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Conversion factors and tables —

Part 1: Basis of tables. Conversion factors

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- British Steel Industry
- Chemical Society
- Department of Trade and Industry
- Department of Trade and Industry (National Physical Laboratory)
- Electricity Council, the Central Electricity Generating Board, and the Area Boards in England and Wales
- Faraday Society
- Institute of Heating and Ventilating Engineers
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Foreword

This standard deals with interconversion from one unit of measurement to another for a number of quantities which are in general use in engineering, industry and trade. The subjects covered are, broadly, metrology, mechanics and heat; the standard does not deal with purely electrical units.

BS 350 was first published in 1930, and was revised in 1944 and again in 1959. It was then that the standard was split into two parts, Part 1 dealing with the basis of tables and conversion *factors*, and Part 2, which first appeared in 1962, giving *detailed conversion tables* for the more frequently used conversions. From those tables in Part 2 conversions could be read off directly or assessed by interpolation, and the onus of multiplication by a six figure factor was removed. In 1967 a Supplement (PD 6203) was issued to Part 2, giving additional detailed tables for SI conversions. BS 350-2 was withdrawn in 1981 since many of the tables included in it had become inconsistent with the International System of Units (SI) and the increasing use of pocket calculators was considered to have made such tables, which often required interpolation, obsolete. PD 6203 is, however, still valid and has been retained.

This, then, is a revision (confirmed on the incorporation of Amendment No.1 in 1983) of BS 350-1:1959 and provides a comprehensive list of conversion factors and notes on their use. The units in about fifty quantities of measurement are given, together with such definitions, and information on the derivation of conversion factors, as are considered necessary for the purpose.

The experience gained with the earlier editions has been a reliable guide to the choice of quantities to be treated in this revision. Only information now considered obsolete has been discarded, and the quantities dealt with have remained substantially unchanged. There have, however, been considerable additions made to the units, and consequently to the conversion factors, and the standard has been fundamentally rearranged for the reason which follows.

In this edition, while interconversion factors between all the important units treated are given, the standpoint from which the various units and conversion factors are discussed is the SI. This marks an important departure from the earlier editions which originally argued from the imperial system and later perforce adopted a mixed imperial-metric standpoint. Imperial units are being progressively discarded and their retention as the standpoint in this standard would have acted as a brake to the progress of metrication. Furthermore, the SI, under the custody of the General Conference of Weights and Measures, forms the precise and natural basis for conversion information on units, and offers firm prospects of an international harmonization in unit practice, after which conversion factors will no longer be required.

The standardization function of this standard lies in the provision of conversion factors reliable to a stated accuracy. The other important but extraneous information in it is there to help the general user when he is faced with the need to make conversions. BS 350 does not purport to define quantities or units, or to standardize the letter symbols or abbreviations used for units. These matters are dealt with elsewhere, but their mention is necessary here and has been made up-to-date with the latest international and national decisions.

Where factors are given in bold print it is to show that they are exact; in general, factors have been rounded to include six significant figures, thus permitting accuracies satisfactory for most practical purposes. The computation of each factor has as far as possible been made from first principles, using eight or more significant figures to minimize the possibilities of errors in rounding. By comparison with previous editions (including BS 350-2) deviations by one digit in the last significant figure of factors involving the UK gallon may sometimes be noticed. These have arisen because the computation in the previous editions was based on $1 \text{ UKgal} = 4.546\,09 \text{ dm}^3$. Since November 1976 the definition of the gallon in the Weights and Measures Act 1963 has been **$4.546\,09 \text{ dm}^3$** . Before that date the definition in the Weights and Measures Act 1963 was such that the gallon could be calculated to be $4.546\,091\,879 \text{ dm}^3$ to ten significant figures and, on advice from the National Physical Laboratory, a more accurate factor was used as a basis for the computation in the present edition. The return, in November 1976, by precise definition to what had earlier been used as an approximation for the value of the gallon (i.e. $4.546\,09 \text{ dm}^3$) clearly implies changes, in some cases, in the final figure of factors involving the UK gallon and in particular, the reversal of the changes as described that occurred between the present and the previous editions of the standard. Table 23 has however now been corrected in this respect. The six significant figures given for conversion factors involving the 15°C calorie are not warranted by the accuracy of definition of that particular unit, but have been retained for the sake of consistency in the layout of the tables.

Six-figure factors are unnecessarily precise for many practical purposes, and will be rounded to fewer significant figures as appropriate. The Department of Trade and Industry has asked users of these tables to be reminded that conversions for trade purposes should be based on the statutory definitions of units in the Weights and Measures Act, 1963. Section 24 of that Act makes it an offence to give short weight or measure (or to overcharge for the goods supplied if they are offered at the stated price per unit weight or measure). The conversion factors should therefore always be chosen so that the rounding is in the customers' favour, regard being paid to any statutory requirement (such as Marking of Goods Regulations) there may be in this respect.

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

Summary of pages

This document comprises a front cover, an inside front cover, pages i to vi, pages 1 to 96, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

1 Number

1.1 The following prefixes, with significance, name, and symbol as shown below, are used to denote decimal multiples or submultiples of (metric) units. These prefixes developed in conjunction with the metric system, and are now authorized as “SI prefixes”.

Table 1a — Prefixes denoting decimal multiples or submultiples

To indicate multiples		
$\times 10^{18}$	exa	E
$\times 10^{15}$	peta	P
$\times 10^{12}$	tera	T
$\times 10^9$	giga	G
$\times 10^6$	mega	M
$\times 10^3$	kilo	k
$\times 10^2$	hecto	h
$\times 10$	deca	da
To indicate submultiples		
$\times 10^{-1}$	deci	d
$\times 10^{-2}$	centi	c
$\times 10^{-3}$	milli	m
$\times 10^{-6}$	micro	μ
$\times 10^{-9}$	nano	n
$\times 10^{-12}$	pico	p
$\times 10^{-15}$	femto	f
$\times 10^{-18}$	atto	a

1.2 Regarding the meaning of million, billion, etc. the convention shown in Table 1b, accords with the decision of the 9th General Conference of Weights and Measures, Paris 1948, and is in use in European countries including the United Kingdom.

Table 1b — Meaning of million, billion, trillion, etc.

Term	Significance	Corresponding decimal factor
million	thousand $\times$ thousand	10^6
billion	million $\times$ million	10^{12}
trillion	million $\times$ billion	10^{18}
quadrillion	million $\times$ trillion	10^{24}

A different convention is in use in the United States of America, where “million” signifies a thousand times a thousand (10^6), “billion” signifies a thousand times a million (10^9), “trillion” signifies a million times a million (10^{12}), and “quadrillion” signifies a million times a US billion (10^{15}).

In view of the differences between European and USA practice, ambiguities can easily arise with the words “billion”, “trillion” and “quadrillion”, therefore their use should be avoided.

2 Length

2.1 The SI unit of length is the metre (symbol m). It is one of the base units of the SI and is now defined in terms of a specified number of wavelengths of a particular atomic radiation, as given in BS 3763.

NOTE The titles of BS 3763 and all other British Standards referred to in this text are listed on the inside back cover.

2.2 Multiples and submultiples of the metre are formed by using any of the SI prefixes given at 1.1; kilometre (km), decimetre (dm), centimetre (cm), millimetre (mm) and micrometre (μm) are common examples. An alternative term for the micrometre, abrogated by the CGPM but still in common use, is “micron”. The symbol μ , associated in the past with the micron, is incorrect; μm should be used.

