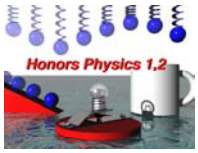


Kinematics
Position, Distance, Displacement

CONCEPT EXPLORATION

To describe the motion of an object it is necessary to develop a special vocabulary. Precise definitions for basic vocabulary words such as position, distance, and displacement will be the focus for this investigation.

To define each of these terms you must identify a starting point or a single point from which the location of the object can be measured. On a graph this point is usually considered to be the "origin".

Engagement Question

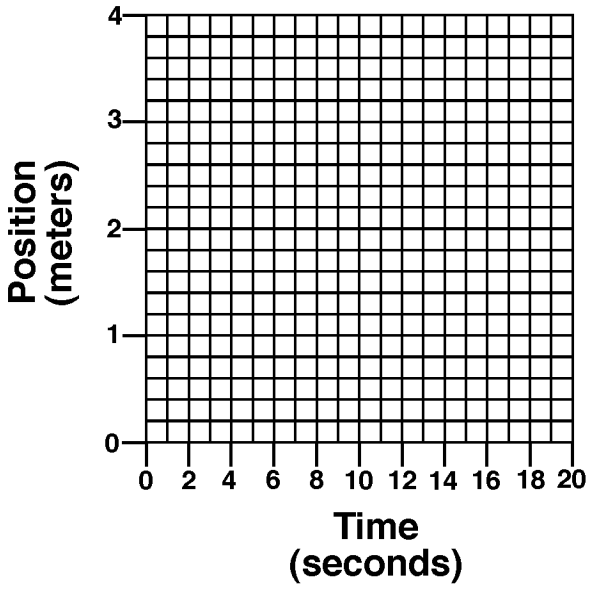
1. Where are you right now?

The Challenge

You will draw a graph that has the position of the object displayed on the vertical axis and the time displayed on the horizontal axis. This **position-time graph** will show the motion for an object that is at rest at two different locations for two different periods of time.

Your Ideas about the Challenge

2. On the graph below sketch what you think the position-time graph will look like for an object that is stationary at the 1-meter position for 10 seconds and then moves to the 2-meter position for an additional 10 seconds. Ignore the time that it might take for the object to move between the two locations.

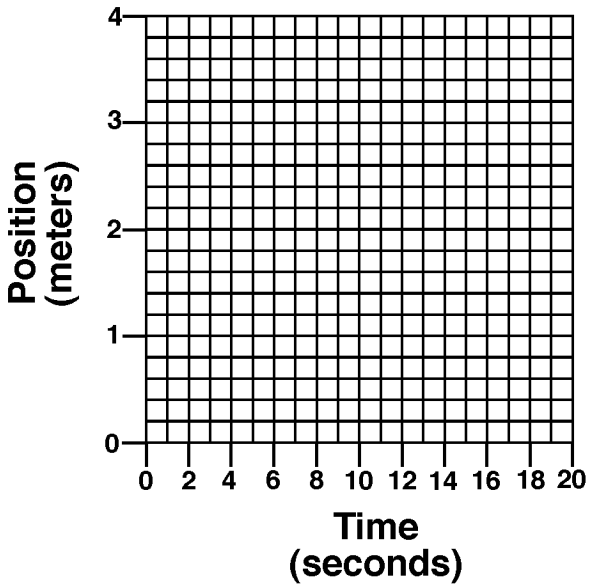


At each lab station you will find the following:
a computer with an interface and a motion detector.

The Investigation

a. One student should stand approximately 1 meter in front of the motion detector with a book held in front of them. The book should be held at the same level as the motion detector so that the book will reflect the "sonic" waves from the detector.
b. While this student maintains this position another student should start the graphing program on the computer.
c. After 10 seconds the standing student should move back 1 meter so that they are now 2 meters away from the motion detector.
d. After an additional 10 seconds the graphing program should be stopped.

3. On the grid provided below draw the shape of the graph that you have on the computer display.



4. How do you explain the parts of your resulting graph that weren't "flat" lines?

5. Evaluate the following student statements about the investigation you performed. Identify ideas that are consistent with your observations and others that are not consistent with your observations.

Student A
"A flat line on a position-time graph indicates that the object, whose position is being graphed, isn't moving."

