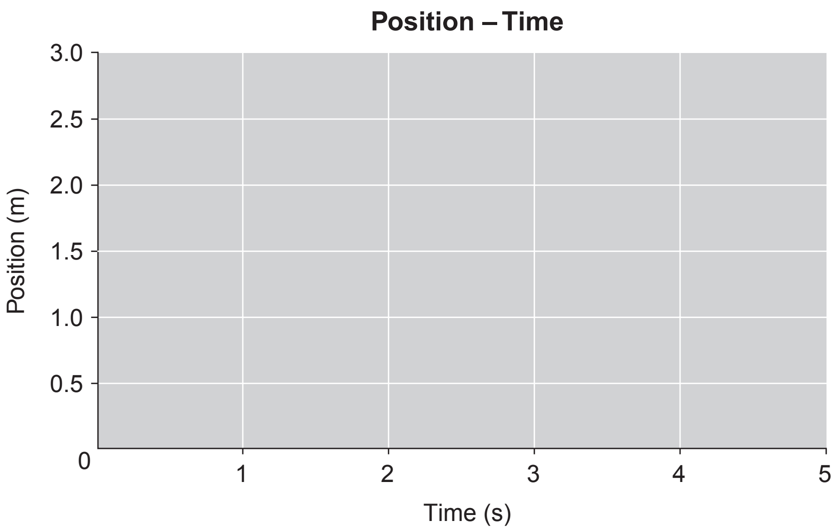
Additional Activity 1.3.3

(Lab Interface BLM) Instantaneous and Average Velocity

We know from earlier work that when something is moving with a constant velocity, the position-time graph of the motion is a straight line, and the slope of this line gives the value of the velocity. We also know that it is very difficult to move with perfectly constant velocity. In fact, most moving objects travel with changing velocity. How do we determine the velocity at an instant? How do we determine the average velocity for a time interval? We will use the motion sensor and software to help develop an understanding of these principles for a cart (or a ball, if a cart is not available) on an inclined plane.

Procedure

1. Connect the motion sensor to the interface and open the file for this activity.
2. Before you start collecting data, predict what the shape of the position-time graph will be when the cart rolls down an incline. Sketch your prediction on the grid below and label it "prediction—down incline."



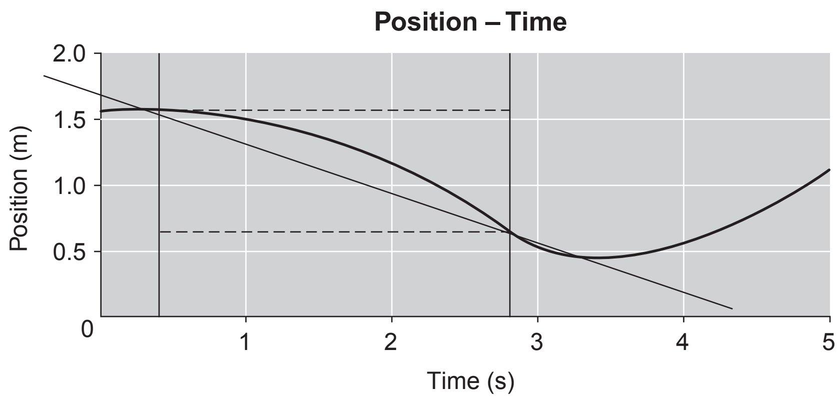
3. Once you have made your prediction, use the computer and motion sensor to collect data for the cart rolling down an incline. Release the cart as soon as you hear a sound coming from the motion sensor and click on "stop" as soon as the cart gets to the bottom of the ramp. Sketch the result on the grid above and label it "actual—down incline."

Analysis

(a) First autoscale the graph using the button at the top of the screen. You will see that the graph is curved. This means that the velocity is constantly changing. How can we get the velocity at a particular instant in time? If we take a very small section of the curve, we can assume that it approximates a straight line. If we take the slope of this line, we would then be able to determine the velocity at that instant, or the *instantaneous velocity*. Click on the tangent tool button. As you drag the cursor along the graph, you will see the tangent line moving along the curve. At each instant, the slope of the line is given. This gives us the instantaneous velocity at any point of interest to us. Where is the velocity the lowest? Where is the velocity the greatest?

Position the tangent tool so that it shows the velocity of the cart at the halfway point in its trip down the incline.

(b) Average velocity over an interval is obtained by calculating the total change in position divided by the total change in time. Using the cursor, you can define the interval by clicking on the first point and dragging the cursor to the second point. A box will appear on the graph with corners positioned on the end points of the interval. At the bottom of the screen, you will see values for Δx and Δy. The average velocity can be obtained by dividing the value of Δy by the value of Δx. This is the same as if you took the slope of the line connecting the first and last points across the interval.

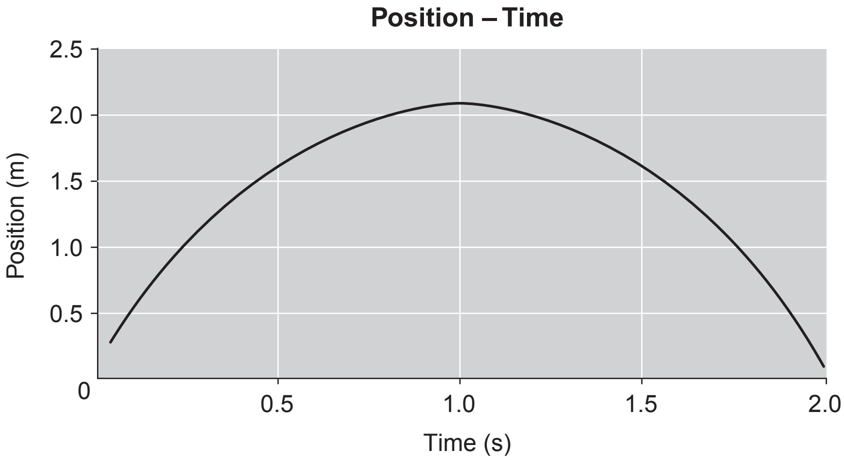


$\Delta x = 2.810$, $\Delta y = -1.077$

$$
\begin{aligned}
v_{av} &= \frac{\Delta y}{\Delta x} \\
&= \frac{-1.007 \text{ m}}{2.810 \text{ s}} \\
v_{av} &= -0.358 \text{ m/s}
\end{aligned}
$$

(c) You should either sketch the graph or print the graph and add the features showing the average and instantaneous velocities obtained. Make sure your graph shows the tangent with the slope given at some point on the curve and also information provided by the tangent tool.

Practice



(d) With the aid of a sketch, show how the track, cart, and motion sensor should be positioned, and indicate how the cart would have to move to give the result shown in the graph above.

(e) Open the second file for this activity. A graph that is the same as the position-time graph above should appear. Use the appropriate tools to determine the instantaneous velocity at 0.5 s and at 1.5 s. Carefully add what you saw on the computer screen to the diagram above.

(f) On the same graph, use the appropriate tools to determine the average velocity for the interval 0.5 s to 2.0 s and for the interval 1.0 s to 1.8 s. Again, carefully add the information to the diagram above.

