Civil Aviation Requirements

For

Units of Measurements to be used in

Air and Ground Operations

CAR — 5

Third Edition – November 2016

Civil Aviation Authority of Nepal

Amendments

Amendments and Corrigenda to these "**CIVIL AVIATION REQUIREMENTS FOR UNITS OF MEASUREMENT TO BE USED IN AIR AND GROUND OPERATIONS**"Nepal are issued by Director General of CAA, Nepal. The space below is provided to keep a record of such amendments.

Record of amendments and corrigenda

Amendments			
No	**Date of Issue**	**Date Entered**	**Entered by**

Corrigenda			
No	**Date of Issue**	**Date Entered**	**Entered by**

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FOREWORD

Article 28 (Air navigation facilities and standard system) of the Convention on International Civil Aviation requires each contracting State to provide, in its territory, airports radio services, meteorological services and other air navigation facilities to facilitate international air navigation, in accordance with the standards and recommended practices or established from time to time, pursuant to the Convention.

ICAO Annex 5 provides the Standards and Recommended Practices pertaining to the Units of Measurements to be used in Air and Ground Operations which are required to be adopted by the Contracting State.

This CAR-5, **Units of Measurementto be used in Air and Ground operation,** is enacted by Civil Aviation Authority of Nepal **Pursuant to Rule 81 of Civil Aviation Rule 2052 (1996) and Rule-82, Schedule-3 of CAAN Civil Aviation Regulation-2058(2002).** This CAR specifies the national standards for units of measurements to be used in civil aviation air and ground operations in confirmity to ICAO Annexes.

This is a controlled document and is subject to periodic review. Air Navigation Services Safety Standards Department will maintain this document as complete, accurate and up-dated as possible. Comments and recommendations for revision/amendment action to this publication should be forwarded to the Director of ANS Safety Standards Department.

This edition supersedes the previous edition of CAR-5.

All other legislations still stand valid as a part of Civil Aviation requirements for practical purposes.

Sanjiv Gautam

(Director General)

Civil Aviation Authority of Nepal

CHAPTER 1.
DEFINITIONS

When the following terms are used concerning the units of measurement to be used in all aspects of civil aviation air and ground operations, they have the following meanings:

Ampere (A). The ampere is that constant electric current which, if maintained in two straight parallel conductors of infinite length, of negligible circular cross-section, and placed 1 metre apart in a vacuum, would produce between these conductors a force equal to 2×10^{-7}newton per metre of length.

Becquerel (Bq). The activity of a radionuclide having one spontaneous nuclear transition per second.

Candela (cd). The luminous intensity, in the perpendicular direction, of a surface of 1/600 000 square metre of black body at the temperature of freezing platinum under a pressure of 101 325 newtons per square metre.

Celsius temperature (t°c). The Celsius temperature is equal to the difference $t°_C = T - T_0$ between two thermodynamic temperatures T and T_0 where T_0 equals 273.15 kelvin.

Coulomb (C). The quantity of electricity transported in 1 second by a current of 1 ampere.

Degree Celsius (°C). The special name for the unit kelvin for use in stating values of Celsius temperature.

Farad (F). The capacitance of a capacitor between the plates of which there appears a difference of potential of 1 volt whenit is charged by a quantity of electricity equal to 1 coulomb.

Foot (ft). The length equal to 0.304 8 metre exactly.

Gray (Gy). The energy imparted by ionizing radiation to a mass of matter corresponding to 1 joule per kilogram.

Henry (H). The inductance of a closed circuit in which an electromotive force of 1 volt is produced when the electric current in the circuit varies uniformly at a rate of 1 ampere per second.

Hertz (Hz). The frequency of a periodic phenomenon of which the period is 1 second.

Human performance. Human capabilities and limitations which have an impact on the safety and efficiency of aeronautical operations.

Joule (J). The work done when the point of application of a force of 1 newton is displaced a distance of 1 metre in the direction of the force.

Kelvin (K). A unit of thermodynamic temperature which is the fraction 1/273.16 of the thermodynamic temperature of the triple point of water.

Kilogram (kg). The unit of mass equal to the mass of the international prototype of the kilogram.

Knot (kt). The speed equal to 1 nautical mile per hour.

Litre (L). A unit of volume restricted to the measurement of liquids and gases which is equal to 1 cubic decimeter.

Lumen (lm). The luminous flux emitted in a solid angle of 1 steradian by a point source having a uniform intensity of 1 candela

Lux (lx). The illuminance produced by a luminous flux of 1 lumen uniformly distributed over a surface of 1 square metre.
Metre (m). The distance travelled by light in a vacuum during 1/299 792 458 of a second.

Mole (mol). The amount of substance of a system which contains as many elementary entities as there are atoms in0.012 kilogram of carbon-12.

Note.— When the mole is used, the elementary entities must be specified and may be atoms, molecules, ions, electrons, other particles or specified groups of such particles.

Nautical mile (NM). The length equal to 1 852 metres exactly.

Newton (N). The force which when applied to a body having a mass of 1 kilogram gives it an acceleration of 1 metre per second squared.

Ohm (Ω). The electric resistance between two points of a conductor when a constant difference of potential of 1 volt, applied between these two points, produces in this conductor a current of 1 ampere, this conductor not being the source of any electromotive force.

Pascal (Pa). The pressure or stress of 1 newton per square metre.

Radian (rad). The plane angle between two radii of a circle which cut off on the circumference an arc equal in length to theradius.

Second (s). The duration of 9 192 631 770 periods of the radiation corresponding to the transition between the two hyperfine levels of the ground state of the caesium-133 atom.

Siemens (S). The electric conductance of a conductor in which a current of 1 ampere is produced by an electric potential difference of 1 volt.

Sievert (Sv). The unit of radiation dose equivalent corresponding to 1 joule per kilogram.

Steradian (sr). The solid angle which, having its vertex in the centre of a sphere, cuts off an area of the surface of the spher eequal to that of a square with sides of length equal to the radius of the sphere.

Tesla (T). The magnetic flux density given by a magnetic flux of 1 weber per square metre. ***Tonne (t).*** The mass equal to 1 000 kilograms.

Volt (V). The unit of electric potential difference and electromotive force which is the difference of electric potential between two points of a conductor carrying a constant cur rent of 1 ampere, when the power dissipated between these points isequal to 1 watt.

Watt (W). The power which gives rise to the production of energy at the rate of 1 joule per second.

Weber (Wb). The magnetic flux which, linking a circuit of one turn, produces in it an electromotive force of 1 volt as it is reduced to zero at a uniform rate in 1 second.

CHAPTER 2.

APPLICABILITY

Introductory Note.— This CAR contains specifications for the use of a standardized system of units of measurement in civil aviation air and ground operations. This standardized system of units of measurement is based on theInternational System of Units (SI) and certain non-SI units considered necessary to meet the specialized requirements of civil aviation. See Attachment A for details concerning the development of the SI.

2.1 Applicability

The requirements contained in this CAR shall be applicable to all aspects of civilaviation air and ground operations.

CHAPTER 3.
STANDARD APPLICATION OF UNITSOF MEASUREMENT

3.1 SI units

3.1.1 The International System of Units developed and maintained by the General Conference of Weights and Measures (CGPM) shall, subject to the provisions of 3.2 and 3.3, be used as the standard system of units of measurement for all aspects of civil aviation air and ground operations.

3.1.2 Prefixes
The prefixes and symbols listed in Table 3-1 shall be used to form names and symbols of the decimal multiples and sub-multiples of SI units.

Note 1.— As used herein the term SI unit is meant to include base units and derived units as well as their multiples and sub-multiples.

Note 2.— See Attachment B for guidance on the general application of prefixes.

