Additional Activity 1.4.1

(Lab Interface BLM)
Acceleration

Purpose

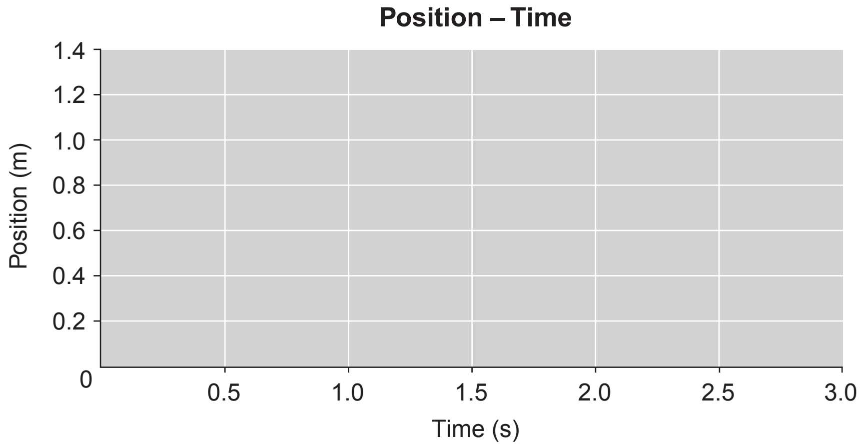
In this activity, you will study the concepts of acceleration and velocity. To carry out this investigation, you will use a motion sensor and a cart on a track (or a ball on a track, if a cart is not available).

Procedure

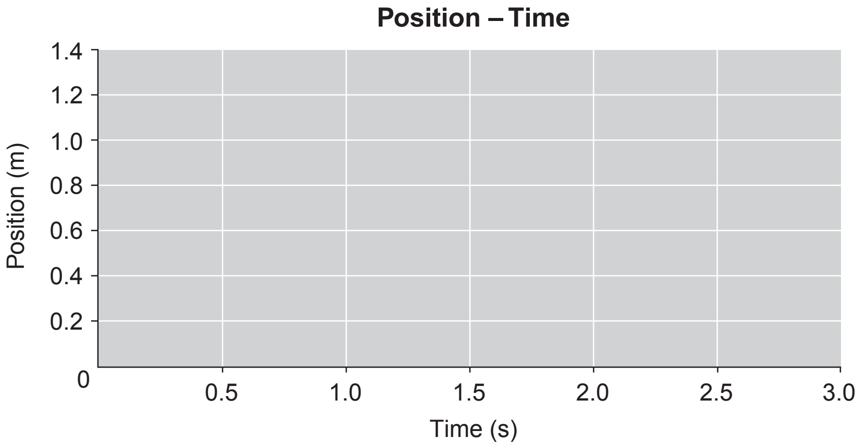
1. Connect the motion sensor to the interface and open the file for this activity.

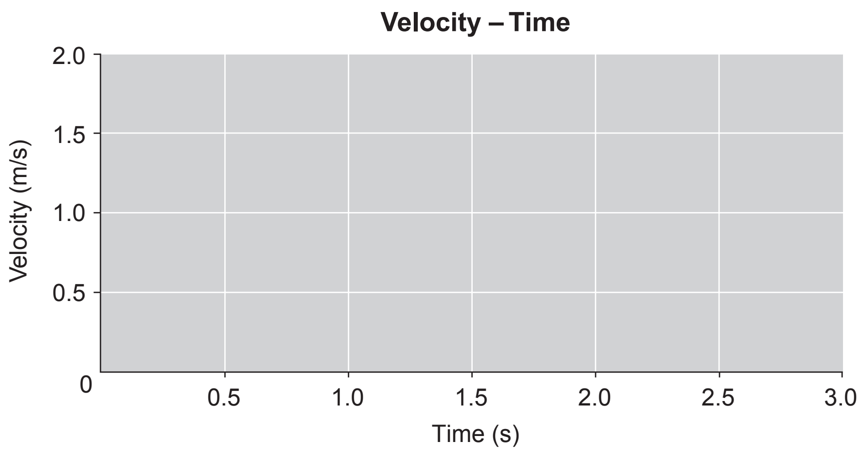
Part 1: Speeding Up—Away

2. In the first part of this investigation, you will release a cart at the top of the track and graph its motion as it rolls down the track, away from the motion sensor. Before you actually begin collect data, predict what the position-time graph will look like by sketching it on the grid below. Label the sketch "prediction—down ramp."



