SPH3U: Vectors

Scalars & Vectors

Scalar: A physical quantity with size (magnitude) but no direction. Examples: time, mass, speed, distance, temperature, volume

Vector: A physical quantity with magnitude and direction. Examples: force, velocity, displacement, acceleration

Reference Point: A point from which position is measured

Representations of vectors

(1) Using arrows

(2) Using symbols

change in position → $\vec{\Delta x}$

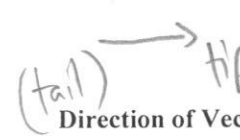
$\vec{v}_1$ ← velocity @ event 1

(3) Using numbers

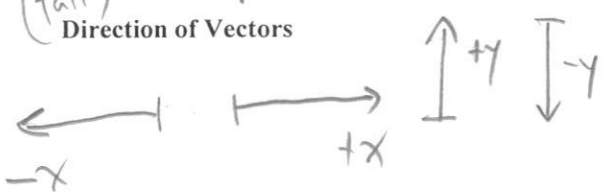
20 m/s [LEFT]

10 m [DOWN]

12 m [E]



Direction of Vectors



SPH3U: Algebra Review/Practice

A: Finding Unknown Quantities

In physics we will be dealing with various equations, and we will need to use algebra to find missing values.
There are two main methods that can be employed:

Method 1: Rearrange the equation to isolate the variable we want to find, then substitute and evaluate	**Method 2**: Substitute the values of known variables, then rearrange and solve for the unknown

Given the equation $A = \frac{a+b}{2} \cdot h$, find a if $A = 20$ cm^2, $b = 6$ cm, $h = 4$ cm

Method 1

$A = \frac{a+b}{2} \cdot h$

$\frac{A}{h} = \frac{a+b}{2}$

$\frac{2A}{h} = a+b$

$\frac{2A}{h} - b = a$

$a = \frac{2(20)}{4} - 6$

$a = 4$ cm

Method 2

$A = \frac{a+b}{2} \cdot h$

$20 = \frac{a+6}{2} \cdot 4$

$\frac{20}{2} = \frac{2(a+6)}{2}$

$10 = a+6$

$-6 \quad -6$

$a = 4$ cm

B: Practice

Find the missing value. In general you can use either method, although it's desirable to be able to use either. Consider significant digits when giving final answer. We'll ignore units…for now. Show your work.

1. Given $P = 20.0$, $l = 8.0$
EQN: $P = 2l + 2w$ Find w

$P = 2l + 2w$

$P - 2l = 2w$

$\frac{P-2l}{2} = w$

$\frac{20.0 - 2(8.0)}{2} = w$

$w = 2.0$

2. Given $y = 5$, $m = 10$, $b = 3$
EQN: $y = mx + b$ Find x

$5 = 10x + 3$

$-3 \quad -3$

$\frac{2}{10} = \frac{10x}{10}$

$\frac{2}{10} = x$

$x = 0.2$

3. Given $\vec{v_2} = 30.0$, $\vec{v_1} = 0.50$, $\vec{a} = 6.0$
EQN: $\vec{v_2} = \vec{v_1} + \vec{a}\Delta t$ Find Δt

$\vec{V}_2 - \vec{V}_1 = \vec{a}\Delta t$

$\frac{\vec{V}_2 - \vec{V}_1}{\vec{a}} = \Delta t$

$\frac{30 - 0.5}{6.0} = \Delta t$

$\Delta t \doteq 4.9$ s

4. Given $\vec{v_2} = 15$ $\vec{v}_{avg} = 26$
Find $\vec{v_1}$ EQN: $\vec{v}_{avg} = \frac{\vec{v_1} + \vec{v_2}}{2}$

$26 = \frac{\vec{V}_1 + 15}{2}$

$52 = \vec{V}_1 + 15$

$-15 \quad -15$

$37 = \vec{V}_1$

5. Given $\vec{a} = 0.50$, $\vec{v_f} = 30.0$, $\Delta t = 6.0$
Find $\vec{v_i}$ EQN: $\vec{a} = \frac{\vec{v_f} - \vec{v_i}}{\Delta t}$

$\vec{a}\Delta t = \vec{V}_f - \vec{V}_i$

$\frac{\vec{a}\Delta t - \vec{V}_f}{-1} = \frac{-\vec{V}_i}{-1}$

$\vec{V}_i = \vec{V}_f - \vec{a}\Delta t$

$= 30.0 - (0.50)(6.0)$

$\vec{V}_i = 27$

6. Given $\vec{v_2} = 8.0$ $\vec{v_1} = 5.0$ $\vec{a} = 2.8$
Find $\Delta\vec{x}$ EQN: $\vec{v}_2{}^2 = \vec{v}_1{}^2 + 2\vec{a}\Delta\vec{x}$

