Science-1A Lecture: Week-2, Monday, January 18, 2021

Next week is our first Quiz, so today I will provide guidance for preparing for that and future Quizzes.

Throughout the course, when we discuss the practice quiz and test problems, you need to have your Equation Sheet available for reference and mark up. It is 6 pages at *https://yosemitefoothills.com/Science-1A/EquationAndSymbolNotes.pdf* .

When you do an actual quiz or test, you must use a clean Equation Sheet so an identical second copy is needed. **The one used for Quizzes and Tests must be kept pristine without any added notes.**

Remember where to find them since I will not bother to repeat these links in future discussions; I will just say "the Equation Sheet".

The Chapter 1 of the textbook and parts of its Appendices are referenced in my note entitled "Preparing for Quiz 1 on Chapter 1 + Appendix A". It is at *https://yosemitefoothills.com/Science-1A/QuizAndTestPractice/Quiz1Preparation.pdf* .

Don't panic if you do not yet have a copy of the textbook. Much of this knowledge is provided in my Algebra Refresher handout at *https://yosemitefoothills.com/Science-1A/Handouts/Week-01/AlgebraRefresher.pdf* .

If and when you do have the textbook, the following notes will make more sense as you look through its Chapter 1 and Appendix.

Example 1.1: At the top of the Equation Sheet is the definition of density with its simple formula:

$$\text{density} = \frac{\text{mass}}{\text{volume}} \quad \text{in words, and} \quad \rho = \frac{m}{V} \quad \text{in symbols}$$

So for this example, you use that formula twice: $\frac{81.0\,\text{g}}{30.0\,\text{cm}^3} = 2.70\,\text{g/cm}^3$ and $\frac{135\,\text{g}}{50.0\,\text{cm}^3} = 2.70\,\text{g/cm}^3$.
They both have the same density, and from Table 1.3, we can see that the material is aluminum. A question about density might possibly have the answer 7.86 g/cm^3 which is close, but not exactly that of iron. Still, one should assume that the measurements were not sufficiently accurate or that the iron had impurities making it slightly less dense. The answer of "iron" would be correct.

Example 1.2 is similar and its answer is provided.

Proportionality and inverse proportionality: The correct answers are

Direct $a \propto b$	Inverse $a \propto \frac{1}{b}$ or $a \propto b^{-1}$
Square $a \propto b^2$	Inverse Square $a \propto \frac{1}{b^2}$ or $a \propto b^{-2}$

The Box Figure 1.1 on page 11 of the text is enlightening. It shows how things spread out from a point source. For example, when you speak, most of the sound energy spreads out in the direction you are speaking. But it spreads out both vertically and horizontally so that people far away from you hear your voice with less intensity. They get less sound energy because it has spread out throughout the room.

This is also true for a flashlight − its beam may be narrow, but it does spread out. A night critter 20 meters distant will be lit with less light energy (per unit area) because the beam spreads out both horizontally and vertically. A critter 60 m distant will be lit up with $\left(\frac{20\,\text{m}}{60\,\text{m}}\right)^2 = \frac{1}{9}$ as much light energy. This is called the inverse square law. It applies to sound, radio, light, gravity, and radioactive energy coming from "point" sources.

How to Solve Problems (page 11 or 12 of the text) is good advice, but if you don't have the text yet, check out my handout entitled "Advice for Solving Calculation Questions" at *https://yosemitefoothills.com/Science-1A/QuizAndTestPractice/AdviceForSolvingCalculations.pdf*

This handout suggests that you do not need to write the actual numerical answer, just a blank space. That convenience is no longer the case for Science-1A. **To get full credit for a calculation problem, you now also need to write the correct numeric answer followed by the correct units.**

Figure 1.13 (page 12) is simply to refresh your memory about how pi=3.14259.. relates the diameter of a circle to its circumference. I usually write pi with its Greek letter π so the formula is $C=\pi d$ where *d* is the diameter of the circle and *C* is its circumference. You should also remember that the diameter is twice the radius: $d=2r$ so $C=2\pi r$.

The area of a circle is discussed in the handout on page 23 (Areas and Volumes) at *https://yosemitefoothills.com/Science-1A/Handouts/Week-01/CircleAreaAndPythagoreanTheorem.pdf* . Those handouts should be helpful when teaching those ideas to K-7 classes or your kids.

