

A Dictionary of Units

» ÀÚ·á´Â ÀÎÁÍ³Ý»ó¿;¼- ±,ÇÑ ÀÚ·áÀÎµ×,µÅ©,, ½ÃÄÑ³õÀ.Á°í Çβ´Ù°; È±½Ã Áβ°£¿; ÀÚ·á°; ¾ø¾¿Áú°ÍA» ¿ì·ÁÇØ¼- ¿ì,® ¼-¹ö¿; °¹»çÇØ ³õÀ° ÀÚ·á ÀÔ´Û. ¼öÁ±À» °;ÇÏÁö ¾ÊÀ° ¿ø°» ±×´ë·Î ÀÔ´Û.

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 (with a few references to currencies) and also some [notes](#) about this document.

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 -

<i>Category</i>	<i>Name</i>	<i>Abbr</i>
Length	metre	
Mass	ki l ogram	
Ti me	second	
Electric current	ampere	
Temperature	kel vi n	
Amount of substance	mole	
Lumi nous i nte nsi ty	candel a	

[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.

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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.

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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 Herz (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, shown here as [*] is the Greek letter known as '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 electrical 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.

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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]	1 000 000 000 000 000 000 000 000 000	= 10 ²⁴
zetta	[Z]	1 000 000 000 000 000 000 000 000	= 10 ²¹
exa	[E]	1 000 000 000 000 000 000 000	= 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 milli
mega	[M]	1 000 000	(a million)
kilo	[k]	1 000	(a thousand)
		1	
milli	[m]	0.001	(a thousandth)
micro	[*]	0.000 001	(a millionth)
nano	[n]	0.000 000 001	(a thousand milli
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

[*] the symbol used here is the Greek letter known as 'mu'

All of the S I prefixes are multiples or sub-multiples of 1000. However, these are inconvenient for many purposes and so **hecta** (x 100), **deca** (x 10), **deci** (x 0.1), and **centi** (x 0.01) are also used.

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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'.

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. The one exception to this is kilo [k] to avoid any possible confusion with kelvin [K].

A unit which is named after a person is written all in lower case (newton, volt, pascal etc.) when named in full, but using a capital letter (N V P 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.

Units written in abbreviated form are never pluralised. So 'm' could always be either 'metre' or 'metres'. 'ms' would represent 'metre second'.

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.

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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 defined a separate dry gallon of about 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.

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.

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Metric System of Measurements

Length		Area	
10 millimetres	= 1 centimetre	100 sq. mm	
10 centimetres	= 1 decimeter	10 000 sq. cm	
10 decimetres	= 1 metre	100 sq. metr	
10 metres	= 1 dekametre	100 ares	
10 dekametres	= 1 hectometre	10 000 sq. metr	
10 hectometres	= 1 kilometre	100 hectares	
1000 metres	= 1 kilometre	1 000 000 sq. metr	
		Capa	
		10 millilit	
		10 centilit	
		10 decilitr	
		1000 litres	
Volume			
1000 cu. mm	= 1 cu. cm		
1 000 000 cu. cm	= 1 cu. metre		
		Mass	
		1000 grams	= 1 kilogram
		1000 kilograms	= 1 tonne

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The U K (Imperial) System of Measurements

Length		Area	
12 inches	= 1 foot	144 sq. inches	= 1
3 feet	= 1 yard	9 sq. feet	= 1
22 yards	= 1 chain	4840 sq. yards	= 1
10 chains	= 1 furlong	640 acres	= 1
8 furlongs	= 1 mile		
5280 feet	= 1 mile	Capacity	
1760 yards	= 1 mile	20 fluid ounces	= 1
		4 gills	= 1
		2 pints	= 1
		4 quarts	= 1
Volume			
1728 cu. inches	= 1 cubic foot		
27 cu. feet	= 1 cubic yard		
Mass			
437.5 grains	= 1 ounce		
		Troy Weight:	

16 ounces	= 1 pound (7000 grains)	24 grains	= 1
14 pounds	= 1 stone	20 pennyweights	= 1
8 stones	= 1 hundredweight [cwt]	12 ounces	= 1
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
20 fl. ounces	= 1 pint	12 ounces	= 1 pound

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 SI 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.

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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.

The above only covers matters of trade.
Consenting adults (in private) may use any units they please.

