

# Unit 1 Handouts (Physics 100)

Name: \_\_\_\_\_

## 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?
2. What does a negative (downward) slope indicate?
3. What does the steepness of a slope tell you about the object's motion?
4. What does a constant (straight line) slope indicate?
5. What might a smoothly curving line indicate?
6. Sketch a negative slope that is becoming less steep. What does this curve indicate about the motion of an object?
7. Sketch a negative slope that is getting steeper. What does this curve indicate about the motion of an object?
8. Sketch a positive slope that is becoming less steep. What does this curve indicate about the motion of an object?
9. Sketch a positive slope that is getting steeper. What does this curve indicate about the motion of an object?

**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:

**Vector:** A quantity with magnitude and direction. Give an example:

$\Delta$  = **Delta** = “change in”

Formula for  $\Delta$  = Final – initial.

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

	<b>Symbol</b>	<b>Meaning</b> (what it's <u>supposed to mean</u> )	<b>Vector or Scalar?</b>	<b>Common Units</b>
<b>Position</b>		Where something is on a number line.		
<b>Displacement</b>		“Change in position”		
<b>Distance</b>		Like displacement, but doesn't include direction. What a car's odometer keeps track of.		
<b>Total Distance</b>		Sum of all of the distances traveled on a trip.		
<b>Change in Time</b>		How long some event lasts.		
<b>Speed</b>		How fast something is moving. A ratio of distance traveled to travel time elapsed.		
<b>Velocity</b>		Speed <u>and</u> direction.		

If I have a velocity of 3 m/s, what does that mean?

One Definition of Velocity:

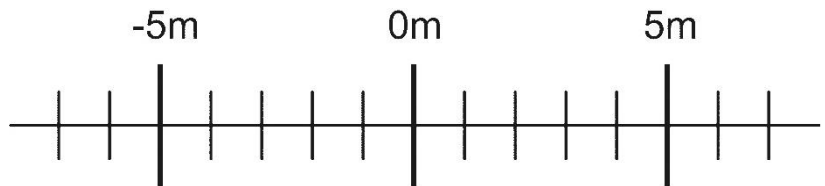
**Average Velocity** (symbol =  $v_{avg}$ ): when we measure velocity, *average velocity* is what we will actually measure. This is the average speed of an object as it travels through a given distance. The object may speed up or slow down over that distance, but the average velocity that we calculate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

**Average Velocity Formula** (Hint: the units provide the formula)

“Initial velocity” symbol =

Final velocity symbol =

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.



Displacement?

Distance traveled?

Average velocity?

Average speed?

**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.

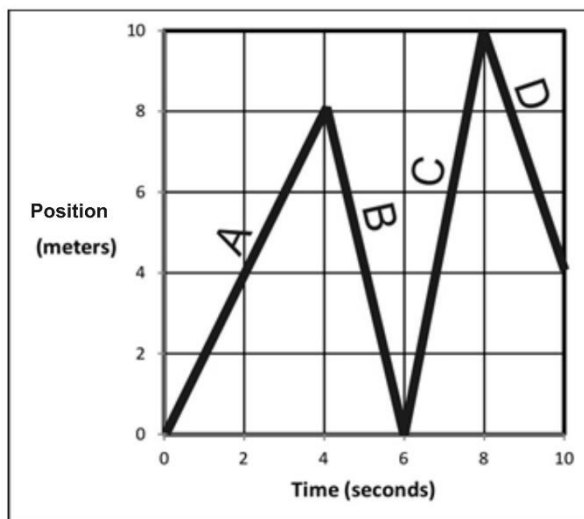
**Displacement** = \_\_\_\_\_

$\Delta t$  = \_\_\_\_\_

**V<sub>average</sub>** = \_\_\_\_\_

**Distance traveled** = \_\_\_\_\_

**Position** at end of segment = \_\_\_\_\_



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

**Displacement** = \_\_\_\_\_

$\Delta t$  = \_\_\_\_\_

**V<sub>average</sub>** = \_\_\_\_\_

**Distance traveled** = \_\_\_\_\_

**Position** at end of segment = \_\_\_\_\_

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

**Displacement** = \_\_\_\_\_

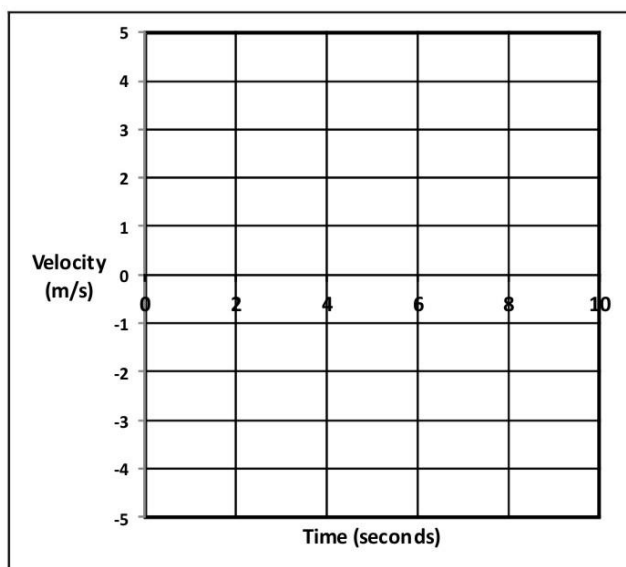
$\Delta t$  = \_\_\_\_\_

**V<sub>average</sub>** = \_\_\_\_\_

**Distance traveled** = \_\_\_\_\_

**Position** at end of segment = \_\_\_\_\_

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.