Table 3-1. SI unit prefixes

Multiplication factor	*Prefix*	*Symbol*
1 000 000 000 000 000 000 = 10^{18}	exa	E
1 000 000 000 000 000 = 10^{15}	peta	P
1 000 000 000 000 = 10^{12}	tera	T
1 000 000 000 = 10^{9}	giga	G
1 000 000 = 10^{6}	mega	M
1 000 = 10^{3}	kilo	k
100 = 10^{2}	hecto	h
10 = 10^{1}	deca	da
0.1 = 10^{-1}	deci	d
0.01 = 10^{-2}	centi	c
0.001 = 10^{-3}	milli	m
0.000 001 = 10^{-6}	micro	µ
0.000 000 001 = 10^{-9}	nano	n
0.000 000 000 001 = 10^{-12}	pico	p
0.000 000 000 000 001 = 10^{-15}	femto	f
0.000 000 000 000 000 001 = 10^{-18}	atto	a

3.2 Non-SI units

3.2.1 Non-SI units for permanent use with the SI

The non-SI units listed in Table 3-2 shall be used either in lieu of, or in addition to, SI units as primary units of measurement but only as specified in Table 3-4.

Table 3-2. Non-SI units for use with the SI

Specific quantities in Table 3-4 related to	*Unit*	*Symbol*	*Definition (in terms of SI units)*
mass	tonne	t	1 t = 10^3 kg
plane angle	degree	°	1° = (π/180) rad
	minute	'	1' = (1/60)° = (π/10 800) rad
	second	"	1" = (1/60)' = (π/648 000) rad
temperature	degree Celsius	°C	1 unit °C = 1 unit K[a)]
time	minute	min	1 min = 60 s
	hour	h	1 h = 60 min = 3 600 s
	day	d	1 d = 24 h = 86 400 s
	week, month, year	-	
volume	litre	L	1 L = 1 dm^3 = $10^{-3} m^3$

a) See Attachment C, Table C-2 for conversion.

3.2.2 Non-SI alternative units permitted for use with the SI

The non-SI units listed in Table 3-3 shall be permitted for use as alternative units of measurement but only for those specific quantities listed in Table 3-4.

Note.— It is intended that the use of the non-SI alternative units listed in Table 3-3 and applied as indicated in Table 3-4 will eventually be discontinued in accordance with individual unit termination datesl. Termination dates, when established, will be given in Chapter 4.

3.3 Application of specific units

3.3.1 The application of units of measurement for certain quantities used in civil aviation air and ground operations shall be in accordance with Table 3-4.

Note.— Table 3-4 is intended to provide standardization of units (including prefixes) for those quantities commonly used in air and ground operations. Basic provisions apply for units to be used for quantities not listed.

3.3.2 Reserved

Table 3-3. Non-SI alternative units permitted for use with the SI

Specific quantities in Table 3-4 related to	Unit	Symbol	Definition (in terms of SI units)
distance (long)	nautical mile	NM	1 NM = 1 852 m
distance (vertical)[a)]	foot	ft	1 ft = 0.304 8 m
speed	knot	kt	1 kt = 0.514 444 m/s

a) altitude, elevation, height, vertical speed.

Table 3-4. Standard application of specific units of measurement

Ref. No.	*Quantity*	*Primary Unit (Symbol)*	*Non-SI alternative unit (symbol)*
1. ***Direction/Space/Time***			
1.1	altitude	m	ft
1.2	area	m^2	
1.3	distance (long)[a)]	km	NM
1.4	distance (short)	m	
1.5	elevation	m	ft
1.6	endurance	h and min	
1.7	height	m	ft
1.8	latitude	° ' "	
1.9	length	m	
1.10	longitude	° ' "	
1.11	plane angle (when required, decimal subdivisions of the degree shall be used)	°	
1.12	runway length	m	
1.13	runway visual range	m	
1.14	tank capacities (aircraft)[b)]	L	
1.15	time	s min h d week month year	

Ref. No.	Quantity	Primary Unit (Symbol)	Non-SI alternative unit (symbol)
1.16	visibility[c)]	km	
1.17	volume	m^3	
1.18	wind direction (wind directions other than for a landing and take-off shall be expressed in degrees true; for landing and takeoff wind directions shall be expressed in degrees magnetic)	°	
2. ***Mass-related***			
2.1	air density	kg/m^3	
2.2	area density	kg/m^2	
2.3	cargo capacity	kg	
2.4	cargo density	kg/m^3	
2.5	density (mass density)	kg/m^3	
2.6	fuel capacity (gravimetric)	kg	
2.7	gas density	kg/m^3	
2.8	gross mass or payload	kg t	
2.9	hoisting provisions	kg	
2.10	linear density	kg/m	
2.11	liquid density	kg/m^3	
2.12	mass	kg	
2.13	moment of inertia	$kg \cdot m^2$	
2.14	moment of momentum	$kg \cdot m^2/s$	
2.15	momentum	$kg \cdot m/s$	
3. ***Force-related***			
3.1	air pressure (general)	kPa	
3.2	altimeter setting	hPa	

Ref. No.	Quantity	Primary Unit (Symbol)	Non-SI alternative unit (symbol)
3.3	atmospheric pressure	hPa	
3.4	bending moment	kN· m	
3.5	force	N	
3.6	fuel supply pressure	kPa	
3.7	hydraulic pressure	kPa	
3.8	modulus of elasticity	MPa	
3.9	pressure	kPa	
3.10	stress	MPa	
3.11	surface tension	mN/m	
3.12	thrust	kN	
3.13	torque	N · m	
3.14	vacuum	Pa	
4. *Mechanics*			
4.1	airspeed[d)]	km/h	kt
4.2	angular acceleration	rad/s^2	
4.3	angular velocity	rad/s	
4.4	energy or work	J	
4.5	equivalent shaft power	kW	
4.6	frequency	Hz	
4.7	ground speed	km/h	kt
4.8	impact	J/m^2	
4.9	kinetic energy absorbed by brakes	MJ	

Ref. No.	*Quantity*	*Primary Unit (Symbol)*	*Non-SI alternative unit (symbol)*
4.10	linear acceleration	m/s^2	
4.11	power	kW	
4.12	rate of trim	°/s	
4.13	shaft power	kW	
4.14	velocity	m/s	
4.15	vertical speed	m/s	ft/min
4.16	wind speed[e)]	m/s	Kt
5. ***Flow***			
5.1	engine airflow	kg/s	
5.2	engine waterflow	kg/h	
5.3	fuel consumption (specific)		
	piston engines	kg/(kW · h)	
	turbo-shaft engines	kg/(kW · h)	
	jet engines	kg/(kN· h)	
5.4	fuel flow	kg/h	
5.5	fuel tank filling rate (gravimetric)	kg/min	
5.6	gas flow	kg/s	
5.7	liquid flow (gravimetric)	g/s	
5.8	liquid flow (volumetric)	L/s	
5.9	mass flow	kg/s	
5.10	oil consumption		
	gas turbine	kg/h	
	piston engines (specific)	g/(kW · h)	
5.11	oil flow	g/s	
5.12	pump capacity	L/min	

Ref. No.	*Quantity*	*Primary Unit (Symbol)*	*Non-SI alternative unit (symbol)*
5.13	ventilation airflow	m^3/min	
5.14	viscosity (dynamic)	Pa · s	
5.15	viscosity (kinematic)	m^2/s	
6. *Thermodynamics*			
6.1	coefficient of heat transfer	W/(m^2· K)	
6.2	heat flow per unit area	J/m^2	
6.3	heat flow rate	W	
6.4	humidity (absolute)	g/kg	
6.5	coefficient of linear expansion	$°C^{-1}$	
6.6	quantity of heat	J	
6.7	temperature	°C	
7. *Electricity and magnetism*			
7.1	capacitance	F	
7.2	conductance	S	
7.3	conductivity	S/m	
7.4	current density	A/m^2	
7.5	electric current	A	
7.6	electric field strength	C/m^2	
7.7	electric potential	V	
7.8	electromotive force	V	
7.9	magnetic field strength	A/m	
7.10	magnetic flux	Wb	

