Hi Everyone!

Welcome to AP Physics 1! Many students find AP Physics 1 to be a challenging, time-consuming course. AP classes are taught as college courses—not just ***college-level*** courses, but actual **college** courses. The course is for serious students and requires dedication, commitment to hard work, and a willingness to be challenged and pushed. This means that if you're having trouble with something, *you* need to be proactive about learning it, either by coming in for help or consulting with your classmates. Remember—*your* job is to succeed; *my* job is to do everything in my power to help you be successful. I will work very hard to prepare lessons and activities to help you be successful, and I expect you to work hard too.

This summer assignment should take several hours for you to complete, so please plan appropriately. I created it with the feedback of previous AP Physics 1 students right after they took the AP exam, so the information in this packet is information in which they felt would best prepare future AP Physics 1 students. There are several parts to the assignment, and ALL parts will be due the first day of class. It is quantity not the difficulty of the problems that has the potential to overwhelm, so do it over an extended period of time. By taking the time to review and understand all parts of this assignment, you will help yourself acclimate to the rigor and pacing of AP Physics 1. Use the book (see below for book information) if you need to, but really this is all stuff you already know how to do (basic math skills).

It is VERY important that this assignment be completed individually. It will be a total waste of your time to copy the assignment from a friend. If you have questions at any time, I will be available via email (ksumner@williamANDreed.com). Although my aim is to return all emails within 5 days, there may be times where I will have limited e-mail access so please be patient.

Please Note: This assignment is a requirement and is NOT for extra credit. It is due on the first day of class. Although you will be graded on completeness on this assignment, there WILL be a short test on this material during the first week of school. So while completing the assignment, determine how well you can demonstrate these skills; you may want to brush up on them prior to returning to school.

Good Luck and have a GREAT summer!!!

Mrs. Sumner

Additional resources:

Tentative textbook for this course: https://openstax.org/details/college-physics (This book is totally FREE and I recommend downloading the high resolution copy and saving it to your computer.)

You will also need to purchase 5 Steps to a 5: AP Physics 1: Algebra-Based **2023 (or 2024)**, Elite Student Edition 1st Edition by Greg Jacobs. You must buy this book by minimester! Last year's students said this book was VERY helpful and they wish they had bought it sooner!!! (Note that this amazon link is for the 2023 edition – either 2023 or 2024 edition is fine: https://www.amazon.com/Steps-Physics-Algebra-Based-Elite-Student/dp/1264498055/ref=sr_1_4?crid=H0U8OQ1K92NQ&keywords=5+steps+to+a+5+ap+physics+1&qid=1684256523&sprefix=5+steps+to+a+%2Caps%2C547&sr=8-4)

Helpful websites:

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

http://www.physicsclassroom.com/Class/vectors/

Professor Dave Explains YouTube channel

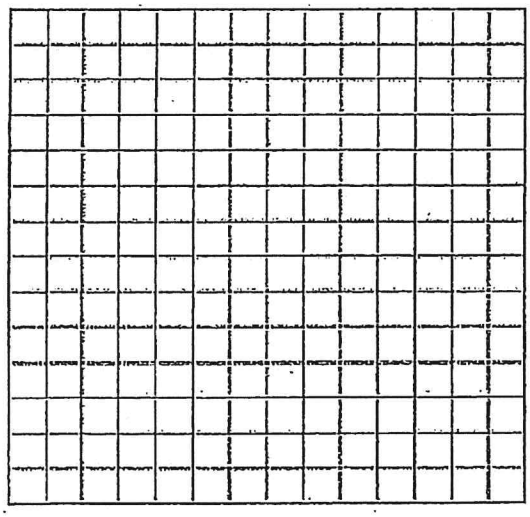
Graphing

You have been asked by your teacher to measure the diameter, radius and circumference of some round objects, such as tin cans, lids, CD's, coins, etc. You have collected the measurements and recorded them in the table below:

Radius (cm)	Circumference (cm)
1.1	3.5
3.2	10.0
4.8	15.1
8.8	27.5
9.6	29.9
12	37.6

13. You are to graph the data in the graph below. The radius is the independent variable here and the circumference is the dependent variable. What does this mean for how you graph the data?

14. Label the axis and with the name of the quantity, appropriate scaling of numbers and units. Then plot the points and draw the best straight line through as many points as possible, known as best-fit-curve (DO NOT JUST CONNECT THE DOTS!)