Appendix A – All of these are very important except for A.3
Much of the advice in Appendix A of the textbook is in my handout entitled "Algebra Refresher" mentioned at the start of this note. If you do have the textbook, read it, but I tell students to ignore section A.3 about significant figures. Many teachers are strict about writing answers and measurements with the "proper" number of significant figures. I spent 30 years doing physics research where we might spend several years making measurements and an additional year figuring out the uncertainty of our final numbers. The rules taught in Appendix A.3 of the text rarely apply to serious measurements and calculations in the real world. There, more advanced statistical techniques are required.

Just use common sense, if you put numbers into a calculation that have only 2 or 3 significant figures, you are not likely to get a number out with more significant figures of accuracy.

For this course, just give two or three significant figures in your answers like 5.92, 0.00031, 6.38×10^{32} . The speed of light is c=299792458 m/s, but usually just using $3.00\times10^{8}\,\mathrm{m/s}$ is fine. (Although some very expensive real-world engineering mistakes have been made by not using a more accurate value!)

Appendix A.6 is important. It is a review of equation graphing. First, remember that when a point is identified as, for example, (-1.50, 4.25), the first number is the *x* value and the second number is the *y* value. Just think about *x* coming before *y* in the alphabet.

With that in mind, scan over the given set of points looking for the largest and smallest *x* values and the largest and smallest *y* values. In the set of numbers in this handout, the *x* values range from -1.50 to +3.50 and the *y* values range from -2.00 to +4.25.

You then look at the graph grid that is available and see how you can conveniently set up coordinates that allow plotting of all points. A nice choice is shown on the last page of that handout along with a graph of the data points and a sketch of the curve through them.

Always make the vertical axis the *y*-axis with +*y* being upward, and the horizontal axis the *x*-axis with +*x* going to the right. Also, it is not good to choose axes on the graph paper that leave your graph squished down into a small fraction of the available grid.

Sample Questions for Quiz 1

Now look at another handout that directly relates to the questions that you might see on Quiz 1. It and its solution pages are in the directory at *https://yosemitefoothills.com/Science-1A/QuizAndTestPractice/* . The questions are not numbered, but let's pretend they are.

The 1st question is simply asking for the volume of a block of wood. It requires multiplying the length, width, and height. But be sure to follow the example solution. The solution starts with the formula to be used, $V = l \cdot w \cdot h$, then with an equal sign introduces the values in parentheses with their units, and finally the answer with its units that follow from the units in the calculation:

$$\boldsymbol{V = l \cdot w \cdot h = (20\,\text{cm}) \cdot (5\,\text{cm}) \cdot (10\,\text{cm}) = 1000\,\text{cm}^3}$$

In the Solutions to this example, an additional version of the answer is given: $= 0.00100\,\text{m}^3$. I give additional versions like this just so you might imagine alternate ways to write the answer, but I do not expect you to do so. You are likely to introduce an unnecessary error. The answer with cm^3 units is the one the follows from the problem setup. That is the one to give. In the very rare case that I might explicitly ask for the answer to be in m^3, you would need to insert a conversion factor and show the answer as

$$\boldsymbol{V = l \cdot w \cdot h = (20\,\text{cm}) \cdot (5\,\text{cm}) \cdot (10\,\text{cm}) \cdot \left(\frac{1\,\text{m}}{100\,\text{cm}}\right)^3 = 0.00100\,\text{m}^3}$$

Failure to include the correct conversion factor with the cube, will cost points. Notice how using the correct conversion factor with the cube makes the units work out correctly. If your units do not work out correctly, look for an error.

The 2nd question is very similar. Once you remember that the formula for the density of a material is at the very top of your Equation Sheet, you just plop the numbers into that formula being careful to include parentheses and units as shown. I will not mark off if you leave out the center dots indicating multiplication because the normal rules for algebra have adjacent parenthetical items being multiplied. I just like to use the dots to make it extra clear.

Once the density value has been calculated (correctly), you can use the table of densities at the top of the first page of your Equation Sheet to see that the material must be lead. Even if you got a number that did not exactly match 11.34 g/cm^3, like 11.32 g/cm^3, the answer would still be lead.