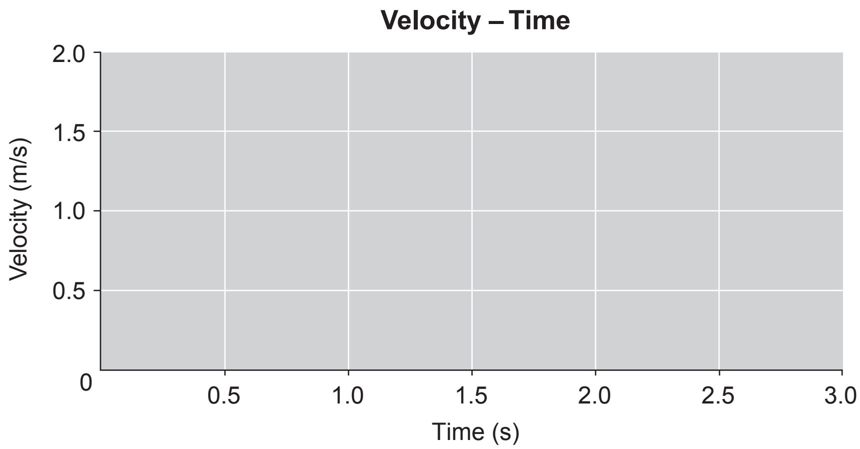
3. After you have made your prediction, use the motion sensor to collect data for the event. Place the motion sensor at the top of an inclined plane onto which you have placed the metal track, if using one. Remember the sensor must be greater than 40 cm from the object to collect good data. Try to release the cart as soon as you hear a noise coming from the motion sensor. Click the "Stop" button just as the car reaches the bottom of the incline. You may need to adjust the angle of the sensor to get good data. When you have been successful in collecting the data, sketch the result in the grid above and label it "actual—down ramp."
4. It is obvious that the velocity is increasing as the cart rolls down the track. However, is the velocity increasing at a uniform or a nonuniform rate? Use the software to plot a velocity-time graph. Don't forget to provide an appropriate title for the graph. Hold the cart about 35 cm from the motion sensor at the top of the incline. Have your partner click the "Start/Collect" button and release the cart as soon as you hear a noise coming from the motion sensor. Click the "Stop" button just as the cart reaches the bottom of the incline, or let the sensor stop on its own. Sketch your results on the grids provided on the following page.

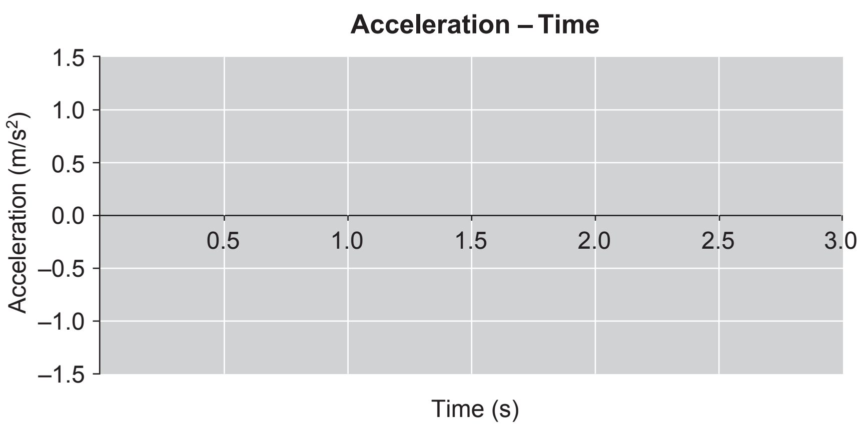




5. What does the shape of the velocity-time graph tell you about the acceleration of the cart while it rolls down the incline? Is it uniform or nonuniform? Is it positive or negative? How can you tell?

6. Determine the value of the acceleration. Change the *y*-axis of the two graphs to show velocity versus time and acceleration versus time. Collect another set of data by placing the cart at the top of the incline, clicking "Start/Collect" when you hear a noise coming from the motion sensor, and clicking "Stop" just as the cart reaches the bottom of the incline. After autoscaling the graph, sketch the result in the grids provided below.





Acceleration is defined as $a = \dfrac{\Delta v}{\Delta t}$ The variable Δv represents the rise and the variable Δt represents the run.

The ratio $\dfrac{\Delta v}{\Delta t}$ is the slope of the velocity-time graph.

Determine the slope of the portion of the velocity-time graph that represents the cart rolling down the incline (after you have let go and before you catch it). Make an accurate sketch of the result in the grid above. Record the acceleration of the cart in the space provided below.

Compare the value obtained by taking the slope of the velocity-time graph to the value given by the acceleration-time graph. Select the relevant section of the acceleration-time graph and click on "Statistics." The "mean" is the average value of the *y*-variable, in this case acceleration. How does the value of the "mean acceleration" compare to the slope of the velocity-time graph?