15. Find the slope of the graph. Does it have a name or a physical meaning?

16. Is the slope constant? How do you know this?

17. Does your graph have a y-intercept, if it does, what is it and does it have any significance?

18. Using the fact that the equation for a straight line is $y = mx + b$ write the specific equation for this graph using the appropriate variables.

Basic Geometry

In Physics we use many basic principles of geometry. We look at circles when dealing with rotation, at triangles when dealing with right-angle trigonometry and area under curves, at angular relationships when dealing with angular forces, refraction of light, etc. Below are some very basic geometric questions.

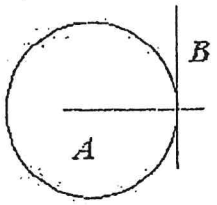
a. Line *B* touches the circle at a single point. Line *A* extends through the center of the circle.

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

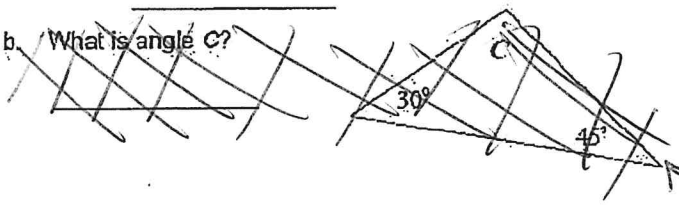
_____

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

_____



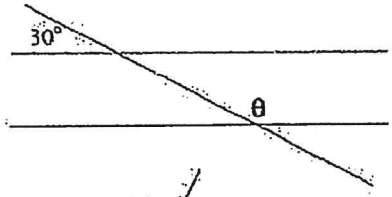
b. What is angle *C*?



not needed!

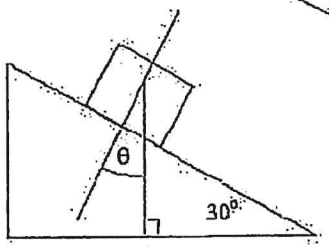
c. What is angle θ ?

_____



d. How large is *θ*?

_____



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

i. What is the circumference in meters?

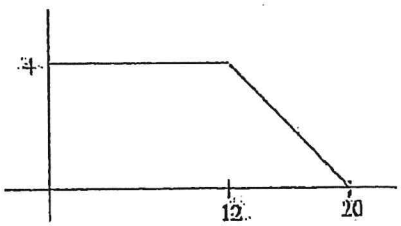
_____

ii. What is its area in square meters?

_____

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

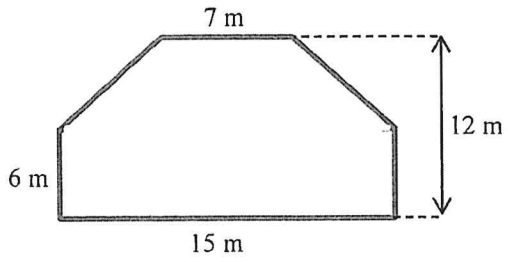
_____



Part 2: Geometry

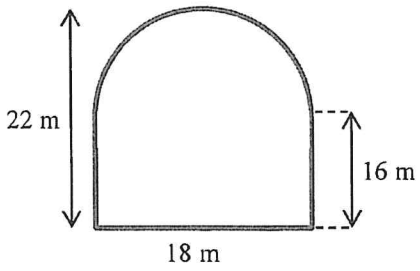
Calculate the area of the following shapes. It may be necessary to break up the figure into common shapes.

1.



Area = _____

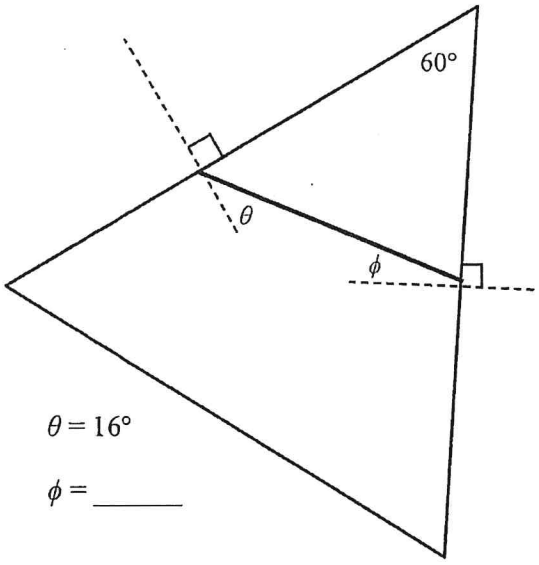
2.



