Physics Headstart - Problem Solving

As you may have dreaded, physics ***will*** involve a good deal of ***problem solving***. You will become a master problem solver, which will, of course, bring you great success in physics, but the utility of problem solving is not limited to science classes. It is of tremendous value in leading what you call your basic day-to-day life. In this class, a good solid problem assault is more important than the actual answer. Let us look at a hypothetical situation: you are solving a problem and have figured out a way to use the data, some equations, and everything is so cool, except, you make a mistake (hey, it could happen!). One of your clumsy fingers hits the divide key instead of the multiply key on your trusty calculator, so that you divide by 10 instead of multiplying by 10. You are off by a factor of 100! This is pretty bad - I mean you aren't even close! But, in this class, if your method is correct, and I can see what you were doing, you will suffer only a minor deduction in points for the problem.

Let us now imagine that you don't show your work but have the right answer. This sounds outrageous, but the Institute requires that your instructor deduct half the points! If your answer is wrong, then you will lose all points for the problem. It is, therefore, in your best interest to learn how to use this problem solving format.

Problem Solving Guidelines:

1. Read the problem carefully at least twice.
2. Draw a diagram with labels.
3. Imagine a movie in your mind of what happens in the problem.
4. Identify basic physics principles, list knowns and unknowns.
5. Write down or develop equation (s) needed. Symbolically solve for unknown.
6. Substitute given values.
7. Get answer with proper units - questions to ask self:
    - Do units match?
    - Is answer reasonable?
    - Is plus or minus sign proper or meaningful?

The Little Stuff: Science has conventions in which certain physical quantities are given specific letters or symbols to represent them in equations. Velocity is "***v***" for example while volume is "***V***". Acceleration is always "***a***", the acceleration of gravity on earth, being somewhat special, is given its own symbol, "***g***". In a math class when you solve a problem, you could use any letter you wanted to represent the different things in the problem, but in physics, you should use the proper agreed upon symbol. There are some symbols that aren't agreed upon and the I will point these out. For example, many sources use "***d***" for distance, the lovely AP pholks use "***x***", sometimes "***y***", sometimes "***s***", and occasionally an "***r***". What a world.

You must show your work on all labs, tests, homework assignments . . . . in short, on ***everything.***

On a test, there will be an automatic 2 point deduction for failure to have proper units. 2 points will be deducted for improper significant figures. 2 points will be deducted for not using dimensional analysis. 2 points for not canceling units. These points could add up! It is very frustrating to have done some work and gotten all the answers correct, but because the work was not shown properly, the assigned grade is a "***C***" (or worse). Don't let this happen to you!

For each problem you solve, you must:

1. Write down the formulas that you will use.
2. Make a list of the knowns, unknowns, and constants appropriate to the problem.
3. Many problems have multiple parts – (a), (b), (c), etc. Organize your work the same way the problem is problem set up.
4. Solve for the unknown (if necessary) ***using the terms*** in the formula. (This means manipulating the symbols in the equation.)
5. Plug in the known values into the solved equation. Include all units and show how they cancel (if they do).
6. Write down your answer - make sure it has the correct units!
7. Make sure your answer has the correct number of significant figures.
8. Draw a circle or square or something around the final answer. This will be the answer that I will look at.

Every time that you write down a measurement (a number that represents some real physical thing) you should include the units, you will lose valuable points for "***neked***" numbers.

Example: Here's a simple chemistry problem. A gas occupies a volume of 2.50 L at a pressure of 1.25 atm. If the pressure is changed to 5.75 atm what is the new volume?

1. Write down the conceptual equation (this would be Boyle's law): $p_1V_1 = p_2V_2$

2. Write down the knowns and unknowns:

$V_1 = 2.5\,L \qquad P_1 = 1.25\,atm \qquad P_2 = 5.75\,atm \qquad V_2 = ?$

3. Now you must solve the equation for $\boldsymbol{V_2}$, the new volume:

$$V_2 = \frac{p_1V_1}{p_2}$$

note that no numbers have been used thus far.

3. Next, plug in the values for the data: (This is known as pluggin' and chuggin'.)

$$V_2 = \frac{1.25\,\cancel{atm}\,(2.50\,L)}{5.75\,\cancel{atm}}$$

(Don't forget to cancel the units!)

