

The Metric System

The metric system was designed in the late 1700's as a way to simplify and standardize measurements. It is used today in most countries throughout the world, and is the accepted standard for measurements in science and medicine. In the metric system, there is one base unit for each type of measurement:

Mass --- gram (g)	Volume --- liter (L)
Length --- meter (m)	Time --- second (s or sec)

Larger or smaller units are derived by multiplying by powers of 10. Prefixes added to the base unit indicate whether the base unit has been increased or decreased:

Larger than base unit

<u>Prefix</u>	<u>Symbol</u>	<u>Value (multiple of base unit)</u>	
Giga-	G	1,000,000,000	(10^9)
Mega-	M	1,000,000	(10^6)
Kilo-	k	1,000	(10^3)
Hecto-	h	100	(10^2)
Deca- (Deka-)	dk	10	(10^1)

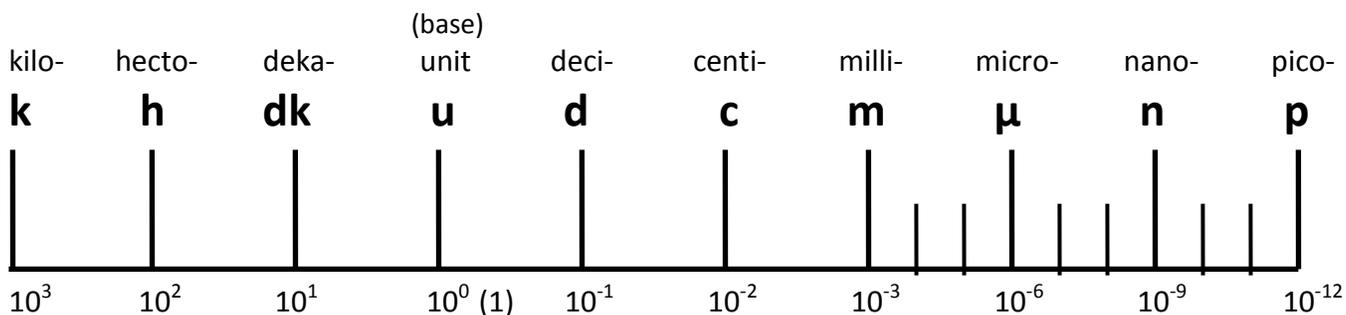
Base units

Gram, meter, liter, second	g,m, L,s	1	(10^0)
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Smaller than base unit

<u>Prefix</u>	<u>Symbol</u>	<u>Value (multiple of base unit)</u>	
deci-	d	0.1	(10^{-1})
centi-	c	0.01	(10^{-2})
milli-	m	0.001	(10^{-3})
micro-	μ	0.000001	(10^{-6})
nano-	n	0.000000001	(10^{-9})
pico-	p	0.000000000001	(10^{-12})

The following scale shows the most commonly used prefixes from largest to smallest (left to right):



Use the sentence “**K**ing **H**enry **D**ied **U**gly **D**rinking **C**hocolate **M**ilk with 3 **M**onks, 3 **N**uns, and 3 **P**riests” to remind you of the correct order of the prefixes. Using the number 3 with Monks, Nuns and Priests also reminds you that there are three “steps”, or powers of 10, from milli- to micro-, from micro- to nano-, and from nano- to pico-.

Converting units within the metric system involves multiplying or dividing by powers of 10, which changes the placement of the decimal point. If you are moving from smaller units to larger ones (from right to left on the scale), the decimal point moves to the left. To convert from larger units to smaller ones, move the decimal to the right. To find out how many places the decimal needs to move, count the steps on the scale between the starting unit and the final unit.

Example: Convert 0.016834 kilograms to centigrams.

Looking at the scale on the previous page, you have to move 5 steps to the right to go from kilo- to centi-, so the decimal point moves 5 places to the right:

$$0.016834 \text{ kg} \rightarrow 1683.4 \text{ cg}$$


You can also change from one unit to another mathematically by using unit analysis with conversion factors. First identify the starting units given in the problem, then determine what units you need to change to. Find the relationship between the two units and use it to set up a conversion factor. Multiply the given value by the conversion factor to change from one unit to the other.

Example: Convert 3470 meters to kilometers.

Your starting unit is meters, and you need to change to kilometers.

By referring to the list of prefixes, you find that 1,000 meters = 1 kilometer, so the two possible conversion factors are:

$$\frac{1 \text{ kilometer}}{1,000 \text{ meters}} \quad \text{or} \quad \frac{1000 \text{ meters}}{1 \text{ kilometer}}$$

In order to cancel out the starting unit (meters), you need the first conversion factor - the one that has the starting units in the denominator (on the bottom).

Given measurement		Conversion factor	=	Final units	=	
3470 meters	x	$\frac{1 \text{ kilometer}}{1000 \text{ meters}}$	=	$\frac{3470 \text{ kilometers}}{1000}$	=	3.470 kilometers

More than one step may be required to complete a conversion. For example, when converting from one metric unit to another, it is usually easier to change from the starting units to base units, and then change to the final unit (i.e. kilograms → grams → centigrams). Problems involving metric-English conversions frequently require more than one step. Try to “plan your course” first by breaking down the conversion into smaller steps.

Example: How many micrograms are in 7.3 kilograms?

Plan: convert kilograms → grams, then grams → micrograms

Relationships: 1 kilogram = 10^3 grams; 1 microgram = 10^{-6} grams

$$7.3 \text{ kilograms} \times \frac{10^3 \text{ grams}}{1 \text{ kilogram}} \times \frac{1 \text{ microgram}}{10^{-6} \text{ grams}} = \frac{(7.3 \times 10^3)}{10^{-6}} \text{ micrograms} = 7.3 \times 10^9 \text{ micrograms}$$

Example: How many milliliters are in a 16.0-oz. carton of juice?

(Given: 1 quart = 32 oz, and 1 quart = 946 milliliters)

Plan: convert ounces → quarts, then quarts → milliliters

$$16.0 \text{ ounces} \times \frac{1 \text{ quart}}{32 \text{ oz}} \times \frac{946 \text{ mL}}{1 \text{ quart}} = \frac{(16.0 \times 946)}{32} \text{ mL} = 473 \text{ milliliters}$$