Area = _____

Calculate the unknown angle values for questions 3-6.

3.

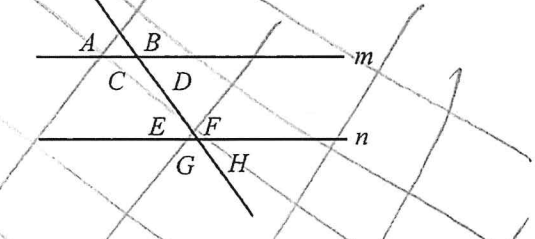


$\theta = 16°$

$\phi =$ _____

4.

not needed!

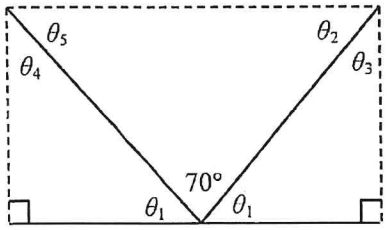


Lines m and n are parallel.

$A = 75°$ $B =$ _____ $C =$ _____ $D =$ _____

$E =$ _____ $F =$ _____ $G =$ _____ $H =$ _____

5.



$\theta_1 =$ _____

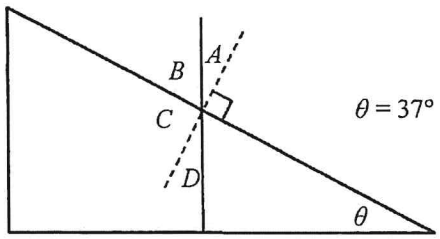
$\theta_2 =$ _____

$\theta_3 =$ _____

$\theta_4 =$ _____

$\theta_5 =$ _____

6.



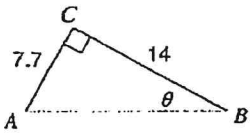
$A =$ _____ $B =$ _____

$C =$ _____ $D =$ _____

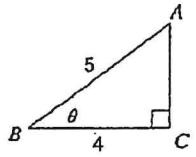
Right Triangles

Directions: Find the measure of the angle or side indicated. Please show all of your work.

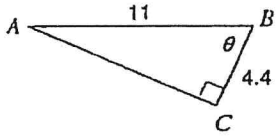
1) Find θ



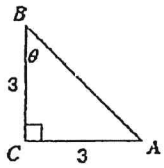
2) Find θ



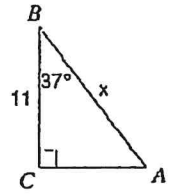
3) Find θ



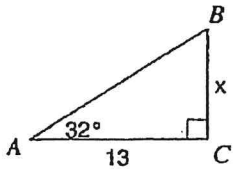
4) Find θ



5) Find x



6) Find x



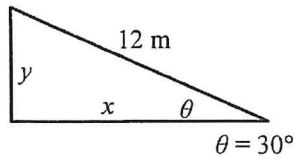
Part 4: Trigonometry – Assume all right triangles

Write the formulas for each one of the following trigonometric functions. Remember SOHCAHTOA!

$\sin\theta =$ $\cos\theta =$ $\tan\theta =$

Calculate the following unknowns using trigonometry. Use a calculator, but show all of your work. Please include appropriate units with all answers. (Watch the unit prefixes!)

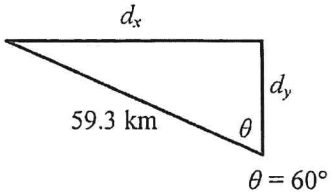
1.



$y =$ _____

$x =$ _____

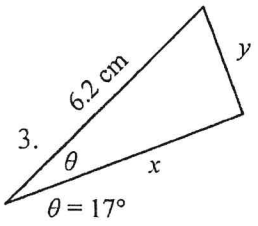
2.



$d_x =$ _____

$d_y =$ _____

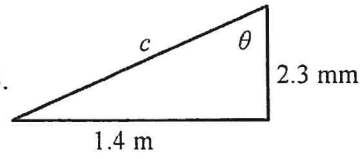
3.



