Acceleration on an Inclined Track

Introduction

The purpose of this lab is to study the relationships between position, velocity and acceleration for a Smart Cart moving up and then down an inclined track. The acceleration of the cart is calculated from a velocity graph, and compared to the acceleration measured directly from the Acceleration Sensor on the cart.

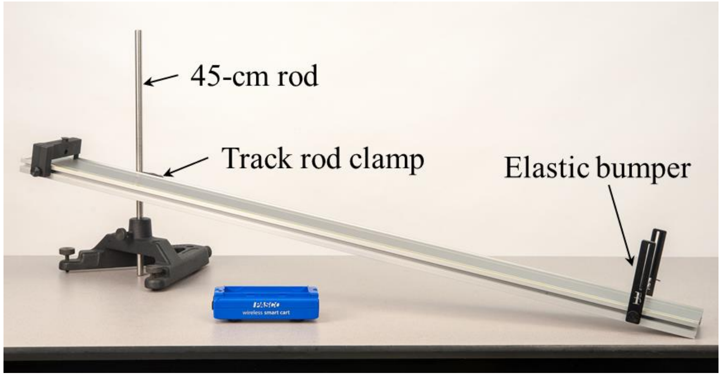

Figure 1: Inclined Track Setup

Equipment

Qty	Items	Part Number
1	Smart Cart (Blue)	ME-1241
1	Dynamics Track End Stops (Only 1 needed)	ME-8971
1	Track Rod Clamp	ME-9836
1	1.2m Starter Dyn Track	ME-9493
1	Large Rod Base	ME-8735
1	Rod, 45 cm	ME-8736
1	Elastic Bumper (Elastic & 1 pair brackets needed)	ME-8998
Required, but not included:		
1	PASCO Capstone software	

Setup

1. Set up the track as shown in Figure 1 using the rod base and 45-cm rod.
2. Install the fixed End Stop at the top of the incline (see Figure 1), and an Elastic Bumper at the bottom, using at least two pieces of elastic (see Figure 2).
3. Place the Smart Cart on the track so that its +x-direction, printed on top of the cart, is pointing **up** the track.

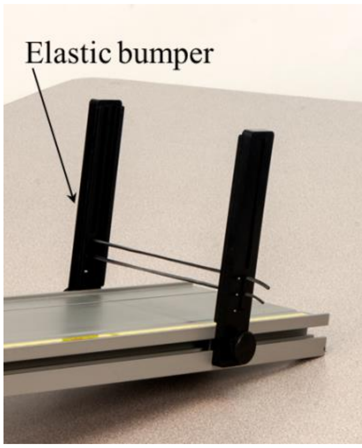

Figure 2: Elastic Bumper

4. Turn on the Smart Cart, and connect it wirelessly in PASCO Capstone.

5. In PASCO Capstone, create a graph of the Smart Cart Position Sensor's "Position" on the vertical axis vs. "Time" on the horizontal axis.

   Add a plot area to the graph and select the Smart Cart Acceleration Sensor's "Acceleration – x" for the vertical axis.

6. On the bottom toolbar: Select the Smart Cart Position Sensor and set its sample rate to 50 Hz. Then select the Smart Cart Acceleration Sensor and set it to 50 Hz. Then click the Zero button for the Smart Cart Acceleration Sensor. If you change the incline of the track, you must go back and re-zero the sensor.

7. To check that the cart is oriented correctly and that the sensors are working correctly:

   Start recording data, and move the cart up and down the track. Check that the position graph makes sense.

   Then, let the cart remain at rest on the track for several seconds, and check that the acceleration graph now reads zero. If not, re-zero Smart Cart Acceleration Sensor.

   Stop recording.

Procedure

1. In Capstone, set the following Recording Conditions on the lower toolbar: a Start Condition based on the Position measurement, Rises Above 0.30 m; and a Stop Condition based on the Position measurement, Falls Below 0.30 m. These settings make it easier to get clean data. Later, when you click Record, actual data recording starts only after the cart has moved past 30 cm, and automatically stops when returns past the same point. You can change these values to suit your experiment.

2. Hold the cart at rest at the lowest point on the inclined track, making sure the +x-direction printed on top of the cart is pointing up the incline.

3. Start recording data and then give the cart a quick push up the incline. Make sure you let go before the car has gone past 30 cm, when actual recording begins. Try to get the cart to reach as close as possible to the end of the track, but without hitting the end stop at the top. Allow it to coast all the way back down. Recording should stop automatically.

   Repeat if needed until you get a smooth position graph. You can delete unwanted runs using the Delete feature in the lower toolbar.

Analysis - Acceleration Sensor Graph

1. On the Acceleration – x graph, is the acceleration increasing, decreasing, or remaining approximately constant? Is the sign of acceleration positive or negative? What is the significance of the sign?

2. Click on the Acceleration – x graph to select it. On the graph toolbar, turn on statistics, and select the Mean and Standard Deviation. Change the Tool Properties for the statistics tool on the graph, so there are 2 decimal places. Record the mean acceleration with its standard deviation.

3. Also on the Acceleration – x graph, add a Multi-Coordinates tool and move it to the time when the cart is at its highest point. (You can identify this time by looking at the Position graph.) Change the Tool Properties, so the Vertical Coordinate has 2 decimal places. Record the acceleration of the cart at this time. How does it compare to the mean value. Why isn't it zero?

4. Do the following to compare accelerations when the cart moves uphill vs. downhill:

   Moving uphill: Use the highlighter tool on the Acceleration – x graph to select the range of data for which the cart moves uphill. Record this mean acceleration with its standard deviation.

   Moving downhill: Move the highlighter tool area to select the range of data for which the cart moves downhill. Record this mean acceleration with its standard deviation.

   How do the accelerations compare for the cart moving uphill vs. downhill? What might account for the difference?

Analysis – Comparing Graphs

1. Add a graph of Velocity versus Time. Note that this Velocity is found by calculation from the Position Sensor data.

2. Click on the Position graph to select it. Use the Annotation tool to label the following: (a) the part of the graph where the cart moves uphill, (b) the part of the graph where the cart moves downhill, and (c) the moment on the graph where cart is at the highest point on the track.

   Repeat for the Velocity graph.

3. Referring to the Velocity graph: What is the sign of the velocity when the cart moves uphill? Downhill? At the highest point?

4. Referring to the Acceleration – x graph: What is the sign of the acceleration when the cart moves uphill? Downhill? At the highest point? Is the acceleration ever zero?

5. Click on the Velocity graph to select it. Turn on a Linear curve fit from the Graph tool palette to find the acceleration (the slope). How does this compare to the acceleration you previously found from the Acceleration – x graph (from the Acceleration Sensor)?

6. Also on the Velocity graph, turn on the highlighter tool:

   Move the highlighter tool to highlight the range of data for which the cart moves up the track. Record the acceleration (slope) for this range.

   Repeat for the range of data for which the cart moves down the track.

   Is there a difference? How do these values compare to those you previously found from the Acceleration – x graph?

7. Is the slope of the Velocity graph ever zero? What does that tell you about the acceleration?