# 2 Measuring and Graphing Speed

LABORATORY

**ALTHOUGH MANY FACTORS** contribute to vehicle accidents, speeding is the most common driving behavior that increases your risk of getting into an accident. Speeding is involved in about 27% of fatal vehicle accidents in the United States.

**Speed** is the distance an object travels in a certain amount of time. For example, a car that travels a distance of 80 kilometers (km) in 1 hour has an average speed of 80 km per hour. Any object's speed can be calculated by dividing the distance traveled by the time taken, as shown in this equation:

$$\text{speed} = \frac{\text{distance}}{\text{time}}$$

People use many different units to describe speed. These include miles per hour (MPH), kilometers per hour (KPH or km/h), and meters per second (m/s). In this activity, you will learn how to measure speed, and how motion graphs help you understand speed.

## GUIDING QUESTION

**How can you measure and graph the speed of a moving object?**


*This car speedometer shows speed in miles per hour and in kilometers per hour. Kilometers per hour is the speed unit commonly used in most other countries outside of the United States.*

## MATERIALS

*For each group of four students*

- 2 track pieces
- 1 cart
- 1 ramp
- 1 meter stick
- 1 marker
- masking tape
- calculator

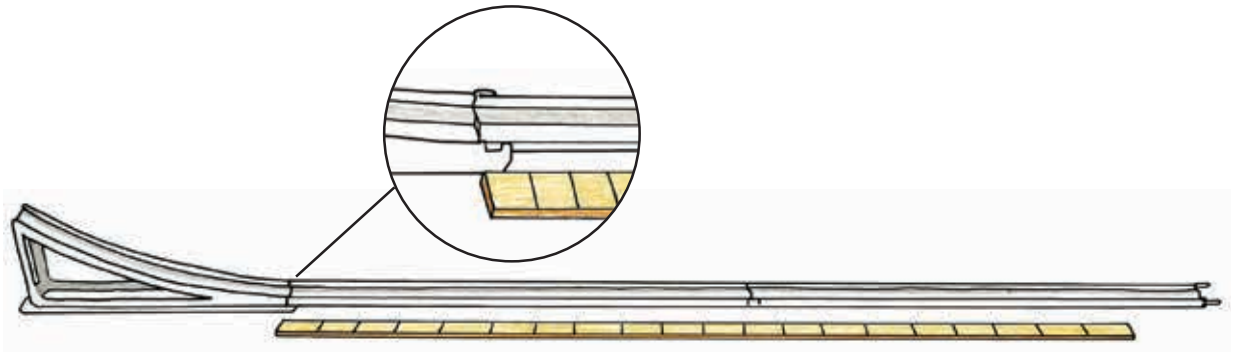
*For each pair of students*

- 1 set of 8 strips cut from Student Sheet 2.1, "Trip Strips"
- 1 Student Sheet 2.2, "Teasha's and Josh's Trips to School"
- 1 pair of scissors
- tape or glue

## PROCEDURE

### Part A: Measuring Time and Distance

1. Set up the ramp and track as shown below:



2. Next to the level part of the track, tape two pieces of masking tape to the table exactly 100 centimeters (cm) apart. Make a line with your marker on the tape to show precisely where 0 cm is and where 100 cm is.

3. In your science notebook, make a table like the one below:

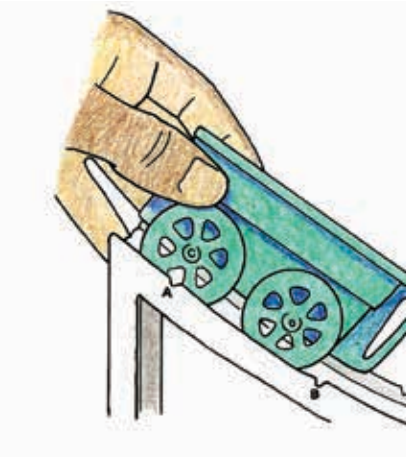
**Cart Speed**

| *Trial* | *Distance (cm)* | *Time (s)* | *Speed (cm/s)* |
|---|---|---|---|
| *1* | *100* | | |
| *2* | *100* | | |
| *3* | *100* | | |
| | | *Average* | |