2.3 Some units of length having associations with the metric system but not forming part of the SI are:

1 ångström(Å)	$= 10^{-10} \text{ m}$	Refer to note
1 international nautical mile (n mile)	$= 1\,852 \text{ m}$	
1 astronomical unit (AU)	$= 1.496 \times 10^{11} \text{ m}$	1
1 parsec (pc)	$= 3.0857 \times 10^{16} \text{ m}$	2
1 light year (l.y.)	$= 9.4605 \times 10^{15} \text{ m}$	3

2.4 The definitive UK (or imperial) and US unit of length is the yard, legally defined (since 1959 in the USA and since 1963 in the UK) as follows:

$$1 \text{ yard} = 0.9144 \text{ m}$$

2.5 The connection between multiples and submultiples of the yard is indicated in the following traditional table of named UK and US units of length, defined (for the UK) in the Weights and Measures Act, 1963.

		(1 in = 0.0254 m)	Refer to note 4
1 foot (ft) = 12 inches (in)	(1 ft = 0.3048 m)		
1 yard (yd) = 3 feet (ft)	(1 yd. = 0.9144 m)		
1 chain = 22 yards (yd)	(1 chain = 20.1168 m)		5
1 furlong = 10 chains	(1 furlong = 201.168 m)		
1 mile = 8 furlongs	(1 mile = 1609.344 m)		6

2.6 Some less usual, or more specialized, UK and US named units of length are:

1 micro-inch (μin)	$= 10^{-6} \text{ in}$	$= 0.0254 \mu\text{m}$	$= 25.4 \times 10^{-9} \text{ m}$	Refer to note
1 thou	$= 10^{-3} \text{ in}$	$= 25.4 \mu\text{m}$	$= 25.4 \times 10^{-6} \text{ m}$	7
1 mil	$= 10^{-3} \text{ in}$	$= 25.4 \mu\text{m}$	$= 25.4 \times 10^{-6} \text{ m}$	8
1 point	$= \frac{1}{72} \text{ in (approx)}$		$= 0.351 \text{ mm (approx)}$	9
1 iron	$= \frac{1}{48} \text{ in}$		$= 0.529\,167 \text{ mm}$	10
1 line	$= \frac{1}{40} \text{ in}$		$= 0.635 \text{ mm}$	11
1 line or ligne	$= \frac{1}{12} \text{ in}$		$= 2.116\,67 \text{ mm}$	12
1 em	$= \frac{1}{6} \text{ in}$		$= 4.233\,33 \text{ mm}$	13
1 hand	$= 4 \text{ in}$		$= 10.16 \text{ cm}$	14
1 link	$= \frac{1}{100} \text{ chain}$	$= 0.66 \text{ ft}$	$= 0.201\,168 \text{ m}$	
1 US survey foot	$= \frac{1}{0.999\,998} \text{ ft}$	$= \frac{18}{39.37} \text{ m}$	$= 0.304\,801 \text{ m}$	
1 fathom	$= 6 \text{ ft}$		$= 1.8288 \text{ m}$	
1 rod, pole, or perch	$= 5\frac{1}{2} \text{ yd}$		$= 5.0292 \text{ m}$	15
1 engineer's chain	$= 100 \text{ ft}$		$= 30.48 \text{ m}$	
1 cable-length	—		—	16
1 UK nautical mile	$= 6\,080 \text{ ft}$		$= 1853.18 \text{ m}$	17
1 telegraph nautical mile	$= 6\,087 \text{ ft}$		$= 1855.32 \text{ m}$	

Notes on section 2

- NOTE 1 Approximately the mean distance between the Sun and the Earth.
 NOTE 2 The distance at which 1 AU subtends an angle of 1 second (1").
 NOTE 3 Approximate distance travelled by light in 1 year.
 NOTE 4 An exception is the US survey foot, shown in 2.6.
 NOTE 5 The legally defined chain, commonly called Gunter's chain in the USA.
 NOTE 6 Also known as a statute mile. There is no recognized abbreviation for mile and the complete word "mile" is used as the unit symbol.
 NOTE 7 Colloquial, for one-thousandth of an inch.
 NOTE 8 Colloquial, for one-thousandth of an inch. For other meanings of mil see 3.5, 4.4 and (Note 2) of section 7.
 NOTE 9 Printing trade. (Originally defined by 83 picas = 83 × 12 points = 35 cm).
 NOTE 10 Boot and shoe trade.
 NOTE 11 Button trade.
 NOTE 12 Watch trade.
 NOTE 13 Printing trade.
 NOTE 14 Height of horses.
 NOTE 15 Obsolete.
 NOTE 16 A nautical term not precisely defined in the UK. In its most general concept it is equal to one-tenth of an unspecified nautical mile, but other values have been used, including the value 120 fathoms (720 ft).
 NOTE 17 Obsolescent as the international nautical mile becomes adopted in the UK.

For conversion factors for a number of widely-used units of length see Table 2.

3 Area (length squared)

3.1 The coherent SI unit of area is the square metre (symbol m²), a derived unit.

3.2 Areas are also expressed in terms of the squares of any of the multiples and submultiples of the metre formed by the use of the SI prefixes, e.g. square millimetre (mm²), square centimetre (cm²), square decimetre (dm²), square kilometre (km²).

In accordance with the rule concerning prefixes attached to units raised to a power, the relationship between each of these and the square metre is as follows:

$$1 \text{ mm}^2 = \left(\frac{\text{m}}{1000}\right)^2 = 10^{-6} \text{ m}^2$$

$$1 \text{ cm}^2 = \left(\frac{\text{m}}{100}\right)^2 = 10^{-4} \text{ m}^2$$

$$1 \text{ dm}^2 = \left(\frac{\text{m}}{10}\right)^2 = 10^{-2} \text{ m}^2$$

$$1 \text{ km}^2 = (1000 \text{ m})^2 = 10^6 \text{ m}^2$$

3.3 A metric unit with a special name is the are (symbol a).

$$1 \text{ a} = 100 \text{ m}^2$$

This, and more especially its multiple the hectare (symbol ha), are used for land measurement of area.

$$1 \text{ ha} = 100 \text{ a} = 10\,000 \text{ m}^2$$

Another specially named metric unit is the barn, used in atomic physics in the measurement of cross sections.

$$1 \text{ barn} = 10^{-28} \text{ m}^2$$

3.4 The connection between various traditional UK and US units of area, and their relationship to the square metre, are as follows:

				Refer to note
1 square foot (ft ²)	= 144 square inches (in ²)	(1 in ²)	= 6.4516 × 10 ⁻⁴ m ²)	1
1 square yard (yd ²)	= 9 square feet	(1 ft ²)	= 0.092 903 0 m ²)	
1 rood	= 1 210 square yards	(1 yd ²)	= 0.836 127 m ²)	
1 acre = 4 roods	= 4 840 square yards	(1 rood)	= 1011.71 m ²)	
		(1 acre)	= 4046.86 m ²)	
1 square mile (mile ²)	= 640 acres	1 mile ²	= 2.589 99 × 10 ⁶ m ²)	

Table 2 — Length

Exact values are printed to bold type.

	metre	inch ^a	foot	yard	chain	furlong	mile	fathom	UK nautical mile	International nautical mile
	m	in	ft	yd						n mile
1 metre =	1	39.3701	3.280 84	1.093 61	0.049 709 7	$4.970\,97 \times 10^{-3}$	$6.213\,71 \times 10^{-4}$	0.546 807	$5.396\,12 \times 10^{-4}$	$5.399\,57 \times 10^{-4}$
1 inch =	0.0254	1	0.083 333 3	0.027 777 8	$1.262\,63 \times 10^{-3}$	$1.262\,63 \times 10^{-4}$	$1.578\,28 \times 10^{-5}$	$1.388\,89 \times 10^{-2}$	$1.370\,61 \times 10^{-5}$	$1.371\,49 \times 10^{-5}$
1 foot =	0.3048	12	1	0.333 333	0.015 151 5	$1.515\,15 \times 10^{-3}$	$1.893\,94 \times 10^{-4}$	0.166 667	$1.644\,74 \times 10^{-4}$	$1.645\,79 \times 10^{-4}$
1 yard =	0.9144	36	3	1	0.045 454 5	$4.545\,45 \times 10^{-3}$	$5.681\,82 \times 10^{-4}$	0.5	$4.934\,21 \times 10^{-4}$	$4.937\,37 \times 10^{-4}$
1 chain =	20.1168	792	66	22	1	0.1	0.0125	11	$1.085\,53 \times 10^{-2}$	$1.086\,22 \times 10^{-2}$
1 furlong =	201.168	7 920	660	220	10	1	0.125	110	0.108 553	0.108 622
1 mile =	1609.344	63 360	5 280	1 760	80	8	1	880	0.868 421	0.868 976
1 fathom =	1.8288	72	6	2	$9.090\,91 \times 10^{-3}$	$9.090\,91 \times 10^{-2}$	$1.136\,36 \times 10^{-3}$	1	$9.868\,42 \times 10^{-4}$	$9.874\,73 \times 10^{-4}$
1 UK nautical mile =	1853.18	72 960	6 080	2026.67	92.1212	9.212 12	1.151 52	1013.33	1	1.000 64
1 international nautical mile =	1 852	72 913.4	6076.12	2025.37	92.0624	9.206 24	1.150 78	1012.69	0.999 361	1

