AP Physics Summer Assignment

Complete this before you show up for the first class in August. This assignment will be graded for accuracy, and there will be a test on the contents of this packet (mostly found in CH 1,2,3 but not all) in the first week of class.

**Follow Instructions!**

You should be reading the whole chapter, not just trying to complete the packet based on what you think you already know.

You are to do all work on the paper of the packet, unless instructed otherwise, so work in pencil.

You will need at least two sheets of graph paper. Write your name on them!

**For the entire year, unless told otherwise, you must show … ➔

1. Formula first,
2. Plug in numbers with units (lined up, so you can see what you are plugging in for what),
3. Show the Algebraic simplification process,
4. answer with Units and
5. a number of Significant Digits that matches the uncertainty of the given information.

These steps should be followed all year… whether or not they are specifically instructed on any given assignment

**You should begin early and email or call me if you have any questions.**

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You should be reading the whole chapter, not just trying to complete this packet based on what you think you already know. The question often refers you to a specific section, but that assumes you have read the chapter first. Reviewing a section within the context of the whole chapter is much more useful than just looking at a section out of context. If you are confused about an instruction, etc. let me know as soon as you find it (i.e. Yes, contact me during the summer).

Read Chapter 1 and answer the following questions. Follow Instructions.
In addition to the info in these questions, you will also need to:
  o Be able to use the bold faced metric prefix info in Table 1-2
  o Be familiar with the present day definitions of each of the three base units (there are two for mass)

1. Review the very first Sample Problem (p.4) about OOM (order of magnitude), then estimate the OOM of how many grains of sand would fit in a gallon milk jug. Note: This assignment is meant to provide enough space for you to show your work right on the sheet. Note: you are estimating the order of magnitude of the answer, not calculating the answer itself.
   Assumptions:  
   Calculations:

2. A number with an order of magnitude of 15 is divided by a number with an order of magnitude of 3.
   What is the order of magnitude of the answer? ___________________

3. (THIS QUESTION IS INTERESTING, BUT OPTIONAL) Review the second Sample Problem, in which they discuss the answer to the question, “How can a building sink into the ground. “
   A) State the formula for the Void Ratio.
   B) List each variable symbol from the formula and state what it stands for.
   C) If this ratio is > 0.80, what is the term for what can happen to the soil? ___________________

4. Review 1-4. Using the method of chain-link conversions (learned last year), determine the distance in gigameters (Gm) between Earth and the orb that used to be a planet. HAVE YOU BEEN READING and FOLLOWING INSTRUCTIONS??!!??! …just checking. Here are some more. 😊
   • Note: You are some of the strongest math students in the school. I know that you can do things in your heads that other students struggle with. I also know that, because of this, you tend to do too much in your heads. Show your work! Make me proud! Don't fail. 😊
   • Hint: The distance in meters is listed in Table 1-3 (in Section 1-5).
   • Note 1: As shown, you should ALWAYS use horizontal lines in fractions and fractional units… NOT slanted lines.
   • Note 2: You could do a lot of individual conversions, but you should try to “link” together multiple conversions by multiplying by several conversion fractions at once.
5. A) Using the same method, do Ch 1 Problem #41. Note the difference between the Conceptual Questions that do not require calculating and the Problems that always involve calculations. Also note that the answers to all odd problems are provided in the back of your textbook.

B) A large fish tank is 1.0m by 2.0m by 0.8m. How many m$^3$ of water are needed to fill it to the brim?

C) Convert your answer to cm$^3$. Show your work, using the method discussed above. Make sure the units cancel correctly… Note that meters do not cancel m$^3$. The correct answer is 1600000cm$^3$.

D) What is the order of magnitude of the tank’s volume in cm$^3$? _______________

E) In one fell swoop, convert your answer to Liters and then gallons.

1.000 L = 1000mL  1.000 US gallon = 3.785 liters  1mL = 1cm$^3$

6. List the unit names and symbols for the three base units of Le Système International d'Unités?
Read Ch 2 and answer the following questions. Remember that you should be reading the whole chapter, not just trying to complete this packet based on what you think you already know.

