NASA SP-7012

Physical Constants and Conversion Factors

SECOND REVISION

Mechtly

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

NASA SP-7012

THE INTERNATIONAL SYSTEM OF UNITS

PHYSICAL CONSTANTS and CONVERSION FACTORS

SECOND REVISION

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FOREWORD

The International System of Units, Système International d'Unités (designated SI in all languages), is the system of units of measurement which has been adopted by 41 of the principal industrial nations of the world which are signatories to the Convention of the Meter. The 11th, 12th, 13th, and 14th General Conferences on Weights and Measures (meeting in October of 1960, 1964, 1967, and 1971, respectively) have brought the International System of Units to a state of completeness and coherence which make it increasingly more attractive for all applications.

The National Bureau of Standards ol the United States announced in Administrative Bulletin 64–6 dated February 1964 that—

> Henceforth it shall be the policy of the National Bureau of Standards to use the units of the International System (SI), as adopted by the Eleventh General Conference on Weights and Measures . . . , except when the use of these units would obviously impair communication or reduce the usefulness of a report to the primary recipients.

A similar position was enunciated by the National Aeronautics and Space Administration in NASA Policy Directive NPD 2220.4 dated September 14, 1970—

> Measurement values employed in NASA Technical Reports, Technical Notes, Technical Memoranda, Contractor Reports, and Special Publications shall be expressed in the International System of Units (SI).

However, the Official-in-Charge of a NASA Headquarters Office or the Director of a NASA Field Installation retains the authority to waive the provisions of NPD 2220.4 in special cases.

This document, NASA SP–7012, gives the names, symbols, and definitions of SI units, the values of physical constants expressed in SI units, and tables of numerical factors for converting miscellaneous units to SI units. It was first published in October 1964. A revised edition was published in 1969 to include resolutions agreed to by members of the 12th and 13th General Conferences, and new values of physical constants derived by Taylor, Parker, and Langenberg. The present edition incorporates material from the records of the 14th General Conference of 1971, but retains the 1969 values of physical constants. SP–7012 was originally compiled by Dr. E. A. Mechtly when he was employed as a physicist at the Marshall Space Flight Center. He is now an associate professor of electrical engineering at the University of Illinois in Urbana.

HISTORY OF THE INTERNATIONAL SYSTEM OF UNITS

The International System of Units evolved from the unit of length, the meter, and the unit of mass, the kilogram, which were created by members of the Paris Academy of Sciences, and adopted by the National Assembly of France in 1795. The meter, the kilogram, and several other units came to be known as the metric system of units.

The U.S. Congress legalized the use of the metric system throughout the United States on July 28, 1866. The Act of 1866 reads, in part,

> It shall be lawful throughout the United States of America to employ the weights and measures of the metric system; and no contract or dealing, or pleading in any court, shall be deemed invalid or liable to objection because the weights or measures expressed or referred to therein are weights or measures of the metric system.

Effective on April 5, 1893, and subsequently, all legal units of measure used in the United States have been metric units or are defined as exact numerical multiples of metric units. The action establishing metric units as the ultimate base of all U.S. Customary Units is known as the "Mendenhall Order." T. C. Mendenhall was U.S. Superintendent of Standard Weights and Measures in 1893.

A highly significant step in the establishment of internationally uniform standard units of measurement was the signing of the Convention of the Meter by the United States and sixteen other nations on May 20, 1875.

The Convention of the Meter provides for an International Bureau of Weights and Measures on neutral ground at Sèvres, near Paris, France; for an International Committee on Weights and Measures; and for an international General Conference on Weights and Measures. The function of these organs is to devise, refine, and maintain precise internationally uniform standards of measure. The Committee, and Conference voting members, are leading professional metrologists (men who have made the science of measurement their careers) and in many cases are the directors of national bureaus of standards. The Director of the U.S. National Bureau of Standards is a member of both the Committee and the General Conference.

The Eleventh General Conference on Weights and Measures convened in Paris during October 1960, with Dr. A. V. Astin representing the United States. At the Eleventh General Conference, the metric system of units (based on the meter, kilogram, second, ampere, kelvin, and candela) was given the name "International System of Units," and the abbreviation "SI" in all languages.

The Twelfth General Conference convened in Paris during October 1964. Among other actions, the Twelfth Conference redefined the word "liter" as a special name for the cubic decimeter, and authorized temporary use of the "atomic second," but did not abrogate the definition of the second, which is based on the ephemeris of the Earth.

The Thirteenth Conference, meeting in October 1967, did abrogate the ephemeris definition of the second, and replaced it with the atomic definition. Among the other actions of the Thirteenth Conference were a revision of the definition of the candela, a redesignation of the unit of thermodynamic temperature, the kelvin (K), and the addition of six derived units to the international system.

The Fourteenth General Conference, meeting in October 1971, adopted the mole, symbol mol, as an SI base unit, adopted the name pascal, symbol Pa, for N/m^2, and adopted the name siemens, symbol S, for Ω^{-1} among other actions. At the time of the Fourteenth Conference, 41 nations were signatory to the Convention of the Meter.

The Fifteenth General Conference is scheduled for 1975, a century after the initial signing of the Convention of the Meter.

The International System of Units is recommended by members of the General Conference on Weights and Measures for all scientific, technical, practical, and teaching purposes.

On the following pages are the names, symbols, and definitions of SI units, the values of physical constants expressed in SI units, and numerical factors for converting miscellaneous units to SI units.

NAMES AND SYMBOLS OF SI UNITS

Quantity	*Name of Unit*	*Symbol*	
	SI BASE UNITS		
length	meter	m	
mass	kilogram	kg	
time	second	s	
electric current	ampere	A	
thermodynamic temperature	kelvin	K	
luminous intensity	candela	cd	
amount of substance	mole	mol	
	SI DERIVED UNITS		
area	square meter	m^2	
volume	cubic meter	m^3	
frequency	hertz	Hz	s^{-1}
mass density (density)	kilogram per cubic meter	kg/m^3	
speed, velocity	meter per second	m/s	
angular velocity	radian per second	rad/s	
acceleration	meter per second squared	m/s^2	
angular acceleration	radian per second squared	rad/s^2	
force	newton	N	$kg \cdot m/s^2$
pressure (mechanical stress)	pascal	Pa	N/m^2
kinematic viscosity	square meter per second	m^2/s	
dynamic viscosity	newton-second per square meter	$N \cdot s/m^2$	
work, energy, quantity of heat	joule	J	$N \cdot m$
power	watt	W	J/s
quantity of electricity	coulomb	C	$A \cdot s$
potential difference, electromotive force	volt	V	W/A
electric field strength	volt per meter	V/m	
electric resistance	ohm	Ω	V/A
capacitance	farad	F	$A \cdot s/V$
magnetic flux	weber	Wb	$V \cdot s$
inductance	henry	H	$V \cdot s/A$
magnetic flux density	tesla	T	Wb/m^2
magnetic field strength	ampere per meter	A/m	
magnetomotive force	ampere	A	
luminous flux	lumen	lm	$cd \cdot sr$
luminance	candela per square meter	cd/m^2	
illuminance	lux	lx	lm/m^2
wave number	1 per meter	m^{-1}	
entropy	joule per kelvin	J/K	
specific heat capacity	joule per kilogram kelvin	$J/(kg \cdot K)$	
thermal conductivity	watt per meter kelvin	$W/(m \cdot K)$	
radiant intensity	watt per steradian	W/sr	
activity (of a radioactive source)	1 per second	s^{-1}	
	SI SUPPLEMENTARY UNITS		
plane angle	radian	rad	
solid angle	steradian	sr	

