

Summer Assignment

(Borrowed and revised from .northviewcounseling)

Fall 2016 – Spring 2017

- I. AP Physics 1 is a rigorous class that necessitates some skill from your math classes. This summer's 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 perhaps a means to assess whether you are correctly placed in Advanced Placement Physics.
- II. Physics and AP Physics in particular, require a proficiency in algebra, trigonometry, and geometry. In addition to the science concepts Physics often seems like a course in applied mathematics. 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 use them. Another key area in Physics is the understanding of vectors. This assignment is designed to teach and get some practice before we review the concepts in class ourselves.
- 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 read the text and instructions throughout.
- IV. **What is due the first day of school? (Date: _____)**

Read all of the information included in this document.

- A. Complete the math problems section
- B. Complete the very first physics problem section
- C. Please bring or print out the above assignments and do your work on the print-outs.

Frequency Asked Questions

- **What if I don't get all the problems or don't understand the instructions?**
 - *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*
- **I have a busy schedule this summer, or school is almost starting and I haven't begun this. How long should it take?**
 - *Given that you have completed Algebra II with a B or higher, most of the concepts in this should already be familiar with you. It would be reasonable to finish this assignment within 1.5-2 hours.*
- **Can I work on this with a friend who will also be in AP Physics?**
 - *Yes, but please remember to do your own work. This assignment isn't really about just finishing it, it's about getting practice with your mind and the types of mathematics we will be using. It will be nearly pointless to finish this if you don't think and struggle with these problems a little bit!*

Summer Work

Since physics is the study of relationships in nature, and these relationships are often expressed in the form of mathematical equations, we are requiring you to spend time this summer learning (memorizing) some equations and units to get started first semester. I suggest making note cards for each one.

Units:

Variable	Symbol	SI unit	Common name for measure
Mass	m	kg	-
Length/displacement	d, l, h, x, or y	m	-
Time	t	sec	-
Velocity	v	m/s	-
Acceleration	a	m/s/s	-
Force	F	kg·m/s ²	Newton (N)
Kinetic energy	K	kg·m ² /s ²	Joule (J)
Potential energy	U	kg·m ² /s ²	Joule (J)
Torque	τ	N·m	-
Work	W	N·m	Joule
Momentum	p	kg·m/s	-
Power	P	J/s	Watt (W)
Spring constant	k	N/m	-

Equations (Mechanics)

Prompt	Equation
Average velocity	$v = \frac{x_f - x_i}{\Delta t}$
Average acceleration	$a = \frac{v_t - v_0}{t}$
Kinematics equation (no x)	$v_f = v_i + at$
Kinematics equation (no a)	$\Delta x = \frac{1}{2}(v_i + v_0)t$
Kinematics equation (no t)	$2a\Delta x = v_t^2 - v_0^2$
Kinematics equation (no v _t)	$\Delta x = v_0 t + \frac{1}{2}at^2$
Newton's second law	$\sum F = ma$
Frictional force in terms of the normal force	$F_f = \mu F_N$
Torque	$\tau = F \cdot d$
Linear momentum	$p = mv$
Impulse (2 definitions)	$I = \Delta p = F \cdot \Delta t$
Kinetic energy	$K = \frac{1}{2}mv^2$
Potential energy due to gravity near Earth's surface	$U_g = mgh$
Work (2)	$W = Fd\cos\theta \quad \text{and} \quad W_{net} = KE_f - KE_i$
Mechanical Power (2)	$P = \frac{W}{\Delta t} \quad ; \quad P = F \cdot v$
Potential energy due to a spring	$U_s = \frac{1}{2}k(\Delta x)^2$
Law of gravity	$F_g = \frac{GM_1M_2}{r^2}$
Centripetal acceleration	$a_c = \frac{v^2}{r}$
Weight (near Earth's surface)	$F_g = mg$

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 2.00×10^2 , but 2.00×10^8 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. $T_s = 2\pi \sqrt{\frac{4.5 \times 10^{-2} \text{ kg}}{2.0 \times 10^3 \text{ kg/s}^2}} =$ 0.30 s (or $3.0 \times 10^{-1} \text{ s}$)

b. $K = \frac{1}{2} (6.6 \times 10^2 \text{ kg}) (2.11 \times 10^4 \text{ m/s})^2 =$ _____

c. $F = \left(9.0 \times 10^9 \frac{\text{N} \cdot \text{m}^2}{\text{C}^2} \right) \frac{(3.2 \times 10^{-9} \text{ C})(9.6 \times 10^{-9} \text{ C})}{(0.32 \text{ m})^2} =$ _____

d. $\frac{1}{R_p} = \frac{1}{4.5 \times 10^2 \Omega} + \frac{1}{9.4 \times 10^2 \Omega}$ $R_p =$ _____

e. $e = \frac{1.7 \times 10^3 \text{ J} - 3.3 \times 10^2 \text{ J}}{1.7 \times 10^3 \text{ J}} =$ _____

f. $1.33 \sin 25.0^\circ = 1.50 \sin \theta$ $\theta =$ _____

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

h. $\gamma = \frac{1}{\sqrt{1 - \frac{2.25 \times 10^8 \text{ m/s}}{3.00 \times 10^8 \text{ m/s}}}} =$ _____