4. Follow your teacher's instructions for how to measure the amount of time it will take your cart to travel 100 cm.
5. Hold the cart so that its rear axle is at Notch A on the ramp, as shown below. When ready, release the cart and measure how long it takes the cart to travel 100 cm. Record your data in your data table.
6. Repeat Step 5 two more times. Use the Trial 2 and 3 rows to record your data.
7. Use the equation below to calculate the speed of the cart for each trial:

$$\text{speed} = \frac{\text{distance}}{\text{time}}$$

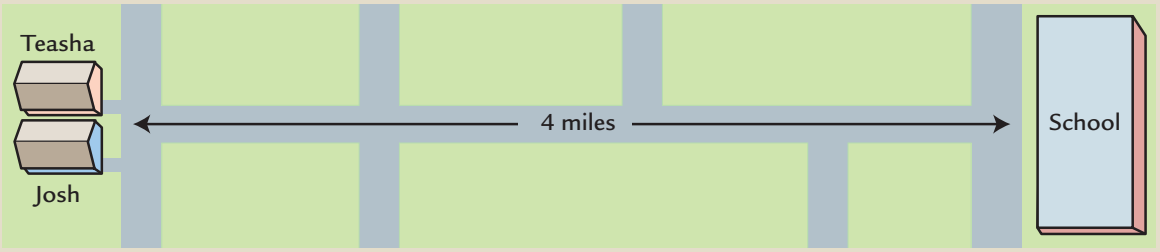
8. Calculate the average of the three trials. Record the average of the calculated speeds in your table.
9. Answer Analysis item 1 in your science notebook.



## Part B: Interpreting Motion Graphs

In Part A, you calculated the average speed of a cart during its trip on a track. But sometimes the speed of an object changes during a trip. For example, the driver of a car often changes the speed of the car because of traffic or road conditions. When the speed of an object changes over the course of a trip, a motion graph is useful because it shows the speed during all parts of the trip.

Teasha and Josh live next door to each other at the end of a long straight road that goes directly to their school. They live 4 miles from the school, and their parents drive them there in the mornings.



10. Cut apart the eight trip strips along the dotted lines on Student Sheet 2.1, "Trip Strips."
11. Read the trip strips. Each strip represents a piece of a story. Some of the strips describe Teasha's trip to school. The others describe Josh's trip.
12. With your partner, identify the strip that matches each segment of the two motion graphs shown on Student Sheet 2.2, "Teasha's and Josh's Trips to School."
13. Glue or tape each strip onto the segment of the graph that it describes.
14. Explain your choices in your science notebook.

## ANALYSIS

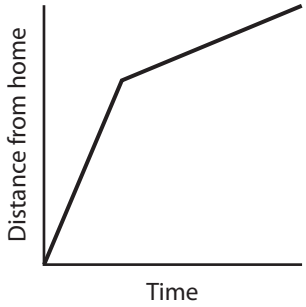
1. What is a car's speed in m/s if it travels
   a. 5 m in 0.1 s?
   b. 5 m in 0.2 s?
   c. 10 m in 0.2 s?
2. Identify a place on each motion graph where
   a. the line is flat. What does it mean when the slope of the line is zero?
   b. the slope of the line changes. What does a change in the slope of a motion graph indicate?
3. Which student—Teasha or Josh—started out faster? Explain how you know this.
4. How far into the trip did Josh turn around? Describe what the graph looks like at this point in the trip.
5. Look at the motion graphs that indicate distance vs. time, shown on the next page. Match the descriptions here to the correct graphs.
   a. A car moving at a constant speed stops and then moves in the opposite direction at the same speed.
   b. A car moving at a constant speed stops and then moves faster in the same direction.
   c. A car moving at a constant speed changes to a higher constant speed.

d. A car moving at a constant speed changes to a lower constant speed.

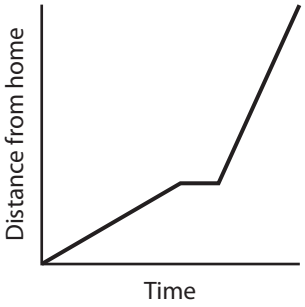
**Graph 1**


**Graph 2**


**Graph 3**




**Graph 4**




## EXTENSION 1

Visit the *SEPUP Third Edition Force and Motion* page of the SEPUP website at *www.sepuplhs.org/middle-third-edition*. Post your results and compare your data set to that of students in other classes.

## EXTENSION 2

If the speed limit is 60 MPH, could the police give a speeding ticket to any of the drivers of the cars in Analysis item 1?

*Hint*: 1,000 m = 1 km = 0.62 miles

## EXTENSION 3

Create one or more new characters also riding in cars for the scenario in Part B of this activity. For each character, make up another set of trip strips and a motion graph to go with them.

# 3 Speed and Kinetic Energy

LABORATORY

**Any moving object,** like the cart in the last activity, has a type of energy called **kinetic energy** of motion. While we can't see energy, we can detect when energy is transformed from one type into another, or when it is transferred from one object to another. The vehicles most Americans drive get most of their energy from gasoline. The energy stored in the chemical bonds in the molecules that make up gasoline is transformed into the kinetic energy of motion of the vehicle. Your cart system in this activity will rely on a different kind of energy transformation—from gravitational potential energy to kinetic energy of motion.

In the last activity, you learned how to measure speed and represent changes in speed on a graph. In this activity, you will begin exploring how you can change the speed of a car, and how a car's speed relates to the energy of that car. You will also begin to explore how speed affects car and driver safety.

