Mr. Malik's Summer Assignment Packet for the AP® Physics 1 Course, LHS, 2017-18 School Year

Welcome to **AP® Physics 1**! I am *very* excited to be teaching this class here at Lakeside for the 2nd consecutive year. Now that I have some "lead time" [I am writing this during Spring Break, 2017!] to actually reflect on the course specifics and plan out the entire upcoming year of the class in advance, I am going to be making some big changes (improvements) as to how I teach the class – so disregard whatever you've heard about this class from past students! Too bad they didn't get to experience this newly revamped AP® class!! *(I hope they still benefitted well from the course anyway...)*

One such improvement, in order to avoid falling into the all-too-common curriculum *pacing* challenge, is *this* very summer 'homework' **packet**.... A lot of other upgrades are being planned and worked out right at the time of my writing this, and certainly the biggest change involves my full intent to implement the **Flipped Classroom** approach to teaching this class going forward. This is a trending new model for student learning that makes the homework the notes (AKA "lecture") portion of the class, and so the *classwork* **is** (what is traditionally considered) the *homework*... and of course labs and tests happen in class too! [Feel free to do an internet search of *"flipped classroom"* for a better understanding of this method.] It is, in my opinion, the best & most efficient way to deliver 21st century instruction, and it does require a bit of that 21st century *technology* to make it possible.

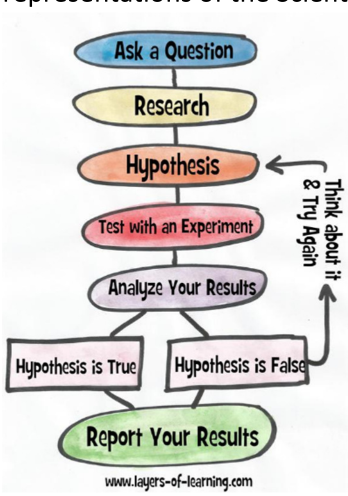
Throughout the year, your homework assignments will be primarily to watch instructional video clips (shorter than 30 minutes a piece). To aid my ability to check that you're completing this homework, I plan to use a very helpful tool called **EdPuzzle.com**. You will be required to create a student account and to join my class online, and homework will be "graded" entirely online based on completion and comprehension of the videos. **No action online is necessary at this time!** But, should you have any questions or need clarification about any of this during the summer, do not hesitate to visit my school website at **http://www.lakesidehs.dekalb.k12.ga.us/MrMalik.aspx**; or shoot me an email at **naoman_f_malik@dekalbschoolsga.org**. *[<<< QR codes provided on last page of packet] --Mr. Malik*

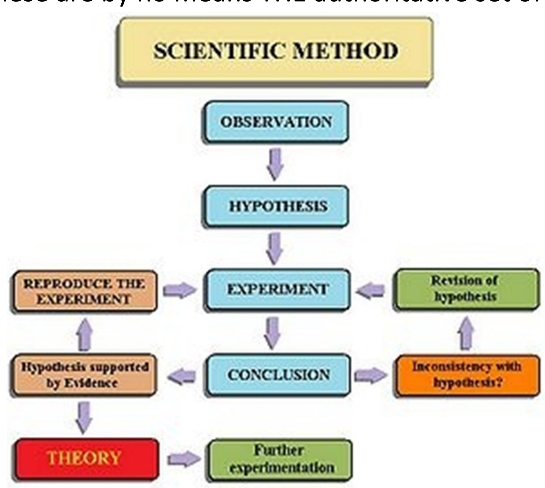
Please READ ALL OF THIS PACKET and COMPLETE ALL WORK WITHIN IT *PRIOR TO* THE START OF SCHOOL in the Fall! There *will be* a short QUIZ given during the FIRST WEEK of school, and THIS PACKET WILL BE TAKEN UP for a completion grade on that day (date TBA)!! You may use external resources as needed, but **you** are expected to complete this packet independent of your fellow students!

I. *How to Science* – a brief reading, passage by Mr. Malik

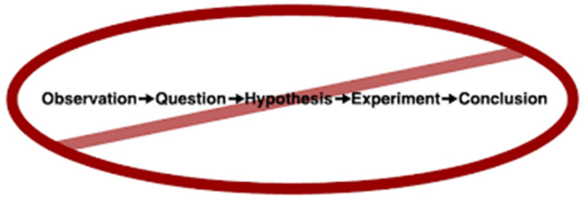
Why does every set of educational standards written for Physics courses include the overall scientific process? The Georgia Performance Standards (or is it Georgia Standards of Excellence?) call them "Habits of mind" for science. The College Board refers to them as Science Practices. You may have been taught the process as The Scientific Method. Whatever moniker we use for it, the essence of what we are teaching is that *scientists* (which is everyone, really) employ a certain logical process in order to gain useful, factual, evidence-based information. This is what we call **science**. The way scientific data is collected and used in this method – which has been perfected over centuries by human society – is more of a general philosophy for supporting and justifying scientific findings than it is a "process" or a "technique," and therefore it is a bit malleable and does not always have to follow a "cookbook" pattern of steps. Whichever way you may have learned about it in the past, you were certainly taught some important key *components* of this scientific method, as well as some much-needed *terminology* which we *will* continue to use (but not harp on too much). So, back to the original question – why does this end up being included in most, if not all, *physics* curricula? Well, to put it bluntly, Physics is the grand-daddy of **all** branches of science. That's why! (*Disclaimer: If you ask your other science teachers about the validity of this statement, some may agree while many will probably scoff at the idea – let those teachers deny the facts out of pride in their own respective fields of study... it's healthy to have that sort of passion!*) Physics does – truly – attempt to explain *everything* in the Universe, from the grand scale of galaxies all around & how they formed to things that go on at the smallest of scales; so even Chemistry, Biology, Astronomy, Oceanography, Environmental Science, Forensics, etc. – they are all actually subsets of Physics! *Some* refer to Physics as "the **basic science**," but then *you all* would roll your eyes at that, soon enough, saying that this stuff is anything **but** *basic*! But the point is that it is the quintessential all-encompassing ***science*** subject. Therefore, physics teachers are always tasked with explaining to students the "scientific method," whether we like to or not. And believe me, I think I speak for most physics teachers when I say, we would much rather just jump right into the *real* physics from Day 1. But... here we are, and we must learn to crawl before we can walk & run. And this stuff most definitely *IS* important.... It's just not going to be as thrilling as some of the more Phun Physics™ [trademark :)*] that we do later on.... **Note: other than most of the paragraphs in this packet, 90% of the rest (images, punny phrases, etc.) is "borrowed"~~TM~~*

