Chapter 2

The International System of Measuring Units (SI)

SUMMARY

The metric system is simple and easy to learn. Do not become confused with all the details given in this chapter. You probably will not see most of the units in practical use. You should, however, learn the most common units for length, area, volume, mass, and temperature shown in Table 2-1. Prefixes are shown in Table 2-2. Preferred units are shown in **bold.** How the metric units relate to inch units are covered in Chapter 17. See conversion program.

TABLE 2-1 SI UNITS

Quantity	Symbol (Name)	Prefix and Symbol*	Other Metric Unit
Length	**m (meter)**	nm (nanometer) = 10^{-9} m **µm (micrometer) = 10^{-6} m** **mm (millimeter) = 10^{-3} m** cm (centimeter) = 10^{-2} m dm (decimeter) = 10^{-1} m hm (hectometer) = 10^{2} m **km (kilometer) = 10^{3} m**	micron = µm = 0.001 mm
Area	**m^2 (square meter)**	**mm^2 (square millimeter) = 10^{-6} m^2** cm^2 (square centimeter) = 10^{-4} m^2 dm^2 (square decimeter) = 10^{-2} m^2 **hm^2 (square hectometer) = 10^{4} m^2** **km^2 (square kilometer) = 10^{6} m^2**	1 a (are) = 100 m^2 **1 hm^2** = 1 ha (hectare) = 10 000 m^2
Volume	**m^3 (cubic meter)**	mm^3 (cubic millimeter) = 10^{-9} m^3 cm^3 (cubic centimeter) = 10^{-6} m^3 dm^3 (cubic decimeter) = 10^{-3} m^3	**1 µL (microliter) =** 1 mm^3 **1 mL (milliliter) =** 1 cm^3 **1 L (liter) =** 1 dm^3 **1 kL (kiloliter) =** 1 m^3
Mass$^{(1)}$	**kg (kilogram)**	µg (microgram) = 10^{-9} kg mg (milligram) = 10^{-6} kg **g (gram) = 10^{-3} kg** **Mg (megagram) = 10^{3} kg**	Mass of water; 1 mg = 1 µL = 1 mm^3 1 g = 1 mL = 1 cm^3 1 kg = 1 L = 1 dm^3 1 Mg = 1 kL = 1 m^3 1 t_{metric} = 1000 kg
Temperature	**K (kelvin)**	The absolute temperature $T_K = T_O + t_C = 273.15 + {}^{o}C$	**^{o}C (degree Celsius)**
Speed	**m/s (meter per second)**		**1 km/h = 1/3.6 m/s**
Acceleration	**m/s^2 (meter per second squared)**		
Force	**N (newton)**	µN (micronewton) = 10^{-6} N mN (millinewton) = 10^{-3} N daN (dekanewton) = 10 N$^{(2)}$ **kN (kilonewton) = 10^{3} N** **MN (meganewton) = 10^{6} N**	See NOTE $^{(1)}$ for Mass

TABLE 2-1 SI UNITS (CONT'D)

Quantity	Symbol (Name)	Prefix and Symbol*	Other Metric Unit
Torque	**N•m**	μN•m (micronewton x meter) = 10^{-6} N•m mN•m (millinewton x meter) = 10^{-3} N•m **kN•m (kilonewton x meter) = 10^{3} N•m** MN•m (meganewton x meter) = 10^{6} N•m	
Pressure, Stress	**Pa (pascal = N/m^2)**	μPa (micropascal) = 10^{-6} N/m^2 mPa (millipascal) = 10^{-3} N/m^2 **kPa (kilopascal) = 10^{3} N/m^2** **MPa (megapascal) = 10^{6} N/m^2** GPa (gigapascal) = 10^{9} N/m^2	1 mbar (millibar) = 100 Pa 1 bar = 100 kPa 10 bar = 1 MPa = 1 N/mm^2
Energy, Work, Heat	**J (joule)**	mJ (millijoule) = 10^{-3} J **kJ (kilojoule) = 10^{3} J** **MJ (megajoule) = 10^{6} J** GJ (gigajoule) = 10^{9} J	1 kWh (kilowatthour) = 1000 W x 3600 s = 3.6 106 J = 3.6 MJ
Power	**W (watt = J/s = N•m/s)**	μW (microwatt) 10^{-6} W **mW (milliwatt) 10^{-3} W** **kW (kilowatt) 10^{3} W** MW (megawatt) 10^{6} W GW (gigawatt) 10^{9} W	1 W = 1 J/s = 1 N•m/s metric horsepower, 1 $\text{hp}_{\text{metric}}$ = 75 kg_f•m/s = 735 W

Notes: *Preferred in **bold**

1. In the metric system there are separate distinct units for mass and force. The kilogram is restricted to mass. The newton is the unit of force and should be used in place of the "kilogram-force." The newton instead of the kilogram-force should be used in combination units which include force, for example, pressure or stress (N/m^2 = Pa), energy (N•m = J), and power (N•m/s = W).