DEFINITIONS OF SI UNITS

meter (m)

The *meter* is the length equal to 1 650 763.73 wavelengths in vacuum of the radiation corresponding to the transition between the levels 2 p_{10} and 5 d_5 of the krypton-86 atom.

kilogram (kg)

The *kilogram* is the unit of mass; it is equal to the mass of the international prototype of the kilogram. (The international prototype of the kilogram is a particular cylinder of platinum-iridium alloy which is preserved in a vault at Sèvres, France, by the International Bureau of Weights and Measures.)

second (s)

The *second* is the duration of 9 192 631 770 periods of the radiation corresponding to the transition between the two hyperfine levels of the ground state of the cesium-133 atom.

ampere (A)

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

kelvin (K)

The *kelvin*, unit of thermodynamic temperature, is the fraction 1/273.16 of the thermodynamic temperature of the triple point of water.

candela (cd)

The *candela* is the luminous intensity, in the perpendicular direction, of a surface of 1/600 000 square meter of a blackbody at the temperature of freezing platinum under a pressure of 101 325 newtons per square meter.

mètre (m)

Le *mètre* est la longueur égale à 1 650 763,73 longueurs d'onde dans le vide de la radiation correspondant à la transition entre les niveaux 2 p_{10} et 5 d_5 de l'atome krypton 86.

kilogramme (kg)

Le *kilogramme* est l'unité de masse; il est égal à la masse du prototype international du kilogramme.

seconde (s)

La *seconde* est la durée de 9 192 631 770 périodes de la radiation correspondant à la transition entre les deux niveaux hyperfins de l'état fondamental de l'atome de césium 133.

ampère (A)

L'*ampère* est l'intensité d'un courant constant qui, maintenu dans deux conducteurs parallèles, rectilignes, de longueur infinie, de section circulaire négligeable et placés à une distance de 1 mètre l'un de l'autre dans le vide, produirait entre ces conducteurs une force égale à 2×10^{-7} newton par mètre de longueur.

kelvin (K)

Le *kelvin*, unité de température thermodynamique, est la fraction 1/273,16 de la température thermodynamique du point triple de l'eau.

candela (cd)

La *candela* est l'intensité lumineuse, dans la direction perpendiculaire, d'une surface de 1/600 000 mètre carré d'un corps noir à la température de congélation du platine sous la pression de 101 325 newtons par mètre carré.

mole (mol)

The *mole* is the amount of substance of a system which contains as many elementary entities as there are carbon atoms in 0.012 kg of carbon 12. The elementary entities must be specified and may be atoms, molecules, ions, electrons, other particles, or specified groups of such particles.

newton (N)

The *newton* is that force which gives to a mass of 1 kilogram an acceleration of 1 meter per second per second.

joule (J)

The *joule* is the work done when the point of application of 1 newton is displaced a distance of 1 meter in the direction of the force.

watt (W)

The *watt* is the power which gives rise to the production of energy at the rate of 1 joule per second.

volt (V)

The *volt* is the difference of electric potential between two points of a conducting wire carrying a constant current of 1 ampere, when the power dissipated between these points is equal to 1 watt.

ohm (Ω)

The *ohm* is 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.

coulomb (C)

The *coulomb* is the quantity of electricity transported in 1 second by a current of 1 ampere.

mole (mol)

La *mole* est la quantité de matière d'un système contenant autant d'entités élémentaires qu'il y a d'atomes dans 0.012 kg de carbone 12. Les entités élémentaires doivent être spécifiées et peuvent être des atomes, des molécules, des ions, des électrons, d'autres particules ou des groupements spécifiés de telles particules.

newton (N)

Le *newton* est la force qui communique à une masse de 1 kilogramme l'accélération de 1 mètre par seconde, par seconde.

joule (J)

Le *joule* est la travail effectué lorsque le point d'application de 1 newton de force se déplace d'une distance égale à 1 mètre dans la direction de la force.

watt (W)

Le *watt* est la puissance qui donne lieu à une production d'énergie égale à 1 joule par seconde.

volt (V)

Le *volt* est la différence de potentiel électrique qui existe entre deux points d'un fil conducteur transportant un courant constant de 1 ampère, lorsque la puissance dissipée entre ces points est égale à 1 watt.

ohm (Ω)

L'*ohm* est la résistance électrique qui existe entre deux points d'un conducteur lorsqu'une différence de potentiel constante de 1 volt, appliquée entre ces deux points, produit, dans ce conducteur, un courant de 1 ampère, ce conducteur n'étant le siège d'aucune force électromotrice.

coulomb (C)

Le *coulomb* est la quantité d'électricité transportée en 1 seconde par un courant de 1 ampère.

farad (F)

The *farad* is the capacitance of a capacitor between the plates of which there appears a difference of potential of 1 volt when it is charged by a quantity of electricity equal to 1 coulomb.

henry (H)

The *henry* is 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.

weber (Wb)

The *weber* is 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.

lumen (lm)

The *lumen* is the luminous flux emitted in a solid angle of 1 steradian by a uniform point source having an intensity of 1 candela.

radian (rad)

The *radian* is the plane angle between two radii of a circle which cut off on the circumference an arc equal in length to the radius.

steradian (sr)

The *steradian* is the solid angle which, having its vertex in the center 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.

farad (F)

Le *farad* est la capacité d'un condensateur électrique entre les armatures duquel apparaît une différence de potentiel électrique de 1 volt, lorsqu'il est chargé d'une quantité d'électricité égale à 1 coulomb.

henry (H)

Le *henry* est l'inductance électrique d'un circuit fermé dans lequel une force électromotrice de 1 volt est produite lorsque le courant électrique qui parcourt le circuit varie uniformément à raison de 1 ampère par seconde.

weber (Wb)

Le *weber* est le flux magnétique qui, traversant un circuit d'une seule spire, y produirait une force électromotrice de 1 volt, si on l'amenait à zéro en 1 seconde par décroissance uniforme.

lumen (lm)

Le *lumen* est le flux lumineux émis dans l'angle solide unité (stéradian), par une source ponctuelle uniforme ayant une intensité lumineuse de 1 candela.

radian (rad)

Le *radian* est l'angle plan compris entre deux rayons qui, sur la circonférence d'un cercle, interceptent un arc de longueur égale à celle du rayon.

stéradian (sr)

Le *stéradian* est l'angle solide qui, ayant son sommet au centre d'une sphère, découpe sur la surface de cette sphère une aire égale à celle d'un carré ayant pour côté le rayon de la sphère.

