# A Dictionary of Units

by ***Frank Tapson***

**This provides a summary of most of the units of measurement to be found in use around the world today (and a few of historical interest), together with the appropriate conversion factors needed to change them into a 'standard' unit of the S I.**

**The units may be found either by looking under the category in which they are used [such as length, mass, density, energy etc.], or else by picking one unit from an alphabetically ordered list of units. There are NO units of currency.There is an outline of the S I; a list of its basic defining standards and also some of its derived units; then another list of all the S I prefixes and some notes on conventions of usage.There is a short historical note on measures generally; descriptions of the Metric system, the U K (Imperial) system with a statement on the implementation of 'metrication' in the U K, and the U S system.Finally there is a list of other sources concerned with the topic of measures and units (including other Web sites) and also some notes about this document.**

**There is a separate document covering FAQ and other Measures**

**A Summary Table of Conversion Factors most often required is available here.**

Or, to get a **Conversion Calculator**, select required category here *[Each is less than 20 kB]*
*Netscape (4.5 - or better) is required.*
Internet Explorer 5.0 also works for most of these.

| | | | | |
|---|---|---|---|---|
| **Length** | **Area** | **Volume** | **Mass** | **Temperature** |
| **Feet & Inches** | | | **Pounds & Ounces** | |
| **Density** | **Pressure & Stress** | **Speed** | **Fuel Consumption** | **Power** |
| or ONE calculator just for **Changing Prefixes** | | | | |
| **Energy** (Work) | **Flow Rate** **by Mass** **by Volume** | | **Force** | **Torque** |
| **Specific Energy** **by Mass** **by Volume** (Calorific Value) | | **Spread Rate** **by Mass** **by Volume** (including Rainfall) | | **Concentration** |

| Line Density (inc. Textiles) | Area Density | Acceleration | Viscosity Dynamic Kinematic |
|---|---|---|---|

There is a Selection of Other Calculators also available

# Summary table of conversion factors most often required

**x** means 'multiply by' . . . **/** means 'divide by' . . . **#** means it is an exact value
All other values given to an appropriate degree of accuracy.

| To change . . | into . . | do this . . | To change . . | into . . | do this . . |
|---|---|---|---|---|---|
| acres | hectares | **x 0.4047** | kilograms | ounces | **x 35.3** |
| acres | sq. kilometres | **/ 247** | kilograms | pounds | **x 2.2046** |
| acres | sq. metres | **x 4047** | kilograms | tonnes | **/ 1000 #** |
| acres | sq. miles | **/ 640 #** | kilograms | tons (UK/long) | **/ 1016** |
| barrels (oil) | cu.metres | **/ 6.29** | kilograms | tons (US/short) | **/ 907** |
| barrels (oil) | gallons (UK) | **x 34.97** | kilometres | metres | **x 1000 #** |
| barrels (oil) | gallons (US) | **x 42 #** | kilometres | miles | **x 0.6214** |
| barrels (oil) | litres | **x 159** | litres | cu.inches | **x 61.02** |
| centimetres | feet | **/ 30.48 #** | litres | gallons (UK) | **x 0.2200** |
| centimetres | inches | **/ 2.54 #** | litres | gallons (US) | **x 0.2642** |
| centimetres | metres | **/ 100 #** | litres | pints (UK) | **x 1.760** |
| centimetres | millimetres | **x 10 #** | litres | pints (US liquid) | **x 2.113** |
| cubic cm | cubic inches | **x 0.06102** | metres | yards | **/ 0.9144 #** |
| cubic cm | litres | **/ 1000 #** | metres | centimetres | **x 100 #** |
| cubic cm | millilitres | **x 1 #** | miles | kilometres | **x 1.609** |
| cubic feet | cubic inches | **x 1728 #** | millimetres | inches | **/ 25.4 #** |
| cubic feet | cubic metres | **x 0.0283** | ounces | grams | **x 28.35** |
| cubic feet | cubic yards | **/ 27 #** | pints (UK) | litres | **x 0.5683** |
| cubic feet | gallons (UK) | **x 6.229** | pints (UK) | pints (US liquid) | **x 1.201** |
| cubic feet | gallons (US) | **x 7.481** | pints (US liquid) | litres | **x 0.4732** |
| cubic feet | litres | **x 28.32** | pints (US liquid) | pints (UK) | **x 0.8327** |
| cubic inches | cubic cm | **x 16.39** | pounds | kilograms | **x 0.4536** |
| cubic inches | litres | **x 0.01639** | pounds | ounces | **x 16 #** |
| cubic metres | cubic feet | **x 35.31** | | | |

