

### Activity P07: Acceleration of a Cart (Acceleration Sensor, Motion Sensor)

Concept	<i>DataStudio</i>
Linear motion	P07 Accelerate Cart.ds

Equipment Needed	Qty	Equipment Needed	Qty
		<b>Dynamics Cart (inc. w/ Track)</b>	1
<b>Motion Sensor (CI-6742)</b>	1	Protractor	1
Block (or book)	1	<b>1.2 m Track System (ME-9429A)</b>	1

#### What Do You Think?

What happens to the acceleration of a cart as it moves up and down an inclined plane?

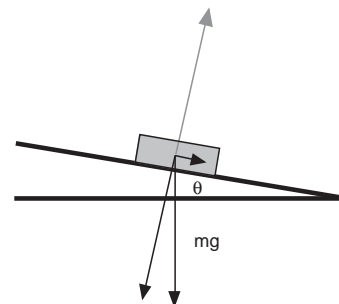
*Take time to answer the 'What Do You Think?' question(s) in the Lab Report section.*

#### Background

If a cart moves on a plane that is inclined at an angle  $\theta$ , 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.

The acceleration of the cart should be  $g \sin \theta$ , both up and down the inclined plane.

$$a = g \sin \theta$$



#### SAFETY REMINDER

- Follow all safety instructions.

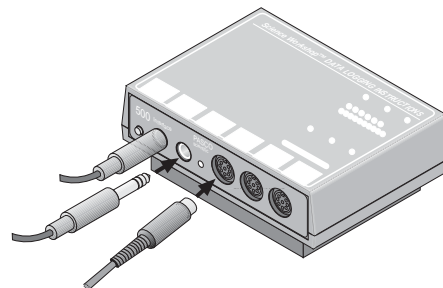
**THINK SAFETY**  
**ACT SAFELY**  
**BE SAFE!**

#### For You To Do

Use a Motion Sensor to measure the motion of a cart that is pushed up an inclined plane. Use *DataStudio* to record the motion and calculate the velocity and acceleration of the cart as it moves up and down the inclined plane. Compare the calculations to data from an Acceleration Sensor mounted on the cart.

#### PART I: Computer Setup

- Connect the *ScienceWorkshop* interface to the computer, turn on the interface, and then turn on the computer.
- Connect the Motion Sensor's phone plugs to Digital Channels 1 and 2 on the interface. Plug the yellow-banded (pulse) plug into Digital Channel 1 and the second plug (echo) into Digital Channel 2.
- Connect the DIN plug of the Acceleration Sensor to Analog Channel A.



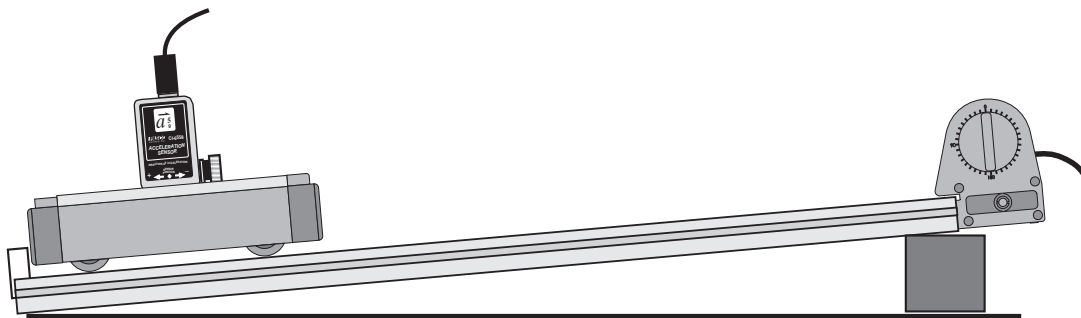
4. Open the file titled as shown:

<i>DataStudio</i>
P07 Accelerate Cart.ds

- The *DataStudio* file has a Workbook display. Read the instructions in the Workbook.
- Data recording is set so the Trigger Rate for the Motion Sensor is 10 samples per second (10 Hz). Data from the Acceleration Sensor is measured 50 times per second (50 Hz).