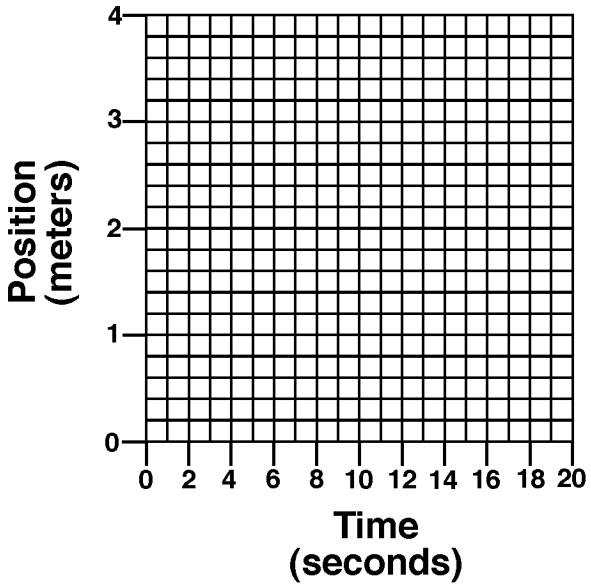
Student B
"Any straight line on a position-time graph shows that the object isn't moving."

Check your work with your teacher

The Investigation (continued)

a. One student should stand approximately 1/2 meter in front of the motion detector holding a book in front of them at the same level as the motion detector.
b. Another student should start the graphing program.
c. After approximately 4 seconds the standing student should quickly take a step back away from the detector and stop.
d. After another 4 seconds the student should again take a step back away from the detector and stop.
e. After another 4 seconds the student should take a step towards the detector and stop.
f. Finally the student should take another step towards the detector and stop for approximately 4 seconds.
g. Stop the graphing program.

7. On the grid provided below sketch the resulting shape of the graph.



8. How far away was this student from the motion detector at the beginning of this activity? In other words, what is the location of this student at the beginning of this activity with respect to the motion detector? Also, what is the location of this student at the end of this activity with respect to the motion detector? Be sure to label your answer with the appropriate units.

These locations are referred to as the student's **position**. Position is always measured with respect to some reference point, in this case the location of the motion detector.

9. How far did this student travel during the entire time period? Be sure to label your answer with the appropriate units.

How far the student traveled is the **distance**.

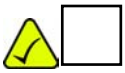
10. Calculate the difference between the final position of the student and the beginning position of the student? Be sure to label your answer with the appropriate units.

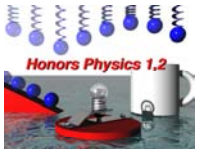
The difference between the final position and the beginning (initial) position for an object is referred to as the **displacement** of the object.

11. What is the displacement of the student during the first 6 seconds?

12. Evaluate the following student statement about the investigation you performed. Identify ideas that are consistent with your observations and others that are not consistent with your observations.

"Displacement and distance are just different names for the same thing."

Check your work with your teacher. 



Kinematics
Position, Distance, Displacement

CONCEPT DEVELOPMENT

A graph is a tool that can compare how two different quantities or concepts are related. Sometimes it can be difficult to understand what is being presented on a graph.

If you thought of a position-time graph as a set of instructions for a 1-dimensional dance you might be able to better understand the complex motion that can be represented by the graph.

Engagement Question

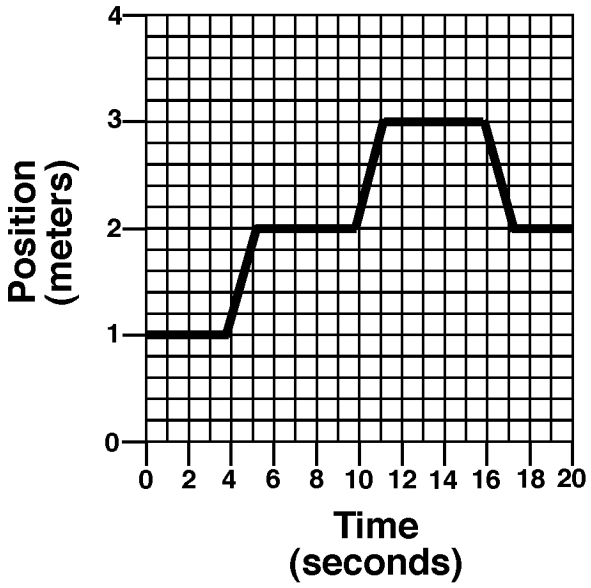
1. You get out of your seat and walk to the restroom. You then return to your seat. What distance did you travel during this time? What was your displacement during this time?

