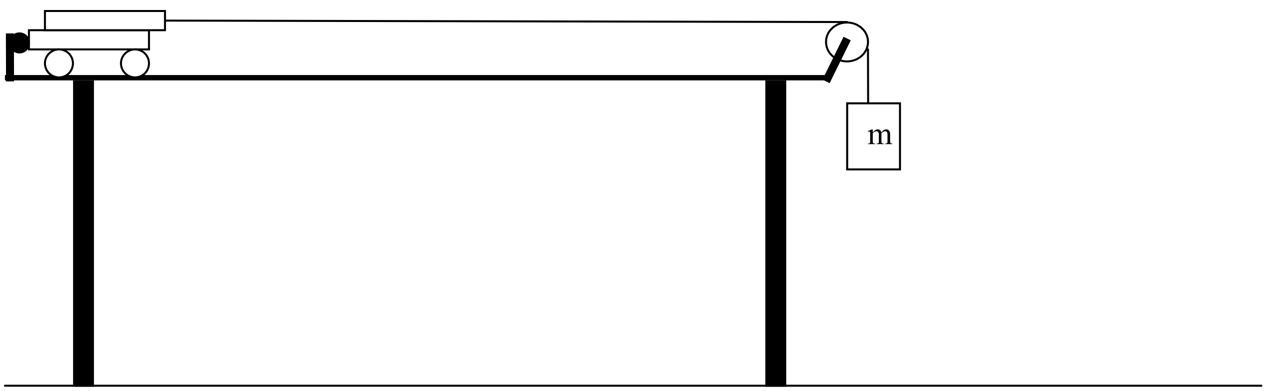
Conservation of Mechanical Energy Activity

Purpose

During the lab, students will become familiar with solving a problem involving the conservation of potential and kinetic energy. A cart is attached to a string with a mass that is hanging over the edge of the table. The goal is to theoretically determine the speed of the cart at the instant the mass hits the floor. The cart will start from rest at the same location for all the trials, and the initial position for all of the trials will be established by holding the cart against the backstop of the track. After the group has calculated a theoretical speed, the group should experimentally determine the speed and compare the results. At the end of the lab, the students will be required to predict the speed of the cart that is attached to a specific mass/string combination.