Ref. No.	Quantity	Primary Unit (Symbol)	Non-SI alternative unit (symbol)
7.11	magnetic flux density	T	
7.12	power	W	
7.13	quantity of electricity	C	
7.14	resistance	Ω	
8. *Light and related electromagnetic radiations*			
8.1	illuminance	lx	
8.2	luminance	cd/m^2	
8.3	luminous exitance	lm/m^2	
8.4	luminous flux	lm	
8.5	luminous intensity	cd	
8.6	quantity of light	lm· s	
8.7	radiant energy	J	
8.8	wavelength	m	
9. *Acoustics*			
9.1	frequency	Hz	
9.2	mass density	kg/m^3	
9.3	noise level	dB[f)]	
9.4	period, periodic time	s	
9.5	sound intensity	W/m^2	
9.6	sound power	W	
9.7	sound pressure	Pa	
9.8	sound level	dB[f)]	

Ref. No.	***Quantity***	***Primary Unit (Symbol)***	***Non-SI alternative unit (symbol)***
9.9	static pressure (instantaneous)	Pa	
9.10	velocity of sound	m/s	
9.11	volume velocity (instantaneous)	m^3/s	
9.12	wavelength	m	
10. *Nuclear physics and ionizing radiation*			
10.1	absorbed dose	Gy	
10.2	absorbed dose rate	Gy/s	
10.3	activity of radionuclides	Bq	
10.4	dose equivalent	Sv	
10.5	radiation exposure	C/kg	
10.6	exposure rate	C/kg · s	

a) As used in navigation, generally in excess of 4 000 m.
b) Such as aircraft fuel, hydraulic fluids, water, oil and high pressure oxygen vessels.
c) Visibility of less than 5 km may be given in m.
d) Airspeed is sometimes reported in flight operations in terms of the ratio MACH number.
e) A conversion of 1 kt = 0.5 m/s is used for the representation of wind speed.
f) The decibel (dB) is a ratio which may be used as a unit for expressing sound pressure level and sound power level. When used, the reference level mustbe specified.

CHAPTER 4.
TERMINATION OF USE OFNON-SI ALTERNATIVE UNITS

Introductory Note.— The non-SI units listed in Table 3-3 have been retained for use as alternative units because of their widespread use and to avoid potential safety problems which could result from the lack of coordination concerning the termination of their use. It is expected that the establishment of termination dates will be well in advance of actual termination. Any special procedures associated with specific unit termination will be circulated through this CAR.

4.1 The termination dates for the use of alternative non-SI units listed in Table 3-3 is listed in Table 4-1 below.

Table 4-1. Termination dates for non-SI alternative units

Non-SI alternative unit	***Termination date***
Knot Nautical mile Foot	Not yet established, however termination dates will be established and circulated well in advance of actual termination.

ATTACHMENT A.

DEVELOPMENT OF THE INTERNATIONALSYSTEM OF UNITS (SI)

1 Historical background

1.1 The name SI is derived from "Système Internationaled'Unités". The system has evolved from units of length and mass (metre and kilogram) which were created by members of the Paris Academy of Sciences and adopted by the French National Assembly in 1795 as a practical measure to benefit industry and commerce. The original system became known asthe metric system. Physicists realized the advantages of the system and it was soon adopted in scientific and technical circles.

1.2 International standardization began with an 1870 meeting of 15 States in Paris that led to the International Metric Convention in 1875 and the establishment of a permanent International Bureau of Weights and Measures. A General Conference on Weights and Measures (CGPM) was also constituted to handle all international matters concerning the metricsystem. In 1889 the first meeting of the CGPM legalized the old prototype of the metre and the kilogram as the international standard for unit of length and unit of mass, respectively. Other units were agreed in subsequent meetings and by its 10th Meeting in 1954, the CGPM had adopted a rationalized andcoherent system of units based on the metre-kilogram-second-ampere (MKSA) system which had been developed earlier, plus the addition of the kelvin as the unit of temperature and the candela as the unit of luminous intensity.

1.3 The 11th CGPM, held in 1960 and in which 36 States participated, adopted the name International System of Units (SI) and laid down rules for the prefixes, the derived and supplementary units and other matters, thus establishing comprehensive specifications for international units of measurement. CGPM reviews the system of units for the refinements in the system, redefinition or renaming the system of units and adoption for the global unification.

2 International Bureau of Weights and Measures

2.1 The Bureau International des Poids et Mesures (BIPM) was set up by the Metre Convention signed in Parison 20 May 1875 by 17 States during the final session of the Diplomatic Conference of the Metre. This Convention was amended in 1921. BIPM has its headquarters near Paris and its upkeep is financed by the Member States of the Metre Convention. The task of BIPM is to ensure worldwide unification of physical measurements; it is responsible for:

- establishing the fundamental standards and scales for measurement of the principal physical quantities and maintaining the international prototypes;
- carrying out comparisons of national and in ternational standards;
- ensuring the coordination of corresponding measuring techniques;
- carrying out and coordinating the determinations relating to the fundamental physical constants.

2.2 BIPM operates under the exclusive supervision of the International Committee of Weights and Measures (CIPM),which itself comes under the authority of the General Conference of Weights and Measures (CGPM). The International Committee consists of 18 members each belonging to a different State; it meets at least once every two years.

2.3 The activities of BIPM, which in the beginning were limited to the measurements of length and mass and to metrological studies in relation to these quantities, have been extended to standards of measurement for electricity (1927), photometry (1937) and ionizing radiations (1960). Physicists or technicians working in the laboratories of BIPMdo metrological research, and also undertake measurement and certification of material standards of the above-mentioned quantities. BIPM from time to time publishes the reports on the development of the metric system throughout the world.

3 International Organization for Standardization

The International Organization for Standardization (ISO) is a worldwide federation of national standards institutes which, although not a part of the BIPM, provides recommendations for the use of SI and certain other units. ISO Document 1000 and the ISO Recommendation R31 series of documents provide extensive detail on the application of the SI units. ICAO maintains liaison with ISO regarding the standardized application of SI units in aviation.

ATTACHMENT B.

GUIDANCE ON THE APPLICATION OF THE SI

1 Introduction

1.1 The International System of Units is a complete, coherent system which includes three classes of units:
a) base units;
b) supplementary units; and
c) derived units.

1.2 The SI is based on seven units which are dimensionally independent and are listed in Table B-1.

1.3 The supplementary units of the SI are listed in Table B-2 and may be regarded either as base units or as derivedunits.

Table B-1. SI base units

Quantity	*Unit*	*Symbol*
amount of a substance	mole	mol
electric current	ampere	A
length	metre	m
luminous intensity	candela	cd
mass	kilogram	kg
thermodynamic temperature	kelvin	K
time	second	s

Table B-2. SI supplementary units

Quantity	*Unit*	*Symbol*
plane angle	radian	rad
solid angle	steradian	sr

1.4 Derived units of the SI are formed by combining base units, supplementary units and other derived units according to the algebraic relations linking the corresponding quantities. The symbols for derived units are obtained by means of the mathematical signs for multiplication, division and the use of exponents. Those derived SI units which have special names and symbols are listed in Table B-3.

Note.— The specific application of the derived units listed in Table B-3 and other units common to civilaviation operations is given in Table 3-4.

Table B-3. SI derived units with special names

Quantity	***Unit***	***Symbol***	***Derivation***
absorbed dose (radiation)	gray	Gy	J/kg
activity of radionuclides	becquerel	Bq	l/s
capacitance	farad	F	C/V
conductance	siemens	S	A/V
dose equivalent (radiation)	sievert	Sv	J/kg
electric potential, potential difference, electromotive force	volt	V	W/A
electric resistance	ohm	Ω	V/A
energy, work, quantity of heat	joule	J	N · m
force	newton	N	kg · m/s^2
frequency (of a periodic phenomenon)	hertz	Hz	l/s
illuminance	lux	lx	lm/m^2
inductance	henry	H	Wb/A
luminous flux	lumen	lm	cd ·sr
magnetic flux	weber	Wb	V · s
magnetic flux density	tesla	T	Wb/m^2
power, radiant flux	watt	W	J/s
pressure, stress	pascal	Pa	N/m^2
quantity of electricity, electric charge	coulomb	C	A · s

1.5 The SI is a rationalized selection of units from the metric system which individually are not new. The great advantage of SI is that there is only one unit for each physical quantity — the metre for length, kilogram (instead of gram) for mass, second for time, etc. From these elemental or base units, units for all other mechanical quantities are derived. Some of these derived units have only generic names such as metre per second for velocity; others have special names such as newton (N) for force, joule (J) for work or energy, watt (W) for power.

