

One Dimensional Motion using an Incline Plane Activity

Purpose

A cart traveling down an inclined plane approximately represents a condition of constant acceleration. Using two photogates, an almost frictionless track, and a cart, you will determine the time it takes the cart to travel various distances, and you will create a scatter plot position vs. time using Excel. After fitting your data with an appropriate fit, the fit equation can be used to determine the velocity (initial velocity) of the cart as it reaches the first photogate, and the acceleration of the cart. After you have determined the initial velocity and the acceleration of your cart, your TA will position your photogates a set distance apart, and you will determine the time that it will take for your cart to go from photogate 1 to photogate 2.

Pre Lab (10 pts)

Part I (40pts total)

A photogate is a device that uses a beam of light and a detector to act as a switch. When the beam of light is broken, the detector can send a signal to a controller that could activate a multitude of devices. In this case, we will use two photogates to start and stop a timer.

Physically connect the photogates to the PASCO interface, and make sure the interface is turned on. Since the cart is too wide to fit through the photogates, an item referred to as a five pattern picket fence (PF) will be installed on the cart. The PF is a flat piece of plastic with various dark patterns. The dark patterns can be used to block the photogate's beam. Select which pattern you would like to use (it is recommended to use one of the rows with a solid pattern), and set the height of the photogates correspondingly. Each photogate has a red LED that should come on when the photogate is blocked. It is important that the photogates be set to the same height.

We will now be using a program to collect and analyze data. The program is called **PASCO Capstone** and can be found in the Windows Start Menu.

In the Start Menu, open all programs. Click on COSAM Software and then click on Physics. You should find the **PASCO Capstone** file under Physics. Open Capstone.

Open PASCO Capstone and select Hardware Setup on the top left (see Figure 1). Ensure the Science Workshop 750 / Universal 850 is detected and select Port 1 to add a sensor and select “photogate” from the dropdown menu. Repeat for port 2, adding a second photogate (see figure 2).



Figure 1



Figure 2

Click the **Timer Setup** button in the left sidebar and set-up a timer (Figure 3). The timer should start when Photogate #1 is blocked, and the timer should stop when Photogate #2 is blocked. Begin by selecting “build your own timer” in the dropdown. While in the Timer setup window, select both photogates, and select “Blocked” for the timing sequence of each (Figure 4).

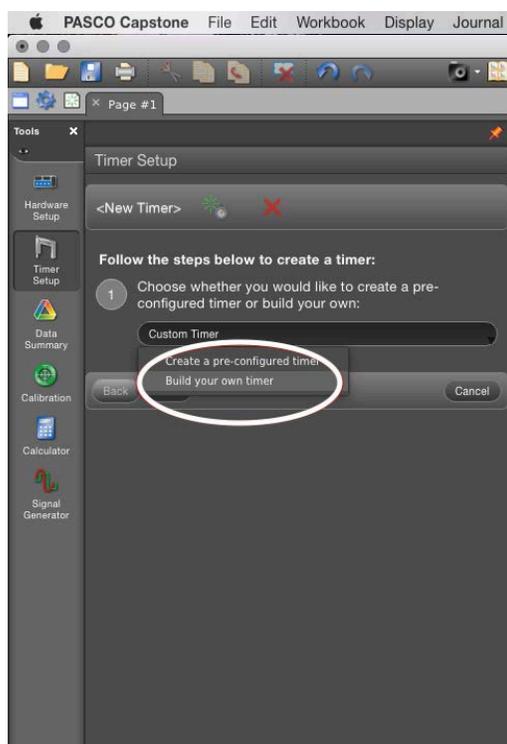


Figure 3

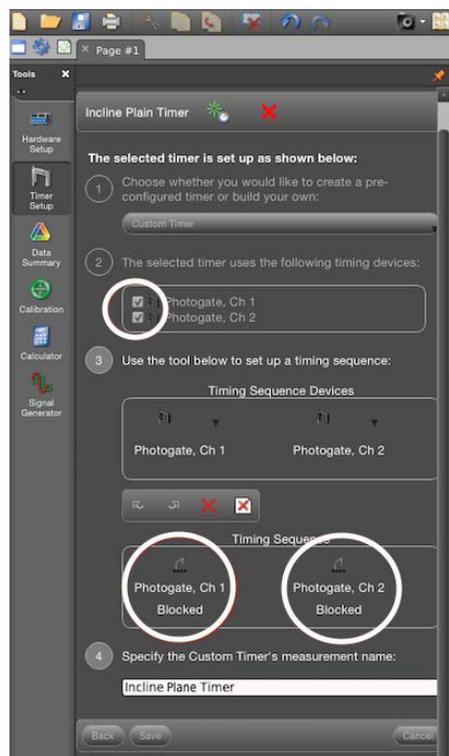
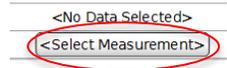


Figure 4

Press the next button, and give the timer an appropriate name. After naming the timer press the save button.

In order to monitor the timer, a table will need to be created. Drag the **Table** icon from the Display right sidebar to the center of the application (Figure 5). There should be two columns in the table. The first column will be used to track the distance between photogates. Click on the “Select Measurement” button in the first column.



Select “Create New” and then “User-Entered Data”. Now change the column label to ‘Distance’ and the units to ‘m’. The second column will be used to collect the time between photogates. After clicking on the “Select Measurement” button in the second column, choose the name of your custom timer. The completed table should look something like Figure 6.