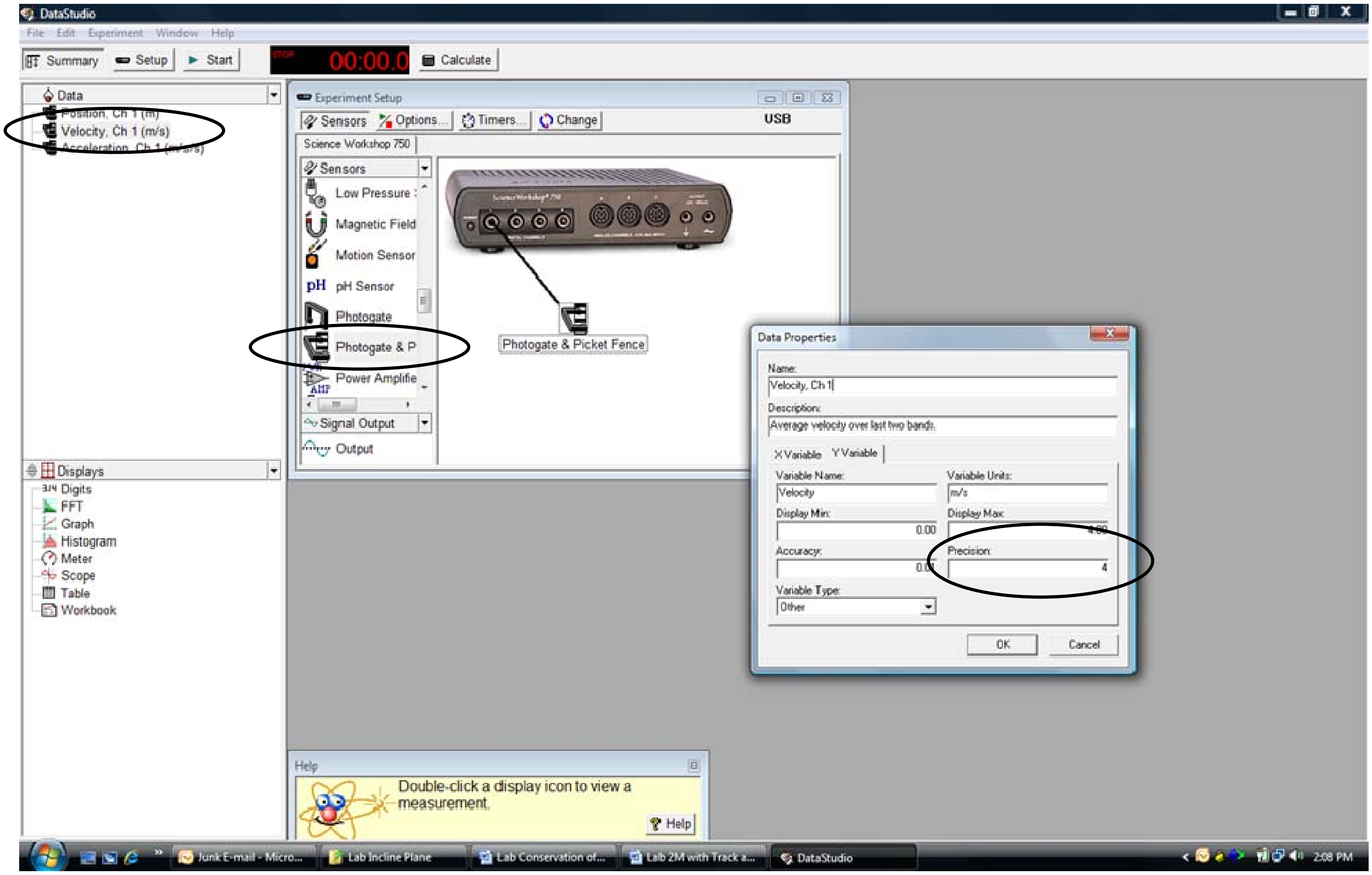


Part I (35pts total)

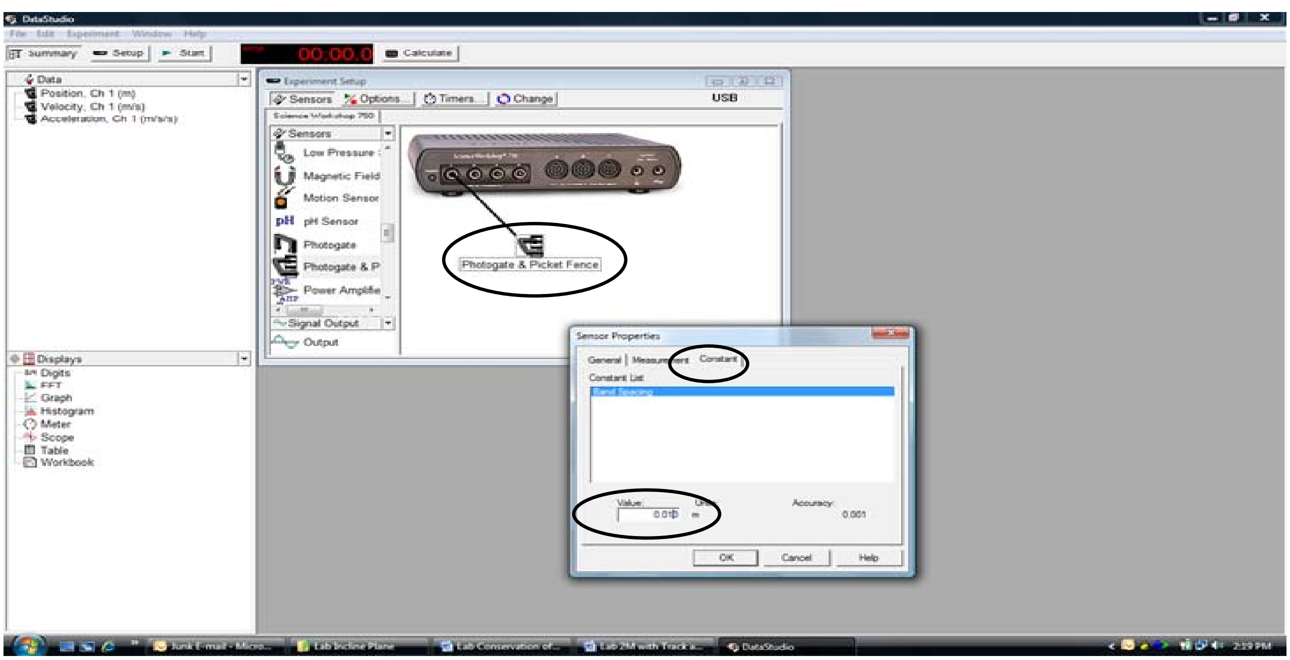
A photogate is a device that uses a beam of light and a detector to act as a switch. When the beam of light is broken, the detector can send a signal to a controller that could activate a multitude of devices. In this case, we will use a photogate in conjunction with a “picket fence” (PF) to determine a velocity. The PF is a flat piece of plastic with various dark patterns. The patterns on the PF are equally spaced apart and each time the photogate sees a marking, it starts and/or stops a timer. Using the known distances between the markings and the time it takes to travel between each marking, a velocity can be determined. In this case, we will use the pattern on the picket fence that has two markings with leading edges that are 1.00 cm apart.