| To change . . | into . . | do this . . | To change . . | into . . | do this . . |
|---|---|---|---|---|---|
| | | | square cm | sq. inches | **x 0.1550** |
| feet | centimetres | **x 30.48 #** | square feet | sq. inches | **x 144 #** |
| feet | metres | **x 0.3048 #** | square feet | sq. metres | **x 0.0929** |
| feet | yards | **/ 3 #** | square inches | square cm | **x 6.4516 #** |
| fl.ounces (UK) | fl.ounces (US) | **x 0.961** | square inches | square feet | **/ 144 #** |
| fl.ounces (UK) | millilitres | **x 28.41** | square km | acres | **x 247** |
| fl.ounces (US) | fl.ounces (UK) | **x 1.041** | square km | hectares | **x 100 #** |
| fl.ounces (US) | millilitres | **x 29.57** | square km | square miles | **x 0.3861** |
| gallons | pints | **x 8 #** | square metres | acres | **/ 4047** |
| gallons (UK) | cubic feet | **x 0.1605** | square metres | hectares | **/ 10 000 #** |
| gallons (UK) | gallons (US) | **x 1.2009** | square metres | square feet | **x 10.76** |
| gallons (UK) | litres | **x 4.54609 #** | square metres | square yards | **x 1.196** |
| gallons (US) | cubic feet | **x 0.1337** | square miles | acres | **x 640 #** |
| gallons (US) | gallons (UK) | **x 0.8327** | square miles | hectares | **x 259** |
| gallons (US) | litres | **x 3.785** | square miles | square km | **x 2.590** |
| grams | kilograms | **/ 1000 #** | square yards | square metres | **/ 1.196** |
| grams | ounces | **/ 28.35** | tonnes | kilograms | **x 1000 #** |
| hectares | acres | **x 2.471** | tonnes | tons (UK/long) | **x 0.9842** |
| hectares | square km | **/ 100 #** | tonnes | tons (US/short) | **x 1.1023** |
| hectares | square metres | **x 10000 #** | tons (UK/long) | kilograms | **x 1016** |
| hectares | square miles | **/ 259** | tons (UK/long) | tonnes | **x 1.016** |
| hectares | square yards | **x 11 960** | tons (US/short) | kilograms | **x 907.2** |
| inches | centimetres | **x 2.54 #** | tons (US/short) | tonnes | **x 0.9072** |
| inches | feet | **/ 12 #** | yards | metres | **x 0.9144 #** |

# The Systeme International [S I]

Le Systeme international d'Unites officially came into being in October 1960 and has been adopted by nearly all countries, though the amount of actual usage varies considerably.

It is based upon 7 principal units, 1 in each of 7 different categories -

| *Category* | *Name* | *Abbreviation* |
|---|---|---|
| Length | metre | m |
| Mass | kilogram | kg |
| Time | second | s |
| Electric current | ampere | A |
| Temperature | kelvin | K |
| Amount of substance | mole | mol |
| Luminous intensity | candela | cd |

Definitions of these basic units are given. Each of these units may take a prefix. From these basic units many other units are derived and named.

Return to the top of this document

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# Definitions of the Seven Basic S I Units

**metre [m]**
: The metre is the basic unit of length. It is the distance light travels, in a vacuum, in 1/299792458*th* of a second.

**kilogram [kg]**
: The kilogram is the basic unit of mass. It is the mass of an international prototype in the form of a platinum-iridium cylinder kept at Sevres in France. *It is now the only basic unit still defined in terms of a material object, and also the only one with a prefix[kilo] already in place.*

**second [s]**
: The second is the basic unit of time. It is the length of time taken for 9192631770 periods of vibration of the caesium-133 atom to occur.

**ampere [A]**
: The ampere is the basic unit of electric current. It is that current which produces a specified force between two parallel wires which are 1 metre apart in a vacuum.*It is named after the French physicist Andre Ampere (1775-1836).*

**kelvin [K]**
: The kelvin is the basic unit of temperature. It is 1/273.16*th* of the thermodynamic temperature of the triple point of water. *It is named after the Scottish mathematician and physicist William Thomson 1st Lord Kelvin (1824-1907).*

**mole [mol]**
: The mole is the basic unit of substance. It is the amount of substance that contains as many elementary units as there are atoms in 0.012 kg of carbon-12.