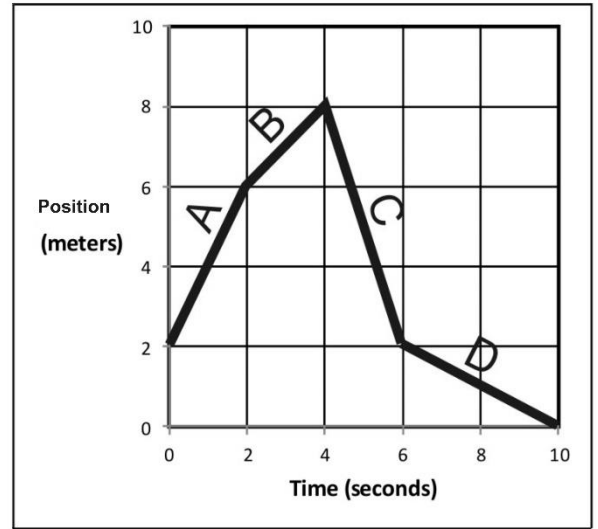
**Displacement** = \_\_\_\_\_

$\Delta t$  = \_\_\_\_\_

**V<sub>average</sub>** = \_\_\_\_\_

**Distance traveled** = \_\_\_\_\_

**Position** at end of segment = \_\_\_\_\_



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

**Displacement** = \_\_\_\_\_

$\Delta t$  = \_\_\_\_\_

**V<sub>average</sub>** = \_\_\_\_\_

**Distance traveled** = \_\_\_\_\_

**Position** at end of segment = \_\_\_\_\_

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

**Displacement** = \_\_\_\_\_

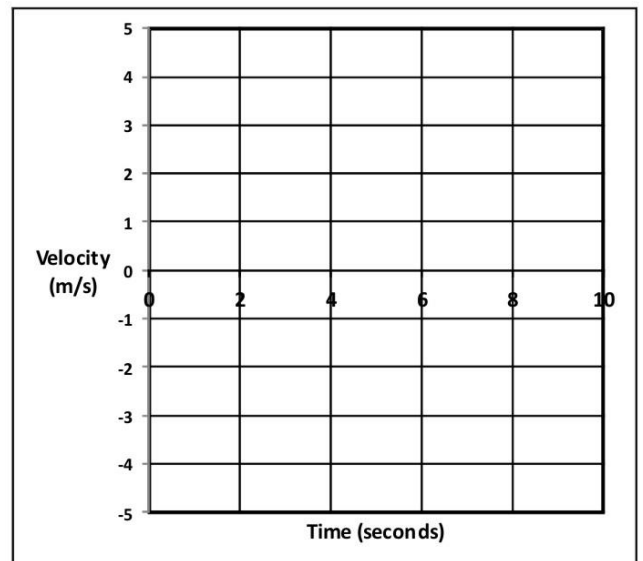
$\Delta t$  = \_\_\_\_\_

**V<sub>average</sub>** = \_\_\_\_\_

**Distance traveled** = \_\_\_\_\_

**Position** at end of segment = \_\_\_\_\_

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:**

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

\_\_\_\_\_ 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)

2)

Negative acceleration is also called \_\_\_\_\_

Common metric units for acceleration are:

**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...

**Velocity adds \_\_\_\_\_ each second.**

**Acceleration adds \_\_\_\_\_ each second.**

**Velocity is the slope of a \_\_\_\_\_ vs \_\_\_\_\_ graph.**

**Acceleration is the slope of a \_\_\_\_\_ vs \_\_\_\_\_ graph.**

**The acceleration formula:**

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

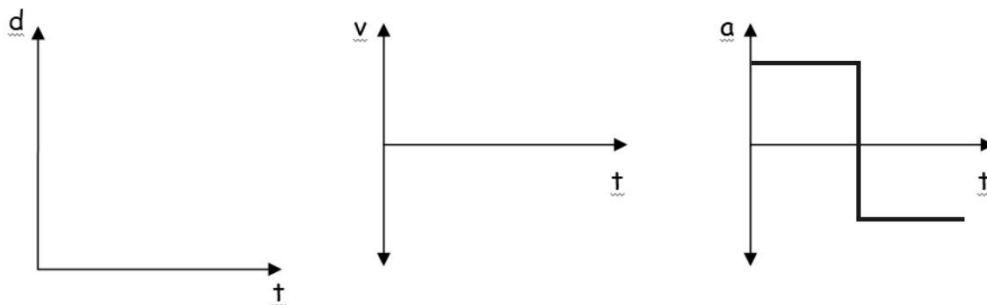
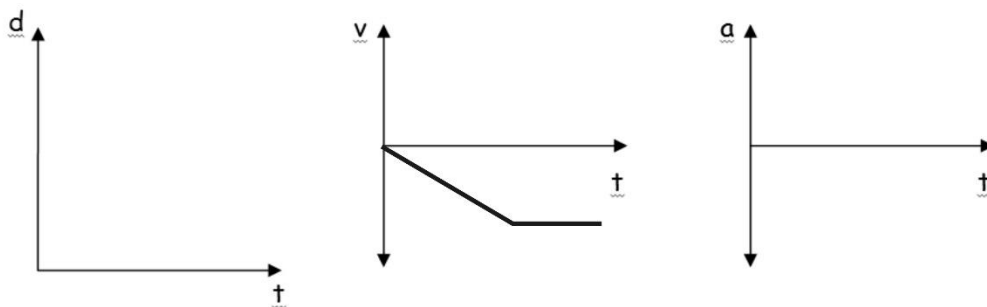
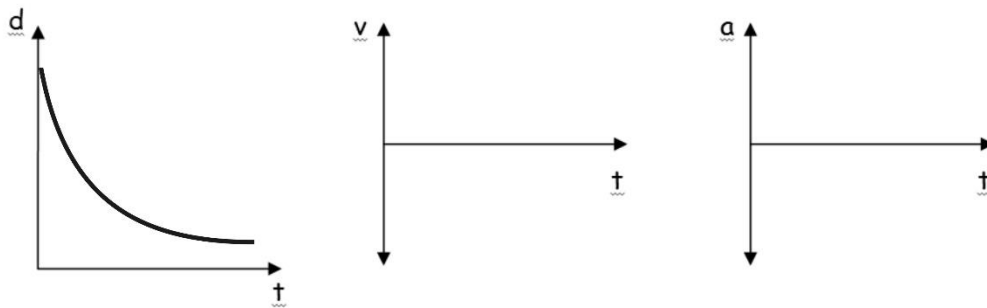
$a_{\text{average}} =$

