



## Explore 1: Playing with Toy Cars

<b>Type of Lesson:</b>	<u>Content with Process:</u> Focus is on constructing knowledge through active learning.	
<b>Learning Goal &amp; Instructional Objectives</b>	Students conduct experiments to collect data (time and distance) for calculating the average speed of a car as a function of its mass, the height of the ramp, and surface of the ramp. <i>Instructional Objectives:</i> <ol style="list-style-type: none"> <li>1. Calculate the speed of an object using the appropriate formula with data gathered in the laboratory and printed information.</li> <li>2. Calculate the acceleration of an object using the appropriate formula with data given in the problem.</li> </ol>	
	$s = \frac{d}{t}$ $a = \frac{v_f - v_i}{\Delta t}$	
<b>Key Questions:</b>	What factors affect the average speed of a small toy car? How does each factor affect the motion of the car?	
<b>IPC Content TEKS:</b>	4A	Calculate speed and acceleration in systems such as moving toys.
<b>Related Process TEKS:</b>	<b>(1) Scientific processes.</b> The student, for at least 40% of instructional time, conducts field and laboratory investigations using safe, environmentally appropriate, and ethical practices The student is expected to: (A) demonstrate safe practices during field and laboratory investigations;	
	<b>(2) Scientific processes.</b> The student uses scientific methods during field and laboratory investigations. The student is expected to: (A) plan and implement experimental procedures including asking questions, formulating testable hypotheses, and selecting equipment and technology; (B) collect data and make measurements with precision; (C) organize, analyze, evaluate, make inferences, and predict trends from data; and (D) communicate valid conclusions.	
	<b>(3) Scientific processes.</b> The student uses critical thinking and scientific problem solving to make informed decisions. The student is expected to: (A) analyze, review, and critique scientific explanations, including hypotheses and theories, as to their strengths and weaknesses using scientific evidence and information; (B) draw inferences based on data related to promotional materials for products and services; (C) evaluate the impact of research on scientific thought, society, and the environment;	
<b>To the Teacher:</b>	If you have photo gates and computers available, adapt the lab so that students can more accurately measure the time and calculate the speed. Since this experiment cannot accurately measure the final velocity of the toy car as it reaches the bottom of the ramp, acceleration was calculated in the analysis section using a given final velocity.  Students must know that velocity is defined as speed and direction. Acceleration is defined as the change in velocity divided by the change in time.	
<b>Multiple Intelligences:</b>	<i>Logical-Mathematical Intelligence—</i>	Consists of the ability to detect patterns, reason deductively, and think logically. This intelligence is most often associated with scientific and mathematical thinking.
	<i>Linguistic Intelligence—</i>	Involves having a mastery of language. This intelligence includes the ability to effectively manipulate language to express oneself rhetorically or poetically. It also allows one to use language as a means to remember information.



	<i>Spatial Intelligence—</i>	Gives one the ability to manipulate and create mental images in order to solve problems. This intelligence is not limited to visual domains. Gardner notes that spatial intelligence is also formed in blind children.
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**Materials:**

- One toy car per team
- One ramp per team. The ramp should be at least one meter long
- One stopwatch per team
- One meter stick per team
- Sandpaper and towels to cover the ramps
- Waxed paper for the ramp (one full roll of waxed paper)
- Masking tape (one roll)



**SAFETY NOTE:** See Texas Science Safety Manual for lab and investigation guidelines: [http://www.tenet.edu/teks/science/safety/safety\\_manual.html](http://www.tenet.edu/teks/science/safety/safety_manual.html)

**Engage:**

Introduce the ideas of speed and acceleration by discussing car races such as the Indianapolis 500. Find out what students know by asking the following facilitation questions.

**Facilitation Questions:**

1. How fast do you think those cars are going?
2. How can a driver figure out the car's speed if the car's speedometer is not working?
3. How does a race car driver change the speed of the car?
4. What is the difference between acceleration and speed?

**Explore:****Part 1: Height of ramp**

1. With the ramp flat on a table or floor, place the back of the car's wheels at one end of the ramp and measure the distance from the front of the car to the end of the ramp. Record this distance on the data sheet.
2. Raise the ramp up on the blocks. Measure the height in meters and record on the data sheet.
3. Place the back of the car's wheels at the top end of the ramp.
4. Release the car as you start the stopwatch.
5. Stop timing when the front of the car gets to the bottom of the ramp. Record this time on the data sheet.
6. Repeat steps 3-5 two more times then calculate the average time and record on the data sheet.
7. Calculate the average speed of your car by using the formula:  $\text{speed} = \frac{\text{distance}}{\text{time}}$  or  $s = \frac{d}{t}$ .
8. Raise one end of the ramp on two blocks and repeat steps 2-7.
9. Raise one end of the ramp on three blocks and repeat steps 2-7.