**candela [cd]**

The candela is the basic unit of luminous intensity. It is the intensity of a source of light of a specified frequency, which gives a specified amount of power in a given direction.

Return to the top of this document

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# Derived Units of the S I

From the 7 basic units of the SI many other units are derived for a variety of purposes. Only some of them are explained here. The units printed in **bold** are either basic units or else, in some cases, are themselves derived.

**farad [F]**

The farad is the SI unit of the capacitance of an electrical system, that is, its capacity to store electricity. It is a rather large unit as defined and is more often used as a microfarad. *It is named after the English chemist and physicist Michael Faraday (1791-1867).*

**hertz [Hz]**

The hertz is the SI unit of the frequency of a periodic phenomenon. One hertz indicates that 1 cycle of the phenomenon occurs every **second**. For most work much higher frequencies are needed such as the kilohertz [kHz] and megahertz [MHz]. *It is named after the German physicist Heinrich Rudolph Hertz (1857-94).*

**joule [J]**

The joule is the SI unit of work or energy. One joule is the amount of work done when an applied force of 1 **newton** moves through a distance of 1 **metre** in the direction of the force.*It is named after the English physicist James Prescott Joule (1818-89).*

**newton [N]**

The newton is the SI unit of force. One newton is the force required to give a mass of 1 **kilogram** an acceleration of 1 **metre** per **second** per **second.** *It is named after the English mathematician and physicist Sir Isaac Newton (1642-1727).*

**ohm [ ]**

The ohm is the SI unit of resistance of an electrical conductor. Its symbol, is the capital Greek letter 'omega'. *It is named after the German physicist Georg Simon Ohm (1789-1854).*

**pascal [Pa]**

The pascal is the SI unit of pressure. One pascal is the pressure generated by a force of 1 **newton** acting on an area of 1 square **metre**. It is a rather small unit as defined and is more often used as a kilopascal [kPa]. *It is named after the French mathematician, physicist and philosopher Blaise Pascal (1623-62).*

**volt [V]**

The volt is the SI unit of electric potential. One volt is the difference of potential between two points of an electical conductor when a current of 1 **ampere** flowing

between those points dissipates a power of 1 **watt**. *It is named after the Italian physicist Count Alessandro Giuseppe Anastasio Volta (1745-1827).*

**watt [W]**

The watt is used to measure power or the rate of doing work. One watt is a power of 1 **joule** per **second**. *It is named after the Scottish engineer James Watt (1736-1819).*

Note that prefixes may be used in conjunction with any of the above units.

Return to the top of this document

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# The Prefixes of the S I

The S I allows the sizes of units to be made bigger or smaller by the use of appropriate prefixes. For example, the electrical unit of a watt is not a big unit even in terms of ordinary household use, so it is generally used in terms of 1000 watts at a time. The prefix for 1000 is *kilo* so we use kilowatts[kW] as our unit of measurement. For makers of electricity, or bigger users such as industry, it is common to use megawatts[MW] or even gigawatts[GW]. The full range of prefixes with their [symbols or abbreviations] and their multiplying factors *which are also given in other forms* is

```
        yotta [Y] 1 000 000 000 000 000 000 000 000   = 10^24
        zetta [Z] 1 000 000 000 000 000 000 000               = 10^21
        exa   [E] 1 000 000 000 000 000 000           = 10^18
        peta  [P] 1 000 000 000 000 000                       = 10^15
        tera  [T] 1 000 000 000 000                   = 10^12
        giga  [G] 1 000 000 000                   (a thousand millions =
a billion)
        mega  [M] 1 000 000                       (a million)
        kilo  [k] 1 000                           (a thousand)
        hecto [h] 100
        deca  [da]10
                  1
        deci  [d] 0.1
        centi [c] 0.01
        milli [m] 0.001                           (a thousandth)
        micro [µ] 0.000 001                       (a millionth)
        nano  [n] 0.000 000 001                   (a thousand millionth)
        pico  [p] 0.000 000 000 001                   = 10^-12
        femto [f] 0.000 000 000 000 001                       = 10^-15
        atto  [a] 0.000 000 000 000 000 001           = 10^-18
        zepto [z] 0.000 000 000 000 000 000 001               = 10^-21
        yocto [y] 0.000 000 000 000 000 000 000 001   = 10^-24
```

[µ] the symbol used for **micro** is the Greek letter known as 'mu'

Nearly all of the S I prefixes are multiples or sub-multiples of 1000. However, these are inconvenient for many purposes and so **hecto**, **deca**, **deci**, and **centi** are also used.