**Acceleration Formula Practice Problems:**

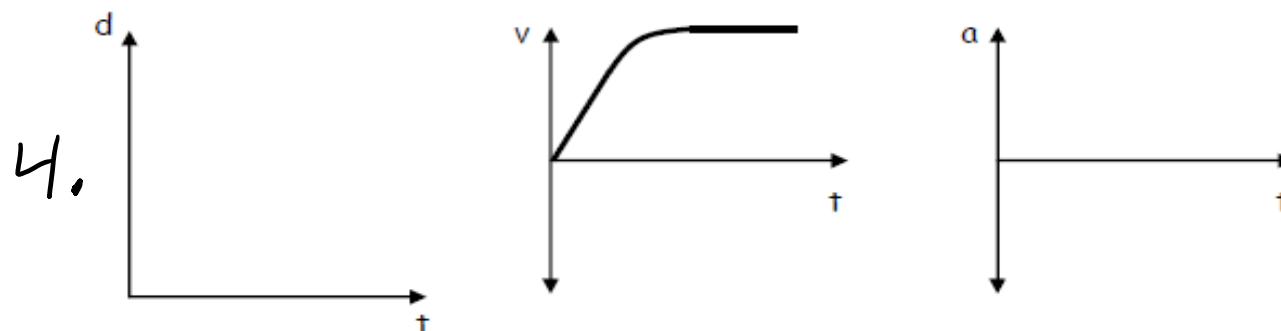
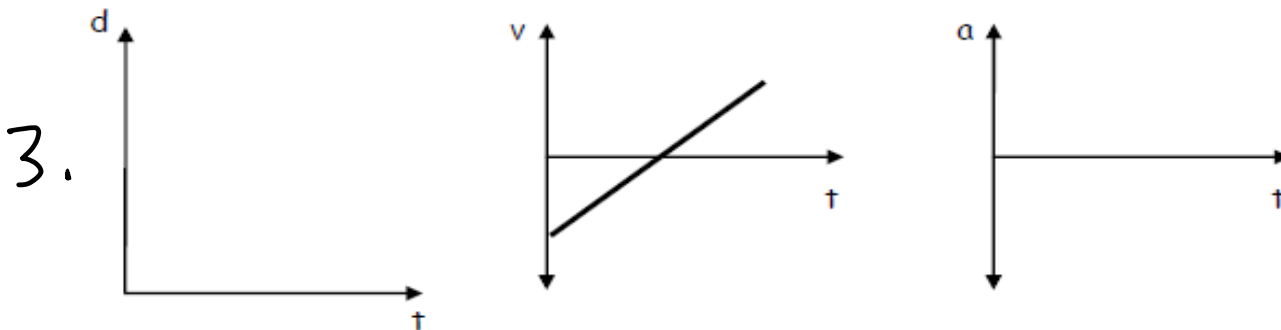
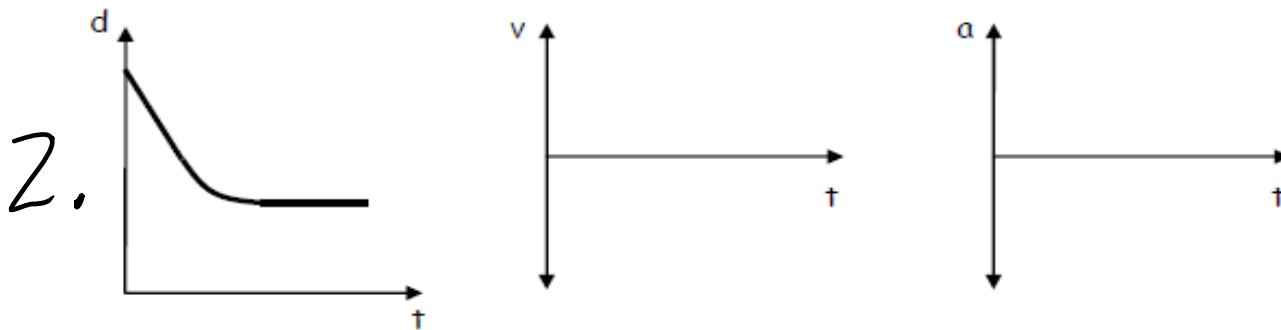
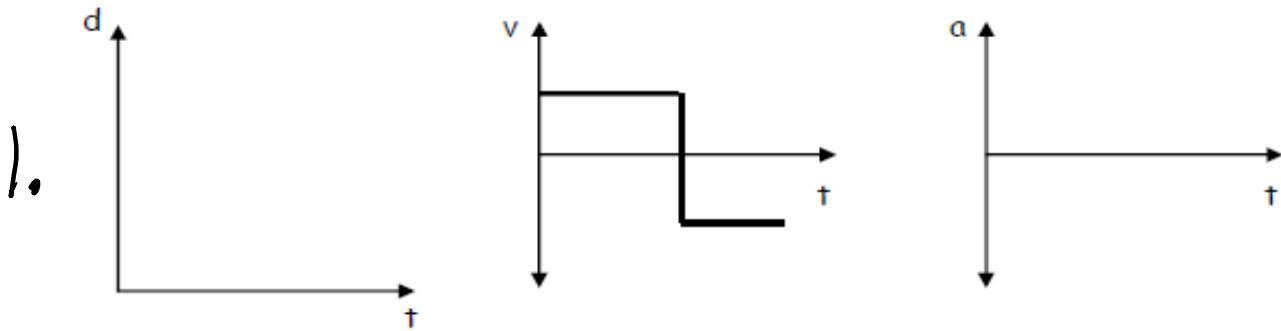
- Suppose your velocity is 2m/s. One second later, your velocity is 6m/s. What is your average acceleration over this time period?
- When your watch reads 8:01:32 AM, your velocity is 6m/s. At 8:01:40 AM (on the same day), your velocity is 2m/s. What is your average acceleration over this time period?