1.6 Other advantage of SI unit is the use of a unique and well-defined set of symbols and abbreviations. Such symbols and abbreviations eliminate the confusion that can arise from current practices in different disciplines such as the use of “b” for both the bar (a unit of pressure) and barn (a unit of area).

1.7 Another advantage of SI is its retention of the decimal relation between multiples and sub-multiples of the base units for each physical quantity. Prefixes are established for designating multiple and sub-multiple units from "exa" (10^{18}) down to "atto" (10^{-18}) for convenience in writing and speaking.

1.8 Another major advantage of system of SI units is its coherence. In a coherent system, the product or quotient of any two unit quantities is the unit of the resulting quantity. For example, in any coherent system, unit area results when unit length is multiplied by unit length, unit velocity when unit length is divided by unit time, and unit force when unit mass is multipliedby unit acceleration.

Note.— Figure B-1 illustrates the relationship of the units of the SI.

2 SI prefixes

2.1 Selection of prefixes

2.1.1 In general, the SI prefixes should be used to indicate orders of magnitude, thus eliminating non-significant digits and leading zeros in decimal fractions and providing a convenient alternative to the powers-of-ten notation preferredincomputation.

Forexample: 12 300 mm becomes 12.3 m;
12.3×10^3 m becomes 12.3 km;
0.001 23 µA becomes 1.23 nA

2.1.2 When expressing a quantity by a numerical value and a unit, prefixes should preferably be chosen so that the numerical value lies between 0.1 and 1000. To minimize variety, it is recommended that prefixes representing powers of 1000 be used. However, in the following cases, deviation from the above may be indicated:

a) in expressing area and volume, the prefixes hecto, deca, deci and centi may be required: for example, square hectometre, cubic centimetre;

b) in tables of values of the same quantity, or in a discussion of such values within a given context, it is generally preferable to use the same unit multiple throughout; and

c) for certain quantities in particular applications, one particular multiple is customarily used. For example, the hectopascal is used for altimeter settings and the millimetre is used for linear dimensions in mechanical engineering drawings even when the values lie outside the range 0.1 to 1000.

2.2 Prefixes in compound units[1]

It is recommended that only one prefix be used in forming a multiple of a compound unit. Normally the prefix should be attached to a unit in the numerator. One exception to this occurs when the kilogram is one of the units.

For example:

V/m, *not* mV/mm;

MJ/kg, *not* kJ/g

2.3 Compound prefixes

Compound prefixes, formed by the juxtaposition of two or more SI prefixes, are not to be used.

[1]A compound unit is a derived unit expressed in terms of two or more units, that is, not expressed with a single special name.

For example:

1 nm *not* 1mµm;

1 pF *not* 1µµF

If values are required outside the range covered by the prefixes, they should be expressed using powers of ten applied to the base unit.

2.4 Powers of units

An exponent attached to a symbol containing a prefix indicates that the multiple or sub-multiple of the unit (the unit with its prefix) is raised to the power expressed by the exponent.

For example:

$1\ cm^3 = (10^{-2}m)^3 = 10^{-6}m^3$
$1\ ns^{-1} = (10^{-9}s)^{-1} = 10^9\ s^{-1}$
$1\ mm^2/s = (10^{-3}m)^2/s = 10^{-6}m^2/s$

3 Style and usage

3.1 Rules for writing unit symbols

3.1.1 Unit symbols should be printed in Roman (upright) type regardless of the type style used in the surrounding text.

3.1.2 Unit symbols are unaltered in the plural.

3.1.3 Unit symbols are not followed by a period except when used at the end of a sentence.

3.1.4 Letter unit symbols are written in lower case (cd) unless the unit name has been derived from a proper name, in which case the first letter of the symbol is capitalized (W, Pa). Prefix and unit symbols retain their prescribed form regardless of the surrounding typography.

3.1.5 In the complete expression for a quantity, a space should be left between the numerical value and the unit symbol.

For example, write 35 mm not 35mm, and 2.37 lm, not 2.37lm. When the quantity is used in an adjectival sense, a hyphen is often used, for example, 35-mm film.

Exception: No space is left between the numerical value and the symbols for degree, minute and second of plane angle, and degree Celsius.

3.1.6 No space is used between the prefix and unit symbols.

3.1.7 Symbols, not abbreviations, should be used for units. For example, use “A”, not “amp”, for ampere.

3.2 Rules for writing unit names

3.2.1 Spelled-out unit names are treated as common nouns in English. Thus, the first letter of a unit name is not capitalized except at the beginning of a sentence or in capitalized material such as a title, even though the unit name may be derived from a proper name and therefore be represented as a symbol by a capital letter (see 3.1.4). For example, normally write “newton” not “Newton” even though the symbol is N.

3.2.2 Plurals are used when required by the rules of grammar and are normally formed regularly, for example, henries for the plural of henry. The following irregular plurals are recommended:

Singular	*Plural*
lux	lux
hertz	hertz
siemens	siemens

3.2.3 No space or hyphen is used between the prefix and the unit name.

3.3 Units formed by multiplication and division

3.3.1 *With unit names:*

Product, use a space (preferred) or hyphen:newton metre *or* newton-metre.

In the case of the watt hour the space may be omitted, thus: watthour.

Quotient, use the word per and not a solidus: metre per second *not* metre/second.

Powers, use the modifier squared or cubed placed after the unit name: metre per second squared.

In the case of area or volume, a modifier may be placed before the unit name: square millimetre, cubic metre.

This exception also applies to derived units using area or volume: watt per square metre.

Note.— To avoid ambiguity in complicated expressions, symbols are preferred to words.

3.3.2 *With unit symbols:*

Product may be indicated in either of the following ways: Nm *or* N · m for newton metre.

Note.— When using for a prefix a symbol which coincides with the symbol for the unit, special care should be taken to avoid confusion. The unit newton metre for torque should be written, for example, Nm *or* N · m *to avoid confusion with* mN, *the millinewton.*

An exception to this practice is made for computer printouts, automatic typewriter work, etc., where the dot half high is notpossible, and a dot on the line may be used.

Quotient, use one of the following forms: m/s or $m.s^{-1}m$ *or*m/s.

In no case should more than one solidus or slash be used in the same expression unless parentheses are inserted to avoid ambiguity.

For example, write:

J/(mol· K) *or* $J \cdot mol^{-1} \cdot K^{-1}$ *or* (J/mol)/K
but *not* J/mol/K.

3.3.3 Symbols and unit names should not be mixed in the same expression. Write:

joules per kilogram *or* J/kg *or* $J \cdot kg^{-1}$
but *not* joules/kilogram *or* joules/kg *or* joules · kg^{-1}.

3.4 Numbers

3.4.1 The preferred decimal marker is a point on the line (period); however, the comma is also acceptable. When writing numbers less than one, a zero should be written before the decimal marker.

3.4.2 The comma is not to be used to separate digits. Instead, digits should be separated into groups of three, counting from the decimal point towards the left and the right, and using a small space to separate the groups. For example:

73 655 7 281 2.567 321 0.133 47

The space between groups should be approximately the width of the letter "i" and the width of the space should be constant even if variable-width spacing is used between the words.

3.4.3 The sign for multiplication of numbers is a cross (×) or a dot half high. However, if the dot half high is used asthe multiplication sign, a point on the line must not be used as a decimal marker in the same expression.

3.4.4 Attachment of letters to a unit symbol as a means of giving information about the nature of the quantity under consideration is incorrect. Thus MWe for "megawatts electrical (power)", Vac for "volts ac" and kJt for "kilojoules thermal (energy)" are not acceptable.

