1.6 Conversion tables for units

The table below gives conversion factors from a variety of units to the corresponding SI unit. Examples of the use of this table have already been given in the preceding section. For each physical quantity the name is given, followed by the recommended symbol(s). The SI unit is given, followed by the esu, emu, Gaussian unit (Gau), atomic unit (au), and other units in common use, with their conversion factors to SI. The constant ζ which occurs in some of the electromagnetic conversiton factors is the (exact) pure number $2.997\,924\,58\times10^{10} = c_0/(\text{cm s}^{-1})$.

The inclusion of non-SI units in this table should not be taken to imply that their use is to be encouraged. With some exceptions, SI units are always to be preferred to non-SI units. However, since may of the units below are to be found in the scientific literature, it is convenient to tabulate their relation to the SI.

For convenience units in the esu and Gaussian systems are quoted in terms of the four dimensions *length, mass, time,* and *electric charge*, by including the franklin (Fr) as an abbreviation for the electrostatic unit of charge and $4\pi\varepsilon_0$ as a constant with dimensions $(charge)^2/(energy\times length)$. This gives each physical quantity the same dimensions in all systems, so that all conversion factors are pure numbers. The factors $4\pi\varepsilon_0$ and the Fr may be eliminated by writing Fr = esu of charge = $\text{erg}^{½}\ \text{cm}^{½} = \text{cm}^{3/2}\ \text{g}^{½}\ \text{s}^{-1}$, and $4\pi\varepsilon_0 = \varepsilon^{\text{ir})} = 1\ \text{Fr}^2\ \text{erg}^{-1}\ \text{cm}^{-1} = 1$, to recover esu expressions in terms of three base units (see section 7.3 below). The symbol Fr should be regarded as a compact representation of (esu of charge).

Conversion factors are either given exactly (when the = sign is used), or they are given to the approximation that the corresponding physical constants are known (when the ≈ sign is used). In the latter case the uncertainty is always less than ±5 in the last digit quoted.

Name	*Symbol*	*Relation to SI*
length, l		
metre (SI unit)	m	
centimetre (cgs unit)	cm	$= 10^{-2}$ m
ångström	Å	$= 10^{-10}$ m
micron	μ	= μm $= 10^{-6}$ m
millimicron	mμ	= nm $= 10^{-9}$ m
x unit	X	$\approx 1.002\times10^{-13}$ m
fermi	f, fm	= fm $= 10^{-15}$ m
inch	in	$= 2.54\times10^{-2}$ m
foot	ft	= 12 in = 0.3048 m
yard	yd	= 3 ft = 0.9144 m
mile	mi	= 1760 yd = 1609.344 m
nautical mile		= 1852 m
astronomical unit	AU	$= 1.496\,00\times10^{11}$ m
parsec	pc	$\approx 3.085\,68\times10^{16}$ m
light year	l.y.	$\approx 9.460\,528\times10^{15}$ m
light second		= 299 792 458 m
area, A		
square metre (SI unit)	m^2	
barn	b	$= 10^{-28}$ m^2
acre		≈ 4046.856 m^2
are	a	$= 100$ m^2
hectare	ha	$= 10^4$ m^2
volume, V		
cubic metre (SI unit)	m^3	
litre	l, L	$= dm^3 = 10^{-3}$ m^3
lambda	λ	= μl $= 10^{-6}$ dm^3
barrel (US)		≈ 158.987 dm^3
gallon (US)	gal (US)	$= 3.785\,41$ dm^3
gallon (UK)	gal (UK)	$= 4.546\,09$ dm^3

Name	*Symbol*	*Relation to SI*
mass, m		
kilogram (SI unit)	kg	
gram (cgs unit)	g	$= 10^{-3}$ kg
electron mass (au)	m_e	$\approx 9.109\ 39 \times 10^{-31}$ kg
unified atomic mass unit, daltonS	u, Da	$= m_a(^{12}C)/12 \approx 1.660\ 540 \times 10^{-27}$ kg
gamma	γ	= μg
tonne	t	$=$ Mg $= 10^{3}$ kg
pound (avoirdupois)	lb	= 0.453 592 37 kg
ounce (avoirdupois)	oz	≈ 28.3495 g
ounce (troy)	oz (trou)	≈ 31.1035 g
grain	gr	= 64.798 91 mg
time, t		
second (SI, cgs unit)	s	
au of time	h/E_h	$\approx 2.418\ 88 \times 10^{-17}$ s
minute	min	= 60 s
hour	h	= 3600 s
day[1]	d	= 86 400 s
year[2]	a	≈ 31 556 952 s
svedberg	Sv	$= 10^{-13}$ s

(1) Note that the day is not exactly in terms of the second since so-called leap-seconds are added or subtracted from the day semiannually in order to keep the annual average occurrence of midnight at 24:00 on the clock.

(2) The year is not commensurable with the day and not a constant. Prior to 1967, when the atomic standard was introduced, the tropical year 1900 served as the basis for the definition of the second. For the epoch 1900.0. it amounted to 365.242 198 79 d ≈ 31 556 925.975 s and it decreases by 0.530 seconds per century. The calendar years are exactly defined in terms of the day:

Julian year = 365.25 d
Gregorian year = 365.2425 d.

