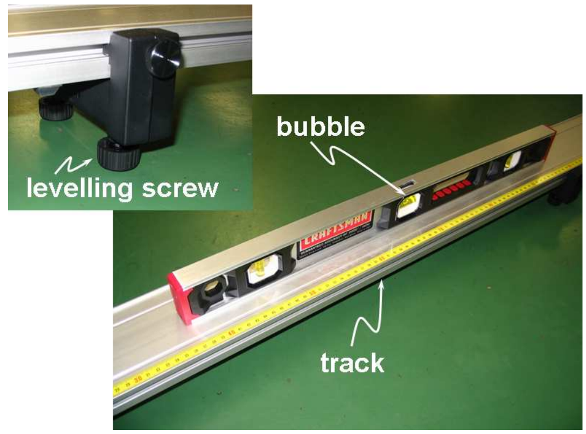
Purpose

In this lab, you will investigate the motion of a cart that moves along a horizontal and inclined track using a motion sensor.

Materials

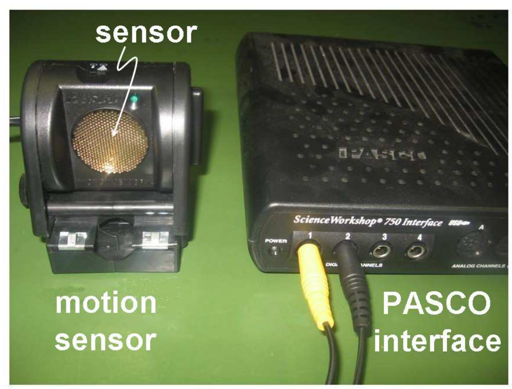
Collision cart, PASCO track, motion sensor, PASCO interface, ME-9495 angle indicator, cart launcher, stand and track-mounting bracket.

Levelling the Track



1. The track comes equipped with feet that incorporate levelling screws. Lay a level along the track as indicated in the figure at right and adjust the levelling screws until the bubble is centered between the lines.
2. Check your level by placing the collision cart on the track. It should not roll in either direction. If it does, readjust the levelling screws.

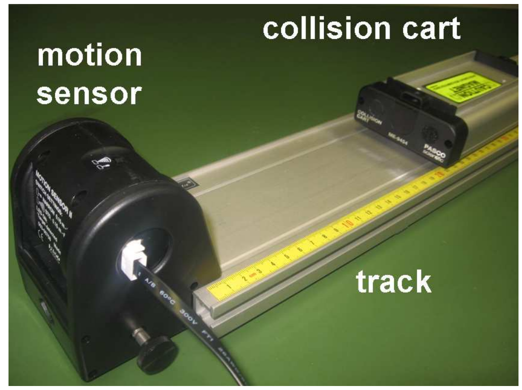
Setting Up the Motion Sensor



1. Ensure that the PASCO interface is connected to the USB port of the computer and that its power supply cable is connected. Connect the yellow and black cables of the motion sensor to Channel 1 and Channel 2 of the PASCO interface, respectively.
2. Open Data Studio. Click on the option Create Experiment. (The interface icon shown below should appear. Available channels will be circled in yellow.)

3. Click on Channel 1 (leftmost yellow circle). From the popup menu choose Motion Sensor. If you are successful, Data Studio should depict the connected Motion Sensor as in the picture at left.
4. While still in the Setup menu, choose Position for the quantity to be measured. (Deselect the Velocity and Acceleration.) Close the Setup window.
5. On the left-hand side window, click and drag the Position data property down to the Graph icon. This should open up a graph on the right window.
6. Check if the motion sensor is working properly by clicking on the Start button on the toolbar. You should see dots plotted on the graph. Click the Stop button on the toolbar. If you don't see any dots, re-check your connections and repeat steps 1–6.

Using the Motion Sensor



1. Put the motion sensor on the zero end of the PASCO track. Make sure the wide/narrow beam selector on top of the motion sensor is set to the narrow beam and that the gold sensor is oriented along the track. Position the collision cart at the 20-cm mark. (The motion sensor is not sensitive to objects within 20 cm.)
2. Delete the data from any previous runs. Click the Start button on the Data Studio toolbar. Let it run for five seconds then click Stop.

? What are the mean value and standard deviation of the points in the plot generated? Be careful with your units. Double click on the Position icon in the Data Window to open the Data Properties popup. Set the number of decimal places on the Numeric tab so that you obtain two significant figures for σ. Turn off the Scientific Notation Thresholds.

3. Now position the collision cart at the 40-cm mark. Again, click Start on Data Studio and let it run for five seconds before clicking Stop.

? What are the mean value and standard deviation of the points in the plot generated?

4. Predict what the readings will be on the graph when the cart is moved to the 60-, 80- and 100-cm marks. Verify your predictions. Position the dynamic cart and acquire five seconds of data at each of the three locations.

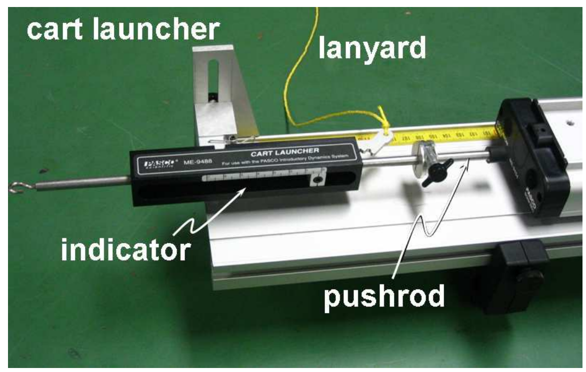
Location (cm)	Prediction	Observation	Comparison
60			
80			
100			

? How do your predictions compare with your observations? Use Excel to compute the comparison values.

