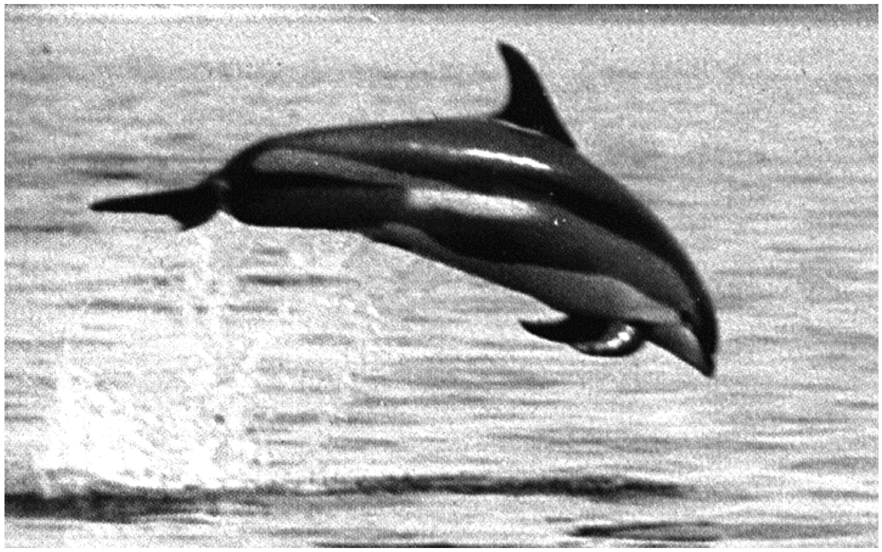
Name: ______________________________
Partners: ______________________________
____

PHYSICS 220 LAB #2: PROJECTILE MOTION



As a dolphin leaps out of the water, it experiences a change in velocity that is the same as that of any other mass moving freely close to the surface of the earth. It is undergoing what physicist's call projectile motion. The path it follows while above the water has the same mathematical characteristics as a basketball on its way to the hoop or any other object that is not strongly affected by air resistance.

(Equipment: PC, Lab Pro, Photogate & stand, long Plexiglas with stripes)

OBJECTIVES

A. To study the nature of motion near the earth's surface.
B. To understand that projectile motion can be described as independent horizontal and vertical motions.
C. To learn how to use a video analysis program.

OVERVIEW

The motion of an object in free fall is too fast to analyze carefully without the aid of some equipment. You will use a timing gate which measures when objects go past and video analysis software which allows you to get data about the motion of an object in a movie.

When air resistance can be ignored, the motion of a projectile is relatively simple since the horizontal and vertical parts of the motion can be described separately. If you call the horizontal axis "x" and the vertical one "y", the equations of motion are:

$$x = x_i + v_{xi}t \qquad v_x = v_{xi}$$

$$y = y_i + v_{yi}t + \tfrac{1}{2}a_y t^2 \qquad v_y = v_{yi} + a_y t$$

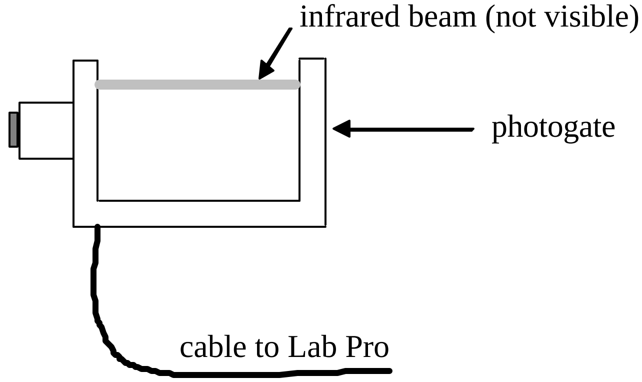
where x_0 and y_0 are the components of the initial position and v_{x0} and v_{y0} are the components of the initial velocity. Ideally, there is no acceleration in the horizontal direction and in the vertical direction the acceleration is 9.8 m/s^2 downward (the sign depends on how you choose your axis).

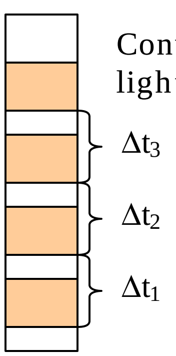
PRE-LAB (to be completed before coming to lab)

Prior to coming to lab, read through this write-up and perform all the exercises labeled "**Pre-Lab**". You will also want to copy this work onto the back pages of the lab, which I will collect during the first 5 minutes of lab.