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.

i. $v^2 = v_o^2 + 2a(s - s_o)$, $a = \frac{v^2 - v_o^2}{2(s - s_o)}$ o. $B = \frac{\mu_o I}{2\pi r}$, $r =$ _____

j. $K = \frac{1}{2} kx^2$, $x =$ _____ p. $x_m = \frac{m\lambda L}{d}$, $d =$ _____

k. $T_p = 2\pi \sqrt{\frac{\ell}{g}}$, $g =$ _____ q. $pV = nRT$, $T =$ _____

l. $F_g = G \frac{m_1 m_2}{r^2}$, $r =$ _____ r. $\sin \theta_c = \frac{n_1}{n_2}$, $\theta_c =$ _____

m. $mgh = \frac{1}{2} mv^2$, $v =$ _____ s. $qV = \frac{1}{2} mv^2$, $v =$ _____

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

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

kilometers (*km*) to meters (*m*) and meters to kilometers
 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*)

gram (*g*) to kilogram (*kg*)
 Celsius ($^{\circ}C$) to Kelvin (*K*)
 atmospheres (*atm*) to Pascals (*Pa*)
 liters (*L*) to cubic meters (m^3)

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 searching for "Metric conversions". Enjoy!

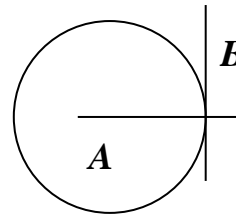
- | | | | | | |
|---------------------------|---|-------------------|-----------------------------|---|-------------|
| u. 4008 g | = | <u>4.008</u> kg | bb. 25.0 μm | = | _____ m |
| v. 1.2 km | = | _____ m | cc. 2.65 mm | = | _____ m |
| w. 823 nm | = | _____ m | dd. 8.23 m | = | _____ km |
| x. 298 K | = | _____ $^{\circ}C$ | ee. 5.4 L | = | _____ m^3 |
| y. 0.77 m | = | _____ cm | ff. 40.0 cm | = | _____ m |
| z. 8.8×10^{-8} m | = | _____ mm | gg. 6.23×10^{-7} m | = | _____ nm |
| aa. 1.2 atm | = | _____ Pa | hh. 1.5×10^{11} m | = | _____ km |

Solve the following geometric problems. Research "Geometry Angle Cheat Sheet" online for help.

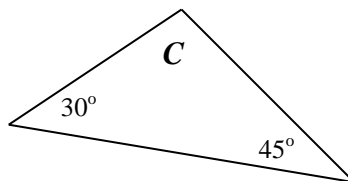
- a. Line **B** touches the circle at a single point. Line **A** extends through the center of the circle.
- i. What type of line is line **B** in reference to the circle?

B is a tangent line

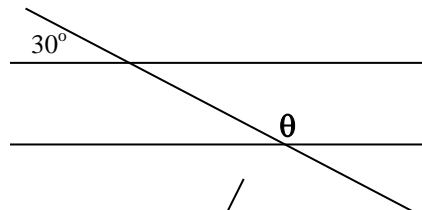
- ii. How large is the angle between lines **A** and **B**?



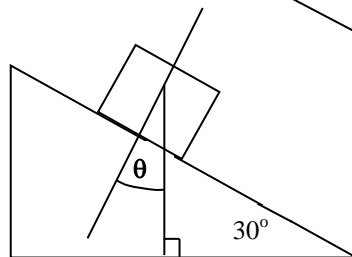
- b. What is angle **C**?



- c. What is angle θ ?



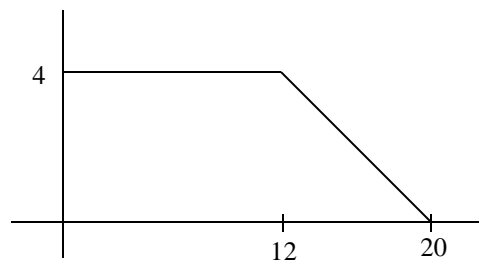
- d. How large is θ ?