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The U S System of Measurements

Most of the US system of measurements is the same as that for the UK. The biggest differences to be noted are in Capacity which has both liquid and dry measures as well as being based on a different standard - the US liquid gallon is smaller than the UK gallon. There is also a measurement known at the US survey foot. It is gradually being phased out as the maps and land plans are re-drawn under metrication. (The changeover is being made by putting 39.37 US survey feet = 12 metres)

Length		Area	
12 inches	= 1 foot	144 sq. inches	= 1
3 feet	= 1 yard	9 sq. feet	= 1
220 yards	= 1 furlong	4840 sq. yards	= 1
8 furlongs	= 1 mile	640 acres	= 1
5280 feet	= 1 mile	1 sq. mile	= 1
1760 yards	= 1 mile	36 sections	= 1
Volume			
1728 cu. inches	= 1 cubic foot		
27 cu. feet	= 1 cubic yard		
Capacity (Dry)		Capacity (Liquid)	
2 pints	= 1 quart	16 fluid ounces	=
8 quarts	= 1 peck	4 gills	=
4 pecks	= 1 bushel	2 pints	=
		4 quarts	=
Mass		Troy Weight:	
437.5 grains	= 1 ounce	24 grains	= 1
16 ounces	= 1 pound (7000 grains)	20 pennyweights	= 1
14 pounds	= 1 stone	12 ounces	= 1
100 pounds	= 1 hundredweight [cwt]		
20 cwt	= 1 ton (2000 pounds)		
Apothecaries' Measures		Apothecaries' Weight	
60 minims	= 1 fl. dram	20 grains	= 1 scruple
8 fl. drams	= 1 fl. ounce	3 scruples	= 1 dram
16 fl. ounces	= 1 pint	8 drams	= 1 ounce
		12 ounces	= 1 pound

As with the UK system these measures were originally defined by physical standard measures - the yard, the pound, the gallon and the bushel. They are now all defined by reference to the SI measures of the metre, the kilogram and the litre. These equivalent measures are **exact**.

1 yard = 0.9144 metres - same as UK

1 pound = 0.453 592 37 kilograms - same as UK

1 gallon (liquid) = 3.785 411 784 litres

1 bushel (dry) = 35.239 070 166 88 litres

Note particularly that the US gallon is a different size to the UK gallon so that NO liquid measures of the same name are the same size in the US and UK systems.

Also that the ton(US) is 2000 pounds while a ton(UK) is 2240 pounds. These are also referred to as a

short ton and long ton respectively.

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Categories of Units

[length](#)

[area](#)

[volume or capacity](#)

[mass](#)

[density, area](#)

[density, line](#)

[density, volume](#)

[energy](#)

[force](#)

[fuel consumption](#)

[line density](#)

[mass per unit length](#)

[mass per unit area](#)

[mass per unit volume](#)

[power](#)

[pressure](#)

[speed](#)

[spread rate \(by mass\)](#)

[spread rate \(by volume\)](#)

[stress](#)

[torque](#)

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List of Units

The units are listed in alphabetical order but scanning can be speeded up by selecting the initial letter of the unit from these individual letters or groups

[A](#) - [B](#) - [C](#) - [D](#) - [E](#) - [F](#) - [G](#) - [H](#) - [IJ](#) - [K](#) - [L](#) - [M](#)

[N](#) - [O](#) - [PQ](#) - [R](#) - [S](#) - [T](#) - [UVW](#) - [XYZ](#)

A

[acres](#)
[angstroms](#)
[ares](#)
[astronomical units](#)
[atmospheres](#)

B

[barleycorns](#)
[barrels \(oil\)](#)
[bars](#)
[British thermal units](#)
[Btu/hour etc.](#)
[bushels](#)

C

[calories](#)
[calories per hour etc.](#)
[carats, metric](#)
[centigrade heat units](#)
[centilitres](#)
[centimetres](#)
[centimetres of mercury or water](#)
[centimetres per minute etc.](#)
[chains \(surveyors'\)](#)
[circular inches](#)
[cubic \(+ any units\)](#)
[cubic measures per area](#)
[cubits](#)

D

[decilitres](#)
[denier](#)
[drex](#)
[dynes](#)

E

[ells \(UK\)](#)
[ems \(pica\)](#)
[ergs \(energy\)](#)
[ergs \(torque\)](#)

F

[fathoms](#)

[feet](#)
[feet of water](#)
[feet per hour etc.](#)
[fluid ounces](#)
[foot pounds-force](#)
[foot pounds-force per minute etc.](#)
[foot poundals](#)
[furlongs](#)