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SI PREFIXES

The names of multiples and submultiples of SI units may be formed by application of the prefixes:

Factor by which unit is multiplied	Prefix	Symbol
10^{12}	tera	T
10^{9}	giga	G
10^{6}	mega	M
10^{3}	kilo	k
10^{2}	hecto	h
10	deka	da
10^{-1}	deci	d
10^{-2}	centi	c
10^{-3}	milli	m
10^{-6}	micro	μ
10^{-9}	nano	n
10^{-12}	pico	p
10^{-15}	femto	f
10^{-18}	atto	a

The International Organization for Standardization (ISO) recommends the following rules for the use of SI prefixes:

a) Prefix symbols are printed in roman (upright) type without spacing between the prefix symbol and the unit symbol.

b) An exponent affixed to a symbol containing a prefix indicates that the multiple or sub-multiple of the unit is raised to the power expressed by the exponent,

for example: $1\ \mathrm{cm}^3 = 10^{-6}\ \mathrm{m}^3$
$1\ \mathrm{cm}^{-1} = 10^{2}\ \mathrm{m}^{-1}$

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

for example: 1 nm *but not:* 1 mμm

The International Organization for Standardization (ISO) has issued additional recommendations with the aim of securing uniformity in the use of units.

According to these recommendations:

a) The product of two or more units is preferably indicated by a dot. The dot may be dispensed with when there is no risk of confusion with another unit symbol

for example: N·m or N m *but not:* mN

b) A solidus (oblique stroke, /), a horizontal line, or negative powers may be used to express a derived unit formed from two others by division

for example: m/s, $\frac{\mathrm{m}}{\mathrm{s}}$ or $\mathrm{m \cdot s^{-1}}$

c) The solidus must not be repeated on the same line unless ambiguity is avoided by parentheses. In complicated cases negative powers or parentheses should be used

for example: $\mathrm{m/s^2}$ or $\mathrm{m \cdot s^{-2}}$ *but not:* $\mathrm{m/s/s}$

$\mathrm{m \cdot kg/(s^3 \cdot A)}$ or $\mathrm{m \cdot kg \cdot s^{-3} \cdot A^{-1}}$ *but not:* $\mathrm{m \cdot kg/s^3/A}$

UNITS OUTSIDE THE INTERNATIONAL SYSTEM

The International Committee on Weights and Measures recognized in 1969 that users of SI units will also wish to employ certain other units which, although they are not SI units, are in widespread use. These units play such an important part that they must be retained for general use with the International System of Units. They are the following:

UNITS IN USE WITH THE INTERNATIONAL SYSTEM

Name	Symbol	Value in SI unit
minute	min	1 min = 60 s
hour	h	1 h = 60 min = 3 600 s
day	d	1 d = 24 h = 86 400 s
degree	°	1° = (π/180) rad
minute	′	1′ = (1/60)° = (π/10 800) rad
second	″	1″ = (1/60)′ = (π/648 000) rad
liter	l	1 l = 1 dm^3 = 10^{-3} m^3
tonne	t	1 t = 10^3 kg

It is likewise necessary to recognize, outside the International System, some other units which are useful in specialized fields of scientific research, because their values expressed in SI units must be obtained by experiment, and are therefore not known exactly. They are the following:

UNITS USED WITH THE INTERNATIONAL SYSTEM WHOSE VALUES IN SI UNITS ARE OBTAINED EXPERIMENTALLY

Name	Symbol	Definition
electronvolt	eV	([a])
unified atomic mass unit	u	([b])
astronomical unit	(c)	([c])
parsec	pc	([d])

([a]) 1 electronvolt is the kinetic energy acquired by an electron in passing through a potential difference of 1 volt in vacuum.

([b]) The unified atomic mass unit is equal to the fraction 1/12 of the mass of an atom of the nuclide ^{12}C.

([c]) The astronomical unit does not have an international symbol; abbreviations are used, for example, AU in English, UA in French, AE in German, a.e.д in Russian, etc. The astronomical unit of distance is the length of the radius of the unperturbed circular orbit of a body of negligible mass moving around the Sun with a sidereal angular velocity of 0.017 202 098 950 radian per day of 86400 ephemeris seconds. In the system of astronomical constants of the International Astronomical Union the value adopted for it is: 1 AU = 149 600 $\times 10^6$ m.

([d]) 1 parsec is the distance at which 1 astronomical unit subtends an angle of 1 second of arc.

In 1969, the International Committee on Weights and Measures listed three additional classes of non-SI units: (1) 12 units which may be used for a limited time, (2) 9 units preferably not used, and (3) 11 units to be avoided. These deprecated units and preferred SI units are discussed in *The International System of Units (SI)*, NBS Special Publication 330. Another useful guide is the *Metric Practice Guide*, ASTM publ. no. E380–72.

PHYSICAL CONSTANTS

The following lists of physical constants are from the work of B. N. Taylor, W. H. Parker, and D. N. Langenberg (*Reviews of Modern Physics*, July 1969). Their least-squares adjustment of values of the constants depends strongly on a highly accurate (2.4 ppm) determination of e/h from the ac Josephson effect in superconductors, and is believed to be more accurate than the 1963 adjustment which appears to suffer from the use of an incorrect value of the fine structure constant as an input datum. See also NBS Special Publication 344 issued March 1971.

