PhyzExamples: Unit Conversion part 1

EXAMPLE #1

How many seconds are there in a day? What? You *don't* know off the top of your head? Ah, but you *do* know all the information needed to solve the problem. You know all the **conversion factors:**

There are 60 seconds in 1 minute:	1min = 60s	$\frac{1\text{min}}{60\text{s}}$ or $\frac{60\text{s}}{1\text{min}}$
There are 60 minutes in 1 hour:	1hr = 60min	or
There are 24 hours in a day:	1dy = 24hr	or

Think of all conversion factors as fractions just waiting to happen. For example, 1min = 60s can be thought of as the fraction 1min/60s or as 60s/min, both fractions numerically equal to 1 (fractions were obtained by the old “dividing both sides” trick). So next to each conversion factor listed above, write its **two** corresponding fractions. The basic premise of unit conversion is to take a value given in one unit and convert it into its equivalent value in another unit. Mathematically, that means cancelling the old unit, and bringing in the new one. Here’s how it's done:

Begin by writing the given value as a fraction. If this means simply writing the value "over 1" then do it!

$$1\text{ day} = \frac{1\text{ day}}{1}$$

Next, choose a conversion factor that, when multiplied by "1day / 1" will cancel "day" and bring in a new unit (in this case, we cannot go directly from "days" to "seconds," so we will use the intermediary steps of "hours" and "minutes"). Right now, we need a factor with "day" in the denominator. Write it in below and slash out the cancelled units.

$$1\text{ day} = \frac{1\text{ day}}{1} \times \underline{\hspace{2cm}}$$

Now, choose a factor with "hour" in the denominator so that hours will be eliminated. Write it in, again cancelling the units. Do not multiply or divide the numbers yet.

$$1\text{ day} = \frac{1\text{ day}}{1} \times \underline{\hspace{2cm}} \times \underline{\hspace{2cm}}$$

Next, eliminate "minutes"

$$1\text{ day} = \frac{1\text{ day}}{1} \times \underline{\hspace{2cm}} \times \underline{\hspace{2cm}} \times \underline{\hspace{2cm}} = \boxed{\text{THE ANSWER} \quad \underline{\hspace{2cm}}\ \text{s}}$$

All right! The only units left uncancelled are "seconds" which are the units we need (remember the original question?). So now it's time to calculate, or "plug and chug," as we say in the biz.

Example #2

Suppose you were told that the deepest point in Sleeping Bear Bay [in picturesque Northern Michigan] was 100 fathoms. Being the sports fan that you are, a fathom means nothing to you. “How many football fields is that?” you wonder. According to your know-it-all little (brother/sister), a fathom is 6ft. “Well,” you think, “a fathom is six feet, which means two yards; a football field is 100yards; so 100 fathoms translates into 200 yards which means it's two football fields down to the bottom of the bay. Am I smart or what?”

Let’s see that thought process again in slo-mo, using Mr. Baird's electronic chalkboard:

$$100\text{ fathoms} = \frac{100\ \cancel{\text{fathoms}}}{1} \times \frac{6\ \cancel{\text{feet}}}{1\ \cancel{\text{fathom}}} \times \frac{1\ \cancel{\text{yard}}}{3\ \cancel{\text{feet}}} \times \frac{1\text{ football field}}{100\ \cancel{\text{yards}}} = 2\text{ football fields}$$

First: 100 fathoms written as a fraction. Excellent opening move!

Next, multiply by the conversion factor so that fathoms cancel: A mathematical TKO!

Another conversion factor and feet are outta there!

The final conversion factor: from yards to football fields. Again, the crucial point is to arrange the conversion factor so that the units you don't want get annihilated, and the units you do want are left uncancelled.

PhyzExamples: Conversions part 2 and Dimensional Analysis

TWO AT A TIME

Sometimes you need to convert two units simultaneously. Consider converting ft/s into km/hr. Not only do you need to convert the units of length from feet to kilometers, but you must also convert the units of time from seconds to hours. Let's work out a single numerical factor that will convert any number of ft/s into units of km/hr. To calculate the conversion factor, we must ask ourselves, "how many km/hr is 1 ft/s?" So we begin with 1.0ft/s...

$$1.0\ \text{ft/s} = \frac{1.0\text{ft}}{\text{s}} \times \frac{\text{m}}{3.281\text{ft}} \times \frac{\text{km}}{1000\text{m}} \times \frac{60\text{s}}{\text{min}} \times \frac{60\text{min}}{\text{hr}} = 1.1\ \text{km/hr}$$

STRATEGY: First of all, write the initial unit as a proper fraction. This is a simple but important step.

I have arbitrarily chosen to first convert the units of distance. I could have decided to convert the units of time first. I could have also converted directly from feet to kilometers, since the table lists the conversion 1km=3281ft

Once I've left km in the numerator, I can go to work on the denominator. Notice that I can't convert both the length unit and the time unit at the same time: There is no such conversion factor of 30s=1ft !!! Again, I made this conversion the slow way. I could've used the conversion factor 1hr=3600s.

THE BIG IDEA

Paying close attention to units is exceedingly important in physics. *This is something new!* Paying close attention to units was probably not important in many other classes you've had (like math classes). In other classes, you may have only been concerned with pure numbers: how many apples Katy could buy if she had *x* nickels, *y* dimes, and *z* quarters; or how old Peter was if he was three times as old as Susan and half as old as Helga, the cleaning lady. Out here in the real universe, units of quantities are every bit as important as the numerical value.

Dimensional analysis allows you to determine a great deal of information about relations simply by considering the dimensions (or units) involved. What good does this do you? Many mistakes that cost students so many valuable quiz points could've been avoided if only the student had paid attention to units.

Example: an equation whose value we will study in a future unit gives time T (seconds) in terms of a length L (meters) and an acceleration g (meters/second^2) and a unitless constant (2π). The equation is:

$T = 2\pi \sqrt{(L/g)}$ Dimensional analysis reveals that the units come out to be seconds [$\sqrt{(\text{m}/\text{m/s}^2)} = \text{s}$]

Unfortunately, a student forgot if the fraction under the radical sign was L/g or g/L. He flipped a coin during the test and opted for g/L, plugged in some numbers, left out any consideration for units and is now serving time in a local correctional facility. If he had only considered units! [$\sqrt{(\text{m/s}^2/\text{m})} = 1/\text{s}$]

The Big Point? Never consider any physical quantity without simultaneously considering its unit. Always check units in your calculations: Don't blindly punch in a series of numbers and assume you're right; convince yourself you're right using **dimensional analysis.**

