

Name: _____ **Book:** ____ **Period:** ____ **Due Date:** _____
Lab Partners: _____

P rojectiles - Vertical Motion - WebAssign

Purpose: To study the vertical motion of projectiles as freely falling bodies. Once a projectile loses contact with its launcher, the only force it experiences is gravity. You will launch a projectile vertically with three different initial velocities and analyze its behavior as it travels up and down along a vertical "free-fall" trajectory under the influence of gravity alone.

Part One: The Muzzle Speed of a Projectile

Procedure:

1. Place the projectile launcher on the floor near the wall and fire it vertically upward.
(Never look down the muzzle of the launcher, especially when a projectile is in place and ready to launch.)
 2. Place a post-it note on the wall to mark the highest point reached by the ball at each launcher setting. Try several launchings at each setting to refine your initial placement of the post-it note.
 3. Measure the distance between the **top of the launcher** and the **highest point** reached by the projectile.
 4. Repeat the procedure using all three launcher settings (Short Range, Medium Range, and Long Range).
5. Launcher Label: _____; Launcher Height = y_i = _____ cm = _____ m

Launcher Setting	y_f = Maximum Height	y_f = Maximum Height	$y_f - y_i$ = Displacement
Short Range	_____ cm	_____ m	_____ m
Medium Range	_____ cm	_____ m	_____ m
Long Range	_____ cm	_____ m	_____ m

$y_f - y_i$ is the Displacement from the top of the launcher up to the Highest Point reached by the ball.

Calculations: (Assume in this analysis that the positive direction is upward.)

At the top of the flight, $v = 0$. During the entire flight, $g = -9.80 \text{ m/s}^2$. The ball rises by a displacement of $y_f - y_i$. Using the third accelerated motion equation, $v_f^2 = v_i^2 + 2g(y_f - y_i)$, calculate the initial velocity, v_i .

Launcher Position	v_i = Launch Velocity	v_i to the correct number of Significant Digits
Short Range	_____ m/s	= _____ m/s
Medium Range	_____ m/s	= _____ m/s
Long Range	_____ m/s	= _____ m/s

The projectiles used with these launchers are light enough that we can assume the initial velocity is independent of orientation. You can also assume that the initial velocity is independent of the local value of g . That is to say that the launcher produces the same initial velocity independently of which way it points, or planet or moon you launch from.

Part Two: Measuring the Height of the Balcony

This exercise is performed in lieu of a BASE-jumping demonstration and it's a much safer, as well.

- Drop a ball from the top of the balcony railing. Use a stopwatch to time the duration of the free-fall. Repeat the procedure until you are confident of the drop time to the nearest tenth of a second. If you have three times that cluster together, report the average to the nearest 1/100th of a second. Don't anticipate the drop or the landing with the stopwatch. Wait for the ball to start moving and then wait for it to hit bottom before pushing the start/stop button on the stopwatch.

Measured Drop Time _____ s

- Measure the balcony height using three different methods.

(A) Measured Height = _____ (using string with a knot every meter) _____ m

(B) Measured Height = _____ (tape measure) _____ m

(C) Measure the parts of the stairway and balcony:

Step Height = _____ cm/step

Measured Height = $\frac{\text{Step Height}}{\text{Step Height}}$ m/step x $\frac{\text{# of Steps}}{\text{# of Steps}}$ steps + $\frac{\text{Railing Height}}{\text{Railing Height}}$ m = $\frac{\text{Height to Top of Rail}}{\text{Height to Top of Rail}}$ m

- Calculate the balcony height using the measured drop time and the accelerated motion equations.
Show your work here: **(In all the analyses in this section, downward is the positive direction.)**

Calculated Balcony Height (*using the measured drop time*) = _____ m

- Assuming the tape-measured height is the correct height; calculate the %Uncertainty in the calculated height based on the measured drop time. Show your work here:

%Uncertainty in calculated balcony height (*relative to the height from section 2B*) = _____ %

- Calculate the correct (*true*) drop time using the tape-measured balcony height (from section 2B).
Show your work here:

True drop time based on tape-measured balcony height = _____ s

- %Uncertainty in measured drop time from section 1 (*relative to the true drop time calculated in Section 5 above*).
Show your work here:

%Uncertainty = _____ %

Part Two: Analysis Questions: (Downward is still the positive direction.)