**Part Two: Mass of Car** (Height stays the same, mass changes)

1. Raise one end of the ramp on one block. Measure the height in meters and record on the data sheet.
2. Place the back wheels of the car at the top end of the ramp.
3. Time how long it takes to reach the bottom of the ramp. Record on the data sheet.
4. Repeat steps 2 and 3 two more times then calculate the average time and record on the data sheet.
5. Add a known mass to the car then repeat steps 2 - 4 recording all measurements on the data sheet.
6. Add a second known mass to the car then repeat steps 2- 4 recording all measurements on the data sheet.
7. Record observations in your journal.

**Part Three: Surface of the ramp** (Height of ramp changes, mass stays the same)

1. Raise one end of the ramp on 2 blocks. Measure the height in meters and record on the data sheet.
2. Place the back wheels of the car at the top end of the ramp.
3. Time how long it takes to reach the bottom of the ramp. Record on the data sheet.
4. Repeat steps 2 and 3 two more times, then calculate the average time and record on the data sheet.
5. Cover the surface of the ramp with a higher friction material such as a towel or sandpaper.
6. Repeat steps 2 - 4 two more times then calculate the average time and record on the data sheet. NOTE: If the car stops before it reaches the bottom of the ramp, measure the distance from the top of the ramp to the back wheels and record this distance on the data sheet.
7. Cover the ramp with waxed paper.
8. Repeat steps 2 - 4 two more times then calculate the average time and record on the data sheet.
9. Record observations in your journal.

**Explain:**

Have students record their calculations in their lab journals and communicate their findings in a class discussion.

**Part Four: Calculation, Graphs and Analysis**

1. Calculate the average speed for each line in the chart using the formula:  
$$\text{speed} = \frac{\text{distance}}{\text{time}} \text{ or } s = \frac{d}{t}.$$
2. Graph the data from Parts One, Two, and Three on separate graphs.
3. Identify the manipulated variable and responding variable for Parts One, Two, and Three.
4. Write about your findings in your journal and attach your graphs.



## Data Sheets\*

### Part 1: Does the height of the ramp affect the average speed of the car?

Distance Traveled (m)	Height of Ramp (m)	Time (s)	Average Time (s)	Average Speed (m/s)
			Average time (s)	
			Average time (s)	

### Part 2: Does the mass of the car affect the average speed of the car?

Distance Traveled (m)	Mass on Car (g)	Time (s)	Average Time (s)	Average Speed (m/s)
			Average time (s)	
			Average time (s)	

### Part 3: Does the surface of the ramp affect the average speed of the car?

Distance Traveled (m)	Surface of Ramp (m)	Time (s)	Average Time (s)	Average Speed (m/s)
			Average time (s)	
			Average time (s)	

\*Have students use Excel to construct graphs of their data.



**Elaborate:** Have students respond to the following questions in their science journals and then discuss their responses as a team.

**Analysis:**

**1. Why did you do each timing three times, and then average them?**

*For more accuracy in experiments, measurements should be done more than once.*

**2. How did the height of the ramp affect the average speed of the car?**

*The average speed increased because gravity was able to act on the car over a longer vertical distance.*

**3. How did the mass of the car affect its average speed?**

*When the car goes down the ramp, gravity pulls at it with the same acceleration no matter what its mass is. (Teacher note: Students have problems with this concept because many of them believe that heavier objects will hit the ground first.) The final velocity of each car no matter what its mass should be the same velocity. There are some factors that may influence the results. These include air resistance, wheel traction, and the pressure exerted on the car's axles due to the increased mass. (Teacher note: A discussion of Galileo before the exploration might help the students understand this concept.)*

**4. How did the surface of the ramp affect the average speed of the car?**

*The more the friction between the ramp and the car wheels, the slower the car will travel. The wax should make the car go faster. However, if the friction is too little, the wheels will not be able to have traction with the surface and might go slower. Students must look at their data to see if that situation happened.*

**5. What other factors do you believe would affect the average speed of the car? How do you think that each factor would affect the speed?**

*This is open to student opinion. They might want to test wheel size (circumference) or change the front of the car so it has less air resistance. Let them visualize their cars and what they could do to change the speed.*

**6. What sources of error were involved in this lab? How do you think each source of error affected your results?**

*Timing correctly was probably the area of most error. If the time was wrong, it would definitely affect the average speed accuracy. To try to overcome this error possibility, three time measurements were done for each trial.*

**7. What was the initial velocity of the car at the point that you let the car go?**

*It was 0 meters per second because the car was not moving until it was released.*

**8. If a device measured the final velocity of a car as 2 m/s south on the ramp, calculate the acceleration of the car if it took 4 seconds to reach the bottom of the ramp. Use the formula:**

$$\text{acceleration} = \frac{\text{final velocity} - \text{initial velocity}}{\text{change in time}}$$

$$a = \frac{2 \text{ m/s} - 0 \text{ m/s}}{4 \text{ s}} = 0.5 \text{ m/s/s or } 0.5 \text{ m/s}^2 \text{ [South]}$$



Have students answer these questions using data, observations, and information learned from this experience and record responses in their journals.