4. Write down the answer: $V_2 = 0.543\,L$

5. It needs to have the proper number of significant figures, but this has been taken care of, so make a circle around it or make a square around it or something:

$$\boxed{V_2 = 0.543\,L}$$

That's all there is to it.

This is the way that the class is. This is the way you must solve problems. Things will not change. I do not want to hear any whining about this. Accept it, learn it, adopt it, and make use of it. Do not cry about it. Students will be heard saying things like: "How come I lost so many points? I got the right answer!" In a most indgnant voice. The answer is simple.

I am amazingly good at finding little errors. The odd unit that wasn't cancelled, the failure to have a unit on some obscure number, the wrong number of significant figures, etc. There is not appeal from any of this, so learn how to solve the problems properly and get on with your life.

Science 10 Review

Scalar vs. Vector

Scalar quantities have

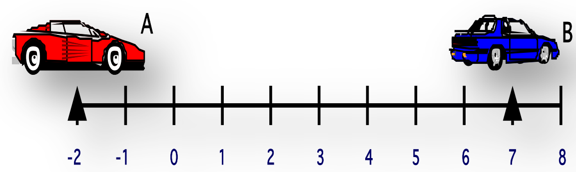
Vector quantities have We represent them as ________________________

Distance ( ):

Is distance a scalar or a vector? ______________

Displacement ( ):

Is displacement a scalar or a vector? _______________



a) what is the *distance* of Car **A** from Car **B**? ____________

b) what is the *distance* of Car **B** from Car **A**? ____________

c) what is the *position* of Car **A**? _____________

of Car **B**? _____________

d) what is the *displacement* of Car **A** measured from Car **B**? _____________

e) what is the *displacement* of Car **B** measured from Car **A**? _____________

Ex: A student walks 5 m east and then 3 m west.

a) What is the distance (scalar) travelled?

b) What is the student's displacement (vector)?

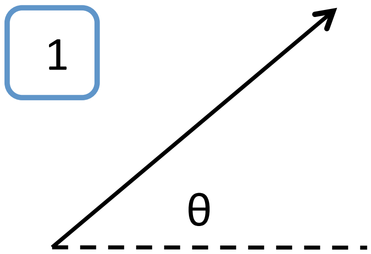
Ex: A polar bear meanders 275 m east and then turns around and ambles 425 m west.

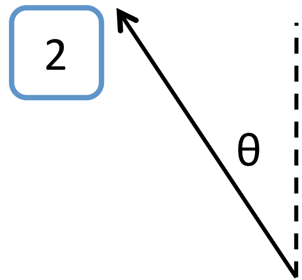
a) What was the distance travelled by the bear?

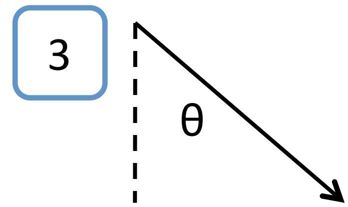
b) What was the bear's displacement?

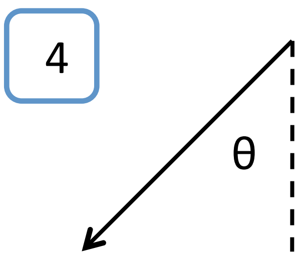
NOTE: When adding Vectors…

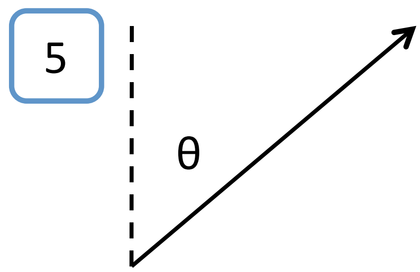
Describe the following angles

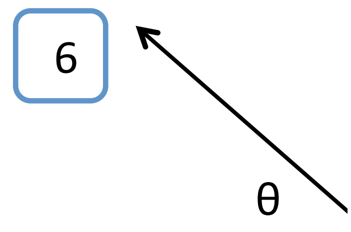




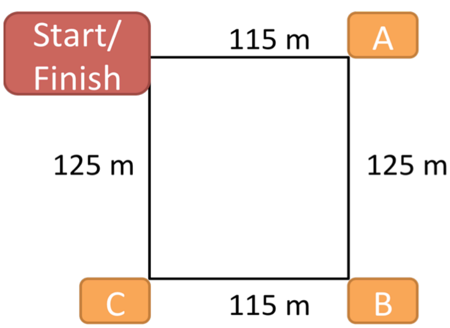








Ex: A little girl takes her dog for a walk around a city block as shown.



a) What is the distance travelled?

b) What is her final displacement?

c) What was her displacement at B?

d) What was her displacement at C?