In addition to the info in these questions, you will also need to:
- understand the relationships between the graphs in Sample Problem 2-2 (p.18) – Elevator Cab
- understand and show algebraically how Equation 2-9 is derived from 2-5 and 2-7, 2-8.

7. On average, a woodpecker’s head slows down to rest from 7.5 ms\(^{-1}\) in .75ms. Note: ms\(^{-1}\) is shorthand for “meters per second” and that the “m” in “ms” is the abbreviation for the metric prefix, “milli”, or \(10^{-3}\). How many g’s does a woodpecker experience when he pecks? That is to say, what is the ratio of the acceleration its head experiences to the acceleration due to gravity (g) at the surface of Earth?

8. Extra Credit (EC): Why do scientists believe that the woodpecker does not get a concussion every time he pecks?

9. Read Checkpoint 1 (in section 2-3). For each pair, draw scaled versions of each pair of vectors head-to-tail and then draw the vector that is their vector sum (from the tail of the first to the head of the second). This is very simple… like arrows above a number line. Do not just add mathematically. Draw Them head to tail! If you do not recall how to do this from math class, you can search the internet for “adding vectors graphically”, or wait until you have read Ch3 of your textbook, but these are very simple examples.

a) b) c)

10. Remember, Formula First, etc… A track is two 100m straightaways connected by two 100m curves. Draw this. Calculate the average speed and average velocity of a runner who runs the 200.0 meter dash (1 straightaway and one curve) in 25.0 seconds. The perpendicular distance between the two straightaways is 70.0m. Remember that velocity is a vector and therefore has both magnitude and direction. If you think they have the same magnitude, you are incorrect.

Note: The Graph Paper you will need for this assignment is provided as the last few pages of this section of the assignment.

11. At time t (in seconds), a particle’s distance (inches) from the x axis varies as described by \(x = 15\sin(0.2t)\)

Graph Position vs. Time. Range \([0 \leq t \leq 12]\). Set the scale so that the graph will take up most of the page.

Time should be on the horizontal axis and the horizontal axis should be aligned with the longer side of the paper. You will only need positive values of position (y-axis). USE RADIAN MODE.

A) In pencil, lightly draw the line connecting the points representing \(t=4\) and \(t=10\). Label it “\(t = 4\) to \(t=10\)”.

B) The slope of a line \(\frac{y_2 - y_1}{x_2 - x_1} = \frac{\Delta y}{\Delta x}\), which is this case \(\frac{\Delta x}{\Delta t}\) = _____________

C) Repeat steps A and B for the pair of points when \(t=4\) and \(t=8\). Label accordingly.

D) Repeat steps A and B for the pair of points when \(t=4\) and \(t=6\). Label accordingly.

E) Repeat steps A and B for the pair of points when \(t=4\) and \(t=5\). Label accordingly.

F) Repeat steps A and B for the pair of points when \(t=4\) and \(t=4.5\). Label accordingly.

G) Summarize your calculations in the table to the right.

<table>
<thead>
<tr>
<th>Time Interval (sec)</th>
<th>Slope (in/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(4)(\rightarrow)(10)</td>
<td>(10)</td>
</tr>
<tr>
<td>(4)(\rightarrow)(8)</td>
<td>(8)</td>
</tr>
<tr>
<td>(4)(\rightarrow)(6)</td>
<td>(6)</td>
</tr>
<tr>
<td>(4)(\rightarrow)(5)</td>
<td>(5)</td>
</tr>
<tr>
<td>(4)(\rightarrow)(4.5)</td>
<td>(4.5)</td>
</tr>
</tbody>
</table>

12. When you calculated the slopes, you were finding the average velocities. What happened as the time interval got shorter? What would have happened if you had continued, using shorter and shorter time intervals (ie. \(4\)\(\rightarrow\)\(4.5\) or \(4\)\(\rightarrow\)\(4.1\) or \(4\)\(\rightarrow\)\(4.0001\))?
13. You have graphically been finding the Limit of \( \frac{\Delta x}{\Delta t} \) at \( t=4 \), as \( \Delta t \) approaches zero. This represents the slope of the curve at \( t=4 \), or the instantaneous ________________ or in other words, the instantaneous Rate of Change of Displacement per unit time.

