The International System of Units (SI)

Introduction

This is a brief summary of the SI, the modern metric system of measurement. Long the language universally used in science, the SI has become the dominant language of international commerce and trade. These "essentials" are adapted from NIST Special Publication 811 (SP 811), prepared by B.N. Taylor and entitled *Guide for the Use of the International System of Units (SI)*, and NIST Special Publication 330 (SP 330), edited by B.N. Taylor and entitled *The International System of Units (SI)*. Users requiring more detailed information may access SP 811 and SP 330 online. Locus strives to adhere by SI units wherever possible. Some explanation for key units is presented below.

SI Base Units

The SI is founded on seven SI base units for seven base quantities assumed to be mutually independent, as given in Table 1.

Table 1. SI base units

	SI base unit	
Base quantity	**Name**	**Symbol**
length	meter	m
mass	kilogram	kg
time	second	s
electric current	ampere	A
thermodynamic temperature	kelvin	K
amount of substance	mole	mol
luminous intensity	candela	cd

SI-Derived Units

Other quantities, called derived quantities, are defined in terms of the seven base quantities via a system of quantity equations. The SI derived units for these derived quantities are obtained from these equations and the seven SI base units. Examples of such SI derived units are given in Table 2, where it should be noted that the symbol 1 for quantities of dimension 1 such as mass fraction is generally omitted.

Table 2. Examples of SI derived units

	SI-Derived Unit	
Derived Quantity	**Name**	**Symbol**
area	square meter	m^2
volume	cubic meter	m^3
speed, velocity	meter per second	m/s

Table 2. Examples of SI derived units

	SI-Derived Unit	
Derived Quantity	**Name**	**Symbol**
acceleration	meter per second squared	m/s^2
wave number	reciprocal meter	m^{-1}
mass density	kilogram per cubic meter	kg/m^3
specific volume	cubic meter per kilogram	m^3/kg
current density	ampere per square meter	A/m^2
magnetic field strength	ampere per meter	A/m
amount-of-substance concentration	mole per cubic meter	mol/m^3
luminance	candela per square meter	cd/m^2
mass fraction	kilogram per kilogram, which may be represented by the number 1	kg/kg = 1

Units Outside the SI

Certain units are not part of the International System of Units, that is, they are outside the SI, but are important and widely used. Consistent with the recommendations of the International Committee for Weights and Measures (CIPM, Comité International des Poids et Mesures), the units in this category that are accepted for use with the SI are given in Table 3.

Table 3. Units outside the SI that are accepted for use with the SI

Name	**Symbol**	**Value in SI units**
minute (time)	min	1 min = 60 s
hour	h	1 h = 60 min = 3600 s
day	d	1 d = 24 h = 86 400 s
degree (angle)	°	1° = (π/180) rad
minute (angle)	′	1′ = (1/60)° = (π/10 800) rad
second (angle)	″	1″ = (1/60)′ = (π/648 000) rad
liter	L	1 L = 1 dm^3 = 10^{-3} m^3
metric ton [a]	t	1 t = 10^3 kg
neper	Np	1 Np = 1
bel [b]	B	1 B = (1/2) ln 10 Np [c]
electronvolt [d]	eV	1 eV = 1.602 18 x 10^{-19} J, approximately
unified atomic mass unit [e]	u	1 u = 1.660 54 x 10^{-27} kg, approximately

Table 3. Units outside the SI that are accepted for use with the SI

Name	Symbol	Value in SI units
astronomical unit [f]	ua	1 ua = 1.495 98 x 10^{11} m, approximately

[a] In many countries, this unit is called "tonne.''

[b] The bel is most commonly used with the SI prefix deci: 1 dB = 0.1 B.

[c] Although the neper is coherent with SI units and is accepted by the CIPM, it has not been adopted by the General Conference on Weights and Measures (CGPM, *Conférence Générale des Poids et Mesures*) and is thus not an SI unit.

[d] The electronvolt is the kinetic energy acquired by an electron passing through a potential difference of 1 V in vacuum. The value must be obtained by experiment, and is therefore not known exactly.

[e] The unified atomic mass unit is equal to 1/12 of the mass of an unbound atom of the nuclide ^{12}C, at rest and in its ground state. The value must be obtained by experiment, and is therefore not known exactly.

[f] The astronomical unit is a unit of length. Its value is such that, when used to describe the motion of bodies in the solar system, the heliocentric gravitation constant is $(0.017\ 202\ 098\ 95)^2$ $ua^3 \cdot d^{-2}$. The value must be obtained by experiment, and is therefore not known exactly.

The liter in Table 3 deserves comment. This unit and its symbol l were adopted by the CIPM in 1879. The alternative symbol for the liter, L, was adopted by the CGPM in 1979 in order to avoid the risk of confusion between the letter l and the number 1. Thus, although both l and L are internationally accepted symbols for the liter, to avoid this risk the preferred symbol for use in the United States is L. Neither a lowercase script letter l nor an uppercase script letter L are approved symbols for the liter.

SI Prefixes

The 20 SI prefixes used to form decimal multiples and submultiples of SI units are given in Table 4.

Table 4. SI prefixes

Factor	Name	Symbol	Factor	Name	Symbol
10^{24}	yotta	Y	10^{-1}	deci	d
10^{21}	zetta	Z	10^{-2}	centi	c
10^{18}	exa	E	10^{-3}	milli	m
10^{15}	peta	P	10^{-6}	micro	µ
10^{12}	tera	T	10^{-9}	nano	n
10^{9}	giga	G	10^{-12}	pico	p
10^{6}	mega	M	10^{-15}	femto	f
10^{3}	kilo	k	10^{-18}	atto	a
10^{2}	hecto	h	10^{-21}	zepto	z
10^{1}	deka	da	10^{-24}	yocto	y

It is important to note that the kilogram is the only SI unit with a prefix as part of its name and symbol. Because multiple prefixes may not be used, in the case of the kilogram the prefix names of Table 4 are used with the unit name "gram" and the prefix symbols are used with the unit symbol "g." With this exception, any SI prefix may be used with any SI unit, including the degree Celsius and its symbol °C.

The micro (µ) in Table 4 deserves comment. This prefix is commonly reported by analytical labs as the lowercase letter “u” and is imported into EIM with the same prefix. However, user should be aware that this is not accepted standard for reporting and should flag such reporting on their reports. For example, if results are reported as ug/L the correct reading should be µg/L (microgram per Liter).

The letter “u” represents a different unit (see Table 3) and should be avoided in final reporting.