Notice in the title that I've used *science* as a verb. That's because it is one. Well, not literally; your English teachers would shoot me an angry glare for saying that. It is of course a noun, in the literal grammatic sense. But it *should* be a verb, because it is something that you **do**. (Hence, I keep talking about "sciencing" as though that's the correct English usage of the word.) This is also why no science class is complete without many labs, demonstrations, and solving problems and so on. Every time you partake in one of these aforementioned activities, and not just passively read a passage like this one or out of the many chapters in your textbook, you will be instituting the scientific process in one way or another! That's why it's the very first thing you're taught about. Let's take a look at just two flow-chart representations of the Scientific Method, and these are by no means THE authoritative set of steps:





Now, there are certainly many other renditions of a Scientific Method flowchart, but all of the valid ones have one thing in common with the one above. That is that they are *cyclical*. If you are ever presented with a graphic for the Scientific Method and it doesn't have that feedback loop or a circular, ongoing nature to it, then you can categorically dismiss it as not fit for the high school or college level understanding of the process used in science. That's the first key to understanding the Scientific



Method, which is that it is an *attitude*, or culture, toward learning or conducting research that is never satisfied with any one result and is **always** subject to revision. (This, by the way, can be implemented even in non-scientific fields like business, journalism*, or politics – just as a person can practice meditation without being a monk, one can appreciate and use the Scientific Method in areas outside of science. ****except the FAKE NEWS!***) For depicting the never-ending nature, the chart on the right is more accurate, as it shows a cycle regardless of what the results seem to indicate for any one experiment. With these two example charts in mind, let's go over some of the basics and terminology that we see up there.

One thing you may notice is that there is disagreement as to what steps to place before Hypothesis. But the ones we see above do include things like Observation, Research, and Question. These are all words that need no explanation, and their meanings speak for themselves. Although, do these steps all have to take place prior to making a Hypothesis? And, is there a specific order to them, all the time? The answer to both of these questions is *No*. The main idea here is that prior knowledge (first-hand observations and/or research) plus curiosity about something generally lead to an individual making a hypothesis. So, what exactly is a Hypothesis? It is NOT a *question*, which can be open-ended and does not provide any type of suggested answers. Nor is it a *prediction*, which simply forms an educated guess as to what may happen under certain circumstances (i.e., *if* X*, then* Y). More precisely, a **hypothesis** is a *testable explanation* of what does happen, based on prior understandings and observations. It may be phrased as the answer to a **question**, and it may *lead* to some **predictions**; but it is more of a general statement of *WHY* you think what you think about a phenomenon. Basically: *hypothesis = X* causes *Y* **because** *Z*. And, once again, the key to a hypothesis being legitimate and *scientific* is that it **can be tested** somehow via experiment. If a statement/explanation *cannot be tested*, it does not belong in the Scientific Method!

Let's now jump down to the part of the flowchart that looks at the conclusion/results of the experiment that was done in order to test the hypothesis. Notice that there are two possibilities depicted: the hypothesis is "right" or "wrong." Once again, the chart on the right shows this segment with more accuracy. Words like *true*, *right*, *correct*, ***proven***, *wrong*, and *false* are too definitive descriptors for experimental results and should be avoided when using the Scientific Method. In reality, we can interpret results (*evidence*) from experimentation to support, partially support, or contradict the hypothesis statement. An experiment, or even a slew of them, *cannot ever* **prove** a hypothesis true. Science would not have come as far as it has if we simply *proved* things only to move on and never reexamine. This would be a decidedly *unscientific* approach to issues. Rather, we can use experiment after experiment to continue to *support* and bolster the case for the original hypothesis. After countless iterations of this process, we may then develop a popular, well-accepted, highly refined explanation that we can then call a **theory**. Once again, this is not to say that it cannot later be *disproven* and rejected! On the contrary, any hypothesis (or theory) *can be* **disproven** at any time. It is totally fine to use this word, as all it takes is one reliable or well-conducted scientific experiment showing contradictory data to disprove a hypothesis or parts of a hypothesis. Any part of a hypothesis that is inconsistent with experimental data **must** be discarded/revised, and this is where the other side of the feedback loop comes in. The nature of a scientist is to try to reformulate a new hypothesis that takes into account the new evidence and explains the problem in a way that can then be tested again by experimentation. Sometimes the hardest thing for a scientist to do is to discard and walk away from a hypothesis that he or she put a lot of work into, because of a couple of "inconvenient" experimental results that contradicted that hypothesis. We do see this occasionally in science history and even in modern times, where a stubborn scientist grows defensive of his/her work because another experimenter somewhere has found some key information that disproves any part of the proposed hypothesis. This all-too-human instinct to categorically defend one's work is actually what goes against the spirit of the scientific method; although it is a rather natural reaction that is tough for most to avoid, this type of response can actually stifle scientific progress, and history does not look favorably upon instances where this has occurred. The true essence of the Scientific Method is to *be vulnerable*, to actually try your hardest *to disprove* your *own* hypothesis, truly putting it to the test – literally speaking. Designing experiments that actually attempt to *contradict* one's own hypotheses is the hallmark of a true scientist.

Finally, a good scientist should always communicate the results of the above methodology, in order to help further the advancement of scientific knowledge. The more collaboration and communication that takes place in the scientific community, the more effective this whole process is (and less redundancy ends up taking place – *thanks, Internet!*).