## GUIDING QUESTION

**What is the relationship between an object's speed and its kinetic energy?**

## MATERIALS

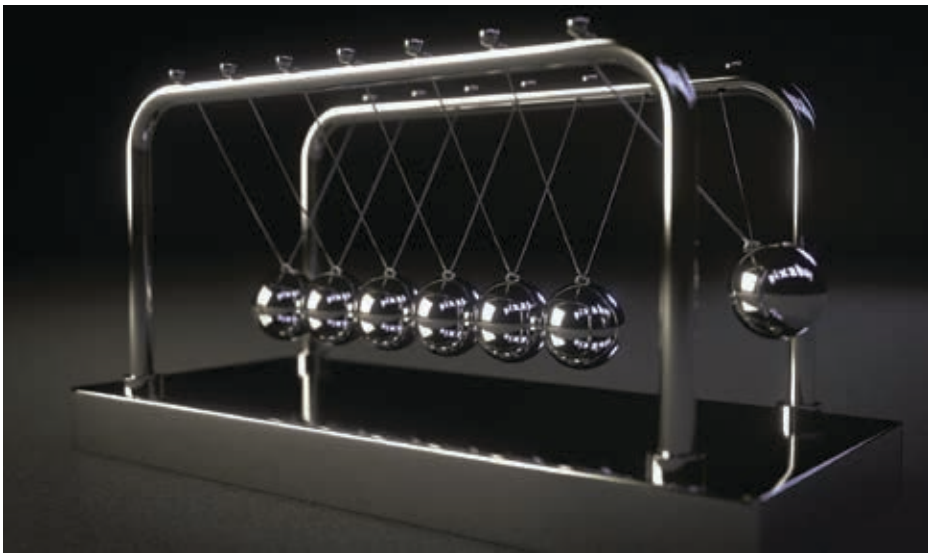
*For each group of four students*

- 2 track pieces
- 1 ramp
- 1 cart
- 1 block
- 1 meter stick
- 1 marker
- calculator
- masking tape

## PROCEDURE

### Part A: The Effect of Release Height

1. Look at your ramp, and notice the three notches. Imagine what would happen to the cart speed if you released the cart from Notch B or Notch C. In your science notebook, predict how releasing it from a lower height would affect its speed. Use the following terms in your prediction: speed, kinetic energy, gravitational potential energy, and energy transformation.
2. To test your prediction, use the cart system that you have already experimented with.
3. In your science notebook, prepare a data table for recording your measurements of release height (independent variable) and cart speed (dependent variable).
4. Follow your teacher's instructions for how to measure speed.
5. Carry out your experiment, and record your data.
6. Share your results as instructed by your teacher.

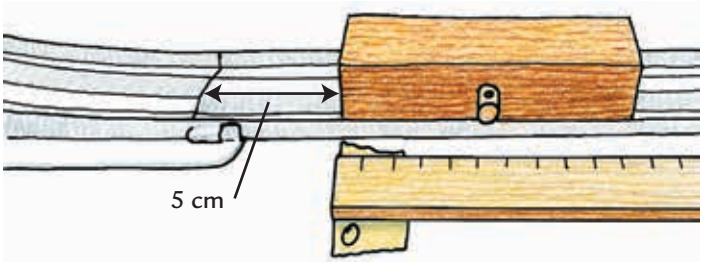


*What will happen when the moving steel ball hits the stationary balls?*

## Part B: Speed and Energy

7. Imagine there was an obstacle at the bottom of the ramp. In your science notebook, predict what would happen to the object after the cart was released from Notch A. Make predictions for what would happen when the cart was released from Notch B and Notch C. Use the following terms in your prediction: speed, kinetic energy, and energy transfer.

8. To test your prediction, use the cart system with the addition of a wooden block, as shown below. Mark the track 5 cm from the bottom edge of the ramp, and place the block there.



9. In your science notebook, make a data table like the one below, and add the independent variable and the dependent variable, along with the units:

**Effect of Cart Speed on the Block**

| *Independent variable* | *Dependent variable* | | | | | *Average* |
|---|---|---|---|---|---|---|
| | *Trial 1* | *Trial 2* | *Trial 3* | *Trial 4* | *Trial 5* | |
| | | | | | | |
| | | | | | | |
| | | | | | | |

10. Carry out your experiment, and record your data.
11. Share your results as instructed by your teacher.

## ANALYSIS

1. According to your data from Part A, what is the effect of release height on speed?
2. According to your data from Part B, what is the effect of speed on the movement of the block? Describe and explain the pattern you observed.
3. Your friend says that an object moving at a faster speed has more kinetic energy. Do you agree with your friend? Use evidence from this activity to describe why or why not.
4. **Car and Driver Safety:** How do you think speed affects car and driver safety?