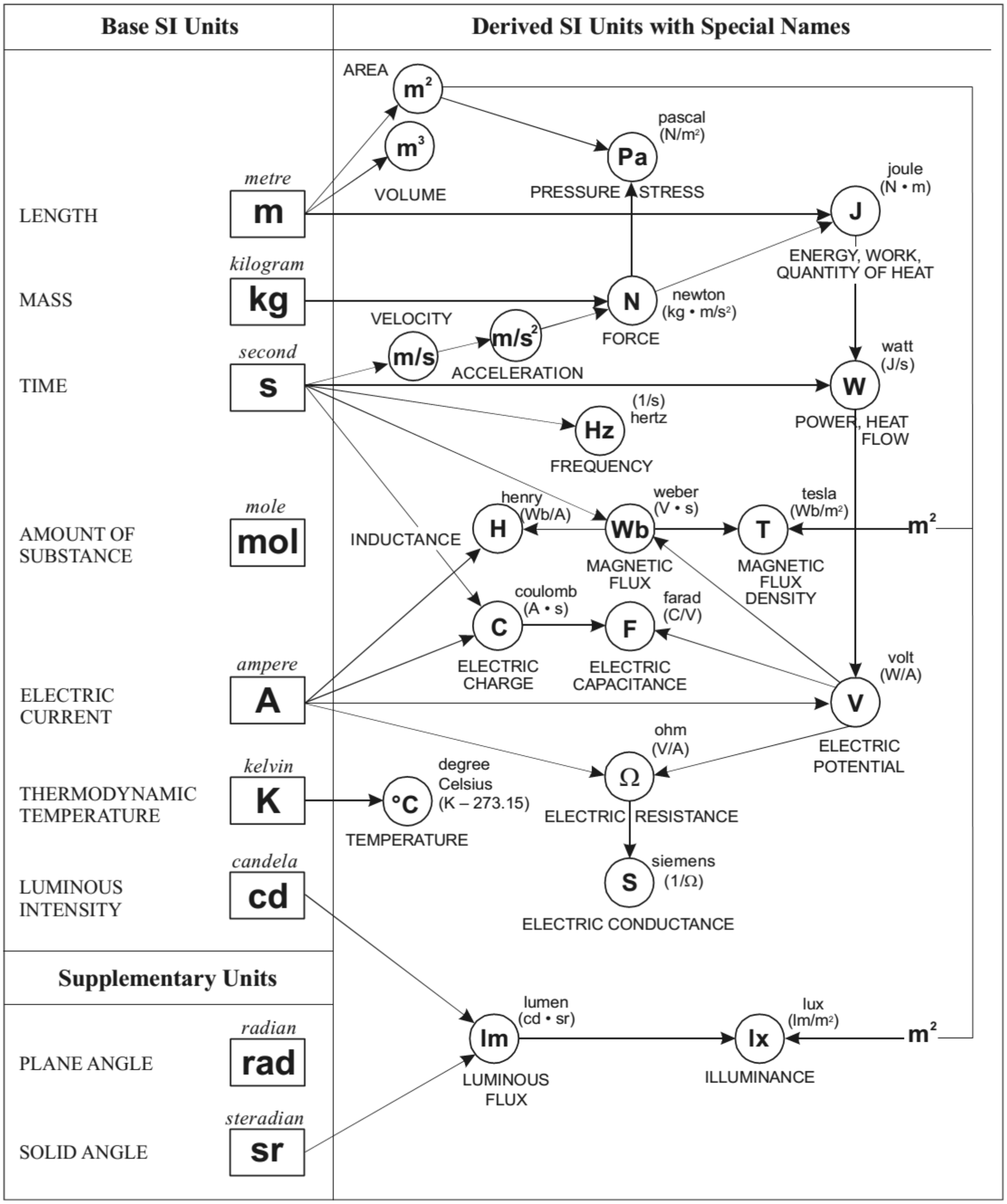
Base SI Units
Derived SI Units with Special Names
LENGTH
metre
m
MASS
kilogram
kg
TIME
second
s
AMOUNT OF SUBSTANCE
mole
mol
ELECTRIC CURRENT
ampere
A
THERMODYNAMIC TEMPERATURE
kelvin
K
LUMINOUS INTENSITY
candela
cd
Supplementary Units
PLANE ANGLE
radian
rad
SOLID ANGLE
steradian
sr
AREA
m²
m³
VOLUME
pascal
(N/m²)
Pa
PRESSURE, STRESS
joule
(N • m)
J
ENERGY, WORK, QUANTITY OF HEAT
N
newton
(kg • m/s²)
FORCE
VELOCITY
m/s
m/s²
ACCELERATION
watt
(J/s)
W
POWER, HEAT FLOW
(1/s)
hertz
Hz
FREQUENCY
henry
(Wb/A)
H
INDUCTANCE
weber
(V • s)
Wb
MAGNETIC FLUX
tesla
(Wb/m²)
T
MAGNETIC FLUX DENSITY
m²
coulomb
(A • s)
C
ELECTRIC CHARGE
farad
(C/V)
F
ELECTRIC CAPACITANCE
volt
(W/A)
V
ELECTRIC POTENTIAL
ohm
(V/A)
Ω
ELECTRIC RESISTANCE
degree
Celsius
(K – 273.15)
°C
TEMPERATURE
siemens
(1/Ω)
S
ELECTRIC CONDUCTANCE
lumen
(cd • sr)
lm
LUMINOUS FLUX
lux
(lm/m²)
lx
ILLUMINANCE
m²

Figure B-1

ATTACHMENT C.

CONVERSION FACTORS

1. General

1.1 The list of conversion factors which is contained in this Attachment is provided to express the definitions of miscellaneous units of measure as numerical multiples of SI units.

1.2 The conversion factors are presented for ready adaptation to computer readout and electronic data transmission. The factors are written as a number greater than 1 and less than 10 with six or less decimal places. This number is followed by the letter E (for exponent), a plus or minus symbol, and two digits which indicate the power of 10 by which the number must be multiplied to obtain the correct value. For example:

3.523 907 E – 02 is $3.523\,907 \times 10^{-2}$ *or* 0.035 239 07

Similarly,

3.386 389 E + 03 is $3.386\,389 \times 10^{3}$ *or* 3 386.389

1.3 An asterisk (*) after the sixth decimal place indicates that the conversion factor is exact and that all subsequent digits are zero. Where less than six decimal places are shown, more precision is not warranted.

1.4 Further examples of use of the tables:

To convert from	*to*	*Multiply by*
pound-force per square foot	Pa	4.788 026 E + 01
inch	m	2.540 000*E – 02

thus:

1 lbf/ft^2 = 47.880 26 Pa

1 inch = 0.025 4 m (exactly)

2. Factors not listed

2.1 Conversion factors for compound units which are not listed herein can easily be developed from numbers given in the list by the substitution of converted units, as follows.

Example: To find conversion factor of lb·ft/s to kg · m/s:

first convert

1 lb to 0.453 592 4 kg

1 ft to 0.304 8 m

then substitute:

(0.453 592 4 kg) × (0.304 8 m)/s = 0.138 255 kg · m/s

Thus the factor is 1.382 55 E – 01.