^a For a detailed table of conversions from inches to millimetres and vice versa, see BS 2856. The conversions to inches are there given to the nearest 10^{-7} in.

3.5 A specialized UK and US unit of area (used in connection with sections of wire) is the “circular mil”.

Refer to note

$$1 \text{ circular mil} = 7.853\,98 \times 10^{-7} \text{ in}^2 = 5.067\,07 \times 10^{-10} \text{ m}^2$$

2

Notes on section 3

NOTE 1 The rood is obsolescent in the UK and rarely used in the USA.

NOTE 2 The circular mil has an area equal to that of a circle one-thousandth of an inch in diameter. For other meanings of mil see 2.6, 4.4 and section 7, Note 2.

For conversion factors for a number of widely-used units of area see Table 3a and Table 3b.

4 Volume and capacity (length cubed)

4.1 The coherent SI unit of volume is the cubic metre (symbol m^3), a derived unit.

4.2 Volumes are also expressed in terms of the cubes of any of the multiples and submultiples of the metre formed by the use of the SI prefixes; of these the cubic decimetre (dm^3), the cubic centimetre (cm^3), and the cubic millimetre (mm^3) are common examples.

The relationship between each of these and the cubic metre is as follows:

$$1 \text{ dm}^3 = \left(\frac{\text{m}}{10}\right)^3 = 10^{-3} \text{ m}^3$$

$$1 \text{ cm}^3 = \left(\frac{\text{m}}{100}\right)^3 = 10^{-6} \text{ m}^3$$

$$1 \text{ mm}^3 = \left(\frac{\text{m}}{1000}\right)^3 = 10^{-9} \text{ m}^3$$

4.3 In the SI no distinction is drawn between units of volume and units of capacity. However, a metric unit with a special name, used in conjunction with the SI and commonly used for the measurement of liquids and fluids, is the litre (symbol l^1).

$$1 \text{ litre} = 1 \text{ dm}^3 = 10^{-3} \text{ m}^3$$

(This definition has applied in the SI since 1964, but see 4.3.1 below.)

The SI prefixes are used with the litre, leading for example to the hectolitre (hl), centilitre (cl), millilitre (ml) and microlitre (μl).

$$1 \text{ hl} = 100 \text{ litre} = 10^{-1} \text{ m}^3$$

$$1 \text{ cl} = \left(\frac{1}{100}\right) \text{ litre} = 10^{-5} \text{ m}^3$$

$$1 \text{ ml} = \left(\frac{1}{1000}\right) \text{ litre} = 10^{-6} \text{ m}^3 = 1 \text{ cm}^3$$

$$1 \mu\text{l} = \left(\frac{1}{10^6}\right) \text{ litre} = 10^{-9} \text{ m}^3 = 1 \text{ mm}^3$$

¹⁾ Although in this standard the symbol used for the litre is the lower case letter “l”, it has long been recognized that in some typefaces it was difficult to distinguish between the lower case letter “l” and numeral 1. The 16th General Conference of Weights and Measures (1979) accordingly recognized the use of the upper case letter “L” as an alternative symbol for the litre. In British Standards “L” is now the preferred symbol but “l”, which is still widely used, is recognized as acceptable. See also BS 5555.

Table 3a — Area

Exact values are printed in bold type.

	square metre m ²	hectare ha	square inch in ²	square foot ft ²	square yard yd ²	rood	acre	square mile mile ²
1 square metre = m ²	1	1×10^{-4}	1550.00	10.763 9	1.195 99	$9.884\,22 \times 10^{-4}$	$2.471\,05 \times 10^{-4}$	$3.861\,02 \times 10^{-7}$
1 hectare = ha	10 000	1	1550.00×10^4	107 639	11 959.9	9.884 22	2.471 05	$3.861\,02 \times 10^{-3}$
1 square inch = in ²	6.4516×10^{-4}	6.4516×10^{-8}	1	$6.944\,44 \times 10^{-3}$	$7.716\,05 \times 10^{-4}$	$6.376\,90 \times 10^{-7}$	$1.594\,23 \times 10^{-7}$	$2.490\,98 \times 10^{-10}$
1 square foot = ft ²	0.092 903 0	$9.290\,30 \times 10^{-6}$	144	1	0.111 111	$9.182\,74 \times 10^{-5}$	$2.295\,68 \times 10^{-5}$	$3.587\,01 \times 10^{-8}$
1 square yard = yd ²	0.836 127	$8.361\,27 \times 10^{-5}$	1 296	9	1	$8.264\,46 \times 10^{-4}$	$2.066\,12 \times 10^{-4}$	$3.228\,31 \times 10^{-7}$
1 rood =	1011.71	0.101 171	1 568 160	10 890	1 210	1	0.25	$3.906\,25 \times 10^{-4}$
1 acre =	4046.86	0.404 686	6 272 640	43 560	4 840	4	1	1.5625×10^{-3}
1 square mile = mile ²	$2.589\,99 \times 10^6$	258.999	$4.014\,49 \times 10^9$	$2.787\,84 \times 10^7$	3.0976×10^6	2 560	640	1

Table 3b — Area of section of wire

Exact values are printed in bold type

		circular mil	square millimetre mm ²	square inch in ²
1 circular mil ^a	=	1	$5.067\ 07 \times 10^{-4}$	$7.853\ 98 \times 10^{-7}$
1 square millimetre mm ²	=	1973.53	1	$1.550\ 00 \times 10^{-3}$
1 square inch in ²	=	$1.273\ 24 \times 10^6$	645.16	1
^a For definition of circular mil, see 3.5, Note 2.				

4.3.1 Units of capacity for the measurement of liquids (and sometimes of dry goods also) have been treated as base units at various times in the past, and have been defined independently of length. Thus in the metric system from 1901 to 1964 the litre was defined as the volume occupied by a mass of one kilogram of water under specified conditions (at its temperature of maximum density and under a pressure of one standard atmosphere). Since 1964, however, the litre has been re-defined within the SI as a special name for the volume of one cubic decimetre (which is as it was before 1901). Since 1 November 1976, the 1964 definition has been embodied within the law of the United Kingdom. Because of these changes, where a very high degree of precision is called for, it is necessary to establish which definition of the litre is intended. In the tables which follow in this standard a litre as defined according to the 1901 definition is described as the “litre (1901)”, and the litre as it is now defined according to the SI is described simply as the “litre”.

1 litre (1901) = 1.000 028 litre

4.4 In the French timber trade the volume of one cubic metre goes under the obsolescent name “stère” (symbol st). Similarly, in the timber trade in Germany the cubic metre has been described as the “Festmeter” (Fm) or “Raummeter” (Rm), and these two special names are also obsolescent.

Another obsolescent metric-based volume unit is the “mil”, used in the UK in pharmaceutical work, particularly for prescriptions, to denote a millilitre (see *British Pharmacopoeia*, 1953). For other meanings of “mil” see 2.6, 3.5, and section 7, Note 2.

