Metric System and its History

Following is an explanation of the Metric System and its history. This is part of a set of pages on the metric system and metric system conversion; to see the main page (and other related pages), click on ***Metric System Conversion Table / Chart and Converter for Metric Conversions***.

The metric system is an internationally agreed set of units for measurement. Since 1960, the metric system is correctly known as the SI system, which is short for Systeme International d'Unites (International System of Units). However, it is still commonly (although somewhat incorrectly) continues to be referred to as the metric system. It has only seven basic measures (known as units), listed in the following table, of which the first four are in common use and the other three are mainly for technical and scientific purposes.

Type of measure	Standard Unit	Symbol
length	meter	m
mass (weight)	kilogram	kg
temperature	degree Kelvin (see discussion below)	K
time	second	s
electric current	ampere	A
amount of substance	mole	mol
luminous intensity	candela	cd

Although the kilogram is commonly used as a measure of **weight**, it is actually defined as a measure of **mass**. Weight is a measure of how heavy something is, whereas mass is a measure of the amount of matter. To illustrate, a 120 pound woman would weigh only 20 pounds on the moon (due to the moon having lower gravity than the earth), whereas a 50kg woman is 50kg on both the earth and the moon. In other words, her weight (how heavy she is) is less on the moon but her mass (how much matter she has) is unchanged. For everyday use, the difference between mass and weight is irrelevant, as everyone is together on the earth. However, for scientific calculations (e.g. objects being launched into space), the difference is important.

Also, temperature is officially measured in degrees Kelvin, but in day-to-day use the Celsius system is used instead. The original metric measure of temperature was the Celsius system, where 0°C was set to the freezing point of water. Officially, this has now been replaced by the Kelvin system, where 0°K is set to absolute zero (e.g. the temperature of outer space, at a point completely remote from any source of heat). However, it is much more natural to say 'what a hot day, it must be 40°C' than to say 'what a hot day, it must be 313°K'. Consequently, the system Celsius lives on in common usage.

The key to the simplicity of the metric system is its use of multiples of 10, and its reliance on only seven different base units. These units can then be combined to make other measures. For example, speed can be expressed as meters per second or volume in terms of cubic meter (a liter is the volume equal to a cube with each side 0.1 meters).

There are also some variations in spelling. In some countries the unit of length is spelled "meter", while in others it is spelled "metre". Likewise the unit of volume may be spelled "liter" or "liter" and abbreviated to "L" or "l".

Metric Prefixes

In the metric system, the standard units of measurement (see above table) are multiplied by 10 or divided by 10 in order to produce larger or smaller units. For example, a decimeter is a tenth of a meter and a decameter is 10 meters. For even larger or smaller units, one continues to divide or multiple by 10. For example, one can either say '1000 meters' or one can say 'a kilometer', as kilo means '1000' (which is 10 * 10 *10). The following table lists all of the prefixes.

This use of base 10 greatly simplifies calculations and is a major reason that the metric system has been so widely adopted. A simple illustration of this is to first measure a room in yards and inches and calculate the amount of required carpet in square yards, then repeat the measurement in meters and centimeters and calculate the amount of carpet in square meters. The latter calculation is far quicker and simpler.

One can either use the multiplication prefix combined with the measurement (e.g. kilometer) or the multiplication symbol combined with the measurement symbol (e.g. km). Combining a symbol with a non-symbol (e.g. kmeter or kilom) is not done.

For a list of some of the common measures and prefixes, click on ***Table of Metric and Imperial units***. Following is a complete list of the prefixes, but many of them are not in common usage and consequently may not be understood by everyone. For example, most people will say '10 meters' rather than '1 decameter'. Both are correct, but the former is much more frequently used and understood.

Multiplication factor (scientific notation)	**Prefix**	**Symbol**
(10^{24})	yotta	Y
$(10^{21)}$	zetta	Z
(10^{18})	exa	E
(10^{15})	peta	P
(10^{12})	tera	T
1 000 000 000 (10^{9})	giga	G
1 000 000 (10^{6})	mega	M
1000 (10^{3})	kilo	k
100 (10^{2})	hecto	h
10 (10^{1})	deka	da
0.1 (10^{-1})	deci	d
0.01 (10^{-2})	centi	c
0.001 (10^{-3})	milli	m
0.000 001 $(10^{-6)}$	micro	µ
0.000 000 001 (10^{-9})	nano	n
(10^{-12})	pico	p
(10^{-15})	femto	f
(10^{-18})	atto	a
(10^{-21})	zepto	z
(10^{-24})	yocto	y

History and Definition of the Meter

The word 'meter' is from the Greek word 'metron', which means 'a measure'. At the time the metric system was being defined, there were two competing approaches to the definition of the length of the meter. The initial suggestion was that it be the length of 'a pendulum having a half-period of one second'. The alternative approach was to set it to one ten-millionth of 'the length of the earth's meridian along a quadrant'. Specifically, one ten-millionth of the distance from the North Pole to the equator, along the meridian running near Dunkirk in France. The French Academy of Science, which was tasked with developing the metric system, decided on the latter approach in 1991 (on the basis that the former approach does not give a consistent measure, as slight variations in the earth's gravity from one place to another would result in different values).

This distance was calculated (with a slight error, as the flattening of the earth due to its rotation was not taken into account), and a brass bar of metal was cast to this length. This metal bar was then used as the standard. Since then, although the length has remained constant, several changes have been made to the definition in order to increase the precision of the measurement. First this involved replacing the brass bar by a platinum bar (and subsequently a platinum-iridium bar) and specifying the conditions (e.g. temperature) under which the bar is stored. Later, for even greater precision, the definition was changed to reflect constant physical phenomenon rather than a metal rod. The following table summarizes the major changes. The definition used since 1983 is accurate to within $2.5*10^{-11}$.