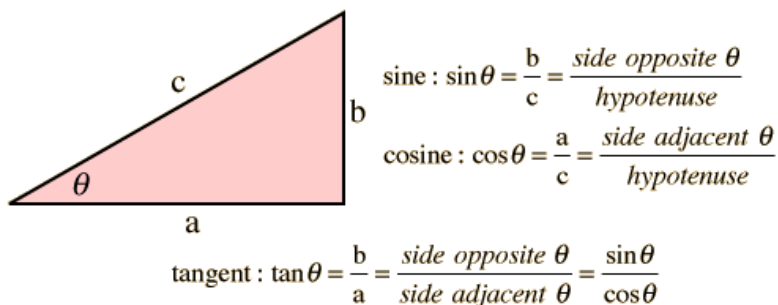
- e. The radius of a circle is 5.5 cm,
i. What is the circumference in meters?

- ii. What is its area in square meters?

- f. What is the area under the curve (function) at the right?



Using the generic triangle to the right, Right Triangle Trigonometry and the Pythagorean Theorem, solve the following. **Your calculator must be in degree mode.** Use the following strategy of SOH CAH TOA:



When solving for the angle θ , use the inverse sin, cos, (\sin^{-1} , \cos^{-1} , \tan^{-1})

- g. $\theta = 55^\circ$ and $c = 32$ m, solve for a and b .

- j. $a = 250$ m and $b = 180$ m, solve for θ and c .

ex. $c \cdot \sin(\theta) = b \rightarrow 32 \sin(55) = \boxed{26.2 \text{ m}}$

$c \cdot \cos(\theta) = a \rightarrow 32 \cos(55) = \boxed{18.4 \text{ m}}$

- h. $\theta = 45^\circ$ and $a = 15$ m/s, solve for b and c .

- k. _____
 $a = 25$ cm and $c = 32$ cm, solve for b and θ .

- i. _____
 $b = 17.8$ m and $\theta = 65^\circ$, solve for a and c .

- l. _____
 $b = 104$ cm and $c = 65$ cm, solve for a and θ .

Vectors

Many of the quantities in physics are vectors. **This makes proficiency in vectors extremely important.**

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 **magnitude only.**

Examples: time, mass, and temperature

Vector: A physical quantity with **both a magnitude and a direction.** A directional quantity.

Examples: velocity, acceleration, force

Notation: \vec{A} or \vec{A}

Length of the arrow is proportional to the vectors magnitude.

Direction the arrow points is the direction of the vector.

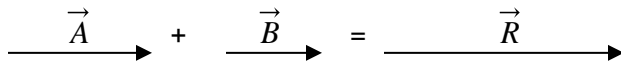
Negative Vectors

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



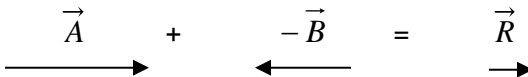
Vector Addition and subtraction

Think of it as vector addition only. The result of adding vectors is called the resultant. \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.

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


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.

This is very important. 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 that will be discussed in our 2-dimensional kinematics unit.

How are vectors used in Physics?

They are used everywhere!

Speed

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

$v_s = 10 \text{ m/s}$ 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.

$v = 10 \text{ m/s}$ north, or $v = 10 \text{ m/s}$ 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 your 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?

Answer before you keep reading.

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.

Rate

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 the numerical (magnitude) part of velocity. Velocity only differs from speed in that it specifies a direction.

$$v = \frac{\Delta x}{\Delta t} \quad v \text{ stands for velocity; } \Delta x \text{ stands for displacement (change in position); } \Delta t \text{ stands for time}$$

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? Suppose 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 from the origin at the end of the problem. $+20 - 10 = 10$ meter.

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

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

On the all tests, and assignments, including the AP exam (Tuesday, May 2, 2017) you must:

- 1. List the original equation used.**
- 2. List known and unknown information and verify unit agreement.**
- 3. Show correct substitution.**
- 4. Arrive at the correct answer with correct units.**

Distance and displacement are measured in meters (m)

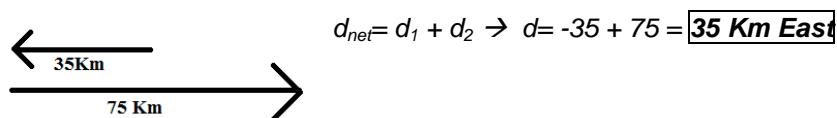
Speed and velocity are measured in meters per second (m/s)

Time is measured in seconds (s)

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

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

- 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?