# Speeding Up

You may have noticed that an object rolling down a hill starts out slowly and then speeds up. In this activity, you will measure the maximum speed of the cart as it rolls down a ramp from different starting positions. You will use a Motion Detector to measure the speed of the cart.

## OBJECTIVES

- Measure velocity using a Motion Detector.
- Calculate average velocities.
- Determine the relationship between velocity and release point.

## MATERIALS

computer
Vernier computer interface
Vernier data-collection software
Motion Detector
1.5 m board
car
5.6 × 12.7 cm (3 × 5 in) index card
meter stick
books, bricks, or box to support ramp
large book

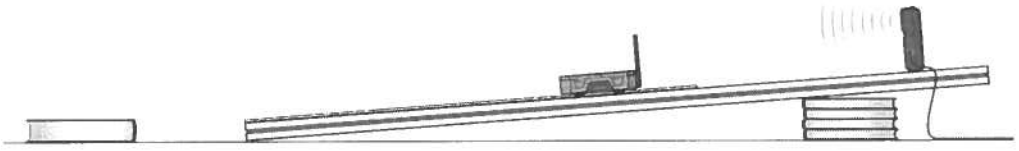

*Figure 1*

## PROCEDURE

1. Set up the board as shown in Figure 1. The high end of the ramp should be no more than 30 cm from the floor. Place a large book 1 m from the bottom end of ramp. This book will stop your car after it leaves the ramp.

2. Tape the index card to the back of the car.

3. If your Motion Detector has a switch, set it to Cart (see Figure 2). Connect the Motion Detector to a digital port of the interface. Position the Motion Detector at the top and center of

the track as shown in Figure 1.

*Figure 2*

4. Start the Vernier data-collection program and open the file "34 Speeding Up" from the *Middle School Science with Vernier* folder.
5. Collect data.
   a. Place your car on the board so the front edge of the car is at the 40 cm line.
   b. Click Collect, and then release the car.
6. Click Statistics, . Record the maximum speed in your data table.
7. Repeat Steps 5 and 6 two more times.
8. Repeat Steps 5–7 with the front of the cart at the 60 cm position and again with the front of the cart at the 80 cm position.

## DATA

| Table 1: Maximum Speed (m/s) | | | |
|---|---|---|---|
| Trial | 40 cm | 60 cm | 80 cm |
| 1 | | | |
| 2 | | | |
| 3 | | | |

| Table 2 | |
|---|---|
| Release position (cm) | Average maximum speed (m/s) |
| | |
| | |
| | |

## PROCESSING THE DATA

1. Calculate the average maximum speed for each release position. Show your work, and write the average values in Table 2.

2. Graph these results on Page 2 of the experiment file. Plot Release Position (in cm) on the horizontal axis and Velocity (in m/s) on the vertical axis. Describe the shape of the graph.
3. What happened to the maximum speed as you released the cart from higher points?
4. Explain two ways to make the cart's maximum speed greater, and explain why you think they would be successful.

## EXTENSIONS

1. Repeat the experiment with ramps of different heights.
2. Redo the experiment with different amounts of mass on the cart. Summarize your results in a few sentences.

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1. In the Electronic Resources you will find multiple versions of each student experiment—one for each supported data-collection software or app (e.g., Logger *Pro* and Graphical Analysis). Deliver to your students the version that supports the software and hardware they will use. Sign in to your account at **vernier.com/account** to access the Electronic Resources. See Appendix A for more information. **Note**: The printed version of the book and the PDF of the entire book (found in the Electronic Resources) include only the Logger *Pro* versions of the experiments.

2. Students may be confused that they are looking at a velocity *vs.* time graph to determine maximum speed. For the purposes of this experiment, speed and velocity are numerically the same. While the definitions of speed and velocity are not identical, researching the differences between the definitions can be a good short assignment for students.

3. Make sure the Motion Detector is positioned at least 15 cm from the release point of the car. See **www.vernier.com/til/5** for more tips on using the Motion Detector.

4. Free-rolling toy cars and the Pencil Car descried in the student pages of Experiment 35, "Indy 100," work well. If you have access to dynamics carts and tracks, such as the Vernier Dynamics Cart and Track System (order code: DTS), they also work well.

5. In the Procedure, students are directed to tape an index card to the back of their car to act as an ultrasonic reflector. Painter's masking tape works well as it is sticky enough to hold the card in place while being easy to remove without leaving a sticky residue.

6. Tape a meter stick to the board to act as a guide for the cars. If the cars are not staying on the ramp, you may want to tape two meter sticks to a ramp and run the cars between them. You may find it necessary to adjust the release positions and ramp height for your equipment.

7. For additional information about the Vernier probeware used in this experiment, including tips and product specifications, visit **www.vernier.com/manuals** and download the appropriate user manual.

8. If you are using Go Direct sensors, see **www.vernier.com/start/go-direct** for information about how to connect your sensor.

## ESTIMATED TIME

We estimate that this experiment can be completed in one 45–60 minute class period.


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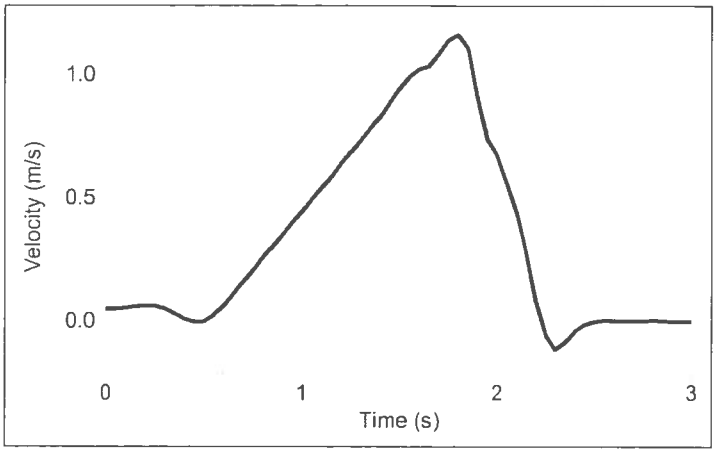
## SAMPLE RESULTS

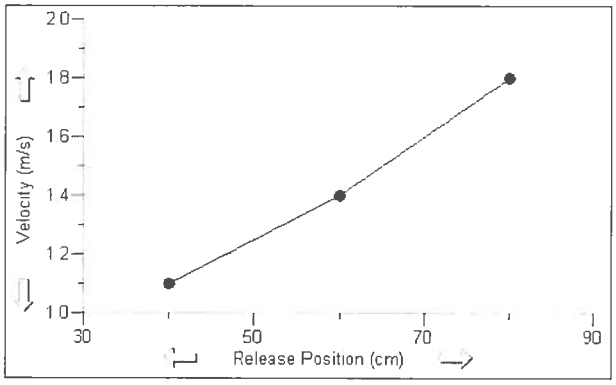



| Release position (cm) | Average maximum speed (m/s) |
|---|---|
| 40 | 1.1 |
| 60 | 1.4 |
| 80 | 1.8 |

## ANSWERS TO QUESTIONS

1. See Sample Results.

2.




3. The maximum speed increased as the cart was released from higher points.

4. Answers may vary. Moving the release position farther up the track should increase the maximum speed because the cart would have more time for speeding up. Increasing the height (or steepness) of the track should increase the cart's maximum speed because things go faster down steeper hills.