PART ONE: One-Dimensional Free Fall

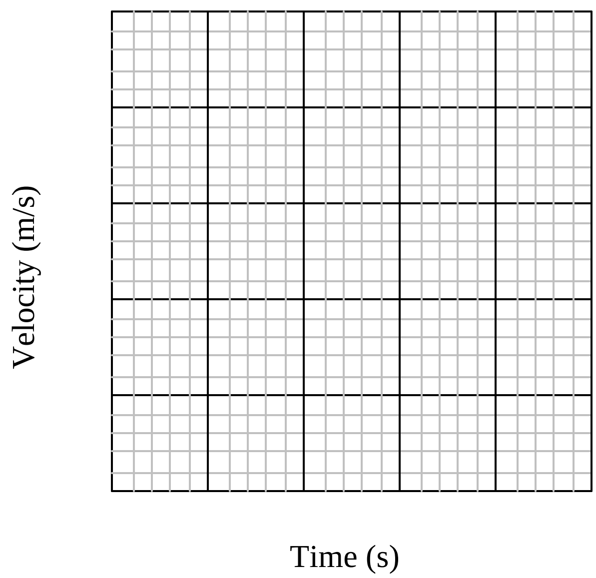
1. Plug the Photo Gate into Lab Pro's Dig/Sonic 1 port. Double click on the file **Photo Gate** (in Physics Experiments / Physics 220 – 221/ Projectile Motion) to start the program with the appropriate set up.
2. Press "Collect" and slowly pass a piece of plexigass with stripes on it through the photogate. The light (red LED) on the photogate should light up anytime there is something in the middle of it blocking the infrared beam. Carefully observe what the timer measures. Press "Stop" to stop acquiring data.





Convince yourself that the timer starts and stops when the photogate's light beam transitions from unblocked to blocked.

3. Measure the distance on the Plexiglas that passes during one time measurement and enter it into the program. Under the menu Experiment, select Sensors, click on the Photo gate icon, and select Distance or Length. In the new window, scroll down to User Defined and enter the distance. Be sure you give it in correct units.
4. Now you are ready to let the plexiglass strip free-fall through the photogate. Hold the plexiglass so that all of the stripes are above the photogate. Push “Collect”. When you release the plexiglass, the timer will automatically start collecting data. Push the “Stop” button after the plexiglass has passed all of the way through.
5. The program will automatically produce a velocity vs. time graph using the width of the stripes and the time they take to pass. Sketch the graph on the grid below and write down the slope <u>with appropriate units</u>. (Note: A positive velocity means downward in this case!)



Slope = ______________________________

Pre-Lab: What do you expect the slope of the graph to be (give numeric value with units)?

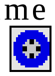
Question: Is the numeric value of the slope of the graph what you expect it to be? Explain.

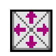
Before Proceeding: *Check your answer with the instructor.*

PART TWO: Two-Dimensional Motion

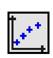
1. Select one of the following movies from Physics Experiments / Physics220-221 / Projectile Motion: 30°Launch.mov, 45°Launch.mov, or 60°Launch.mov.

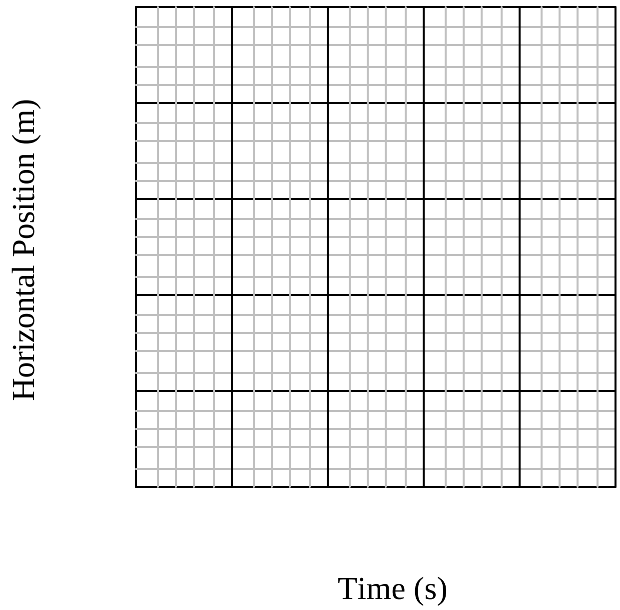
2. Open the movie in **VideoPoint 2.0** (found on the Launcher on the computer desktop) and enter “1” for the “number of features or objects to be located.” To make it easier to see, enlarge the movie by selecting “Fill Screen” under the *Movie* menu.

3. Use the  button to skip over movie frames before the object was in the air (not in contact with anything else). For each frame in which the object is in the air, carefully move the cursor to the location of the center of the object and click the mouse button. Once you have selected both points in a frame, the program will automatically move to the next frame in the movie. If the cursor changes from a “cross hair”, use the  button to continue marking locations. If you miss-click, you will have the opportunity to correct that shortly.