The 3rd question is a variation on the density calculation where you need to determine the mass when given density and volume values. You use your powers of algebra to rearrange the density formula to obtain

$$\boldsymbol{\rho = \frac{m}{V} \quad \text{so} \quad m = \rho V = (19.1\,\text{g/cm}^3) \cdot (120\,\text{cm}^3) = 2292\,\text{g}}$$

Again, I have left off the alternate versions of the answer. The above is all I expect from you. You could leave out the word "so", but it would be wrong to replace "so" by and equal sign. Just leaving a moderately large space is adequate.

If you were to do your algebra wrong and write $m = \frac{\rho}{V}$ ***WRONG*** , then your answer would be

$$\boldsymbol{\rho = \frac{m}{V} \quad \text{so} \quad m = \frac{\rho}{V} = \frac{19.1\,\text{g/cm}^3}{120\,\text{cm}^3} = 0.159\,\text{g/cm}^6 \quad \text{WRONG!!!}}$$

But notice how your units tell you the something is wrong. Mass needs to have units of g and you got g/cm^6 ! You would need to find where you went wrong – how did the two cm^3 not cancel?

Perhaps, instead of being asked to find the mass, the question gave you the density and mass and asked you to find the volume. You would then need to rearrange the density equation to look like $V = \frac{m}{\rho}$, and then do that calculation where your units will be $\frac{\mathrm{g}}{\mathrm{g/cm^3}} = \mathrm{g} \cdot \frac{\mathrm{cm^3}}{\mathrm{g}} = \mathrm{cm^3}$.

The 4th question is about how masses scale with size in 3 dimensions. This is discussed in Chapter 1 of the text at page 7 in a section entitled "RATIOS AND GENERALIZATIONS".

Two cubes of gold are considered, one with sides that are 3 times larger than the sides of the other. So if the sides of the smaller cube are 2 cm long, its volume will be $(2\ \mathrm{cm})^3 = 8\ \mathrm{cm}^3$. The larger cube with sides 2x3=6 cm long will have a volume of $(6\ \mathrm{cm})^3 = 216\ \mathrm{cm}^3$. Since each side was 3 times longer, the volume is $3^3 = 27$ times as large. If another cube had sides 5 times as large, 10 cm on a side, then its volume would be $5^3 = 125$ times as large or $125 \times 8\ \mathrm{cm}^3 = 1000\ \mathrm{cm}^3$.

My critter cam recorded a large bobcat passing by. The next day, I went out with a meter stick and determined that the bobcat was about twice as tall as a large house cat. It would also be twice as long and twice as wide, so its mass would be $2^3 = 8$ times as great as the house cat.

When painting a floor area that requires 1 bucket of paint, you can guess that another floor area that is 3 times as wide and 3 times as long will require be $3 \times 3 = 3^2 = 9$ buckets of paint.

Areas scale as the square of sides, volumes scale as the cube of the sides. This applies to cubes, balls, cylinders, and bobcats. Our bones gain strength according to their cross-sectional area, so as animals get bigger, they need much larger legs. The ratio of body mass to bone strength is proportional to size; spiders just need thin legs in comparison their body size, people need medium legs, and elephants need huge legs.

The 5th question is just about knowing the meaning of $\boldsymbol{a \propto b}$, $\boldsymbol{a \propto 1/b}$, $\boldsymbol{a \propto b^2}$, and $\boldsymbol{a \propto 1/b^2}$.

The 6th question is discussed at the start of the Algebra Refresher handout at *https://yosemitefoothills.com/Science-1A/Handouts/Week-01/AlgebraRefresher.pdf* .

The 7th question is discussed in the 3rd section (Rearranging Equations) of the Algebra Refresher handout which is at *https://yosemitefoothills.com/Science-1A/Handouts/Week-01/AlgebraRefresher.pdf* .

The 8th question is a more complicated density calculation that requires use of scientific notation. The top of the Equation Sheet gives the formula for density, $\rho = \frac{m}{V}$, but in this question, the radius of the Earth is given, not its volume. Fortunately, the Earth is nearly a sphere and the question gives the formula for calculating the volume of a sphere from its radius, $V = \frac{4}{3}\pi r^3$. So the start of the answer is given, and you just need to finish it:

$$\boldsymbol{\rho = \frac{m}{V} = \frac{m}{\frac{4}{3}\pi r^3} = \frac{5.97 \times 10^{24}\ \mathrm{kg}}{\frac{4}{3}\pi\left(6.38 \times 10^{6}\ \mathrm{m}\right)^3} = 5488\ \mathrm{kg/m^3}}$$