**deca** also appears as **deka [da]** or **[dk]** in the USA and Contintental Europe. So much for standards!

Return to the top of this document

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# Conventions of Usage in the S I

There are various rules laid down for the use of the SI and its units as well as some observations to be made that will help in its correct use.

Any unit may take only ONE prefix. For example 'millimillimetre' is incorrect and should be written as 'micrometre'.
Most prefixes which make a unit bigger are written in capital letters (M G T etc.), but when they make a unit smaller then lower case (m n p etc.) is used.
Exceptions to this are the kilo [k] to avoid any possible confusion with kelvin [K]; hecto [h]; and deca [da] or [dk]
A unit which is named after a person is written all in lower case (newton, volt, pascal etc.) when named in full, but starting with a capital letter (N V Pa etc.) when abbreviated. An exception to this rule is the litre which, if written as a lower case 'l' could be mistaken for a '1' (one) and so a capital 'L' is allowed as an alternative. It is intended that a single letter will be decided upon some time in the future when it becomes clear which letter is being favoured most in use.
Units written in abbreviated form are NEVER pluralised. So 'm' could always be either 'metre' or 'metres'. 'ms' could represent 'metre second' (whatever that is) or, more correctly, 'millisecond'.
An abbreviation (such as J N g Pa etc.) is NEVER followed by a full-stop unless it is the end of a sentence.
To make numbers easier to read they may be divided into groups of 3 separated by spaces (or half-spaces) but NOT commas.
The SI preferred way of showing a decimal fraction is to use a comma (123,456) to separate the whole number from its fractional part. The practice of using a point, as is common in English-speaking countries, is acceptable providing only that the point is placed ON the line of the bottom edge of the numbers (123.456).
It will be noted that many units are eponymous, that is they are named after persons. This is always someone who was prominent in the early work done within the field in which the unit is used.

Return to the top of this document

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# A Brief History of Measurement

One of the earliest types of measurement concerned that of length. These measurements were usually based on parts of the body. A well documented example (the first) is the Egyptian cubit which was derived from the length of the arm from the elbow to the outstretched finger tips. By 2500 BC this had been standardised in a royal master cubit made of black marble (about 52 cm). This cubit was divided into 28 digits (roughly a

finger width) which could be further divided into fractional parts, the smallest of these being only just over a millimetre.

In England units of measurement were not properly standardised until the 13th century, though variations (and abuses) continued until long after that. For example, there were three different gallons (ale, wine and corn) up until 1824 when the gallon was standardised.

In the U S A the system of weights and measured first adopted was that of the English, though a few differences came in when decisions were made at the time of standardisation in 1836. For instance, the wine-gallon of 231 cubic inches was used instead of the English one (as defined in 1824) of about 277 cubic inches. The U S A also took as their standard of dry measure the old Winchester bushel of 2150.42 cubic inches, which gave a dry gallon of nearly 269 cubic inches.

Even as late as the middle of the 20th century there were some differences in UK and US measures which were nominally the same. The UK inch measured 2.53998 cm while the US inch was 2.540005 cm. Both were standardised at 2.54 cm in July 1959, though the U S continued to use 'their' value for several years in land surveying work - this too is slowly being metricated.

In France the metric system officially started in June 1799 with the declared intent of being 'For all people, for all time'. The unit of length was the metre which was defined as being one ten-millionth part of a quarter of the earth's circumference. The production of this standard required a very careful survey to be done which took several years. However, as more accurate instruments became available so the 'exactness' of the standard was called into question. Later efforts were directed at finding some absolute standard based on an observable physical phenomenon. Over two centuries this developed into the S I. So maybe their original slogan was more correct than anyone could have foreseen then.

