AP Physics C - Summer Assignment Name ___________________________

Mr. Grunbeck - Half Hollow Hills HS East **Fall 2016 – Spring 2017**

"Hmmm..I think we need a bigger mule."

This upcoming year in physics will be reexamining many concepts you have already discovered in your previous physics class but in much greater detail (both in terms of application and mathematics), in addition to a few new ones. An understanding of certain mathematical techniques will be required, which we will go over in class. To insure we have sufficient class time to accomplish everything we need to do, you will be expected to complete the following math review and material from Chapter 2 - Motion in a Straight Line from the AP Physics C textbook. I will hand out the textbook in September. I have also posted a *pencast* on my eboard which should help you with the math techniques from Chapter 2. The problems and outline will be due on the first day of class. ***Make sure you read and complete each of the following***. Enjoy the summer! I look forward to having a phun philled second year of physics with all of you.

I. AP classes in NY are at a disadvantage. Many states and school districts follow the college schedule where classes begin in August and end in May. So the national exams are geared to these schools. You must take the exam one month early. This necessitates a fast pace. This summer homework will allow us to start on the Physics subject matter immediately when school begins. This packet is a math review to brush up on valuable skills, and to a smaller degree a means to assess whether you are correctly placed in AP Physics.

II. Physics, and AP Physics C in particular, requires an exceptional proficiency in algebra, trigonometry, geometry and CALCULUS. Mathematics, particularly calculus, is the language of physics. After all, Isaac Newton invented calculus in order to describe rates of change. The following assignment includes mathematical problems that are considered routine in AP Physics. This includes knowing several key metric system conversion factors and how to employ them. Another key area in Physics is an understanding of vectors.

III. The attached pages contain a brief review, hints, and example problems. It is hoped that combined with your previous math knowledge this assignment is merely a review and a means to brush up before school begins in the fall. Please print out and hand in your answers to the math review section of this document on the first day of class.

IV. The following pages also contain a brief synopsis of our first topic, motion in a straight line, along with some problems from the textbook for your practice. Please do the best you can do, and if you did not obtain the correct answers, please try a different approach until you do get the right answer. In the real world, the "correct" answer is never known at the outset, so physicists employ several approaches to the same problem to make sure all answers agree.

(*I have posted a separate document on the eboard with correct answers to these problems so you can check your answers)

V. ***There will be a test covering the math review during the second week of class.***

VI. What if I can't do all the problems correctly or don't understand the instructions?

~~**PANIC!**~~ Simply do the best you can, but show some work / effort in order to receive credit.Come to class the first day with your questions, in order to resolve these issues prior to the test.

Math Review:

Name: ______________________

1. The following are ordinary physics problems. Place the answer in scientific notation when appropriate and simplify the units (Scientific notation is used when it takes less time to write than the ordinary number does. As an example 200 is easier to write than 2.00x10², but 2.00x10⁸ is easier to write than 200,000,000). Do your best to cancel units, and attempt to show the simplified units in the final answer.

   a. $T_s = 2\pi\sqrt{\dfrac{4.5\times10^{-2}\,kg}{2.0\times10^{3}\,kg/s^2}} =$ ____________

   b. $K = \dfrac{1}{2}\left(6.6\times10^{2}\ kg\right)\left(2.11\times10^{4}\ m/s\right)^2 =$ ____________

   c. $F = \left(9.0\times10^{9}\dfrac{N\cdot m^2}{C^2}\right)\dfrac{\left(3.2\times10^{-9}C\right)\left(9.6\times10^{-9}C\right)}{\left(0.32m\right)^2} =$ ____________

   d. $\dfrac{1}{R_p} = \dfrac{1}{4.5\times10^{2}\Omega} + \dfrac{1}{9.4\times10^{2}\Omega}$ $\qquad R_P =$ ____________

   e. $e = \dfrac{1.7\times10^{3}\ J - 3.3\times10^{2}\ J}{1.7\times10^{3}\ J} =$ ____________

   f. $1.33\sin 25.0° = 1.50\sin\theta$ $\qquad \theta =$ ____________

   g. $K_{max} = \left(6.63\times 10^{-34} J\cdot s\right)\left(7.09\times 10^{14} s^{-1}\right) - 2.17\times 10^{-19} J =$ ____________

   h. $\gamma = 1\Big/\sqrt{1-\dfrac{2.25\times10^{8}\,m/s}{3.00\times10^{8}\,m/s}} =$ ____________

2. Often problems on the AP exam are done with variables only. Solve for the variable indicated. Don't let the different letters confuse you. Manipulate them algebraically as though they were numbers.