Add each of the following vectors and find the total resultant.

1) 15 m East and 25 m North

2) 220.0 m North and 80.0 m West

3) 2.2 m South and 1.8 m North

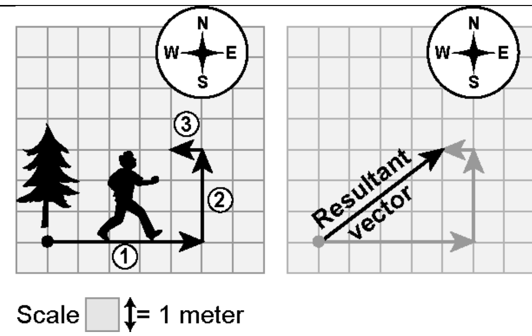
4) 150 m East and 180 m South

5) 45.0 m South and 30.0 m East and 15.0 m North

Physics **<u>Vector Worksheet #1</u>**

In physics we distinguish between scalars and vectors. Scalars and quantities that are a number and a unit; vectors are a number and a unit plus a direction. There are a number of different ways to show the direction of a vector: left-right-up-down, x and y components, and polar coordinates – a length and an angle. A good example of the difference between scalars and vectors is to compare distance (a scalar) with displacement (a vector). If a person walks around a track, then the distance she travels is the number of meters that she walked (400 for a standard track.) On the other hand, if the person started and finished at the same point, then her displacement would be zero.

Example #1: Andreas walks 5 meters to the east, then 3 meters north, and then 1 meter west. The left graph shows this progression. Andreas has travelled a total distance of 9 meters, because 5 m + 8 m + 1 m = 9m. To find his displacement we need to determine how far his final position is from his initial position, and in what direction he would have had to travel to get from the start to the finish. (For now, we won't worry about the direction.) You add up all the east-west components (remembering that east is positive and west is negative) and you get a total x-component of 4 m. You only have one north-south component, so that is 3 m. To find the resultant vector, which is the displacement, you make a new triangle with the total x –component ((4 m) and the total y-component (3 m) and you find the hypogenous, 5 m.



Find the total displacement for the following cases:

1) A bee flies 12 m north, 8 meters west, and then 4 meters south.

2) A person walks 6 blocks south, 4 blocks west and then 2 blocks north. What is their displacement in blocks?

3) In a soccer game a ball is kicked

Solving Vectors using x and y – components

Another way to write this type of problem is to use x and y –component notation instead of using the compass directions. This is when you write things in the form (x,y). To solve this type of problem you need to add up all the x-components and, separately, add up all the y-components. Sometimes you will be asked to put the result on a graph, other times you can just write the result in x and y – component notation.

Example: Add the following three vectors (5 , 6) m, (-2, 0) m , (4 , -2) m

Solution: The x-components are 5m + -2 m + 4 m = 7m

The y-components are 6m + 0 m + -2 m = 4m

Thus, the resultant vector is (7 , 4)m

For 1 and 2 below add the vectors to determine the resultant vector:

1) (-5 , 4) m, (8 , -8) m, (3 , -2)

2) (0 , -12) m, (8 , 7) m , (-4 , 5) m

3) Three vectors are added and the resultant is (-8 , 6) m. If two of the vectors are (3 , 6) m and (-5, 4) m find the third vector.

4) A boat that moves with a constant velocity of 12 m/s is moving on a river with a constant current of 4 m/s. What is the resultant velocity of the boat if:
   a) The boat is traveling to the north and the current is to the south?
   b) The boat is traveling to the south and the current is to the south?
   c) The boat travels to the east, across the current, while the current is to the south?

