Physics – Classwork **Name:**
Kinematics - Free Fall Problem Set I **Date:**

Vocabulary **Free Fall:** The movement of an object in response to a gravitational attraction.

When an object is released, it falls toward the earth due to the gravitational attraction the earth provides. As the object falls, it will accelerate at a constant rate of about 9.8 m/s^2 regardless of its mass. However, to make calculations more expedient and easier to do without a calculator, sometimes this number will be written as $g = 10.0\ m/s^2$.

There are many different ways to solve free fall exercises. The sign convention used may be chosen by you or your teacher. The downward direction will be positive, and anything falling downward will be written with a positive velocity and position; anything moving upward will be represented with a negative velocity and position. Remember: Gravity *always* acts to pull an object down. The gravitational acceleration will may be written as a positive or negative number depending on how direction is defined by the coordinate system. Note that sometimes the "a" for acceleration is also written as "a_g"or just "g".

The displacement of a falling object in a given amount of time is written as

$$\Delta x = v_0\Delta t + (½)a\Delta t^2$$

The final velocity of a falling object can be represented by the equation

$$v_1^2 = v_0^2 + 2a\Delta x$$

or by the earlier equation, $a = (v_1 - v_o)/\Delta t$,

rewritten as $v_1 = v_o + a\Delta t$,

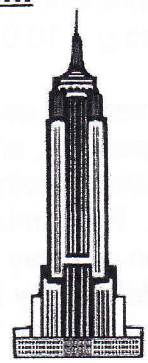
Therefore, these equations can be used for objects moving horizontally as well as vertically.

It is common to neglect air resistance in most free fall exercises, although in real life, air resistance is a factor that must be taken into account. We will also assume that the initial speed of all objects in free fall is zero, unless otherwise specified.

Solved Examples: Free Fall

1) King Kong carries Fay Wray up the 321 m-tall Empire State Building. At the top of the skyscraper, Fay Wray's shoe falls from her foot. How fast will the shoe be moving when it hits the ground?

Sketch:



Given:

$v_o = 0$ m/s

$g = 10.0$ m/s^2

$v_f = ?$

Solve:

$v_f^2 = v_o^2 + 2g\Delta x$

$v_f = \sqrt{(v_o^2 + 2g\Delta x)}$

$v_f = \sqrt{(0 + 2(10.0 \text{ m/s}^2)(321 \text{ m})}$

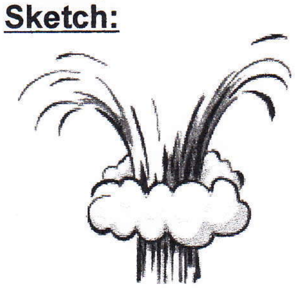
$v_f = \sqrt{(6420 \text{ m}^2/\text{s}^2)}$

$v_f = 80.1$ m/s

2) The Steamboat Geyser in Yellowstone National park, Wyoming is capable of shooting its hot water up from the ground with a speed of 48.0 m/s. How high can this geyser shoot?

Solution: Remember, the geyser is shooting up; therefore it must have a negative initial velocity.

Sketch:



Given:

$v_o = -48.0$ m/s

$v_f = 0$

$g = 10.0$ m/s^2

$\Delta x = ?$

Solve:

$v_1^2 = v_o^2 + 2g\Delta x$

$\Delta x = (v_1^2 - v_o^2)/2g$

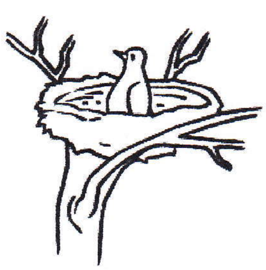
$\Delta x = [(0 \text{ m/s})^2 - (-48.0 \text{ m/s})^2]/2(10.0\text{m/s}^2)$

$\Delta x = -115$ m

As you might expect, the final answer has a negative displacement. This means that the total distance the water traveled is measured up from the ground.

3) A baby blue jay sits in a tall tree awaiting the arrival of its dinner. As the motion lands on the nest, she drops a worm toward the hungry chick's mouth, but the worm misses and falls from the nest to the ground in 1.50 s. How high up is the nest?

Sketch:



Given:

$v_o = 0$ m/s

$g = 10.0$ m/s

$t = 1.50$ s

$\Delta x = ?$

Solve:

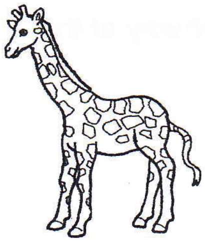
$\Delta x = v_o\Delta t + (½)g\Delta t^2$

$\Delta x = 0 + (½)(10.0 \text{ m/s}^2)(1.50 \text{ s})^2$

$\Delta x = 11.3$ m

4) A giraffe, who stands 6.00 m tall, bites a branch off a tree to chew on the leaves, and he lets the branch fall to the ground. How long does it take the branch to hit the ground?

Sketch:



Given:

$\Delta x = 6.00$ m

$g = 10.0$ m/s^2

$v_o = 0$ m/s

$\Delta t = ?$

Solve:

$\Delta x = v_o\Delta t + (½)g\Delta t^2$

$\Delta t = \sqrt{(2\Delta x/g)}$

$\Delta t = \sqrt{[2(6.00 \text{ m})/10.0 \text{ m/s}^2]}$

$\Delta t = \sqrt{1.20 \text{ s}^2}$

$\Delta t = 1.10$ s

Practice Exercises: Free Fall

1) Billy, a mountain goat, is rock climbing on his favorite slope one sunny spring morning when a rock comes hurtling toward him from a ledge 40.0 m above. Billy ducks and avoids injury.

a) How fast is the rock traveling when it passes Billy?

b) How does this speed compare to that of a car traveling down the highway at the speed limit of 25 m/s (equivalent to 55 mi/h)?

Sketch: **Given:** **Solve:**

Answer: a. _______

Answer: b. _______

2) Reverend Chanter climbs to the church belfry one morning to determine the height of the church. From an outside balcony he drops a book and observes that it takes 2.00 s to strike the ground below.

a) How high is the balcony of the church belfry?

b) Why would it be difficult to determine the height of the belfry balcony if the Reverend dropped only one page out of the book?

Sketch: **Given:** **Solve:**

Answer: a. _______

Answer: b. ____

____

3) How long is Ella, a ballerina, in the air when she leaps straight up with a speed of 1.0 m/s?

Sketch: **Given:** **Solve:**

Answer: ________

4) In order to open the clam it catches, a seagull will drop the clam repeatedly onto a hard surface from high in the air until the shell cracks. If a seagull flies to a height of 25 m, how long will the clam take to fall?

Sketch: **Given:** **Solve:**

Answer: ________

5) At Six Flags Great Adventure Amusement Park in New Jersey, a popular ride known as "Free Fall" carries passengers up to a height of 33.5 m and drops them to the ground inside a small cage. How fast are the passengers going at the bottom of this exhilarating journey?

Sketch: **Given:** **Solve:**

Answer: ________

6) A unique type of basketball is played on the planet Zarth. During the game, a player flies above the basket and drops the ball in from a height of 10 m. If the ball takes 5.0 s to fall, find the acceleration due to gravity on Zarth.

Sketch: **Given:** **Solve:**

Answer: ________