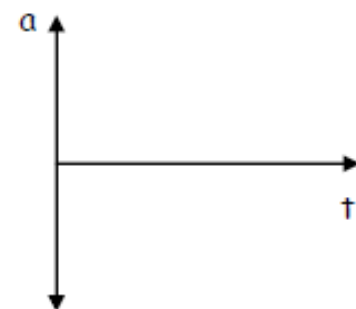
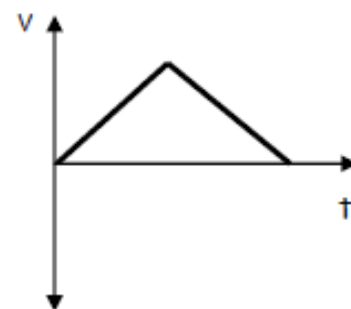
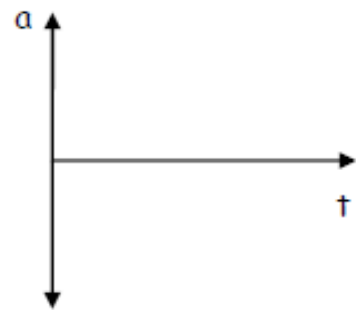
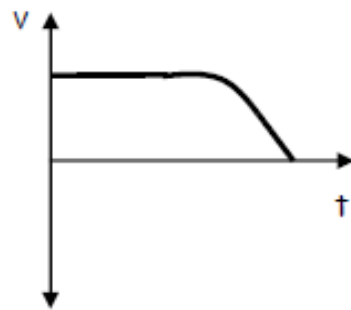
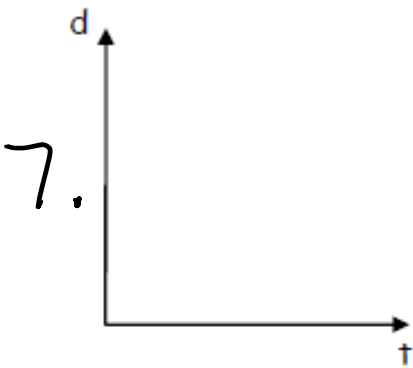
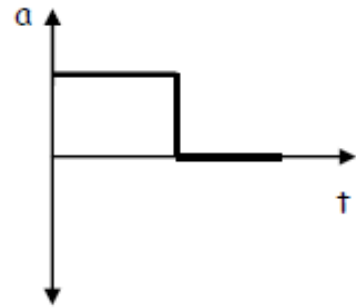
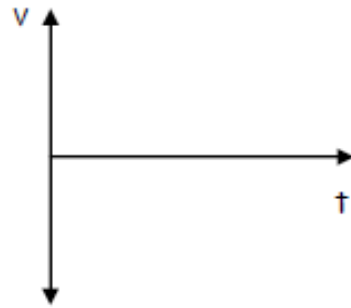
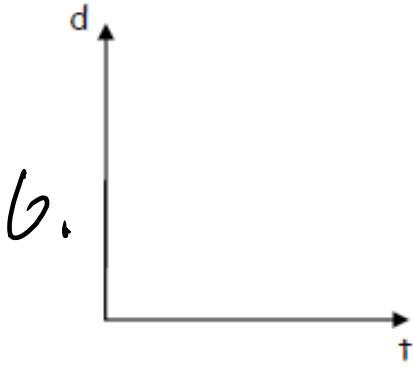
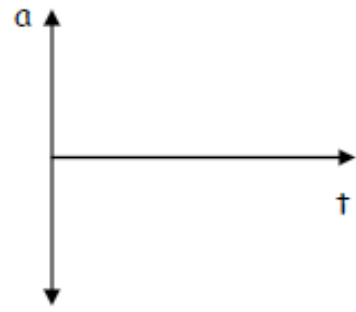
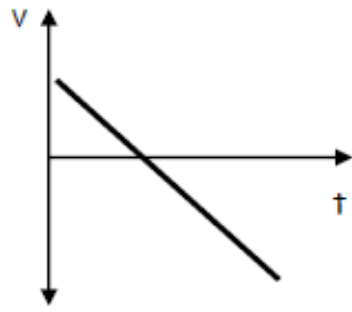
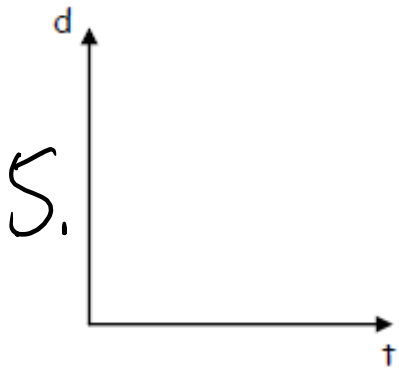
**Motion Graphs:**

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.**



**Graph Comparisons:** use the information provided in one graph to complete the other two graphs. Be aware that some graphs may be unrealistic, and some may have multiple correct solutions.