G

[gallons](#)
[gallons per area](#)
[gigajoules](#)
[gigawatts](#)
[grains](#)
[grains per gallon](#)
[grams](#)
[gram-force centimetres](#)
[grams per area](#)
[grams per cm](#)
[grams per \(any volume\)](#)

H

[hands](#)
[hectares](#)
[hides](#)
[horsepower](#)
[horsepower hours](#)
[hundredweights](#)

IJ

[inches](#)
[inches of mercury or water](#)
[inches of rain \(by mass\)](#)
[inches of rain \(by volume\)](#)
[inches per minute etc.](#)
[joules](#)
[joules per hour etc.](#)

K

[kilocalories](#)
[kilocalories per hour etc.](#)
[kilograms-force](#)
[kilogram-force metres \(energy\)](#)
[kilogram-force metres \(torque\)](#)
[kilogram-force metres per hour etc.](#)
[kilogram-force per area](#)

[kilograms](#)
[kilograms per area](#)
[kilograms per metre](#)
[kilograms per volume](#)
[kilojoules](#)
[kilojoules per hour etc.](#)
[kilometres](#)
[kilometres per hour etc.](#)
[kilometres per litre](#)
[kilonewton per square metre](#)
[kilonewtons](#)
[kilopascals](#)
[kilowatts](#)
[kilowatt hours](#)
[kips \(weight\)](#)
[kips \(force\)](#)
[kips per square inch](#)
[knots](#)

L

[leagues](#)
[light years](#)
[links \(surveyors'\)](#)
[litres](#)
[litres per area](#)

M

[Mach number](#)
[megajoules](#)
[meganewtons](#)
[meganewtons per square metre](#)
[megawatts](#)
[metres](#)
[metres of water](#)
[metres per second etc.](#)
[microns \(=micrometres\)](#)
[miles](#)
[miles per gallon](#)
[miles per hour etc.](#)
[millibars](#)
[milligrams per cm](#)
[milligrams per \(any volume\)](#)
[millilitres](#)
[millimetres of mercury or water](#)
[millimetres of rain \(by mass\)](#)
[millimetres of rain \(by volume\)](#)

N

[newton metres \(energy\)](#)

[newton metres \(torque\)](#)
[newtons \(per area\)](#)
[newtons \(force\)](#)
[newtons \(weight\)](#)

O

[ounces](#)
[ounces per inch](#)
[ounces per area](#)
[ounces per volume](#)

PQ

[parsecs](#)
[pascals](#)
[perch \(=rods or poles\)](#)
[picas](#)
[pints](#)
[points \(printers'\)](#)
[poundals](#)
[poundals per square foot](#)
[pounds](#)
[pounds per area](#)
[pounds per foot](#)
[pounds per volume](#)
[pounds-force](#)
[pound-force inches](#)
[pounds-force per area](#)
[quarts](#)

R

[roods](#)

S

[slugs \(or g-pounds\)](#)
[stones](#)
[square \(+ any units\)](#)
[squares \(of timber\)](#)
[sthenes](#)

T

[tex](#)
[therms](#)
[tonnes](#)
[ton-force metres](#)
[tonnes-force](#)
[tonnes-force per area](#)

[tonnes per hectare](#)
[tonnes per km](#)
[tonnes per volume](#)
[ton-force feet](#)
[tons](#)
[tons-force](#)
[tons-force per area](#)
[tons per acre](#)
[tons per mile](#)
[tons per volume](#)
[townships](#)
[troy ounce](#)

UVW

[watt second](#)
[watt hours](#)
[watts](#)

XYZ

[yards](#)
[yards per hour etc.](#)

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Length

The S I unit of length is the **metre**. To change any of these other units of length into their **equivalent values in metres** use the operation and conversion factor given. Those marked with # are **exact**.