5) An airplane travels with a constant velocity of 210 m/s and in the upper atmosphere where the plane is traveling there is a wind that is blowing at a constant velocity of 60 m/s to the east. Determine the resultant velocity for the plane when it is traveling
   a) To the east.
   b) To the west
   c) To the north

Science 10 Review

Speed and Velocity

® Speed (v):

- Speed is a

® Velocity (v):

- Velocity is a

Where Δ means

Ex: A student travels 11 m north and then turns around and travels 25 m south. If the total time of travel is 12 s, find:

a) The student's average speed.

b) The student's average velocity.

1) How long does it take a car traveling at 45km/h to travel 100.0 m?

2) How far does a skateboarder travel in 22 s if his average velocity is 12.0 m/s?

3) A shopping cart moves from a point 3.0 m West of a flagpole to a point 18.0 m East of the flagpole in 2.5 s. Find its average velocity.

Average Velocity vs. Average Speed

Procedure:

Data:

Student 1

Time:

Student 2

Time:

Calculations:

Student 1

Speed

Velocity

Student 2

Speed

Velocity

Describing Motion Verbally with Speed and Velocity

Read from **Lesson 1** of the **1-D Kinematics** chapter at **The Physics Classroom**:

http://www.physicsclassroom.com/Class/1DKin/U1L1d.html

MOP Connection: Kinematic Concepts: sublevels 3 and 6

Review:

1. A ________ quantity is completely described by magnitude alone. A ________ quantity is completely described by a magnitude with a direction.
   a. scalar, vector b. vector, scalar

2. Speed is a _________ quantity and velocity is a _________ quantity.
   a. scalar, vector b. vector, scalar

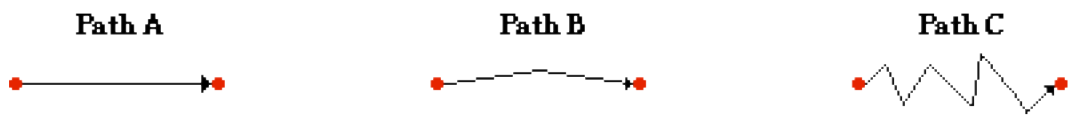
Speed vs. Velocity

Speed and velocity are two quantities in Physics that seem at first glance to have the same meaning. While related, they have distinctly different definitions. Knowing their definitions is critical to understanding the difference between them.

Speed is a quantity that describes how fast or how slow an object is moving.

Velocity is a quantity that is defined as the rate at which an object's position changes.

3. Suppose you are considering three different paths (A, B and C) between the same two locations.

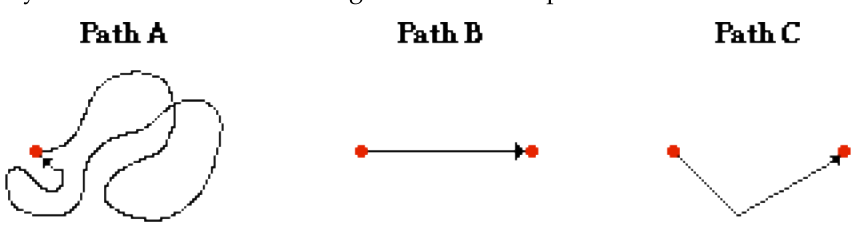


   Along which path would you have to move with the greatest speed to arrive at the destination in the same amount of time? __________ Explain.

4. **True** or **False**: It is possible for an object to move for 10 seconds at a high speed and end up with an average velocity of zero.
   a. True b. False

5. If the above statement is true, then describe an example of such a motion. If the above statement is false, then explain why it is false.

6. Suppose that you run for 10 seconds along three different paths.



   Rank the three paths from the lowest average speed to the greatest average speed. _________

   Rank the three paths from the lowest average velocity to the greatest average velocity. _________

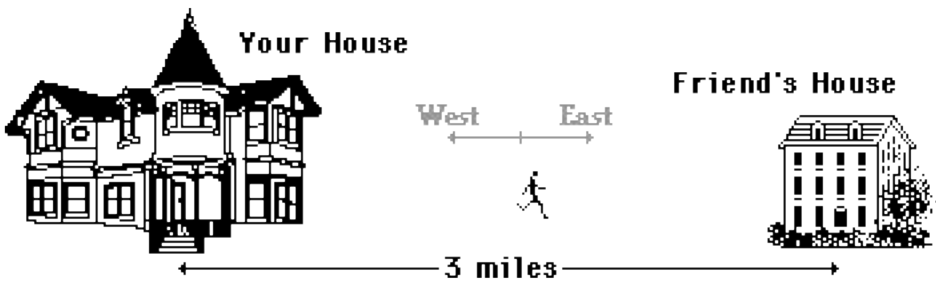
Calculating Average Speed and Average Velocity