Quantity	Symbol	Value	Error ppm	Prefix	Unit
Speed of light in vacuum	c	2. 997 925 0	0. 33	$\times 10^{8}$	m s^{-1}
Gravitational constant	G	6. 673 2	460	10^{-11}	N m^{2} kg^{-2}
Avogadro constant	N_A	6. 022 169	6. 6	10^{26}	kmol^{-1}
Boltzmann constant	k	1. 380 622	43	10^{-23}	J K^{-1}
Gas constant	R	8. 314 34	42	10^{3}	J kmol^{-1} K^{-1}
Volume of ideal gas, standard conditions	V_0	2. 241 36	--------	10^{1}	m^{3} kmol^{-1}
Faraday constant	F	9. 648 670	5. 5	10^{7}	C kmol^{-1}
Unified atomic mass unit	u	1. 660 531	6. 6	10^{-27}	kg
Planck constant	h	6. 626 196	7. 6	10^{-34}	J s
	$h/2\pi$	1. 054 591 9	7. 6	10^{-34}	J s
Electron charge	e	1. 602 191 7	4. 4	10^{-19}	C
Electron rest mass	m_e	9. 109 558	6. 0	10^{-31}	kg
		5. 485 930	6. 2	10^{-4}	u
Proton rest mass	m_p	1. 672 614	6. 6	10^{-27}	kg
		1. 007 276 61	0. 08	----------	u
Neutron rest mass	m_n	1. 674 920	6. 6	10^{-27}	kg
		1. 008 665 20	0. 10	----------	u
Electron charge to mass ratio	e/m_e	1. 758 802 8	3. 1	10^{11}	C kg^{-1}
Stefan-Boltzmann constant	σ	5. 669 61	170	10^{-8}	W m^{-2} K^{-4}
First radiation constant	$2\pi hc^2$	3. 741 844	7. 6	10^{-16}	W m^{2}
Second radiation constant	hc/k	1. 438 833	43	10^{-2}	m K
Rydberg constant	R_∞	1. 097 373 12	0. 10	10^{7}	m^{-1}
Fine structure constant	α	7. 297 351	1. 5	10^{-3}	
	α^{-1}	1. 370 360 2	1. 5	10^{+2}	
Bohr radius	a_0	5. 291 771 5	1. 5	10^{-11}	m
Classical electron radius	r_e	2. 817 939	4. 6	10^{-15}	m
Compton wavelength of electron	λ_C	2. 426 309 6	3. 1	10^{-12}	m
	$\lambda_C/2\pi$	3. 861 592	3. 1	10^{-13}	m
Compton wavelength of proton	$\lambda_{C,p}$	1. 321 440 9	6. 8	10^{-15}	m
	$\lambda_{C,p}/2\pi$	2. 103 139	6. 8	10^{-16}	m
Compton wavelength of neutron	$\lambda_{C,n}$	1. 319 621 7	6. 8	10^{-15}	m
	$\lambda_{C,n}/2\pi$	2. 100 243	6. 8	10^{-16}	m
Electron magnetic moment	μ_e	9. 284 851	7. 0	10^{-24}	J T^{-1}
Proton magnetic moment	μ_p	1. 410 620 3	7. 0	10^{-26}	J T^{-1}
Bohr magneton	μ_B	9. 274 096	7. 0	10^{-24}	J T^{-1}
Nuclear magneton	μ_n	5. 050 951	10	10^{-27}	J T^{-1}
Gyromagnetic ratio of protons in H_2O	γ'_p	2. 675 127 0	3. 1	10^{8}	rad s^{-1} T^{-1}
	$\gamma'_p/2\pi$	4. 257 597	3. 1	10^{7}	Hz T^{-1}
Gyromagnetic ratio of protons in H_2O corrected for diamagnetism of H_2O.	γ_p	2. 675 196 5	3. 1	10^{8}	rad s^{-1} T^{-1}
	$\gamma_p/2\pi$	4. 257 707	3. 1	10^{7}	Hz T^{-1}
Magnetic flux quantum	Φ_0	2. 067 853 8	3. 3	10^{-15}	Wb
Quantum of circulation	$h/2m_e$	3. 636 947	3. 1	10^{-4}	J s kg^{-1}
	h/m_e	7. 273 894	3. 1	10^{-4}	J s kg^{-1}

Unitless numerical ratios	Value	Error ppm	Prefix
(c^2) kg/eV	5. 609 538	4. 4	10^{35}
(c^2) u/eV	9. 314 812	5. 5	10^{8}
u/kg	1. 660 531	6. 6	10^{-27}
(c^2) m_e/eV	5. 110 041	3. 1	10^{5}
(c^2) m_p/eV	9. 382 592	5. 5	10^{8}
(c^2) m_n/eV	9. 395 527	5. 5	10^{8}
eV/J	1. 602 191 7	4. 4	10^{-19}
(h^{-1}) eV/Hz	2. 417 965 9	3. 3	10^{14}
$(hc)^{-1}$ eV m	8. 065 465	3. 3	10^{5}
(k^{-1}) eV/K	1. 160 485	42	10^{4}
(hc) (eV m)$^{-1}$	1. 239 854 1	3. 3	10^{-6}
(hc) R_∞/J	2. 179 914	7. 6	10^{-18}
(hc) R_∞/eV	1. 360 582 6	3. 3	10^{1}
(c) R_∞/Hz	3. 289 842 3	0. 35	10^{15}
(hc/k) R_∞/K	1. 578 936	43	10^{5}
m_p/m_e	1. 836 109	6. 2	10^{3}
μ_e/μ_B	1. 001 159 638 9	0. 0031	
μ'_p/μ_B	1. 520 993 12	0. 066	10^{-3}
μ_p/μ_B	1. 521 032 64	0. 30	10^{-3}
μ'_p/μ_n	2. 792 709	6. 2	
μ_p/μ_n	2. 792 782	6. 2	

Other important constants
π=3.141 592 653 589
e=2.718 281 828 459
$\mu_0=4\pi\times10^{-7}$ H/m (exact), permeability of free space
$=1.256\ 637\ 061\times10^{-6}$ H/m
$\epsilon_0=\mu_0^{-1}c^{-2}$ F/m, permittivity of free space
$=8.854\ 185\times10^{-12}$ F/m

CONVERSION FACTORS

The following tables express the definitions of miscellaneous units of measure as exact numerical multiples of coherent SI units, and provide multiplying factors for converting numbers and miscellaneous units to corresponding new numbers and SI units.

The first two digits of each numerical entry represent a power of 10. An asterisk follows each number which expresses an exact definition. For example, the entry "−02 2.54*" expresses the fact that 1 inch=2.54×10^{-2} meter, exactly, by definition. Most of the definitions are extracted from National Bureau of Standards documents. Numbers not followed by an asterisk are only approximate representations of definitions, or are the results of physical measurements.

The conversion factors are listed alphabetically and by physical quantity.

The Listing by Physical Quantity includes only relationships which are frequently encountered and deliberately omits the great multiplicity of combinations of units which are used for more specialized purposes. Conversion factors for combinations of units are easily generated from numbers given in the Alphabetical Listing by the technique of direct substitution or by other well-known rules for manipulating units. These rules are adequately discussed in many science and engineering textbooks and are not repeated here.