Other values are given to an appropriate degree of accuracy. *Where some uncertainty is indicated it means that a good idea of the size of the unit can be given but that a better value would depend upon knowing the period and/or culture in which the unit was being used.*

angstroms	divide by 10 000 000
astronomical units	x 149 598 550 000
barleycorns	x 0.008 467
centimetres	x 0.01 #
chains (surveyors')	x 20.1168 #
cubits	x (0.45 to 0.5)
ells (UK)	x 0.875 (<i>but many va</i>)
ems (pica)	x 0.004 233 3
fathoms	x 1.8288 #
feet (UK and US)	x 0.3048 #
feet (US survey)	x 0.3048 006 096
furlongs	x 201.168 #
hands	x 0.106 #
inches	x 0.0254 #
kilometres	x 1000 #
leagues	x (4000 to 5000)
light years	x 9 460 500 000 000
links (surveyors')	x 0.201 168 #

metres [m]	1
microns (=micrometres)	x 0.000 001 #
miles (UK and US)	x 1609.344 #
miles (nautical)	x 1852 #
parsecs	x 30 856 770 000 000
perch (=rods or poles)	x 5.0292 #
picas	x 0.004 233 333
points (printers')	x 0.000 352 777
yards	x 0.9144 #

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Area

The S I unit of area is the **square metre**. To change any of these other units of area into their **equivalent values in square metres** use the operation and conversion factor given. Those marked with # are **exact**. Other values are given to an appropriate degree of accuracy. *Where some uncertainty is indicated it means that a good idea of the size of the unit can be given but that a better value would depend upon knowing the period and/or culture in which the unit was being used.*

acres	x 4046.856 422 4 #
ares	x 100 #
circular inches	x 0.000 506 707 479
hectares	x 10 000 #
hides	x 485 000 (<i>with wide</i>)
roods	x 1011.714 105 6 #
square centimetres	x 0.000 1 #
square feet (UK and US)	x 0.092 903 04 #
square feet (US survey)	x 0.092 903 411 613
square inches	x 0.000 645 16 #
square kilometres	x 1 000 000 #
square metres	1
square miles	x 2 589 988.110 336
square millimetres	x 0.000 001 #
squares (of timber)	x 9.290 304 #
square rods (or poles)	x 25.292 852 64 #
square yards	x 0.836 127 36 #
townships	x 93 239 571.972

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Volume or Capacity

The S I unit of volume is the cubic metre. However, this seems to be much less used than the **litre** (1000 litres = 1 cubic metre). To change any of these other units of volume into their **equivalent values in litres** use the operation and conversion factor given. Those marked with # are **exact**. Other values are given to an appropriate degree of accuracy.

barrels (oil)	x 158.987 294 928 #
bushels (UK)	x 36.368 72 #

bushels, dry (US)	x 35.239 070 166 88
centilitres	x 0.01 #
cubic centimetres	x 0.001 #
cubic decimetres	1
cubic dekametres	x 1 000 000 #
cubic feet	x 28.316 846 592 #
cubic inches	x 0.016 387 064 #
cubic metres	x 1000 #
cubic millimetres	x 0.000 001 #
cubic yards	x 764.554 857 984 #
decilitres	x 0.1 #
fluid ounces (UK)	x 0.028 413 062 5 #
fluid ounces (US)	x 0.029 573 534 562
gallons (UK)	x 4.546 09 #
gallons, dry (US)	x 4.404 883 770 86 #
gallons, liquid (US)	x 3.785 411 784 #
litres [l or L]	1
millilitres	x 0.001 #
pints (UK)	x 0.568 261 25 #
pints, dry (US)	x 0.550 610 471 357
pints, liquid (US)	x 0.473 176 473 #
quarts (UK)	x 1.136 522 5 #
quarts, dry (US)	x 1.101 220 942 715
quarts, liquid (US)	x 0.946 352 946 #

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Mass (or Weight)

The S I unit of mass is the **kilogram**. To change any of these other units of mass into their **equivalent values in kilograms** use the operation and conversion factor given. Those marked with # are **exact**. Other values are given to an appropriate degree of accuracy.

carats, metric	x 0.000 2 #
grains	x 0.000 064 798 91 #
grams	x 0.001 #
hundredweights, long	x 50.802 345 44 #
hundredweights, short	x 45.359 237 #
kilograms [kg]	1
kips	x 453.592 37 #
newtons	divide by 9.806 65 #
ounces, avoirdupois	x 0.028 349 523 125
ounces, troy	x 0.031 103 476 8 #
pounds	x 0.453 592 37 #
slugs (or g-pounds)	x 0.068 521
stones	x 6.350 293 18 #
tons (UK or long)	x 1016.046 908 8 #
tons (US or short)	x 907.184 74 #
tonnes	x 1000 #