   a. $v^2 = v_o{}^2 + 2a(s - s_o)$ $\quad , a =$ ____________

   b. $K = \dfrac{1}{2}kx^2$ $\quad , x =$ ____________

   c. $T_p = 2\pi\sqrt{\dfrac{\ell}{g}}$ $\quad , g =$ ____________

   d. $F_g = G\dfrac{m_1m_2}{r^2}$ $\quad , r =$ ____________

   e. $mgh = \dfrac{1}{2}mv^2$ $\quad , v =$ ____________

   f. $x = x_o + v_o t + \dfrac{1}{2}at^2$ $\quad , t =$ ____________

   g. $B = \dfrac{\mu_o}{2\pi}\dfrac{I}{r}$ $\quad , r =$ ____________

   h. $x_m = \dfrac{m\lambda L}{d}$ $\quad , d =$ ____________

   i. $pV = nRT$ $\quad , T =$ ____________

   j. $\sin\theta_c = \dfrac{n_1}{n_2}$ $\quad , \theta_c =$ ____________

   k. $qV = \dfrac{1}{2}mv^2$ $\quad , v =$ ____________

   l. $\dfrac{1}{f} = \dfrac{1}{s_o} + \dfrac{1}{s_i}$ $\quad , s_i =$ ____________

3. Science uses the ***MKS*** system (***SI***: System Internationale). ***MKS*** stands for meter, kilogram, second. These are the units of choice of physics. The equations in physics depend on unit agreement. So you must convert to ***MKS*** in most problems to arrive at the correct answer.

kilometers (*km*) to meters (*m*)	and meters to kilometers	gram (*g*) to kilogram (*kg*)
centimeters (*cm*) to meters (*m*)	and meters to centimeters	
millimeters (*mm*) to meters (*m*)	and meters to millimeters	
nanometers (*nm*) to meters (*m*)	and meters to nanometers	
micrometers (μm) to meters (*m*)		

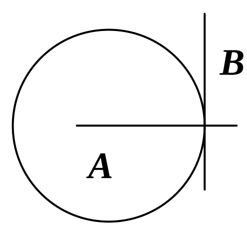
Other conversions will be taught as they become necessary.

What if you don't know the conversion factors? Colleges want students who can find their own information (so do employers). Hint: Try a good dictionary and look under "measure" or "measurement". Or the Internet? Enjoy.

a.	4008 *g*	= ________________	*kg*	h.	25.0 μm	= ________________	*m*
b.	1.2 *km*	= ________________	*m*	i.	2.65 *mm*	= ________________	*m*
c.	823 *nm*	= ________________	*m*	j.	8.23 *m*	= ________________	*km*
d.	298 *K*	= ________________	^oC	k.	5.4 *L*	= ________________	m^3
e.	0.77 *m*	= ________________	*cm*	l.	40.0 *cm*	= ________________	*m*
f.	$8.8\text{x}10^{-8}$ *m*	= ________________	*mm*	m.	$6.23\text{x}10^{-7}$ *m*	= ________________	*nm*
g.	1.2 *atm*	= ________________	*Pa*	n.	$1.5\text{x}10^{11}$ *m*	= ________________	*km*

4. Solve the following geometric problems.

a. Line ***B*** touches the circle at a single point. Line ***A*** extends through the center of the circle.



i. What is line ***B*** in reference to the circle?

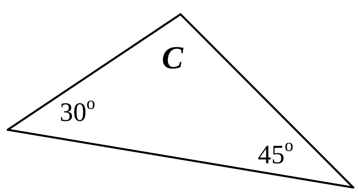
____

ii. How large is the angle between lines ***A*** and ***B***?

____

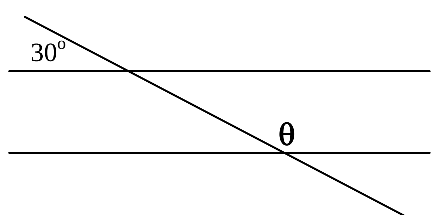
b. What is angle ***C***?

____



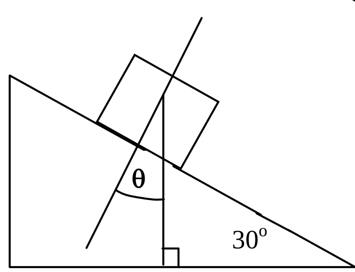
c. What is angle **θ** ?

____



d. How large is ***θ***?

____



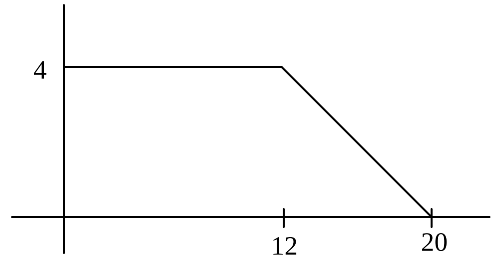
e. The radius of a circle is 5.5 *cm*,

i. What is the circumference in <u>meters</u>?

____

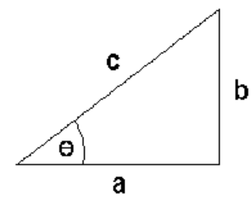
ii. What is its area in <u>square meters</u>?

____



f. What is the area under the curve at the right?

____



5. Using the generic triangle to the right, Right Triangle Trigonometry and Pythagorean Theorem solve the following. ***<u>Your calculator must be in degree mode.</u>***

a. **θ** = 55° and ***c*** = 32 *m*, solve for ***a*** and ***b***.