Table C-1. Conversion factors to SI units

(Symbols of SI units given in parentheses)

To convert from	*to*	*Multiply by*
abampere	ampere (A)	1.000 000 * E + 01
abcoulomb	coulomb (C)	1.000 000 * E + 01
abfarad	farad (F)	1.000 000 * E + 09
abhenry	henry (H)	1.000 000 * E – 09
abmho	siemens (S)	1.000 000 * E + 09
abohm	ohm (Ω)	1.000 000 * E – 09
abvolt	volt (V)	1.000 000 * E – 08
acre (U.S. survey)	square metre (m^2)	4.046 873 E + 03
ampere hour	coulomb (C)	3.600 000 * E + 03
are	square metre (m^2)	1.000 000 * E + 02
atmosphere (standard)	pascal (Pa)	1.013 250 * E + 05
atmosphere (technical = 1 kgf/cm^2)	pascal (Pa)	9.806 650 * E + 04
bar	pascal (Pa)	1.000 000 * E + 05
barrel (for petroleum, 42 U.S. liquid gal)	cubic metre (m^3)	1.589 873 * E – 01
British thermal unit (International Table)	joule (J)	1.055 056 E + 03
British thermal unit (mean)	joule (J)	1.055 87 E + 03
British thermal unit (thermochemical)	joule (J)	1.054 350 E + 03
British thermal unit (39°F)	joule (J)	1.059 67 E + 03
British thermal unit (59°F)	joule (J)	1.054 80 E + 03
British thermal unit (60°F)	joule (J)	1.054 68 E + 03
Btu (International Table) · ft/h · ft^2 · °F (k, thermal conductivity)	watt per metre kelvin (W/m · K)	1.730 735 E + 00
Btu (thermochemical) · ft/h · ft^2 · °F (k, thermal conductivity)	watt per metre kelvin (W/m · K)	1.729 577 E + 00
Btu (International Table) · in/h · ft^2 · °F (k, thermal conductivity)	watt per metre kelvin (W/m · K)	1.442 279 E – 01
Btu (thermochemical) · in/h · ft^2 · °F (k, thermal conductivity)	watt per metre kelvin (W/m · K)	1.441 314 E – 01
Btu (International Table) · in/s · ft^2 · °F (k, thermal conductivity)	watt per metre kelvin (W/m · K)	5.192 204 E + 02
Btu (thermochemical) · in/s · ft^2 · °F (k, thermal conductivity)	watt per metre kelvin (W/m · K)	5.188 732 E + 02
Btu (International Table)/h	watt (W)	2.930 711 E – 01
Btu (thermochemical)/h	watt (W)	2.928 751 E – 01
Btu (thermochemical)/min	watt (W)	1.757 250 E + 01
Btu (thermochemical)/s	watt (W)	1.054 350 E + 03
Btu (International Table)/ft^2	joule per square metre (J/m^2)	1.135 653 E + 04
Btu (thermochemical)/ft^2	joule per square metre (J/m^2)	1.134 893 E + 04
Btu (thermochemical)/ft^2 · h	watt per square metre (W/m^2)	3.152 481 E + 00
Btu (thermochemical)/ft^2 · min	watt per square metre (W/m^2)	1.891 489 E + 02
Btu (thermochemical)/ft^2 · s	watt per square metre (W/m^2)	1.134 893 E + 04
Btu (thermochemical)/in^2 · s	watt per square metre (W/m^2)	1.634 246 E + 06

* An asterisk (*) after the sixth decimal place indicates that the conversion factor is exact and that all subsequent digits are zero. Where less than six decimal places are shown, more precision is not warranted.

To convert from	*to*	*Multiply by*
Btu (International Table)/h · ft^2 · °F (C, thermal conductance)	watt per square metre kelvin (W/m^2 · K)	5.678 263 E + 00
Btu (thermochemical)/h · ft^2 · °F (C, thermal conductance)	watt per square metre kelvin (W/m^2 · K)	5.674 466 E + 00
Btu (International Table)/s · ft^2 · °F	watt per square metre kelvin (W/m^2 · K)	2.044 175 E + 04
Btu (thermochemical)/s · ft^2 · °F	watt per square metre kelvin (W/m^2 · K)	2.042 808 E + 04
Btu (International Table)/lb	joule per kilogram (J/kg)	2.326 000 *E + 03
Btu (thermochemical)/lb	joule per kilogram (J/kg)	2.324 444 E + 03
Btu (International Table)/lb · °F (c, heat capacity)	joule per kilogram kelvin (J/kg · K)	4.186 800 *E + 03
Btu (thermochemical)/lb · °F (c, heat capacity)	joule per kilogram kelvin (J/kg · K)	4.184 000 E + 03
calibre (inch)	metre (m)	2.540 000 *E – 02
calorie (International Table)	joule (J)	4.186 800 *E + 00
calorie (mean)	joule (J)	4.190 02 E + 00
calorie (thermochemical)	joule (J)	4.184 000 *E + 00
calorie (15°C)	joule (J)	4.185 80 E + 00
calorie (20°C)	joule (J)	4.181 90 E + 00
calorie (kilogram, International Table)	joule (J)	4.186 800 *E + 03
calorie (kilogram, mean)	joule (J)	4.190 02 E + 03
calorie (kilogram, thermochemical)	joule (J)	4.184 000 *E + 03
cal (thermochemical)/cm^2	joule per square metre (J/m^2)	4.184 000 *E + 04
cal (International Table)/g	joule per kilogram (J/kg)	4.186 800 *E + 03
cal (thermochemical)/g	joule per kilogram (J/kg)	4.184 000 *E + 03
cal (International Table)/g · °C	joule per kilogram kelvin (J/kg · K)	4.186 800 *E + 03
cal (thermochemical)/g · °C	joule per kilogram kelvin (J/kg · K)	4.184 000 *E + 03
cal (thermochemical)/min	watt (W)	6.973 333 E – 02
cal (thermochemical)/s	watt (W)	4.184 000 *E + 00
cal (thermochemical)/cm^2 · min	watt per square metre (W/m^2)	6.973 333 E + 02
cal (thermochemical)/cm^2 · s	watt per square metre (W/m^2)	4.184 000 *E + 04
cal (thermochemical)/cm · s · °C	watt per metre kelvin (W/m · K)	4.184 000 *E + 02
centimetre of mercury (0°C)	pascal (Pa)	1.333 22 E + 03
centimetre of water (4°C)	pascal (Pa)	9.806 38 E + 01
centipoise	pascal second (Pa · s)	1.000 000 *E – 03
centistokes	metre squared per second (m^2/s)	1.000 000 *E – 06
circular mil	square metre (m^2)	5.067 075 E – 10
clo	kelvin metre squared per watt (K · m^2/W)	2.003 712 E – 01
cup	cubic metre (m^3)	2.365 882 E – 04
curie	becquerel (Bq)	3.700 000 *E + 10
day (mean solar)	second (s)	8.640 000 E + 04
day (sidereal)	second (s)	8.616 409 E + 04
degree (angle)	radian (rad)	1.745 329 E – 02
°F · h · ft^2/Btu (International Table) (R, thermal resistance)	kelvin metre squared per watt (K · m^2/W)	1.761 102 E – 01
°F · h · ft^2/Btu (thermochemical) (R, thermal resistance)	kelvin metre squared per watt (K · m^2/W)	1.762 280 E – 01
dyne	newton (N)	1.000 000 *E – 05
dyne · cm	newton metre (N · m)	1.000 000 *E – 07
dyne/cm^2	pascal (Pa)	1.000 000 *E – 01