...Wait a second, Mr. Malik, did you forget to explain what a ***Law*** *is???* Why, no, I purposely did not include it above, because it is not related to theories and hypotheses in the way that most people *think*: There's a common **misperception** that Laws are just glorified Theories, and that Laws > Theories > Hypotheses. That's not exactly the case. A scientific **law** is always some kind of *universal* truth (or fact) that continues to be supported all the time and everywhere, regardless of circumstance. It is accepted by everyone, usually stated as a simple mathematical relationship between quantities (like $E=mc^2$) without really any *explanation* at all as to *why* it's true; and tends to address a very broad topic in nature (e.g., Laws of: motion, gravitation, thermodynamics). A good resource on the differences between terminology and addressing the common misconceptions is here: futurism.com/hypothesis-theory-or-law/

Short Answer Questions *(write out answer in paragraph form, using complete original sentences)*: What have you learned from past science teachers on what key aspects make up the SCIENTIFIC METHOD? Do you believe that all Scientists undergo this process every time they do science? Explain your answer. Is it still *science* if one does not necessarily follow the universally accepted "process" in the traditional order?

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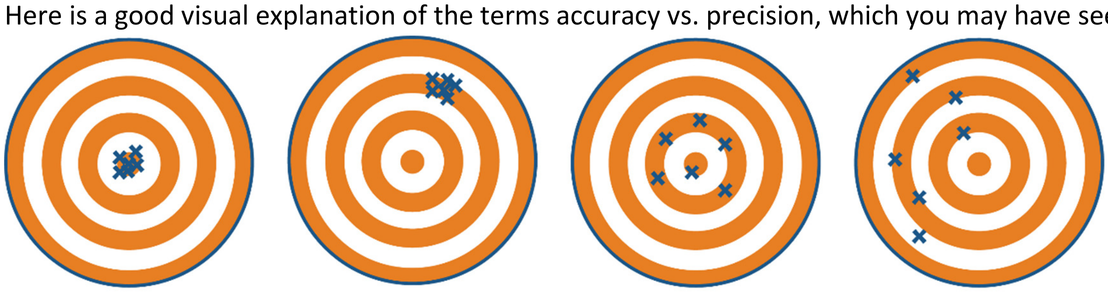
II. *Measuring: Precision and Accuracy*

Ah, one of the most fundamental scientific activities is the measurement. Measuring is obviously a very important concept, and it relates to the next several sections in this packet. So, starting again with basics, there are two principle "aims" in making a good measurement: *accuracy* and *precision*. What are they, how are they similar, and what is the difference between these two terms?

Accuracy in measuring refers to how close you can get to the true value that you are trying to measure. It can be affected by the correctness of the measuring device (which is typically set by the manufacturer and is typically not a questionable concern when using lab equipment), the user of the tool's ability to correctly calibrate (or "zero") the tool, the user's familiarity with the correct usage of the measuring equipment, and the methodology employed in making the measurement itself (which is dependent on experimental setup). ***Precision*** of measurements is the ability to produce repeatable measured values within a tight range of one another. *More* precise ***measuring tools*** are primarily responsible for producing *higher* precision in measurements. Thus, precision will be affected by: the number of markings on an *analog* measuring device **or** to how many places past the decimal the readout for a *digital* tool will go. It also does depend on the user's ability to see/read the device correctly and to employ proper measuring techniques.

A very commonly used measuring device in the physics lab is the **meter stick**, **ruler**, or **tape measure** – all of which are used to measure distances/lengths. Another tool you may encounter is the triple beam **balance**, which you've probably used in chemistry. All of these mentioned devices are *analog*, and therefore will require a proper understanding for how to report your measurements. Their *precision* will depend entirely on the scale of markings on the device. There are, of course, *digital* counterparts to these: the digital caliper or digital mass scale, for instance. Another type of measurement you will do often – which will always be taken digitally – is timing, and for that you'll use a **stopwatch**. These digital devices are usually *more precise* (and easier to use) than the analog ones. *Accuracy* in <u>all</u> cases will depend on your use of good measuring practices and making sure to *calibrate/zero* the tool each time.

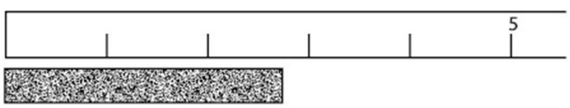
Here is a good visual explanation of the terms accuracy vs. precision, which you may have seen before:

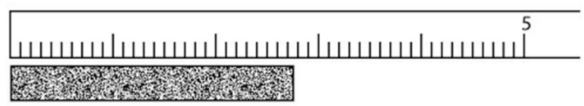


High Accuracy High Precision | Low Accuracy High Precision | High Accuracy Low Precision | Low Accuracy Low Precision

The goal of course will be to have as high accuracy *and* high precision as possible. [Note: a few outliers may appear in data from time to time, but if you can recognize, identify, and disregard them appropriately, it is not a problem.] One way a former colleague/physical science teacher explained it to his students was using NFL QB's. I found it amusing and everything, but I'm sure it won't speak to everyone. Here's my take on his idea: **High Accuracy and High Precision** is like one of my favs Peyton Manning (always hits his target). **Low Accuracy and High Precision** would be like Philip Rivers (always overthrows his targets). **High Accuracy but Low Precision** is like Alex Smith? (hit or miss, but usually close?). And **Low Accuracy & Low Precision** is like (although I do love the guy, no longer playing...) Tim Tebow (just all over the place!). Some of these references might be a bit dated, but you get the picture (...if you're into football at all). Feel free to comment with your own thoughts in the margins!