____

b. **θ** = 45° and ***a*** = 15 *m/s*, solve for ***b*** and ***c***.

____

c. ***b*** = 17.8 *m* and **θ** = 65°, solve for ***a*** and ***c***.

____

d. ***a*** = 250 *m* and ***b*** = 180 *m*, solve for **θ** and ***c***.

____

e. ***a*** =25 *cm* and ***c*** = 32 *cm*, solve for ***b*** and **θ**.

____

f. ***b*** =104 *cm* and ***c*** = 65 *cm*, solve for ***a*** and **θ**.

____

Vectors

Most of the quantities in physics are vectors. ***<u>This makes proficiency in vectors extremely important</u>***.

Magnitude: Size or extent. The numerical value.

Direction: Alignment or orientation of any position with respect to any other position.

Scalars: A physical quantity described by a single number and units. A quantity described by **<u>magnitude only</u>**.

Examples: time, mass, and temperature

Vector: A physical quantity with **<u>both a magnitude and a direction</u>**. A directional quantity.

Examples: velocity, acceleration, force

Notation: $\vec{A}$ or $\vec{A}$ →

<u>Length</u> of the arrow is <u>proportional to the vectors magnitude</u>.
<u>Direction</u> the arrow points <u>is the direction of the vector</u>.

Negative Vectors

Negative vectors have the same magnitude as their positive counterpart. They are just pointing in the opposite direction.

$\vec{A}$ → ← $-\vec{A}$

Vector Addition and subtraction

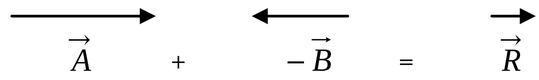
Think of it as vector addition only. The result of adding vectors is called the <u>result</u>ant. $\vec{R}$

$\vec{A}+\vec{B}=\vec{R}$ $\vec{A}$ → + $\vec{B}$ → = $\vec{R}$ →

So if ***A*** has a magnitude of 3 and ***B*** has a magnitude of 2, then ***R*** has a magnitude of 3+2=5.

When you need to subtract one vector from another think of the one being subtracted as being a negative vector. Then add them.

$\vec{A} + \vec{B}$ is really $\vec{A} + -\vec{B} = \vec{R}$



A negative vector has the same length as its positive counterpart, but its direction is reversed. So if ***A*** has a magnitude of 3 and ***B*** has a magnitude of 2, then ***R*** has a magnitude of 3+(-2)=1.

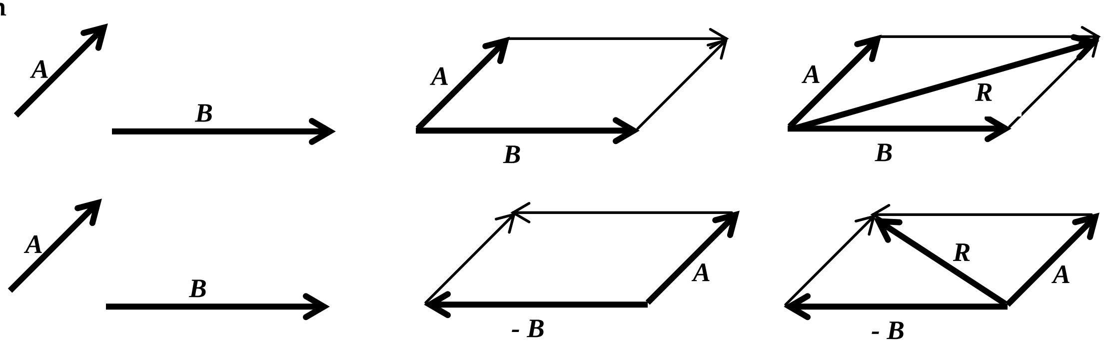
<u>This is very important</u>. In physics a negative number does not always mean a smaller number. Mathematically –2 is smaller than +2, but in physics these numbers have the same magnitude (size), they just point in different directions (180° apart).

There are two methods of adding vectors

Parallelogram

A + B

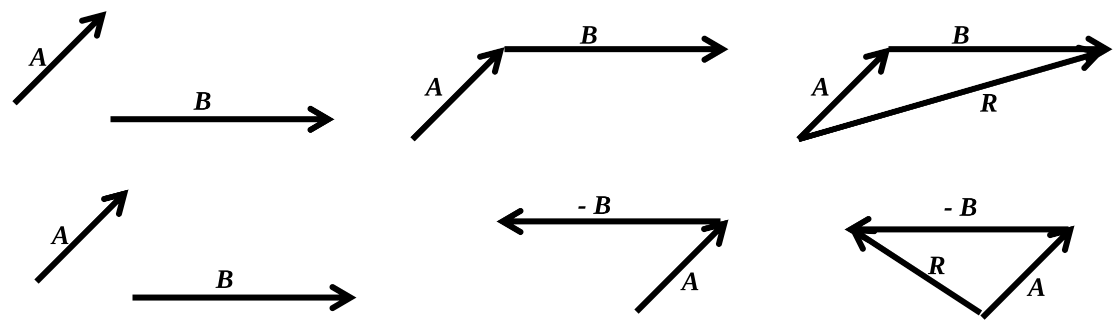
A – B



Tip to Tail

A + B

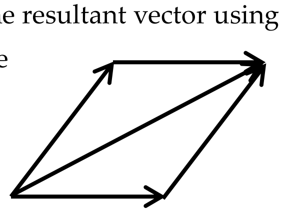
A – B



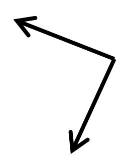
It is readily apparent that both methods arrive at the exact same solution since either method is essentially a parallelogram. It is useful to understand both systems. In some problems one method is advantageous, while in other problems the alternative method is superior.