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Line density

Line density is a measure of mass per unit length. The S I compatible unit of line density is **kilograms/metre**. A major use of line density is in the textile industry to indicate the coarseness of a yarn or fibre. For that purpose the SI unit is rather large so the preferred unit there is the **tex**. (1 tex = 1 gram/kilometre) To change any of these other units of line density into their **equivalent values in kilograms/metre** use the operation and conversion factor given. Those marked with # are **exact**. Other values are given to an appropriate degree of accuracy.

denier	divide by 9 000 000
drex	divide by 10 000 000
grams/centimetre	divide by 10 #
grams/kilometre (tex)	divide by 1 000 000
grams/metre	divide by 1000 #
grams/millimetre	1
kilograms/kilometre	divide by 1000 #
kilograms/metre	1
milligrams/centimetre	divide by 10 000 #
milligrams/millimetre	divide by 1000 #
ounces/inch	x 1.116 125
ounces/foot	x 0.093 01
pounds/inch	x 17.858
pounds/foot	x 1.488 164
pounds/yard	x 0.496 055
pounds/mile	x 0.000 281 849
tex	divide by 1 000 000
tons(UK)/mile	x 0.631 342
tons(US)/mile	x 0.563 698
tonnes/kilometre	1

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Density

Density is the shortened term generally used in place of the more accurate description *volumetric density*. It is a measure of mass per unit volume. The S I compatible unit of density is **kilograms/cubic metre**. However, this is a rather large unit for most purposes (iron is over 7000, wood is about 600 and even cork is over 200). A much more useful size of unit is **kilograms/litre** (for which the previous values then become 7, 0.6 and 0.2 respectively). This unit also has the great advantage of being numerically unchanged for grams/cubic centimetre and tonnes/cubic metre. To change any of these other units of density into their **equivalent values in kilograms/litre** use the operation and conversion factor given. Those marked with # are **exact**. Other values are given to an appropriate degree of accuracy.

grains/gallon(UK)	divide by 70 156
grains/gallon(US)	divide by 58 418
grams/cubic centimetre	1
grams/litre	divide by 1000 #
grams/millilitre	1
kilograms/cubic metre	divide by 1000 #
milligrams/millilitre	divide by 1000 #
milligrams/litre	divide by 1 000 000

kilograms/litre	1
ounces/cubic inch	x 1.729 994 044
ounces/gallon(UK)	x 0.006 236 023
ounces/gallon(US)	x
pounds/cubic inch	x 27.679 904
pounds/cubic foot	x 0.016 018 463
pounds/gallon(UK)	x 0.099 776 373
pounds/gallon(US)	x 0.119 826 427
tonnes/cubic metre	1
tons(UK)/cubic yard	x 1.328 939 184
tons(US)/cubic yard	x 1.186 552 843

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Energy or work

The S I unit of energy or work is the **joule**. To change any of these other units of energy or work into their **equivalent values in joules** use the operation and conversion factor given. Those marked with # are **exact**. Other values are given to an appropriate degree of accuracy.

British thermal units	divide by 1055.75 #
calories	divide by 4.1868 #
centigrade heat units	x 1900.4
ergs	divide by 10 000 000
foot pounds-force	x 1.355 817
foot poundals	x 0.042 140
gigajoules [GJ]	x 1000 000 000 #
horsepower hours	x 2 684 520
joules [J]	1
kilocalories	divide by 4186.8 #
kilogram-force metres	x 9.806 65 #
kilojoules [kJ]	x 1000 #
kilowatt hours [kWh]	x 3 600 000 #
megajoules [MJ]	x 1 000 000 #
newton metres [Nm]	x 1 #
therms	x 105 575 000 #
watt seconds [Ws]	1
watt hours [Wh]	x 3600 #

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Force

The S I unit of force is the **newton**. To change any of these other units of force into their **equivalent values in newtons** use the operation and conversion factor given. Those marked with # are **exact**. Other values are given to an appropriate degree of accuracy.

dynes	divide by 100 000 #
kilograms force	x 9.806 65 #
kilonewtons [kN]	x 1000 #
ki ps	x 4448.222

meganewtons [MN]	x 1 000 000 #
newtons [N]	1
pounds force	x 4. 448 222
poundals	x 0. 138 255
sthenes (=kN)	x 1000
tonnes force	x 9806. 65 #
tons(UK) force	x 9964. 016
tons(US) force	x 8896. 443

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Fuel Consumption

Fuel consumption of any means of transport (car, aeroplane, ship etc.) that uses fuel is a measure giving the relationship between the distance travelled for an amount of fuel used. The most common example is the car where it is usually expressed (in English-speaking countries) in miles per gallon. It could also be expressed in gallons per mile. However, for a car the latter method gives a rather small figure: 35 miles per gallon is about 0.0286 gallons per mile. In that case it would be better to give a figure for 100 miles, so it would be 2.86 gallons per 100 miles. That is the metric way of expressing fuel consumption - as litres per 100 kilometres.