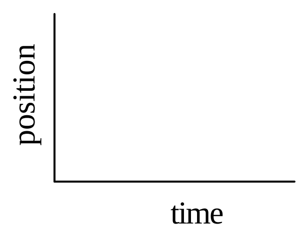
4. Step through the movie again using the  and  buttons and adjust the locations of any points that aren’t well placed by dragging them around or using the  button to nudge them in the appropriate direction.

5. Click on the ruler button  to set the distance scale for the movie. Select “1 meter” and click “continue.” Next click on the ends of the meter stick in the movie. (The program should be able to figure out how many frames per second to set the time scale.)

6. Click on the graph button  to create new graph. Make a graph of the x-component of the position vs. time by selecting “Point S1”, “x”, and “position” for the vertical axis. (Note: The first variable listed should always appear on the vertical axis.) Sketch and label the graph on the grid below. If the plot is too scrunched, you can narrow the time range by clicking on and replacing the first and/or last value along the axis.



Pre-lab: Sketch the horizontal position vs. time you'd expect for projectile motion.



7. Under the *Graph* menu, select "Add/Edit Fit". Make a "linear" fit to the data. Write the equation for x(t) below. Don't just copy what's above the graph: *Include units* with each constant; what it calls "x" you'd call something else…

   $x =$

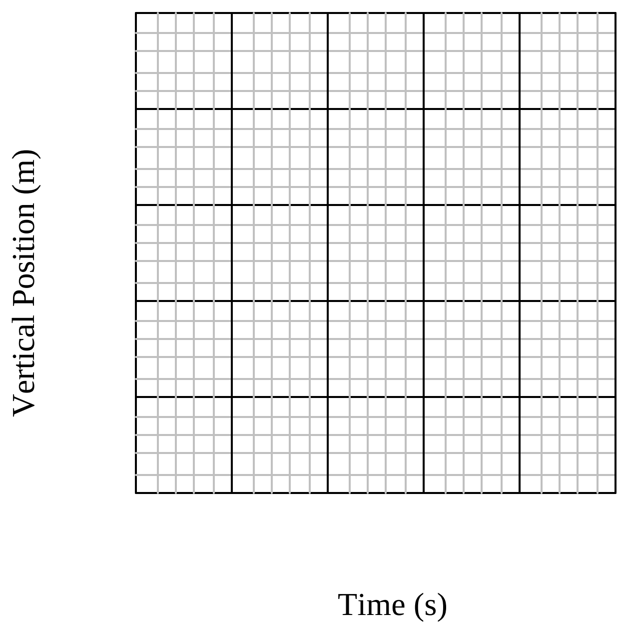
Pre-Lab: What kinematic equation (bottom of pg. 1) describes the horizontal component of projectile's position as a function of time?

$x =$

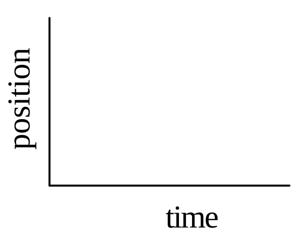
Question: Comparing the two preceding equations, what are the kinematic quantities that each of the numeric values in the fit equation represent (note: not asking for "slope" and "Y-intercept")?

Question: Does the sign of each of the constants make sense? Explain in terms of the motion of the object.

8. Make a graph of the y-component of the position vs. time by selecting “Point S1”, “y”, and “position” for the vertical axis. Sketch and label the graph on the grid below.



Pre-Lab: Sketch what you expect for the vertical component of projectile motion.



9. Under the *Graph* menu, select “Add/Edit Fit”. Make a fit with order to the data. (If you don’t know the type of fit line, try applying a few different ones until one fits well.) Write the equation for y(t) below.

Again, don't just copy what's above the graph: *Include units* with each constant, what it calls "x" you'd call something else…

$y =$

Pre-Lab: What kinematic equation describes the vertical component of projectile's position?

$y =$

Question: Comparing the two preceding equations, what is the kinematic meaning of each of the numeric values in the equation that fits your data?

Question: Does the sign of each of the constants make sense? Explain in terms of the motion of the object.

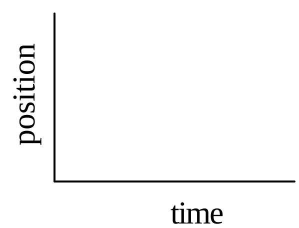
Question: What is the acceleration due to gravity (g) according to your data? (Hint: Use one of the fits to the data, <u>not</u> individual data points.)

Before turning in: *Check you answer with the instructor.*

Pre-Lab #2 **Name:** ___________________

Pre-Lab: What do you expect the slope of the graph to be (give numeric value with units)?

Pre-lab: Sketch the horizontal position vs. time you'd expect for projectile motion.



Pre-Lab: What equation describes the horizontal component of projectile's position as a function of time?

$x(t) =$

Pre-Lab: Sketch what you expect for the vertical component of projectile motion.