ALPHABETICAL LISTING

To convert from	*to*	*multiply by*
abampere	ampere	+01 1.00*
abcoulomb	coulomb	+01 1.00*
abfarad	farad	+09 1.00*
abhenry	henry	−09 1.00*
abmho	siemens	+09 1.00*
abohm	ohm	−09 1.00*
abvolt	volt	−08 1.00*
acre	meter^2	+03 4.046 856 422 4*
angstrom	meter	−10 1.00*
are	meter^2	+02 1.00*
astronomical unit (IAU)	meter	+11 1.496 00
astronomical unit (radio)	meter	+11 1.495 978 9
atmosphere	newton/meter^2	+05 1.013 25*
bar	newton/meter^2	+05 1.00*
barn	meter^2	−28 1.00*
barrel (petroleum, 42 gallons)	meter^3	−01 1.589 873
barye	newton/meter^2	−01 1.00*
board foot (1′×1′×1″)	meter^3	−03 2.359 737 216*
British thermal unit:		
(IST before 1956)	joule	+03 1.055 04
(IST after 1956)	joule	+03 1.055 056
British thermal unit (mean)	joule	+03 1.055 87
British thermal unit (thermochemical)	joule	+03 1.054 350
British thermal unit (39° F)	joule	+03 1.059 67
British thermal unit (60° F)	joule	+03 1.054 68
bushel (U.S.)	meter^3	−02 3.523 907 016 688*
cable	meter	+02 2.194 56*
caliber	meter	−04 2.54*
calorie (International Steam Table)	joule	+00 4.1868
calorie (mean)	joule	+00 4.190 02
calorie (thermochemical)	joule	+00 4.184*
calorie (15° C)	joule	+00 4.185 80

To convert from	*to*	*multiply by*
calorie (20° C)	joule	+00 4.181 90
calorie (kilogram, International Steam Table)	joule	+03 4.1868
calorie (kilogram, mean)	joule	+03 4.190 02
calorie (kilogram, thermochemical)	joule	+03 4.184*
carat (metric)	kilogram	−04 2.00*
Celsius (temperature)	kelvin	$t_K = t_C + 273.15$
centimeter of mercury (0° C)	newton/meter^2	+03 1.333 22
centimeter of water (4° C)	newton/meter^2	+01 9.806 38
chain (engineer or ramden)	meter	+01 3.048*
chain (surveyor or gunter)	meter	+01 2.011 68*
circular mil	meter^2	−10 5.067 074 8
cord	meter^3	+00 3.624 556 3
cubit	meter	−01 4.572*
cup	meter^3	−04 2.365 882 365*
curie	disintegration/second	+10 3.70*
day (mean solar)	second (mean solar)	+04 8.64*
day (sidereal)	second (mean solar)	+04 8.616 409 0
degree (angle)	radian	−02 1.745 329 251 994 3
denier (international)	kilogram/meter	−07 1.00*
dram (avoirdupois)	kilogram	−03 1.771 845 195 312 5*
dram (troy or apothecary)	kilogram	−03 3.887 934 6*
dram (U.S. fluid)	meter^3	−06 3.696 691 195 312 5*
dyne	newton	−05 1.00*
electron volt	joule	−19 1.602 191 7
erg	joule	−07 1.00*
Fahrenheit (temperature)	kelvin	$t_K = (5/9)\ (t_F + 459.67)$
Fahrenheit (temperature)	Celsius	$t_C = (5/9)\ (t_F - 32)$
faraday (based on carbon 12)	coulomb	+04 9.648 70
faraday (chemical)	coulomb	+04 9.649 57
faraday (physical)	coulomb	+04 9.652 19
fathom	meter	+00 1.828 8*
fermi (femtometer)	meter	−15 1.00*
fluid ounce (U.S.)	meter^3	−05 2.957 352 956 25*
foot	meter	−01 3.048*
foot (U.S. survey)	meter	+00 1200/3937*
foot (U.S. survey)	meter	−01 3.048 006 096
foot of water (39.2° F)	newton/meter^2	+03 2.988 98
footcandle	lumen/meter^2	+01 1.076 391 0
footlambert	candela/meter^2	+00 3.426 259
free fall, standard	meter/second^2	+00 9.806 65*
furlong	meter	+02 2.011 68*
gal (galileo)	meter/second^2	−02 1.00*
gallon (U.K. liquid)	meter^3	−03 4.546 087
gallon (U.S. dry)	meter^3	−03 4.404 883 770 86*
gallon (U.S. liquid)	meter^3	−03 3.785 411 784*
gamma	tesla	−09 1.00*
gauss	tesla	−04 1.00*
gilbert	ampere turn	−01 7.957 747 2
gill (U.K.)	meter^3	−04 1.420 652
gill (U.S.)	meter^3	−04 1.182 941 2
grad	degree (angular)	−01 9.00*
grad	radian	−02 1.570 796 3
grain	kilogram	−05 6.479 891*
gram	kilogram	−03 1.00*

To convert from	*to*	*multiply by*
hand	meter	−01 1.016*
hectare	meter^2	+04 1.00*
hogshead (U.S.)	meter^3	−01 2.384 809 423 92*
horsepower (550 foot lbf/second)	watt	+02 7.456 998 7
horsepower (boiler)	watt	+03 9.809 50
horsepower (electric)	watt	+02 7.46*
horsepower (metric)	watt	+02 7.354 99
horsepower (U.K.)	watt	+02 7.457
horsepower (water)	watt	+02 7.460 43
hour (mean solar)	second (mean solar)	+03 3.60*
hour (sidereal)	second (mean solar)	+03 3.590 170 4
hundredweight (long)	kilogram	+01 5.080 234 544*
hundredweight (short)	kilogram	+01 4.535 923 7*
inch	meter	−02 2.54*
inch of mercury (32° F)	newton/meter^2	+03 3.386 389
inch of mercury (60° F)	newton/meter^2	+03 3.376 85
inch of water (39.2° F)	newton/meter^2	+02 2.490 82
inch of water (60° F)	newton/meter^2	+02 2.4884
kayser	1/meter	+02 1.00*
kilocalorie (International Steam Table)	joule	+03 4.186 8
kilocalorie (mean)	joule	+03 4.190 02
kilocalorie (thermochemical)	joule	+03 4.184*
kilogram mass	kilogram	+00 1.00*
kilogram force (kgf)	newton	+00 9.806 65*
kilopound force	newton	+00 9.806 65*
kip	newton	+03 4.448 221 615 260 5*
knot (international)	meter/second	−01 5.144 444 444
lambert	candela/meter^2	+04 $1/\pi$*
lambert	candela/meter^2	+03 3.183 098 8
langley	joule/meter^2	+04 4.184*
lbf (pound force, avoirdupois)	newton	+00 4.448 221 615 260 5*
lbm (pound mass, avoirdupois)	kilogram	−01 4.535 923 7*
league (U.K. nautical)	meter	+03 5.559 552*
league (international nautical)	meter	+03 5.556*
league (statute)	meter	+03 4.828 032*
light year	meter	+15 9.460 55
link (engineer or ramden)	meter	−01 3.048*
link (surveyor or gunter)	meter	−01 2.011 68*
liter	meter^3	−03 1.00*
lux	lumen/meter^2	+00 1.00*
maxwell	weber	−08 1.00*
meter	wavelengths Kr 86	+06 1.650 763 73*
micron	meter	−06 1.00*
mil	meter	−05 2.54*
mile (U.S. statute)	meter	+03 1.609 344*
mile (U.K. nautical)	meter	+03 1.853 184*
mile (international nautical)	meter	+03 1.852*
mile (U.S. nautical)	meter	+03 1.852*
millibar	newton/meter^2	+02 1.00*
millimeter of mercury (0° C)	newton/meter^2	+02 1.333 224
minute (angle)	radian	−04 2.908 882 086 66
minute (mean solar)	second (mean solar)	+01 6.00*
minute (sidereal)	second (mean solar)	+01 5.983 617 4
month (mean calendar)	second (mean solar)	+06 2.628*