The Challenge

You will attempt to duplicate a given position-time graph through your motions in front of a motion detector.

Your Ideas about the Challenge

2. Given the graph you see below write out a series of steps that you will take in front of the motion detector in order to attempt to reproduce the graph on the computer.



At each lab station you will find the following:
a computer with an interface and a motion detector.

The Investigation

a. One student should stand at a starting point in front of the motion detector holding a book in front of them to reflect the "sonic" waves of the motion detector.
b. Another student should start the graphing program while calling out the time that is elapsed on the computer display.
c. The standing student should attempt to move in a prescribed fashion in order to reproduce the given graph on the computer display.
d. At the end of 20 seconds the graphing program should be stopped.

3. List the series of steps, along with the time periods when they were performed, that produced the best duplicate of the given graph. Were they the same as what you had written earlier? If not, what did you fail to take into consideration?

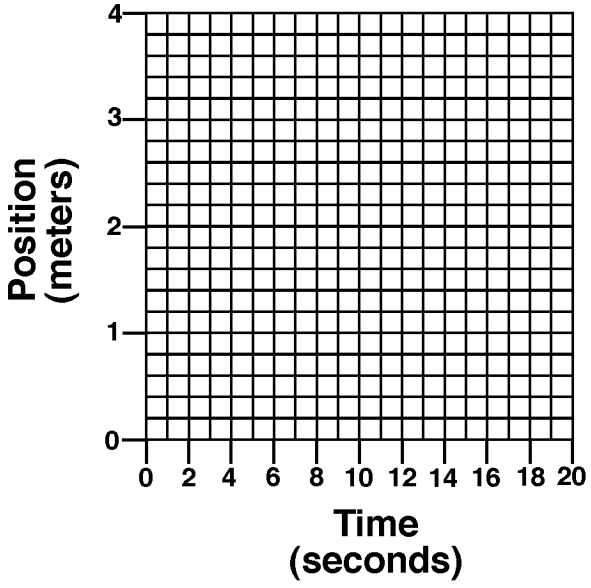
4. Why was the "duplicate" graph <u>not</u> an exact copy of the given graph?

Check your work with your teacher.

The Investigation (continued)

a. One student should stand approximately 1/2 meter in front of the motion detector holding a book in front of them at the same level as the motion detector.
b. Start the graphing program.
c. After approximately 4 seconds the standing student should quickly take a step back away from the detector and stop.
d. After another 4 seconds the student should again take a step back away from the detector and stop. After another 4 seconds the student should take a step towards the detector and stop.
e. Finally the student should take another step towards the detector and stop for approximately 4 seconds.
f. Stop the graphing program.

5. On the grid provided to the right sketch the resulting shape of the graph that you see on your computer display. Try to smooth out the transition times when the student was changing position.



6. What is the student's position at the beginning of this activity? What is the student's position at the end of this activity? Be sure to label your answer with the appropriate units.

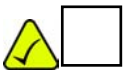
7. What distance did this student travel during the entire time period? Be sure to label your answer with the appropriate units.

8. What is the displacement for this student during this time period? Be sure to label your answer with the appropriate units.

9. What is the displacement of the student during the first 6 seconds? Be sure to label your answer with the appropriate units.

10. Evaluate the following student statement about the investigation you performed. Identify ideas that are consistent with your observations and others that are not consistent with your observations.

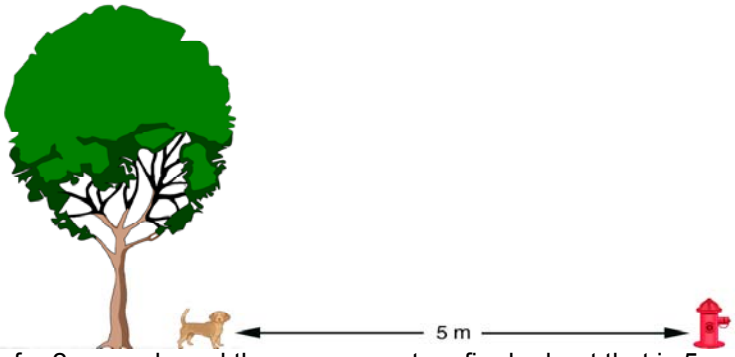
"A straight line on a position-time graph indicates that the object, whose position is being graphed, isn't moving."