7. What if you were to make the incline steeper, how do you think the graph would change?

8. After you have made your prediction, increase the steepness of the incline and collect data for the cart as it rolls down the ramp. Sketch the result on the previous grid and label it "steeper incline."
9. Another way of showing what is happening is to draw a series of velocity vectors. A velocity vector is an arrow that points in the direction of motion and has a length that indicates how fast the object is moving. A series of arrows can then show what is happening with the motion. The series below would be correct for a cart rolling along at a constant speed.

10. In the space below, draw a series of velocity vectors that would show what was happening with the velocity of the cart as it rolled down the incline. You can use a dot to represent a velocity of 0 m/s.

Summary for Part 1: Speeding Up—Away

11. What was the sign of the acceleration?

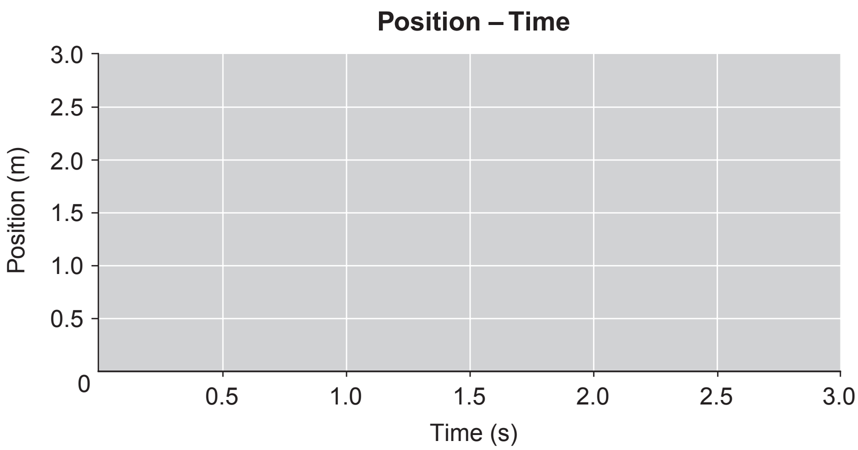
12. How could you use the velocity-time graph to tell the sign of the acceleration?

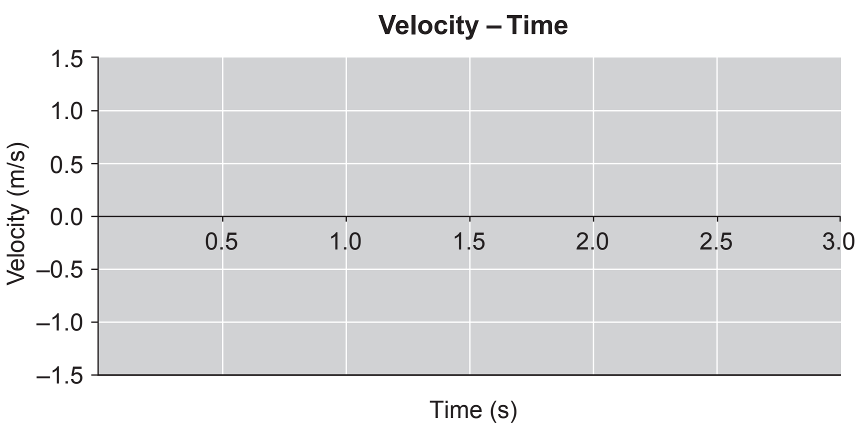
13. How could you use the acceleration-time graph to tell the sign of the acceleration?

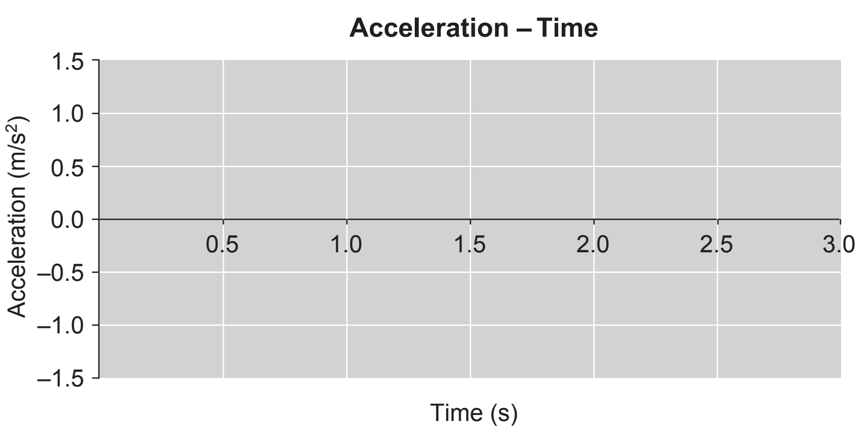
Graphical Summary for Part 1: Speeding Up—Away