4.5 The connection between the traditional UK and US units of volume and their relationship to the cubic metre are as follows:

Symbol	Unit	Metric equivalent
yd ³	1 cubic yard = 27 cubic feet	= 0.764 555 m ³
ft ³	1 cubic foot = 1 728 cubic inches	= 0.028 316 8 m ³
in ³	1 cubic inch	= $1.638\ 71 \times 10^{-5}$ m ³

4.6 As with the litre in the metric system, it is customary to regard certain UK and US volumetric units as units of capacity. These include the UK gallon and its multiples and submultiples, and the US gallon and US bushel, with their multiples and submultiples. The UK and US units of capacity differ markedly from each other²⁾ and it is therefore important to avoid confusion in their use. The prefixes UK and US are used for purpose of their identification in this standard but the qualifications UK or US are frequently omitted in practice. Care is particularly necessary with conversions of the gallon in order to identify which gallon is concerned.

4.6.1 *UK-units of capacity.* These are all based on the UK gallon (UKgal), defined in Schedule 1 of the Weights and Measures Act, 1963, as the space occupied by 10 pounds weight of distilled water under certain conditions specified in the schedule.

Key conversion factors are:

$$\begin{aligned}
 1 \text{ UKgal} &= 4.546\ 09 \text{ dm}^3 \\
 &= 4.546\ 09 \text{ litre} \\
 &= 4.545\ 96 \text{ litre (1901)}
 \end{aligned}$$

²⁾ For a direct comparison of UK and US units of capacity see Table 4d.

The connection between the UK gallon and its various multiples and submultiples is shown in the following list:

Symbol (if any)	Unit	Metric equivalent
UKmin	1 minim ^a	= 0.059 193 9 cm ³
Uk fl dr	1 fluid drachm ^a = 60 minim	= 3.551 63 cm ³
UK fl oz	1 fluid ounce = 8 fluid drachms	= 28.4131 cm ³
—	1 gill = 5 fluid ounces	= 0.142 065 dm ³
UKpt	1 pint = 4 gills (= 20 fluid ounces)	= 0.568 261 dm ³
UKqt	1 quart = 2 pints	= 1.136 52 dm ³
UKgal	1 gallon = 4 quarts (= 160 fluid ounces)	= 4.546 09 dm ³
—	1 peck = 2 gallons	= 9.092 18 dm ³
—	1 bushel = 4 pecks	= 36.3687 dm ³

^a The minim, fluid drachm, peck and bushel are now deleted from Schedule 1 to the UK Weights and Measures Act, 1963, and it is now illegal to use these units for trade purposes.

4.6.2 US units of capacity. The US units of capacity are defined in terms of a specified number of cubic inches. The US gallon is equal in volume to 231 cubic inches and is used for the measurement of liquids only. The US bushel is equal in volume to 2150.42 cubic inches and is used for the measurement of dry commodities only.

The connection between the US gallon and its various multiples and submultiples is shown in the following list:

US units of capacity (liquid measure only)

Symbol (if any)	Unit	Metric equivalent
—	1 US minim	= 0.061 611 5 cm ³
fl dr	1 US fluid dram ^a = 60 minims	= 3.696 69 cm ³
US fl oz	1 US fluid ounce ^b = 8 fluid drams	= 29.573 5 cm ³
gi	1 US gill = 4 fluid ounces	= 0.118 294 dm ³
liq pt	1 US liquid pint = 4 gills (= 16 fluid ounces)	= 0.473 176 dm ³
liq qt	1 US liquid quart = 2 liquid pints	= 0.946 353 dm ³
USgal	1 US gallon = 4 liquid quarts (= 128 fluid ounces)	= 3.785 41 dm ³
bbl	1 US barrel (for petroleum) = 42 gallons	= 158.987 dm ³

^a Sometimes also known as the liquid dram (liq dr) in the USA.

^b Sometimes also known as the liquid ounce (liq oz) in the USA.

4.6.3 US units of capacity (dry measure only). The connection between the US bushel and its various multiples and submultiples is shown in the following list:

Symbol (if any)	Unit	Metric equivalent
—	1 US dry pint	= 0.550 610 dm ³
dry qt	1 US dry quart = 2 dry pints	= 1.101 22 dm ³
pk	1 US peck = 8 dry quarts	= 8.809 76 dm ³
bu	1 US bushel = 4 pecks	= 35.2391 dm ³
bbl (dry)	1 US dry barrel = 7 056 cubic inches	= 115.627 dm ³

Notes on 4.6

NOTE 1 In the UK different values are used for the barrel for different purposes (e.g. the wine barrel is nominally $31\frac{1}{2}$ UKgal and the beer barrel nominally 36 UKgal).

NOTE 2 The barrel (bbl) referred to in the list of US capacity units for dry measure only is the standard barrel in the US for fruits, vegetables and dried commodities, with the exception of cranberries. Cranberries are sold in the US by reference to a standard cranberry barrel containing 5826 cubic inches.

NOTE 3 There are other bushels having different capacities from those mentioned in 4.6.

NOTE 4 Other specialized units of capacity used in the UK timber trade are

1 board foot = 144 in^3 (= $2.359\,74 \text{ dm}^3$)

1 cord = 128 ft^3 (= $3.624\,56 \text{ m}^3$)

1 standard = 165 ft^3 (= $4.672\,28 \text{ m}^3$)

This last is sometimes known as the "Petrograd standard".

NOTE 5 The cran, used in the UK fishing industry, is equal to $37\frac{1}{2}$ UK gallons.

For conversion factors for a number of widely-used units of volume or capacity see Table 4a, Table 4b, Table 4c and Table 4d.

5 Modulus of section, first moment of area

5.1 These quantities have the same dimensions as volume; the coherent SI unit is therefore the metre cubed (m^3).

5.2 They may also be expressed in terms of the cube of any suitable submultiple of the metre; the centimetre cubed (cm^3) and millimetre cubed (mm^3) are commonly used.

5.3 In imperial units the foot cubed (ft^3) or inch cubed (in^3) are usually used.

The relationship between the above-mentioned units can be seen or inferred from Table 4a.

6 Second moment of area, or geometrical moment of inertia

The coherent SI unit for this quantity is the metre to the fourth (m^4). Other commonly used units are the centimetre to the fourth (cm^4) and millimetre to the fourth (mm^4) and, in imperial units, the foot to the fourth (ft^4) and inch to the fourth (in^4). See Table 6 for conversion factors for these units.

Table 4a — Volume and capacity

Exact values are printed in bold type.

	cubic metre m^3	cubic decimetre dm^3 litre ^a 1	litre (1901) ^a	cubic inch in^3	cubic foot ft^3	cubic yard yd^3	UK bushel	US dry pint	US bushel
1 cubic metre m^3	= 1	1 000	999.972	61 023.7	35.3147	1.307 95	27.496 1	1816.17	28.3776
1 cubic decimetre dm^3 1 litre l^a	= 0.001	1	0.999 972	61.023 7	0.035 314 7	$1.307\,95 \times 10^{-3}$	0.027 496 1	1.816 17	0.028 377 6
1 litre (1901) ^a	= $1.000\,028 \times 10^{-3}$	1.000 028	1	61.025 5	0.035 315 7	$1.307\,99 \times 10^{-3}$	0.027 496 9	1.816 22	0.028 378 4
1 cubic inch in^3	= $1.638\,71 \times 10^{-5}$	$1.638\,71 \times 10^{-2}$	0.016 386 6	1	$5.787\,04 \times 10^{-4}$	$2.143\,35 \times 10^{-5}$	$4.505\,81 \times 10^{-4}$	0.029 761 6	$4.650\,25 \times 10^{-4}$
1 cubic foot ft^3	= 0.028 316 8	28.3168	28.3161	1 728	1	0.037 037 0	0.778 604	51.4281	0.803 564
1 cubic yard yd^3	= 0.764 555	764.555	764.533	46 656	27	1	21.0223	1388.56	21.6962
1 UK bushel	= 0.036 368 7	36.3687	36.3677	2219.36	1.284 35	0.047 568 5	1	66.0517	1.032 06
1 US dry pint	= $5.506\,10 \times 10^{-4}$	0.550 610	0.550 595	33.600 3	0.019 444 6	$7.201\,71 \times 10^{-4}$	0.015 139 7	1	0.015 625
1 US bushel	= 0.035 239 1	35.2391	35.2381	2150.42	1.244 46	0.046 091 0	0.968 939	64	1
^a For explanation of the litre, and the litre (1901), see 4.3.									