8. Draw the resultant vector using the parallelogram method of vector addition.

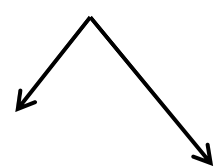
Example



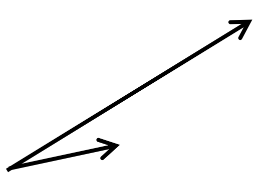
b.



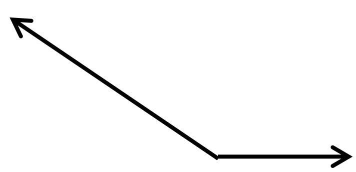
d.



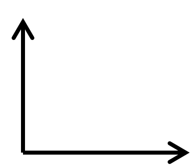
a.



c.

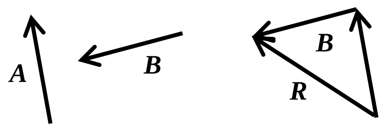


e.

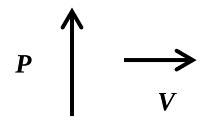


9. Draw the resultant vector using the tip to tail method of vector addition. Label the resultant as vector ***R***

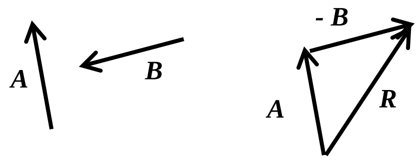
Example 1: ***A*** + ***B***



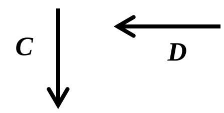
c. ***P*** + ***V***



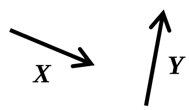
Example 2: ***A*** – ***B***



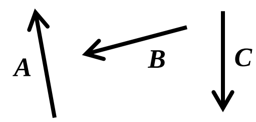
d. ***C*** – ***D***



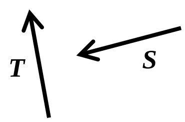
a. ***X*** + ***Y***



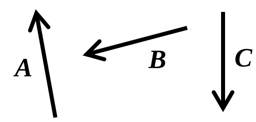
e. ***A*** + ***B*** + ***C***



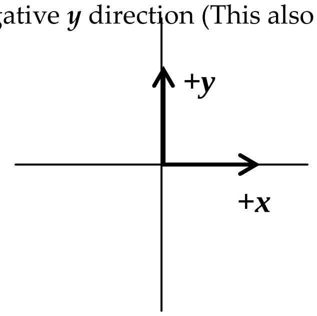
b. ***T*** – ***S***

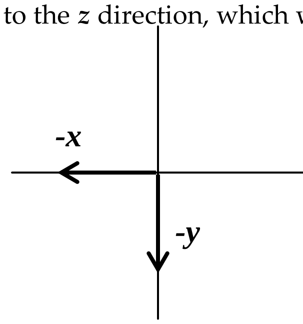


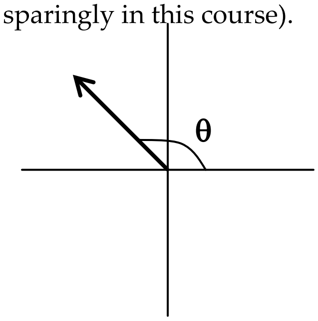
f. ***A*** – ***B*** – ***C***



Direction: What does positive or negative direction mean? How is it referenced? The answer is the coordinate axis system. **In physics a coordinate axis system is used to give a problem a frame of reference.** Positive direction is a vector moving in the positive ***x*** or positive ***y*** direction, while a negative vector moves in the negative ***x*** or negative ***y*** direction (This also applies to the ***z*** direction, which will be used sparingly in this course).





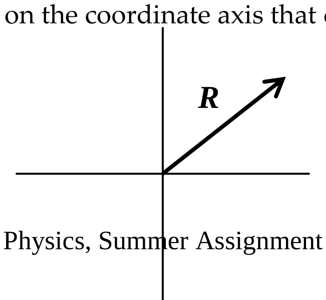


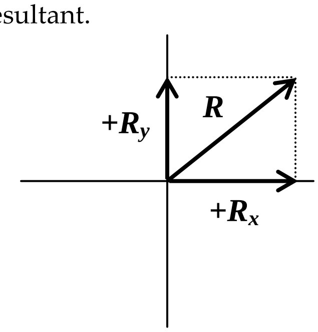
What about vectors that don't fall on the axis? You must specify their direction using degrees measured from East.