14. What is the mathematical symbol abbreviation for writing “the Limit of \( \frac{\Delta x}{\Delta t} \) as \( \Delta t \) approaches zero”? ______________

15. In Calculus, the Rate of Change (slope of the tangent line) of a function is called its Derivative. Thus, since the Instantaneous Velocity (rate of change of displacement per unit time) is the slope of the Displacement vs. Time graph, we say that Velocity is the derivative of Displacement with respect to Time. Similarly, Instantaneous Acceleration is slope of the ________________ vs time curve and so Acceleration is the derivative of ________________ with respect to ________________.

16. Note: \( dt \) is an infinitesimally small (very small) time interval, often called a differential. The differential \( dx \) is the very small displacement that occurs during the differential \( dt \).

Remember, Formula First, etc…

17. How far would a car travel in 5.0 seconds at 14 m/s? 18. How far would a car travel in 5.0 seconds at 8.0 m/s?

Look at table 2-1 in section 2-7. Equations 2-15 and 2-18 are very similar. Consider a car with a velocity of 14 m/s that just spent 5.0 seconds speeding up from 8.0 m/s. Its acceleration must have been \([14-8] \text{ m/s}^2 \) / 5 sec = 1.2 m/s².

19. Use Equation 2-15 to find the car’s displacement during the 5 second time interval.

20. Use Equation 2-18 to find the car’s displacement during the 5 second time interval.

21. In the previous two questions, you calculated how far the car would travel at constant speed. Use this info to explain how the different equations 2-15 and 2-18 give the same displacement.

22. Read the Comment at the very end of section 2-7. In the beginning of the year you will need lots of Physics ________________, but your goal should be Physics Confidence as the result of solving lots of problems.

Consider a rocket traveling at a constant velocity of 450 m/s. Remember: Formula first, etc…

23. Calculate how far the rocket traveled between \( t=0.0 \) and \( t=2.0 \) seconds.

24. Calculate how far the rocket traveled between \( t=3.0 \) and \( t=6.0 \) seconds.
25. Calculate how far the rocket traveled between \( t=7.0 \) and \( t=7.1 \) seconds.

26. On the second sheet of plain graph paper, plot Velocity of the Rocket vs Time. The graph should take up the whole page. Velocity should be on the vertical axis [scale: 0 to 600m/s] and time should be on the horizontal axis (along the longer side of the paper) \([0 \leq t \leq 9]\). Connect the dots.

27. Lightly shade the area below the velocity graph (usually called the velocity “curve”, although it is straight in this simple, constant velocity scenario) for the interval \([0 \leq t \leq 2]\). Recall that \( \text{area}_{\text{rectangle}} = v \Delta t \).
Calculate the area beneath the velocity curve for the interval \([0 \leq t \leq 2]\).

28. With a different pattern, lightly shade the area below the velocity curve for the interval \([3 \leq t \leq 6]\).
Calculate the area beneath the velocity curve for the interval \([3 \leq t \leq 6]\).

29. With a third pattern, lightly shade the area below the velocity curve for the interval \([7 \leq t \leq 7.1]\). Calculate the area beneath the velocity curve for the interval \([7 \leq t \leq 7.1]\). Note that when \( \Delta t \) is very small, there is still an area to calculate. It is just an extremely narrow rectangle.

30. Label the base of each rectangle as \( \Delta t \) and each height as \( v \), with appropriate subscripts for each time interval.

31. Recall: Velocity is the Derivative of Displacement with respect to time, since the slope of our Displacement Vs. Time graph was the object’s velocity. That is to say, the derivative with respect to time (the limit \( \lim_{t \to 0} \) of the slope) of the displacement is the object’s instantaneous velocity. \( v = \frac{dx}{dt} \).
Now, we want to reverse that derivative process. We have information about the velocity and we want to work backwards to get information about the displacement. Effectively, we want to do the derivative process in reverse. We say that taking the “Anti-Derivative” of the velocity gives us the displacement. We are given the velocity (how quickly displacement is changing) at various times and we use that info to determine how far the object travels.