The definition in the table corresponds to the Gregorian year. This is an average based on a year of length 365 days, with leap years of 366 days; leap years are taken *either* when the year is divisible by 4 but is not divisible by 100, *or* when the year is divisible by 400. Whether the year 3200 should be a leap year is still open, but this does not have to be resolved until sometime in the middle of the 32nd century.

Name	*Symbol*	*Relation to SI*
acceleration, a		
SI unit	$m\ s^{-2}$	
standard acceleration of free fall	g_n	$= 9.806\ 65\ m\ s^{-2}$
gal, galileo	Gal	$= 10^{-2}\ m\ s^{-2}$
force, F		
newton (SI unit)[3]	N	$= kg\ m\ s^{-2}$
dyne (cgs unit)	dyn	$= g\ cm\ s^{-2} = 10^{-5}\ N$
au of force	E_h/a_0	$\approx 8.238\ 73\times10^{-8}\ N$
kilogram-force	kgf	$= 9.806\ 65\ N$
energy, U		
joule (SI unit)	J	$= kg\ m^2\ s^{-2}$
erg (cgs unit)	erg	$= g\ cm^2\ s^{-2} = 10^{-7}\ J$
rydberg	Ry	$= E_h/2 \approx 2.179\ 87\times10^{-18}\ J$
electronvolt	eV	$= e\times V \approx 1.602\ 18\times10^{-19}\ J$
calorie, thermochemical	cal_{th}	$= 4.184\ J$
calorie, international	cal_{IT}	$= 4.1868\ J$
15 °C calorie	cal_{15}	$\approx 4.1855\ J$
litre atmosphere	l atm	$= 101.325\ J$
British thermal unit	Btu	$= 1055.06\ J$
pressure, p		
pascal (SI unit)	Pa	$= N\ m^{-2} = kg\ m^{-1}\ s^{-2}$
atmosphere	atm	$= 101\ 325\ Pa$
bar	bar	$= 10^5\ Pa$
torr	Torr	$= (101\ 325/760)\ Pa \approx 133.322\ Pa$
millimetre of mercury (conventional)	mmHg	$= 13.5951\times980.665\times10^{-2}\ Pa \approx 133.322\ Pa$
pounds per squere inch	psi	$\approx 6.894\ 757\times10^3\ Pa$
power, P		
watt (SI unit)	W	$= kg\ m^2\ s^{-3}$
horse power	hp	$= 745.7\ W$

(3) 1 N is approximately the force exerted by the earth upon an apple.

Name	*Symbol*	*Relation to SI*
action, L, J (angular momentum)		
SI unit	J S	= kg m^2 s^{-1}
cgs unit	erg s	= 10^{-7} J s
au of action	$\hbar = h/2\pi$	$\approx$ 1.054 57×10^{-34} J s
dynamic viscosity, η		
SI unit	Pa s	= kg m^{-1} s^{-1}
poise	P	= 10^{-1} Pa s
centipoise	cP	= mPa s
kinematic viscosity, v		
SI unit	m^2 s^{-1}	
stokes	St	= 10^{-4} m^2 s^{-1}
thermodynamic temperature, T		
kelvin (SI unit)	K	
degree Rankine[4]	°R	= (5/9) K
entropy, S		
heat capacity, C		
SI unit	J K^{-1}	
clausius	Cl	= cal$_{th}$/K = 4.184 J K^{-1}
molar entropy, S_m		
molar heat capacity, C_m		
SI unit	J K^{-1} mol^{-1}	
entropy unit	e.u.	= cal$_{th}$ K^{-1} mol^{-1} = 4.184 J K^{-1} mol^{-1}

(4) T/°R = (9/5) T/K. Also, Celsius temperature θ is related to thermodynamic temperature T by equation

$$\theta/°C = T/K - 273.15$$

Similarly Fahrenheit temperature θ_F is related to Celsius temperature θ by the equation

$$\theta_F/°F = (9/5)\,(\theta/°C) + 32$$

Name	*Symbol*	*Relation to SI*
molar volume, V_m		
SI unit	$m^3 mol^{-1}$	
amagat	amagat	= V_m of real gas at 1 atm and 273.15 K
		$\approx 22.4\times10^{-3}$ $m^3 mol^{-1}$
plane angle, α		
radian (SI unit)	rad	
degree	°	= rad×2π/360 ≈ (1/57.295 78) rad
minute	′	= degree/60
second	″	= degree/3600
grade	grad	= rad×2π/400 ≈ (1/63.661 98) rad
radioactivity, A		
becquerel (SI unit)	Bq	= s^{-1}
curie	Ci	= 3.7×10^{10} Bq
absorbed dose of radiation[5]		
gray (SI unit)	Gy	= J kg^{-1}
rad	rad	= 0.01 Gy
dose equialent		
sievert (SI unit)	Sv	= J kg^{-1}
rem	rem	≈ 0.01 Sv

(5) The unit röntgen, employed to express exposure to X or γ radiation, is equal to: R = 2.58×10^{-4} C kg^{-1}

