Acceleration Due to Gravity

Introduction

A cart on an incline will roll down the inclined track as it is pulled by gravity. While the direction of the force of gravity is straight down, the acceleration component parallel to the inclined surface is only a fraction of the total accleration due to gravity.

The purpose of this lab is to measure the acceleration of a cart moving down an incline, and compare the measured value to the theoretical.

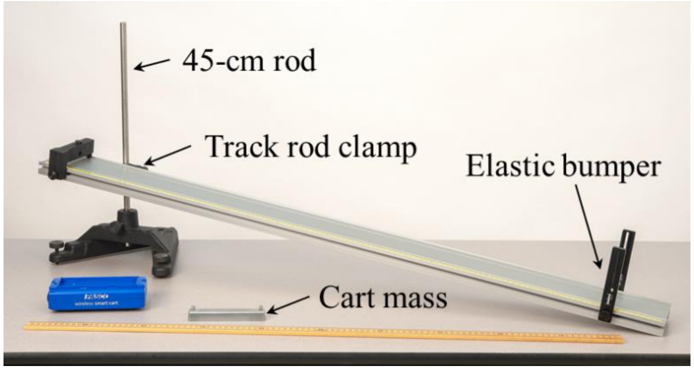

Figure 1: Measuring Acceleration of the Cart Down the Incline

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	250g Cart Mass (Only 1 needed)	ME-6757A
1	Elastic Bumper (Elastic & 1 pair brackets needed)	ME-8998
Required, but not included:		
1	Meter Stick (Only 1 needed)	SE-8827
1	PASCO Capstone software	

Setup

1. Set up the track as shown in Figure 1 using the rod base and 45-cm rod. Note that the lower end of the track rests directly on the table, and that the track feet are NOT used in this experiment. The square nut on the Track Rod Clamp slides into the T-Slot on the track, and allows the track to be secured at various angles.

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 down the track.

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

5. In Capstone, make a graph of velocity vs. time.

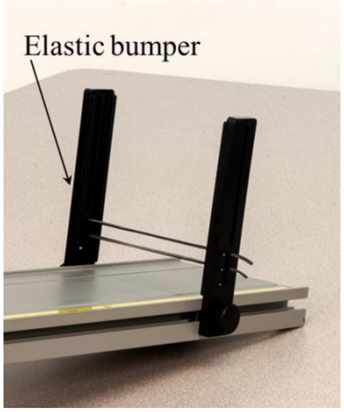

Figure 2: Elastic Bumper

Predicting Acceleration

1. Ignoring friction, the acceleration component of the cart down the incline can be shown to be a = g sinθ, where θ is the angle of the incline above the horizontal.

   If we know the height h and length L of the track (see Figure 3), then we know that sinθ = h/L, and which results in Equation 1:

$$a = g\frac{h}{L} \qquad (1)$$

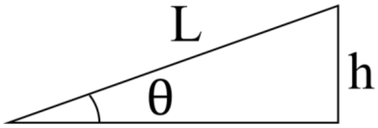

Figure 3: Finding sinθ

2. Carefully measure the length L of the track and record the value.

3. Adjust the height h of the upper end of the track to about 20 cm.

   Carefully measure h and record the value. The height should be measured to the **underside** of the track as shown in Figure 4.

4. Use Equation 1 to calculate the accepted value of acceleration of the cart down the incline. Record the value.

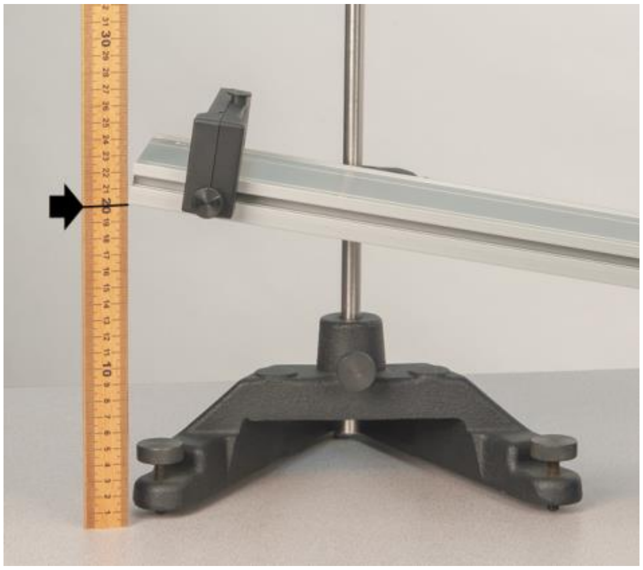

Figure 4: Measuring h

Measuring Acceleration

1. In Capstone, before recording data on the velocity vs. time graph, set the following Recording Conditions on the lower toolbar: a Start Condition based on the Position measurement, is above 0.10 m; and a Stop Condition based on the Position measurement, is above 0.70 m. These settings make it easier to get clean data because, after you click Record, actual data recording starts only after the cart has moved 10 cm, and automatically stops when it reaches 70 cm. You can change these values to suit your experiment.

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

3. Start recording data and release the cart. Repeat if needed until you get a nice velocity graph. You can delete unwanted runs using the Delete feature in the lower toolbar.

4. Turn on the curve fit tool on the graph tool palette, and select a Linear fit. What is the physical meaning of the slope? Does it have units? What is the uncertainty in your value? Record these.

5. Compare to the accepted (theory) value using the percent error calculation:

$$\%\ \text{Error} = \frac{\text{Measured} - \text{Accepted}}{\text{Accepted}} \cdot 100$$

6. Was your measured (actual) value high or low compared to the accepted value you calculated earlier? What might account for this?

Increased Mass

1. If the cart's mass is increased, make a prediction: Do you think the cart's acceleration will increase, decrease or stay the same? Explain.

2. Add the mass bar to the cart, and then record a new velocity graph.

3. Measure its new acceleration (the slope). How does this compare to your prediction? Explain.

Increased Height

1. Next you will measure acceleration for various values of h, and graph the cart's acceleration vs. the ratio h/L. Review Equation 1, which indicates that this graph should be linear with slope equal to g. The steps that follow will help you test this statement.

2. In Capstone, create a new table.

   In the first column, Create a user-entered data called h in units of m.

   In the second column, create a new calculation. In the calculation editor that appears on the table, enter:

   "h/L"= [h (m)]/1.22 with no units

   (Note: This assumes your track length is L = **1.22** m, but you should change it to match your measured value of L here.)

   Make a third column with user-entered data called Cart Acceleration in units of m/s^2.

3. In the first row of the table, use the data from your previous data run of the cart with the extra mass:

   Enter 0.20 in the h column.

   The "h/L" column should calculate automatically.

   In the Cart Acceleration column, enter the value of the slope of the velocity vs. time graph.

4. Raise the height to 0.25 m, being careful to measure to the lower side of the track as shown in Figure 4.

   Record a new velocity vs. time graph, and measure the new acceleration.

   Record these values in the next row of the table.

5. Repeat for track heights of 0.30 m and 0.35 m.

6. Create a graph with Cart Acceleration on the vertical axis and "h/L" on the horizontal axis. Turn on the curve fit tool, and select the Linear fit. Record the slope.

7. Remember, according to Equation 1, the slope of this graph should ideally be equal to g. How does your slope compare? What factors account for the difference?