Component Vectors

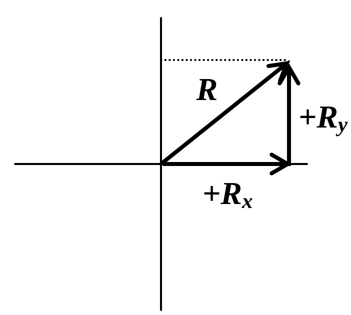
A resultant vector is a vector resulting from the sum of two or more other vectors. Mathematically the resultant has the same magnitude and direction as the total of the vectors that compose the resultant. Could a vector be described by two or more other vectors? Would they have the same total result?

This is the reverse of finding the resultant. You are given the resultant and must find the component vectors on the coordinate axis that describe the resultant.





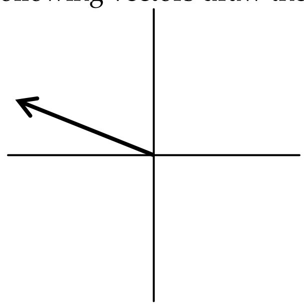
or



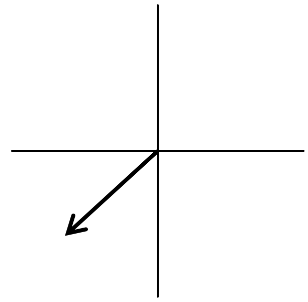
Any vector can be described by an ***x*** axis vector and a ***y*** axis vector which summed together mean the exact same thing. The advantage is you can then use plus and minus signs for direction instead of the angle.

10. For the following vectors draw the component vectors along the ***x*** and ***y*** axis.

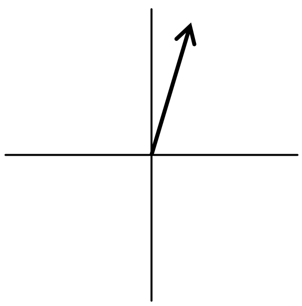
a.



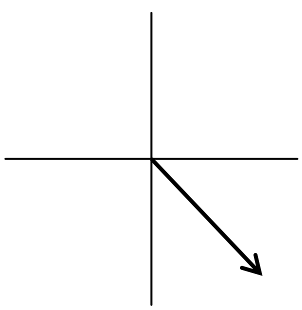
d.

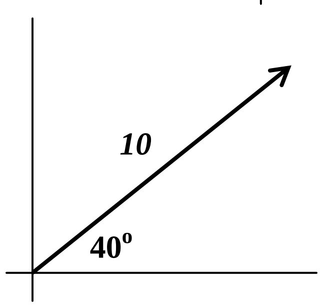


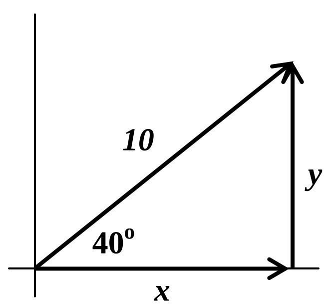
b.



c.







Obviously the quadrant that a vector is in determines the sign of the ***x*** and ***y*** component vectors.

Trigonometry and Vectors

Given a vector, you can now draw the ***x*** and ***y*** component vectors. The sum of vectors ***x*** and ***y*** describe the vector exactly. Again, any math done with the component vectors will be as valid as with the original vector. The advantage is that math on the ***x*** and/or ***y*** axis is greatly simplified since direction can be specified with plus and minus signs instead of degrees. But, how do you mathematically find the length of the component vectors? Use trigonometry.

$$\cos\theta = \frac{adj}{hyp} \qquad \sin\theta = \frac{opp}{hyp},\ adj = hyp\cos\theta \quad opp = hyp\sin\theta$$

$$x = hyp\cos\theta \qquad y = hyp\sin\theta$$

$$x = 10\cos 40^{o} \qquad y = 10\sin 40^{o}$$

$$x = 7.66 \qquad y = 6.43$$

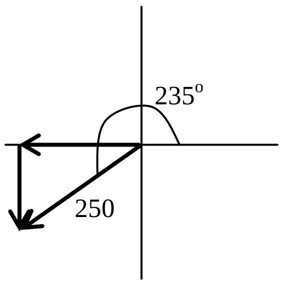
11. Solve the following problems. You will be converting from a polar vector, where direction is specified in ***degrees measured counterclockwise from east***, to component vectors along the x and y axis. Remember the plus and minus signs on you answers. They correspond with the quadrant the original vector is in.

Hint: Draw the vector first to help you see the quadrant. Anticipate the sign on the x and y vectors. Do not bother to change the angle to less than 90°. Using the number given will result in the correct + and – signs.

The first number will be the magnitude (length of the vector) and the second the degrees from east.

Your calculator must be in degree mode.