? Based on what you just did, explain what the motion sensor is doing in the different cases that you have investigated.

Motion on a Horizontal Track

1. Delete the data from any previous runs: Select Experiment from the Menu bar and choose Delete ALL Data Runs. In Data Studio, click Setup. Then choose Position, Velocity and Acceleration for the quantities to be measured. Drag down the Position to the graph icon. Graph 1 should appear as a submenu for the graph. Then drag the Velocity and Acceleration down to Graph 1. Three graphs should be displayed simultaneously on the right window.



2. Affix the cart launcher to the track at the end opposite the motion sensor. Place the dynamic cart at the 20-cm mark. The motion sensor is very sensitive, so avoid bumping the table while collecting data.
3. Click the Start button on the Data Studio toolbar.
4. Gently push the collision cart away from the motion sensor.
5. Click the Stop button on the Data Studio toolbar when the cart reaches the cart launcher.

If your resulting data are particularly noisy, repeat steps 3–5. Make sure that you expand the plots so that you can see the variation in the data.

! We are interested in analyzing the *trends* in the data after the cart has been pushed. Use the Fit tool or Statistics tool and select the appropriate range of data to quantify your answers.

? **A.** Based on the position vs. time graph, how does the displacement of the cart vary with time? Don't forget to adjust the digits displayed for each quantity so that two significant figures are reported for σ.

? **B.** Based on the velocity vs. time graph, how does the velocity of the cart vary with time? What is the mean velocity?

? **C.** Based on the acceleration vs. time graph, how does the acceleration of the cart vary with time? What is the mean acceleration? Is it different from zero?

6. Using the Fit tool, determine the slope of the position vs. time graph just after the cart was set in motion.

? What is the value (don't forget the units) of the slope? How does this compare with the value of the velocity obtained in Question **B** above?

7. Using the Fit tool, determine the slope of the velocity vs. time graph just after the cart was set in motion.

? What is the value (and units) of the slope? How does this compare with the value of acceleration obtained in Question **C** above?

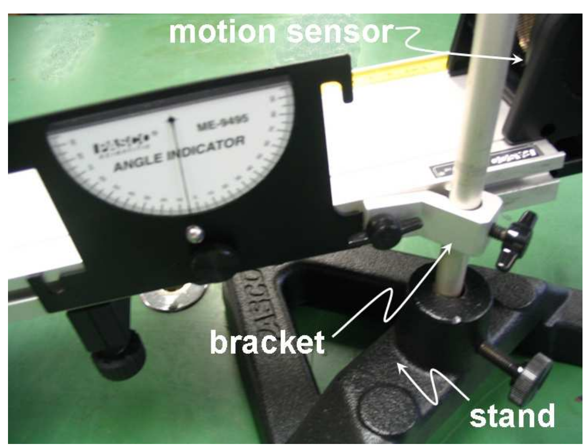
8. Reposition the cart at the 20-cm mark. Again click the Start button and push the cart, faster this time, toward the far end of the track. Click Stop when the cart reaches the cart launcher.

? What changes do you see on the different graphs?

Produce a plot of at least two runs, that best represent your observations. Choose runs where your data are not overly noisy. Delete other runs from the plot. Export the plot (select Display and Export picture from the menu bar) and save it in your My Documents directory. Open Microsoft Word and include the picture (Insert...Picture...From file).

Motion on an Inclined Track

1. Affix the angle indicator and attach the bracket and stand at the zero end of the PASCO track as indicated in the figure at right. Set the angle to about 5 degrees.
2. Clear the data from previous runs. Set up Data Studio to again acquire Position, Velocity and Acceleration data.
3. Hold the cart at the 20-cm mark and click the Start button on the toolbar.
4. Release the cart without pushing and click the Stop button when the cart reaches the far end of the track.



? From the plots, how do the position, velocity and acceleration vary with time?

? How does the acceleration differ from the case where the track was horizontal?

5. Again set up Data Studio to acquire Position, Velocity and Acceleration data.

! In this section, we are going to launch the cart toward the Motion Sensor. Do NOT allow the cart to strike the sensor.

6. Set the cart launcher so that the indicator reads 4 and the pushrod touches the cart at its center. Launch the cart by pulling sharply on the lanyard. Make sure that the cart DOES NOT travel past the 20-cm mark. If it does, adjust the launcher to a lower value.
7. Reset the cart launcher and click Start on Data Studio. Click the Stop button when the cart returns to the launcher.

? From the plots, how do the position, velocity and acceleration vary with time? During which portion of the time is the cart travelling up the incline? Which portion represents downward motion?

? How does the acceleration compare with the results from step 4?

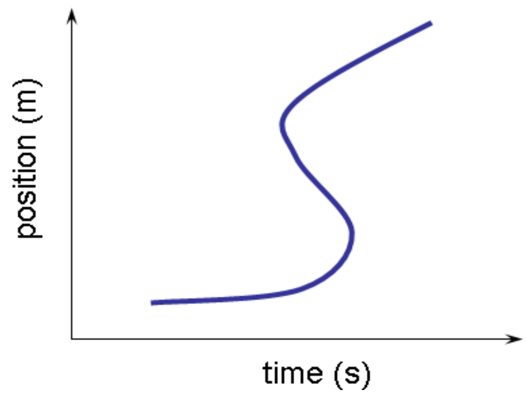
? Explain why physicists would refer to the cart motion as "uniformly accelerated."

Produce a plot of the data that best represent your findings. Export it and paste it into the Word document on the same page as the previous plot.

Making Connections

How is the motion sensor that you used similar to or different from the radar guns that traffic officers use in tracking the speed of motorists?

Does the plot at right describe a possible trajectory for cart motion? Justify your answer.



Reconstruct the position and acceleration plots from the velocity graph shown at right.