The rules below give a way of converting some of these different forms of measurement of fuel consumption. All the values are given to an accuracy of 4 significant figures.

To change	into
miles per gallon (UK)	miles per gallon (US) multiply
miles per gallon (UK)	miles per litre multiply by
miles per litre	miles per gallon (UK) multiply
miles per gallon (UK)	kilometres per litre multiply
miles per gallon (US)	miles per gallon (UK) multiply
miles per gallon (US)	miles per litre multiply by
miles per litre	miles per gallon (US) multiply
miles per gallon (US)	kilometres per litre multiply
X miles per gallon	gallons per 100 miles, divide (both gallons must of the same)
X miles per gallon (UK)	litres per 100 miles, divide
X miles per gallon (US)	litres per 100 miles, divide

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Power

The S I unit of power is the **watt**. To change any of these other units of energy or work into their **equivalent values in watts** use the operation and conversion factor given. Those marked with # are **exact**. Other values are given to an appropriate degree of accuracy.

Btu/hour	x 0. 293 071
Btu/minute	x 17. 584 263
Btu/second	x 1055. 055
calories/hour	x 0. 001 639

calories/minute	x 0.069 78
calories/second	x 4.1868
ft lb-force/minute	x 0.022 597
ft lb-force/second	x 1.355 82
gigawatts [GW]	x 1 000 000 000
horsepower	x 745.7
watts [W]	1
joules/hour	divide by 3600 #
joules/minute	divide by 60 #
joules/second	1
kilocalories/hour	x 1.163
kilocalories/minute	x 69.78
kg-force metres/hour	x 0.002 724
kg-force metres/minute	x 0.163 444
kilowatts [kW]	x 1000 #
megawatts [MW]	x 1 000 000 #

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Pressure or Stress

The S I unit of pressure is the **pascal**. The units of pressure are defined in the same way as those for stress - force/unit area. To change any of these other units of pressure (or stress) into their **equivalent values in pascals** use the operation and conversion factor given. Those marked with # are **exact**. Other values are given to an appropriate degree of accuracy.

atmospheres	x 101 325
bars	x 100 000 #
centimetres of mercury	x 1333.22
centimetres of water	x 98.066 5 #
feet of water	x 2989.066 92 #
inches of water	x 249.088 91 #
inches of mercury	x 3386.388
kg-force/sq. centimetre	x 98 066 5 #
kg-force/sq. metre	x 9.806 65 #
kilonewton/sq. metre	x 1000 #
kilopascal [kPa]	x 1000 #
kip/sq. inch	x 6 894 760
meganewtons/sq. metre	x 1 000 000 #
metres of water	x 9806.65 #
millibars	x 100 #
pascals [Pa]	1
millimetres of mercury	x 133.322
millimetres of water	x 9.806 65 #
newtons/sq. centimetre	x 10 000
newtons/sq. metre	1
newtons/sq. millimetre	x 1 000 000 #
pounds-force/sq. foot	x 47.880
pounds-force/sq. inch	x 6894.757
poundals/sq. foot	x 1.448 16
tons(UK) - force/sq. foot	x 107 251
tons(UK) - force/sq. inch	x 15 444 256
tons(US) - force/sq. foot	x 95 760
tons(US) - force/sq. inch	x 13 789 500

tonnes-force/sq. cm	x 98 066 500 #
tonnes-force/sq. metre	x 9806.65 #

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Speed

The S I compatible unit of speed is **metres/second**. To change any of these other units of speed into their **equivalent values in metres/second** use the operation and conversion factor given. Those marked with # are **exact**. Other values are given to an appropriate degree of accuracy.