To convert from	*to*	*multiply by*
nautical mile (international)	meter	+03 1.852*
nautical mile (U.S.)	meter	+03 1.852*
nautical mile (U.K.)	meter	+03 1.853 184*
oersted	ampere/meter	+01 7.957 747 2
ounce force (avoirdupois)	newton	−01 2.780 138 5
ounce mass (avoirdupois)	kilogram	−02 2.834 952 312 5*
ounce mass (troy or apothecary)	kilogram	−02 3.110 347 68*
ounce (U.S. fluid)	$meter^3$	−05 2.957 352 956 25*
pace	meter	−01 7.62*
parsec (IAU)	meter	+16 3.085 7
pascal	$newton/meter^2$	+00 1.00*
peck (U.S.)	$meter^3$	−03 8.809 767 541 72*
pennyweight	kilogram	−03 1.555 173 84*
perch	meter	+00 5.0292*
phot	$lumen/meter^2$	+04 1.00
pica (printers)	meter	−03 4.217 517 6*
pint (U.S. dry)	$meter^3$	−04 5.506 104 713 575*
pint (U.S. liquid)	$meter^3$	−04 4.731 764 73*
point (printers)	meter	−04 3.514 598*
poise	newton $second/meter^2$	−01 1.00*
pole	meter	+00 5.0292*
pound force (lbf avoirdupois)	newton	+00 4.448 221 615 260 5*
pound mass (lbm avoirdupois)	kilogram	−01 4.535 923 7*
pound mass (troy or apothecary)	kilogram	−01 3.732 417 216*
poundal	newton	−01 1.382 549 543 76*
quart (U.S. dry)	$meter^3$	−03 1.101 220 942 715*
quart (U.S. liquid)	$meter^3$	−04 9.463 592 5
rad (radiation dose absorbed)	joule/kilogram	−02 1.00*
Rankine (temperature)	kelvin	$t_K = (5/9)t_R$
rayleigh (rate of photon emission)	1/second $meter^2$	+10 1.00*
rhe	$meter^2$/newton second	+01 1.00*
rod	meter	+00 5.0292*
roentgen	coulomb/kilogram	−04 2.579 76*
rutherford	disintegration/second	+06 1.00*
second (angle)	radian	−06 4.848 136 811
second (ephemeris)	second	+00 1.000 000 000
second (mean solar)	second (ephemeris)	Consult American Ephemeris and Nautical Almanac
second (sidereal)	second (mean solar)	−01 9.972 695 7
section	$meter^2$	+06 2.589 988 110 336*
scruple (apothecary)	kilogram	−03 1.295 978 2*
shake	second	−08 1.00
skein	meter	+02 1.097 28*
slug	kilogram	+01 1.459 390 29
span	meter	−01 2.286*
statampere	ampere	−10 3.335 640
statcoulomb	coulomb	−10 3.335 640
statfarad	farad	−12 1.112 650
stathenry	henry	+11 8.987 554
statohm	ohm	+11 8.987 554
statute mile (U.S.)	meter	+03 1.609 344*
statvolt	volt	+02 2.997 925
stere	$meter^3$	+00 1.00*

To convert from	*to*	*multiply by*
stilb	candela/meter^2	+04 1.00
stoke	meter^2/second	−04 1.00*
tablespoon	meter^3	−05 1.478 676 478 125*
teaspoon	meter^3	−06 4.928 921 593 75*
ton (assay)	kilogram	−02 2.916 666 6
ton (long)	kilogram	+03 1.016 046 908 8*
ton (metric)	kilogram	+03 1.00*
ton (nuclear equivalent of TNT)	joule	+09 4.20
ton (register)	meter^3	+00 2.831 684 659 2*
ton (short, 2000 pound)	kilogram	+02 9.071 847 4*
tonne	kilogram	+03 1.00*
torr (0° C)	newton/meter^2	+02 1.333 22
township	meter^2	+07 9.323 957 2
unit pole	weber	−07 1.256 637
yard	meter	−01 9.144*
year (calendar)	second (mean solar)	+07 3.1536*
year (sidereal)	second (mean solar)	+07 3.155 815 0
year (tropical)	second (mean solar)	+07 3.155 692 6
year 1900, tropical, Jan., day 0, hour 12	second (ephemeris)	+07 3.155 692 597 47*
year 1900, tropical, Jan., day 0, hour 12	second	+07 3.155 692 597 47

LISTING BY PHYSICAL QUANTITY

ACCELERATION

foot/second^2	meter/second^2	−01 3.048*
free fall, standard	meter/second^2	+00 9.806 65*
gal (galileo)	meter/second^2	−02 1.00*
inch/second^2	meter/second^2	−02 2.54*

AREA

acre	meter^2	+03 4.046 856 422 4*
are	meter^2	+02 1.00*
barn	meter^2	−28 1.00*
circular mil	meter^2	−10 5.067 074 8
foot^2	meter^2	−02 9.290 304*
hectare	meter^2	+04 1.00*
inch^2	meter^2	−04 6.4516*
mile^2 (U.S. statute)	meter^2	+06 2.589 988 110 336*
section	meter^2	+06 2.589 988 110 336*
township	meter^2	+07 9.323 957 2
yard^2	meter^2	−01 8.361 273 6*