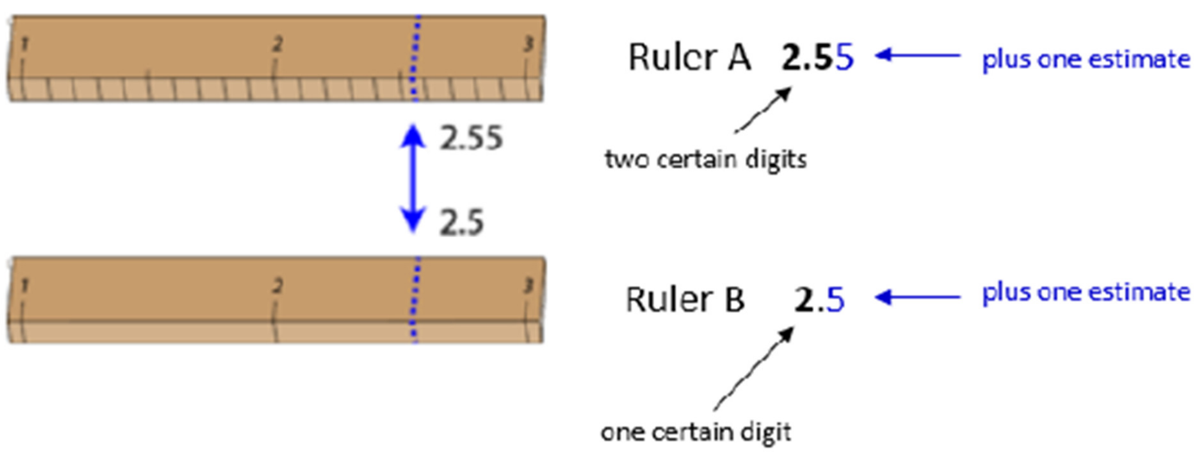
So, how exactly are measurements reported with the correct precision, from an analog measuring device? We'll use the ruler/meter stick in all of our examples below. Take a look at the two diagrams below, showing a different ruler being used to measure the same thing. First of all, notice we should have no accuracy problems so long as the *zero position on the ruler is lined up correctly*. Now take a close look at the difference in precision between the two rulers. Which one is more precise? _________



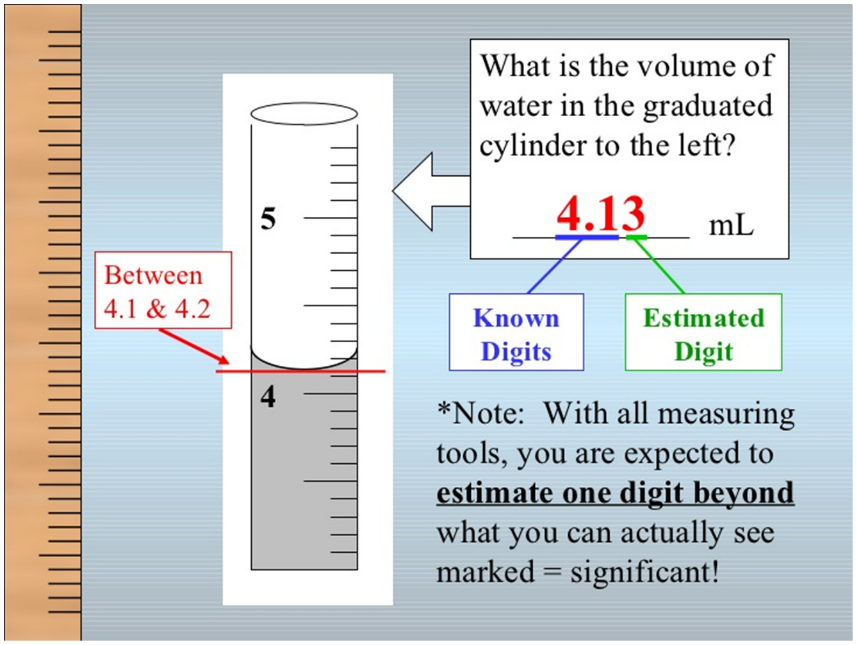


How do you know it is more precise of a measuring tool? ______________________________________

Now to the big takeaway from this section: When measuring lengths using a meter stick, report the measurement to the most precise decimal place that is available to you. The way to do this is to write down ALL of the "known" or *certain digits* of the measurement, and then to estimate (visually) to your best ability one additional "estimated" digit. So, it is not 100% accurate since there is some *uncertainty* built-in with this method. See the following, and then answer a couple of practice questions that follow:



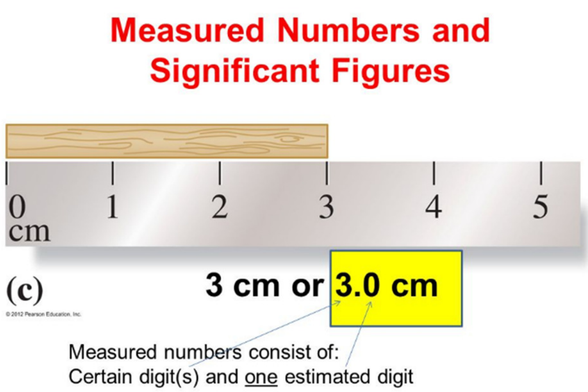
Question: What should you do to still make a very accurate measurement if the "*zero*-end" of the meter stick is worn to the point of not being able to see the marking at zero (Ø)? *[Answer here:]*



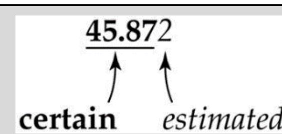
Pro Tip (as shown to the left):

When measuring a **volume** from a graduated cylinder, always measure from the bottom of the *meniscus*!

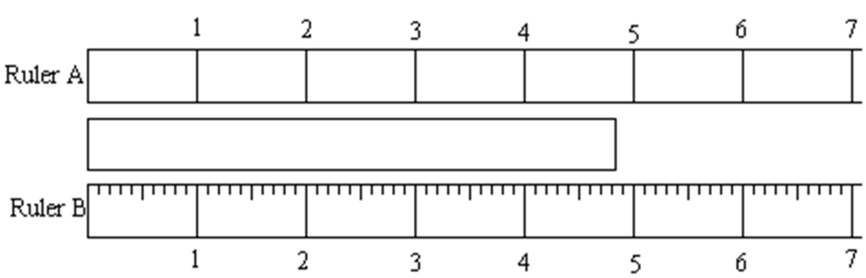
The above example shows the way to measure volume with a graduated cylinder, incorporating the same "estimated digit" technique. Even if the thing being measured seems to fall right on a marking line on the measuring instrument, you will report a '0' as the estimated digit; this ensures that we are reflecting the precision of the measuring device consistently. Here's a pictorial example of that [<u>3.**0** cm</u> is correct]:



To recap:



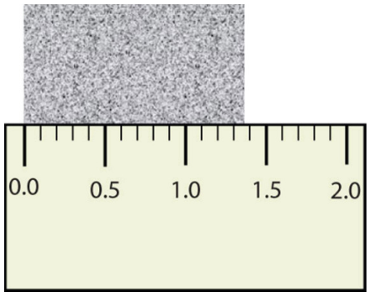
Now, some for you to try on your own: Report the correct measurement value (to appropriate degree of precision) for.... *(assume below to be in units of **cm**)*

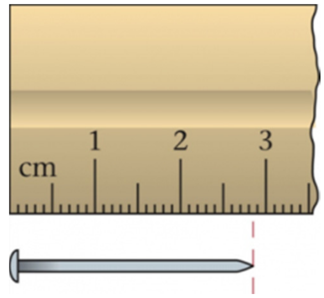


Ruler A = ______

Ruler B = ______

Next, measure the length of the block and of the nail using the rulers provided (assume units of cm):

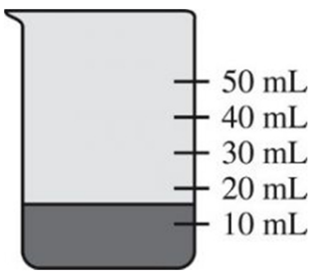




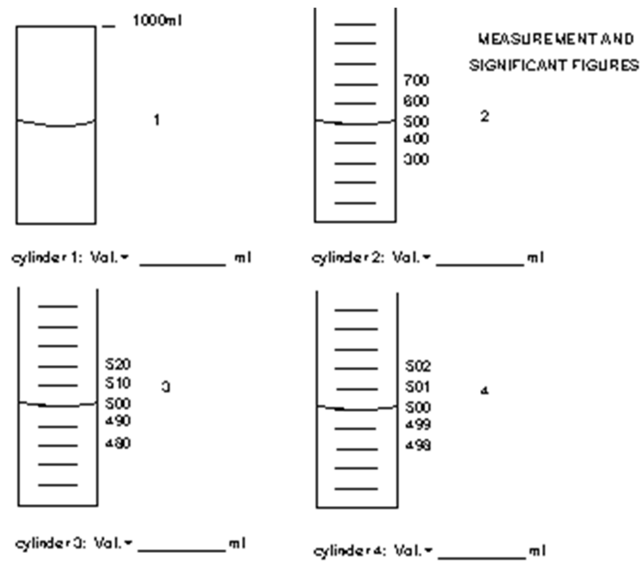
Block: ________ cm

Nail: ____________

Finally, let's try some volumes from a few graduated cylinder readings:



Vol. = ______ mL



III. *Significant Figures ...and their significance in this class....*

Certainly, you've heard about them and even studied them, perhaps ad nauseum. But what is the point of *sig figs*? The last problem above might provide some insight into answering this question. The correct number of significant digits to use in reporting each of those last 4 graduated cylinder volume measurements actually corresponds with the problem number (1-4). But yet, you probably got the same number for each one. The difference of course, is the ***precision*** of the value. And that is what *sig figs* are ALL about! If I am around 5 foot & 5.5 inches from a quick measurement, I would not report that height in feet by saying that I am 5.4583333333333333333 feet! That is what the calculator spits out, though, when I do the quick conversion. But this number, while numerically accurate, ***conveys*** a **far** too confident sense of **precision**. I did not measure my height using a micrometer or anything like that, so there should not be nearly this many digits in my reported height. You intuitively know that it should be rounded, but most do not realize there are rules as to how many digits to round to! (not to mention, I never miss out on an opportunity to round my height UP! [I actually just say I'm 5'6" but I know that's not scientifically precise enough!!]). Should I round to 5.5 feet? 5.458 feet? Neither! According to the sig fig rules, I divided 65.5 inches by 12 inches/feet (12 is an *exact* value here, with *infinite* sig figs) to get the answer so my final result should only have 3 sig figs; hence, 5.46 feet.

All of this is to show the *WHY* (purpose) for the significant figure rules. Without a doubt, most of you reading this have already learned from chemistry class the sig fig rules down to the finest details. I hope you will be relieved to learn that I (and every other physics/engineering teacher/professor I've ever come across) will *NOT* be enforcing these rules to the letter; but we WILL be enforcing the "spirit" of, or your understanding of, these rules! Admittedly, I myself will not always follow every rule, but there are some answers that even I will have to deduct points for... Basically, be reasonable with your rounding. If you just heedlessly copy down every digit in your calculator for values without paying any mind to precision and you *under*-round, I will take off a point or so for such an answer and violation of the sig fig spirit. Alternately, if you take a value like 58.671 that needs to be 3 or more sig figs, and round it to 60, that will also cost you at least a point deduction! And, no matter what, Physics quantities are to be reported as ***DECIMALS***!!! <u>DO NOT EVER PUT YOUR FINAL ANSWER TO A PHYSICS QUESTION IN FRACTION FORM! DO NOT INCLUDE ANY RADICAL SIGNS, CONSTANTS LIKE π, OR ANY OTHER MATHEMATICAL EXPRESSIONS THAT ARE RESERVED ONLY FOR EXACT QUANTITIES IN YOUR FINAL ANSWER!!!</u> This goes against everything the sig fig rules represent, and makes **no sense** as a physics answer! Always reduce your values to **<u>decimal form</u>**!

The following questions should hopefully be no more than a review for you on the basic sig fig rules (answer with correct # of sig figs):

1. 3.548 * 6.1045 * 2.30 = __________ 3.548 * 6.1045 * 2.3 = __________

2. 83.7645 + 457.312 + 3.1 = _________ 3. 2.6 π = ___________

4. Report the **average** of these *3 values*: 2.30 cm 2.20 cm 2.30 cm average = _________

IV. *Graphing: answering some fundamental questions about graphs*

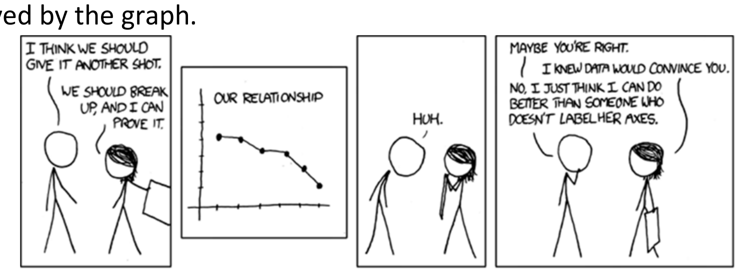
You already know all about graphs. We're going to focus primarily on one solitary type of graph: the scatter plot. But we're going to really get into some important best fit line details and even something called "linearizing" data on a scatter plot. Graphing is for a purpose, and that purpose is to determine relationships between variables. In an AP science class, we must learn to *quantify* those relationships!