centimetres/minute	divide by 6000 #
centimetres/second	divide by 100 #
feet/hour	divide by 11 811
feet/minute	x 0.0005 08 #
feet/second	x 0.3048 #
inches/minute	divide by 2362.2
inches/second	x 0.0254 #
kilometres/hour	divide by 0.06 #
kilometres/second	x 1000 #
knots	x 0.514 444
Mach number	x 331.5
metres/hour	divide by 3600 #
metres/minute	divide by 60 #
metres/second [m/s]	1
miles/hour	x 0.447 04 #
miles/minute	x 26.8224 #
miles/second	x 1609.344 #
yards/hour	divide by 3937
yards/minute	x 0.015 24
yards/second	x 0.9144 #

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Spread Rate (by mass)

The spread rate of a substance is a measure of how much of it there is covering a unit area. The 'how much' can be measured by volume or by mass. The S I compatible unit of spread rate by mass is **kilograms/square metre**. It is also a measure of area density (mass/unit area) and is similar to - but not the same as - pressure, which is force/unit area. For the rainfall conversions a density of 1 kg/litre has been assumed. To change any of these other units of spread rate into their **equivalent values in kilograms/square metre** use the operation and conversion factor given. Those marked with # are **exact**. Other values are given to an appropriate degree of accuracy.

grams/sq. centimetre	x 10 #
grams/sq. metre	divide by 1000 #
inches of rainfall	x 2.54
kilograms/hectare	divide by 10 000 #
kilograms/sq. centimetre	x 10 000 #
milligrams/sq. metre	divide by 1000 #
millimetres of rainfall	1

ki lo grams/sq. metre	1
ounces/sq. foot	x 0. 305 152
ounces/sq. inch	x 43. 942
ounces/sq. yard	di vi de by 49. 494
pounds/acre	di vi de by 8921. 791
pounds/sq. foot	x 4. 882 428
pounds/sq. inch	x 703. 07
pounds/sq. yard	x 0. 542 492
tonnes/hectare	di vi de by 10 #
tons(UK) /acre	di vi de by 3. 982 942
tons(US) /acre	di vi de by 4. 460 896

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Spread Rate (by volume)

The spread rate of a substance is a measure of how much of it there is covering a unit area. The 'how much' can be measured by volume or by mass. The S I compatible unit of spread rate by volume is **cubic metres/square metre**. However, this is a rather large unit for most purposes and so litres/square metre is often preferred. To change any of these other units of spread rate into their **equivalent values in litres/square metre** use the operation and conversion factor given. Those marked with # are **exact**. Other values are given to an appropriate degree of accuracy.

cubi c feet/acre	di vi de by 142. 913
cubi c inches/sq. yard	di vi de by 51. 024
cubi c yards/sq. mile	di vi de by 3387. 577
cubi c metres/hectare	di vi de by 10 #
cubi c metres/sq. km	di vi de by 1000 #
cubi c metres/sq. metre	x 1000 #
fl. ounces(UK) /sq. yard	di vi de by 29. 428
litres/square metre	1
gallons(UK) /acre	di vi de by 890. 184
gallons(US) /acre	di vi de by 1069. 066
gallons(UK) /hectare	di vi de by 2199. 692
gallons(US) /hectare	di vi de by 2641. 721
inches of rainfall	x 25. 4 #
litres/hectare	di vi de by 10 000 #
millitres/sq. metre	di vi de by 1000 #
millimetres of rainfall	1

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Torque

The S I compatible unit of torque is the **newton metre**. To change any of these other units of torque into their **equivalent values in newton metres** use the operation and conversion factor given. Those marked with # are **exact**. Other values are given to an appropriate degree of accuracy.

ergs (= dyne cm)	di vi de by 10 000 000
gram-force centimetres	x 0. 000 098 066 5 #
kg-force centimetres	x 0. 098 066 5 #

kg-force metres	x 9. 806 5 #
newton centimetres	divide by 100 #
newton metres [Nm]	1
ounce-force inches	divide by 141. 612
pound-force inches	x 0. 112 984
pound-force feet	x 1. 355 818
poundal feet	x 0. 042 140
ton(UK) - force feet	x 3 037. 032
ton(US) - force feet	x 2 711. 636
tonne-force metres	x 9 806. 65 #

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Other Sources

Conversion Tables of Units for Science and Engineering by Ari L Horvath

Macmillan Reference Books, London, 1986 (147 pages)

ISBN 0 333 40857 8

Probably the most comprehensive set of conversion factors in print, covering both old and modern units. There are 77 tables covering categories from Length to Radiation dosage. The Length table alone lists 107 units together with the conversion factors needed to change each one into metres.