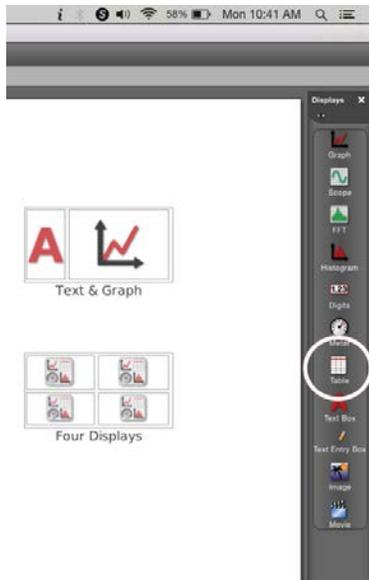


Figure 5

	Set Distance (m)	<No Data Selected> Time Between Photogates (s)
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		

Figure 6

Now, on the bottom left, change Continuous Mode to Keep Mode. See Figure 7.



Figure 7

Data Collection

Before collecting data, it is recommended to review the list of hints that are located on the first page of the Data Sheet.

Start the data collection process by pressing the **Preview** button. While in **Preview** mode, data from a data run can be kept by pressing the **Keep Sample** checkmark, or data collection can be stopped by pressing the button with the red square. However, if you press the button with the red square prior to pressing the **Keep** button, the last data point will be lost. If you do not wish to keep the last data point collected, just rerun the trial without clicking a button, and the data point will be automatically replaced with the new data point.

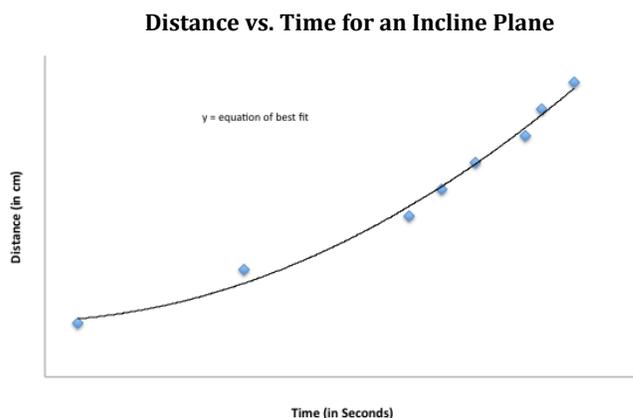
Prior to releasing the cart, flick a finger through the second photogate to ensure that the timer is not running. The timer may begin running if the cart is pushed up the inclined track to the start position.

After the first time is kept, click in the cell containing the first time and use the following icons located in the menu bar of the table to adjust the number of decimal places being displayed to four decimal places.



When a time is kept, the corresponding distance should be manually recorded in the table. Multiple times should be collected for the same distance. After collecting times for a particular distance, move the second photogate to begin collecting times for a new distance. It is highly recommended to keep the first photogate's position constant. After the second photogate is repositioned for a new distance, continue collecting data as before. The red square (stop data acquisition) button should not be pressed until all data is collected.

After all data has been collected, copy the Capstone data table, and paste it into Excel. Add a row of data so that 0,0 is included in your data. This represents zero time at position zero. Using Excel, create a scatter plot of distance vs time. Fit the data with an appropriate fit, and display the fit equation on the plot. Do not force the fit through zero. Make sure the coefficients of the fit equation are displayed to at least four decimal places. Using the fit equation, determine the acceleration and initial velocity of the cart.



Your Excel plot should look *something* like this. Be sure to plot distance and time on the correct axes. Also ensure you have the correct line and equation of best fit. How does it correlate to a kinematics equation?

Part II (50pts total)

After the acceleration and the initial velocity have been determined, the TA will remove the picket fence from the station and reposition your second photogate. The group will need to predict the time it will take the cart to travel between the two photogates. After the group has determined the time it will take for the cart to travel between the photogates, the TA will return your picket fence and witness the times. The average of three trials will determine the group's time, and a grade will be based on percent error.

Name: _____

Banner ID: _____

Lab Group ID: _____

Number of Lab Partners: _____

Data Sheet

Lab 2M with Track and Photogates

Hints:

1. Be mindful of which photogate is plugged into which port.
2. The first photogate should be positioned such that it is not blocked before the cart is released. It is recommended to allow the cart to move at least 5cm before the first photogate is blocked.
3. Since the timer does not begin until the first photogate is blocked, it would be beneficial to correspond the position of the first photogate as the initial position with a value of zero. Therefore when the cart reaches the initial position, the cart will have an initial velocity that is not zero.
4. Do not move the position of the first photogate after you begin collecting data.
5. It is critical to start the cart from rest and from the same point on the track for each trial. Pull the back of the cart against the stop located at the top of the incline and release the cart without giving it a push.
6. The angle of the track must remain constant.
7. Be aware that the adjustable backstop and one end of the cart have magnets.
8. Use MS Excel to plot and fit your data.

Pre Lab (10 pts) _____

Part I (40pts total)

Print and attach the table of distances and times from capstone.

Attach the plot of position vs time (10, 8, 5, or 0 points)

Group's Determination of the Cart's Acceleration: _____ (15, 10, 5, or 0 points)

Group's Determination of the Cart's Initial Velocity (at the 1st Photogate): _____ (15, 7, or 0 points)

TA Verification of the plot's fit coefficients. A: _____ B: _____ C: _____

Attach all data, calculations, and plots.

Part II (50pts total)

Position of PG1: _____ Position of PG2: _____

[The TA should remove the group's picket fence after positioning the photogates]

Time predicted by group for cart to travel from PG1 to PG2: _____ (A)

Actual Times Witnessed by TA _____

Average of Actual Times (B): _____

$$\text{Percent Difference} = \frac{|A - B|}{B} \times 100\% = \underline{\hspace{2cm}}$$

Percent Difference	$\leq 0.5\%$	$\leq 1\%$	$\leq 2\%$	$\leq 3\%$	$\leq 4\%$	$> 4\%$
Points	50	45	40	25	10	0