On the set of axes on the *following page*, please **complete the diagram** by placing the following <u>*words*</u> in the correct locations on the graph: *x-axis* *y-axis* *Independent Variable* *Dependent Variable* *Title*

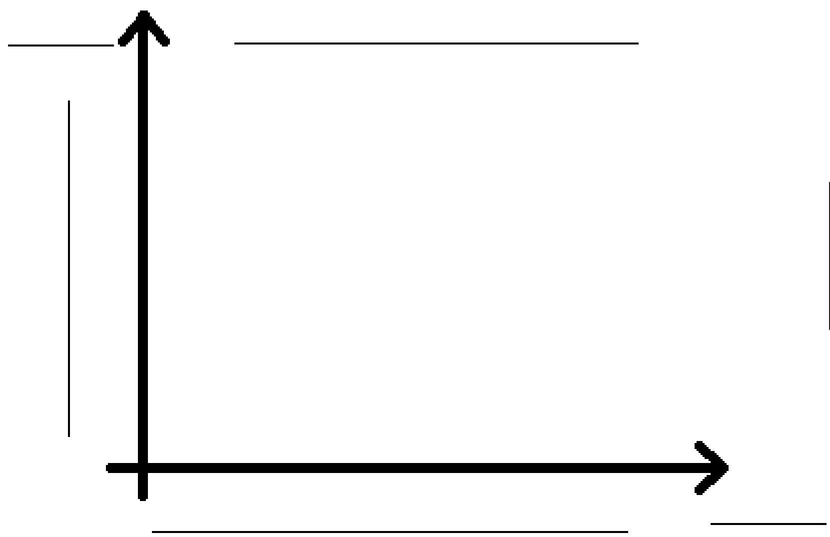
Also, **draw two lines** on the graph representing: *Direct* relationship between *y* and *x* [**label "Direct"**]
...and *Inverse* relationship between *y* and *x* [**label "Inverse"**]

Labeling the x- and the y-axes with the correct quantities (variables) is of ***critical*** importance! Without the proper labels, number scales <u>*with Units*</u>, and information appearing on a graph showing data trends, there would be no useful purpose served by the graph.

See what I mean? →

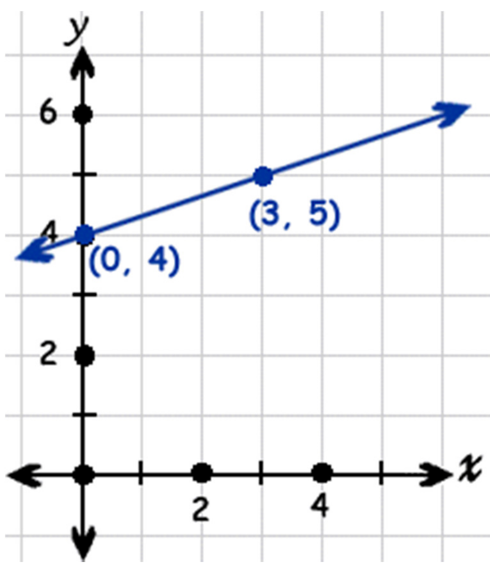


XKCD "Convincing"; Original here: HTTP://XKCD.COM/833/



← *label this graph (as indicated in directions on previous page)*

By far, the most important graphical relationship that we will encounter is the straight line. Note that when analyzing all of the data on a scatter plot, if the relationship between the two variables appears to be linear, the ***line of best fit*** needs to be determined by approximating the data as a *single, solid,* ***straight*** **line**. Understanding the **slope** of a line on a graph, and knowing how to find it, is a fundamental concept that will continue to be brought up in this course. As a reminder, the slope of a line on a graph is **the rise over the run** between *any two points* on that line. Take a look at the graph below and ***find the slope*** of the line, showing your work (each step of calculations) in the space provided beside the graph:

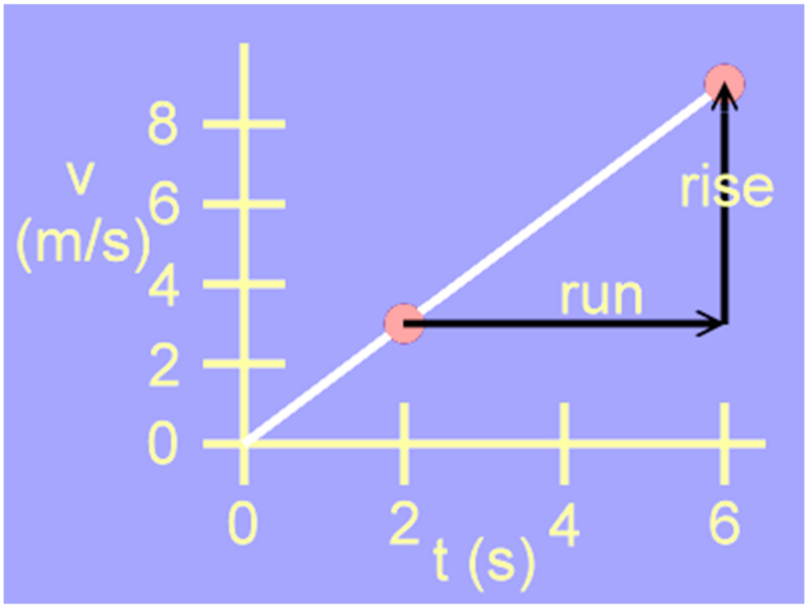


slope, **k** = ____________ (slope will be called ***k***, not *m*)

For sure, you have been taught about the algebraic equation for a straight line on an x-y plane. That is one of the reasons knowing the slope is so crucial. You may have learned the equation as $y = mx + b$, where m is the slope and b is the y-intercept. To avoid later confusion, we're simply going to replace the m with a k. So the new formula is $y = \mathbf{k}x + b$. Using the y-intercept from the above graph, ***write the full linear equation*** for the line (here):

The final form of your linear equation should actually include the two constants *k* and *b* **as numerical values**, and it should show the variables *y* and *x* in their original (letter) form. This is an exercise we will repeat several times throughout the school year, and you need to get used to doing it!

