PHYSICS DIAGNOSTIC SUMMER PACKET

For High School Physics: Algebra/Trigonometry-Based for SY 2020-2021

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This ‘summer packet’ is a diagnostic tool to measure student preparation for a high school course in Algebra/Trigonometry-based Physics. It is NOT for AP Physics or any Calculus-based high school Physics course. Students taking this course have already met the pre-requisites set by PGCPS.

Most of the material covered in a course of Physics you are NOT expected to know yet. The concepts will be taught in a series of units built into the PGCPS curriculum following NGSS and MD State Standards. You should already have a grasp of the arithmetic operations used in Algebra 1, Algebra 2, Geometry, and Trigonometry. Students should have met the pre-requisites of grades of A and high B in math up to and including Algebra 2. The basics of Trigonometry are Geometry (triangles, angle measure, etc.) will also be needed. Calculus is NOT needed for this course.*

The following pages contain information and a few example problems utilizing some of the more basic arithmetic operations we will be using in our course. Do not worry about understanding the analytic and conceptual aspects yet. That will come in time with course instruction.

Turn in your “Summer Diagnostic” packet during your first Physics class. Do not stress yourself over being right or wrong. We will make corrections as the course progresses through the school year.

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*Knowing some Calculus will certainly be helpful with the arithmetic problem solving, but not necessary for grasping the concepts of Physics. We will NOT be using Calculus in this course; however, I will point out the Calculus ‘version’ of problem solving from time to time for the benefits of students who have had Calculus. In short, knowing Calculus makes the math ‘faster’, but Algebra and Trigonometry makes learning what Physics IS and how it is quantified easier.

Systeme Internationale Units (S.I. Units)

Based on the Metric System used throughout much of the world, S.I. Units were adopted as the scientific standard by which scientists across multiple fields speaking many different languages and dialects from many countries worldwide can quantify and communicate their findings and data (evidence and results) to each other. Briefly, mathematics is the 'universal language' of science, and S.I. Units are the common words understood by all scientists and researchers globally. It is important to know them.

To the best of your ability, select the following correct answers below.

The standard S.I. Unit for the measurement of length is

a) meter
b) kilometer
c) liter

The standard S.I. Unit for brightness is

a) luminescence
b) candela
c) wattage

The standard S.I. Unit for power is

a) Joule
b) Horsepower
c) Watt

The standard S.I. Unit for force is

a) Newton
b) Horsepower
c) Joule

Particularly in America, the use of the Old English System for measurements has caused some confusion for students learning Physics. In order to intuitively grasp equivalent quantities, students begin Physics study by learning how to do conversions – a simple math skill that must become 'second nature' for accuracy.

Once the conversion skill is mastered, and it must be mastered, other more advanced and analytic skills such as Dimensional Analysis – a useful tool for making preliminary checks for correct answers – can begin.

Example: Convert 5 inches to centimeters.

Answer: There are 2.54 centimeters for every inch. Therefore, $\frac{2.54 \text{ cm}}{1.00 \text{ in}}$ Convert

$$\frac{2.54 \text{ cm}}{1.00 \text{ in}} \times 5 \text{ in} = 12.7 \text{ cm}$$ or approximately 0.13 meters.

the following:

3 cm to inches.

12 ounces to Liters (using 1 Liter = 33.8 ounces).

Density in S.I. Units from 2 pounds per cubic gallon to kilograms per cubic liter. (This one is significantly harder, so don't be discouraged if you have trouble with it! You will be able to do it by test time with ease.)

Trigonometric Identities

In Geometry, Trigonometry, and Pre-Calculus you learn a mnemonic device called "SOH-CAH-TOA". It is a useful memory aid for solving triangles. Other things you learn are: that the angles of a triangle add to 180 degrees; a circle is 360 degrees; a Cartesian coordinate system has 4 *quad*rants. Many of these will be used in Physics.

