Speed and velocity are rates. They tell us how much distance is covered in a unit of time. Velocity differs from speed because velocity depends on direction, while speed does not. Velocity can be expressed by the formula

\[ v = \frac{d}{t} \]

where \( v \) = velocity or speed (in m/s), \( d \) = distance traveled (in meters), and \( t \) = time (in sec). In this activity, you will study the velocity of a car after it is released from different points on a ramp. A Motion Detector will be used to measure velocity.

**Objectives:** In this experiment, you will

- Use a computer-interfaced Motion Detector to measure velocity.
- Record data.
- Graph results.
- Determine the relationship between velocity and release point.

**Materials**

- Vernier computer interface car with large index card attached
- Vernier Motion Detector
- LabQuest
- meter stick
- ramp

**Procedure**

1. Set up a ramp on a chair as shown in Picture 1. The 1 cm end of the ramp should be on the floor. The motion detector should be positioned as it is in Picture 2, facing down the ramp. Place a binder or book 1 m from the bottom end of ramp to stop your car.
2. Tape a large index card to the back of a car, making sure that the card does not impede the car’s motion.
3. Connect the Motion Detector to DIG/SONIC 1 on the LabQuest.
4. On the LabQuest, set the “Duration” of the data collection for 2 seconds. You do this from the first page (the one with the big red “DIG 1: Position” on it).
5. On the Graph page, choose Show Graph 2 (the Velocity vs. Time graph).
6. Place your car on the ramp with its front at the 40 cm line. Click the green arrow and release the car **AFTER** you hear the rapid clicks coming from the Motion Detector.
7. If the run was a clean run, save your data by touching the stylus to the file cabinet.
8. Touch the stylus to the highest point on the graphed line to determine the maximum velocity reached. Record the maximum velocity in your data table.
9. Repeat Steps 6-8 for two more trials, and record the maximum velocity for each. 
10. Repeat Steps 6-8 at 60 cm and 80 cm release positions.

<table>
<thead>
<tr>
<th>Maximum Velocity (m/s)</th>
</tr>
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<tbody>
<tr>
<td>Trial</td>
</tr>
<tr>
<td>-------</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>2</td>
</tr>
<tr>
<td>3</td>
</tr>
<tr>
<td>Average Maximum Velocity</td>
</tr>
</tbody>
</table>

**Processing the Data**

What happened to the velocity as the car was released from higher points?

Using clear scientific language, describe what caused the differences in velocity.
Graph your results below. Plot Release Position (range of 0-100 cm) on the x axis, and Velocity on the y axis. Draw a line of best fit on your graph.

Estimate the average velocity for the car at a release point of 20 cm and at 100 cm. Describe how you determined your estimates.
Describe one way you could make the car go down the ramp faster without changing the height of the ramp or the release positions, and one way you could make the car go slower.

On the Velocity-Time graph below, sketch a line that demonstrates an object moving at a constant velocity, and a line that demonstrates an object moving at an increasing velocity. Label each line.

Of the two lines on the above graph, which (if any) show an object that is accelerating? Explain your reasoning.

On the Distance-Time graph below, sketch a line that demonstrates an object moving at a constant velocity, and a line that demonstrates an object moving at an increasing velocity. Label each line.

Evaluate the two graphs you have drawn on this page. Are the two lines on each graph the same shape or not? Using clear scientific language, explain why the lines are shaped the way they are.