# 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.

In addition, the students will utilize the Work Energy Theorem to determine the acceleration of the cart.
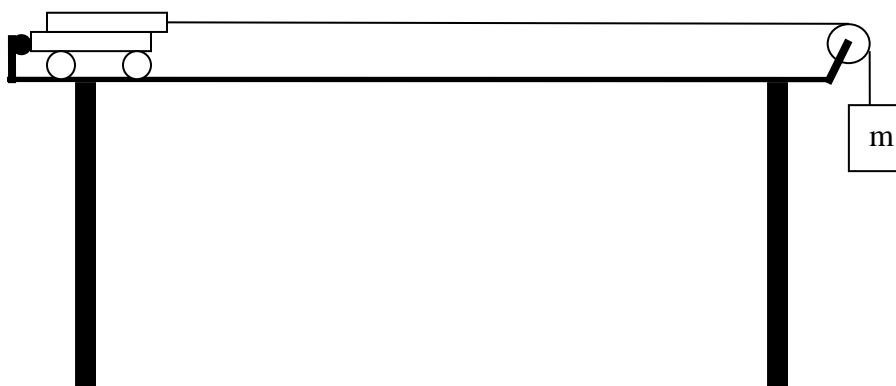
Part I (25pts total)

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.

Use the digital scale at the front of the room to determine the mass of your cart.

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

Log on to the computer and choose the COSAM pool. Double click the 'phy-lab' icon on the desktop, and open the PASCO Capstone program. Under File, select Open Experiment, choose the file folder named "capstone-

activities", and then select the _Conservation of Mechanical Energy Activity_. After the file opens, there should be a table displayed to collect speeds.

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 string 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 for each of the four different mass/string length combinations.
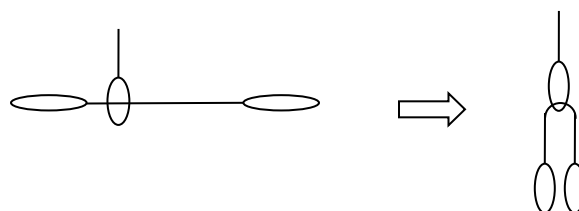
When the **_Preview_** button is clicked, you will have an option to keep data by clicking the **_Keep Sample_** button or to stop collecting data by clicking the button with the red square (**_Stop_**). However, if you click the button with the red square prior to clicking the **_Keep Sample_** button, 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 speeds for a particular mass/string combination, click the button with the red square, and the trial for that particular mass/string combination will be complete. To better keep track of your runs, click on the name of each run and rename it such that the mass and height are referenced. Run several trials with different mass/string combinations to practice predicting the speed.

The computer and equipment should now be ready to record the speed of the cart just before the hanging mass hits the floor. 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 TA will give you a set of conditions for Part II

C:\Users\patridm\Documents\Labs\Capstone - PASCO\Capstone Labs for AU\Conservation of Mechanical Energy\Conservation of Mechanical Energy with Work Energy Activity for Capstone Rev 2.docx

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 begin working on Part III while you are waiting for your TA to return and test your prediction.***

Part III (25pts total)

Using the experimental values from Part II, calculate the acceleration of the cart utilizing the Work Energy Theorem. Compare this calculated acceleration by using both kinematics and sum of forces (free body diagrams) to calculate the acceleration of the cart.

After you have calculated the acceleration of the cart and compared the results, the TA will return to your station and experimentally determine the acceleration of the cart.

Name: _____   **Banner ID:** _____

Lab Group ID: _____   **Number of Lab Partners:** _____

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. For part II, 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 (25 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				

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: _____

$$\text{Percent Difference} = \frac{|A - B|}{(A + B)/2} \ x100\% \ = \ \rule{4cm}{0.4pt}$$

Circle the groups score

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

Part III (25pts total)

Use a separate sheet of paper to show all work and attach.

Values for the Calculated Acceleration of the Cart using Experimental Data from Part II

Work Energy	
Kinematics	
Sum of Forces (Free Body Diagram)	

Experimental Acceleration of the Cart (Replace the pulley on the track with a Smart Pulley, connect the Smart Pulley to the interface, and open the "Work Energy Part III Conservation of Energy" File)	