Position the cart about 35 cm from the motion sensor at the top of the incline. Click "Start/Collect" and release the cart as soon as you hear a noise coming from the motion sensor. Click "Stop" just as the cart reaches the bottom of the track. In the space below, sketch the resulting graphs. On each of the three graphs add the following labels:

A—when you started pushing the cart
B—the instant you let go of the cart
C—the instant the cart reached the bottom of the track

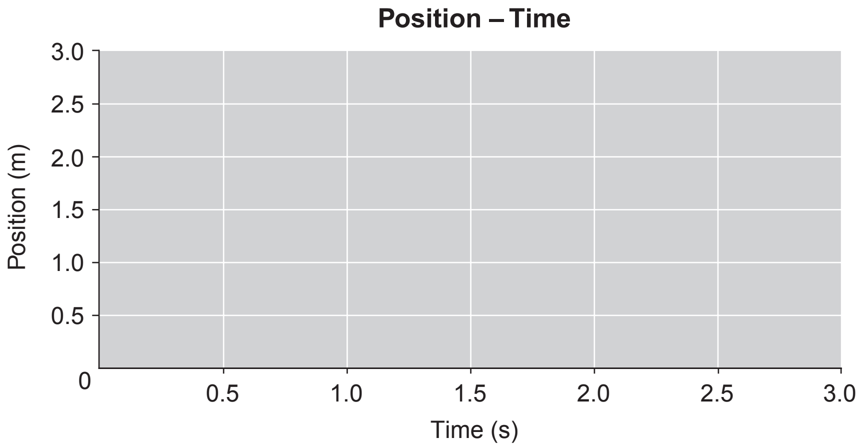


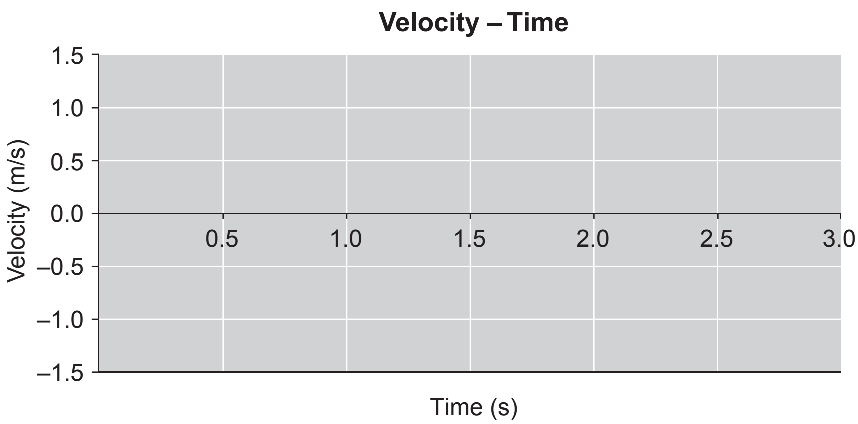


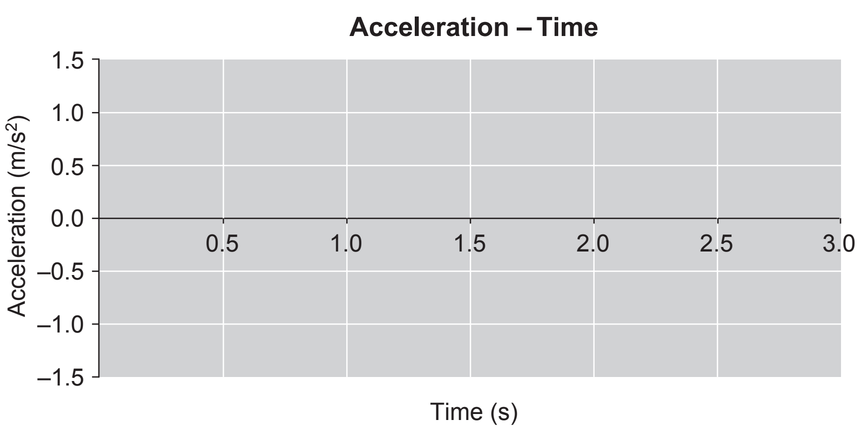


Part 2: Slowing Down—Away

14. Set up the equipment so that the motion sensor is positioned at the bottom of the incline. In this case, as soon as you hear a noise coming from the motion sensor, you will give the cart a push up the incline, away from the sensor. One of your partners will catch it at the top of the incline and another partner will click "Stop" at the instant the cart reaches the top of the incline. On the grids below, sketch the position-time, velocity-time, and acceleration-time graphs that you think will result. Label the sketches "prediction—up ramp."