$x =$ _____

$y =$ _____

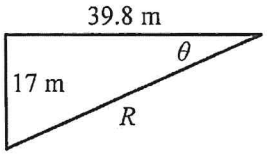
4.



$c =$ _____

$\theta =$ _____

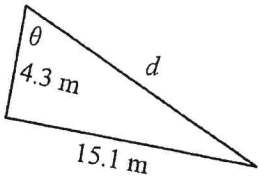
5.



$R =$ _____

$\theta =$ _____

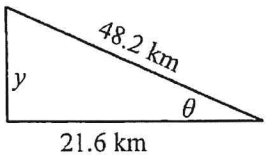
6.



$d =$ _____

$\theta =$ _____

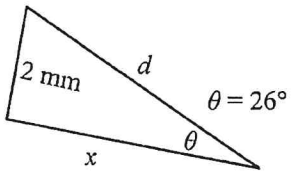
7.



$y =$ _____

$\theta =$ _____

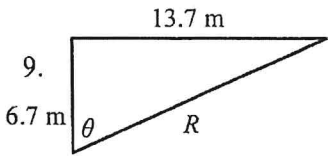
8.



$x =$ _____

$d =$ _____

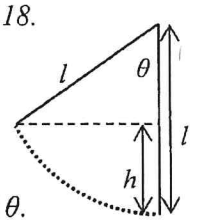
9.



$R =$ _____

$\theta =$ _____

Use the figure below to answer problems 17 and 18.



17. Find an expression for h in terms of l and θ.

18. What is the value of h if $l = 6$ m and $\theta = 40°$?

Part 5: Algebra ~only do the circled problems - the rest are extra practice

Solve the following (almost all of these are extremely **easy** – it is *important* for you to work *independently*). Units on the numbers are included because they are essential to the concepts, however they do not have any *effect* on the actual numbers you are putting into the equations. In other words, the units do not change how you do the algebra. Show every step for every problem, including writing the original equation, all algebraic manipulations, and substitution! You should practice doing all algebra *before* substituting numbers in for variables.

Section I: *For problems 1-5, use the three equations below:*

$$v_f = v_0 + at \qquad x_f = x_0 + v_0 t + \frac{1}{2}at^2 \qquad v_f^2 = v_0^2 + 2a(x_f - x_0)$$

1. Using equation (1) solve for t given that $v_0 = 5$ m/s, $v_f = 25$ m/s, and $a = 10$ m/s^2.

2. $a = 10$ m/s^2, $x_0 = 0$ m, $x_f = 120$ m, and $v_0 = 20$ m/s. Use the second equation to find t.

3. $v_f = -v_0$ and $a = 2$ m/s^2. Use the first equation to find $t/2$.

4. How does each equation simplify when $a = 0$ m/s^2 and $x_0 = 0$ m?

Section II: *For problems 6 – 11, use the four equations below.*

$$\Sigma F = ma \qquad f_s \leq \mu_s N$$
$$f_k = \mu_k N \qquad F_s = -kx$$

5. If $\Sigma F = 10$ N and $a = 1$ m/s^2, find m using the first equation.

6. Given $\Sigma F = f_k$, $m = 250$ kg, $\mu_k = 0.2$, and $N = 10m$, find a.

7. $\Sigma F = T - 10m$, but $a = 0$ m/s^2. Use the first equation to find m in terms of T.

8. Given the following values, determine if the third equation is valid. $\Sigma F = f_s$, $m = 90$ kg, and $a = 2$ m/s^2. Also, $\mu_s = 0.1$, and $N = 5$ N.

9. Use the first equation in Section I, the first equation in Section II and the givens below, find ΣF. $m = 12$ kg, $v_0 = 15$ m/s, $v_f = 5$ m/s, and $t = 12$ s.

10. Use the last equation to solve for F_s if $k = 900$ N/m and $x = 0.15$ m.

Section III: *For problems 12, 13, and 14 use the two equations below.*

$$a = \frac{v^2}{r} \qquad \tau = rF\sin\theta$$

11. Given that v is 5 m/s and r is 2 meters, find a.

12. Originally, $a = 12$ m/s^2, then r is doubled. Find the new value for a.

13. Use the second equation to find θ when $\tau = 4$ Nm, $r = 2$ m, and $F = 10$ N.

Section IV: *For problems 15 – 22, use the equations below.*

$$K = \frac{1}{2}mv^2 \qquad W = F(\Delta x)\cos\theta \qquad P = \frac{W}{t}$$

$$\Delta U_g = mgh \qquad U_s = \frac{1}{2}kx^2 \qquad P = Fv_{avg}\cos\theta$$

14. Use the first equation to solve for K if $m = 12$ kg and $v = 2$ m/s.

15. If $\Delta U_g = 10$ J, $m = 10$ kg, and $g = 9.8$ m/s^2, find h using the second equation.

16. $K = \Delta U_g$, $g = 9.8$ m/s^2, and $h = 10$ m. Find v.