To convert from	*to*	*Multiply by*
electronvolt	joule (J)	1.602 19 E – 19
EMU of capacitance	farad (F)	1.000 000 * E + 09
EMU of current	ampere (A)	1.000 000 * E + 01
EMU of electric potential	volt (V)	1.000 000 * E – 08
EMU of inductance	henry (H)	1.000 000 * E – 09
EMU of resistance	ohm (Ω)	1.000 000 * E – 09
erg	joule (J)	1.000 000 * E – 07
$erg/cm^2 \cdot s$	watt per square metre (W/m^2)	1.000 000 * E – 03
erg/s	watt (W)	1.000 000 * E – 07
ESU of capacitance	farad (F)	1.112 650 E – 12
ESU of current	ampere (A)	3.335 6 E – 10
ESU of electric potential	volt (V)	2.997 9 E + 02
ESU of inductance	henry (H)	8.987 554 E + 11
ESU of resistance	ohm (Ω)	8.987 554 E + 11
faraday (based on carbon-12)	coulomb (C)	9.648 70 E + 04
faraday (chemical)	coulomb (C)	9.649 57 E + 04
faraday (physical)	coulomb (C)	9.652 19 E + 04
fathom	metre (m)	1.828 8 E + 00
fermi (femtometre)	metre (m)	1.000 000 * E – 15
fluid ounce (U.S.)	cubic metre (m^3)	2.957 353 E – 05
foot	metre (m)	3.048 000 * E – 01
foot (U.S. survey)	metre (m)	3.048 006 E – 01
foot of water (39.2°F)	pascal (Pa)	2.988 98 E + 03
ft^2	square metre (m^2)	9.290 304 * E – 02
ft^2/h (thermal diffusivity)	metre squared per second (m^2/s)	2.580 640 * E – 05
ft^2/s	metre squared per second (m^2/s)	9.290 304 * E – 02
ft^3 (volume; section modulus)	cubic metre (m^3)	2.831 685 E – 02
ft^3/min	cubic metre per second (m^3/s)	4.719 474 E – 04
ft^3/s	cubic metre per second (m^3/s)	2.831 685 E – 02
ft^4 (moment of section)	metre to the fourth power (m^4)	8.630 975 E – 03
ft · lbf	joule (J)	1.355 818 E + 00
ft · lbf/h	watt (W)	3.766 161 E – 04
ft · lbf/min	watt (W)	2.259 697 E – 02
ft · lbf/s	watt (W)	1.355 818 E + 00
ft · poundal	joule (J)	4.214 011 E – 02
free fall, standard (g)	metre per second squared (m/s^2)	9.806 650 * E + 00
ft/h	metre per second (m/s)	8.466 667 E – 05
ft/min	metre per second (m/s)	5.080 000 * E – 03
ft/s	metre per second (m/s)	3.048 000 * E – 01
ft/s^2	metre per second squared (m/s^2)	3.048 000 * E – 01
footcandle	lux (lx)	1.076 391 E + 01
footlambert	candela per square metre (cd/m^2)	3.426 259 E + 00
gal	metre per second squared (m/s^2)	1.000 000 * E – 02
gallon (Canadian liquid)	cubic metre (m^3)	4.546 090 E – 03
gallon (U.K. liquid)	cubic metre (m^3)	4.546 092 E – 03
gallon (U.S. dry)	cubic metre (m^3)	4.404 884 E – 03
gallon (U.S. liquid)	cubic metre (m^3)	3.785 412 E – 03
gal (U.S. liquid)/day	cubic metre per second (m^3/s)	4.381 264 E – 08

To convert from	*to*	*Multiply by*
gal (U.S. liquid)/min	cubic metre per second (m^3/s)	6.309 020 E – 05
gal (U.S. liquid)/hp · h (SFC, specific fuel consumption)	cubic metre per joule (m^3/J)	1.410 089 E – 09
gamma	tesla (T)	1.000 000 * E – 09
gauss	tesla (T)	1.000 000 * E – 04
gilbert	ampere (A)	7.957 747 E – 01
grad	degree (angular)	9.000 000 * E – 01
grad	radian (rad)	1.570 796 E – 02
gram	kilogram (kg)	1.000 000 * E – 03
g/cm^3	kilogram per cubic metre (kg/m^3)	1.000 000 * E + 03
gram-force/cm^2	pascal (Pa)	9.806 650 * E + 01
hectare	square metre (m^2)	1.000 000 * E + 04
horsepower (550 ft · lbf/s)	watt (W)	7.456 999 E + 02
horsepower (electric)	watt (W)	7.460 000 * E + 02
horsepower (metric)	watt (W)	7.354 99 E + 02
horsepower (water)	watt (W)	7.460 43 E + 02
horsepower (U.K.)	watt (W)	7.457 0 E + 02
hour (mean solar)	second (s)	3.600 000 E + 03
hour (sidereal)	second (s)	3.590 170 E + 03
hundredweight (long)	kilogram (kg)	5.080 235 E + 01
hundredweight (short)	kilogram (kg)	4.535 924 E + 01
inch	metre (m)	2.540 000 * E – 02
inch of mercury (32°F)	pascal (Pa)	3.386 38 E + 03
inch of mercury (60°F)	pascal (Pa)	3.376 85 E + 03
inch of water (39.2°F)	pascal (Pa)	2.490 82 E + 02
inch of water (60°F)	pascal (Pa)	2.488 4 E + 02
in^2	square metre (m^2)	6.451 600 * E – 04
in^3 (volume; section modulus)	cubic metre (m^3)	1.638 706 E – 05
in^3/min	cubic metre per second (m^3/s)	2.731 177 E – 07
in^4 (moment of section)	metre to the fourth power (m^4)	4.162 314 E – 07
in/s	metre per second (m/s)	2.540 000 * E – 02
in/s^2	metre per second squared (m/s^2)	2.540 000 * E – 02
kilocalorie (International Table)	joule (J)	4.186 800 * E + 03
kilocalorie (mean)	joule (J)	4.190 02 E + 03
kilocalorie (thermochemical)	joule (J)	4.184 000 * E + 03
kilocalorie (thermochemical)/min	watt (W)	6.973 333 E + 01
kilocalorie (thermochemical)/s	watt (W)	4.184 000 * E + 03
kilogram-force (kgf)	newton (N)	9.806 650 * E + 00
kgf · m	newton metre (N · m)	9.806 650 * E + 00
kgf · s^2/m (mass)	kilogram (kg)	9.806 650 * E + 00
kgf/cm^2	pascal (Pa)	9.806 650 * E + 04
kgf/m^2	pascal (Pa)	9.806 650 * E + 00
kgf/mm^2	pascal (Pa)	9.806 650 * E + 06
km/h	metre per second (m/s)	2.777 778 E – 01
kilopond	newton (N)	9.806 650 * E + 00
kW · h	joule (J)	3.600 000 * E + 06
kip (1 000 lbf)	newton (N)	4.448 222 E + 03

To convert from	*to*	*Multiply by*
kip/in^2 (ksi)	pascal (Pa)	6.894 757 E + 06
knot (international)	metre per second (m/s)	5.144 444 E – 01
lambert	candela per square metre (cd/m^2)	1/π *E + 04
lambert	candela per square metre (cd/m^2)	3.183 099 E + 03
langley	joule per square metre (J/m^2)	4.184 000 *E + 04
lb · ft^2 (moment of inertia)	kilogram metre squared (kg · m^2)	4.214 011 E – 02
lb · in^2 (moment of inertia)	kilogram metre squared (kg · m^2)	2.926 397 E – 04
lb/ft · h	pascal second (Pa · s)	4.133 789 E – 04
lb/ft · s	pascal second (Pa · s)	1.488 164 E + 00
lb/ft^2	kilogram per square metre (kg/m^2)	4.882 428 E + 00
lb/ft^3	kilogram per cubic metre (kg/m^3)	1.601 846 E + 01
lb/gal (U.K. liquid)	kilogram per cubic metre (kg/m^3)	9.977 633 E + 01
lb/gal (U.S. liquid)	kilogram per cubic metre (kg/m^3)	1.198 264 E + 02
lb/h	kilogram per second (kg/s)	1.259 979 E – 04
lb/hp · h (SFC, specific fuel consumption)	kilogram per joule (kg/J)	1.689 659 E – 07
lb/in^3	kilogram per cubic metre (kg/m^3)	2.767 990 E + 04
lb/min	kilogram per second (kg/s)	7.559 873 E – 03
lb/s	kilogram per second (kg/s)	4.535 924 E – 01
lb/yd^3	kilogram per cubic metre (kg/m^3)	5.932 764 E – 01
lbf · ft	newton metre (N · m)	1.355 818 E + 00
lbf · ft/in	newton metre per metre (N · m/m)	5.337 866 E + 01
lbf · in	newton metre (N · m)	1.129 848 E – 01
lbf · in/in	newton metre per metre (N · m/m)	4.448 222 E + 00
lbf · s/ft^2	pascal second (Pa · s)	4.788 026 E + 01
lbf/ft	newton per metre (N/m)	1.459 390 E + 01
lbf/ft^2	pascal (Pa)	4.788 026 E + 01
lbf/in	newton per metre (N/m)	1.751 268 E + 02
lbf/in^2 (psi)	pascal (Pa)	6.894 757 E + 03
lbf/lb (thrust/weight (mass) ratio)	newton per kilogram (N/kg)	9.806 650 E + 00
light year	metre (m)	9.460 55 E + 15
litre	cubic metre (m^3)	1.000 000 *E – 03
maxwell	weber (Wb)	1.000 000 *E – 08
mho	siemens (S)	1.000 000 *E + 00
microinch	metre (m)	2.540 000 *E – 08
micron	metre (m)	1.000 000 *E – 06
mil	metre (m)	2.540 000 *E – 05
mile (international)	metre (m)	1.609 344 *E + 03
mile (statute)	metre (m)	1.609 3 E + 03
mile (U.S. survey)	metre (m)	1.609 347 E + 03
mile (international nautical)	metre (m)	1.852 000 *E + 03
mile (U.K. nautical)	metre (m)	1.853 184 *E + 03
mile (U.S. nautical)	metre (m)	1.852 000 *E + 03
mi^2 (international)	square metre (m^2)	2.589 988 E + 06
mi^2 (U.S. survey)	square metre (m^2)	2.589 998 E + 06
mi/h (international)	metre per second (m/s)	4.470 400 *E – 01
mi/h (international)	kilometre per hour (km/h)	1.609 344 *E + 00
mi/min (international)	metre per second (m/s)	2.682 240 *E + 01