Once you have made your predictions, collect data to see if you were correct. Sketch the results on the grids on the previous page and label the graphs "actual—up ramp." What do the graphs say about the motion of the cart as it rolls up the incline?

15. For each of the three graphs (position-time, velocity-time, acceleration-time), label the following points:

    A—when you started pushing the cart

    B—when you took your hand off the cart

    C—when your partner caught the cart at the top of the incline.
16. To make it easier to see the detail provided by the velocity-time and acceleration-time graphs, repeat the run up the incline. Select the relevant section of the graph that represents the motion after you released the cart and before it is caught. Use the software to find the slope of the velocity-time graph for the cart.
17. How would the graph change if you were to use a steeper incline? Make the angle of inclination larger and collect data to show the result. Label the graph "steeper incline." If your teacher requires it, print a copy of this graph so that you will have it for your report.
18. If an object is moving with a positive velocity, how can you tell from the value of its acceleration whether it is speeding up or slowing down?
19. In the space below, draw a series of velocity vectors to illustrate what happens to the velocity of the cart as it rolls up the incline.

Summary for Part 2: Slowing Down—Away

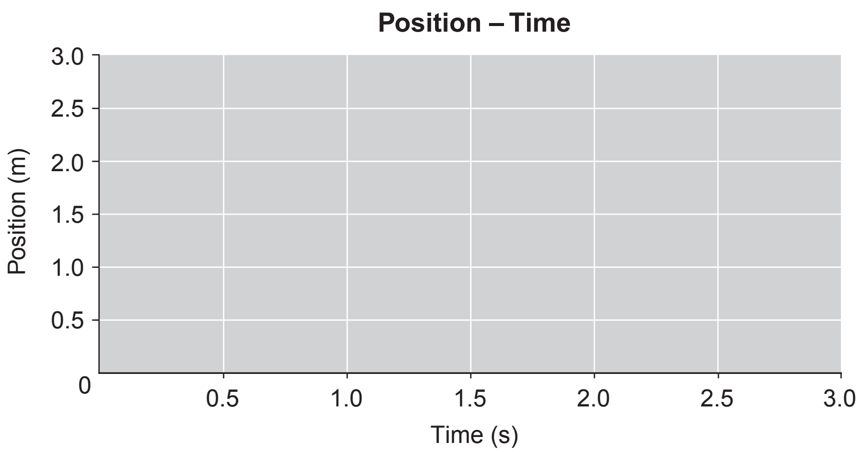
20. What was the sign of the acceleration?
21. How could you use the velocity-time graph to tell the sign of the acceleration?

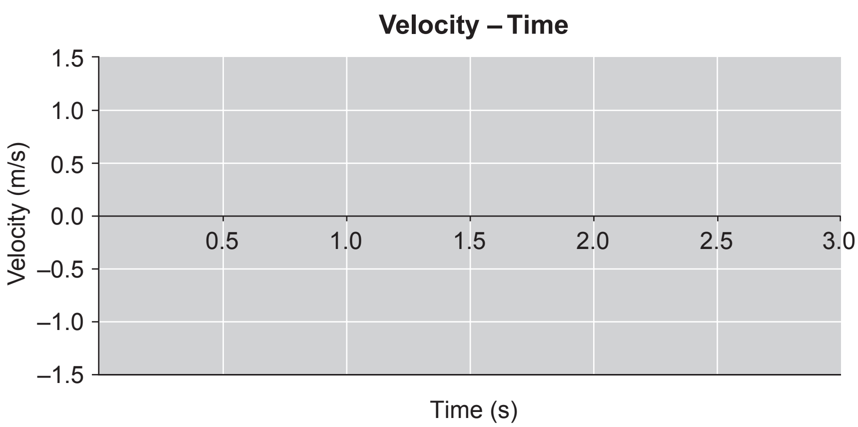
(Activity 1.4.1 continued)