$8.0^2 = 5.0^2 + 2(2.8)(\Delta\vec{x})$

$64.0 = 25.0 + 5.6\Delta\vec{x}$

$-25.0 \quad -25.0$

$\frac{39.0}{5.6} = \frac{5.6\Delta\vec{x}}{5.6}$

$\Delta x \doteq 6.96$

$\Delta\vec{x} \doteq 7.0$

Answers (I think!)
1. $w = 2$ 2. $x = 0.2$ 3. $\Delta t = 4.9$ 4. $\vec{v_1} = 37$ 5. $\vec{v_i} = 27$ 6. $\Delta\vec{x} = 7.0$

C: Testing a Claim – Constant Speed

You have a hunch that your object / person moves with a constant speed. Now it is time to test this hypothesis.

To describe the *position* of an object along a line we need to know the distance of the object from a reference point, or origin, on that line and which direction it is in.

1. **Plan.** Discuss with your group a process that will allow you to test the hypothesis mentioned above using the idea of *position*. *Check this with your teacher.*

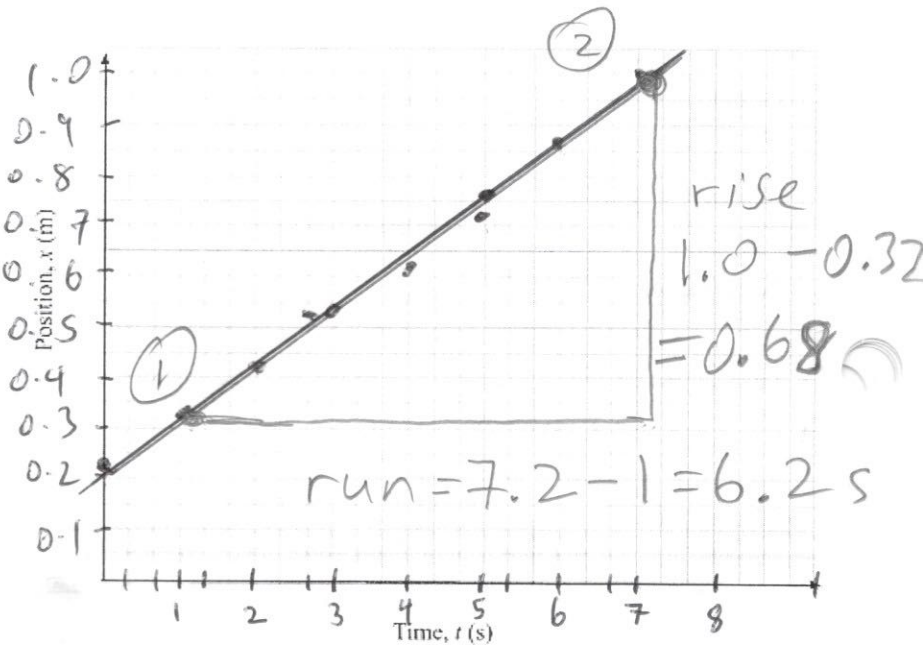
2. **Measure.** Record your data below for the motion of

Position (m)	0.21	0.32	0.42	0.53	0.66	0.77	0.88	1.00	1.12
Time (s)	0	1	2	3	4	5	6	7	8

Graphing. Choose a convenient scale for your physics graphs that uses most of the graph area. The scale should increase by simple increments. Label each axis with a name and units.

Line of Best-Fit. The purpose of a line of best fit is to highlight a pattern that we believe exists in the data. Real data always contains uncertainties that lead to *scatter* (wiggle) amongst the data points. A best-fit line helps to average out this scatter and uncertainty. Any useful calculations made from a graph should be based on the best-fit line and **not** on the data chart or individual points. As a result, we **never** connect the dots in our graphs of data.

3. **Represent.** Plot your data on a graph with position on the vertical axis and time on the horizontal axis.