Check your work with your teacher. 

CONCEPT REFINEMENT

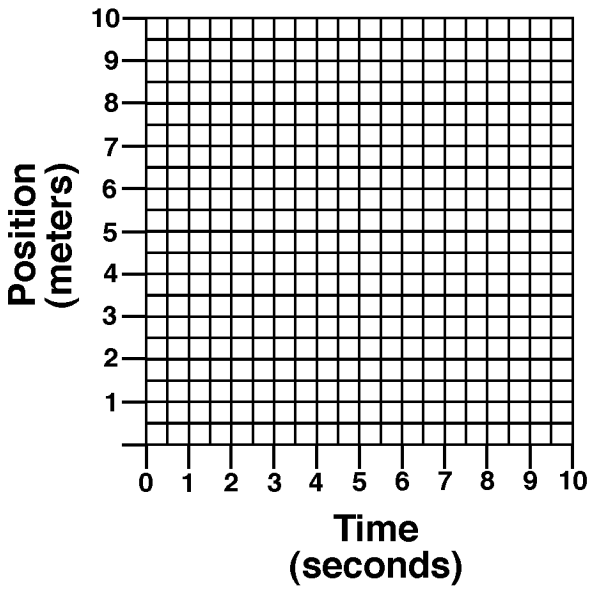
Review

You have had the opportunity to both view and produce position-time graphs that represented the motion of objects that were at rest at a variety of locations. You should also be able to describe the position of an object with respect to a given point of reference. Finally, you should know the difference between distance and displacement.



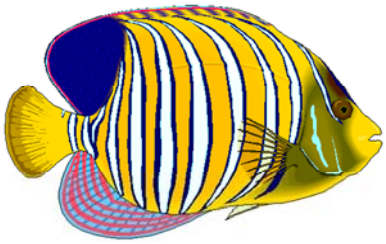
A dog stands beneath a tree for 2 seconds and then runs over to a fire hydrant that is 5 meters away. The dog then stands beside the hydrant for 4 seconds before it returns to its location beneath the tree.

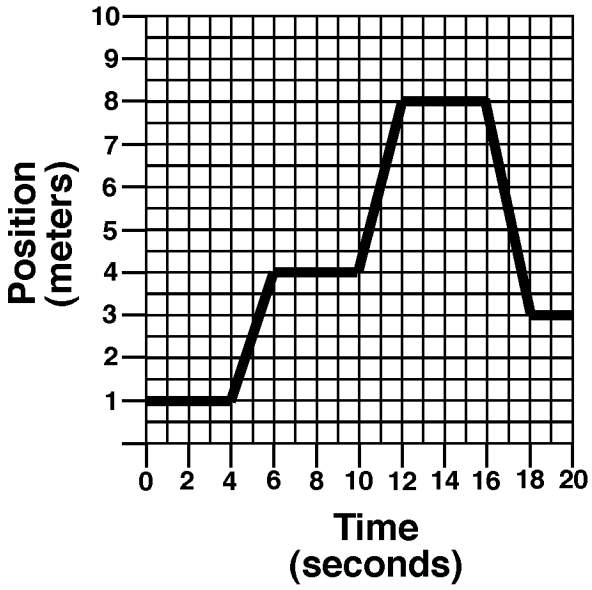
1. On the position-time grid provided below sketch the graph that would represent the motion of this dog during this time period.



Check your work with your teacher.

The graph below represents the motion of a fish moving along a straight-line path for a period of 20 seconds. The fish begins its motion 1 meter away from a large rock.





Based on the graph you see above answer the following questions.

2. What is the position for this fish at the following times:

a. zero seconds? _____

b. 2 seconds? _____

c. 8 seconds? _____

d. 14 seconds? _____

e. 20 seconds? _____

3. What distance did the fish travel from the zero-second position up to the:

a. 2-second position? _____

b. 8-second position? _____

c. 14-second position? _____

d. 20-second position? _____

4. What is the displacement for this fish as measured between the 0-second position and the:

a. 2-second position? _____

b. 8-second position? _____

c. 14-second position? _____

d. 20-second position? _____

5. What must the fish have been doing during the times that resulted in non-flat portions on the graph?

Check your work with your teacher.