The average speed of an object is the rate at which an object covers distance. The average velocity of an object is the rate at which an object changes its position. Thus,

$$\text{Ave. Speed} = \frac{\text{distance}}{\text{time}} \qquad \text{Ave. Velocity} = \frac{\text{displacement}}{\text{time}}$$

Speed, being a scalar, is dependent upon the scalar quantity distance. Velocity, being a vector, is dependent upon the vector quantity displacement.

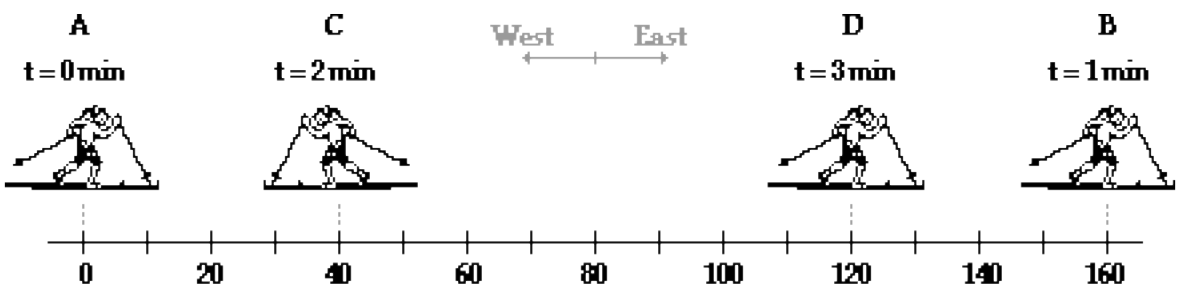
7. You run from your house to a friend's house that is 3 miles away in 30 minutes. You then immediately walk home, taking 1 hour on your return trip.



a. What was the average speed (in mi/hr) for the entire trip? _______________

b. What was the average velocity (in mi/hr) for the entire trip? _______________

8. A cross-country skier moves from location A to location B to location C to location D. Each *leg* of the back-and-forth motion takes 1 minute to complete; the total time is 3 minutes. The unit of length is meters.



Calculate the average speed (in m/min) and the average velocity (in m/min) of the skier during the three minutes of recreation. **PSYW**

Ave. Speed =

Ave. Velocity =

Science 10 Review

Uniform Accelerated Motion

® Acceleration:

- Acceleration is a______________.

Anytime an object's...

The acceleration of an object can be found with:

Where:

1) A sprinter starts from rest and reaches a speed of 12 m/s in 4.25 s. Find his acceleration.

2) A car starts from rest and accelerates at 15 m/s^2 for 3.0 s. What is its top speed?

3) If a snowboarder is traveling at 8.0 m/s how long will it take her to reach 36.0 m/s if she can accelerate at a rate of 3.5 m/s^2