17. The third equation can be used to find W if you know that F is 10 N, Δx is 12 m, and θ is 180°.

18. Given $U_s = 12$ joules, and $x = 0.5$ m, find k using the fourth equation.

19. For $P = 2100$ W, $F = 30$ N, and $\theta = 0°$, find v_{avg} using the last equation in this section.

Section V: *For problems 23 – 25, use the equations below.*

$$p = mv \qquad F\Delta t = \Delta p \qquad \Delta p = m\Delta v$$

20. p is 12 kgm/s and m is 25 kg. Find v using the first equation.

21. "Δ" means "final state minus initial state". So, Δv means $v_f - v_i$ and Δp means $p_f - p_i$. Find v_f using the third equation if $p_f = 50$ kgm/s, $m = 12$ kg, and v_i and p_i are both zero.

22. Use the second and third equation together to find v_i if $v_f = 0$ m/s, $m = 95$ kg, $F = 6000$ N, and $\Delta t = 0.2$ s.

Section VI: *For problems 26 – 28 use the three equations below.*

$$T_s = 2\pi\sqrt{\frac{m}{k}} \qquad T_p = 2\pi\sqrt{\frac{l}{g}} \qquad T = \frac{1}{f}$$

23. T_p is 1 second and g is 9.8 m/s^2. Find l using the second equation.

24. $m = 8$ kg and $T_s = 0.75$ s. Solve for k.

25. Given that $T_p = T$, $g = 9.8$ m/s^2, and that $l = 2$ m, find f (the units for f are Hertz).

Section VII: For problems 29 – 32, use the equations below.

$$F_g = -\frac{GMm}{r^2} \qquad U_g = -\frac{GMm}{r}$$

26. Find F_g if $G = 6.67 \times 10^{-11}$ m^3 kg^{-1} s^{-2}, $M = 2.6 \times 10^{23}$ kg, $m = 1200$ kg, and $r = 2000$ m.

27. What is r if $U_g = -7200$ J, $G = 6.67 \times 10^{-11}$ m^3 kg^{-1} s^{-2}, $M = 2.6 \times 10^{23}$ kg, and $m = 1200$ kg?

28. Use the first equation in Section IV for this problem. $K = -U_g$, $G = 6.67 \times 10^{-11}$ m^3 kg^{-1} s^{-2}, and $M = 3.2 \times 10^{23}$ kg. Find v in terms of r.

29. Using the first equation above, describe how F_g changes if r doubles.

SOLVING EQUATIONS

Often problems on the AP exam are done with variables only. Below are various physics formulas. Don't worry about what the variables mean for now; we will learn that later. Just solve for the variable indicated. Don't let the different letters confuse you. Manipulate them algebraically as though they were numbers. Remember, there is a video tutorial on the website if you need some help.

Directions: Use algebra to solve for the indicated variable. Please show all work.