Physically connect a photogate to the PASCO interface, and make sure the interface is turned on. Install the PF on the cart, and set the height of the photogate to correspond to the appropriate pattern. Each photogate has a red LED that should come on when the photogate is blocked.

Open Data Studio on the computer, and select Create Experiment. Select the photogate & picket fence icon. Note that a Position, Velocity, and Acceleration Icon were added to the Data Section. Double click on the Velocity Icon and change the precision to 4 on the Y Variable and X Variable tabs.

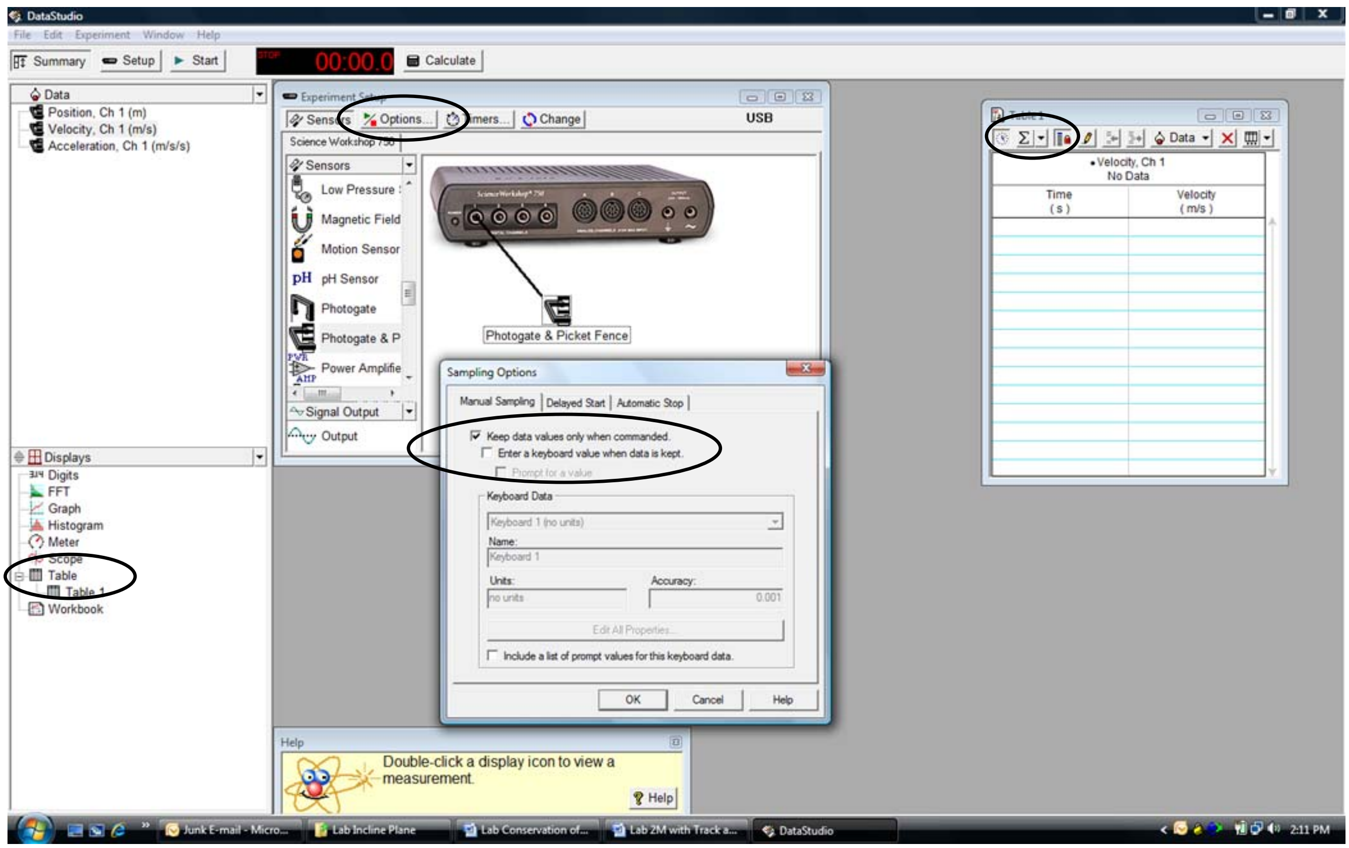


Now double click on the Photogate & Picket Fence icon that is connected to your virtual interface box. Under the ***Constant*** tab in the window that appears, change the constant to 0.010 m. This is the spacing between the leading edges of the bands on the PF.



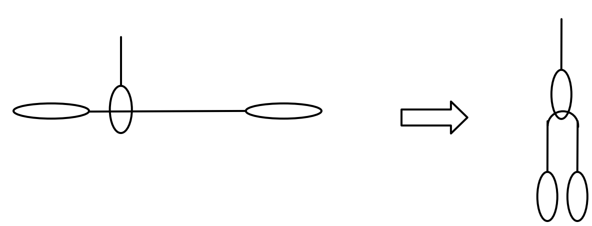
In order to monitor the velocity, a table will need to be created. Drag the Table icon to the Velocity icon in the Data Section. Since it would be more accurate to average the times from several runs of each mass/string combination, it would be prudent to set some Start/Stop options and to apply some statistics. In the table window, press the button with the sigma symbol, and the max, min, and mean will be added to your table.

Now, click the ***Options*** button located in the virtual interface box window. Under the ***Manual Sampling*** tab, make sure that only the ***Keep data value when commanded*** box is checked; if the other boxes are checked, un-check them. When the appropriate boxes are checked, press the ***OK*** button. Now when the ***Start*** button is pressed, you will have an option to keep data by pressing the ***Keep*** button or to stop collecting data 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. When you are done collecting velocities for a particular mass/string combination, press the button with the red square, and the trial for that particular mass/string combination will be complete. Run several trials with different mass/string combinations to practice predicting the velocity.



To position the photogate, the group needs to determine where the first band of the PF will be located when the mass hits the floor. Position the photogate such that the first band of the PF will enter the photogate slightly after the mass hits the floor (i.e. the LED on the photogate should not flash on until after the hanging mass hits the floor). Remember to re-position the photogate when you change the length of the string.