Remember that all vectors include…

- Up or to the right are…

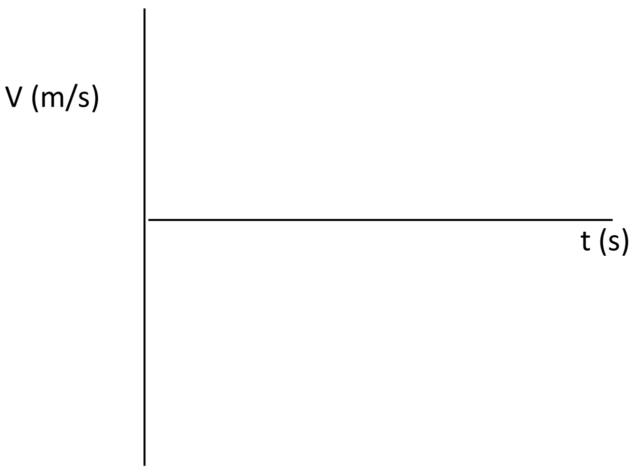
- Down or to the left are…

An object's velocity and acceleration can…

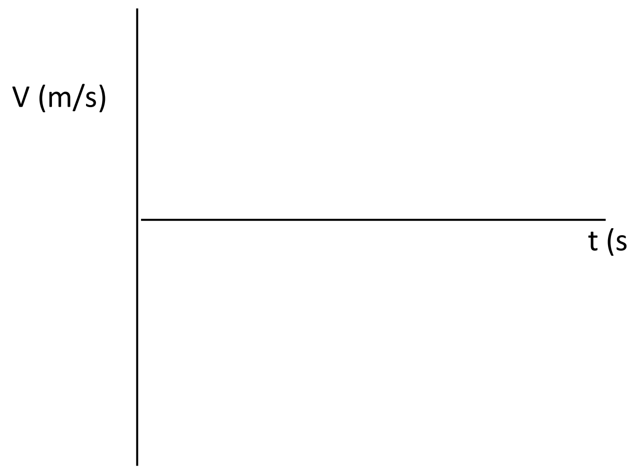
	Velocity	**Acceleration**
A car sitting at a stop light hits the gas		
From rest you back out of your driveway		
A plane lands and comes to a stop		
You drop a rock off a cliff		
You throw a rock straight up		

<u>Sketch v vs. t graphs of the following situations:</u>

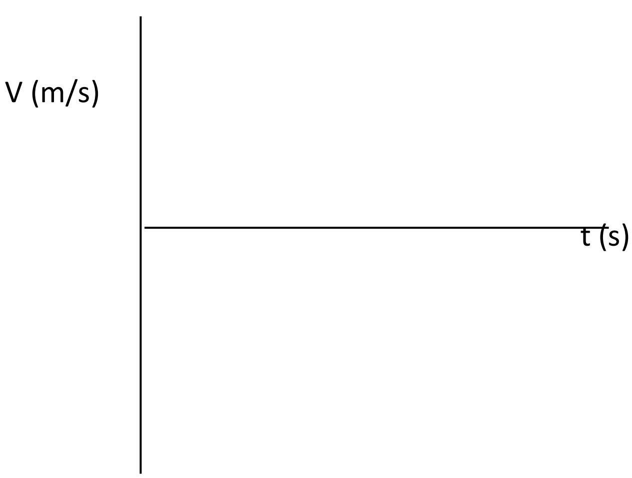
1) A hockey player skates at full speed then comes to a sudden stop.



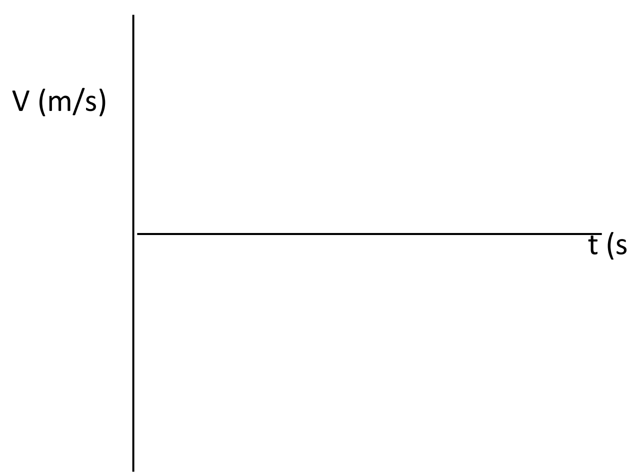
2) A football is kicked straight up and then falls back down.



3) A swimmer swims the length of a pool at a constant speed, quickly turns around and swims back.



4) A skydiver jumps from a plane, speeds up to terminal velocity, falls for awhile then pulls the chute, slowing down.



Name ____ Date _________ Period ______

Acceleration

1. Define acceleration in your own words. What does it mean if an object decelerates?

2. While traveling along a highway a driver slows from 24 m/s to 15 m/s in 12 seconds. What is the automobile's acceleration?

3. A parachute on a racing dragster opens and changes the speed of the car from 85 m/s to 45 m/s in a period of 4.5 seconds. What is the acceleration of the dragster?

4. A helicopter's speed increases from 25 m/s to 60 m/sec in 5 seconds. What is the acceleration of this helicopter?

5. The cheetah, which is the fastest land mammal, can accelerate from 0.0 mi/hr to 70.0 mi/hr in 3.0 seconds. What is the acceleration of the cheetah (in units of mph/sec)?

