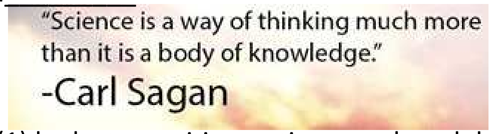
Name______________________________________

Period________



Lesson 2: Describing Motion with Words and Graphs

After completing the next few activities, you should be able to: (1) look at a position vs time graph and describe the motion of an object, (2) look at the motion of an object and sketch a graph representing that motion.

2.1 Experiment. Making Position vs Time Graphs

For parts a-c, (1) first sketch your prediction with a dotted line then (2) use the motion detector to record your motion as described in each example and (3) sketch the position graph you observe in each case with a solid line.

(a) Walk away from the origin slowly and steadily

PREDICTION: _ _ _ _ _ _ _ _

ACTUAL:

position

time

position

time

(b) Walk away from the origin medium fast and steadily

PREDICTION: _ _ _ _ _ _ _ _

ACTUAL:

position

time

position

time

(c) Start at the other end and walk toward the origin slowly and steadily

PREDICTION: _ _ _ _ _ _ _ _

ACTUAL:

position

time

position

time

(d) Describe the difference between the graph you made by walking away slowly and walking away more quickly.

(e) Is it possible for an object to move so that it produces an absolutely vertical line on a position time graph? Explain.

(f) Describe the difference between the graph made by walking toward the origin and walking away from the origin.

2.2 Experiment: Predicting a Position vs Time Graph

(a) Suppose you were to

start 1m in front of the origin and walk away steadily at a moderate speed for 2 seconds until you are 3m away,

then stop for 1 second,

and then walk toward the origin quickly for 1 second so that you are back where you started.

Sketch your prediction on the set of axes below:

PREDICTION:

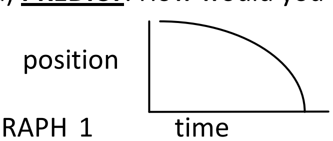
(b) Test your prediction by **actually moving in the way described** above and using the motion detector to graph your actual motion. Sketch the shape of your actual motion graph on set of axes below.

ACTUAL:

(c) Was your prediction the same as the final result? Now move in such a way as to create an actual graph matching your prediction. Describe how had to move to make the graph that looks like your prediction.

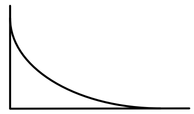
2.3 Matching Position vs Time Graphs

(a) **PREDICT**: How would you have to move to produce curved position vs time graphs shaped like this?



GRAPH 1

To make GRAPH 1 (shown above) I PREDICT that I will have to move like this:

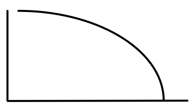
position 

GRAPH 2 time

To make GRAPH 2 (shown above) I PREDICT that I will have to move like this:

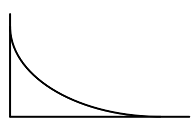
(b) Now move in such a way as to produce the shapes shown above.

Describe how you had to move to produce a position vs time graph with each of the shapes shown.

position 

GRAPH 1 time

To make GRAPH 1 (shown above) I ACTUALLY moved like this:

position 

GRAPH 2 time

To make GRAPH 2 (shown above) I ACTUALLY moved like this:

(d) What is the general difference between motions which result in a **straight-line** position vs time graph and those that result in a **curved-line** position vs time graph?

2.4 Experiment: Making Velocity vs Time Graphs

(a) Recreate your data from 2.1 parts a-c to make velocity graphs of all three motions by tapping **Position** on the y-axis and selecting **Velocity** after each trial.

A. Walk away from the origin slowly and steadily

B. Walk away from the origin medium fast and steadily

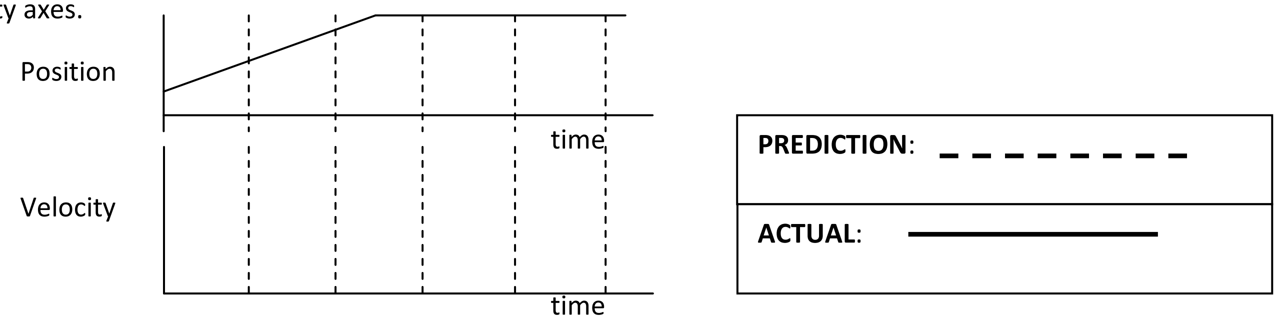
C. Start at the other end and walk toward the origin slowly and steadily

(b) What is the most important difference between the graph made by slowly walking away from the detector and the one made by walking away more quickly?