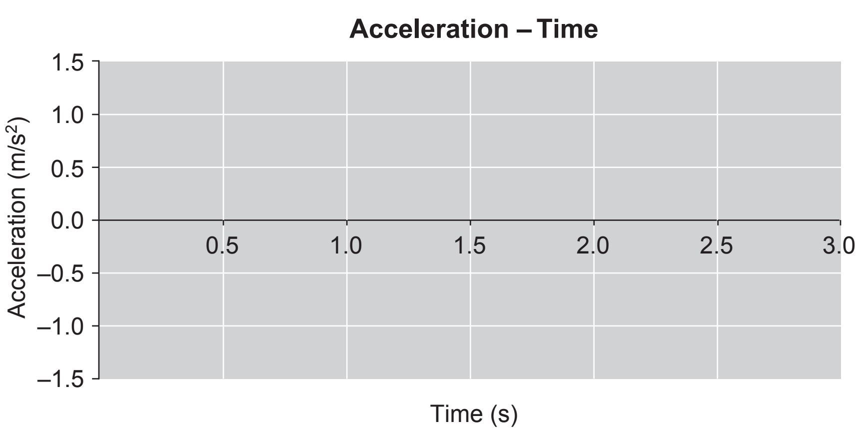
22. How could you use the acceleration-time graph to tell the sign of the acceleration?

Part 3: Speeding Up—Toward

23. Set up the equipment so that the sensor is positioned at the bottom of the incline. You will release the cart from the top of the ramp and your partner will catch it at the bottom of the ramp, about 20 cm away from the motion sensor. Think about the motion that the cart will experience and sketch your predictions for position-time, velocity-time, and acceleration-time on the grids below. Label the sketches "prediction—toward, speeding up."







24. After you have made your predictions, collect data as the cart rolls down the incline toward the motion sensor. Sketch the results in the grids above and label the graphs "actual—speeding up toward." Label each of the graphs as follows:

    A—released cart

    B—caught cart

25. Collect data for another run. Click "Start/Collect" and release the cart as soon as you hear a noise coming from the motion sensor. Click "Stop" when your partner catches the cart in front of the motion sensor. What do the shapes of the velocity-time and acceleration-time graphs tell you about the motion experienced by the cart as it rolled down the incline?

    Use the smart tool to find the acceleration by finding the slope of the velocity-time graph as the cart rolls down the incline. Use the statistics tool to find the average, or mean acceleration from the acceleration-time graph, during the time the cart is rolling down the incline (i.e., after it is released and before it is caught).

26. What do you think would happen if you made the incline steeper? After you make your prediction, carry out the activity to check your prediction. If required, print a copy of this graph so you can include it with your report.

27. Draw a series of velocity vectors to show how the velocity changes as the cart rolls up the incline. Start on the right side of the page and progress to the left side.

Summary for Part 3: Speeding Up—Toward

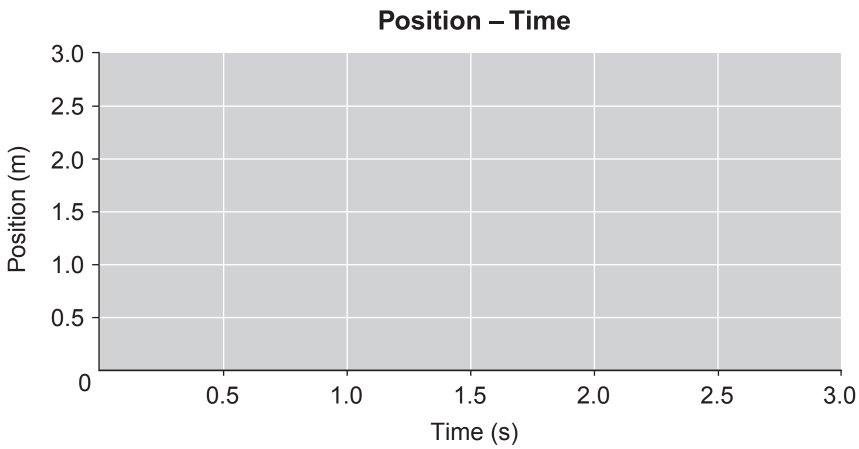
28. What is the sign of the acceleration in this case?

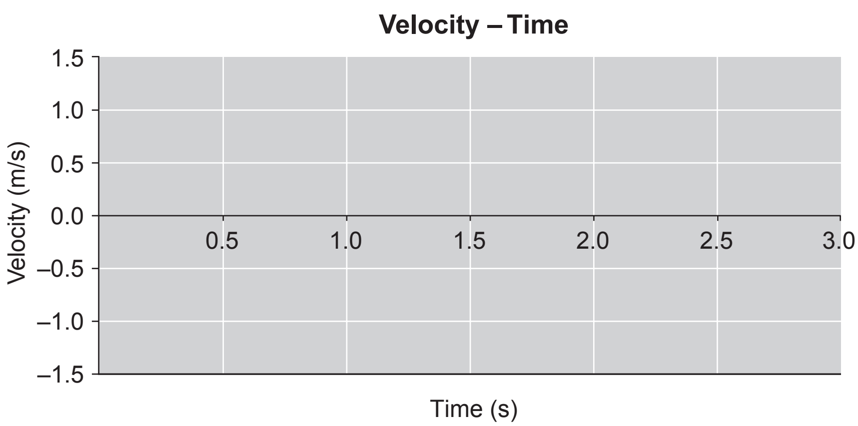
29. How can you tell from examining the velocity-time graph?