6. A car traveling at a speed of 30.0 m/s encounters an emergency and comes to a complete stop. How much time will it take for the car to stop if its deceleration is – 4.0 m/s^2?

7. A cart rolling down an incline for 5.0 seconds has an acceleration of 4.0 m/s^2. If the cart has a beginning speed of 2.0 m/s, what is its final speed?

8. If a car can go from 0.0 to 60.0 mi/hr in 8.0 seconds, what would be its final speed after 5.0 seconds if its starting speed were 50.0 mi/hr? (Hint: determine the car's acceleration)

Science 10 Review

Graphing

For d vs. t graphs:

- Slope =

For v vs. t graph:

- Slope =
- Area under graph =

Imagine a car at a stop light. When the light turns green it accelerates forward at a constant rate.

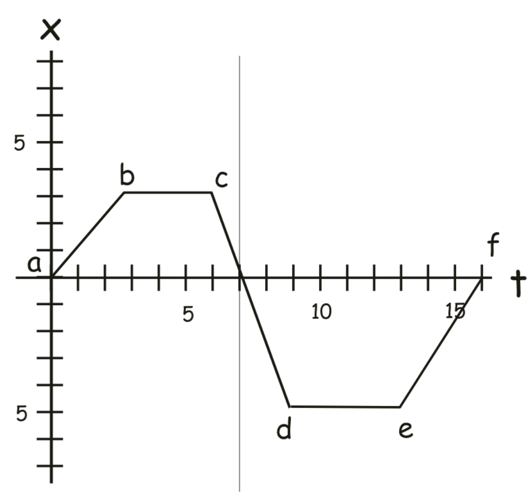
Sketch d vs. t, v vs. t and a vs. t graphs of its motion.

Ex: Rennata Gass is driving through town at 25.0 m/s and begins to accelerate at a constant rate of $-1.0\ m/s^2$. Eventually Rennata comes to a complete stop.
Represent Rennata's accelerated motion by sketching a velocity-time graph. Use the velocity-time graph to determine the distance traveled while decelerating.

Ex: Otto Emissions is driving his car at 25.0 m/s. Otto accelerates at 2.0 m/s^2 for 5 seconds. Otto then maintains this constant velocity for 10.0 more seconds.
Represent the 15 seconds of Otto Emission's motion by sketching a velocity-time graph. Use the graph to determine the distance Otto traveled during the entire 15 seconds.

Ex: A car travels along a straight section of road. A distance vs time graph illustrating its motion is graphed to the right.

(a) Indicate every time ***t*** for which the cart is at rest.
(b) Indicate every time interval for which the speed of the cart is increasing.
(c) What is the velocity from: a – b, b – c. c - d, d – e, and e – f?



Position Time Graph

Physics Graphing Worksheet

1) Draw the position vs. time graph for the following trip made by a bug. Before making your graph draw the bug's path on a number line so you know what the maximum displacements are. Also, add up all the times so you know the total time
   a) The bug starts at x=2m and crawls to the left 6m in 10 seconds.
   b) It then rests for 2 seconds and crawls a further 2m to the left in 6 seconds.
   c) The bug then crawls 10m to the right in 8 seconds.
   d) It returns to its starting point in the next 4 seconds.
   e) Find the velocity of the bug for each of the 4 intervals a) to d).
   f) What is the total distance covered by the bug?
   g) What is the total displacement of the bug?
   h) What is the average speed of the bug?
   i) What is the average velocity of the bug?
   j) Draw the velocity vs time graph for the bug.

2) Refer to the velocity time graph below to answer the following questions. Interval A is from t=0-2s, B from 2-5s, C from 5-7s, D from 7-9s and E from 9-10s.
   a) Describe the motion of the object for each of the 5 intervals. You may use speeding up, slowing down, going at constant velocity, to the left or to the right.
   b) When does the object turn around?
   c) Find the acceleration for each of the 5 intervals.
   d) Find the displacement for each of the 5 intervals.
   e) If the object starts at the origin at t=0 find the position of the object at t=2,5,7,9 and 10 seconds.
   f) What is the total distance covered?
   g) What is the total displacement?
   h) Draw the acceleration vs time graph.