DENSITY

gram/centimeter^3	kilogram/meter^3	+03 1.00*
lbm/inch^3	kilogram/meter^3	+04 2.767 990 5
lbm/foot^3	kilogram/meter^3	+01 1.601 846 3
slug/foot^3	kilogram/meter^3	+02 5.153 79

To convert from	*to*	*multiply by*

ENERGY

British thermal unit:		
(IST before 1956)	joule	+03 1.055 04
(IST after 1956)	joule	+03 1.055 056
British thermal unit (mean)	joule	+03 1.055 87
British thermal unit (thermochemical)	joule	+03 1.054 350
British thermal unit (39° F)	joule	+03 1.059 67
British thermal unit (60° F)	joule	+03 1.054 68
calorie (International Steam Table)	joule	+00 4.1868
calorie (mean)	joule	+00 4.190 02
calorie (thermochemical)	joule	+00 4.184*
calorie (15° C)	joule	+00 4.185 80
calorie (20° C)	joule	+00 4.181 90
calorie (kilogram, International Steam Table)	joule	+03 4.1868
calorie (kilogram, mean)	joule	+03 4.190 02
calorie (kilogram, thermochemical)	joule	+03 4.184*
electron volt	joule	−19 1.602 191 7
erg	joule	−07 1.00*
foot lbf	joule	+00 1.355 817 9
foot poundal	joule	−02 4.214 011 0
joule (international of 1948)	joule	+00 1.000 165
kilocalorie (International Steam Table)	joule	+03 4.1868
kilocalorie (mean)	joule	+03 4.190 02
kilocalorie (thermochemical)	joule	+03 4.184*
kilowatt hour	joule	+06 3.60*
kilowatt hour (international of 1948)	joule	+06 3.600 59
ton (nuclear equivalent of TNT)	joule	+09 4.20
watt hour	joule	+03 3.60*

ENERGY/AREA TIME

Btu (thermochemical)/foot² second	watt/meter²	+04 1.134 893 1
Btu (thermochemical)/foot² minute	watt/meter²	+02 1.891 488 5
Btu (thermochemical)/foot² hour	watt/meter²	+00 3.152 480 8
Btu (thermochemical)/inch² second	watt/meter²	+06 1.634 246 2
calorie (thermochemical)/cm² minute	watt/meter²	+02 6.973 333 3
erg/centimeter² second	watt/meter²	−03 1.00*
watt/centimeter²	watt/meter²	+04 1.00*

FORCE

dyne	newton	−05 1.00*
kilogram force (kgf)	newton	+00 9.806 65*
kilopond force	newton	+00 9.806 65*
kip	newton	+03 4.448 221 615 260 5*
lbf (pound force, avoirdupois)	newton	+00 4.448 221 615 260 5*
ounce force (avoirdupois)	newton	−01 2.780 138 5
pound force, lbf (avoirdupois)	newton	+00 4.448 221 615 260 5*
poundal	newton	−01 1.382 549 543 76*

LENGTH

angstrom	meter	−10 1.00*
astronomical unit (IAU)	meter	+11 1.496 00
astronomical unit (radio)	meter	+11 1.495 978 9
cable	meter	+02 2.194 56*

To convert from	*to*	*multiply by*
caliber	meter	−04 2.54*
chain (surveyor or gunter)	meter	+01 2.011 68*
chain (engineer or ramden)	meter	+01 3.048*
cubit	meter	−01 4.572*
fathom	meter	+00 1.8288*
fermi (femtometer)	meter	−15 1.00*
foot	meter	−01 3.048*
foot (U.S. survey)	meter	+00 1200/3937*
foot (U.S. survey)	meter	−01 3.048 006 096
furlong	meter	+02 2.011 68*
hand	meter	−01 1.016*
inch	meter	−02 2.54*
league (U.K. nautical)	meter	+03 5.559 552*
league (international nautical)	meter	+03 5.556*
league (statute)	meter	+03 4.828 032*
light year	meter	+15 9.460 55
link (engineer or ramden)	meter	−01 3.048*
link (surveyor or gunter)	meter	−01 2.011 68*
meter	wavelengths Kr 86	+06 1.650 763 73*
micron	meter	−06 1.00*
mil	meter	−05 2.54*
mile (U.S. statute)	meter	+03 1.609 344*
mile (U.K. nautical)	meter	+03 1.853 184*
mile (international nautical)	meter	+03 1.852*
mile (U.S. nautical)	meter	+03 1.852*
nautical mile (U.K.)	meter	+03 1.853 184*
nautical mile (international)	meter	+03 1.852*
nautical mile (U.S.)	meter	+03 1.852*
pace	meter	−01 7.62*
parsec (IAU)	meter	+16 3.085 7
perch	meter	+00 5.0292*
pica (printers)	meter	−03 4.217 517 6*
point (printers)	meter	−04 3.514 598*
pole	meter	+00 5.0292*
rod	meter	+00 5.0292*
skein	meter	+02 1.097 28*
span	meter	−01 2.286*
statute mile (U.S.)	meter	+03 1.609 344*
yard	meter	−01 9.144*

MASS

carat (metric)	kilogram	−04 2.00*
gram (avoirdupois)	kilogram	−03 1.771 845 195 312 5*
gram (troy or apothecary)	kilogram	−03 3.887 934 6*
grain	kilogram	−05 6.479 891*
gram	kilogram	−03 1.00*
hundredweight (long)	kilogram	+01 5.080 234 544*
hundredweight (short)	kilogram	+01 4.535 923 7*
kgf second^2 meter (mass)	kilogram	+00 9.806 65*
kilogram mass	kilogram	+00 1.00*
lbm (pound mass, avoirdupois)	kilogram	−01 4.535 923 7*
ounce mass (avoirdupois)	kilogram	−02 2.834 952 312 5*
ounce mass (troy or apothecary)	kilogram	−02 3.110 347 68*
pennyweight	kilogram	−03 1.555 173 84*
pound mass, lbm (avoirdupois)	kilogram	−01 4.535 923 7*

To convert from	*to*	*multiply by*
pound mass (troy or apothecary)	kilogram	−01 3.732 417 216*
scruple (apothecary)	kilogram	−03 1.295 978 2*
slug	kilogram	+01 1.459 390 29
ton (assay)	kilogram	−02 2.916 666 6
ton (long)	kilogram	+03 1.016 046 908 8*
ton (metric)	kilogram	+03 1.00*
ton (short, 2000 pound)	kilogram	+02 9.071 847 4*
tonne	kilogram	+03 1.00*