Explain fully. All conclusions are recorded in their lab journals. Students must analyze factors that affect the speed of a car and support their answers using data from the lab. At this point, go back to the Indianapolis 500 Car Race and discuss how drivers increase the speed and acceleration of their cars during the race. Discuss why certain cars accelerate faster than others. Ask about cruise control and its application to speed and acceleration. Also, include in the discussion how velocity can change even if speed is constant (because the direction changes).



"I'd offer you a lift home, but the company cars are well . . . you know."

# MOTION UNIT

# Fast and Furious—Off to the Races!

**Evaluate:** Use this rubric to assess student understanding of speed and acceleration of the car.

POINTS	Scientific Accuracy	Reasoning	Communication	Collaboration	
<b>4</b> Excellent	My measurements are precise and I included units in all calculations. Tables and graphs are accurate and variables are correctly identified.	My answers to the analysis questions show application level and are well reasoned. I am able to support my conclusions with lots of examples.	I answered all questions clearly and accurately. My answers are clear with examples and data to back up conclusions. I recorded all calculations and answers in my lab journal.	Our team made all measurements together. We solved the problems as a collaborative team in an atmosphere of respect.	
<b>3</b> Good	My measurements are somewhat precise and I included units in my calculations. Tables and graphs are complete and variables are identified.	My answers to the analysis questions show application level. I am able to support my conclusions with some examples.	I answered all questions clearly and accurately. I used examples and data to back up some of my conclusions. I recorded most of my calculations and answers in my lab journal.	Our team made measurements together. We solved the problems as a team.	
<b>2</b> Fair	My measurements are complete but may or may not be accurate. Tables and graphs are somewhat complete and a few variables are identified.	My answers to the analysis questions show application level. I am able to support my conclusions with a few examples.	I answered the questions. I used some examples and data to back up some of my conclusions. I recorded some of my calculations and answers in my lab journal.	Our team made a few measurements together. We solved some of the problems as a team.	
<b>1</b> Poor	My measurements are not complete and are not very accurate. My tables and graphs are incomplete and no variables are identified.	My answers to the analysis questions show a superficial understanding. I don't get what we are doing. I am not able to support my conclusions with examples.	I did not answer the questions and I didn't record my calculations in my journal.	I did not work with my team. We didn't collaborate at all during this experience.	
	Subtotal: ____	Subtotal: ____	Subtotal: ____	Subtotal: ____	<b>TOTAL:</b> ____/16pts

## References/Resources/Websites:

- ❖ Science's 10 Most Beautiful Experiments including Galileo rolling balls down inclined planes and Foucault's Pendulum: <http://physics.nad.ru/physics/english/top10.htm>
- ❖ High School Physics—Differentiating Instruction: <http://www.ascd.org/pdi/demo/diffinstr/l2act1.html>
- ❖ Toy Car Velocity: [http://www.scienceman.com/pgs/archive12\\_toycars.html](http://www.scienceman.com/pgs/archive12_toycars.html)
- ❖ Toy Challenge: <http://www.sciencenewsforkids.org/articles/20031224/refs.asp>
- ❖ NASA's The Physics of Toys: [http://www.nasaexplores.com/show2\\_912a.php?id=01-084&gl=912](http://www.nasaexplores.com/show2_912a.php?id=01-084&gl=912)
- ❖ Teaching Physics with Toys: [http://www.tsbkm.com/prod\\_detail/8](http://www.tsbkm.com/prod_detail/8)
- ❖ Coursework on Newton's Laws: [http://www.courseworkbank.co.uk/GCSE/Physics\\_Coursework/Force\\_Mass\\_and\\_Acceleration/](http://www.courseworkbank.co.uk/GCSE/Physics_Coursework/Force_Mass_and_Acceleration/)
- ❖ Physics Concepts: <http://my.execpc.com/~culp/rockets/physics.html>
- ❖ Velocity and Acceleration Animations: <http://www.physicsclassroom.com/mmedia/kinema/acceln.html>
- ❖ Describing Motion with Words: <http://www.physicsclassroom.com/Class/1DKin/U1L1d.html>
- ❖ Car Cartoons: [http://www.cartoonstock.com/directory/c/company\\_car.asp](http://www.cartoonstock.com/directory/c/company_car.asp)