Year	Definition of the Meter
1793	1 / 10 000 000 of the distance from the pole to the equator.
1795	Provisional meter bar constructed in brass.
1799	Definitive prototype meter bars constructed in platinum.
1889	International prototype meter bar in platinum-iridium, cross-section X.
1906	1 000 000 / 0.643 846 96 wavelengths in air of the red line of the cadmium spectrum.
1960	1 650 763.73 wavelengths in vacuum of the radiation corresponding to the transition between levels 2p10 and 5d5 of the krypton-86 atom.
1983	Length traveled by light in vacuum during 1 / 299 792 458 of a second.

History and Definition of Gram & Kilogram

A gram was initially defined as a cubic centimeter of water at its temperature of maximum density (4°C). Likewise, a kilogram was defined as a cubic decimeter of water (a cube 0.1 meters on each side), which is a thousand cubic centimeters or a thousand grams. This mass (weight) has been reproduced in a metal weight (platinum-iridium), which is now used as the standard. In other words, a kilogram is no longer officially defined in terms of the mass of a volume of water, but rather in terms of the mass of the corresponding official metal weight. Accordingly, a gram is now defined as one-thousandth of this metal weight, rather than in terms of a cubic centimeter of water.

Current Official Definitions

Measure	Definition
meter	The length of the path traveled by light in a vacuum during 1/299 792 458 of a second (see above discussion).
kilogram	The unit of mass equal to that of the international prototype of the kilogram (see above discussion). It is the only metric base unit defined in terms of an object; the other six are defined in terms of physical phenomenon.
second	The duration of 9 192 631 770 periods of the radiation corresponding to the transition between the two hyperfine levels of the ground state of the cesium 133 atom.
ampere	The constant current which, if maintained in two straight parallel conductors of infinite length, of negligible circular cross-section, and place 1 meter apart in vacuum, would produce between these two conductors a force equal to $2 * 10^{-7}$ newton per meter of length. *It is named after the French physicist Andre Ampere.*
kelvin	The unit of thermodynamic temperature, is the fraction 1/273.16 of the thermodynamic temperature of the triple point of water. *It is named after the Scottish mathematician and physicist Lord Kelvin.*
mole	The amount of substance of a system which contains as many elementary entities as there are atoms in 0.012 kilogram of carbon 12.
candela	The luminous intensity, in a given direction, of a source that emits monochromatic radiation of frequency $540 * 10^{12}$ hertz and that has a radiant intensity in that direction of 1/683 watt per steradian.

Notable Measures

Quantity	In metric	Imperial or USA
Freezing point of water	0°C	32°F
Boiling point of water	100°C	212°F
Healthy temperature of a person	37°C	98.6°F
Density of water	1 kg/l	10 pounds/Imperial gallon 8.35 pounds/USA gallon
Speed of light	300 000 km/s	186 000 miles/s
Speed of sound	330 m/s	1090 feet/s
Circumference of Earth	40 000 km	25 000 miles
Distance between earth and sun	150 000 000 km	93 000 000 miles
Distance between earth and moon	385 000 km	240 000 miles
Altitude of geostationary orbit	35 800 km	22 300 miles
Earth's gravity	10 m/s^2	32 feet/s^2

Notes:

- The above freezing and boiling points of water are the values for pure water. As most water (river, lakes, and especially sea water) has some impurities, the freezing points and boiling points are not exactly 0°C and 100°C for this water.
- The "healthy temperature" noted above is the accepted value. There are slight variations from person to person. More importantly, this is the 'average' temperature when measured orally; if measured elsewhere on the body the reading will normally be somewhat different.
- The Imperial/USA measures are only approximate, in particular due to imprecision and inconsistency in the measures (e.g. different definitions of a gallon).
- Figures are rounded to the nearest figure for simplicity (e.g. the speed of light is actually only 299 792 458 m/s).

Key Dates in History of Metric System

1585	A decimal system for weights and measures is proposed (by Simon Stevin, in his book "*The tenth*").
1670	Gabriel Mouton, Vicar of St. Paul's Church in Lyons and an astronomer, proposes a metric system. Authorities credit him as the originator of what was to become the metric system.
1790	Thomas Jefferson proposed a decimal based measurement system for the USA. A subsequent vote in the USA congress to replace the current UK-based system by a metric system was lost by only one vote.
1790s	Investigations conducted into reforming French weights and measures, which result in development and adoption of the metric system. Credit for authorizing this is variously assigned (depending on which document one reads) to Louis XVI, Napoleon and the National Assembly of France.
1795	The metric system becomes the official system of measurement in France
1840	Metric system compulsory in France since this date.
1800s	International support for metric system grows. International scientific community switches to metric system.
1900s	By 1900, 39 countries had officially switched to the metric system. By the end of the century virtually all countries, with the USA being the only notable exception, had switched to the metric system.
1959	UK and USA redefine the inch to be 2.54 cm. In 1963 the UK redefines the pound to be exactly 0.45359237 kilograms. In 1985 the UK redefines the gallon to be exactly 3.785411764 liters. The USA took similar steps, although the USA gallon is smaller and consequently has been redefined as 3.785411784 liters.
1960	The metric system officially renamed to "Système International d'Unités" (International System of Units), and given the official symbol SI.
Current	The metric system has been adapted by virtually every country, with the only notable exception being the USA (the other non-metric countries are Liberia and Burma). Some countries (such as the UK) are still in transition to the metric system.