Acceleration on an Inclined Track

Kinematics: linear motion; constant acceleration, graphing	

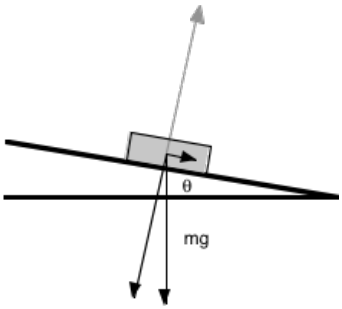
Qty	Equipment and Materials	Part Number
1	PASPORT Xplorer GLX	PS-2002
1	PASPORT Motion Sensor	PS-2103
1	1.2 m PASCO Track	
1	GOcar	ME-6951
2	Book	

Purpose

The purpose of this activity is to investigate the relationship between position, velocity, and acceleration for linear motion.

Background

Constant acceleration means a constant change of velocity. This could mean a constant change of speed, a constant change of direction (such as uniform circular motion), or a combination. Although constant velocity is straightforward, the graphical representation of constant *acceleration* involves many fundamental concepts of kinematics. The *slope* of a plot of velocity versus time for an object is the acceleration of the object. The ratio of the *units* along the vertical and horizontal axes of a graph of velocity and time give the units for the object's acceleration. Whether the slope of velocity is positive or negative reveals the direction of the object's acceleration relative to the sensor.



If a cart moves on a plane that is inclined at an angle θ, the component of force acting on the cart in a direction that is parallel to the surface of the plane is $mg \sin \theta$, where m is the mass of the cart, and g is the acceleration due to gravity.

If the friction on the cart is ignored, the acceleration of the cart should be $g \sin \theta$ both up and down the inclined plane.

Preview

Use a Motion Sensor to measure the motion of a cart as it moves up and down an inclined plane. Use the Xplorer GLX to record and display the motion. Determine whether the acceleration up and down the inclined plane is constant.

Safety Precaution

- Follow all directions for using the equipment.

Procedure

GLX Setup

1. Connect the Motion Sensor to one of the sensor ports on the top end of the GLX. Put the range selection switch on the Motion Sensor to the 'near' (cart) setting.

Fig. 1: Motion Sensor setting

2. Turn on the GLX (⏻).

- The Graph screen opens with a graph of Position (m) versus Time (s).

Equipment Setup

1. Place the PASCO track on a table and attach the Motion Sensor to one end of the track.
2. Use a couple of books to raise that end of the track so it is inclined at a small angle.
3. Place the cart at the bottom of the track so the cart is facing the sensor. Aim the sensor so its signal will reflect from the cart as the cart moves up and then back down the track.

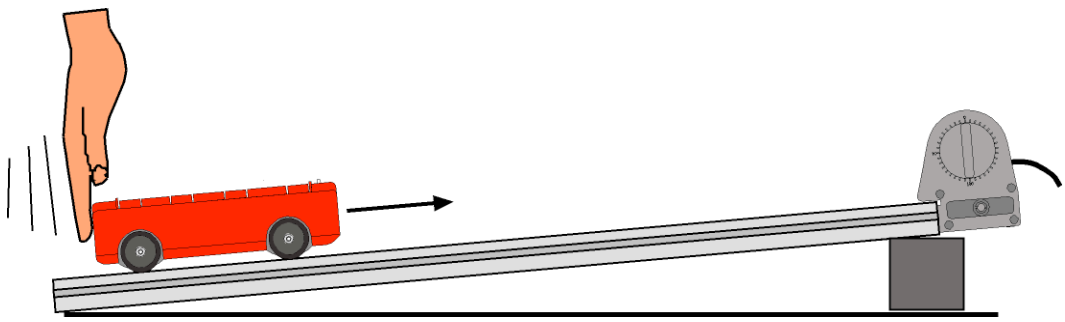


Fig. 2: Equipment setup

Record Data

- NOTE: The procedure is easier if one person handles the cart and a second person operates the Xplorer GLX.

1. Press Start (▶) on the GLX to begin measuring the sensor signal.
2. Give the cart a firm push toward the Motion Sensor. (Don't let the cart get closer than 15 cm to the sensor.) Continue collecting data until the cart has returned to the bottom of the track.
3. Press ▶ to end data recording just as the cart reaches the end of the track.

- The Graph screen will display the plot of position and time.