The Dent Dictionary of Measurement by Darton and Clark

J M Dent, London, 1994 (538 pages)

ISBN 0 460 861379

Very comprehensive coverage of all kinds of units (including currencies), ordered in conventional dictionary form, and giving several conversion factors.

The Economist Desk Companion

Random Century, London, 1992 (272 pages)

ISBN 0 7126 9816 7

A handy compendium of units used in Science, Medicine, Engineering, Industry, Commerce, Finance and many other places, together with all the necessary conversion factors. There is also much other incidental (but related) information.

The Encyclopaedia Britannica

The modern E B has many references to units, but extensive use needs to be made of the index to find them all. It gives a wide selection of weights and measures from countries around the world and the appropriate conversion factors.

World Weights and Measures

Statistical Office of the United Nations, New York 1955 (225 pages)

A very comprehensive survey of each country in the world (as it was then) from Aden to Zanzibar, giving the units used in each for Length, Area and Capacity with their British and Metric equivalents. There is an appendix on the measures used for selected commodities. Currencies are also given. The indexes are very thorough.

The Weights and Measures of England by R D Connor

H M S O, London, 1987 (422 pages)

ISBN 0 460 86137 9

A scholarly and detailed account of the history of the development of the British (Imperial) system of

weights and measures from the earliest times.

British Weights and Measures by R E Zupko

A history from Antiquity to the Seventeenth Century

The University of Wisconsin Press, 1977 [248 pages]

ISBN 0 299 07340 8

The actual history occupies only 100 pages. There is then an extensive list of the various units used in commerce, tables of many pre-Imperial units, a long list of pre-metric measures used in Europe together with their British and metric equivalents, and nearly 40 pages giving other sources.

The World of Measurements by H Arthur Klein

Allen and Unwin, London, 1975 (736 pages)

ISBN 0 04 500024 7

A very readable and comprehensive account of the history of units used in measuring, from the earliest known beginnings and around the world.

On the World Wide Web

There is an [this program \(in the USA\)](#) which (it is claimed) is updated weekly.

International Standards Organisation [I S O]

This organisation (based in Switzerland) is responsible for the world-wide publication of standards for just about anything for which standards can be set. Whilst none of the actual data is online, details of the work of ISO and the publications they produce are.

Amongst many documents on offer there are -

[A general index which provides an overview of all catalogues](#)

[A list of its publications dealing with units in specific technical fields](#)

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Notes

Errors

Whilst every care has been taken in the compilation of this document, and many checks have been carried out, the possibility of an error is always present in a work like this and that must be borne in mind by all users. The author would be glad to be told of any errors detected.

Accuracy

In a general dictionary like this it is impossible to know just what accuracy is needed by any particular user. Where the given value is an **exact** one then it has been signalled. In most cases other values are accurate to at least the number of significant figures shown. In some cases it might be more than that as trailing zeros have not been included.

Presentation

The conversion factors have mainly been presented as multipliers, but exceptions to that have been made for two reasons. First, it is easier to convey the exact value 'divide by 60' rather than the approximation 'multiply by 0.0166667' and it is more likely to be keyed in without errors if a calculator is being used. Second, most calculators accept only 8 digits, which means that 'multiply by 0.000 084 666' will become '0.000 0846' (3 significant figures) whereas 'divide by 11 811' will give the result to 6 significant figures. The appearance of a '1' needs no operator but shows that the named unit is exactly equivalent to the standard unit.

Inverse usage

In nearly all cases the conversion factors have been given to change 'non-standard' units into standard units of the SI. For those cases where it is necessary to do a conversion the other way it is only a matter of reversing the operation. For example to convert feet into metres you **multiply** by 0.3048 so, to convert metres into feet you **divide** by 0.3048. Following on from this it can be seen how conversions can be made between non-standard units, changing first into the standard unit and then back into the required unit.

Symbols

In a few places it will be noticed that some symbols have not been displayed. This a limitation imposed by the current state of HTML and/or the browsers being used to read this document. This also applies to notation such as the superscripts 2 and 3 in matters of area and volume. Further developments (in both the language and the browsers) should allow this situation to be improved in later editions.

Feedback

Clearly there are many more categories and units that could be included. However, for a 'start-up' document only those most commonly met with have been covered. Suggestions for inclusion in the future would be looked at with interest. This document could be growing for some time yet.

Queries, comments, corrections and contributions will be welcomed by Frank Tapson at:
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Publishing history

First placed online 19th June 1995.

Updates: nil