Table 4b — Volume and capacity

Exact values are printed in bold type.

	cubic metre m^3	cubic decimetre dm^3 litre ^a l	litre (1901) ^a	cubic inch in^3	cubic foot ft^3	UK pint ^b UKpt	UK gallon ^c UKgal	US liquid pint US liq pt	US gallon USgal
1 cubic metre m^3	1	1 000	999.972	61 023.7	35.3147	1759.75	219.969	2113.38	264.172
1 cubic decimetre dm^3 1 litre ^a l	0.001	1	0.999 972	61.023 7	0.035 314 7	1.759 75	0.219 969	2.113 38	0.264 172
1 litre (1901) ^a	$1.000\,028 \times 10^{-3}$	1.000 028	1	61.025 5	0.035 315 7	1.759 80	0.219 975	2.113 44	0.264 179
1 cubic inch in^3	$1.638\,71 \times 10^{-5}$	0.016 387 1	0.016 386 6	1	$5.787\,04 \times 10^{-4}$	0.028 837 2	$3.604\,65 \times 10^{-3}$	0.034 632 0	$4.329\,00 \times 10^{-3}$
1 cubic foot ft^3	0.028 316 8	28.3168	28.3161	1 728	1	49.8307	6.228 83	59.8442	7.480 52
1 UK pint ^b UKpt	$0.568\,261 \times 10^{-3}$	0.568 261	0.568 246	34.6774	0.020 068 0	1	0.125	1.200 95	0.150 119
1 UK gallon ^c UK gal	$4.546\,09 \times 10^{-3}$	4.546 09	4.545 96	277.420	0.160 544	8	1	9.607 60	1.200 95
1 US liquid pint US liq pt	$4.731\,76 \times 10^{-4}$	0.473 176	0.473 163	28.875	0.016 710 1	0.832 674	0.104 084	1	0.125
1 US gallon USgal	$3.785\,41 \times 10^{-3}$	3.785 41	3.785 31	231	0.133 681	6.661 39	0.832 674	8	1
^a For explanation of the litre, and the litre (1901) see 4.3. ^b Also called “imperial pint”. ^c Also called “imperial gallon”.									

Table 4c — Volume and capacity

Exact values are printed in bold type.

	cubic centimetre cm^3 millilitre ml	millilitre (1901)	cubic inch in^3	UK minim UKmin	UK fluid drachm UK fl dr	UK fluid ounce UK fl oz	US fluid ounce US fl oz
1 cubic centimetre cm^3 1 millilitre ml	1	0.999 972	0.61 023 7	16.8936	0.281 561	0.035 195 1	0.033 814 0
1 millilitre (1901) ^a	= 1.000 028	1	0.061 025 5	16.8941	0.281 568	0.035 196 1	0.033 815 0
1 cubic inch in^3	= 16.3871	16.3866	1	276.837	4.613 95	0.576 744	0.554 113
1 UK minim UKmin	= 0.059 193 9	0.059 192 2	$3.612\ 23 \times 10^{-3}$	1	0.016 666 7	$2.083\ 33 \times 10^{-3}$	$2.001\ 58 \times 10^{-3}$
1 UK fluid drachm UK fl dr	= 3.551 63	3.551 53	0.216 734	60	1	0.125	0.120 095
1 UK fluid ounce US fl oz	= 28.4131	28.4123	1.733 87	480	8	1	0.960 760
1 UK fluid ounce US fl oz	= 29.5735	29.5727	1.804 69	499.604	8.326 74	1.040 84	1
NOTE 1 $\text{mm}^3 = 10^{-3} \text{ cm}^3 = 1 \mu\text{l}$ (see also 4.2). ^a For explanation of the litre, and the litre (1901) see 4.3.							

Table 4d — Relationship between UK (imperial) and US units of capacity

1 UK minim	= 0.960 760 US minim
1 UK fluid drachm	= 0.960 760 US fluid ^a dram
1 UK fluid ounce	= 0.960 760 US fluid ^b ounce
1 UK gill	= 1.200 95 US gill
1 UK pint	= 1.200 95 US liquid pint
1 UK quart	= 1.200 95 US liquid quart
1 UK gallon	= 1.200 95 US gallon
1 UK pint	= 1.032 06 US dry pint
1 UK quart	= 1.032 06 US dry quart
1 UK peck	= 1.032 06 US peck
1 UK bushel	= 1.032 06 US bushel
1 US minim	= 1.040 84 UK minim
1 US fluid ^a dram	= 1.040 84 UK fluid drachm
1 US fluid ^b ounce	= 1.040 84 UK fluid ounce
1 US gill	= 0.832 674 UK gill
1 US liquid pint	= 0.832 674 UK pint
1 US liquid quart	= 0.832 674 UK quart
1 US gallon	= 0.832 674 UK gallon
1 US dry pint	= 0.968 939 UK pint
1 US dry quart	= 0.968 939 UK quart
1 US peck	= 0.968 939 UK peck
1 US bushel	= 0.986 939 UK bushel
^a Sometimes also known as the liquid dram in the USA.	
^b Sometimes also known as the liquid ounce in the USA.	

Table 6 — Second moment of area

Exact values are printed in bold type.

	m ⁴	cm ⁴	ft ⁴	in ⁴
1 m ⁴ =	1	1 × 10⁸	115.862	2 402 510
1 cm ⁴ =	1 × 10⁻⁸	1	1.158 62 × 10 ⁻⁶	0.024 025 1
1 ft ⁴ =	0.863 097 × 10 ⁻²	863 097	1	20 736
1 in ⁴ =	41.6231 × 10⁻⁸	41.6231	4.822 53 × 10 ⁻⁵	1
NOTE 1 mm ⁴ = 10 ⁻⁴ cm ⁴ = 10 ⁻¹² m ⁴ .				

7 Plane angle

7.1 The coherent SI unit of plane angle is the radian (symbol rad), a supplementary³⁾ unit. It is the angle between two radii of a circle which cut off on the circumference an arc equal in length to the radius.

³⁾ In October 1980 the International Committee of Weights and Measures decided to interpret the class of supplementary units in the International System as a class of dimensionless derived units for which the General Conference of Weights and Measures leaves open the possibility of using these or not in expressions of derived units of the International System.

Thus a complete circle subtends an angle of 2π rad at its centre, and a right angle (**L**)

equals $\frac{2\pi}{4}$ rad = $\frac{\pi}{2}$ rad.

7.2 Angular units of such practical importance that they are retained for general use in conjunction with the SI are the traditional units degree ($^{\circ}$), minute ($'$), second ($''$).

The full circle subtends an angle of 360 degrees (360°) at its centre, and thus the right angle (**L**) = 90 degrees (90°).

$$1 \text{ degree } (1^{\circ}) = 60 \text{ minutes } (60') = \frac{\pi}{180} \text{ rad}$$

$$1 \text{ minute } (1') = 60 \text{ seconds } (60'') = \frac{\pi}{60 \times 180} \text{ rad}$$

$$1 \text{ second } (1'') = \frac{\pi}{3\,600 \times 180} \text{ rad}$$

It is often convenient to express sub-divisions of the degree in decimal form, rather than to use minutes and seconds.

