Work-Energy Theorem

Equipment

1	Smart Cart (Blue)	ME-1241
1	Dynamics Track Feet (Pair)	ME-8972
1	Dynamics Track End Stops (Pair)	ME-8971
1	Track Rod Clamp	ME-9836
1	1.2m Starter Dynamics Track	ME-9493
1	Elastic Bumper	ME-8998
1	Elastic Cord	(in ME-8998)
1	250g Cart Mass (Pair)	ME-6757A
1	Braided String	SE-8050
Required but not included:		
1	550 Universal Interface	UI-5001
1	PASCO Capstone	
1	Mass Balance	SE-8707

Introduction

A Force Sensor is used to measure the changing force applied by the stretched elastic cord, while the Smart Cart records its resulting velocity. Calculations are made and the work done by the elastic cord is compared to the increase in kinetic energy.

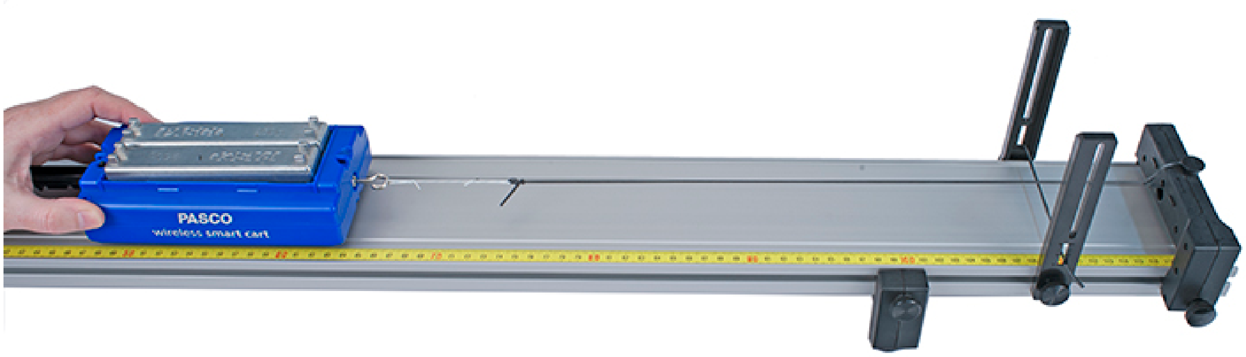

Figure 1: Setup with Elastic Cord Tied to Hole in Endstop

Theory

According to the Work-Energy Theorem, the resulting change in kinetic energy of an object is equal to the total work done on that object.

$$\Delta KE = Work$$

In this lab, the amount of work done is calculated by taking the area under the curve on a force versus position graph.

Setup

1. Install the Elastic Bumper and adjustable feet to the track as shown in Figure 1. Attach an endstop to each end of the track

2. Install the hook on the Smart Cart force sensor. Turn on the Smart Cart and connect to it in Capstone.

3. Place both masses in the cart and use a balance scale to measure the total mass. Then remove one mass and measure the total mass of the cart and one mass.

4. Adjust the "level" of the track using the adjustable feet. Place the cart on the track and give it a small push away toward the end of the track that has the Elastic Bumper. Click on Record. Your data will look better if you stop recording before the cart hits the Elastic Bumper.

5. Using the screw feet, adjust the level of the track so that the cart travels at a constant speed when moving away from the sensor. By setting up the track so that it is slightly downhill, you will be eliminating the effects of unwanted frictional forces.

6. Tie a short loop of string to the hook on the Smart Cart as shown in Figure 1. Cut a 35 cm long piece of Elastic Cord, and tie it onto the endstop through the endstop hole and the loop of string as shown.

7. In PASCO Capstone, set the sample rate of the Smart Cart Position and Force sensors to 50 Hz.

8. Create a graph of Velocity vs. Time.

Procedure: Force and Velocity

1. Add a plot area to the Velocity vs. Time graph. Put the Force on the vertical axis of the second plot area.

2. Open the Recording Conditions and set the Stop Condition to Measurement Based on Position Is Above 0.55 m.

3. With the string slack on the hook, zero the force sensor in software.

4. Pull the cart back, stretching the elastic cord, until the cart is 20 cm from the end of the track.

5. Click on Record and then release the cart. The stop condition should automatically halt recording before the cart reaches the elastic bumper.

6. Check that you have good, smooth velocity data. You need to clearly see a maximum in the velocity before it stops. You might need to adjust the automatic stop condition.

7. Get one good run and rename the run "Two Masses".

8. Remove one of the masses from the cart and get another good run. Rename this run "One Mass".

Work Done

9. Create a graph of Force vs. Position.

10. Use the Run Selection tool to display the run you named "Two Masses".

11. For a Hooke's Law spring, the graph of F vs. x results in a straight line, where the slope of that line is the spring constant. Does the elastic cord used in this lab follow Hooke's Law?

12. Use the Area tool to find the area under the curve. You may need to use the Selection tool to select only the part of the curve.

13. What is the physical significance of the area? What are the correct units?

14. Repeat for the second run.

Change in Kinetic Energy

15. Create a graph of Velocity vs. Position.

16. Use the Run Selection tool to display the run you named "Two Masses". Find the maximum velocity of the cart. Turn on the statistics showing the maximum, or you can also use the coordinates tool.

17. Use this velocity and the mass of the cart to calculate the kinetic energy of the cart.

18. Compare this to the work done by the elastic cord. What do you conclude?

19. Repeat for the second run. Remember the mass changed! Which of the following changed a lot from run one to run two, and which did not change much at all?
    a. Work done by cord
    b. Change in cart kinetic energy
    c. Change in cart velocity