4. **Calculate and Interpret.** Calculate the slope of the graph (using the line of best fit, don't forget the units). Interpret the meaning of the slope of a position-time graph. (What does this quantity tell us about the object?)
Reminder: slope = rise / run.

$$\frac{\text{rise}}{\text{run}} = \frac{0.68\ \text{m}}{6.2\ \text{s}} = 0.11\ \text{m/s}$$

5. **Reason.** Imagine an experiment with a different buggy that produced a similar graph, but with a steeper line of best fit. What does this tell us about that buggy? Explain.

moving faster

6. **Predict.** Predict (without using a graph) where the buggy would be found 2.0 s after your last measurement.

1.12 + slope x 2 y=

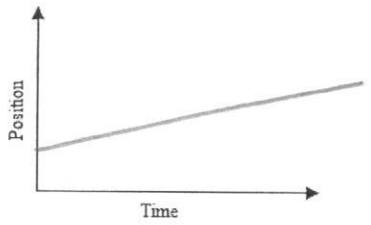
SPH3U: Interpreting Position Graphs

Today you will relate position-time graphs to the motion they represent. We will do this using a motion sensor (***CBR***). The origin is at the sensor and the direction away from the sensor is the positive direction

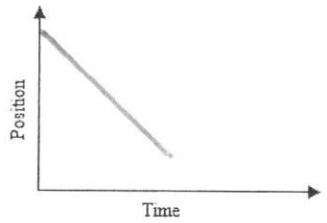
A: Interpreting Position Graphs

1. For each description of a person's motion, sketch your prediction for the position-time graph. Note that in a sketch of a graph we don't worry about exact values, just the correct general shape.

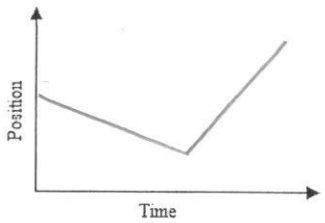
(a) Walking slowly away from the sensor at a steady rate.



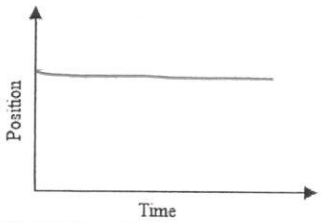
(c) Walking quickly towards the sensor at a steady rate.



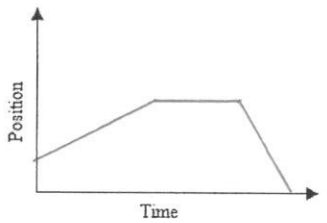
(e) Walking slowly towards, then quickly away



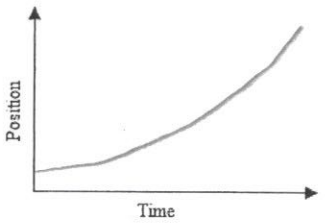
(b) Standing still, far from the sensor



(d) Walking slowly away, stopping, then quickly towards



(f) Walking away and getting faster

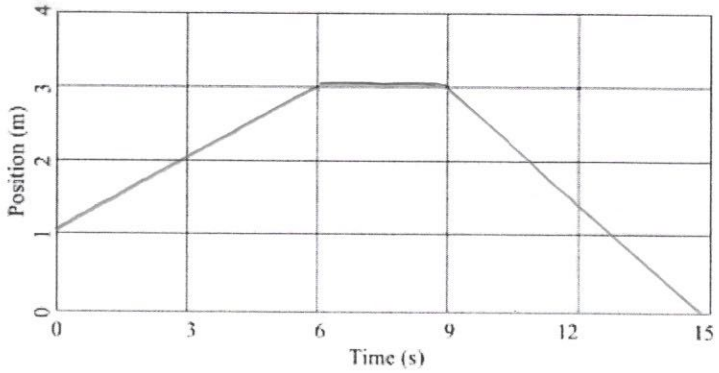


B: The Position Prediction Challenge

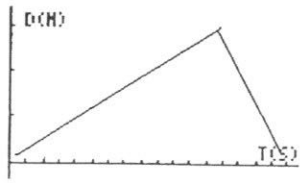
Now for a challenge! From the description of a set of motions, can you predict a more complicated graph?

A person starts 1.0 m in front of the sensor and walks away from the sensor slowly and steadily for 6 seconds, stops for 3 seconds, and then walks towards the sensor quickly for 6 seconds.

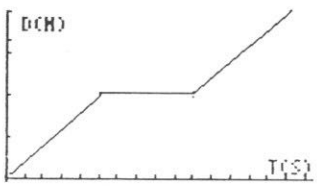
1. Sketch your prediction for the position-time graph for this set of motions.