There should be two different masses and a piece of string that can be added to the string tied to the cart. Note that the short piece of sting does not need to be tied to the string already attached to the cart. Pass one of the loops of the short string through the loop of the string tied



to the cart and then hang the mass from both loops of the short string. This will effectively make the string tied to the cart longer. Between the two different masses and the two different string lengths, you should be able to determine average speeds foe each of the four different mass/string length combinations.

The computer should now be ready to record the speed of the cart. However before running each trial, your group should predict the speed by calculating the speed theoretically. Note that there will be experimental error in the results that the computer provides. The error will probably be around 2-5%. One source of error will be from Rotating Kinetic Energy. Although you may not have learned about Rotating Kinetic Energy, it should be obvious that items other than the cart and hanging mass are in motion. Specifically, the pulley and the wheels of the cart are spinning which results in Rotational Kinetic Energy. However since the mass of the pulley and wheels is very small, the amount of Rotational Kinetic Energy is small. There are other sources of error that you should try to identify.

Before you may move on to Part II, the general energy equation that was used for Part I should be recorded on the Data Sheet along with the results from your trials. The equation should be in variable form. After your TA reviews the equation and your trial results, your group will be asked one of the questions from the list below. The question will be worth 20 points. Only one person will be selected to answer and explain the question. If the person selected answers the question correctly, the group will be awarded 20 points. However if the person answers incorrectly, the point value will be reduced by five points, and the TA will select a second person to answer the same question. Each time the question is answered incorrectly, the point value will be reduced by five points.

Questions: (The TA will expect an answer in general terms; not a numerical value for these questions.)

(1) How much work is performed on the cart during the distance traveled from the backstop to the point the mass hits the floor?

