Conservation of Energy on an Inclined Track

Equipment

	INCLUDES:	
1	Dynamics System	ME-6955
1	Photogate Head	ME-9498A
1	Photogate Bracket	(in ME-8998)
1	Smart Timer Picket Fence	ME-8933
1	Large Rod Base	ME-8735
1	45 cm Rod	ME-8736
1	Elastic Bumper	ME-8998
	NEEDED, BUT NOT INCLUDED:	
1	Meter Stick	SE-8695
1	Balance Scale	SE-8723

Introduction

As the cart rolls freely downhill, gravitational potential energy is converted to kinetic energy. The cart is released from the same height, multiple times, with the photogate measuring the speed at a different location for each run. This allows values to be calculated for both potential and kinetic energy at various heights.

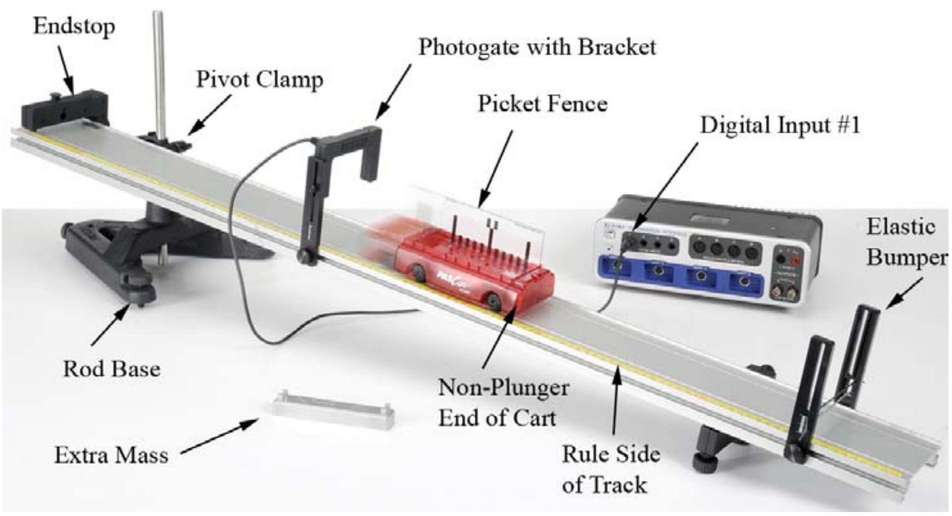

Figure 1: The cart rolls freely down the incline.

Setup

1. Set up the track as shown in Figure 1 using the large rod base and the 45 cm rod. The square nut on the Pivot Clamp slides into the T-Slot on the track, and allows the track to be secured at various angles.

2. Adjust the high end of the track to be about 15 cm to 20 cm above the table.

3. Note the location of the yellow rule on the track. Make sure that zero is at the top (left end) of the track.

4. The Endstop at the top (left end) of the track is used as a starting position for the cart. For each run, the cart will be released (at rest) from this same location.

5. Position the cart so that the non-plunger end is downhill. This end of the cart contains magnets, which must be kept as far as possible from the upper Endstop.

6. Plug the Photogate into Digital Input #1. The Photogate will be placed at various locations to measure the speed of the cart as it rolls downhill.

7. In PASCO Capstone, in the Hardware Setup, select One Photogate (Double Flag) for Digital Input #1 on the interface.

8. Change the data collection mode to Keep Mode on the Experiment Control Bar at the bottom of the page.

9. Create a table as shown: Create Run-Tracked User-Entered data sets called "Mass" with units of kg and "Height" with units of m. The Speed in the second column is the speed recorded from the photogate.

Table I. Height and speed data.

	<No Data Selected>	<No Data Selected>	<No Data Selected>
	Mass (Kg)	Speed (m/s)	Height (m)
1			
2			
3			
4			
5			
6			
7			
8			

10. Adjust the height of the Photogate so that the "Double Flag" on the top of the Picket Fence breaks the beam as the cart moves by.

11. Install the Elastic Bumper at the bottom of the track. The Rubber Cord should be placed so that the cart pushes the cord into the slots, as shown in Figure 2. For safety, it is a good idea to use more than one piece of cord.

12. Each time that the Photogate is moved to a new location, the new height must be measured. A convenient place to measure to is the bottom of the photogate bracket (see Fig. 3). It doesn't matter where you measure to, but you must measure to the same place each time!

13. Make sure that the rod and pivot clamp are secure. You do not want the height of the track to change in the middle of the run!

14. Make sure the endstop at the top of the track is secure. It is your starting position for the cart, and it must be the same for each run.

Figure 2: Elastic Bumper

Note that the Rubber Cord should be inserted into the bracket so that when it is hit by the cart, the cord is pushed into the slots. It is a good idea to use more than one piece of cord.

Measuring the height of the track at the Photogate location. It doesn't matter where you measure to, but you must measure to the same place each time!