(c) How are the velocity vs time graphs different for motion away from and motion toward the detector?

2.5 Experiment: Predicting Velocity Graphs from Position Graphs

(a) Carefully study the position graph shown below and predict the velocity vs time graph that would result from the motion. Using a dashed line, sketch your **prediction** of the corresponding velocity vs time graph on the velocity axes.



(b) After each person in your group has sketched a prediction, test your prediction by matching the position vs time graph shown.

Use a solid line to draw the actual velocity graph on the same graph with your prediction. Do not erase your prediction.

(d) How would the **position** graph be different if you moved faster?

(e) How would the **position** graph be different if you moved slower?

(f) How would the **velocity** graph be different if you moved faster?

(g) How would the **velocity** graph be different if you moved slower?

2.6 Exercise: Average Velocity Calculations

(a) Find the average value of the velocity from one of your horizontal velocity graphs (while you were moving) by dragging across a horizontal portion of your velocity graph of constant motion and selecting Analyze. The average value is listed as the Mean:

Average value of the velocity: _________ m/s

Average velocity can also be calculated as the change in position divided by the change in time, <v> = Δx/Δt (by definition, the slope) which is a quantitative measure of the steepness of the graph.

(b) Use the method described just above to calculate your average velocity from the slope of the position vs time graph. Use two points as far apart as possible, ***but from times while you were still moving***.

(c) Calculate the change in position between points 1 and 2. Also calculate the corresponding change in time. Divide the change in position by the change in time to calculate the average velocity. These points can be obtained by tapping that part of the diagonal line and looking at the statistics shown at the side.

Position1: _____ m Position 2: ________ m Time1:______ s Time2:________ s

Change of Position = (Position2 – Position1) = ____________________ s

Change of Time = (Time2 – Time1) = ____________________ s

Velocity = (Change of Position) / (Change of Time) =

Average value of the velocity using the slope: _________ m/s

(d) Is the average velocity positive or negative?

(e) Is this what you expected? Explain.

(f) Does the average velocity you just calculated from the position graph agree with the average velocity you estimated from the velocity graph in part (a)? (In other words, are they the same or close to the same?)

(g) Do you expect them to agree? Explain.

(h) How would you account for any differences?

2.6 Exercise: Calculating Continental Drift

(a) Though different parts of continents travel at different speeds (some parts can reach speeds of 20 mm/year – fingernail growth speed), assuming that continents are moving apart from each other at a rate of approximately 2 mm each year, calculate the average velocity of a continent in m/s. (The answer should come out to be around 6.3×10^{-11} m/s)

2.7 Exercise: Area Under Velocity Graphs

(a) Use the data from any one of your graphs of constant velocity in for this exercise.
Redraw your graph of constant velocity below:

(b) Approximating your velocity graph to be horizontal, consider the shape of your graph to be rectangular. Find the area between the line on your graph and the x-axis. (Remember that the area of a rectangle can be found by taking the base x height.) **Show your calculation** below.

Area of velocity graph: ________

(c) When multiplying the base (*time*) times the height (*velocity*) include units. What are the units of the area?

(d) For that same time interval, **find the change in position** from your position graph by subtracting the final position from the initial position. Tap **Velocity** and select **Position** to find the position values.
Show your calculation below.

Change in position from position graph: _________ m

(e) Compare your answers from part (a) and part (b).
Do they agree?

Do you expect them to agree?

(f) Rearranging $\langle v \rangle = \Delta x / \Delta t$ by multiplying by Δt, we get $\Delta x = \langle v \rangle * \Delta t$. The area of a rectangle is $A = b*h$.
Compare the two equations that result:

$\Delta x = \Delta t * \langle v \rangle$

$A = b * h$

What physical quantity does “A” correspond to?

What physical quantity does “b” correspond to?

What physical quantity does “h” correspond to?

(g) What does the area under a velocity vs time graph represent?