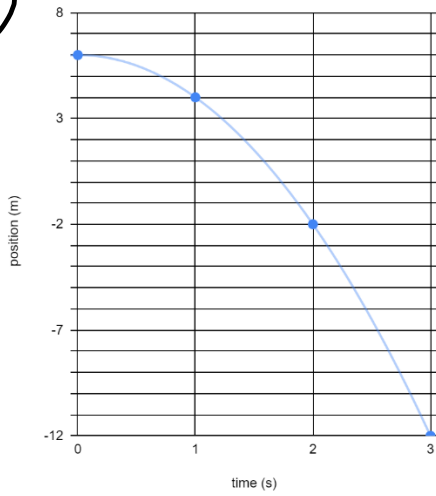




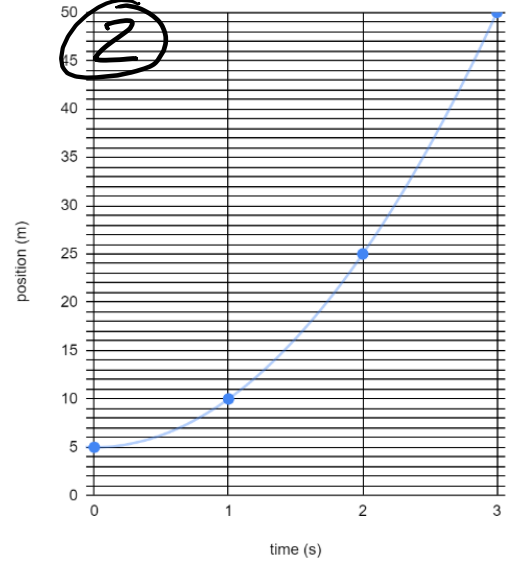
**Motion Graph Calculations Practice**

Show calculations for velocity for two intervals. Then use those velocities to find acceleration.

