Name: _____ Date: _____

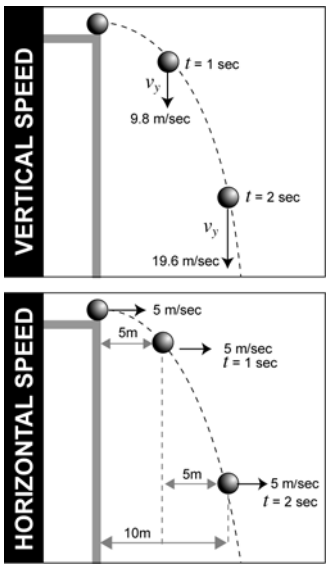
Skill and Practice

6B Projectile Motion

Read:

Projectile motion has vertical and horizontal components

Projectile motion has vertical and horizontal components. Gravity affects the vertical motion of an object. When we drop a ball from a height, we know that its speed increases as it falls. The increase in vertical speed is due to the acceleration gravity, $g = 9.8$ m/s^2. So the vertical speed of the ball will increase by 9.8 m/s after each second. After the first second has passed, the speed will be 9.8 m/s. After the next second has passed, the speed will be 19.6 m/s and so on.



The acceleration of gravity affects only the vertical component of the motion. Horizontal motion is not affected by gravity. So if we neglect the friction from air, when we throw an object horizontally, its initial horizontal speed will not change. For example, if we throw a marble horizontally at a speed of 5 m/s, the marble will be 5 meters horizontally from our hand after one second, 10 meters after 2 seconds, and so forth.

Solving projectile motion problems

Solving projectile motion problems requires using equations. To solve these problems, follow the steps:

- Read the problem carefully. You may want to diagram the problem to help you understand it.
- List what you know from the problem and what you need to solve for.
- Determine which equations for vertical motion or horizontal motion will help you solve the problem. You may need more than one equation to solve the problem. Some important equations are listed below.
- Solve the problem and check your work.

Horizontal distance	$d_x = v_x t$	This equation is a rearranged version of the speed equation: $v = d / t$. v_x should be read as "the initial velocity in the x-direction."
Vertical velocity	$v_y = gt$	Gravity (g) is included in these equations because vertical speed accelerates due to gravity when an object is falling.
Vertical distance	$d_y = 4.9t^2$	

- The equations above are suitable ONLY for situations where the projectile starts with zero vertical velocity, like a ball rolling off a table. If the projectile is launched up or down at an angle, the equations are more complicated.

Example:

A boy runs at a speed of 3.3 meters per second straight off the end of a diving board that is 3 meters above the water. How long is he airborne before he hits the water? What is the horizontal distance he travels while airborne?

a. What do you know?
speed and height

b. What do you need to solve for?
time and horizontal distance

c. What equations will you use?

$$d_y = 4.9t^2 \qquad d_x = v_x t$$

What is the solution to this problem?

time:

$3.0\ \text{m} = 4.9\ t^2$

$0.61 = t^2$

$\sqrt{0.61} = t$

$0.78\ \text{s} = t$

horizontal distance:

$d_x = 3.3\ \text{m/s} \times 0.78\ \text{s}$

$d_x = 2.6\ \text{meters}$

Practice:

Solve the following problems. Show your work.

1. A cat runs and jumps from one roof top to another which is 5 meters away and 3 meters below. Calculate the minimum horizontal speed with which the cat must jump off the first roof in order to make it to the other.

   a. What do you know?

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   b. What do you need to solve for?

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   c. What equation(s) will you use?

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   d. What is the solution to this problem?

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2. An object is thrown off a cliff with a horizontal speed of 10 m/s. After 3 seconds the object hits the ground. Find the height of the cliff and the total horizontal distance traveled by the object.

   a. What do you know?

   b. What do you need to solve for?

   c. What equation(s) will you use?

   d. What is the solution to this problem?

3. If a marble is released from a height of 10 meters, how long would it take for it to hit the ground?

   a. What do you know?

   b. What do you need to solve for?

   c. What equation(s) will you use?

   d. What is the solution to this problem?

4. A ski jumper competing for an Olympic gold medal wants to jump a horizontal distance of 135 meters. The takeoff point of the ski jump is at a height of 25 meters. With what horizontal speed must he leave the jump?

   a. What do you know?

   b. What do you need to solve for?

c. What equation(s) will you use?

d. What is the solution to this problem?

5. A motorcycle stunt driver zooms off the end of a cliff at a speed of 30 meters per second. If he lands after 0.75 seconds, what is the height of the cliff?

a. What do you know?

b. What do you need to solve for?

c. What equation(s) will you use?

d. What is the solution to this problem?

6. A marble rolling at a speed of 2 meters per second falls off the end of a 1-meter high table. How long will the marble be in the air?

a. What do you know?

b. What do you need to solve for?

c. What equation(s) will you use?

d. What is the solution to this problem?

7. **Challenge!** A marshmallow is dropped from a 5-meter high pedestrian bridge and 0.83 seconds later, it lands right on the head of an unsuspecting person walking underneath. How tall is the person with the marshmallow on his head?

   a. What do you know?

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   b. What do you need to solve for?

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   c. What equation(s) will you use?

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   d. What is the solution to this problem?