Here, *m* and *r* are replaced by the values given in the problem statement. Unfortunately, students often forget to cube the radius. They might also have trouble dividing by 4/3. As explained in our Algebra Refresher section of dividing by fractions, the 4/3 needs to be flipped so you actually calculate the following:

$$\boldsymbol{\rho = \frac{3}{4} \cdot \frac{5.97 \times 10^{24}\ \mathrm{kg}}{\pi\left(6.38 \times 10^{6}\ \mathrm{m}\right)^3} = 5488\ \mathrm{kg/m^3}}$$

We will spend Wednesday's lab talking about using a calculator to do various types of calculations, but here is a preview which works on my loaner calculator, but may or may not work with your calculator:

3 x 5.97 x shift 10^x 24 ÷ 4 ÷ shift π ÷ (6.38 x shift 10^x 6) x^3 = and 5,488.121097 is then displayed.

The 10^x key on this calculator is the shift of the log key, π is the shift of the EXP key, and the x^3 is its own key which cubes the previous value (in parentheses in this case).

> My favorite calculator, a 35-year old Hewlett-Packard HP-41C, uses a "reverse Polish" method of entry with a 4 number "stack". Some Clovis teachers use this type of calculator, but I am pretty sure that no students do. It is easier to use once learned, but requires a bit of a mind warp to get comfortable with.

Many other calculators have an EE key for creating the $x10^{24}$. If you know how to do the above problem with your calculator, you could help us by sending an e-mail with the type of calculator and the necessary key strokes to do this calculation.

Often, the quickest way to learn without reading a manual, is to just play. Start with simple operations where you know the answers, and then move on to more complex ones.

The 9th, 10th, and 11th questions just affirm that you know the basic SI units for mass, time and distance. **Don't be fooled by the mass one, its basic unit is the kilogram, not gram.**

The 12th question checks if you studied the 10 unit prefixes mentioned in Section 5, Unit Prefixes, section of the Algebra Refresher handout. It is in
https://yosemitefoothills.com/Science-1A/Handouts/Week-01/AlgebraRefresher.pdf .
You must have those 10 prefixes memorized. They are **not** in your Equation Sheet. Any of the 10 will may show up in quiz and test questions.

Finally, the 13th question checks your graphing skills and requires that you report the slope and *y*-intercept of a line. Follow the instructions given several pages earlier in this note to do the graph.

If the graph is done correctly, the *y*-intercept is easy to see. It is where the line cuts through the vertical (*y*-) axis.

The handout shows the way most algebra books teach how to find the slope by using $m=\frac{\Delta y}{\Delta x}=\frac{y_2-y_1}{x_2-x_1}$ where (x_1, y_1) and (x_2, y_2) are any two points on the line. You will get the same slope if you use (3,1) and (-1,5) as in the example, or use the reverse (-1,5) and (3,1), or use any other pair like (2,2) and (3,1). Each pair of points will give you the same value for the slope *m*.
But there is an easier way to get the slope. It is recognizing that the slope is $m=\frac{\text{rise}}{\text{run}}$ where you look at two convenient places on the line and pretend you are running to the right from the left point to the right point. Your "run" is how far you move along the x-axis, and the "rise" is how much you go upward (positive rise) or downward (negative rise). For example choosing the points (0,4) and (2,2), the run is +2 and the rise is -2. So the slope is $m=\frac{\text{rise}}{\text{run}}=\frac{-2}{+2}=-1$. You can confirm the sign of the slope by looking at the line as a hill as you run toward the right. If it goes downhill, the slope is negative, and if it goes uphill, the slope is positive.

There is a strictly mathematically way to get the *y*-intercept once you have determined the slope. It works as follows:

> You know from your algebra class that the line must obey the equation $y=mx+b$.
> You can then use your slope *m* and any two points (*x*,*y*) to get an equation for the *y*-intercept *b*.
> For example, if you use the point (3,1) with your slope of -1, you get the equations $1=(-1)3+b$.
> This can then be solved by adding 3 to both sides:

$$1+3 = -3 + 3 + b \quad \text{which becomes} \quad 4 = b$$

Any point will work. Trying (2,2), we get $2 = (-1)2 + b$ where we must add 2 to both sides to solve, getting $4=b$ once again.

These are the type of questions you will find on Quiz 1. Let me know if the above explanations are not sufficiently clear.