Unit 1 Handouts (Physics 100)

Name: A1/2

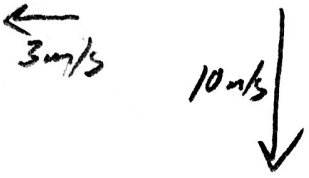
Notes: Kinematics Intro, Basic Terms, Average Velocity

Kinematics: The study of motion without considering its causes.

Scalar: A quantity with magnitude but no direction. Give an example: A speed of 10 m/s

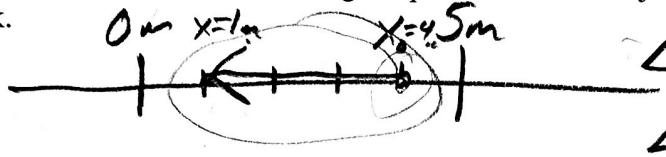
Vector: A quantity with magnitude and direction. Give an example: A velocity of 10 m/s downward.

Δ = **Delta** = "change in"



Formula for Δ = Final – initial.

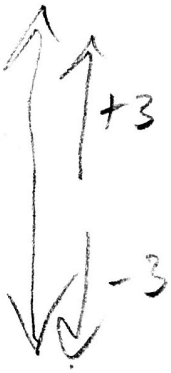
Example Problem: Calculate the "change in position" for an object that moves from the 4m mark to the 1m mark.



$\Delta X = X - X_0$

$\Delta X = 1m - 4m = -3m$

	Symbol	Meaning (what it's *supposed to* mean)	Vector or Scalar?	Common Units
Position	x or y	Where something is on a number line.	S	meters (m)
Displacement	Δx or Δy	"Change in position"	V	m
Distance	d	Like displacement, but doesn't include direction. What a car's odometer keeps track of.	S	m
Total Distance	d	Sum of all of the distances traveled on a trip.	S	m
Change in Time	Δt	How long some event lasts.	S	seconds (s)
Speed	none "speed"	How fast something is moving. A ratio of distance traveled to travel time elapsed.	S	m/s meters per second
Velocity	V	Speed and direction.	V	m/s



+3m/s

If I have a velocity of 3 m/s, what does that mean? 2 Because it's positive

I move forward (right) 3m each second.

One Definition of Velocity:

How many meters you add or subtract to/from your position each second.

***Average* Velocity** (symbol = $\bar{V}$): when we measure velocity, *average velocity* is what we will actually measure. This is the average speed of an object as it travels through a given distance. The object may speed up or slow down over that distance, but the average velocity that we calculate will not show this.

Average Velocity Formula #1 (Hint: the units provide the formula)

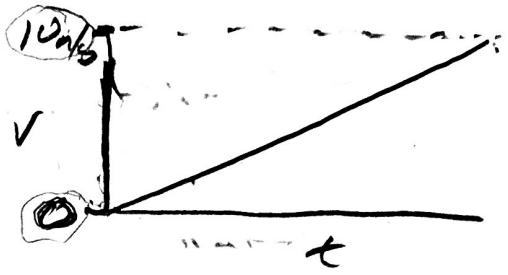
$\bar{V} = \frac{\Delta x}{\Delta t}$ ← meters of displacement ← time

Average Velocity Formula #2

$\bar{V} = \frac{V_0 + V}{2}$

"Initial velocity" symbol = V_0 (Starting)

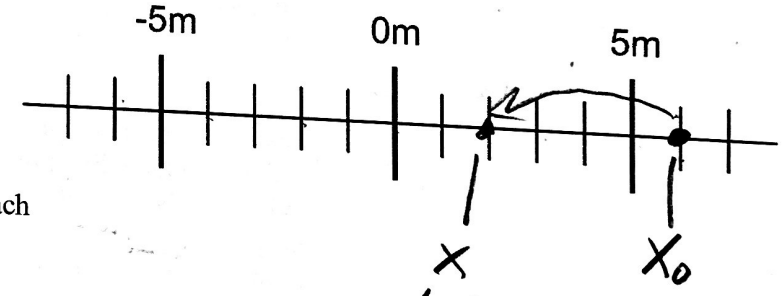
Final velocity symbol = V



Average Speed Formula:

$$\text{speed} = \frac{\text{distance}}{\text{time}}$$

Terminology Practice: A student starts a timer. When the timer gets to 11 seconds, an object is at the 6m mark on the number line to the right. When the timer gets to 13 seconds, the object's new position is -2. Show these positions and times on the number line to the right. Then calculate each of the following.