7.3 A unit of plane angle used in some continental countries is the grade (^{g}) or, as it is called in Germany, the gon. This is a one-hundredth of a right angle.

$$1^g (\text{or } 1 \text{ gon}) = 0.9^{\circ} = \frac{\pi}{200} \text{ rad}$$

Notes on section 7

NOTE 1 Note the possibility of confusion between the hundredth part of a grade in angular measure and the term Centigrade (correctly called Celsius) in connection with temperature.

NOTE 2 The unit "mil" is sometimes used in connection with angular measure. For some purposes the angular mil is taken to be one thousandth of a radian (10^{-3} rad), which is equivalent to $3' 26.25''$. There is, however, another concept in which an angular mil is equal to $360/6\,400$ degrees i.e. $3' 22.5''$. For other meanings of "mil" see 2.6, 3.5, and 4.4.

NOTE 3 In English there is no commonly used expression for the "full angle" subtended by a circle. In German the term "Vollwinkel" is used.

For interconversion factors for the units mentioned in 7.1, 7.2 and 7.3 see Table 7.

Table 7 — Plane angle

Exact values are printed in bold type.

	radian rad	right angle L	degree $^{\circ}$	minute '	second ''	grade (or gon) ^{g} gon
1 radian = rad	1	0.636 620	57.2958	3437.75	206 265	63.6620
1 right angle =	1.570 80	1	90	5 400	324 000	100
1 degree = $^{\circ}$	0.017 453 3	0.011 111 1	1	60	3 600	1.111 11
1 minute = '	$2.908\,88 \times 10^{-4}$	$1.851\,85 \times 10^{-4}$	0.016 666 7	1	60	$1.851\,85 \times 10^{-2}$
1 second = ''	$4.848\,14 \times 10^{-6}$	$3.086\,42 \times 10^{-6}$	$2.777\,78 \times 10^{-4}$	0.016 666 7	1	$3.086\,42 \times 10^{-4}$
1 grade (or gon) ^{g} gon	0.015 708 0	0.01	0.9	54	3 240	1

8 Solid angle

The coherent SI unit of solid angle, the only unit in common use for solid angle, is the steradian (symbol sr), a supplementary⁴⁾ unit. It is the solid angle which, having its vertex at the centre of a sphere, cuts off an area of the surface of the sphere equal to that of a square with sides of length equal to the radius of the sphere.

A complete sphere subtends a solid angle of 4π sr at its centre.

9 Time

9.1 The SI unit of time is the second (symbol s), a base unit. It is now defined as the duration of a specified number of periods of a particular atomic radiation; for details see BS 3763.

9.2 Prior to 1967 the second was defined as a specified fraction of the time taken by the Earth to complete a particular orbit of the Sun. (This second, the “ephemeris second”, is retained for use as a special unit in astronomy, and is as nearly equal to the SI unit as the highest precision of measurement could permit in 1967.)

9.3 Other units of time of such practical importance that they are retained for general use in conjunction with the SI are:

minute (min)	1 min	= 60 s	
hour (h)	1 h	= 60 min	= 3 600 s
day (d)	1 d	= 24 h	= 86 400 s

9.4 Longer durations of time are conveniently expressed in terms of the week, month or year, but the last two of these cannot in general be explicitly related to the second (of time).

1 week	= 7 d	= 604 800 s
1 month	= 28, 29, 30, or 31 days	(according to calendar)
1 year ^a	= 12 months	= 365 or 366 days (according to calendar) = 8 760 h or 8 784 h (according to calendar).

^a The year referred to here is the “calendar year”. Calendar adjustments are based on the “tropical year”, the time interval between two consecutive passages (in the same direction) of the Sun through the Earth’s equatorial plane. In 1900 the duration of the “tropical year” was 365.242 198 78 d and it is decreasing at the rate of 6.14×10^{-6} days per century.

Notes on section 9

NOTE 1 The only time unit commonly used in conjunction with the SI prefixes is the second; e.g. the submultiples millisecond (ms), microsecond (μ s) and nanosecond (ns) which are in wide technological use.

NOTE 2 The symbol “a” is used for year.

NOTE 3 The scale of International Atomic Time (TAI, based directly on the atomic radiation defining the second, is maintained by the Bureau International de l’Heure (BIH) in Paris. Legal time in the UK, as in most countries, is based on a related scale, that of Co-ordinated Universal Time (UTC), broadcast by an international network of radio stations. UTC is defined in such a manner that it differs from TAI by a whole number of seconds. The difference UTC-TAI was set equal to -10 s on 1 January 1972, the date of application of the reformulation of UTC (which previously involved a frequency offset).

This difference can be changed in steps of 1 s, but the use of a positive or negative leap second at the end of a month of UTC, preferably in the first instance at the end of December or of June, and in the second instance at the end of March or of September, to keep UTC in agreement with the time defined by the rotation of Earth with an approximation better than 0.9 s. On 1 January 1981 the difference UTC — TAI was -19 s. In fact, the legal times of most countries are offset from UTC by a whole number of hours (because of time zones and “daylight saving” arrangements).

10 Linear velocity (speed) (length/time)

10.1 The coherent SI unit of linear velocity is the metre per second (symbol m/s), a derived unit.

10.2 Multiples and submultiples of the metre per second are formed by using any of the SI prefixes in conjunction with the metre.

10.3 A metric unit often used for speed is the kilometre per hour (km/h). $1 \text{ km/h} = 0.277\,778 \text{ m/s}$

⁴⁾ In October 1980 the International Committee of Weights and Measures decided to interpret the class of supplementary units in the International System as a class of dimensionless derived units for which the General Conference of Weights and Measures leaves open the possibility of using these or not in expressions of derived units of the International System.

10.4 Various speed units used in the imperial system are:

foot per second	1 ft/s	= 0.3048 m/s
inch per second	1 in/s	= 0.0254 m/s
foot per minute	1 ft/min	= 0.005 08 m/s
mile per hour ^a	1 mile/h	= 0.447 04 m/s

^a Traditionally indicated by the abbreviation m.p.h.

10.5 The knot, one nautical mile per hour, is a unit used for speed in nautical and aeronautical contexts. The international knot (kn) is metric-based, being equal to one international nautical mile per hour.

$$1 \text{ kn} = 1 \text{ 852 m/h} = 0.514 \text{ 444 m/s}$$

The UK knot is imperial-based and obsolescent, being equal to one UK nautical mile per hour.

$$1 \text{ UK knot} = 6 \text{ 080 ft/h} = 0.514 \text{ 773 m/s}$$

For interconversion factors for the above units see Table 10.

11 Angular velocity⁵⁾ (angle/time)

11.1 The coherent SI unit of angular velocity is the radian per second (rad/s), a derived unit.

11.2 Other units used are:

radian per minute	(rad/min)
revolution per minute	(rev/min) or (r/min)
revolution per second	(rev/s) or (r/s)
degree per minute	(°/min)
degree per second	(°/s)

For interconversion factors for the above units see Table 11.

12 Frequency (number/time)

12.1 The coherent SI unit of frequency (of a wave or periodic phenomenon) is the hertz (symbol Hz), a derived unit with a special name. Formerly in this country the hertz was called the cycle per second (c/s). Expressed in terms of base units of the SI both the hertz and the cycle per second are the inverse second i.e. $\frac{1}{\text{s}}$ (or s^{-1}).

12.2 The coherent SI unit of rotational frequency (e.g. a frequency associated with the mechanical rotation of a shaft) is also the inverse second, i.e. $\frac{1}{\text{s}}$ (or s^{-1}). It is commonly known as the revolution per second (rev/s or r/s).