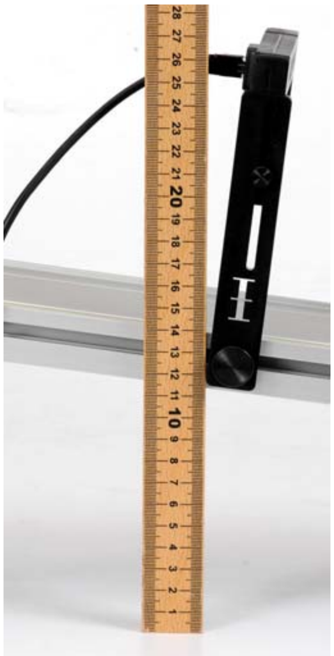

Figure 3: Photogate Height

Procedure: Recording Data in "Keep Mode"

1. To start recording data, click on Preview in the Experiment Control Bar. Run 1 should appear at the top of each column in Table I. Columns 1 and 3 are user entered data (see below) and column 2 is for the measured speed of the cart. The program is set for "Keep Mode", and the speed value for each part will not be stored until you click on "Keep Sample"

2. Use a balance to measure the mass of the "Cart + Picket Fence". Enter the value in column 1. For this part of the experiment, the mass does not change, but the value will need to be entered for each row of data you take.

3. Position the Photogate near the upper end of the track at the 20 cm mark. It doesn't matter if you line up the mark with the left side or right side of the bracket, but you should do it the same way each time you move the photogate. Measure the height of the track at the Photogate location, and record your value in row 1 of column 3.

4. As a test, move the cart (by hand) through the Photogate. You should see a speed appear in row one of column 2. Move the cart back and forth through the Photogate. You should see a new measured speed each time.

5. Position the cart at the top of the incline, firmly against the Endstop. This is the starting position for the cart each time. Make sure that the non-plunger end of the cart is downhill, away from the Endstop. The plunger should be completely retracted.

6. Release the cart from rest, allowing it to freely roll downhill. The speed of the cart will appear in the table, but will not be stored until you press "keep". Try releasing the cart several times to see how much uncertainty there is in the measurement. When you have a good value, click on "Keep Sample". Do NOT press stop!

7. Position the Photogate at the 30 cm mark, and measure the height of the track at the Photogate, and record your value in row 2 of the table.

8. Release the cart from rest at the top of the incline. You should see the speed appear in row two. When you have a good value, click on "Keep Sample". Repeat for Photogate positions of 40, 50, 60 70 and 80 cm. Do not let the cart bounce back up through the Photogate.

9. Click on Stop.

Calculating Energy

1. Create the following calculations in the Capstone calculator (all with units of J):

   Potential Energy = [Mass] (9.8) [Height]

   Kinetic Energy = 0.5[Mass] [Speed]^2

   Total Energy = [Potential Energy] + [Kinetic Energy]

2. Create a table with the Potential Energy and Kinetic Energy.

3. For one of the data sets in Table I, calculate the potential energy and kinetic energy of the cart for that height. Confirm that the corresponding value is correct in Table II.

Table II. Energy

	<No Data Selected>	<No Data Selected>
	Potential Energy (J)	Kinetic Energy (J)
1		
2		
3		
4		
5		
6		
7		
8		

4. Create a graph of Potential Energy vs. Index. Use Add Similar Measurement to add Kinetic Energy and Total Energy to the vertical axis.

5. What happens to the relative value of the potential energy and kinetic energy as the cart rolls down the hill?

6. Evaluate the total energy of the cart. Is energy conserved?

Change Mass:

1. To start recording a new run of data, click on Preview in the Experiment Control Bar. Run 2 should appear at the top of each column in Table I.

2. Add the Mass Bar to the cart and measure the new mass. Enter the value in column 1.

3. Move the Photogate back up to the 20 cm mark. Start with the cart at rest against the stop, and allow the cart to roll through the Photogate as before. When you have a good value, click on "Keep Sample". Do NOT press stop!

4. Repeat for the other five locations.

5. Click on Stop.

Change Angle

1. To start recording a new run of data, click on Preview in the Experiment Control Bar. Run 3 should appear at the top of each column in Table I.

2. Change the height of the end of the track by a few centimeters. Move the Photogate back up to the 20 cm mark and measure the new height. If the old height values are in the table, you can delete them. Record the new value.

3. Measure height and speed values for all locations.

4. Click on Stop.

Analysis

1. Use the Run Select Tool in the Graph Tool Bar to compare the three runs. Is energy conserved?

2. What effect would friction have on the experiment? Do you see this in your data?

3. When you increased the mass of the cart, how did this affect the Potential Energy of the cart at any given location? How did this affect the Kinetic Energy of the cart? How did this affect the speed of the cart? In Table I, compare the speeds for Run 1 to the speeds for Run 2. Is that what you expected?

4. The height used to calculate the Potential Energy was measured to an arbitrary point on the track. What would change in the experiment if you had chosen a different point?