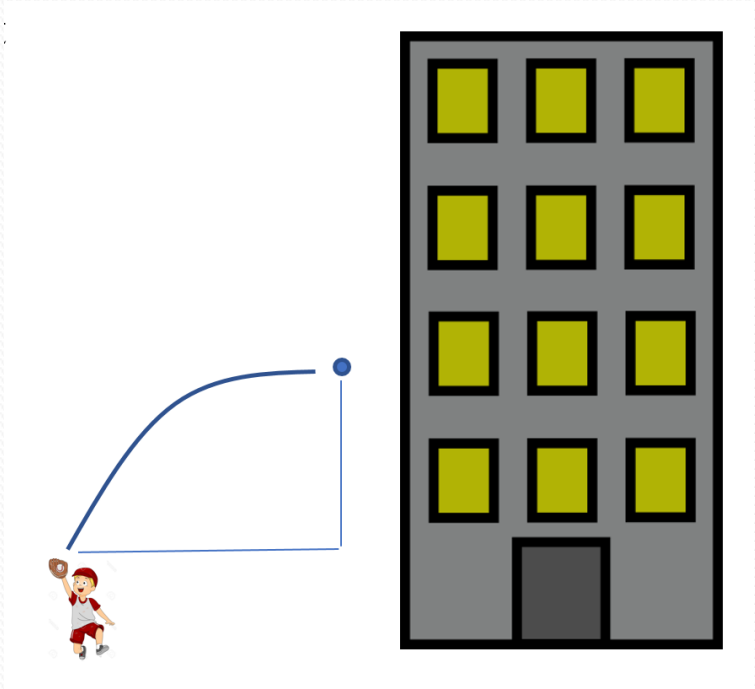


9. A student threw a ball horizontally out of a window 8.0 m above the ground. It was caught by another student who was 10.0 m away. What was the initial velocity of the ball?

$$t = \sqrt{\frac{2d}{g}} = \sqrt{\frac{2(8)}{10}} = 1.26\ s$$

$$x = v_x t$$

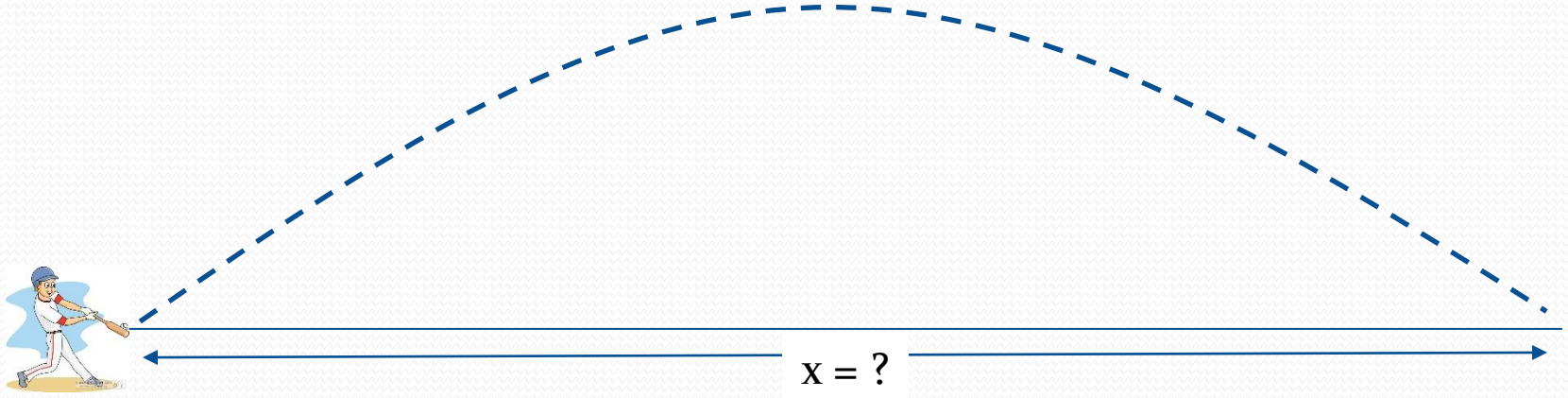
$$v_x = \frac{x}{t} = \frac{10}{1.26} = 7.91\frac{m}{s}$$



10. A baseball was hit at 45 m/s (31.8 m/s horizontally and 31.8 m/s vertically) at an angle of 45° above the horizontal.

a. How long did it remain in the air?

b. How far did it travel horizontally?



10. A baseball was hit at 45 m/s (31.8 m/s horizontally and 31.8 m/s vertically) at an angle of 45° above the horizontal.

a. How long did it remain in the air?

$$total\ flight\ time,$$

$$t = \frac{-2v_i}{a}$$

$$t = \frac{-2(31.8)}{-10} = 6.36\ seconds$$

10. A baseball was hit at 45 m/s (31.8 m/s horizontally and 31.8 m/s vertically) at an angle of 45° above the horizontal.

b. How far did it travel horizontally?

$$x = v_x t$$

$$x = (31.8)(6.36)$$

$$x = 202\ m$$