12.3 Another very commonly used unit of rotational frequency is the revolution per minute (rev/min or r/min, but traditionally indicated by the abbreviation r.p.m.).

$$\begin{aligned}
 1 \text{ rev/min} &= \frac{1}{60} \text{ rev/s} \\
 &= (\text{in SI terms}) \frac{1}{60 \text{ s}} \text{ or } \frac{1}{60} \text{ s}^{-1}
 \end{aligned}$$

⁵⁾ The terms “rotational velocity”, “rotational speed” and “speed of rotation” are commonly used as alternative terms for angular velocity, but are also often thought of as a frequency, particularly when being expressed in revolutions per minute, or per second. When frequency is meant, the revolution should not be identified with angle as it is so identified in Table 11 (1 revolution = 2π radians = 360°), but should be thought of as a number, and a clearer term for expressing this concept is “rotational frequency”. (See also section 12, Frequency.)

Table 10 — Linear velocity

Exact values are printed in bold type.

	metre per second m/s	kilometre per hour km/h	foot per second ft/s	foot per minute ft/min	inch per second in/s	mile per hour mile/h	international knot kn	UK knot
1 metre per second = m/s	1	3.6	3.280 84	196.850	39.3701	2.236 94	1.943 84	1.942 60
1 kilometre per hour = km/h	0.277 778	1	0.911 344	54.6807	10.9361	0.621 371	0.539 957	0.539 612
1 foot per second = ft/s	0.3048	1.097 28	1	60	12	0.681 818	0.592 484	0.592 105
1 foot per minute = ft/min	0.005 08	0.018 288	0.016 666 7	1	0.2	0.011 363 6	$9.874\,73 \times 10^{-3}$	$9.868\,42 \times 10^{-3}$
1 inch per second = in/s	0.0254	0.091 44	0.083 333 3	5	1	0.056 818 2	$4.937\,37 \times 10^{-2}$	$4.934\,21 \times 10^{-2}$
1 mile per hour = mile/h	0.447 04	1.609 344	1.466 67	88	17.6	1	0.868 976	0.868 421
1 international knot = kn	0.514 444	1.852	1.687 81	101.269	20.2537	1.150 78	1	0.999 361
1 UK knot =	0.514 773	1.853 18	1.688.89	101.333	20.266 7	1.151 52	1.000 64	1

Table 11 — Angular velocity and velocity of rotation

Exact values are printed in bold type.

	radian per second rad/s	radian per minute rad/min	revolution per second rev/s	revolution per minute rev/min	degree per second °/s	degree per minute °/min
1 radian per second = rad/s	1	60	0.159 155	9.549 30	57.2958	3437.75
1 radian per minute = rad/min	0.016 666 7	1	0.002 652 58	0.159 155	0.954 930	57.2958
1 revolution per second = rev/s	6.283 19	376.991	1	60	360	21 600
1 revolution per minute = rev/min	0.104 720	6.283 19	0.016 666 7	1	6	360
1 degree per second = °/s	0.017 453 3	1.047 20	0.002 777 78	0.166 667	1	60
1 degree per minute = °/min	$2.908\,88 \times 10^{-4}$	0.017 453 3	$4.629\,63 \times 10^{-5}$	$2.777\,78 \times 10^{-3}$	0.016 666 7	1

12.4 Corresponding angular velocities are obtainable from Table 11 using 1 rev/s as corresponding to 1 Hz, $\frac{1}{s}$ or s^{-1} .

NOTE See also the note under section 11, Angular velocity.

13 Acceleration (length/time squared)

13.1 The coherent SI unit of acceleration is the metre per second squared (symbol m/s^2), a derived unit.

13.2 The centimetre per second squared (cm/s^2), a submultiple of the above, is also called the galileo or gal (symbol Gal).

$$1 \text{ Gal} = 1 \text{ cm/s}^2 = 10^{-2} \text{ m/s}^2$$

A unit that has been commonly used in geodesy is the milligal (mGal).

$$1 \text{ mGal} = 10^{-3} \text{ Gal} = 10^{-5} \text{ m/s}^2$$

13.3 The most-used unit in the imperial system for acceleration is the foot per second squared (ft/s^2).

$$1 \text{ ft/s}^2 = \mathbf{0.3048} \text{ m/s}^2$$

13.4 The standard acceleration of $\mathbf{9.806\,65} \text{ m/s}^2$ plays an important part in the definition of certain units in the older technical systems. When the acceleration of free fall has this value the term “standard gravity” is used, the associated symbol for this quantity being g_n .

The acceleration due to gravity is sometimes used as a unit of acceleration, and called “ g ”, particularly in aeronautical engineering and centrifuge technology. For the sake of precision the standard value $\mathbf{9.806\,65} \text{ m/s}^2$ should be taken for this unit. A close approximation in imperial units is 32.1740 ft/s^2 . These are frequently rounded to 9.81 m/s^2 and 32.2 ft/s^2 .

Interconversion factors for the above units can be seen or inferred from Table 13.

Table 13 — Acceleration

Exact values are printed in bold type

	metre per second squared m/s^2	foot per second squared ft/s^2	standard acceleration due to gravity g_n
1 metre per second squared = m/s^2	1	3.280 84	0.101 972
1 foot per second squared = ft/s^2	0.3048	1	0.031 081 0
standard acceleration due to gravity = g_n	9.806 65	32.1740	1
NOTE 1 Gal = $1 \text{ cm/s}^2 = 10^{-2} \text{ m/s}^2$ 1 mGal = 10^{-5} m/s^2 (see 13.2).			

14 Mass

14.1 The coherent SI unit of mass is the kilogram (symbol kg), a base unit. It is defined as equal to the mass of the international prototype of the kilogram (which is in the custody of the International Bureau of Weights and Measures at Sèvres near Paris).

14.2 Because the name of the base unit of mass already contains the SI prefix “kilo”, multiples and submultiples are formed by adding SI prefixes to the word “gram”. Examples are megagram (Mg), gram (g), milligram (mg) and microgram (µg), as follows:

	Refer to note
1 Mg = 1 000 kg	—
1 g = $\frac{1}{1\,000}$ kg	—
1 mg = 10^{-6} kg	—
1 µg = 10^{-9} kg	1

In practice the megagram is usually referred to by the special name “tonne” (symbol t), and is often called the “metric ton” in the UK and in the USA.

14.3 Some other units of mass having associations with the metric system are:

	Refer to note
1 metric carat = 200 milligrams = 2×10^{-4} kg	2
1 quintal (q) = 100 kg	—
1 atomic mass unit (u) = $1.660\,53 \times 10^{-27}$ kg	—

14.4 The primary unit of mass in the imperial system and in the USA is the pound (lb). In the UK Weights and Measures Act, and in similar legislation in the USA, it is defined precisely and exactly as follows:

$$1 \text{ lb} = 0.453\,592\,37 \text{ kg}$$

14.5 The connection between multiples and submultiples of the pound is indicated in the following traditional lists of named UK and US units of mass.

Avoirdupois units

(a) UK and US units

1 pound	= 16 ounces (oz)	(1 oz = 28.3495 g)
	= 16 × 16 drams (dr)	(1 dr = 1.771 85 g)
	= 7 000 grains (gr)	(1 gr = 0.064 798 91 g)

(b) UK units only

1 stone	= 14 pounds	(= 6.350 29 kg)
1 quarter (qr)	= 28 pounds	(= 12.7006 kg)
1 cental (ctl)	= 100 pounds	(= 45.3592 kg)
1 hundredweight (cwt)	= 112 pounds	(= 50.8023 kg)
1 ton (ton)	= 2 240 pounds	(= 1016.05 kg)

(c) US units only

1 short hundredweight (sh cwt)	= 100 pounds	(= 45.3592 kg)
1 short ton (sh ton)	= 2 000 pounds	(= 907.185 kg)

(In the USA the word ton refers to the “short ton” of 2 000 lb unless otherwise specified. The terms “long ton” or “gross ton” are sometimes used, referring to the ton of 2 240 lb. The hundredweight of 112 lb is often called the “long hundredweight”. The use of the “long” units is decreasing in the USA.)

