Conversion of Units

Some problems in engineering mechanics may involve units that are not in the International System of Units (SI). In such cases, it may be necessary to convert from one system to another. In other cases the units being used may be within the same system but have a different prefix.

This leaflet illustrates examples of both types of conversions.

Converting from one system of units to another

In the U.S. Customary system of units (FPS) length is measured in feet (ft), force in pounds (lb), and time in seconds (s). The unit of mass, referred to as a *slug*, is therefore equal to the amount of matter accelerated at 1 ft s^{-2}, when acted up on by a force of 1 lb (derived from Newton's second law of Motion $\mathbf{F} = m\mathbf{a}$ — see mechanics sheet 2.2) this gives that 1 slug = 1 lb ft^{-1} s^2.

Table 1 provides some direct conversions factors between FPS and SI units.

Quantity	FPS Unit of measurement		SI Unit of measurement
Force	lb	=	4.4482 N
Mass	slug	=	14.5938 kg
Length	ft	=	0.3048 m

Table 1: Conversion factors

Converting from one metric unit to another metric unit

If you are converting large units to smaller units, i.e. converting metres to centimetres, you will need to MULTIPLY by a conversion factor. For example, to find the number of centimetres in 523 m, you will need to MULTIPLY 523 by 100. Thus, 523 m = 52 300 cm.

If you are converting small units to larger units, i.e. converting millimetres to centimetres, you will need to DIVIDE by a conversion factor. For example, to find the number of centimetres in 846 mm, you will need to DIVIDE by 10. Thus, 846 mm = 84.6 cm.

These examples are based on the decimal system of length where 1 m is the SI unit, with there being 100 cm in 1m and 1000 mm in 1m; this implies that there are 10 mm in 1 cm.

Worked example

Convert the speed of light (3.00×10^8 m s^{-1}) to km year^{-1}.

Solution Solving this type of problem involves following a succession of conversions from one metric unit to another.

The first step is to convert from m s^{-1} to km s^{-1} i.e. to change from m to km. This is changing from a smaller unit to a larger one (a kilometre is 1000 m), so we need to divide by 1000.

$$3.00 \times 10^8 \text{ m s}^{-1} = \frac{3.00 \times 10^8}{1000} \text{ km s}^{-1} = 3.00 \times 10^5 \text{ km s}^{-1}.$$

The next step is to convert s^{-1} into year^{-1}. A year is a longer (bigger) unit than a second so that s^{-1} is a bigger unit than year^{-1}. This means that we will be multiplying by a conversion factor. There are 3600 seconds in an hour, 24 hours in a day and 365 days in a year (approx.) so that

$$1 \text{ year} = 3600 \times 24 \times 365 \text{ s} = 3.1536 \times 10^7 \text{ s}.$$

Rearranging this will give us that

$$\frac{1}{3.1536 \times 10^7} \text{ year} = 1\text{s}.$$

Now taking reciprocals of both sides we get,

$$3.1536 \times 10^7 \text{ year}^{-1} = 1 \text{ s}^{-1}.$$

So now we can convert to km year^{-1} by multiplying the result from the previous step with the conversion from s^{-1} to year^{-1};

$$3.00 \times 10^8 \text{ m s}^{-1} = (3.00 \times 10^5) \times (3.1536 \times 10^7) \text{ km year}^{-1} = 9.4608 \times 10^{12} \text{ km year}^{-1}.$$

So, to three significant figures, the speed of light is 9.46×10^{12} km year^{-1}.

Commonly used non-SI units and their conversions

1) The symbol for the *litre* is l. The SI unit for volume is m^3 (cubic metre). The conversion from m^3 to l is $1l = 0.001$ m^3.

2) The *cubic centimetre*, symbol = cm^3, where one cm^3 equals one millilitre (ml). This unit is often used for measuring the volume of solids.

Exercises

1. Convert the folllowing values to SI units using Table 1 where required:
   a) 1297 lb, b) 1.6 slug, c) 3.281 feet

2. Convert the following into FPS units using Table 1 where required:
   a) 3048 m, b) 72 kg, c) 0.8 N

3. Convert 600 ft minute^{-1} into m s^{-1} using the step by step method.

Solutions

1. a) 5769 N. b) 23.35 kg. c) 1 m.

2. a) 10 000 feet. b) 4.9336 slug c) 0.179848 lb.

3. 3.048 m s^{-1}.