Example: 250 at 235°



$$x = hyp\cos\theta$$
$$x = 250\cos 235^o$$
$$x = -143$$
$$y = hyp\sin\theta$$
$$y = 250\sin 235^o$$
$$y = -205$$

a. 89 at 150°

b. 6.50 at 345°

c. 0.00556 at 60°

d. 7.5×10^4 at 180°

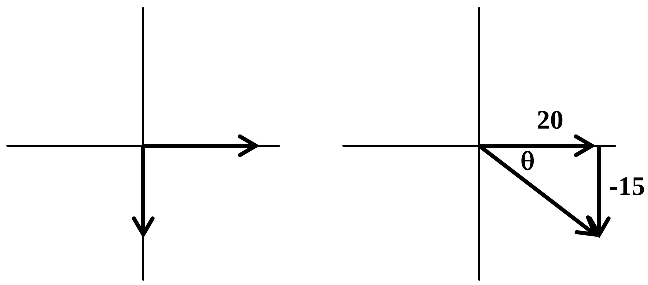
e. 12 at 265°

f. 990 at 320°

g. 8653 at 225°

12. Given two component vectors solve for the resultant vector. This is the opposite of number 11 above. Use Pythagorean Theorem to find the hypotenuse, then use inverse (arc) tangent to solve for the angle.

Example: $x = 20$, $y = -15$



$$R^2 = x^2 + y^2 \qquad \tan\theta = \frac{opp}{adj}$$

$$R = \sqrt{x^2 + y^2} \qquad \theta = \tan^{-1}\left(\frac{opp}{adj}\right)$$

$$R = \sqrt{20^2 + 15^2} \qquad \theta = \tan^{-1}\left(\frac{y}{x}\right)$$

$$R = 25$$

$$360^o - 36.9^o = 323.1^o$$

a. $x = 600$, $y = 400$

d. $x = 0.0065$, $y = -0.0090$

b. $x = -0.75$, $y = -1.25$

e. $x = 20{,}000$, $y = 14{,}000$

c. $x = -32$, $y = 16$

f. $x = 325$, $y = 998$

How are vectors used in Physics?

They are used everywhere!

Speed

Speed is a scalar. It only has magnitude (numerical value).

v_s = 10 *m/s* means that an object is going 10 meters every second. But, we do not know where it is going.

Velocity

Velocity is a vector. It is composed of both magnitude and direction. Speed is a part (numerical value) of velocity.

v = 10 *m/s* north, or ***v*** = 10 *m/s* in the ***+x*** direction, etc.

There are three types of speed and three types of velocity

Instantaneous speed / velocity: The speed or velocity at an instant in time. You look down at your speedometer and it says 20 *m/s*. You are traveling at 20 *m/s* at that instant. Your speed or velocity could be changing, but at that moment it is 20 *m/s*.

Average speed / velocity: If you take a trip you might go slow part of the way and fast at other times. If you take the total distance traveled divided by the time traveled you get the average speed over the whole trip. If you looked at your speedometer from time to time you would have recorded a variety of instantaneous speeds. You could go 0 *m/s* in a gas station, or at a light. You could go 30 *m/s* on the highway, and only go 10 *m/s* on surface streets. But, while there are many instantaneous speeds there is only one average speed for the whole trip.

Constant speed / velocity: If you have cruise control you might travel the whole time at one constant speed. If this is the case then you average speed will equal this constant speed.

A trick question

Will an object traveling at a constant speed of 10 *m/s* also always have constant velocity?

Not always. If the object is turning around a curve or moving in a circle it can have a constant speed of 10 *m/s*, but since it is turning, its direction is changing. And if direction is changing then velocity must change, since velocity is made up of speed and direction.

Constant velocity must have both constant magnitude and constant direction.

Rates of Change

Speed and velocity are rates. A rate is a way to quantify anything that takes place during a time interval. Rates are easily recognized. They always have time in the denominator.

10 *m/s*   10 meters / second

The very first Physics Equation

Velocity and Speed both share the same equation. Remember speed is usually, but not always, the numerical (magnitude) part of velocity. Velocity usually only differs from speed in that it specifies a direction.

$v = \frac{x}{t}$ *v* stands for velocity   ***x*** stands for displacement   ***t*** stands for time

Displacement is a vector for distance traveled in a straight line. It goes with velocity. Distance is a scalar and goes with speed. Displacement is measured from the origin. It is a value of how far away from the origin you are at the end of the problem. The direction of a displacement is the shortest straight line from the location at the beginning of the problem to the location at the end of the problem.

How do distance and displacement differ? Supposes you walk 20 meters down the **+ *x*** axis and turn around and walk 10 meters down the **– *x*** axis.

The distance traveled does not depend on direction since it is a scalar, so you walked 20 + 10 = 30 meter.

Displacement only cares about your distance (and direction) from the origin at the end of the problem. +20 – 10 = + 10 meter. This means that you ended up 10 meters along the +x axis from where you started.

13. Attempt to solve the following problems. Take heed of the following.

Always use the *MKS* system: Units must be in kilograms, meters, seconds.

On the all tests, including the AP exam you must:

1. List the original equation used.

2. Show correct substitution.

3. Arrive at the correct answer with correct units.

Distance and displacement are measured in meters (*m*)

Speed and velocity are measured in meters per second (*m/s*)

Time is measured in seconds (*s*)

Example: A car travels 1000 meters in 10 seconds. What is its velocity?

