Activity 2

Speed and Following Distance

**GOALS**

In this activity you will:

- Define speed.
- Identify constant and changing speeds.
- Interpret distance-time and speed-time graphs.
- Contrast average and instantaneous speeds.
- Calculate the distance traveled at constant speed.

**What Do You Think?**

In a rear-end collision, the driver of the car in back is always found at fault.

- What is a safe distance between your car and the car in front of you?
- How do you decide?

Record your ideas about these questions in your *Active Physics* log. Be prepared to discuss your responses with your small group and the class.

**For You To Do**

1. A strobe photo is a multiple-exposure photo in which a moving object is photographed at regular time intervals. The strobe photo below shows a car traveling at 30 mph.
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\( \text{a) Copy the sketch in your log.} \)

2. Think about the difference between the motion of a car traveling at 30 mph and one traveling at 45 mph.

\( \text{a) Draw a sketch of a strobe photo, similar to the one above, of a car traveling at 45 mph.} \)

\( \text{b) Are the cars the same distance apart? Were they farther apart or closer together than at 30 mph?} \)

\( \text{c) Draw a sketch for a car traveling at 60 mph. Describe how you decided how far apart to place the cars.} \)

3. The following sketch shows a car traveling at different speeds.

\( \text{a) Copy the sketch in your log. Mark where the car is traveling fast, where it is traveling slowly, and where it is traveling at a constant speed. How did you know?} \)

4. A sonic ranger connected to a computer will produce a graph that shows an object’s motion. Use the sonic ranger setup to obtain the following graphs to print or sketch in your log.

\( \text{a) Sketch a graph of a person walking toward the sonic ranger at a normal speed.} \)

\( \text{b) Sketch a graph of a person walking away from the sonic ranger at a normal speed.} \)

\( \text{c) Sketch a graph of a person walking both directions at a very slow speed.} \)

\( \text{d) Sketch a graph of a person walking both directions at a fast speed.} \)

5. Predict what the graph will look like if you walk toward the system at a slow speed and away at a fast speed. Test your prediction.

\( \text{a) Record your prediction in your log.} \)

\( \text{b) Based on your measurements, how accurate was your prediction?} \)
6. Repeat any of the motions in **Steps 4 or 5** for a more thorough analysis.

a) From your graph, determine the total distance you walked.

b) How long did it take to walk that distance?

c) Divide the distance you walked by the time it took. This is your average speed in meters per second (m/s).

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**PHYSICS TALK**

**Speed**

The relationship between speed, distance, and time can be written as:

$\text{Speed} = \frac{\text{Distance traveled}}{\text{Time elapsed}}$

If your speed is changing, this gives your average speed. Using symbols, the same relationship can be written as:

$v_{av} = \frac{\Delta d}{\Delta t}$

where $v_{av}$ is average speed

$\Delta d$ is change in distance or displacement.

$\Delta t$ is change in time or elapsed time.

**Sample Problem 1**

You drive 400 mi. in 8 h. What is your average speed?

**Strategy:** You can use the equation for average speed.

$v_{av} = \frac{\Delta d}{\Delta t}$
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**Givens:**

\[
\Delta d = 400 \text{ mi.} \\
\frac{\Delta d}{\Delta t} = v_{av} \\
= \frac{400 \text{ mi.}}{8 \text{ h}} \\
= 50 \text{ mph (miles per hour)}
\]

Your average speed is 50 mph. This does not tell you the fastest or slowest speed that you traveled. This also does not tell you how fast you were going at any particular moment.

**Sample Problem 2**

Elisha would like to ride her bike to the beach. From car trips with her parents, she knows that the distance is 30 mi. She thinks she can keep up an average speed of about 15 mph. How long will it take her to ride to the beach?