43. $\Delta V = IR$, solve for I

44. $v_f = v_o + at$, solve for a

45. $mgh = \frac{1}{2} mv^2$, solve for v

46. $\Delta x = v_o t$, solve for t

47. $v_f^2 = v_o^2 + 2a(x_f - x_0)$, solve for a

48. $T = 2\pi\sqrt{\frac{l}{g}}$ solve for g

49. $U_s = \frac{1}{2} kx^2$, solve for x

a. $v^2 = v_o^2 + 2a(s - s_o)$ $a =$ _____

b. $K = \frac{1}{2}kx^2$ $x =$ _____

c. $T_p = 2\pi\sqrt{\frac{\ell}{g}}$ $g =$ _____

d. $F_g = G\frac{m_1 m_2}{r^2}$ $r =$ _____

e. $mgh = \frac{1}{2}mv^2$ $v =$ _____

f. $x = x_o + v_o t + \frac{1}{2}at^2$ $t =$ _____

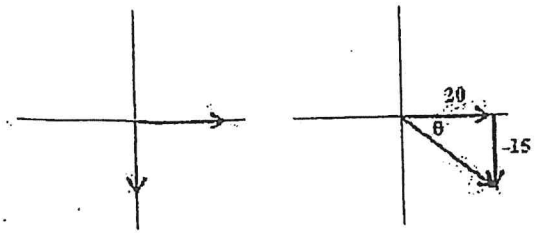
Algebraic Relationships

Consider the following: $z = x/y$ $c = ab$ $l = m\sqrt{n}$ $r = s^2/t^2$

33. As *x* increases and *y* stays constant, *z* _____.
34. As *y* increases and *x* stays constant, *z* _____.
35. As *x* increases and *z* stays constant, *y* _____.
36. As *a* increases and *c* stays constant, *b* _____.
37. As *c* increases and *b* stays constant, *a* _____.
38. As *b* increases and *a* stays constant, *c* _____.
39. As *n* increases and *m* stays constant, *l* _____.
40. As *l* increases and *n* stays constant, *m* _____.
41. If *s* is tripled and *t* stays constant, *r* is multiplied by _____.
42. If *t* is doubled and *s* stays constant, *r* is multiplied by _____.

4. 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: $x = 20,\ y = -15$



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

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

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

$R = 25$ $\qquad \theta = \tan^{-1}\left(\frac{-15}{20}\right) \approx -36.9°$

$360° - 36.9° = 323.1°$

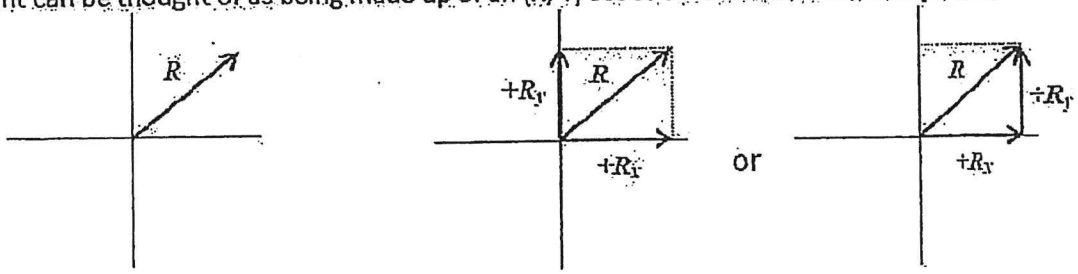
a. $x = 600,\ y = 400$

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

d. $x = 0.0065,\ y = -0.0080$

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

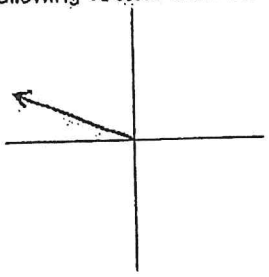
Component Vectors: A resultant vector is mathematically made up of the sum of the component vectors of all of the vectors that make the resultant. Each individual vector, including the resultant can be thought of as being made up of an (X, Y) set of vectors called the components.



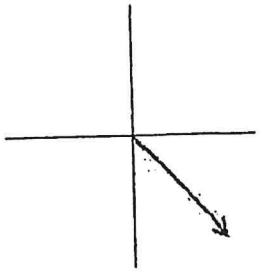
Any vector can be represented by its components, just remember that the sign shows the direction of each of the components.

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

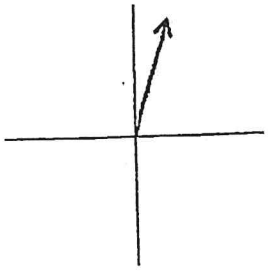
a.



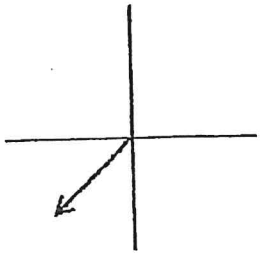
c.



b.



d.



These questions are designed to see how you think, if you can do the algebra necessary for AP Physics 1, and if you can learn carefully selected concepts independently since you will be expected to complete assignments during breaks throughout the year. Although we go over these assignments when you return from breaks, you will be expected to have watched the assigned videos, gone over any shared PowerPoints, and attempted the assigned problems during the break as these topics will NOT be taught "from scratch" in class.