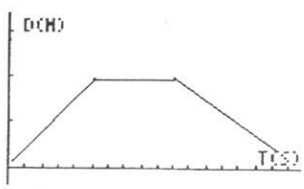
2. Describe the motion of the student.



slowly away then quickly towards



away, stops, away



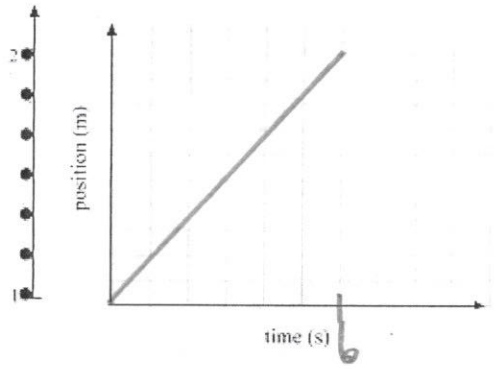
quickly away stops slowly towards.

10

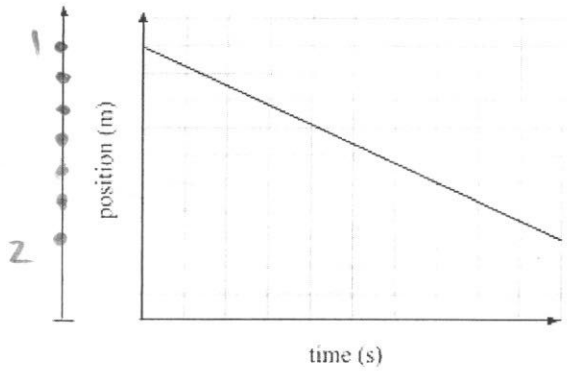
-12-

SPH3U Homework: Position Graphs Name:

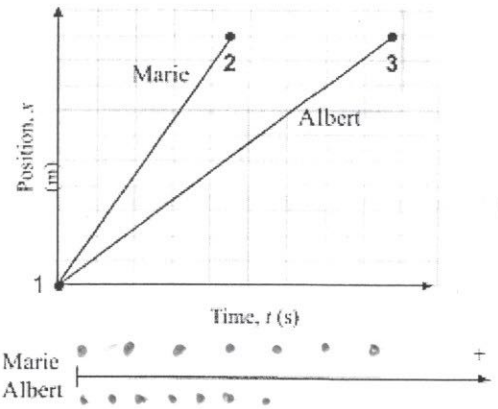
1. Emmy walks along an aisle in our physics classroom. A motion diagram records her position once every second. Two events, her starting position (1) and her final position (2) are labeled. Use the motion diagram to construct a position time graph – you may use the same scale for the motion diagram as the position axis.



2. Use the position-time graph to construct a motion diagram for Isaac's trip along the hallway from the washroom towards our class. We will set **the classroom door as the origin**. Label the start (1) and end of the trip (2).



3. Albert and Marie both go for a stroll from the classroom to the cafeteria as shown in the position-time graph to the right. Draw a motion diagram for both Albert and Marie. Draw the dots for Marie above the line and the dots for Albert below. Label their starting position (1) and their final position (2 or 3).



(a) Who leaves the starting point first?

Same time

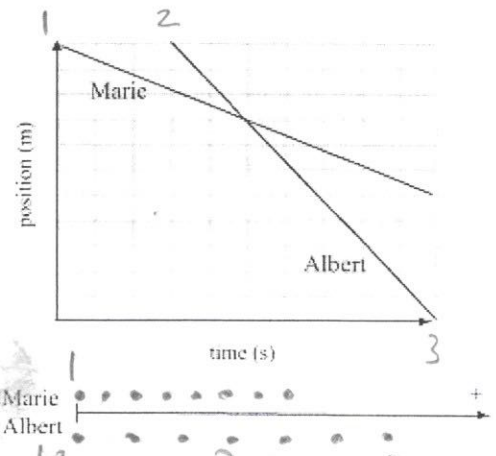
(b) Who travels faster?

Marie

(c) Who reaches the cafeteria first?

Marie

4. Albert and Marie return from the cafeteria as shown in the graph to the right. **Explain** your answer to the following questions according to this graph.



(a) Who leaves the cafeteria first?

Maria – position decreases first

(b) Who is travelling faster?

Albert – line is steeper

(c) What happens at the moment the lines cross?

In same position at same time – bump into each other?

(d) Who returns to the classroom?

Albert, his line reaches the x-axis

(e) Draw a motion diagram for both Albert and Marie. Label their starting position (1 or 2) and their final position (3).

12 10