$v = \frac{x}{t}$ $\qquad v = \frac{1000m}{10s}$ $\qquad v = 100 m/s$

a. A car travels 35 *km* west and 75 km east. What distance did it travel?

b. A car travels 35 *km* west and 75 *km* east. What is its displacement?

c. A car travels 35 *km* west, 90 *km* north. What distance did it travel?

d. A car travels 35 *km* west, 90 *km* north. What is its displacement?

e. A bicyclist pedals at 10 *m/s* in 20 *s*. What distance was traveled?

f. An airplane flies 250.0 *km* at 300 *m/s*. How long does this take?

g. A skydiver falls 3 *km* in 15 *s*. How fast are they going?

h. A car travels 35 *km* west, 90 *km* north in two hours. What is its average speed?

i. A car travels 35 *km* west, 90 *km* north in two hours. What is its average velocity?

That's the end of the math review section. You do not need to print out the rest of this document.

<u>Motion in a Straight Line </u>(from Chapter 2 of textbook):

Last year, your introduction to physics began with kinematics, the classification and comparison of motions. We will begin AP Physics C with the same topic.

You will remember that kinematics starts with straight line motion. This line can be horizontal, vertical, or slanted, but must be straight. Kinematics does not include dynamics (forces - the cause of motion), just the motion itself. This motion may either be constant or accelerated (as in freefall). The moving object is either a particle (a pointlike object such as an electron) or an object that moves like a particle. An arthritic penguin sliding down a straight playground slide might be considered to be moving like a particle; however, a tumbling tumbleweed would not as not all parts of it are moving at the same rate.

You should already know the basic quantities that are used in kinematics. These are position, displacement, velocity, and acceleration. If you are not familiar with these quantities, you should be. Remember that displacement is the change of position, velocity is the rate of change of displacement, and acceleration is the rate of change of velocity. These are all vector quantities.

In your first year of physics, you learned how to calculate average velocity and average acceleration. In AP Physics C, however, we will investigate instantaneous velocity and instantaneous acceleration using calculus. So, please review the five basic kinematics equations so that you can do the average velocity and acceleration problems. You should also review the graphical relationships between position-time, velocity-time, and acceleration-time for both constant velocity and constant accelerated motion. What do you think these graphs look like for non-constant accelerated motion?

Now, how do we find instantaneous velocity and acceleration? Well, let's look at the equation for average velocity: $a = \frac{dv}{dt} = \frac{d^2x}{dt^2}$. In words, this means that average velocity is displacement divided by the time it took for that displacement to happen. Another way to state this is that it is the average velocity over a certain period of time. Instantaneous velocity and instantaneous speed, on the other hand, are how fast something is moving at a particular instant of time. We can't use our average velocity equation to find this, as Δt would be zero in this case, and dividing by zero doesn't work. So, what do we do? Well, Isaac Newton thought about this, and came up with a way to do it. Perhaps he thought something like "We can close in on an instantaneous rate of change by making the denominator smaller and smaller without actually letting it be zero. That is, if the denominator is infinitesimal (smaller than the smallest number we can imagine, but bigger than zero), than we can find the instantaneous rate of change."

In math, you have probably already studied limits, where you let something go to zero. That is what this is. If we simply let Δt "go to zero", then we can find instantaneous rates of change, such as velocity (rate of change of position) and acceleration (rate of change of velocity). In graphical terms, we are finding the slope of a line at a certain point, instead of between points. In case you haven't guessed yet, this is called the derivative. So, the instantaneous velocity is simply the derivative of position with respect to time, and instantaneous acceleration is the derivative of velocity with respect to time or the second derivative of position with respect to time. In equation form, it looks like this:

$$v(t) = \frac{dx}{dt}$$

$$a(t) = \frac{dv}{dt} = \frac{d^2x}{dt^2}$$

These equations simply mean that the velocity at a certain time *t* is equal to the derivative of position as a function of time with respect to time and that the acceleration at a certain time *t* is equal to the derivative of velocity as a function of time with respect to time or is equal to the second derivative of position as a function of time with respect to time.

Note that instantaneous velocity and acceleration do not have bars above the v or a, while average velocity and acceleration do.

How do we do a derivative? If you are unsure, please view a video on basic derivatives which is found here: https://www.youtube.com/watch?v=8gI5WU0l-y0 . Keep in mind that derivatives are just a way of determining the slope of a line (remember that lines are not necessarily straight lines) at a certain point.

We can also work backwards. If we know the acceleration of a particle we can find the velocity and displacement relationships by doing an anti-derivative or integral. This is the mathematical equivalent of finding the area under a line or curve between two points. Please view a video on basic integrals which can be found here: https://www.youtube.com/watch?v=QSzCnAAbOEk . These relationships are as follows:

$$v(t) = \int_{t_0}^{t_f} a\,dt$$

$$x(t) = \int_{t_0}^{t_f} v\,dt$$

The top equation simply means that the velocity at a certain time *t* is equal to the integral of acceleration with respect to time, between times t_0 and t_f. The bottom equation means that the position at a certain time *t* is equal to the integral of velocity with respect to time, between times t_0 and t_f. t_0 and t_f are the initial and final times and are called the limits of integration of these definite integrals. t_0 is pronounced "t-naught".