Apothecaries’ units (used in the UK^a and the USA)

1 scruple ^a	= 20 grains	(= 1.295 98 gram)
1 drachm ^a (in UK)	= 3 scruples	(= 3.887 93 gram)
1 dram (in USA)	= 3 scruples	(= 3.887 93 gram)
1 ounce ^a = 24 scruples	= 480 grains	(= 31.1035 gram)

(oz apoth in UK

oz ap in USA)

Troy units (used in the UK and the USA)

1 ounce troy = 1 apothecaries’ ounce = 480 grains (= 31.1035 gram)

(oz tr in UK

oz t in USA)

^a The apothecaries’ units (scruple, drachm, and apothecaries’ ounce) have been illegal since 1 January 1971 for use in the United Kingdom.

(The apothecaries’ ounce⁶⁾ and the ounce troy are identical in mass and differ from the avoirdupois ounce. Unless otherwise qualified, the term ounce and its abbreviation oz signify the avoirdupois ounce. The pound troy has no legal basis in the UK but is legalized in the USA, where it is defined as a mass equal to 5 760 grains.

1 pound troy (USA only) = 12 ounces troy = 5 760 grains (= 0.373 242 kg)

The grain has the same value in the avoirdupois, troy, and apothecaries’ systems, and is abbreviated to gr in the UK.)

14.6 Some more specialized UK and/or USA named units of mass are:

		Refer to note
1 assay ton (UK)	= 32.667 g	3
1 assay ton (US)	= 29.166 g	4
1 slug	= 32.1740 lb (= 14.5939 kg)	5
1 international corn bushel	= 60 lb (= 27.2155 kg)	6

For interconversion factors for many of the units of mass mentioned above see Table 14a, Table 14b and Table 14c.

Notes on section 14

NOTE 1 The alternative name “gamma” (symbol γ) is sometimes used to indicate a microgram.

NOTE 2 The metric carat has international sanction for use in trade in diamonds, fine pearls, and precious stones. In the UK the legal abbreviation for this unit is CM.

NOTE 3 The number of milligrams in a UK assay ton is equal to the number of ounces troy in a UK ton.

NOTE 4 The number of milligrams in a US assay ton is equal to the number of ounces troy in a US (short) ton.

NOTE 5 The slug is the British technical unit of mass. One pound-force acting on this mass produces an acceleration of 1 foot per second squared.

NOTE 6 Used for the sale of wheat under International Wheat Agreement, 1949.

⁶⁾ The apothecaries’ units (scruple, drachm, and apothecaries’ ounce) have been illegal since 1 January 1971 for use in the United Kingdom.

Table 14a — Mass

Exact values are printed in bold type.

		kilogram kg	pound lb	slug
1 kilogram kg	=	1	2.204 62	0.068 521 8
1 pound lb	=	0.453 592 37	1	0.031 081 0
1 slug	=	14.5939	32.1740	1

15 Mass per unit length (or linear density) (mass/length)**15.1** The coherent SI unit of mass per unit length is the kilogram per metre (symbol kg/m), a derived unit.**15.2** Two specialized units of linear density used in the textile industry and which have an association with the metric system are:1 tex = 1 gram per kilometre = 10^{-6} kg/m1 denier = 1 gram per 9 kilometres = $0.111\ 112 \times 10^{-6}$ kg/m**15.3** A selection of imperial units used in industry, often for wires, rods etc. is:

1 pound per inch (lb/in) (= 17.8580 kg/m)

1 pound per foot (lb/ft) (= 1.488 16 kg/m)

1 pound per yard (lb/yd) (= 0.496 055 kg/m)

1 pound per mile (lb/mile) (= $2.818\ 49 \times 10^{-4}$ kg/m)

1 UKton per 1 000 yards (ton/1 000 yd) (= 1.111 16 kg/m)

1 UKton per mile (ton/mile) (= 0.631 342 kg/m)

Interconversion factors for the units in 15.1 and 15.3 are given in Table 15. For further information on **15.2** reference should be made to BS 947 which gives tables for calculating the tex values of numbers or counts in other systems, including denier.

Table 14b — Mass

Exact values are printed in bold type.

	gram g (0.001 kg)	metric carat	grain^a gr	dram (avoir) dr	drachm (apoth)	ounce (avoir) oz	ounce (troy or apoth) oz tr or oz apoth
1 gram (0.001 kg) = g	1	5	15.4324	0.564 383	0.257 206	0.035 274 0	0.032 150 7
1 metric carat =	0.2	1	3.086 47	0.112 877	0.051 441 2	$7.054\,79 \times 10^{-3}$	$6.430\,15 \times 10^{-3}$
1 grain ^a = gr	0.064 798 9	0.323 995	1	0.036 571 4	0.016 666 7	$2.285\,71 \times 10^{-3}$	$2.083\,33 \times 10^{-3}$
1 dram (avoir) = dr	1.771 85	8.859 23	27.343 75	1	0.455 729	0.0625	0.056 966 1
1 drachm (apoth) =	3.887 93	19.4397	60	2.194 29	1	0.137 143	0.125
1 ounce (avoir) = oz	28.3495	141.748	437.5	16	7.291 67	1	0.911 458
1 ounce (troy or apoth) = oz tr or oz apoth	31.1035	155.517	480	17.5543	8	1.097 14	1
^a The grain has the same value in the avoirdupois, troy and apothecaries' systems. The apothecaries' units (drachm and apothecaries' ounce) are no longer legal for use in the United Kingdom.							

Table 14c — Mass

Exact values are printed in bold type.

		tonne (1 000 kg) (megagram Mg)	pound lb	UK hundredweight cwt	short hundredweight^a sh cwt	UK ton ton	short ton^a sh ton
1 tonne (1000 kg) (1 Mg) t	=	1	2204.62	19.6841	22.0462	0.984 207	1.102 31
1 pound lb	=	$4.535\ 92 \times 10^{-4}$	1	$8.928\ 57 \times 10^{-3}$	0.01	$4.464\ 29 \times 10^{-4}$	0.0005
1 hundredweight cwt	=	0.050 802 3	112	1	1.12	0.05	0.056
1 short hundredweight ^a sh cwt	=	0.045 359 2	100	0.892 857	1	0.044 642 9	0.05
1 UK ton ton	=	1.016 05	2 240	20	22.4	1	1.12
1 short ton ^a sh ton	=	0.907 185	2 000	17.8571	20	0.892 857	1
^a US units. The short hundredweight (of 100 lb) is, in the UK, sometimes called the “cental” (symbol ctl).							

Table 15 — Mass per unit length
(applicable to wires, rods, etc.)

Exact values are printed in bold type.

	kilogram per metre	pound per inch	pound per foot	pound per yard	pound per mile	UKton per 1000 yards	UKton per mile
	kg/m	lb/in	lb/ft	lb/yd	lb/mile	ton/1 000 yd	ton/mile
1 kilogram per metre ^a = kg/m	1	0.055 997 4	0.671 969	2.015 91	3548.00	0.899 958	1.583 93
1 pound per inch = lb/in	17.8580	1	12	36	63 360	16.0714	28.2857
1 pound per foot = lb/ft	1.488 16	0.083 333 3	1	3	5 280	1.339 29	2.357 14
1 pound per yard = lb/yd	0.496 055	0.027 777 8	0.333 333	1	1 760	0.446 429	0.785 714
1 pound per mile = lb/mile	$2.818\,49 \times 10^{-4}$	$1.578\,28 \times 10^{-5}$	$1.893\,94 \times 10^{-4}$	$5.681\,82 \times 10^{-4}$	1	$2.536\,53 \times 10^{-4}$	$4.464\,29 \times 10^{-4}$
1 UKton per 1 000 yards = ton/1 000 yd	1.111 16	0.062 222 2	0.746 667	2.24	3942.4	1	1.76
1 UKton per mile = ton/mile	0.631 342	0.035 353 5	0.424 242	1.272 73	2 240	0.568 182	1
^a 1 kilogram per metre (kg/m) = 1 tonne per kilometre (t/km).							