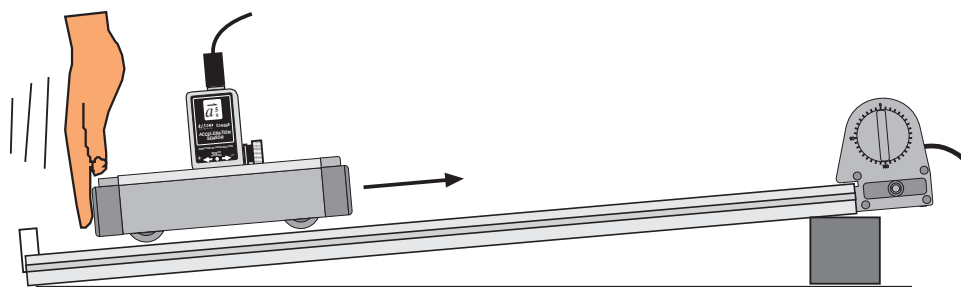
#### **PART II: Sensor Calibration and Equipment Setup**

- You do not need to calibrate the sensors for this activity.
1. Place the track on a horizontal surface. Use a block or book at one end of the track to raise that end.
  2. Use the protractor to measure the incline angle of the track. Record the angle in the Data Table.
  3. Mount the Motion Sensor at the high end of the track. Put a mark on the track 15 cm from the Motion Sensor.



**Preparing to Record Data**

1. Before recording any data for later analysis experiment with the Motion Sensor to make sure it is aligned and can “see” the cart as it moves.
2. Place the cart on the low end of the track (i.e., the end opposite to the Motion Sensor).
3. When everything is ready, start recording data.
4. Give the cart a firm push up the track so the cart will move up the inclined plane toward



and then away from the Motion Sensor.

- **BE CAREFUL! Don't push the cart so firmly that it gets closer than 15 cm to the sensor.**

*Remember: The minimum distance between the cart and the Motion Sensor should be 15 cm.*

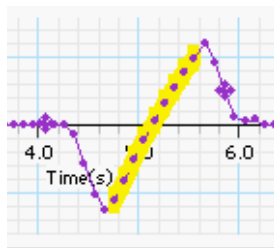
5. Stop recording when the cart returns to the bottom of the track.
- **You may want to rescale the Graph.**
6. If the plot of data is not smooth, check the alignment of the Motion Sensor and repeat the above procedure until the plot is smooth.
  7. Erase your sample run of data.

**PART III: Data Recording**

1. Prepare to measure the motion of the cart as it moves toward the Motion Sensor and then back down the track. Place the cart at the low end of the track.
  2. When everything is ready, start recording data. Give the cart a firm push toward the Motion Sensor. Continue collecting data until the cart has returned to the bottom of the track.
- **If the data points do not appear on the graph, check the alignment of the Motion Sensor and try again.**
3. Set the track to a steeper angle (e.g., 10 degrees) and repeat the data recording.

**Analyzing the Data**

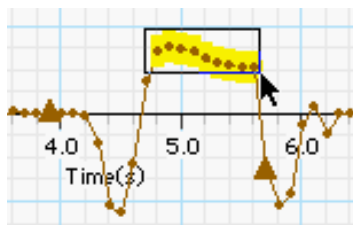
1. In the Motion Sensor's plot of velocity, use the cursor to select the region of the plot that shows the cart's motion after the push and before it stopped at the bottom of the track.



2. Use the Graph display's built-in analysis tools to apply a linear curve fit.
  - Hint: In *DataStudio*, select 'Linear' from the 'Fit' menu.

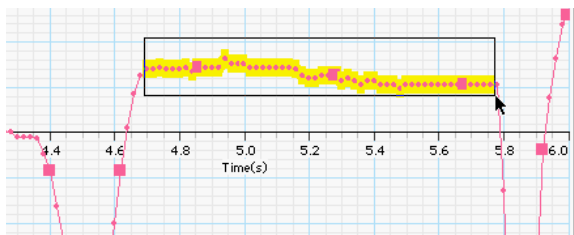
The slope of the best-fit line is the average acceleration. Record the value in the Data Table.

3. In the *Motion Sensor's* plot of acceleration, select the region of the plot that corresponds to the cart's motion after the push and before it stopped at the bottom of the track.



5. Use the 'Statistics' tool to find the mean value of the acceleration *as measured by the Motion Sensor* for your selected region. Record the mean of the acceleration in the Data Table.

6. In the *Acceleration Sensor's* plot of acceleration, select the region of the plot that corresponds to the cart's motion after the push and before it stopped at the bottom of the track.