What does SOH-CAH-TOA stand

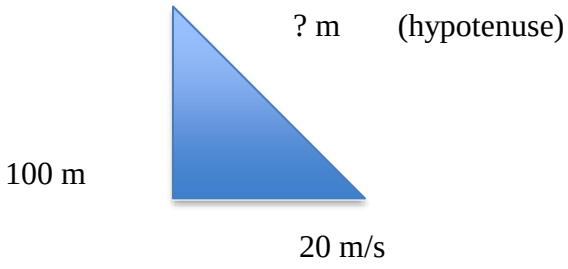
for? Sin = $\frac{\text{opposite}}{\text{Hypotenuse}}$

Cos = $\frac{\text{adjacent}}{\text{Hypotenuse}}$

Tan = $\frac{\text{opposite}}{\text{Adjacent}}$

Not all triangles are 3,4,5 triangles, so we need to use these identities in Physics. Why? Because Physics requires you to see the world around you differently. That is, Engineers, Architects, Builders, Acousticians, and people who make things need to know that measurements are correct and forces are balanced or lie within specific parameters. Just taking a ferry across a flowing river requires the Captain to use these identities to make it to the dock on the other side!

Example: A ferryboat Captain leaves one side a river to reach the dock directly across the river. The distance the ferry must cross to get to the other side is 100 meters. The river is flowing at a rate of 20 meters per second. What is the angle upstream that the Captain must operate the ferry in order to get to the dock directly on the other side? (Note: the ferry must cross against a current that is taking it downstream away from the dock at 20 meters per second. If the boat tries to go straight across the river, it will not reach the dock, but will end up down river from it!) Here's a triangle to illustrate. FIND the hypotenuse and the angles.



Solving for more than one variable.

In the study of motion called Kinematics, there are four basic equations: X

$= vt + 1/2at^2$
$V^2 = v_i^2 + 2\ ax$
$V = v_i + at$
$X = t\ (1/2)\ (\ v_i\ +\ v_f\ )$

Where x = a measure of displacement
V_i = initial velocity
V_f = final velocity
A = acceleration
T = time

In a Physics problem involving motion in a straight line such as an accelerating car from rest (stopped), the initial velocity is zero. The final velocity depends on the acceleration and time allowed for the acceleration.

As you can see, each of these equations involves multiple variables. We will learn many tips to help in solving problems of this kind. The task is to assign the proper amounts to the variables. For example, take our accelerating car:

It travels from rest in a straight line without skidding or slipping, accelerating at 10 meters per second^2 of time. How fast is it going after 30 seconds? (Do we need to know how far it traveled?)

A = 10 meters per second^2 (pretty easy to find in the problem) V_i =
0 meters per second (rest = zero by default)
T = 30 seconds (again pretty easy)
X = displacement traveled
V_f = what we are asked to FIND OUT.

How would you solve it? I leave it to you.

Sometimes it will become necessary to solve for more than one variable. We will deal with these problems when we come to them. For now, if you can solve the previous car problem, you're doing very well!

In the study of waves, we come across more equations with multiple variables. One used frequently is:

$V = f \boldsymbol{\lambda}$

Where V = velocity
f = frequency
$\boldsymbol{\lambda}$ = wavelength

Frequency is measured in Hertz (Hz) and it means cycles per second. It is how many times a wave ripple passes a point in space or some medium each second.

Wavelength is a measure of the distance between crests of each wave as it passes that point.

When you multiply them together, you get the speed of the wave. This is true for sound waves in air, ripples of water when a pebble falls in a pond, or light waves from stars or a TV.

For light waves, we use a special symbol for velocity: c
This symbol stands for the speed of light, which is 3×10^8 meters per second. Therefore, when we are dealing with the phenomenon of light, if we know the speed of light (which is ALWAYS the same!) and we know either the frequency or the wavelength, we can find the other variable.

Try this one:

$c = f (700 \times 10^{-9}$ meters) where f is frequency, and 700 nm is the wavelength (700 nm and 700×10^{-9} are the same thing). Find the frequency f of the wave of light.