Name	*Symbol*	*Relation to SI*
electric current, I		
ampere (SI unit)	A	
esu, Gau	(10/ζ)A	$\approx 3.335\ 64\times10^{-10}$ A
biot (emu)	Bi	= 10 A
electric charge, Q		
coulomb (SI unit)	C	= A s
franklin (esu, Gau)	Fr	= (10/ζ)C $\approx 3.335\ 64\times10^{-10}$ C
emu (abcoulomb)		= 10 C
proton charge (au)	*e*	$\approx 1.602\ 18\times10^{-19}$ C $\approx 4.803\ 21\times10^{-10}$ Fr
charge density, ρ		
SI unit	C m^{-3}	
esu, Gau	Fr cm^{-3}	$= 10^{7}\ \zeta^{-1}$ C $m^{-3} \approx 3.335\ 64\times10^{-4}$ C m^{-3}
electrical potential, V, φ		
volt (SI unit)	V	= J C^{-1} = J A^{-1} s^{-1}
esu, Gau	erg Fr^{-1}	= Fr $cm^{-1}/4\pi\varepsilon_0$ = 299.792 458 V
mean international volt		= 1.00034 V
US international volt		= 1.000 330 V
electric resistance, R		
ohm (SI unit)	Ω	= V A^{-1} = m^{2} kg s^{-3} A^{-2}
mean international ohm		= 1.000 49 Ω
US international ohm		= 1.000 495 Ω
electric field, E		
SI unit	V m^{-1}	= J C^{-1} m^{-1}
esu, Gau	Fr $cm^{-2}/4\pi\varepsilon_0$	$= 2.997\ 924\ 58\times10^{4}$ V m^{-1}
electric field gradient, E_{β}, $q_{\alpha\beta}$		
SI unit	V m^{-2}	= J C^{-1} m^{-2}
esu, Gau	Fr $cm^{-3}/4\pi\varepsilon_0$	$= 2.997\ 924\ 58\times10^{6}$ V m^{-2}
electric dipol moment, p, μ		
SI unit	C m	
esu, Gau	Fr cm	$\approx 3.335\ 64\times10^{-12}$ C m
debye	D	$= 10^{-18}$ Fr cm $\approx 3.335\ 64\times10^{-30}$ C m

Name	*Symbol*	*Relation to SI*
electric quadrupole moment,		
$Q_{\alpha\beta}$, $\Theta_{\alpha\beta}$, eQ		
SI unit	C m^2	
esu, Gau	Fr cm^2	$\approx 3.335\ 64\times10^{-14}$ C m^{-2}
magnetic flux density, B		
(magnetic field)		
tesla (SI unit)	T	= J A^{-1} m^{-2} = V s m^{-2} = Wb m^{-2}
gauss (emu, Gau)	G	= 10^{-4} T
magnetic flux, Φ		
weber (SI unit)	Wb	= J A^{-1} = V s
maxwell (emu, Gau)	Mx	= G cm^{-2} = 10^{-8} Wb
magnetic field, H		
(volume) magnetization, M		
SI unit	A m^{-1}	= C s^{-1} m^{-1}
oersted (emu, Gau)	Oe	= 10^3 A m^{-1}

[But note: in practice the oersted, Oe, is only used as a unit for $H^{(\mathrm{ir})} = 4\pi H$; thus when $H^{(\mathrm{ir})}$ = 1 Oe, $H = (10^3/4\pi)$ A m^{-1}.]

magnetic dipole moment, m, μ		
SI unit	A m^2	= J T^{-1}
emu, Gau	erg G^{-1}	= 10 A cm^2 = 10^{-3} J T^{-1}
Bohr magneton[6]	μ_B	= $eh/2m_e \approx 9.274\ 02\times10^{-24}$ J T^{-1}
nuclear magneton	μ_N	= $(m_e/m_p)\mu_B \approx 5.050\ 79\times10^{-27}$ J T^{-1}
magnetizability, ξ		
SI unit	J T^{-2}	= C^2 m^2 kg^{-1}

(6) The Bohr magneton μ_B is sometimes denoted BM (or B.M.), but this is not recommended.

Name	*Symbol*	*Relation to SI*
magnetic susceptibility, χ, κ		
SI unit	1	
emu, Gau	1	

[But note: in practice susceptibilities quoted in the context of emu or Gaussian units are always values for $\chi^{(ir)} = \chi/4\pi$; thus when $\chi^{(ir)} = 10^{-6}$, $\chi = 4\pi\times10^{-6}$.]

molar magnetic susceptibility, χ_m		
SI unit	$m^3\ mol^{-1}$	
emu, Gau	$cm^3\ mol^{-1}$	$= 10^{-6}\ m^3\ mol^{-1}$

[But note: in practice the units $cm^3\ mol^{-1}$ usually imply that the irrational molar susceptibility is being quoted, $\chi_m^{(ir)} = \chi_m/4\pi$; thus, for example if $\chi_m^{(ir)} = -15\times10^{-6}\ cm^3\ mol^{-1}$, which is often written as '-15 cgs ppm', then $\chi_m = -1.88\times10^{-10}\ m^3\ mol^{-1}$.]