$\Delta t = 2s$

Displacement? $\Delta X = -4m = X - X_0 = 2m - 6m = -4m$

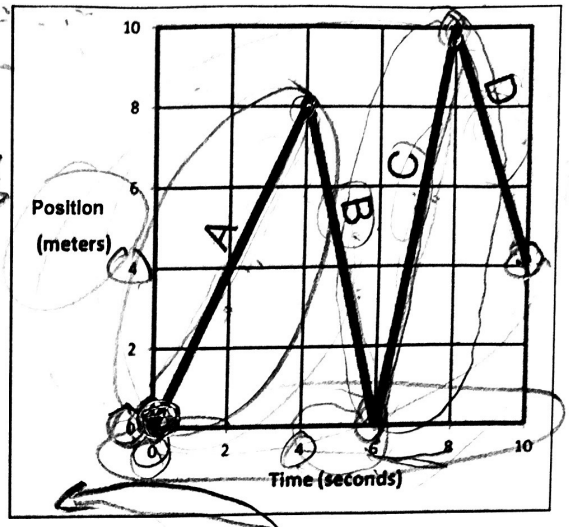
Distance traveled? $d = 4m$

Average velocity? $\bar{V} = \frac{\Delta X}{\Delta t} = \frac{-4m}{2s} = -2m/s$

Average speed? $\frac{\text{distance}}{\Delta t} = \frac{4m}{2s} = 2m/s$

Velocity Practice: The graph on the right shows the movement of an object in front of a motion sensor. Determine the velocity of the moving object for lettered each segment, and use your calculations to fill out a velocity vs. time graph for the object (bottom of page).