(2) Assume that your experimental speed for all of your trials was always slightly greater than your theoretical calculated speed. Also assume that the photogate was positioned properly. How could you explain the error?

(3) Assume your track was perfectly level, how does the Rotational Energy of the pulley and wheels effect the difference between your theoretical speed and the experimental speed.

(4) How would you have to modify your theoretical equation for a level track if the track was not level?

(5) The instructions indicated to place the photogate such that the first band of the PF would go through the photogate slightly after the mass hit the floor. Assuming the track is level, explain why the photogate does not need to be positioned at the precise location of the leading edge of the first band on the PF when the mass hits the floor.

Part II (50pts total)

Your TA will inform you of a mass/string combination to use for the test. Your goal is to theoretically determine the speed of the cart just as the mass hits the floor in the same manner that you have already practiced. Note that you will not have access to the mass your TA specifies to test your results. After you have determined the theoretical speed and made any adjustments for experimental error, your TA will return and test your ***prediction*** by hanging the mass on the string and testing your ***prediction*** against the computer generated speed. Your score will be based on the percent difference between your prediction and the computer generated speed. ***You may work on Part III while you are waiting for your TA to return and test your prediction.***

Part III (15pts total)

Provide the necessary equation on Part III of the Data Sheet

Name: ____________________________ **Name:** _______________________________

Name: ____________________________ **Name:** _______________________________

Data Sheet
Conservation of Mechanical Energy Lab

Hints:

1. Adjust the pulley such that the string is parallel to the track.
2. Make sure the track is level.
3. Adjust the pulley such that the string does not drag or rub against any of the equipment.
4. Actually weigh the hanging mass (m) versus relying on the imprinted values.
5. If your theoretical speeds are significantly different from the experimental speeds, check your work closely.
6. To explain error, determine forms of energy that were not accounted for in your equation.
7. Make a mathematical adjustment for the error to improve your prediction accuracy.
8. Do not allow the cart to crash into the stop near the pulley. If the cart rolls back through the photogate before the Keep button is pushed, the data will be invalid.

Part I (35 pts total)

Theoretical Energy Equation for a cart on a level track (in variable form – i.e. in terms of M, m, g, v, and h). Do not include any corrections for experimental error. (15, 10, 5, or 0 points)

Complete the table below, but also print and attach your table from the computer.

	Trial 1	Trial 2	Trial 3	Trial 4
Theoretical Speed				
Average Experimental Speed				

Points for Group Question (20, 15, 10, 5, or 0 points): _______________

Part II (50pts total)

Circle the String Length Specified by TA: Shortest Length Longest Length

Hanging Mass Specified by TA: ____________________

Explanation of any corrections made for Experimental Error that will make the group's prediction more accurate. (5 points)

(A) Group's ***Predicted*** Value of the Cart Speed (Work should be attached): ___________

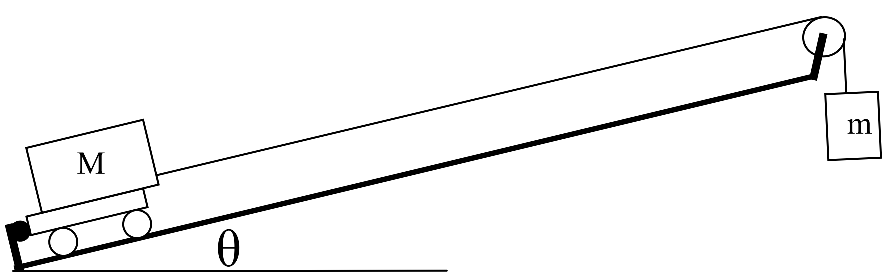
(B) The Cart Speed experimentally determined by the TA: _______________

Percent Difference $= \dfrac{|A - B|}{(A + B)/2}\ x100\%$ = ____________________

Circle the groups score

Percent Difference	<=2%	<=4%	<=5%	<6%	<=8%	>8%
Points	45	40	35	30	20	15

Part III (15pts total)



m > Msinθ

Determine the theoretical energy equation in variable form for a cart traveling up the inclined plane above. The cart starts from rest and the mass is allowed to fall a height of h. Do not include any corrections for friction or rotational energy. All work including a diagram should be attached.

Theoretical Energy Equation for Cart on incline plane in variable form.
(i.e. expressed in terms of M. m, sinθ, g, v, and h) (15, 10, 5, or 0 points)