Here is one more for practice. It is an actual physics graph, so note that the axes are not labeled *x* and *y*, but rather *v* and *t*, for *velocity* and *time*, respectively. Also, importantly, note that the values in the graph are not just numerical, but have a **unit** (sometimes called a dimension) to them. Meters per second (m/s) for velocity and seconds (s) for time. Go ahead and ***find the slope***, and then the ***linear equation*** for this graph. *Note that the slope you find should end up having its own* ***unit*** *(dimension)*! Do your work on the side.



equation of line: _______________

V. *UNITS UNITS UNITS!!!*

In the last graphing problem above, units finally made a little appearance here in this packet. There were a few other places earlier where they were peppered in as well. I was purposely avoiding too much discussion over them until now, because I really wanted to dedicate a whole section (now that most of the other basics are out of the way) to UNITS! They are THAT important (and one of the most commonly omitted details by physics students everywhere)! I think this will be the single most important section in this entire packet.

In physics, when you are trying to quantify something, the values you use are completely worthless if all you have is a number with no unit. The unit makes all the difference; it lets the reader know exactly what type of quantity is being referred to and gives the right sense of scale for how big this number really is. Think about money for a minute. It's not even physics or science, but what are the units for money? Well, in the U.S., they are dollars ($) and cents (¢). (See, they even have symbols like physics units do!) But there are other systems (currencies) of units for money too, and it is still money, isn't it? For instance, you have Euros (€), Pounds (£), and Yen (¥), to name just a few. And then there are equivalences between those currencies (units) known as **exchange rates** (conversion factors). If you worked in finance, you most certainly would NOT want to report a number that you calculated using Mexican Pesos in U.S. Dollars without making the appropriate conversion, would you?? I have heard stories from my days in the business world of things like this happening by a young, inexperienced consultant; and the results are never good when it comes to these kinds of mistakes in the "real world!" (Fortunately, a more senior colleague usually reviews the work done by the newbies and picks up on such mistakes – they're actually not all that hard to spot!) It's just like if your friend owes you 50 dollars, you know how much that is! Let's presume this friend forgot how much he owed you. He asks you to remind him, and you say "fifty." Without another word, he nods in approval; two minutes later comes back and hands you 2 quarters! (or, say, 50 Rupees – worth about the same :/) You wouldn't just shrug and say, "oh well, close enough," now would you!? Of course, the units would matter to you. And if they did hand you a different currency, the proper conversion factor would matter too! Such is the way physics teachers feel about students who “shrug off” mistakes when converting inches to meters, or meters to centimeters, and so on. Even worse: so often, students just don't report a unit *at all* to go with the number they write down. I don't know what a volume of 12.6 means any more than you do... Is that cubic centimeters (cc), liters (L), or gallons (gal)? No idea!!

An important point with units in science is that we always prefer to use the metric (AKA ***SI*** AKA ***MKS***) system of units. This means that those English units you are used to (inches, feet, yards, miles, gallons, pounds, fortnights, ...slugs?) will have to be replaced by the metric system which you'll just have to **get** used to (centimeters, meters, kilometers, liters, Newtons, milliseconds, seconds, kilograms, etc.). This is not dissimilar from learning a new language. In the beginning, you'll find yourselves trying to do quick "translations" (conversions) in your head to understand how big 12 centimeters *really is*, in inches or feet. But eventually, you should be able to speak metric fluently and not need to convert back to your native unit system. Now, among the reasons we prefer the metric system is that it is more or less universally accepted as the standard measuring system of choice, and a big part of that popularity is its convenient reliance on powers of 10 and prefixes that make mathematic/scientific calculations so much easier than they'd be if we were still using the English system. We will occasionally still encounter English units, but mostly just to get a little more practice doing *unit conversions* and to remind ourselves how cumbersome it is to use!

Allow me to just touch upon the basics of the metric system. I'll start by introducing some **base units**. Base units, as opposed to ***derived*** ones, are units that involve direct measuring, with no calculations necessary. Some of the most common ones in the metric system are the gram (g) for mass, the meter (m) for distances, and the second (s) for time. An example of a **derived unit** would be like the *meter per second* (m/s), which is used for speeds or velocities and is *derived* by dividing a length or distance by a time. There are only 7 official base units in the metric system, but the three mentioned above are the majority of what we use in physics. The charm of the metric system is that every base unit can easily be divided up or multiplied into a smaller or larger unit, respectively, by placing a standard prefix in front of the name. And the multiplication/division factor is always a power of 10. The more common prefixes that we'll see are: **k**ilo- (meaning 1,000x), **d**eci- (meaning one tenth), **c**enti- (1/100 or .01), and **m**illi- (1/1000 or .001). There are a handful of others, but you will need to know *these* ones for sure. These quick prefix factors make converting units within the metric system a breeze. Here are some examples of how to use *"conversion factors"* (fractions whose value equals 1, so multiplying by them does not change a quantity's value) to convert units *within* any system OR *across* systems:

Conversion Factors

1 in = 2.54 cm 1 ft = 12 in

$140\,\cancel{cm} \times \frac{1\,\cancel{in}}{2.54\,\cancel{cm}} \times \frac{1\,ft}{12\,\cancel{in}} = \mathbf{4.59\,ft\ or\ 4.6\,ft}$ $55\,\cancel{lbs} \times \frac{1\,kg}{2.2046\,\cancel{lbs}} = \mathbf{24.95\,kg\ or\ 25\,kg}$

Now, let's try doing a few practice conversions of units, showing work just as it's shown above:

1. 27 feet to inches
2. 475 inches to yards
3. 17 cm to inches (~2.54 cm = 1 in.)
4. 74.23 km to meters
5. 21.57 cm to meters
6. 594 g to kilograms
7. 2.6 g to kilograms
8. 352.2 mm to meters
9. 3482 ms to seconds
10. 0.03 km/s to meters per second

General questions on Units, regarding rough estimates of scales or the orders of magnitude of things....