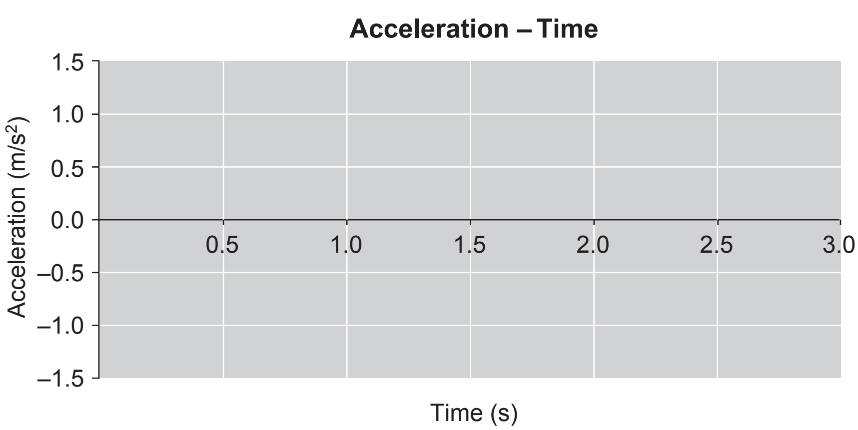
30. How can you tell from examining the acceleration-time graph?

Part 4: Slowing Down—Toward

31. Set up the equipment with the motion sensor positioned at the top of the ramp. In this case, you will give the cart a push toward the motion sensor and your partner will catch the cart when it stops at the top of the incline, about 20 cm away from the motion sensor. Before starting to collect data, sketch your prediction of what the position-time, velocity-time, and acceleration-time graphs will look like, using the grids below. Label the graphs "prediction—slowing down toward."







32. After you have made your predictions, collect data as you push the cart up the incline and catch it when it stops at the top. Sketch your results on the previous grids and label the graphs "actual—slowing down toward." Label each of the graphs as follows:

    A—when you begin to push the cart

    B—when you let go of the cart

    C—when your partner catches the cart at the top of the incline.

33. Collect another data run where you give the cart a push up the incline and catch it when it stops at the top of the ramp. What do the shapes of the velocity-time graph and the acceleration-time graph tell you about the motion experienced by the cart as it rolled up the incline?

    Find the average acceleration by calculating the slope of the velocity-time graph as the cart rolls up the incline. Use the statistics tool to find the average, or mean acceleration from the acceleration-time graph, during the time the cart is rolling up the incline (i.e., after it is released and before it is caught).

34. What changes do you expect to see in the graphs if you make the incline steeper? If required, print a copy of this graph so that you can include it with your report.

35. Draw a series of velocity vectors to show what happens to the velocity as the cart rolls up the incline. Start on the right side of the page and progress to the left side.

Summary for Part 4: Slowing Down—Toward

36. What is the sign of the acceleration in this case?

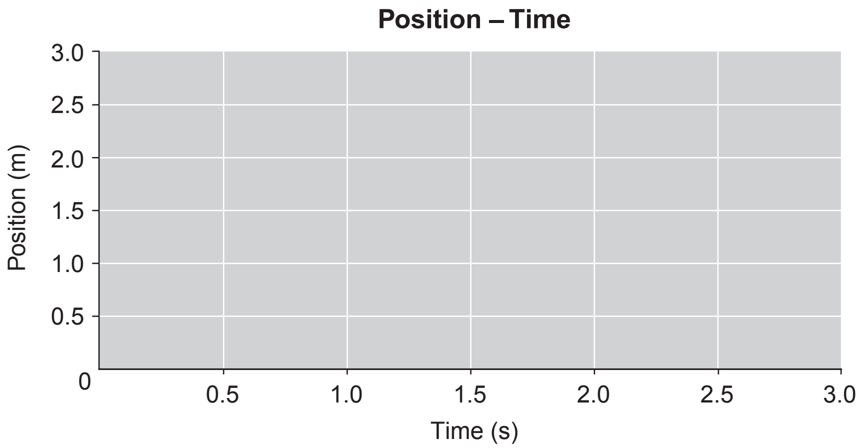
37. How can you tell from the velocity-time graph?

