1. Position: Match Graph

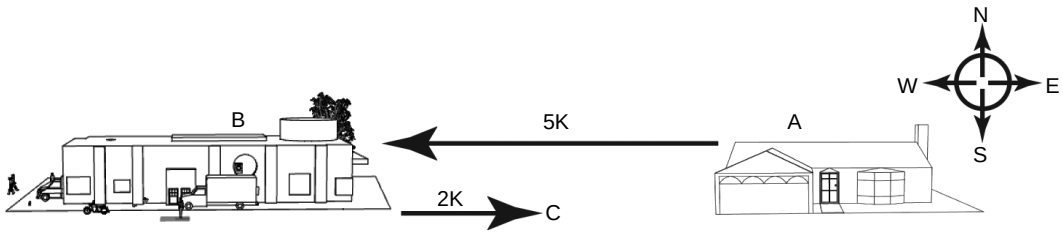
Driving Questions

What is the difference between distance, position, and displacement?

Background

The terms *distance*, *position*, and *distance traveled* are often used interchangeably in everyday language. We also describe a fourth term in science, *displacement*. Displacement is the vector that describes a change in position. This can cause confusion when studying motion because the terms often have very different meanings when they are used in science. We define motion as a change in position relative to a frame of reference. Distance refers to the amount of space between points. In other words, it is a length. Position refers to the location (distance and direction) of an object relative to a specific frame of reference. To reiterate, position includes both direction and distance from a frame of reference.

For example, if you tell someone the distance to your house, you might say, "five kilometers" (5 km). However, if you tell someone the position of your house (point A), you might say, "5 kilometers east of the mall (point B)."



In this description the distance is 5 km, the direction is east, and the frame of reference is the mall.

Distance traveled is the total distance required to get from one position to another. Assuming that you travel on a straight road to the mall, your distance traveled is 5 km and your position is 5 km west of your home. Now, imagine that you turn around and travel from this position toward your house, going a distance of 2 km (point C). Your total distance traveled is then 7 km (5 km + 2 km), but your position is 3 km (5 km-2 km) west of your house. In this example the distance is 3 km, the direction is west, and the frame of reference is your house. In this example your displacement is a vector sum of 5km away from your house and 2 km toward your house resulting in a displacement of 3 km west of your house. Frame of reference refers to the location of the observer while measurements are made of position, motion, or both. For this lab, the motion sensor serves as our point of reference. All motion is relative to the face of the motion sensor, with the motion away from the sensor being the positive direction.

Materials and Equipment

For each student or group:

- Data collection system
- Object to hold (textbook, basket ball (optional))
- Motion sensor
- Rod stand for motion sensor (optional)

Safety

Add these important safety precautions to your normal laboratory procedures:

- Make sure you have at least 2 meters of space in front of the motion sensor.

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.

Match the different types of motion you experienced with the different parts of your Position versus Time plot.	Position yourself in front of the motion sensor, and ensure you have adequate space to move.	Connect the motion sensor to the data collection system.	Carefully move and observe Position versus Time graph as you match the motion described.

Procedure

After you complete a step (or answer a question), place a check mark in the box (☐) next to that step.

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.

Set Up

1. ☐ Start a new experiment on the data collection system. ◆(1.2)

2. ☐ Connect the motion sensor to the data collection system, and make sure the motion sensor switch is in the far or "person" position. ◆(2.1)

3. ☐ Place the motion sensor on a table or rod stand such that you have at least two meters of clear space in front of the sensor and the face of the sensor is level with your midsection.

4. ☐ If you held the motion sensor and pointed it at a fixed position, like a wall, would it change the experiment significantly? Explain?

_____

_____

_____

5. ☐ Display Position on the *y*-axis of a graph with Time on the *x*-axis. ◆(7.1.1)

6. ☐ What do the *x*-axis and *y*-axis represent on the graph on your screen?

_____

_____

Collect Data

7. ☐ Position yourself approximately 40 cm in front of the motion sensor. You may want to hold a book or ball in front of you as a more easily controlled target.

8. ☐ Have your lab partner start recording a run of data. ◆(6.2)

9. ☐ Stand completely still for 2 seconds, and then carefully move backwards as smoothly as possible (away from the motion sensor) for a few seconds.

10. ☐ Stand still for 2 more seconds, and then have your lab partner stop recording data. ◆(6.2)

Analyze Data

11. ☐ Sketch your graph of Position versus Time in the Data Analysis section.

12. ☐ Annotate your graph in the Data Analysis section with descriptions of your motion at different parts of data collection.

Note: If you will be turning in an electronic document only, you can add notes to the graph on your data collection system ◆(7.1.5)

13. ☐ Find the difference between your initial and final position. ◆(9.2)

Part 2 - Moving away from and then toward the motion sensor

Set Up

14. ☐ Use the same set up as in Part 1.

Collect Data

15. ☐ Position yourself approximately 40 cm in front of the motion sensor. You may want to hold a book or ball in front of you as a more easily controlled target.

16. ☐ Have your lab partner start recording a run of data. (6.2)

17. ☐ Carefully move backwards as smoothly as possible (away from the motion sensor) for a few seconds, then stand still for 2 seconds.

18. ☐ Carefully move approximately half way back toward the motion senor, and then have your lab partner stop recording data. (6.2)

Analyze Data

19. ☐ Add this second data run to your graph of Position versus Time in the Data Analysis section.

20. ☐ Annotate your graph in the Data Analysis section with descriptions of your motion at different parts of data collection.