32. Compare your answers for #23,24,25 to your answers for #27,28,29. The Displacement (\( \Delta x \)) of an object during a particular time interval is equal to the area under the corresponding part of the ________________ vs. time curve. The height of the rectangle is the object’s velocity, and its width is \( \Delta t \). Each area was a displacement: \( (v \times \Delta t) \)

33. From the derivative concept, \( v = \frac{dx}{dt} \), it follows that \( dx = v \ dt \). Notice the similarity with Distance = Rate \times Time, and more importantly, with the kinematics equation, \( \Delta x = v_{\text{avg}} \Delta t \). The relationship is the same. The only difference is that \( dx \) and \( dt \) are differentials: ________________ small \( \Delta x \)’s and \( \Delta t \)’s that are associated with a limit as \( \Delta t \) approaches ________________. During an infinitesimally small \( \Delta t \), the area of the rectangle under the velocity curve would be \( dx = v \ dt \).

34. The process of finding an object’s displacement by finding the area under the velocity vs time curve is called “taking the integral” of velocity with respect to time. This integral is also known as the anti-derivative of velocity with respect to time. The power of the process is that we can use it for situations when the velocity is not constant. If \( v \) is not constant, the rectangles are not really rectangular at the top. But if we slice the area into a bunch of really narrow rectangles (use \( dt \)’s instead of just using \( \Delta t \)’s), and add up the areas, the error in area caused by the slants at the top approaches zero as the \( \Delta t \)’s become \( dt \)’s (approach zero).

35. The symbol \( \int \) represents a sum of many very thin rectangular areas. Become familiar with the symbology for this on pp.24/27.
Displacement is the Integral of Velocity with respect to time. \( \Delta x = \int dx = \int v \ dt \)
\( \Delta x \) (the overall change in position) = \( \int dx \) (the sum of many infinitesimally short \( dx \)’s)
Each \( dx = v \ dt \), so the \( \int dx = \int v \ dt \) (the sum of the areas of all the narrow rectangles).
Similarly, Acceleration is the Integral of Velocity with respect to time (the area under the \( a \) vs. \( t \) graph). \( \Delta v = \int dv = \int a \ dt \)
36. A) Until \( t = 2.0 \), an object’s velocity is a constant \( 3.0 \text{m/s} \). It then accelerates for \( 4.0 \text{ seconds} \) at a constant \( 1.25 \text{m/s}^2 \). On the special sheet of graph paper - with 2 sets of pre-labeled axes, graph Velocity vs Time and Acceleration vs. Time. Lightly shade the appropriate rectangle and calculate its area to verify that this fancy new Integral thing is consistent with the kinematics equations. That is to say, that between \( t = 2 \) and \( t = 6 \) (\( \Delta t = 4 \text{ seconds} \)), the object’s change in velocity will be \( \Delta v = v_f - v_o = a\Delta t = 1.25 \text{m/s}^2 \times 4 \text{sec} = 5.0 \text{m/s} \). Thus, we have proved that \( \Delta v = \int dv = \int a \ dt \ldots \) the area under the acceleration vs time curve.

B) Repeat a similar process on the third sheet of plain graph paper. Just one graph this time, not two.
1. For the interval \( [0 \leq x \leq 60 \text{cm}] \). Graph the force exerted the stretch a spring vs its displacement (displacement on the x-axis). \( k = 200 \text{ N/m} \)
2. Using the area relationship, lightly shade the appropriate area under the curve and determine the work done on the spring in stretching it from \( 0 \) to \( 25 \text{cm} \).
3. Verify your findings using the formula for the elastic potential energy stored in a spring, \( \text{PE} = \frac{1}{2}kx^2 \).
4. With a different pattern, lightly shade the area that corresponds to stretching the spring from \( 0 \) to \( 50 \text{cm} \). Does doubling the distance stretched cause the amount of energy stored in the spring to also double?

37. Hang on… ☺️ Calculus and Physics are BFF’s.
   Their relationship is Deeper than the Marianas Trench…
   Wider than the known universe…
   More powerful than Superman and Dr. Charles Francis Xavier, combined.