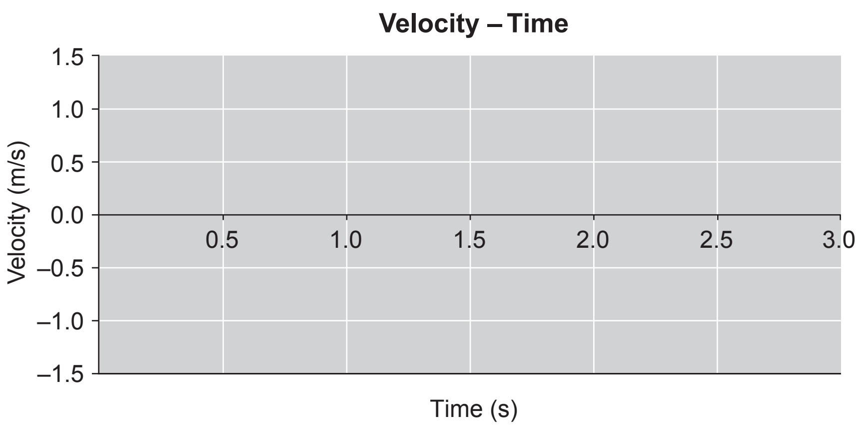
38. How can you tell from the acceleration-time graph?

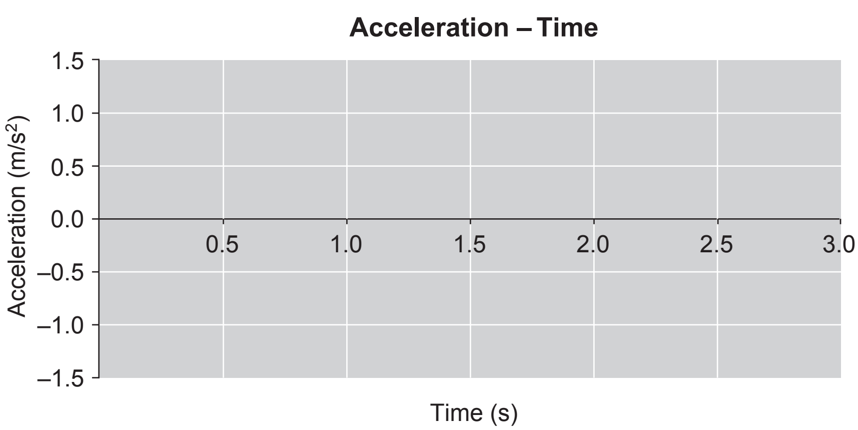
(Activity 1.4.1 continued)

Part 5: Up and Back

39. Set up the equipment with the sensor positioned at the top. In this case, you will give the cart a push up the incline and then catch it when it returns to the starting point. Predict what the position-time, velocity-time, and acceleration-time graphs will look like by sketching them on the grids below. Label the graphs "prediction—up and back."







40. After you have made your predictions, collect data for a back-and-forth trip for the cart. Sketch the results on the previous grids and label the graphs "actual—up and back." Label each of the graphs as follows:

    A—when you started pushing the cart
    B—when you took your hand off the cart
    C—when the cart reached the top of the track
    D—when you caught the cart

41. How does the acceleration that the cart experiences when it is coasting up the track compare to the acceleration that it experiences when it is coasting down the track?

42. Describe the acceleration of the cart at the instant it is stopped at the top of the track.

43. Predict what would happen if you gave the cart a harder push (i.e., the cart would go farther up the track before it stopped and returned).

44. Once you have made your prediction, carry out the activity. Have any of the values associated with the motion remained unchanged when the cart was given a harder push?

45. Predict how the graphs would change if you used a steeper incline.

46. Once you have made your prediction, check your hypothesis by performing a run in which the incline is steeper. When you have finished, print a copy of this graph so that it shows the following three runs:

    Run 1—cart up and back

    Run 2—cart up and back with a harder push

    Run 3—cart up and back on a steeper incline

47. In the space below, sketch a series of velocity vectors to show the velocity of the cart as it rolled up the incline and back down.

48. Complete the chart below by indicating whether the velocity and acceleration are positive, negative, or zero for each of the situations specified.

Part of Trip	Velocity	Acceleration
Cart is being pushed up the incline.		
Cart is coasting up the incline.		
Cart reaches the top.		
Cart is coasting down the incline.		
Cart is being stopped.		

49. You have examined a number of situations for a cart moving in a straight line. Try to formulate a general rule that will help you decide when the acceleration is positive and when it is negative.