Please do not be overly focused on getting the "right" answer to these questions. Understand that while you should try your best on them, just making your best attempt at these questions and the perseverance of honestly attempting all the questions in this packet can be the best indicator of your success in AP Physics 1.

Question 1: Experimental Design

As objects move, they have kinetic energy. This energy can be calculated with the following formula:

$$KE = \frac{1}{2} mv^2$$

where m is the mass of the object and v is its velocity. If an object collides with another object and the total kinetic energy of the objects is the same before and after the collision, then the collision is called an ELASTIC collision. If the total kinetic energy is not the same before and after the collision (ie. energy lost to heat, friction, deformations, etc.) then the collision is known as an INELASTIC collision.

A new toy ball has been introduced and advertises to have a prefect elastic bounce off hard surfaces such as walls and floors. A student hypothesizes that the collision with the ball and the hard surface is very close to being perfectly elastic at low-speed collisions, but gradually changes to a clearly inelastic collision at high-speed collisions. How would the student test his hypothesis?

(a) What quantities would be measured?

(b) Select the lab equipment that should be used from the following list:

_____ Meterstick	_____ Stopwatch	_____ Balance
_____ High speed video capture	_____ String	_____ Mass Set
_____ Force Sensor/Spring scale	_____ Pulley	_____ Cart and track system

(c) How would this equipment be used (experimental setup)?

(d) Describe the procedure in enough detail that other students could replicate the experiment. (Feel free to use a separate piece of paper)

Question 2: Algebraic Derivations and Applications

a. The following formula is used frequently in AP Physics 1 for objects in flight (or falling).

$$x = x_o + v_o t + \tfrac{1}{2} a t^2$$

Where x is the current height of an object, x_0 is the object's initial height, v_0 is the object's initial velocity, t is the length of time the object has been in flight (or falling), and a is the object's acceleration (acceleration due to gravity for falling objects).

Solve this equation for time of flight (t) when the initial velocity is zero.

b. What would happen to the time of flight if the distance of the drop is doubled? Has the time of flight doubled, more than doubled, less than doubled? Explain briefly.

c. Bonus – This question is completely OPTIONAL!!!! This is a TOUGH Algebra derivation and more difficult than the college board will expect of you. But for those up for a challenge, here you go!

Derive the following formula $v^2 = v_o^2 + 2a(x-x_o)$ using the following formulas:

(1) $x = x_o + v_o t + \frac{1}{2} at^2$

(2) $v = v_o + at$

You must use these formulas (and only these formulas) and you must SHOW ALL STEPS!!!!!!

Question 3: Watch this video (and take notes) from Flipping Physics (a student favorite site for physics videos) on Simple Harmonic Motion (https://www.flippingphysics.com/simple-harmonic-motion.html). Then go to this Phet (https://phet.colorado.edu/en/simulation/masses-and-springs) and spend 10 minutes exploring this simulation.

1. Write down three things you either learned from the simulation or the simulation confirmed from the video.

2. Using these equations,

$$T_s = 2\pi\sqrt{\frac{m}{k}} \qquad \text{and} \qquad T = \frac{1}{f}$$

Where T_s = period (in seconds), m = mass of object (in kg), k = spring constant (ie. "stiffness"), and f = frequency (in Hertz (Hz) or sec^{-1})

predict what would happen

a. to the period if you doubled the mass

b. to the frequency if the spring constant is tripled

c. to the period if you halved the amplitude

Justify your answers with references to equations of Simple Harmonic Motion given above.

Comment on the article found below from 5 Steps to a 5: AP Physics B&C (this is an older edition of the book you will need to buy) as it may apply to you. Please be very thoughtful in your response. (1/2- to 1-page commentary on the reading, must be typed, 12 font, single-spaced, normal margins). Print and bring your commentary to class on the first day of school.

Seven Pieces of Advice for AP Physics Students (from 5 Steps to a 5)

Before we even dive into the nitty-gritty of the AP Physics exam, it is important for you to know that the AP exam is an *authentic* physics test. What this means is that it's not possible to "game" this test – in order to do well, *you must know your physics*.

The best way to start preparing for the exam is by doing careful, attentive work in class all year long. We think you can get even more out of your physics class than you think you can. Read these pieces of time-tested advice, follow them, and we promise you'll feel more comfortable about your class *and* the AP exam.

Ignore your grade.