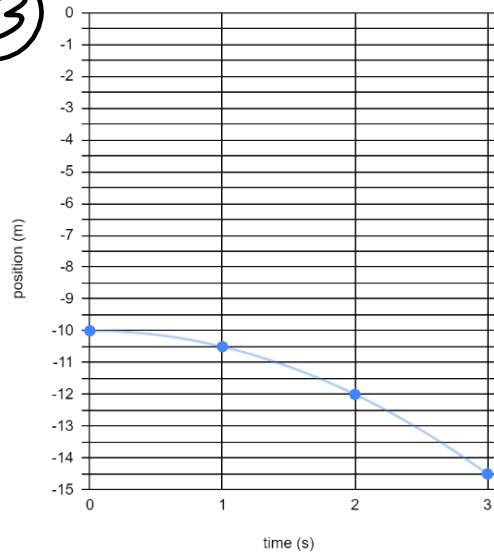
①



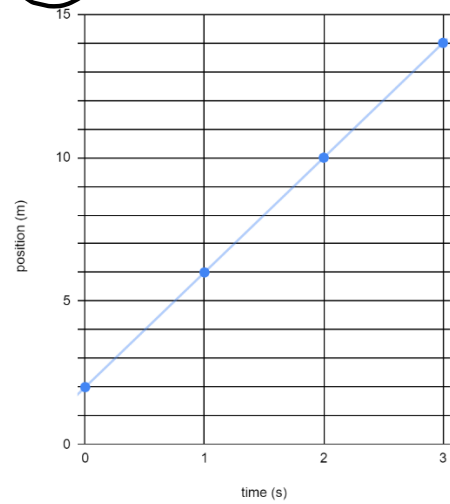
②



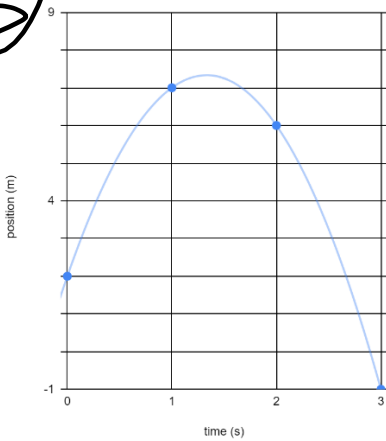
③



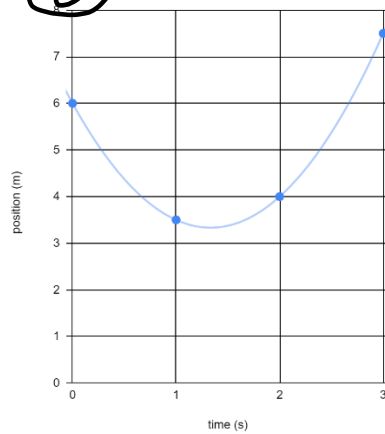
④

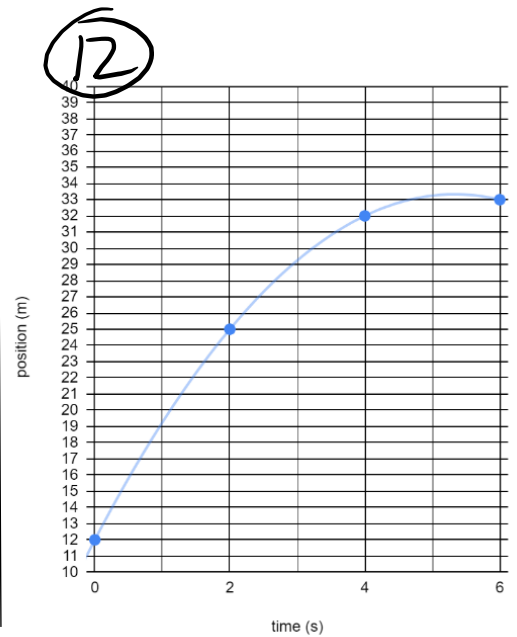
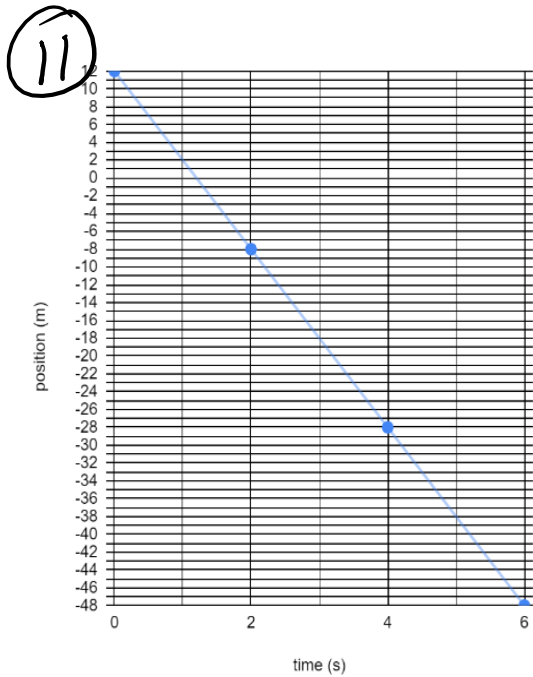
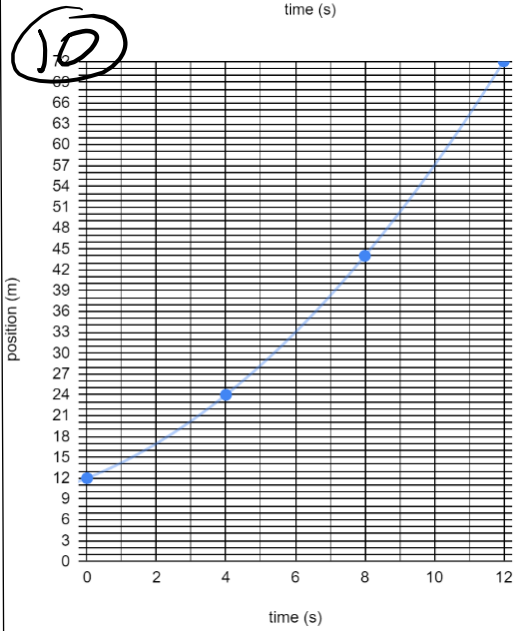
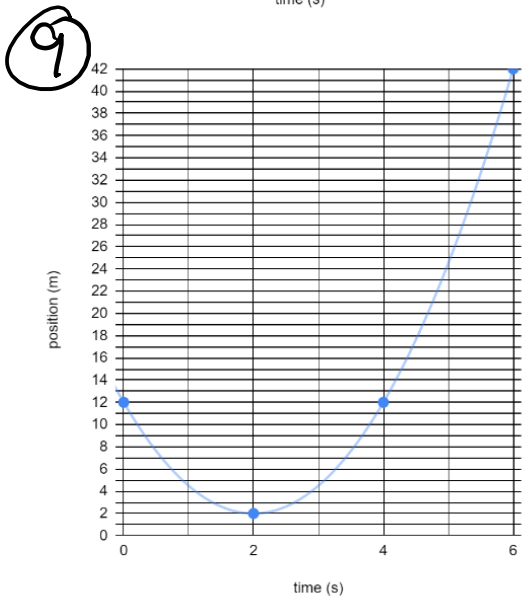
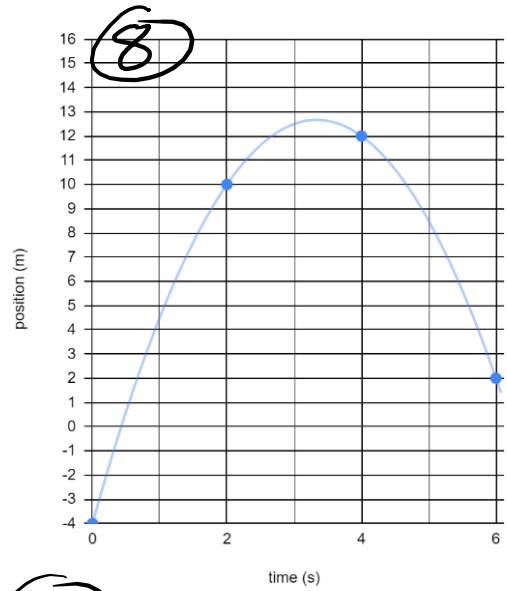
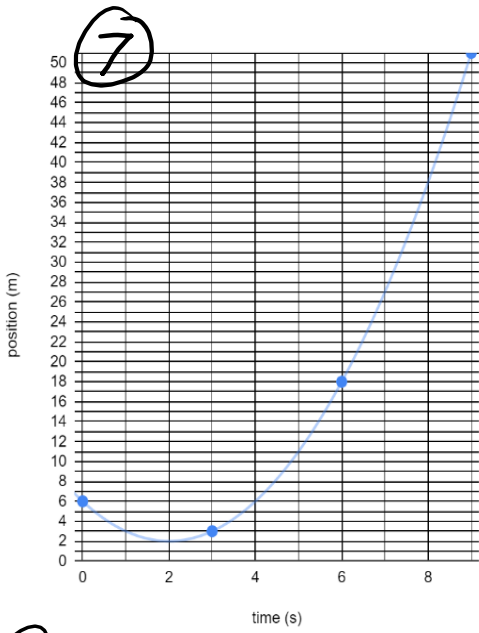