1. To simplify this question, suppose that the acceleration of gravity is exactly 10.0 m/s^2 (*We won't use this assumption very often*). If something is dropped, how far does it fall during the 1st second? (from $t = 0 \text{ s}$ to $t = 1 \text{ s}$)

$$d \text{ (from } t = 0 \text{ s to } t = 1 \text{ s)} = \underline{\hspace{2cm}} \text{ m}$$

2. What is the cumulative distance fallen in the first two seconds? (from $t = 0 \text{ s}$ to $t = 2 \text{ s}$)

$$d \text{ (from } t = 0 \text{ s to } t = 2 \text{ s)} = \underline{\hspace{2cm}} \text{ m}$$

How far does it fall during the 2nd second? (from $t = 1 \text{ s}$ to $t = 2 \text{ s}$)

$$d \text{ (from } t = 1 \text{ s to } t = 2 \text{ s)} = \underline{\hspace{2cm}} \text{ m}$$

3. What is the cumulative distance fallen in the first three seconds? (from $t = 0 \text{ s}$ to $t = 3 \text{ s}$)

$$d \text{ (from } t = 0 \text{ s to } t = 3 \text{ s)} = \underline{\hspace{2cm}} \text{ m}$$

How far does it fall during the 3rd second? ($t = 2 \text{ s}$ to $t = 3 \text{ s}$)

$$d \text{ (from } t = 2 \text{ s to } t = 3 \text{ s)} = \underline{\hspace{2cm}} \text{ m}$$

4. Predict, without using a calculator, the cumulative distance fallen during the first four, then during the first five, and then during the first six seconds.

$$\begin{aligned} d \text{ (from } t = 0 \text{ s to } t = 4 \text{ s)} &= \underline{\hspace{2cm}} \text{ m,} \\ d \text{ (from } t = 0 \text{ s to } t = 5 \text{ s)} &= \underline{\hspace{2cm}} \text{ m,} \\ d \text{ (from } t = 0 \text{ s to } t = 6 \text{ s)} &= \underline{\hspace{2cm}} \text{ m} \end{aligned}$$

Now, without using a calculator, predict the distance fallen during the 4th, 5th, and 6th seconds.

$$\begin{aligned} d \text{ (from } t = 3 \text{ s to } t = 4 \text{ s)} &= \underline{\hspace{2cm}} \text{ m,} \\ d \text{ (from } t = 4 \text{ s to } t = 5 \text{ s)} &= \underline{\hspace{2cm}} \text{ m,} \\ d \text{ (from } t = 5 \text{ s to } t = 6 \text{ s)} &= \underline{\hspace{2cm}} \text{ m} \end{aligned}$$

How is the trend you've noticed in the distances fallen in consecutive seconds related to the acceleration?

Is this a general result? Would it be true, in terms of the local value of g , at various latitudes and elevations on Earth and even on other planets and moons? Why or why not?

Part Three: Testing your Reaction Time

Procedure: (In all the analyses in this section, downward is the positive direction.)

1. Have a partner hold a ruler with the 0.0 cm line at the bottom and let the bottom end hang freely. Place two fingers and the thumb of one hand at the 0 cm mark, but not touching the ruler.

2. After your partner lets go, you must grab the stick as quickly as possible. Do not try to anticipate the drop. Watch and wait for it to move. Record the centimeter mark where you caught the ruler.

Mark = _____ cm = _____ m

3. Now calculate your reaction time. Remember that $v_i = 0$; let $a = g = 9.80 \text{ m/s}^2$, and $y_f - y_i$ will be positive. Show your work here:

Your personal reaction time = _____ s = _____ ms

Part Three: Analysis Questions for reaction time:

1. Suppose you are traveling at 20 miles per hour in a school zone and see a child dart out in front of you. Use your personal reaction time, not your lab partner's, to calculate the number of feet your car will travel before your foot touches the brake pedal. Start by calculating the velocity.

Show your work here:

Velocity = _____ ft/sec; Distance traveled before touching the brakes _____ ft

2. Do the same calculation assuming you are traveling at 70 mph on the freeway.

Show your work here:

Velocity = _____ ft/sec; Distance traveled before touching the brakes _____ ft

3. Now suppose that you are traveling at 70 mph and need to stop in 150 ft. Considering your measured reaction time and the distance traveled before your foot touched the break pedal, what acceleration would you need to achieve in order to stop in the remaining distance? Show your work here:

Distance available for stopping (*after allowing for reaction time*) = _____ ft = _____ m

Initial velocity = 70 mph = _____ ft/min = _____ in/s = _____ m/s

Average acceleration (*after you step on the break, until stopped*) = _____ m/s²
(*Negative acceleration means the acceleration vector points opposite to the velocity vector direction.*)