1. Fill in the correct information for segment **A**, in the graph on the right.



Displacement = +8m

Δt = 4s

Vaverage = 2m/s $\frac{\Delta x}{\Delta t} = \frac{8m}{4s} = 2m/s$

Distance traveled = 8m

Position at end of segment = +8m

2. Fill in the correct information for segment **B**.

Displacement = -8m $\Delta x = x - x_0$ $0 - 8$

Δt = 2s

Vaverage = -4m/s $\frac{-8m}{2s} = -4m/s$ 0m

$\bar{V} = \frac{\Delta x}{\Delta t} = \frac{10m}{2s} = 5m/s$

Distance traveled = +8m

Position at end of segment = 0m

3. Fill in the correct information for the entire trip (segments **A-D**).

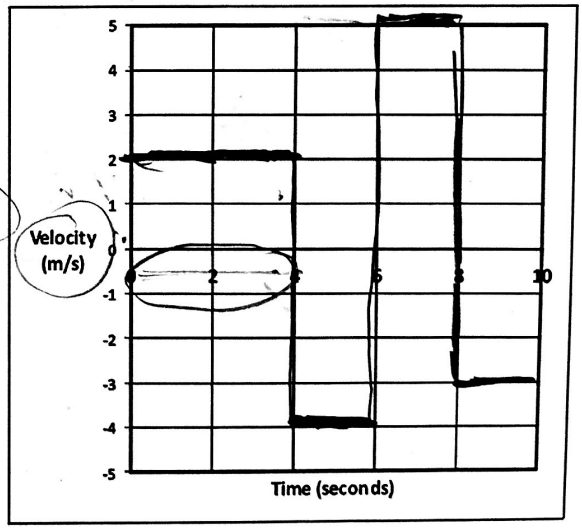
Displacement = 4m

Δt = 10s $\bar{V} = \frac{\Delta x}{\Delta t} = \frac{4m}{10s}$

Vaverage = 0.4m/s 0.4m/s

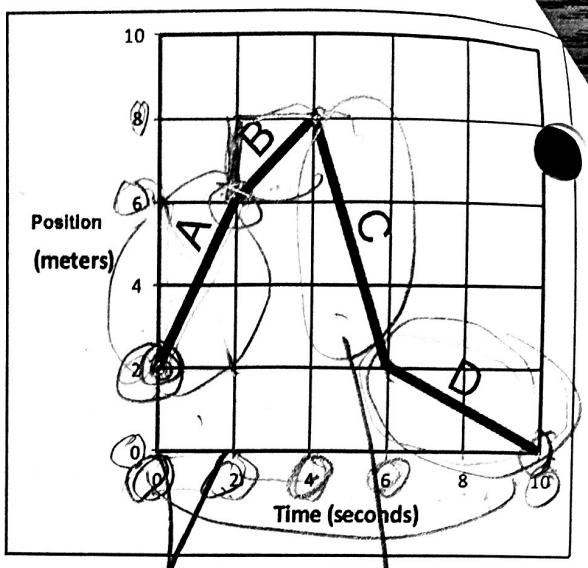
Distance traveled = 32m

Position at end of segment = 4m



4. Use the distance vs. time graph above to fill in the velocity vs. time graph on the right.

5. Fill in the correct information for segment **A**, in the graph on the right.



Displacement = 4m

Δt = 2s

Vaverage = 2m/s $V = \frac{\Delta x}{\Delta t}$

Distance traveled = 4m

Position at end of segment = 6m

$V = \frac{4m}{2s} = 2m/s$ $\frac{2m}{2s} = 1m/s$ $\frac{-6m}{2s} = -3m/s$ $\frac{-2}{4} = -0.5$

6. Fill in the correct information for segment **B**.

Displacement = 2m

Δt = 2s

Vaverage = 1m/s $= \frac{2}{2}$

Distance traveled = 2m

Position at end of segment = 8m

7. Fill in the correct information for the entire trip (segments **A-D**).

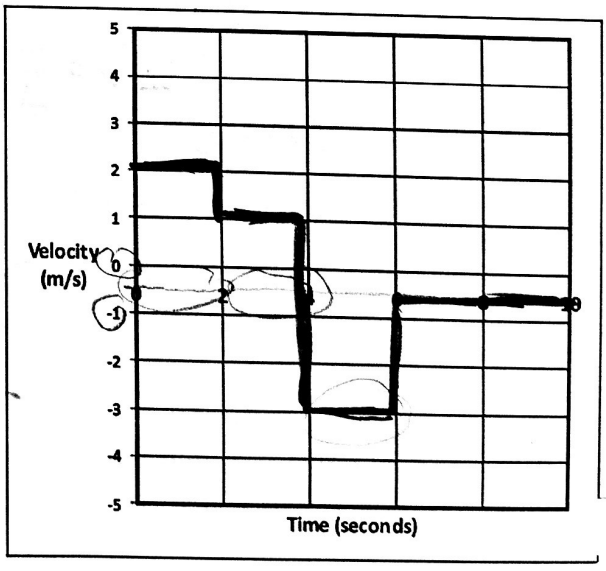
Displacement = -2m $\frac{-2m}{10s} = -0.2m/s$

Δt = 10s

Vaverage = -0.2m/s $(-\frac{1}{5} m/s)$

Distance traveled = 14m

Position at end of segment = 0m

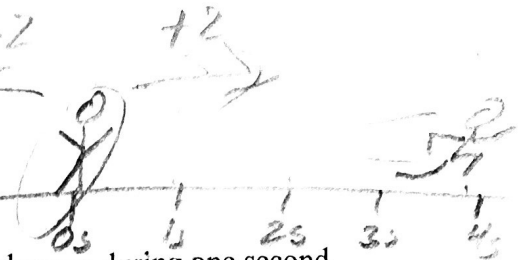


8. Use previous answers and the distance vs. time graph above to fill in the velocity vs. time graph on the right.

Notes: Acceleration and Motion Graphing

Acceleration Notes:

$\bar{v} = \frac{\Delta x}{\Delta t}$ $a = \frac{\Delta v}{\Delta t}$

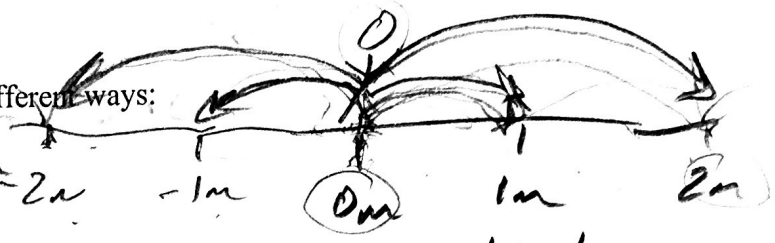


Velocity tells you how something's position changes during one second.

acceleration tells you how something's velocity changes during one second.

Is acceleration a vector or scalar quantity?