⑤



⑥





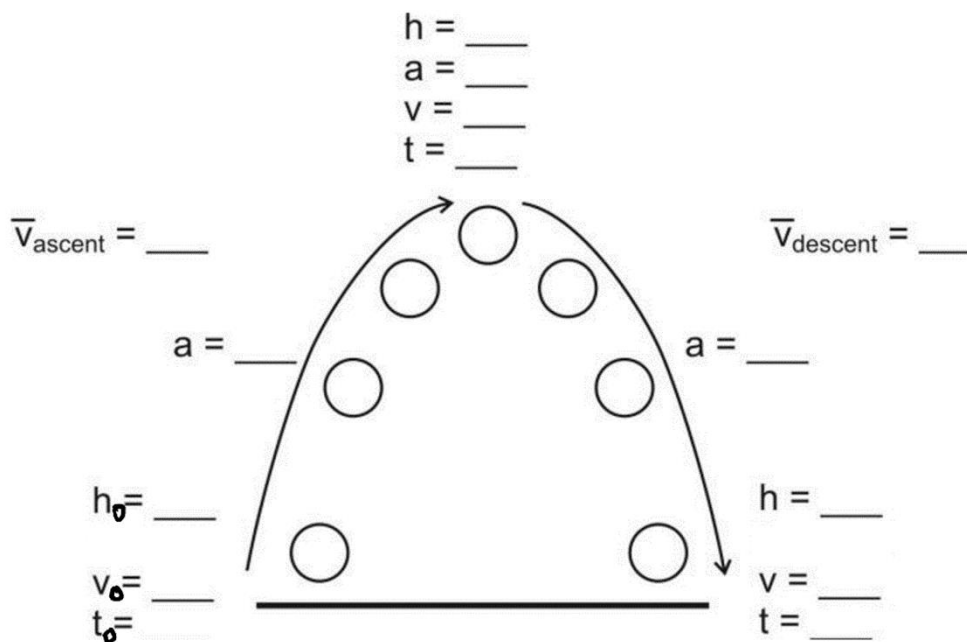
### Notes: Free-Fall, More Kinematics Formulas, and Kinematics Problems

**Free-fall:** The state of being acted upon by only the force of gravity. Objects can be in free-fall if they are moving upward or downward – as long as there is no air resistance or any other force (other than gravity).

**Free-fall acceleration:**  $-9.8\text{m/s}^2$  or  $-g$ . But we will probably use  $-10\text{m/s}^2$  most of the time.

The diagram below is intended to represent an object that is launched vertically upward in the absence of air resistance (i.e. in free-fall). The diagram appears to show the ball moving sideways, but it isn't moving sideways. The apparent sideways motion is unavoidable if we're going to separate upward-moving objects from the downward-moving objects (as we need to do for clarity).

- Fill in one of the blanks in the diagram with a made-up value. Based on that value, fill in the rest. Estimate by using  $g=10\text{m/s}^2$



- Write the

formula for  
acceleration  
(starting from  
rest), based on  
time and  
displacement:

Example Problem: Starting from rest, a student travels a distance of 6m in a time of 2s, accelerating the entire time. What is the student's acceleration over this 2s time period?

3. Write the formula for displacement, based on acceleration (starting from rest) and time:

Example Problem: If a ball is dropped in the absence of air resistance, how far does it fall during the first 3 seconds of its fall?

Review and practice Problems:

4. Write the basic formulas for average velocity and acceleration.
5. Starting from rest, a rubber band car travels 5m in 2.82 seconds.
  - a. What is its average velocity?
  - b. What is its acceleration?
6. The rubber band car travels over the last floor tile in a time of 0.076 seconds. If the distance across the floor tile is 0.305m, what is the rubber band car's average velocity during that time?
7. A runner stands motionless. Then she accelerates at a rate of  $3\text{m/s}^2$  for 3 seconds. How far has she traveled?
8. A car speeds up from 3m/s to 8m/s over a time of 2 seconds. What is its acceleration?
9. A ferrari SF90 can accelerate from 0-60mph in 2.0 seconds. If 60mph is 26.8 m/s...
  - a. What is the Ferrari's acceleration?
  - b. How far does the car travel in those 2 seconds?

**Notes and Practice: Converting Between Units**

Example Problem: A car is traveling with a speed of 55mph. What is its speed in m/s?

Why does this method work?

**Some basic conversions:**

$1\text{m/s} = 2.24\text{mph}$

$1\text{ foot} = 0.305\text{m}$

$1\text{km} = 0.62\text{miles}$

$1\text{m} = 100\text{cm}$

$1\text{ inch} = 2.54\text{cm}$

$1\text{km} = 1,000\text{m}$

$1\text{gallon} = 128\text{ fluid ounces}$

$1\text{ gallon} = 4\text{ quarts}$

$1\text{ mile} = 5280\text{ feet}$

1. 8 feet = \_\_\_\_\_ m
2. 15m = \_\_\_\_\_ feet
3. A 5km race is \_\_\_\_\_ miles long.
4. A 23.6 mile marathon is \_\_\_\_\_ km long
5. 16m/s = \_\_\_\_\_ mph
6. 16m/s = \_\_\_\_\_ mph

7. 1 foot = \_\_\_\_\_ cm = \_\_\_\_\_ m

8. 7 quarts = \_\_\_\_\_ gallons = \_\_\_\_\_ fluid ounces

9. 5 hours = \_\_\_\_\_ days = \_\_\_\_\_ weeks

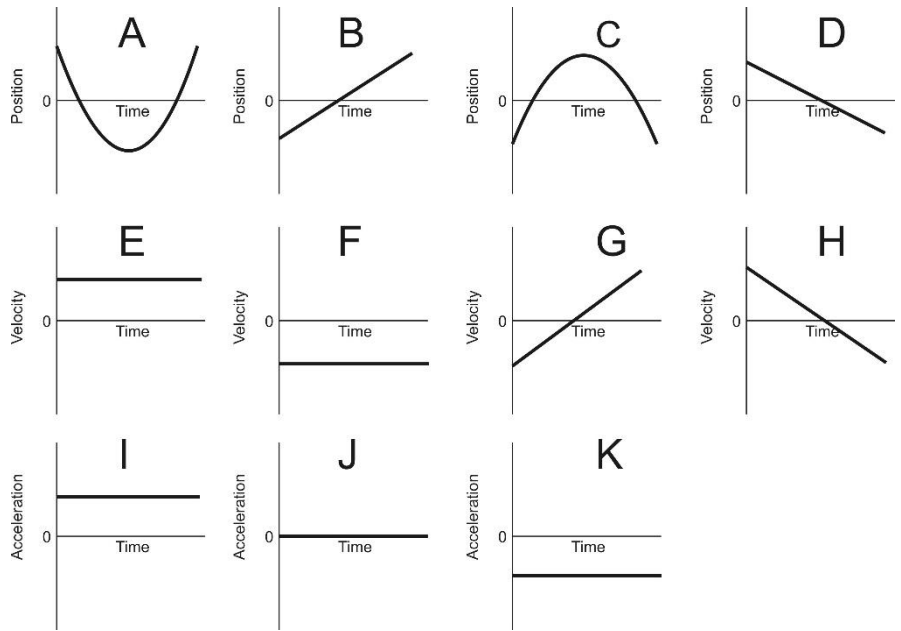
10. 300 feet = \_\_\_\_\_ mile = \_\_\_\_\_ km = \_\_\_\_\_ m