To convert from	*to*	*Multiply by*
mi/s (international)	metre per second (m/s)	1.609 344 *E + 03
millibar	pascal (Pa)	1.000 000 *E + 02
millimetre of mercury (0°C)	pascal (Pa)	1.333 22 E + 02
minute (angle)	radian (rad)	2.908 882 E – 04
minute (mean solar)	second (s)	6.000 000 E + 01
minute (sidereal)	second (s)	5.983 617 E + 01
month (mean calendar)	second(s)	2.628 000 E + 06
oersted	ampere per metre (A/m)	7.957 747 E + 01
ohm centimetre	ohm metre (Ω · m)	1.000 000 *E – 02
ohm circular-mil per ft	ohm millimetre squared per metre ($\Omega \cdot mm^2/m$)	1.662 426 E – 03
ounce (avoirdupois)	kilogram (kg)	2.834 952 E – 02
ounce (troy or apothecary)	kilogram (kg)	3.110 348 E – 02
ounce (U.K. fluid)	cubic metre (m^3)	2.841 307 E – 05
ounce (U.S. fluid)	cubic metre (m^3)	2.957 353 E – 05
ounce-force	newton (N)	2.780 139 E – 01
ozf · in	newton metre (N · m)	7.061 552 E – 03
oz (avoirdupois)/gal (U.K. liquid)	kilogram per cubic metre (kg/m^3)	6.236 021 E + 00
oz (avoirdupois)/gal (U.S. liquid)	kilogram per cubic metre (kg/m^3)	7.489 152 E + 00
oz (avoirdupois)/in^3	kilogram per cubic metre (kg/m^3)	1.729 994 E + 03
oz (avoirdupois)/ft^2	kilogram per square metre (kg/m^2)	3.051 517 E – 01
oz (avoirdupois)/yd^2	kilogram per square metre (kg/m^2)	3.390 575 E – 02
parsec	metre (m)	3.085 678 E + 16
pennyweight	kilogram (kg)	1.555 174 E – 03
perm (0°C)	kilogram per pascal second metre squared ($kg/Pa \cdot s \cdot m^2$)	5.721 35 E – 11
perm (23°C)	kilogram per pascal second metre squared ($kg/Pa \cdot s \cdot m^2$)	5.745 25 E – 11
perm · in (0°C)	kilogram per pascal second metre (kg/Pa · s · m)	1.453 22 E – 12
perm · in (23°C)	kilogram per pascal second metre (kg/Pa · s · m)	1.459 29 E – 12
phot	lumen per square metre (lm/m^2)	1.000 000 *E + 04
pint (U.S. dry)	cubic metre (m^3)	5.506 105 E – 04
pint (U.S. liquid)	cubic metre (m^3)	4.731 765 E – 04
poise (absolute viscosity)	pascal second (Pa · s)	1.000 000 *E – 01
pound (lb avoirdupois)	kilogram (kg)	4.535 924 E – 01
pound (troy or apothecary)	kilogram (kg)	3.732 417 E – 01
poundal	newton (N)	1.382 550 E – 01
poundal/ft^2	pascal (Pa)	1.488 164 E + 00
poundal · s/ft^2	pascal second (Pa · s)	1.488 164 E + 00
pound-force (lbf)	newton (N)	4.448 222 E + 00
quart (U.S. dry)	cubic metre (m^3)	1.101 221 E – 03
quart (U.S. liquid)	cubic metre (m^3)	9.463 529 E – 04
rad (radiation dose absorbed)	gray (Gy)	1.000 000 *E – 02
rem	sievert (Sv)	1.000 000 *E – 02

To convert from	*to*	*Multiply by*
rhe	1 per pascal second (1/Pa · s)	1.000 000 * E + 01
roentgen	coulomb per kilogram (C/kg)	2.58 E – 04
second (angle)	radian (rad)	4.848 137 E – 06
second (sidereal)	second (s)	9.972 696 E – 01
slug	kilogram (kg)	1.459 390 E + 01
slug/ft · s	pascal second (Pa · s)	4.788 026 E + 01
slug/ft^3	kilogram per cubic metre (kg/m^3)	5.153 788 E + 02
statampere	ampere (A)	3.335 640 E – 10
statcoulomb	coulomb (C)	3.335 640 E – 10
statfarad	farad (F)	1.112 650 E – 12
stathenry	henry (H)	8.987 554 E + 11
statmho	siemens (S)	1.112 650 E – 12
statohm	ohm (Ω)	8.987 554 E + 11
statvolt	volt (V)	2.997 925 E + 02
stere	cubic metre (m^3)	1.000 000 * E + 00
stilb	candela per square metre (cd/m^2)	1.000 000 * E + 04
stokes (kinematic viscosity)	metre squared per second (m^2/s)	1.000 000 * E – 04
therm	joule (J)	1.055 056 E + 08
ton (assay)	kilogram (kg)	2.916 667 E – 02
ton (long, 2 240 lb)	kilogram (kg)	1.016 047 E + 03
ton (metric)	kilogram (kg)	1.000 000 * E + 03
ton (nuclear equivalent of TNT)	joule (J)	4.184 E + 09
ton (refrigeration)	watt (W)	3.516 800 E + 03
ton (register)	cubic metre (m^3)	2.831 685 E + 00
ton (short, 2 000 lb)	kilogram (kg)	9.071 847 E + 02
ton (long)/yd^3	kilogram per cubic metre (kg/m^3)	1.328 939 E + 03
ton (short)/h	kilogram per second (kg/s)	2.519 958 E – 01
ton-force (2 000 lbf)	newton (N)	8.896 444 E + 03
tonne	kilogram (kg)	1.000 000 * E + 03
torr (mm Hg, 0°C)	pascal (Pa)	1.333 22 E + 02
unit pole	weber (Wb)	1.256 637 E – 07
W · h	joule (J)	3.600 000 * E + 03
W · s	joule (J)	1.000 000 * E + 00
W/cm^2	watt per square metre (W/m^2)	1.000 000 * E + 04
W/in^2	watt per square metre (W/m^2)	1.550 003 E + 03
yard	metre (m)	9.144 000 * E – 01
yd^2	square metre (m^2)	8.361 274 E – 01
yd^3	cubic metre (m^3)	7.645 549 E – 01
yd^3/min	cubic metre per second (m^3/s)	1.274 258 E – 02
year (calendar)	second (s)	3.153 600 E + 07
year (sidereal)	second (s)	3.155 815 E + 07
year (tropical)	second (s)	3.155 693 E + 07

Table C-2. Temperature conversion formulae

To convert from	*to*	*Use formula*
Celsius temperature ($t°_C$)	Kelvin temperature (t_K)	$t_K = t°_C + 273.15$
Fahrenheit temperature ($t°_F$)	Celsius temperature ($t°_C$)	$t°_C = (t°_F - 32)/1.8$
Fahrenheit temperature ($t°_F$)	Kelvin temperature (t_K)	$t_K = (t°_F + 459.67)/1.8$
Kelvin temperature (t_K)	Celsius temperature ($t°_C$)	$t°_C = t_K - 273.15$
Rankine temperature ($t°_R$)	Kelvin temperature (t_K)	$t_K = t°_R/1.8$