Acceleration can happen in two fundamentally different ways:



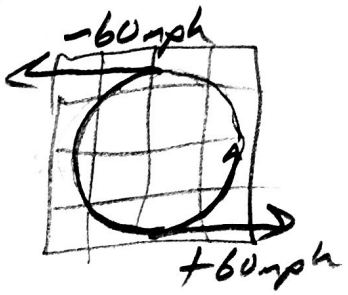
1) Speed up/slow down (change speed)

2) Change direction

Negative acceleration is usually called deceleration

Common metric units for acceleration are:

Velocity = $\frac{m}{s}$ accel = $\frac{m/s}{s} = m/s^2$



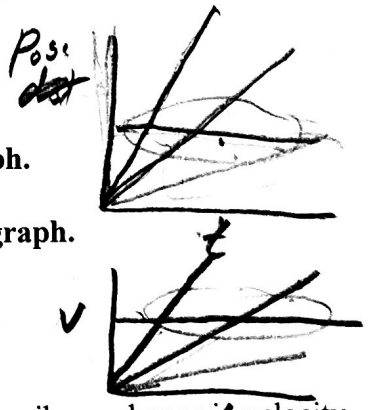
The Analogous Relationship between Velocity and Acceleration:

If Pam has a *velocity* of +6m/s, that means she travels 6m for every second that ticks by. Another way to say this is that, **for each passing second, Pam adds 6m to her position.**

Analogously, if Pam's *acceleration* is +6m/s/s, this means… $6\ m/s^2$ for each passing second she adds 6m/s to her velocity.

Velocity adds position **each second.** 0m/s → 6m/s → 12m/s → 18m/s

Acceleration adds velocity **each second.**



Velocity is the slope of a position **vs** time **graph.**

Acceleration is the slope of a velocity **vs** time **graph.**

The acceleration formula:

Velocity describes a change in position over a time interval. Acceleration describes a change in velocity over a time interval.

$a_{average} = \frac{\Delta v}{\Delta t}$ ← change in velocity / ← change in time

$\frac{4m}{s}\left(\frac{1}{1s}\right) = \frac{4m}{1s^2} = 4m/s^2$

Acceleration Formula Practice Problems:

1. Suppose your velocity is 2m/s. One second later, your velocity is 6m/s. What is your average acceleration over this time period?

$$a = \frac{\Delta V}{\Delta t} = \frac{+4\,m/s}{1s} = 4\,m/s^2$$

2. When your watch reads 8:01:32 AM, your velocity is 6m/s. At 8:01:40 AM (on the same day), your velocity is 2m/s. What is your average acceleration over this time period?