Some common myths involving Physics:

1) If I'm in an elevator approaching the 30th floor of a skyscraper and the rope breaks and the elevator falls, if I jump as high as I can before the elevator hits the ground or just before the impact, I won't get hurt. It'll be like jumping up and down on a stable floor. WRONG! You are still falling from the 30th floor and the elevator floor is falling away from you at the same time.

2) When you 'pull Gs', you are going against gravity. WRONG! 'Gs' is a short-hand for some multiple of acceleration due to gravity. You are accelerating that many times the force of gravity. Every cell of your body will resist that change in your inertia. You can pass out!

3) Centrifugal force holds you against the side of a car rounding a curve so the car doesn't skid. WRONG! This is centripetal force and it is directed toward the center of the curve and along a line tangent to the curve itself. The force of friction keeps the car from skidding also.

Here is a typical problem we'll encounter. Try it.

Torque is the force of turning something around a central shaft like a hinge, a screw, or a bolt. A useful formula is Torque = length of the lever times the force applied to make the turn. A bolt is to be tightened with a torque of 8 kg (meter^2 per second^2). Your wrench is 0.35 m long. What is the force you must exert to tighten the bolt? (Answer: 23 kg (meter per second^2)) See if you can solve the problem.

Projectiles are objects that are thrown with force that make an arcing path. Examples include footballs, basketballs, and anything that is thrown or shot into the air. A football quarterback throws a pass to a receiver all the way down field. To cover the longest distance between himself and the receiver, the quarterback should throw the football

a) at a 30 degree angle
b) at a 60 degree angle
c) at a 45 degree angle

I am driving on a straight road in a convertible with the top down and the cruise control on so there is no variance in my speed or direction. I throw a golf ball straight up into the air with my left hand. The golf ball

a) lands in the back seat
b) lands on the road or my right hand
c) lands in my left hand

We will learn that electricity and magnetism are similar, but NOT the same. They both produce 'fields'.

We will learn that light is both a particle (photon) and a wave made up of both an electric field and a magnetic field at the same time.

True or False: Light has enough energy to knock electrons out of the orbits of atoms.

True or False: The true color of the Sun is more like a tennis ball than an orange. True

or False: Radio waves are the most powerful waves in the EM spectrum.

We will learn how to construct and analyze basic electric circuitry including Ohm's Law, resistors, capacitors, voltages, currents, and more. We will learn how to read basic circuitry diagrams.

Example: For 2 resistors in a series circuit (like cheap Christmas tree lights that go out when one bulb burns out), we can find the 'equivalent resistance' by combining the values of the 2 resistors. I have one resistor at 2 Ohms and another at 10 Ohms in series. Adding them I have an 'equivalent resistance' of 12 Ohms.

But suppose I have these same 2 resistors in a parallel circuit (the way a house is wired, for example). Because they are in parallel, we cannot just add them together to find the equivalent resistance. We must take their reciprocals and add them.

Find the equivalent resistance of the 2 resistors above (2 Ohms and 10 Ohms) in parallel.

Word problems will comprise the core of the Physics course as they are the way the real world's problems are solved. They can be thought of as word problems that are translated into mathematics and quantified. We will have lots of practice! An Honors Physics class at CMIT made up their own mnemonic device to help them to solve Physics problems in steps. It has been used be other classes quite successfully because it is easy to learn and remember.

E D G E S

E = equivalent S.I. units
D = draw a free-body diagram
G = list what is given in the problem
E = select the best equation that covers the variables you have and need to find S = solve and use Dimensional Analysis to check your answer

We will use EDGES every class and every problem! It is a foolproof way to handle the course work as it helps you to visualize the problem and decide how to solve the problem.

As the course progresses, you will become more and more confident that you can do Physics. It makes you see the physical world around you in a different way.
Students find that many things they take for granted daily are truly governed by the laws of Physics that we take for granted without thinking about them.

