Speed and Velocity

Are You Speeding?

Driving Question

What is speed and how is it related to velocity?

Materials and Equipment

For each student or group:

- ☐ Data collection system
- ☐ Motion sensor
- ☐ Reflector (optional)

Safety

Add this important safety precaution to your normal laboratory procedures:

- Make sure students have a clear area in which to work, with no tripping hazards.

Thinking about the Question

In everyday language the word "speed" is used in many ways. You might have heard the expressions "speeding up," "speeding ticket," "speed limit," "speed trap," and "need for speed." You might even have experience with the speedometer of your family's car and observing specific rates of speed during particular types of trips. If you have ever taken a trip, you are also probably familiar with the expressions "one-way" and "round trip." Traveling by any means of transportation involves familiarity with distances, times, speeds, and directions.

In science, "speed" refers to the rate at which an object changes its position. Your experience with traveling in daily life will be very helpful to you as your lab group investigates speed and velocity.

In this activity, you will be working with speed and velocity by walking at a constant pace; that is, walking at a steady rate without speeding up or slowing down. Discuss with your lab group members how you know when you are walking at a constant pace. Practice one another's ideas until you are certain that you can walk without going faster or slower.

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Sequencing Challenge

The steps below are part of the Procedure for this lab activity. They are not in the right order. Determine the proper order and write numbers in the circles that put the steps in the correct sequence.

○	○	○	○
Record and display data on position versus time.	Familiarize yourself with the motion sensor's gold screen so you know where the fixed frame of reference is located.	Begin walking when you hear the clicking sound of the motion sensor.	Make certain that every member of the group is aware of the lab safety procedures.

Investigating the Question

Note: When you see the symbol "�" with a superscripted number following a step, refer to the numbered Tech Tips listed in the Tech Tips appendix that corresponds to your PASCO data collection system. There you will find detailed technical instructions for performing that step. Your teacher will provide you with a copy of the instructions for these operations.

Part 1 – Making predictions

1. ☐ Write your prediction for the following activity:

   Using the motion sensor as the frame of reference, predict what the graph of position versus time will look like for a person who walks away very slowly, stops and pauses just long enough to turn around, and then walks back toward the motion sensor at the same very slow pace.

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2. ☐ Write your prediction for the following activity:

   What would the graph of position versus time look like if the same person completed the same walk as above, but instead walked very quickly?

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3. ☐ If two people walk along a path for the same distance, but one person walks the path in less time than the other, predict how the speeds of the two walkers will compare.

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Part 2 – How do you know if you are speeding?

4. ☐ Start a new experiment on the data collection system. �(1.2)

5. ☐ Connect the motion sensor to the data collection system. �(2.1)

6. ☐ Make sure you have a clear area in which to walk backward and forward relative to the motion sensor. You need at least three meters of clear space.

7. ☐ Place a marker, such as a book, water bottle, or other object, at the end of the walking distance, to signal the walker to stop and turn around. Why is it important for the walker to walk in a straight path directly in line with the gold screen of the motion sensor?

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8. ☐ Display Position on the y-axis of a graph with Time on the x-axis. �(7.1.1)

9. ☐ Choose one lab group member to be the starter (the person who starts and stops data recording), and another lab group member to be the first walker.

10. ☐ The starter should ask the first walker to stand in front of the motion sensor, facing away from it. This student will walk a distance at a constant pace, pause, turn around, and walk back at the same pace.

11. ☐ The starter should make sure the walker is ready, and then start data recording. �(6.2)

12. ☐ On the starter's signal to begin, the walker should walk slowly away from the sensor, at a constant pace, pause at the marker for one or two seconds, turn around, and then walk back toward the motion sensor at the same constant pace.

13. ☐ Stop data recording. �(6.2)

14. ☐ Choose a new starter and walker for the second trial.

15. ☐ Start recording the second data run. �(6.2)

16. ☐ Repeat the same walk that the first walker took, but this time the walker should walk at a constant pace that is a little faster.

17. ☐ Stop recording the second data run. �(6.2) Observe the graphs of position versus time for the two walkers. Note your observations below.

18. ☐ If your teacher says there is time for additional trials, continue collecting data with new starter and walker pairs. Remember to take the same walk as the first walker, making sure to keep a constant pace for the same distance. Why do you think it is important to walk the same distance in each trial?

19. ☐ Display the data runs for each walker. �(7.1.3) What do you notice about each of the graphs?

Part 3 – What does speed have to with velocity?

20. ☐ Prepare a clear area the same way you did to measure position, except this time you will measure velocity.

21. ☐ On a new graph, display both Position on the y-axis and Velocity on the y-axis with Time on the x-axis. �(7.1.10)

22. ☐ You will again work in pairs of starter and walker.

23. ☐ The first walker should choose a distance to walk, and mark that distance with a marker (book, water bottle, or something similar).

24. ☐ Start data recording. �(6.2)

25. ☐ On the starter's signal to begin, the walker should walk at a constant pace away from the motion sensor (toward the marker), and stop. The walker should then turn and face the motion sensor and walk back toward the motion sensor at a different speed.

26. ☐ After the walker has arrived back at the motion sensor, stop data recording. �(6.2)

27. ☐ Review your position versus time and velocity versus time data for this walker. Note below any patterns or observations you see:

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Answering the Question

Analysis

1. How did your predictions from Part 1 compare to the results from Part 2?

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2. Choose two data runs from Part 2 to compute the speed of the walkers. To do this, look at the portion of the graph where the walker was moving away from the motion sensor. Determine the total distance for that part of the walk, and determine the time it took for the walker to complete that part of the walk. The speed is found by dividing the distance by the time:

3. Follow the same procedure to compute the speed of both walkers for the portion of the graph where the walkers were moving away from the motion sensor and for the portion of the graph where the walkers were walking towards the motion sensor.

4. Examine your graphs of position versus time. How does the slope, or steepness, of the graphs, compare to the speeds of the walkers you just calculated?

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5. How can you tell from the position graph where each walker's speed was zero?

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6. How can you tell from the position graph the direction each walker was walking?

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7. Now look at your graphs of position and velocity versus time. How can you tell from the velocity data when the walker's speed was zero?

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8. How can you tell from the velocity data which direction the walker was walking?

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9. What is the difference between a velocity of 0.5 meters per second (m/s) and a velocity of –0.5 meters per second (m/s)?

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10. How are speed and velocity related to each other?

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Multiple Choice

Circle the best answer or completion to each of the questions or incomplete statements below.

1. If the distance between you and your ________________changes, then your position has changed.

    A. Velocity
    B. Constant speed
    C. Frame of reference

2. The___________________of a moving object can be positive or negative.

    A. Constant speed
    B. Final speed
    C. Velocity

3. On a position versus time graph, the____________________of the graph indicates the speed.

    A. Speed
    B. Slope
    C. Velocity

4. The motion sensor measures your____________________as the distance, in meters, you are away from it.

    A. Position
    B. Constant speed
    C. Average speed

Key Term Challenge

Fill in the blanks from the list of randomly ordered words in the Key Term Challenge Word Bank.

average speed	frame of reference	position	slope

1. As your distance from the reference point changes, your_____________changes,

2. In this investigation, the motion sensor is the_________________________.

3. The___________________is the total distance traveled divided by the time it took to travel that distance.

4. On a position versus time graph, the__________of the graph indicates the speed.