21. ☐ Find the difference between your initial and final position. (9.2)

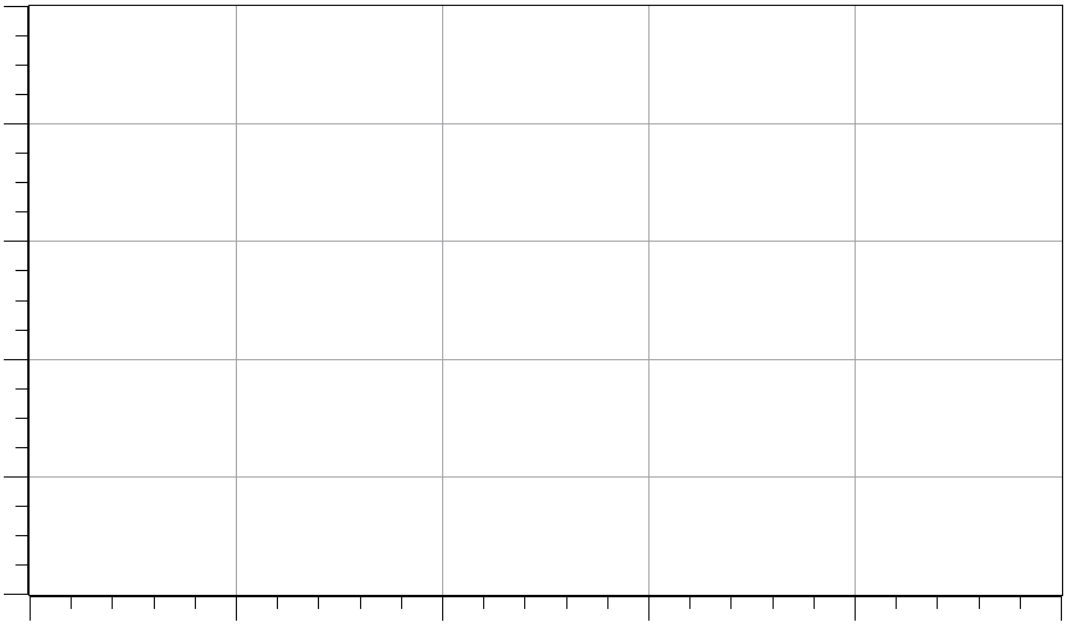
22. ☐ Add a note to your graph with value of the difference. (7.1.5)

23. ☐ Save your data as described by your teacher. (11.1)

Data Analysis

- ☐ Sketch the graph that you followed below and annotate each section of the graph with a description of how you were moving to match that section.

Graph 1: Position versus Time



Analysis Questions

1. From the first data run on your sketch in the Data Analysis section, identify your initial position and your final position?

_____

_____

_____

2. For the first run, what was the distance you travelled?

_____

_____

3. **For the first run what was your displacement?**

4. **From the second data run on your sketch in the Data Analysis section, identify your initial position and your final position?**

5. **For the second run, what was the distance you travelled?**

6. **For the second run what was your displacement?**

Synthesis Questions

Use available resources to help you answer the following questions.

1. **If you were using a motion sensor to measure the motion of a cart on a track, and the graph of the motion was a straight line starting at 0.2 meter at zero seconds and ending at 1.1 meter at 4 seconds, what is the displacement of the cart?**

2. **At a field meet, a runner in a 2 kilometers event runs on a circular track that is exactly 2 kilometers in circumference so he only has to run one lap. What was his distance traveled in meters, and what was his displacement at the end of the lap?**

_____

_____

_____

3. **A graph of Position versus Time of a car travelling down a straight road that starts at a driveway and ends at the post office shows the car travelling 5 miles away from the driveway in 15 minutes, and then 2.5 mile toward the driveway in 5 minutes. What distance did the car travel, and what was the car's final position?**

_____

_____

4. **An ant follows a straight chemical trail that starts at its nest to a piece of bread 23 centimeters away. At the end of the day it delivers 10 piece of bread to the nest. What was the total distance the ant travelled in meters, its initial position, and its final position?**

_____

_____

Multiple Choice Questions

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

1. **When trying to measure a soccer ball's displacement in real time when it is dropped from a height of 1.8 m, what is the best tool to use?**

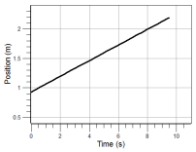
- **A.** Force sensor
- **B.** Motion sensor
- **C.** Meter stick
- **D.** Acceleration sensor

2. **A fellow student tells you that her daily walk to school is 6 km. What is this measurement?**

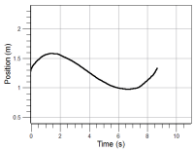
- **A.** Initial position
- **B.** Final position
- **C.** Displacement
- **D.** Distance travelled

3. Which graph best represents an object moving away from a motion sensor at a constant speed?

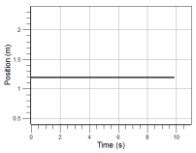
A.



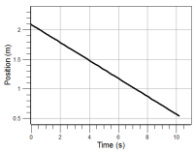
B.



C.



D.



Key Term Challenge

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

1. Motion is defined as a change in _____ relative to a frame of reference. Distance refers to the length of a _____ between points. In other words, it is the scalar value of length. Position refers to the location (distance and direction) of an object relative to a specific _____.

2. Position includes both direction and _____ from a frame of reference. Frame of reference refers to the location of the observer while measurements are made of position and/or _____. The vector displacement only includes the distance and a _____.

3. A ranger _____ through the woods used a pedometer to determine that he had walked 10 miles along the woodland trails. When he checked his map, he found that he was only a mile and a half north of the point that he started. He had no idea when he started that the trail was so twisted and was surprised that his _____ could be 10 miles, but his _____ was only 1.5 miles north.

Key Term Challenge Word Bank

Paragraph 1	Paragraph 2	Paragraph 3
Direction	Direction	Displacement
Frame of reference	Distance	Distance Travelled
Path	Motion	Motion
Position	Scalar	Travelling