Okay, armed with this new information, and your knowledge of kinematics from last year, please do the following problems from Chapter 2 of the textbook, Motion in a Straight Line. Please keep in mind that in freefall problems $a = -g = -10\ m/s^2$. We never substitute $-10\ m/s^2$ for g and we use $-10\ m/s^2$ instead of $-9.81\ m/s^2$ for ease of calculation as we always want to keep our minds on basic concepts and not get bogged down in the numbers.

Answers to these problems are in a separate .pdf document on my eboard, so you can check your answers. If you have questions on any of these problems, please ask them on the first day of class. I will be checking your work on these on the first day of school, so please try your best to do them.

Problems:

3. An automobile travels on a straight road for 40 km at 30 km/h. It then continues in the same direction for another 40 km at 60 km/h. (a) What is the average velocity of the car during this 80 km trip? (Assume that it moves in the positive x direction.) (b) What is the average speed? (c) Graph x versus t and indicate how the average velocity in found on the graph.

7. The position of an object moving along an x axis is given by $x = 3t-4t^2+t^3$, where x is in meters and t in seconds. (a) What is the position of the object at $t = 1, 2, 3,$ and 4 s? (b) What is the object's displacement between $t= 0$ and $t = 4$s? (c) What is its average velocity for the time interval from $t = 2$ s to $t = 4$ s? (d) Graph x versus t for $0 \leq t \leq 4$ s and indicate how the answer for (c) can be found on the graph.

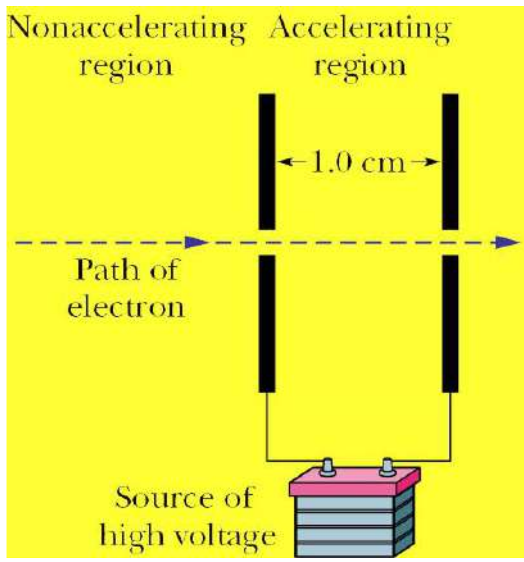
11. (a) If a particle's position is given by $x = 4 - 12t + 3t^2$ (where t is in seconds and x is in meters), what is its velocity at $t = 1$ s? (b) Is it moving in the positive or negative direction of x at this time? (c) What is its speed just then? (d) Is the speed larger or smaller at later times? (Try answering the next two questions without further calculation.) (e) Is there ever an instant when the velocity is zero? (f) Is there a time after $t = 3$ s when the particle is moving in the negative direction of x ?

19. A proton moves along the x axis according to the equation $x = 50t + 10t^2$. Units are as in above questions. Calculate (a) the average velocity of the proton during the first 3.0 s of its motion, (b) the instantaneous velocity of the proton at $t = 3.0$ s, and (c) the instantaneous acceleration of the proton at $t = 3.0$ s. (d) Graph x versus t and indicate how the answer to (a) can be obtained from the plot. (e) Indicate the answer to (b) on the graph. (f) Plot v versus t and indicate on it the answer to (c).

21. The position of a particle moving along the x axis depends on the time according to the equation $x = ct^2 - bt^3$, units are as in above questions. (a) What units must c and b have? Let their numerical values be 3.0 and 2.0, respectively. (b) At what time does the particle reach its

maximum x position? From t = 0.0 s to t = 4.0 s, (c) what distance does the particle move and (d) what is its displacement? At t = 1.0, 2.0, 3.0 and 4.0 s, what are (e) its velocities and (f) its accelerations?

29. An electron with initial velocity $v_0 = 1.50 \times 10^5$ m/s enters a region 1.0 cm long where it is electrically accelerated (see figure below). It emerges with velocity $v = 5.70 \times 10^6$ m/s. What is its acceleration, assumed constant? (Such a process occurs in CRT television sets, not flat screens.)



43. (a) With what speed must a ball be thrown vertically form ground level to rise to a maximum height of 50 m? (b) How long will it be in the air? (c) Sketch graphs of y, v, and a versus t for the ball. ON the first two graphs, indicate the time at which 50 m is reached.

49. A key falls from a bridge that is 45 m above the water. It falls directly into a model boat, moving with constant velocity, that is 12 m from the point of impact when the key is released. What is the speed of the boat?

57. Two diamonds begin a free fall from rest from the same height, 1.0 s apart. How long after the first diamond begins to fall will the two diamonds be 10 m apart?