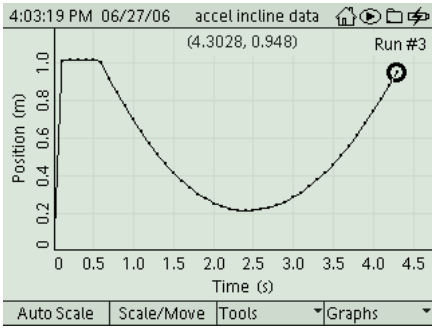


Fig. 3: Position graph

Analysis

First, find the slope of the velocity versus time to determine the acceleration of the cart both whet it goes up the track and also when it comes back down the track.

Next, find the average value of the acceleration in the acceleration versus time graph.

1. In the Graph screen, press ✓ to activate the vertical axis label. Press ✓ again to open the menu for the axis. Use the down arrow to select 'More' and press ✓ to activate the submenu.

2. Select 'Velocity' from the submenu and press ✓ to activate your choice. The graph will show Velocity (m/s) and Time (s).

- Notice that part of your graph is negative (below the x-axis) and part of the graph is positive (above the x-axis). This is because the sensor interprets motion *toward* it as negative and motion *away* from it as positive.

3. Use the right-left arrow keys to move the cursor to the point in the graph where the cart begins to move. Press ***F3*** (F3) to open the 'Tools' menu. Select 'Linear Fit' and press ✓ to activate your choice.

- The *Slope* of the linear fit is the average acceleration of the cart.

4. Record the value of the slope in the Lab Report.

5. Press F3 to open the 'Tools' menu and press ✓ to deselect 'Linear Fit'.

6. Change the graph to show acceleration and time. Press ✓ to activate the vertical axis. Press ✓ again to open the axis menu. Select 'Acceleration' from the menu and press ✓ to activate your choice.

7. Select the region of the graph that shows the motion of the cart up and back down the track. Use the right-left arrow keys to move the cursor to the point where the cart begins to move.

8. Press ✓ to open the 'Tools' menu, select 'Statistics' and press ✓ to activate your choice.

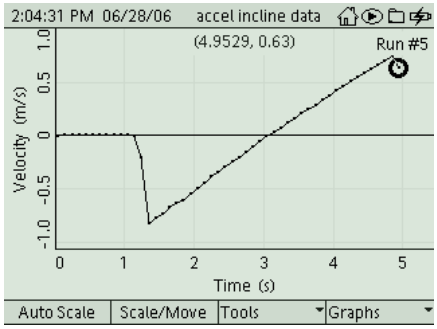


Fig. 4: Velocity graph

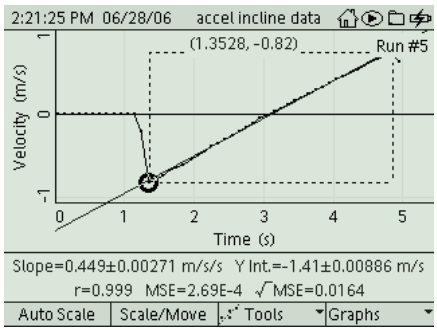


Fig. 5: Linear Fit

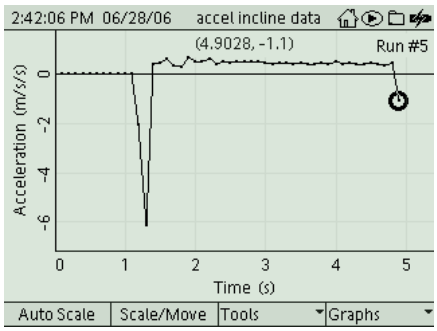


Fig. 6: Acceleration graph

- The Statistics show 'Min.', 'Max.', 'Avg.', and 'σ'. The 'Avg.' is the average acceleration of the cart.

9. Record the value of the average acceleration in the Lab Report.

Record your results and answer the questions in the Lab Report.

Lab Report - Activity 4: Acceleration on an Inclined Track

Name _____ Date _____

Data

Sketch your graph of data from the Motion Sensor for position versus time and for velocity versus time for the cart up and down the incline. Include labels and units for your y-axes and x-axes.

Data Table

Item	Value
Acceleration (slope)	m/s^2
Acceleration (average)	m/s^2

Questions

1. Describe the position versus time plot of the Graph screen. Why does the distance begin at a maximum and decrease as the cart moves up the inclined plane?

2. Describe the velocity versus time plot.

3. Describe the acceleration versus time plot of the Graph display.

4. How does the acceleration determined in the plot of velocity compare to the average value of acceleration from the plot of acceleration?