Name: ______________________________ Date: __________

Skill and Practice

3I Acceleration Due to Gravity

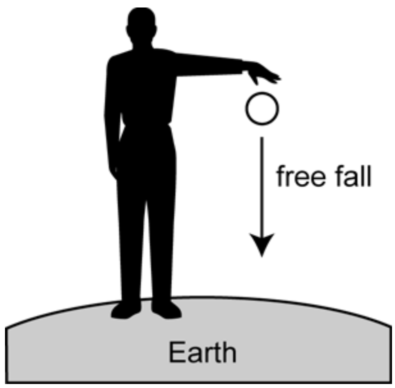
Read:

Acceleration due to gravity is known to be 9.8 meters/second/second or 9.8 m/s^2 and is represented by *g*. Three conditions must be met before we can use this value:

(1) the object must be in free fall

(2) the object must have negligible air resistance, and

(3) the object must be close to the surface of Earth.



In all of the examples and problems, we will assume that these conditions have been met. Remember that speed refers to “how fast” in any direction, but velocity refers to “how fast” in a specific direction. The sign of numbers in these calculations is important. Velocities upward shall be positive, and velocities downward shall be negative. Because the *y*-axis of a graph is vertical, change in height shall be indicated by *y*.

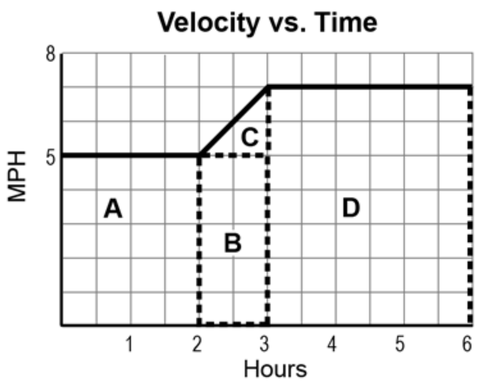
Here is the equation for solving for velocity:

$$\text{final velocity} = \text{initial velocity} + (\text{the acceleration due to the force of gravity} \times \text{time})$$

OR

$$v = v_0 + gt$$

Imagine that an object falls for one second. We know that at the end of the second it will be traveling at 9.8 meters/second. However, it began its fall at zero meters/second. Therefore, its average velocity is half of 9.8 meters/second. We can find distance by multiplying this average velocity by time.



Here is the equation for solving for distance. See if you can find these concepts in the equation:

$$\text{distance} = \frac{\text{the acceleration due to the force of gravity} \times \text{time}}{2} \times \text{time}$$

OR

$$y = \frac{1}{2}gt^2$$

Example:

Example 1: How fast will a pebble be traveling 3.0 seconds after being dropped?

$$v = v_0 + gt$$

$$v = 0 + (-9.8 \text{ m/s}^2 \times 3.0 \text{ s})$$

$$v = -29 \text{ m/s}$$

(Note that *gt* is negative because the direction is downward.)

Example 2: A pebble dropped from a bridge strikes the water in 4.0 seconds. How high is the bridge?

$$y = \frac{1}{2}gt^2$$

$$y = \frac{1}{2} \times 9.8 \text{ m/s} \times 4.0 \text{ s} \times 4.0 \text{ s}$$

$$y = \frac{1}{2} \times 9.8 \text{ m/s}^2 \times 4.0 \text{ s} \times 4.0 \text{ s}$$

$$y = 78.4 \text{ meters}$$

Note that the seconds cancel. The answer written with the correct number of significant figures is 78 meters. The bridge is 78 meters high.

Practice:

1. A penny dropped into a wishing well reaches the bottom in 1.50 seconds. What was the velocity at impact?

2. A pitcher threw a baseball straight up at 35.8 meters per second. What was the ball's velocity after 2.50 seconds? (Note that, although the baseball is still climbing, gravity is accelerating it downward.)

3. In a bizarre but harmless accident, a watermelon fell from the top of the Eiffel Tower. How fast was the watermelon traveling when it hit the ground 7.80 seconds after falling?

4. A water balloon was dropped from a high window and struck its target 1.1 seconds later. If the balloon left the person's hand at –5.0 meters per second, what was its velocity on impact?

5. A stone tumbles into a mine shaft and strikes bottom after falling for 4.2 seconds. How deep is the mine shaft?

6. A boy threw a small bundle toward his girlfriend on a balcony 10. meters above him. The bundle stopped rising in 1.5 seconds. How high did the bundle travel? Was that high enough for her to catch it?

The equations demonstrated so far can be used to find time of flight from speed or distance, respectively. Remember that an object thrown into the air represents two mirror-image flights, one up and the other down.

	Original equation	Rearranged equation to solve for time
Time from velocity	$v = v_0 + gt$	$t = \frac{v - v_0}{g}$
Time from distance	$y = \frac{1}{2}gt^2$	$t = \sqrt{\frac{2y}{g}}$

7. At about 55 meters per second, a falling parachuter (before the parachute opens) no longer accelerates. Air friction opposes acceleration. Although the effect of air friction begins gradually, imagine that the parachuter is free falling until terminal speed (the constant falling speed) is reached. How long would that take?

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8. The climber dropped her compass at the end of her 240-meter climb. How long did it take to strike bottom?