11. 5m = \_\_\_\_\_ cm = \_\_\_\_\_ inches = \_\_\_\_\_ feet



6. Match each of the position graphs with one velocity graph and one acceleration graph that represent the same motion.

Position Graph	Velocity Graph	Acceleration Graph
A		
B		
C		
D		



7. A car traveling with a velocity of 21m/s slows down to 15m/s. If it takes 3 seconds for the car to slow down, what is the car's acceleration during this time period?

8. A ball is dropped from a high place. The ball free-falls for 5 seconds.

a. What is the acceleration of a free-falling object?

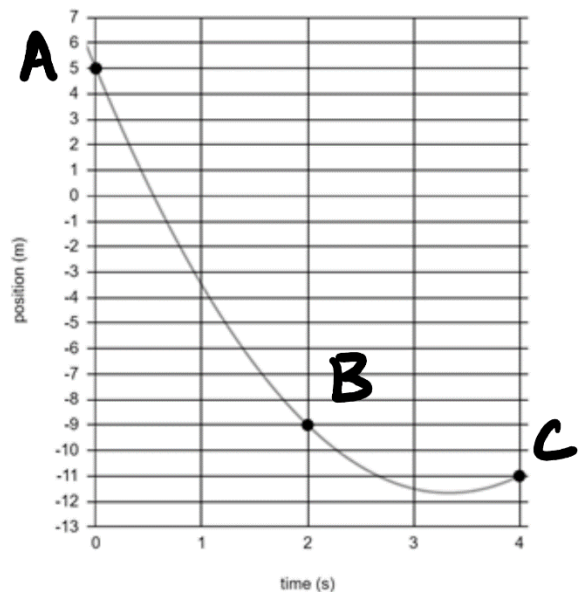
b. How fast is the ball traveling after falling for 5 seconds?

9. The graph on the right shows the positions of a moving object at three different moments in time.

a. What was the average velocity of the object between points A and B?

b. What was the average velocity of the object between points B and C?

c. What was the object's acceleration?



**Kinematics Test Review: Part 2**

Formulas that always work:

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

Formulas that only work when starting from rest

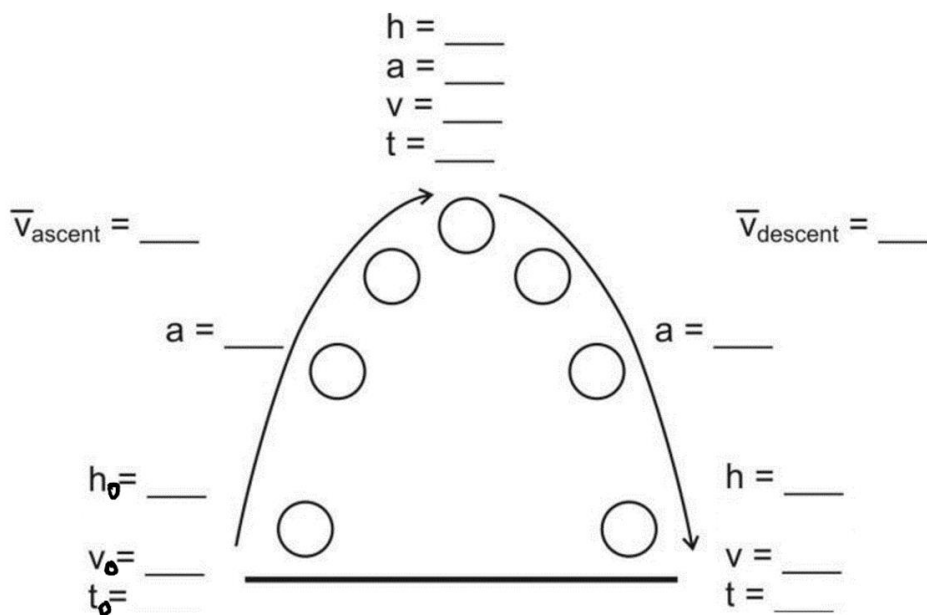
$$a = \frac{2\Delta x}{t^2} \quad \Delta x = \frac{1}{2} a t^2$$

10. Write the basic units for each of the following:

- |                 |                 |
|-----------------|-----------------|
| a. Position     | b. Speed        |
| b. Acceleration | c. Displacement |
| d. Velocity     | e. Time         |

11. Suppose an object is launched directly upward in the absence of air resistance (i.e. it is in free-fall). Between the time it is launched and the time it lands, a time of 6 seconds elapses. The object begins and ends at a height of zero meters.

Fill in all of the missing data below, given that the entire trip takes 6 seconds. [Hint: Start by writing "6s" next to the final time (t).]

Some basic conversions:

1m/s = 2.24mph

1 foot = 0.305m

1km = 0.62miles

1m = 100cm

1 inch = 2.54cm

1km = 1,000m

1gallon = 128 fluid ounces

1 gallon = 4 quarts

1 mile = 5280 feet

12. If a pool tractor travels 5m, how many feet is this?

13. A car is travelling at a speed of 60mph. What is its speed in m/s?