**This next section is a Vital summary of the entire year.**
**Embrace it, Learn it, Repeat it often… SLOPE…. AREA….!**

Almost everything we discuss this year will involve either:

- A SLOPE relationship, aka a Derivative, such as:
  - \( v(t) = \frac{dx}{dt} \) - velocity as a function of time is the slope of the position vs time graph)
  - \( F(t) = \frac{dW}{dt} = \frac{dE}{dt} \) - Force as a function of time is the slope of the Work or Energy vs. time graph, or
  - similarly, \( dx = v(t)dt \), or \( dW = F(t) \ dt \)

- Or an AREA relationship, aka an integral, such as:
  - \( \Delta x \frac{dx}{dt} = \int v(t) \ dt \)
    - “an object’s change in position is the integral of velocity with respect to time”, or
    - “an object’s change in position is the area under the velocity vs. time graph”
  - \( \text{Work} = \Delta E = \int F(t) \ dt \)
    - “the work done on an object or the change in an object’s energy is the integral of the force exerted on it with respect to time”, aka the area under the Force vs. time graph”.

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Read Ch 3 and answer the following questions. Remember that you should be reading the whole chapter, not just trying to complete this packet based on what you think you already know.

In addition to the info in these questions, you will also need to:
- be familiar with the vocabulary: scalar, displacement, resultant, resolving, unit vector
- understand dot and cross products well enough to do a problem if given equations 3-20 and 3-27

38. Read the Sample Problem in section 3-6 about the Vector Navigation or Path Integration that some ants use to make a quick trip home after random wandering to look for food. In the space below, draw a path of an ant searching for food and then its path home. Label Home. Draw a few small arrows along the path to represent some of the instantaneous displacement vectors that the ant is adding up in its head, such that it always knows its overall displacement from home and thus which way to go to get home.

39. Write a vector formula that represents the associative law of vector addition. _________________________________

40. Write a vector formula that represents the commutative law of vector addition. ________________________________

41. How are vector \( d \) and vector \(-d\) similar and different?

42. Describe a situation in which the magnitude of the displacement of an object equals the distance it traveled.

43. Describe a situation in which the magnitude of the displacement of an object does not equal the distance it traveled.

44. A hawk is flying at 110 miles/hour in a direction that points 20.0 degrees off of straight down. Sketch its velocity vector and its components. Prove that the horizontal and vertical components of the hawk’s velocity vector are 37.6 m/s horizontally and 103 m/s downward.

45. What is the velocity vector of a Tomahawk missile whose velocity components are 25 km/s West and 40 km/s North? Note: Vectors have magnitude and direction. You will need Pythagorean theorem as well as \( \tan^{-1} \) to find the answer. The answer should be expressed in terms similar to, “The missile’s velocity is 75 m/s in a direction 23 degrees South of West”.

46. Let’s say that the last step in a solution is to take the inverse sin of 0.8. Do it. \( \sin^{-1}(0.8) = \) ______ degrees.
   Your teacher tells you that that you have the correct number of significant figures, but your answer is wrong.
   You check your calculator and it is indeed in degree mode. The teacher says that the answer is 127 degrees. Within the Sample Problem in section 3-4, there are some valuable Problem Solving Tactics. Whenever the book lists such PST’s, they are usually very valuable. Discuss the tactic that helps you understand how to find the correct answer.

47. Answer the Checkpoint in Section 3-6.
48. A) At \( t = 3.0 \) seconds after it is released, a football is moving at 13m/sec in a direction 25 degrees below the +x axis. Sketch the vector and, using trigonometry, find the components of the football’s velocity vector.

B) Express this vector in Unit Vector (i j) form. Basically, you just put \( \hat{i} \), \( \hat{j} \) with little hats in front of the components and then write a + or – sign between them to show their direction and that you are “combining” them by vector addition. Sample Problems in sections 3-5 and 3-6 list vectors in this form. “i hat” is a vector of magnitude 1 in the direction of the x-axis… “j hat” is in the direction of the y-axis.

49. Read Sections 3-7 carefully – several times (it is short). Try to appreciate the power of what they are telling you.

50. Read Section 3-8. Use the following to summarize what you learn:
   • Formula for the Dot Product of two vectors:

   • Formula for the Cross Product of two vectors:

   • How are they different?

   • Summary of how to use the Right Hand Rule (RHR) to determine the direction of the cross product of two vectors: