

5.5: Unit Conversions

It is very common to have to work with quantities that are given in units other than the units you'd like to work with. Converting from one set of units to another involves a straightforward, virtually foolproof technique that's very simple to double-check. We'll illustrate the method here with some examples.

Appendix 63.14 gives a number of important conversion factors. More conversion factors are available from sources such as the *CRC Handbook of Chemistry and Physics*.

1. Write down the unit conversion factor as a ratio, and fill in the units in the numerator and denominator so that the units cancel out as needed.
2. Now fill in the numbers so that the numerator and denominator contain the same length, time, etc. (This is because you want each factor to be a multiplication by 1, so that you don't change the quantity—only its units.)

Simple Conversions

A simple unit conversion involves only one conversion factor. The method for doing the conversion is best illustrated with an example.

✓ Example 5.5.1

Convert 7 feet to inches.

Solution

First write down the unit conversion factor as a ratio, filling in the units as needed:

$$(7\text{ft}) \times \frac{\text{in}}{\text{ft}} \quad (5.5.1)$$

Notice that the units of feet cancel out, leaving units of inches. The next step is to fill in numbers so that the same length is in the numerator and denominator:

$$(7\text{ft}) \times \frac{12\text{in}}{1\text{ft}} \quad (5.5.2)$$

Now do the arithmetic:

$$(7\text{ft}) \times \frac{12\text{ in}}{1\text{ft}} = 84\text{inches} \quad (5.5.3)$$

More Complex Conversions

More complex conversions may involve more than one conversion factor. You'll need to think about what conversion factors you know, then put together a chain of them to get to the units you want.

✓ Example 5.5.2

Convert 60 miles per hour to feet per second.

Solution

First, write down a chain of conversion factor ratios, filling in units so that they cancel out correctly:

$$60 \frac{\text{mile}}{\text{hr}} \times \frac{\text{ft}}{\text{mile}} \times \frac{\text{hr}}{\text{sec}} \quad (5.5.4)$$

Units cancel out to leave ft/sec. Now fill in the numbers, putting the same length in the numerator and denominator in the first factor, and the same time in the numerator and denominator in the second factor:

$$60 \frac{\text{mile}}{\text{hr}} \times \frac{5280\text{ft}}{1\text{mile}} \times \frac{1\text{hr}}{3600\text{sec}} \quad (5.5.5)$$

Finally, do the arithmetic:

$$60 \frac{\text{mile}}{\text{hr}} \times \frac{5280\text{ft}}{1\text{mile}} \times \frac{1\text{hr}}{3600\text{sec}} = 88 \frac{\text{ft}}{\text{sec}} \quad (5.5.6)$$

✓ Example 5.5.3

Convert 250,000 furlongs per fortnight to meters per second.

Solution

We don't know how to convert furlongs per fortnight directly to meters per second, so we'll have to come up with a chain of conversion factors to do the conversion. We do know how to convert: furlongs to miles, miles to kilometers, kilometers to meters, fortnights to weeks, weeks to days, days to hours, hours to minutes, and minutes to seconds. So we start by writing conversion factor ratios, putting units where they need to be so that the result will have the desired target units (m/s) :

$$250,000 \frac{\text{furlong}}{\text{fortnight}} \times \frac{\text{mile}}{\text{furlong}} \times \frac{\text{km}}{\text{mile}} \times \frac{\text{m}}{\text{km}} \times \frac{\text{fortnight}}{\text{week}} \times \frac{\text{week}}{\text{day}} \times \frac{\text{day}}{\text{hr}} \times \frac{\text{hr}}{\text{min}} \times \frac{\text{min}}{\text{sec}} \quad (5.5.7)$$

If you check the units here, you'll see that almost everything cancels out; the only units left are m/s, which is what we want to convert to. Now fill in the numbers: we want to put either the same length or the same time in both the numerator and denominator:

$$\begin{aligned} 250,000 \frac{\text{furlong}}{\text{fortnight}} &\times \frac{1 \text{ mile}}{8 \text{ furlongs}} \times \frac{1.609344 \text{ km}}{1 \text{ mile}} \times \frac{1000 \text{ m}}{1 \text{ km}} \times \frac{1 \text{ fortnight}}{2 \text{ weeks}} \times \frac{1 \text{ week}}{7 \text{ days}} \times \frac{1 \text{ day}}{24 \text{ hr}} \times \frac{1 \text{ hr}}{60 \text{ min}} \\ &\times \frac{1 \text{ min}}{60 \text{ sec}} \\ &= 41.58 \text{ m/s} \end{aligned}$$

Conversions Involving Powers

Occasionally we need to do something like convert an area or volume when we know only the length conversion factor.

✓ Example 5.5.4

Convert 2000 cubic feet to gallons.

Solution

Let's think about what conversion factors we know. We know the conversion factor between gallons and cubic inches. We don't know the conversion factor between cubic feet and cubic inches, but we can convert between feet and inches. The conversion factors will look like this:

$$2000\text{ft}^3 \times \left(\frac{\text{in}}{\text{ft}}\right)^3 \times \frac{\text{gal}}{\text{in}^3} \quad (5.5.8)$$

With these units, the whole expression reduces to units of gallons. Now fill in the same length in the numerator and denominator of the first factor, and the same volume in the numerator and denominator of the second factor:

$$2000\text{ft}^3 \times \left(\frac{12\text{in}}{1\text{ft}}\right)^3 \times \frac{1\text{gal}}{231\text{in}^3} \quad (5.5.9)$$

Now do the arithmetic:

$$2000\text{ft}^3 \times \left(\frac{12\text{in}}{1\text{ft}}\right)^3 \times \frac{1 \text{ gal}}{231\text{in}^3} = 14,961 \text{ gallons} \quad (5.5.10)$$

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