**Strategy:** You can use the equation for average speed.

\[
v_{av} = \frac{\Delta d}{\Delta t}
\]

However, you will first need to rearrange the terms to solve for elapsed time.

\[
\Delta t = \frac{\Delta d}{v_{av}}
\]

**Solution:**

\[
\Delta t = \frac{30 \text{ mi.}}{15 \text{ mph}} \\
= 2 \text{ h}
\]
FOR YOU TO READ

Representing Motion

One way to show motion is with the use of strobe photos. A strobe photo is a multiple-exposure photo in which a moving object is photographed at regular time intervals. The sketches you used in Steps 1, 2, and 3 in For You To Do are similar to strobe photos. Here is a strobe photo of a car traveling at the average speed of 50 mph.

Another way to represent motion is with graphs. The graph below shows a car traveling at the average speed of 50 mph.

Kilometers and Miles

Highway signs and speed limits in the USA are given in miles per hour, or mph. Almost every other country in the world uses kilometers to measure distances. A kilometer is a little less than two-thirds of a mile. Kilometers per hour (km/h) is used to measure highway driving speed. Shorter distances, such as for track events and experiments in a science class, are measured in meters per second, m/s.

You will use mph when working with driving speeds, but meters per second for data you collect in class. The good news is that you do not need to change measures between systems. It is important to be able to understand and compare measures.

To help you relate the speeds with which you are comfortable to the data you collect in class, the chart below gives approximate comparisons.

<table>
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<th></th>
<th>School zone</th>
<th>Residential street</th>
<th>Suburban interstate</th>
<th>Rural interstate</th>
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<td>mph</td>
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<td>35</td>
<td>55</td>
<td>75</td>
</tr>
<tr>
<td>km/h</td>
<td>40</td>
<td>55</td>
<td>90</td>
<td>120</td>
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<tr>
<td>m/s</td>
<td>11</td>
<td>16</td>
<td>25</td>
<td>34</td>
</tr>
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Reflecting on the Activity and the Challenge

You now know how reaction time and speed affect the distance required to stop. You should be able to make a good argument about tailgating as part of the Chapter Challenge. If your car can be designed to limit tailgating or to alert drivers to the dangers of tailgating, it will add to improved safety.

Physics To Go

1. Describe the motion of each car moving to the right. The strobe pictures were taken every 3 s (seconds).
   a) 
   b) 

2. Sketch strobe pictures of the following:
   a) A car starting at rest and reaching a final constant speed.
   b) A car traveling at a constant speed then coming to a stop.

3. For each graph below, describe the motion of the car:

   a) 
   b) 
   c) 
   d)
4. A racecar driver travels at 110 m/s (that’s almost 250 mph) for 20 s. How far has the driver traveled?

5. A salesperson drove the 215 miles from New York City to Washington, DC, in 412 hours.
   a) What was her average speed?
   b) How fast was she going when she passed through Baltimore?

6. If you planned to walk to a park that was 5 miles away, what average speed would you have to keep up to arrive in 2 hours?

7. Use your average response time from Activity 1 to answer the following:
   a) How far does your car travel in meters during your response time if you are moving at 55 mph (25 m/s)?
   b) How far does your car travel during your response time if you are moving at 35 mph (16 m/s)? How does the distance compare with the distance at 55 mph?
   c) Suppose you are very tired and your response time is doubled. How far would you travel at 55 mph during your response time?

8. According to traffic experts, the proper following distance you should leave between your car and the vehicle in front of you is two seconds. As the vehicle in front of you passes a fixed point, say to yourself “one thousand one, one thousand two.” Your car should reach the point as you complete the phrase. How can the experts be sure? Isn’t two seconds a measure of time? Will two seconds be safe on the interstate highway?

9. You calculated the distance your car would move during your response time. Use that information to determine a safe following distance at:
   a) 25 mph
   b) 55 mph
   c) 75 mph
10. Apply what you learned in this activity to write a convincing argument that describes why following a car too closely (tailgating) is dangerous. Include the factors you would use to decide how close counts as “tailgating.”

**Stretching Exercises**

Measure a distance of about 100 m. You can use a football field or get a long tape or trundle wheel to measure a similar distance. You also need a watch capable of measuring seconds. Determine your average speed traveling that distance for each of the following:

- a) a slow walk
- b) a fast walk
- c) running
- d) on a bicycle
- e) another method of your choice