This must be the most ridiculous statement you've ever read. But this may also be the most important of these suggestions. Never ask yourself or your teacher "Can I have more points on this assignment?" or "Is this going to be on the test?" You'll worry so much about giving the teacher merely what she wants that you won't learn physics in the way that's best for you. Whether your score is perfect or near zero, ask, "Did I really understand all aspects of these problems?"

Remember, the AP exam tests your physics knowledge. If you understand physics thoroughly, you will have no trouble at all on the AP exam. But, while you may be able to argue yourself a better grade in your physics *class*, even if your comprehension is poor, the AP readers are not so easily moved.

If you take my advice - if you really, truly ignore your grade and focus on physics - your grade will come out in the wash. You'll find that you got a very good grade after all, because you understood the subject so well. But you *won't care*, because you're not worried about your grade!

Don't bang your head against a brick wall.

Our meaning here is figurative, although of course, there are literal benefits also. Never spend more than 10 minutes or so staring at a problem without getting somewhere. If you honestly have no idea what to do at some stage of a problem, STOP. Put the problem away. Physics has a way of becoming clearer after you take a break.

On the same note, if you're stuck on some algebra, don't spend forever trying to find what you know is a trivial mistake, say a missing negative sign or some such thing. Put the problem away, come back in an hour, and start from scratch. This will save you time in the long run.

And finally, if you've put forth a real effort, you've come back to the problem many times and you still can't get it: relax. Ask the teacher for the solution, and allow yourself to be enlightened. You will not get a perfect score on every problem. But you don't care about your score, remember?

Work with other people.

When you put a difficult problem aside for a while, it always helps to discuss that problem with others. Form study groups. Have a buddy in class with whom you are consistently comparing solutions.

Although you may be able to do all your work in every other class without help, we have never met a student who is capable of solving every physics problem on his or her own. It is not shameful to ask for help. Nor is it dishonest to seek

assistance – as long as you're not copying or allowing a friend to carry you through the course. Group study is permitted and encouraged in virtually every physics class around the globe.

Ask questions when appropriate.

We know your physics teacher may seem mean or unapproachable, but in reality, physics teachers do want to help you understand their subject. If you don't understand something, don't be afraid to ask. Chances are that the rest of the class has the same question. If your question is too basic or requires too much class time to answer, the teacher will tell you so.

Sometimes the teacher will not answer you directly, but will give you a hint, something to think about so that you might guide yourself to your own answer. Don't interpret this as a refusal to answer your question. You must learn to think for yourself, and your teacher is helping you develop the analytical skills you need for success in physics.

Keep an even temper.

A football team should not give up because they allow an early field goal. Similarly, you should not get upset at poor performance on a test or problem set. No one expects you to be perfect. Learn from your mistakes, and move on – it's too long a school year to let a single physics assignment affect your emotional state.

On the same note, however, a football team should not celebrate victory because it scores a first-quarter touchdown. You might have done well on this test, but there's the rest of a nine-month course to go. Congratulate yourself, then concentrate on the next assignment.

Don't Cram.

Yes, we know that you got an "A" on your history final because, after you slept through class all semester, you studied for 15 straight hours the day before the test and learned everything. And, yes, we know you are willing to do the same thing this year for physics. We warn you, both from our and from others' experience: it won't work. Physics is not about memorization and regurgitation. Sure, there are some equations you need to memorize. But problem solving skills cannot be learned overnight.

Furthermore, physics is cumulative. The topics you discuss in December rely on the principles you learned in September. If you don't understand basic vector analysis and free-body diagrams how can you understand the relationship between an electric field (which is a vector quantity) and an electric force, or the multitude of other vector quantities that you will eventually study?

So, the answer is to keep up with the course. Spend some time on physics every night, even if that time is only a couple minutes, even if you have no assignment due the next day. Spread your "cram time" over the entire semester.

Never forget, physics is phun.

The purpose of all these problems, these equations, these exams, is to gain a knowledge about physics - a deeper understanding of how the natural world works. Don't be so caught up in the grind of your coursework that you fail to say "Wow!" occasionally. Some of the things you're learning are truly amazing. Physics gives insight into some of humankind's most critical discoveries, our most powerful inventions, and our most fundamental technologies. Enjoy yourself. You have an opportunity to emerge from your physics course with wonderful and useful knowledge, and unparalleled intellectual insight. Do it.