Just to get used to some magnitude scales for these metric units, here are a few quick questions to check your estimating abilities:

1. A *milligram* (mg) is a measure of ______? a. length b. mass c. weight d. time

2. A *kilosecond* (ks) is (greater than / smaller than) a *centisecond* (cs) and is = to _______ s.
3. Which (abbreviated) unit might be used to reasonably measure the length of a football field?

   a. mm b. cm c. m d. lightyear e. s f. kg

   - The approximate number of these would be about: 1 10 100 1,000
4. Write the name of the metric unit (and its abbreviation) that is *best* used to measure the *length* of your pencil ______________________________(_________)
5. What would be a good metric unit to use when measuring the mass of a bicycle? _______(____)
6. A good metric unit to measure the height of a ceiling from the floor is the ___________(_____).
7. The *width* of your pencil lead might be measured in _________________(_______).
8. The time it takes for the tire of a car to complete one revolution (full rotation, 360°) while traveling at 100 km/hr. could be measured in ___________________(________).

VI. *Math Review*

Mathematics is the *language** of science. There is absolutely **no** separating the two! So, let's review some algebra that is going to be used time and time again in this class. It's very important to get used to solving for a variable *algebraically* when you don't have any numbers to plug in at all...

$z = xy$ Solve this equation for *x*.

$p = q/r$ Solve this equation for *r*.

$d\pi + M = 2(cf)^2 - \theta$ Solve this equation for *c*.

$c^2 = a^2 + b^2$ Solve this equation for *b*.

$\tan(\alpha) = x/y$ Solve this equation for *α*.

> ****Heads Up***:*
> -------------
> *Another important math skill that we'll continue to develop and practice is* ***translating*** *from words to math-ematical expressions and back to verbal ones!*

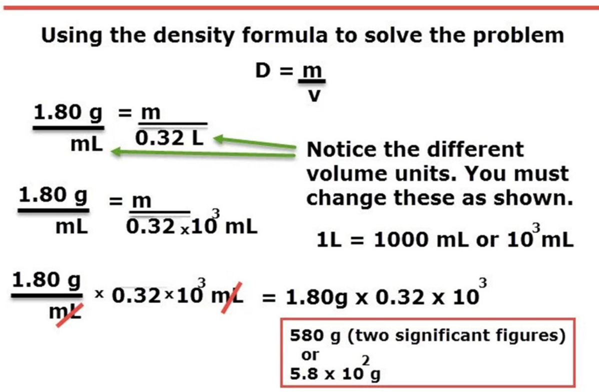
Always be mindful of the correct order of operations. Also, note how to switch your calculator between radian and degree mode, as that will be important in this class. *[Lots more* ***trig****. review to come later!!!]*

Math with units....

One thing that confuses a lot of students is that each variable in a real physics equation usually requires a value *with a unit* to occupy that quantity in the formula. So, instead of the math tradition of replacing the letters with numbers and then using algebra to solve for the mathematical answer, the variables in physics tend to be replaced with an entire *quantity* - meaning a number *with* a **unit** after it, which will be represented with a different letter or set of letters! Due to your habits from math class, a lot of students don't like writing in all those numbers AND letters together!! We're going to have to fix that.

The importance of *"Dimensional Analysis"* (the mathematical focus on units in working out a scientific equation) **cannot** be emphasized enough! If the *UNITS* don't work out properly, then something about the problem was not solved correctly, period! When the units **do** work out, all is well. What is the meaning behind these statements? Let's take a closer look. Here is an example using the *Density* formula, showing how the units *must* always work out to find the correct solution:

← solving for **m**ass knowing **D**ensity and **V**olume.



Notice that, in the example, the numbers for density and volume cannot be combined mathematically in their original form to solve for mass, even though the formula used is correct. This is because the units do not agree. A quick use of *dimensional analysis* will determine that. When we do math operations on physical quantities with units, the operations are performed on **both** the numbers **and** the units associated with them. In this process, units are treated the same way variables would be treated in an algebraic formula problem. If one unit is divided by an identical unit, they do cancel out; and if one is multiplied by itself, it gets squared. Unalike units can likewise be combined by dividing or multiplying. This is how derived units are formed. For instance, *areas* are measured in m^2 (meters-squared) and speeds in m/s (meters per second). ***In the space above, show with units how the same problem would yield the* incorrect *solution if the volume unit of .32 L was* not *changed to mL*.**

VII. *What is Physics?*

Yes, that is the question I want you to try your best to answer in a few short words or sentences. Feel free to include a few examples, but mainly, **define broadly** what this field of study is. Please answer **in your own words** without "looking up" an answer. So, to your understanding, *What is Physics?*

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Now that you've thought about what it is, I would like you to enter into the school year with some ideas as to what **personal interests** in life that you already enjoy might intersect with some of our physics curriculum. Every semester, I've given my physics students at all levels the opportunity to complete a **project** that tackles a real-world activity or phenomenon and explores the physics behind it. This gives you the chance to tie something "real" (something YOU find interesting) to the study of **physics**. As you may have realized by now, the reach of *physics* in the "real world" is practically endless, and so it is impossible for any student of physics NOT to find some topic of interest that excites them and that helps bring the study of physics closer to home. There will be time for explaining how this project works, for going over syllabi and for having a more formal discussion of the meaning of physics later – including things like why its study is so important in the first place (such that it has been deemed a necessary component to your high school education). In other words: ***<u>Why</u>*** *do we physics?* But for now, just gear up for the rollercoaster ride of learning physics that's about to come your way! :)

VIII. ***Final [Survey] Question***: Do you have any favorite "pop culture" science-y personalities/channels/ programs (such as a YouTube channel or TV show or famous scientist/activist/educator)? If so, what or who?

____

IX. ***Agreement***: I have read this ENTIRE packet, and made an earnest attempt to correctly complete the work herein.

____ ___________ _______________________________

Student Signature Date Full Name (Printed)

QR Codes for additional info - Mr. Malik's email and website links:

email →

website →