7. Use the 'Statistics' tool to find the mean value of the acceleration *as measured by the Acceleration Sensor* for your selected region. Record the mean of the value in the Data Table.
8. Calculate the theoretical value for the acceleration of the cart based on the track's angle and record it in the Data Table.

$$a = g \sin \theta$$

**Record your results in the Lab Report section.**

Name \_\_\_\_\_

Class \_\_\_\_\_

Date \_\_\_\_\_

## Lab Report - Activity P07: Acceleration of a Cart

### What Do You Think?

What happens to the acceleration of a cart as it moves up and down an inclined plane?

### Data Table

Item	Run #1	Run #2
angle of track	degrees	degrees
acceleration (slope)	m/sec <sup>2</sup>	m/sec <sup>2</sup>
acceleration (mean)	m/sec <sup>2</sup>	m/sec <sup>2</sup>
acceleration (theoretical)	m/sec <sup>2</sup>	m/sec <sup>2</sup>

### Questions

1. Describe the position versus time plot of the Graph display. 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 of the Graph display.
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 mean value of acceleration from the plot of acceleration?

5. What is the percent difference between the acceleration determined in the plot of velocity and the theoretical value for acceleration?

Remember, **percent difference** =  $\left| \frac{\text{theoretical} - \text{actual}}{\text{theoretical}} \right| \times 100\%$

6. How did the acceleration change when the track became steeper?

**Appendix: Modify a ScienceWorkshop File**

Modify an existing *ScienceWorkshop* file to add the Acceleration Sensor.

**Open the ScienceWorkshop File**

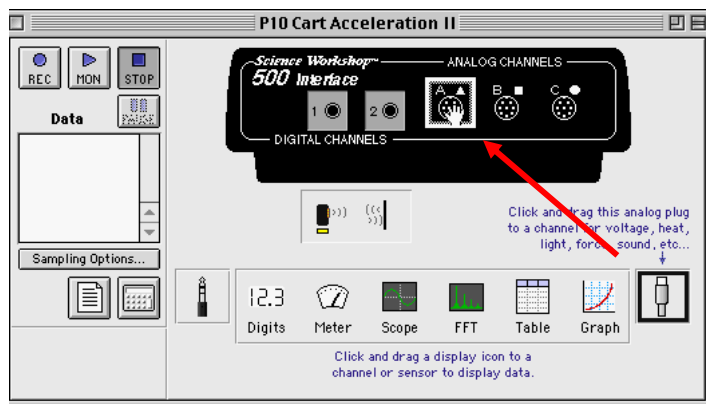
Open the file titled as shown:

<i>ScienceWorkshop</i> (Mac)	<i>ScienceWorkshop</i> (Win)
P10 Accelerate Cart 2	P10_CAR2.SWS

- The *ScienceWorkshop* file has a Graph display of position, velocity, and acceleration for the Motion Sensor. You need to add an Acceleration Sensor to the Experiment Setup window, set the sample rate, and create a Graph display for the new sensor.

**Set Up the Acceleration Sensor**

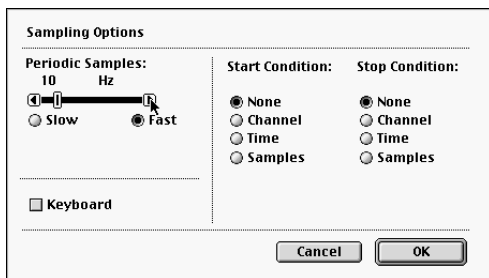
In the Experiment Setup window, click and drag the analog sensor plug to Channel A. Select ‘Acceleration Sensor’ from the list of sensors. Click ‘OK’ to return to the Experiment Setup



window.

**Set the Sampling Options**

Click the ‘Sampling Options’ button in the Experiment Setup window or select ‘Sampling Options’ from the Experiment menu to open the Sampling Options window. Under ‘Periodic



Samples’ click the right arrow to set the sample rate at ‘50 Hz’ (50 measurements per second).

**Set Up the Display**

In the Experiment Setup window, click and drag the Graph display icon to the Acceleration Sensor icon.

Select 'Acceleration (m/s/s)' from the list of calculations and click 'Display'. **Result:** A Graph display opens for the Acceleration Sensor showing Acceleration versus Time.