POWER

Btu (thermochemical)/second	watt	+03 1.054 350 264 488
Btu (thermochemical)/minute	watt	+01 1.757 250 4
calorie (thermochemical)/second	watt	+00 4.184*
calorie (thermochemical)/minute	watt	−02 6.973 333 3
foot lbf/hour	watt	−04 3.766 161 0
foot lbf/minute	watt	−02 2.259 696 6
foot lbf/second	watt	+00 1.355 817 9
horsepower (550 foot lbf/second)	watt	+02 7.456 998 7
horsepower (boiler)	watt	+03 9.809 50
horsepower (electric)	watt	+02 7.46*
horsepower (metric)	watt	+02 7.354 99
horsepower (U.K.)	watt	+02 7.457
horsepower (water)	watt	+02 7.460 43
kilocalorie (thermochemical)/minute	watt	+01 6.973 333 3
kilocalorie (thermochemical)/second	watt	+03 4.184*
watt (international of 1948)	watt	+00 1.000 165

PRESSURE

atmosphere	newton/meter^2	+05 1.013 25*
bar	newton/meter^2	+05 1.00*
barye	newton/meter^2	−01 1.00*
centimeter of mercury (0° C)	newton/meter^2	+03 1.333 22
centimeter of water (4° C)	newton/meter^2	+01 9.806 38
dyne/centimeter^2	newton/meter^2	−01 1.00*
foot of water (39.2° F)	newton/meter^2	+03 2.988 98
inch of mercury (32° F)	newton/meter^2	+03 3.386 389
inch of mercury (60° F)	newton/meter^2	+03 3.376 85
inch of water (39.2° F)	newton/meter^2	+02 2.490 82
inch of water (60° F)	newton/meter^2	+02 2.4884
kgf/centimeter^2	newton/meter^2	+04 9.806 65*
kgf/meter^2	newton/meter^2	+00 9.806 65*
lbf/foot^2	newton/meter^2	+01 4.788 025 8
lbf/inch^2 (psi)	newton/meter^2	+03 6.894 757 2
millibar	newton/meter^2	+02 1.00*
millimeter of mercury (0° C)	newton/meter^2	+02 1.333 224
pascal	newton/meter^2	+00 1.00*
psi (lbf/inch^2)	newton/meter^2	+03 6.894 757 2
torr (0° C)	newton/meter^2	+02 1.333 22

SPEED

foot/hour	meter/second	−05 8.466 666 6
foot/minute	meter/second	−03 5.08*
foot/second	meter/second	−01 3.048*
inch/second	meter/second	−02 2.54*

To convert from	to	multiply by
kilometer/hour	meter/second	−01 2.777 777 8
knot (international)	meter/second	−01 5.144 444 444
mile/hour (U.S. statute)	meter/second	−01 4.4704*
mile/minute (U.S. statute)	meter/second	+01 2.682 24*
mile/second (U.S. statute)	meter/second	+03 1.609 344*

TEMPERATURE

Celsius	kelvin	$t_K = t_C + 273.15$
Fahrenheit	kelvin	$t_K = (5/9)(t_F + 459.67)$
Fahrenheit	Celsius	$t_C = (5/9)(t_F - 32)$
Rankine	kelvin	$t_K = (5/9)t_R$

TIME

day (mean solar)	second (mean solar)	+04 8.64*
day (sidereal)	second (mean solar)	+04 8.616 409 0
hour (mean solar)	second (mean solar)	+03 3.60*
hour (sidereal)	second (mean solar)	+03 3.590 170 4
minute (mean solar)	second (mean solar)	+01 6.00*
minute (sidereal)	second (mean solar)	+01 5.983 617 4
month (mean calendar)	second (mean solar)	+06 2.628*
second (ephemeris)	second	+00 1.000 000 000
second (mean solar)	second (ephemeris)	Consult American Ephemeris and Nautical Almanac
second (sidereal)	second (mean solar)	−01 9.972 695 7
year (calendar)	second (mean solar)	+07 3.1536*
year (sidereal)	second (mean solar)	+07 3.155 815 0
year (tropical)	second (mean solar)	+07 3.155 692 6
year 1900, tropical, Jan., day 0, hour 12	second (ephemeris)	+07 3.155 692 597 47*
year 1900, tropical, Jan., day 0, hour 12	second	+07 3.155 692 597 47

VISCOSITY

centistoke	meter²/second	−06 1.00*
stoke	meter²/second	−04 1.00*
foot²/second	meter²/second	−02 9.290 304*
centipoise	newton second/meter²	−03 1.00*
lbm/foot second	newton second/meter²	+00 1.488 163 9
lbf second/foot²	newton second/meter²	+01 4.788 025 8
poise	newton second/meter²	−01 1.00*
poundal second/foot²	newton second/meter²	+00 1.488 163 9
slug/foot second	newton second/meter²	+01 4.788 025 8
rhe	meter²/newton second	+01 1.00*

VOLUME

acre foot	meter³	+03 1.233 481 837 547 52*
barrel (petroleum, 42 gallons)	meter³	−01 1.589 873
board foot	meter³	−03 2.359 737 216*
bushel (U.S.)	meter³	−02 3.523 907 016 688*
cord	meter³	+00 3.624 556 3
cup	meter³	−04 2.365 882 365*
dram (U.S. fluid)	meter³	−06 3.696 691 195 312 5*
fluid ounce (U.S.)	meter³	−05 2.957 352 956 25*
foot³	meter³	−02 2.831 684 659 2*

To convert from	*to*	*multiply by*
gallon (U.K. liquid)	meter³	−03 4.546 087
gallon (U.S. dry)	meter³	−03 4.404 883 770 86*
gallon (U.S. liquid)	meter³	−03 3.785 411 784*
gill (U K.)	meter³	−04 1.420 652
gill (U.S.)	meter³	−04 1.182 941 2
hogshead (U.S.)	meter³	−01 2.384 809 423 92*
inch³	meter³	−05 1.638 706 4*
liter	meter³	−03 1.00*
ounce (U.S. fluid)	meter³	−05 2.957 352 956 25*
peck (U.S.)	meter³	−03 8.809 767 541 72*
pint (U.S. dry)	meter³	−04 5.506 104 713 575*
pint (U.S. liquid)	meter³	−04 4.731 764 73*
quart (U.S. dry)	meter³	−03 1.101 220 942 715*
quart (U.S. liquid)	meter³	−04 9.463 529 5
stere	meter³	+00 1.00*
tablespoon	meter³	−05 1.478 676 478 125*
teaspoon	meter³	−06 4.928 921 593 75*
ton (register)	meter³	+00 2.831 684 659 2*
yard³	meter³	−01 7.645 548 579 84*

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