Return to the top of this document

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# Metric System of Measurements

| Length | Area |
|---|---|
| 10 millimetres = 1 centimetre | 100 sq. mm = 1 sq. cm |
| 10 centimetres = 1 decimeter | 10 000 sq. cm = 1 sq. metre |
| 10 decimetres = 1 metre | 100 sq. metres = 1 are |
| 10 metres = 1 decametre | 100 ares = 1 hectare |
| 10 decametres = 1 hectometre | 10 000 sq. metres = 1 hectare |

10 hectometres = 1 kilometre  100 hectares = 1 sq. kilometre
1000 metres = 1 kilometre  1 000 000 sq. metres = 1 sq. kilometre

**Volume**

1000 cu. mm = 1 cu. cm
1000 cu. cm = 1 cu. decimetre
1000 cu. dm = 1 cu. metre
1 million cu. cm = 1 cu. metre

**Capacity**

10 millilitres = 1 centilitre
10 centilitree = 1 decilitre
10 decilitres = 1 litre
1000 litres = 1 cu. metre

**Mass**

1000 grams = 1 kilogram
1000 kilograms = 1 tonne

The distinction between 'Volume' and 'Capacity' is artificial and kept here only for historic reasons.
A **millitre** is a **cubic centimetre** and a **cubic decimetre** is a **litre**. But see under 'Volume' for problems with the **litre**.

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# The U K (Imperial) System of Measurements

**Length**

12 inches = 1 foot
3 feet = 1 yard
22 yards = 1 chain
10 chains = 1 furlong
8 furlongs = 1 mile
5280 feet = 1 mile
1760 yards = 1 mile

**Area**

144 sq. inches = 1 square foot
9 sq. feet = 1 square yard
4840 sq. yards = 1 acre
640 acres = 1 square mile

**Volume**

1728 cu. inches = 1 cubic foot
27 cu. feet = 1 cubic yard

**Capacity**

20 fluid ounces = 1 pint
4 gills = 1 pint
2 pints = 1 quart
4 quarts = 1 gallon (8 pints)

**Mass (Avoirdupois)**

437.5 grains = 1 ounce
16 ounces = 1 pound (7000 grains)
14 pounds = 1 stone
8 stones = 1 hundredweight [cwt]

**Troy Weights**

24 grains = 1 pennyweight
20 pennyweights = 1 ounce (480 grains)
12 ounces = 1 pound (5760 grains)

```
          20 cwt      = 1 ton (2240 pounds)

            Apothecaries' Measures                Apothecaries' Weights
          20 minims      = 1 fl.scruple         20 grains   = 1 scruple
           3 fl.scruples = 1 fl.drachm           3 scruples = 1 drachm
           8 fl.drachms  = 1 fl.ounce            8 drachms  = 1 ounce (480
grains)
          20 fl.ounces   = 1 pint               12 ounces   = 1 pound
(5760 grains)
```

The old Imperial (now UK) system was originally defined by three standard measures - the yard, the pound and the gallon which were held in London. They are now defined by reference to the S I measures of the metre, the kilogram and the litre. These equivalent measures are **exact**.

1 yard = 0.9144 metres - same as US
1 pound = 0.453 592 37 kilograms - same as US
1 gallon = 4.546 09 litres
Note particularly that the UK gallon is a different size to the US gallon so that NO liquid measures of the same name are the same size in the UK and US systems.
Also that the ton(UK) is 2240 pounds while a ton(US) is 2000 pounds. These are also referred to as a long ton and short ton respectively.

Return to the top of this document

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# Metrication in the U K

There have been three major Weights and Measures Acts in recent times (1963, 1976 and 1985) all gradually abolishing various units, as well re-defining the standards. All the Apothecaries' measures are gone, and of the Troy measures, only the ounce remains. Currently legislation has decreed that -

From the 1st October 1995, for economic, public health, public safety and administrative purposes, only metric units are allowed EXCEPT that -

- pounds and ounces for weighing of goods sold from bulk
- pints and fluid ounces for beer, cider, waters, lemonades and fruit juices in RETURNABLE containers
- therms for gas supply
- fathoms for marine navigation

may be used until 31st December 1999.

The following may continue to be used WITHOUT time limit -

- miles, yards, feet and inches for road traffic signs and related measurements of speed and distance

- pints for dispensing draught beer and cider, and for milk in RETURNABLE containers
- acres for land registration purposes
- troy ounces for transactions in precious metals.

Sports are exempt from all of this, but most of them have (voluntarily) changed their relevant regulations into statements of equivalent metric measures.

That is how the legislation is framed. In common usage the 'old' units are still very apparent.

Return to the top of this document