$\Delta V = V - V_0 = 2m/s - 6m/s = -4m/s$

$\Delta t = t - t_0 = 8:01:40 - 8:01:32 = 8s$

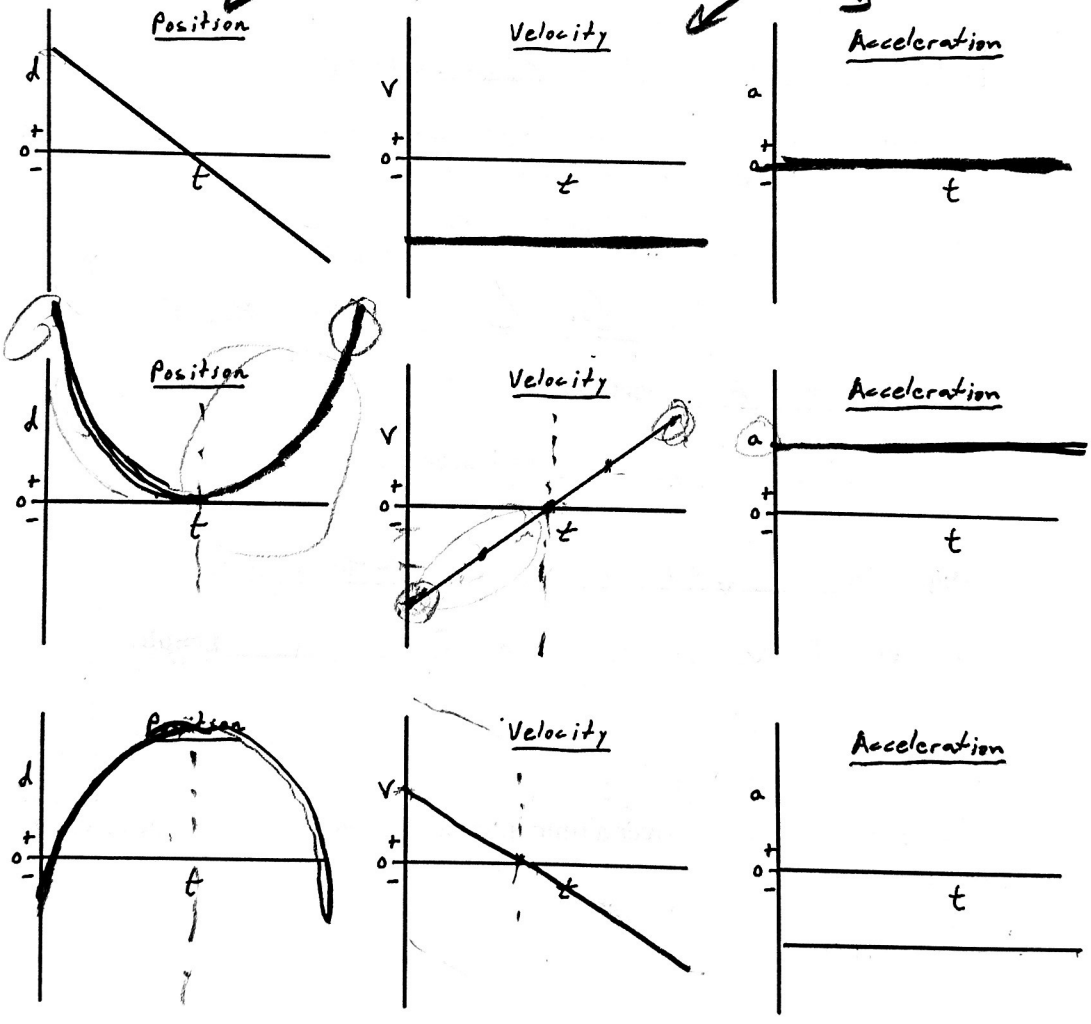
$a = \frac{\Delta V}{\Delta t} = \frac{-4m/s}{8s}$

$a = -0.4\,m/s^2$

Motion Graphs:

Each row of graphs below comprises a position vs. time graph, a velocity vs. time graph, and an acceleration vs. time graph. Every graph in a row conveys the same motion. For each row, use the one completed graph to fill in the incomplete graphs with reasonable curves. Some rows will have a wider variety of possible answers. **Assume that all acceleration is constant.**

Slope of ↘ = → Slope of ↘ = ↘



Motion Matching Activity Questions: (see directions on website)

On a motion sensor graph of position vs. time…

1. What does a positive (upward) slope tell you about the object's motion?

It's moving away from the sensor.

2. What does a negative (downward) slope indicate?

Moving toward sensor

3. What does the steepness of a slope tell you about the object's motion?

Steepness = speed (steeper = faster)

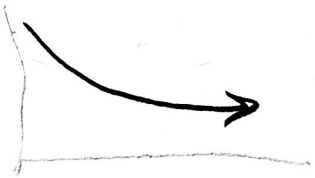
4. What does a constant (straight line) slope indicate?

Constant speed

5. What might a smoothly curving line indicate?

changing speed (acceleration)

6. Sketch a negative slope that is becoming less steep. What does this curve indicate about the motion of an object?

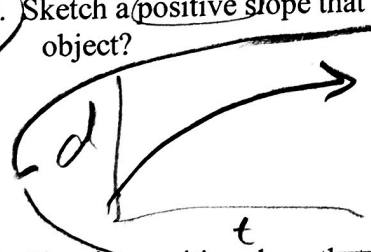


Toward sensor
Slowing down

7. Sketch a negative slope that is getting steeper. What does this curve indicate about the motion of an object?

Toward sensor
Speeding up

8. Sketch a positive slope that is becoming less steep. What does this curve indicate about the motion of an object?



Away from sensor
Slowing down

9. Sketch a ~~positive slope that~~ is getting steeper. What does this curve indicate about the motion of an object?

Away
Speeding up

Motion Graph Matching: The graphs below represent four different motions. Group the graphs that go together. Start with either a position graph or a velocity graph. Then find two more graphs (of the other varieties) that show the same motion. When you're done, you should have four groups of 3 letters. In each group, there should be the letter of a position, velocity, and acceleration graph.

A F K

B H K

C E J

D G I

A I L

B J M

C H K

D G L

E F L

-5 m/s