Considerable confusion exist in the use of the term "mass" and "weight." Mass is the property of matter to which it owes its inertia. If a body at rest on the earth's surface is released from the forces holding it at rest, it will experience the acceleration of free fall (acceleration of gravity, *g*). The force required to restrain it against free fall is commonly called weight. The acceleration of free fall varies in time and space, and weight is proportional to it. While at any point in time and space, weight can therefore vary, mass does not. Observed *g* can differ by over 0.5% between various points on the earth's surface. Therefore, the difference of local *g* from the agreed standard value, 9.80665 m/s^2, must be taken into account for precise measurements where *g* is involved, such as delicate weigh

The term "mass" should be used to indicate the quantity of matter in an object. The term "weight" is commonly used where the technically correct word is mass. Because of this widespread nontechnical use, the word weight should be avoided in technical reports. In converting quantities that has been presented as weight, care must be taken to determine whether force or mass is intended.

2. The dekanewton has some usage in EU since 1 daN = 1.02 kg (force).

Units and symbols

SI prefixes

The prefixes listed in Table 2-2 are used to form names and symbols of the decimal multiples and submultiples of the SI units. These prefixes or their symbols are attached to names or symbols of units, forming what are properly called “multiples and submultiples of metric units”. For recommended application of prefixes, see Table 2-1

TABLE 2-2 SI PREFIXES

SI prefix name	Symbol	Multiplication factor
yotta	**Y**	10^{24}
zetta	**Z**	10^{21}
exa	**E**	10^{18}
peta	**P**	10^{15}
tera	**T**	10^{12}
giga	**G**	10^{9}
mega	**M**	10^{6}
kilo	**k**	10^{3} = 1000 = E+03
hecto	**h**	10^{2} = 100 = E+02
deka	**da**	10^{1} = 10 = E+01
deci	**d**	10^{-1} = 0.1 = E-01
centi	**c**	10^{-2} = 0.01 = E-02
milli	**m**	10^{-3} = 0.001 = E-03
micro	**µ**	10^{-6}
nano	**n**	10^{-9}
pico	**p**	10^{-12}
femto	**f**	10^{-15}
atto	**a**	10^{-18}
zepto	**z**	10^{-21}
yocto	**y**	10^{-24}

Classes of units

The metric units are divided into two classes: base units and derived units. See definitions.

Base units

The metric system is built upon the seven well-defined base units of Table 2-3, which by convention are regarded as independent. Note that throughout this publication the word “quantity” means a measurable attribute of a phenomenon or of matter.

TABLE 2-3 SI BASE UNITS (ANSI SI 10)

Quantity	Unit	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

*See Temperature on p.37

Derived units

Derived SI units are shown in Table 2-4. Those SI derived units that have special names and symbols are listed in Table 2-5 and 6. Derived units are formed by combining base 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 use of exponents. For example, the SI unit for speed is the meter per second (m/s or m•s^{-1}) and that for density is kilogram per cubic meter (kg/m^3 or kg•m^{-3}).

TABLE 2-4 SI DERIVED UNITS WITH SPECIAL NAMES AND SYMBOLS (ANSI SI 10)

Quantity	SI unit Name	Symbol	Expression in terms of other SI units
angle, plane	radian*	rad	m/m = 1
angle, solid	steradian*	sr	$m^2/m^2 = 1$
Celsius temperature**	degree Celsius	^oC	K
electric capacitance	farad	F	C/V
electric charge, quantity of electricity	coulomb	C	A•s
electric conductance	siemens	S	A/V
electric inductance	henry	H	Wb/A
electric 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	1/s
illuminance	lux	lx	lm/m^2
luminous flux	lumen	lm	cd•sr
magnetic flux	weber	Wb	V•s
magneric flux density	tesla	T	Wb/m^2
power, radiant flux	watt	W	J/s
pressure, stress	pascal	Pa	N/m^2

NOTES: *See last paragraph of History on p.42
**See Temperature on p.37

It is frequently advantageous to express derived units in terms of other derived units with special names; for example, the metric unit for surface tension is usually expressed as N/m instead of kg/s^2 and that for electric dipole moment is usually expressed as C•m instead of A•s•m.

TABLE 2-5 SI DERIVED UNITS WITH SPECIAL NAMES FOR HUMAN HEALTH (ANSI SI 10)

Quantity	SI unit		
	Name	Symbol	Expression in terms of other SI units
activity (of a radionuclide)	becquerel	Bq	1/s
absorbed dose, specific energy imparted kerma, absorbed dose index	gray	Gy	J/kg
dose equivalent, dose equivalent index	sievert	Sv	J/kg

TABLE 2-6 SI DERIVED UNITS WITHOUT SPECIAL NAMES (ANSI SI 10)

Quantity	SI unit Name	SI unit Symbol
absorbed dose rate	gray per second	Gy/s
acceleration	meter per second squared	m/s^2
angular acceleration	radian per second squared	rad/s^2
angular velocity	radian per second	rad/s
area	square meter	m^2
concentration (of amount of substance)	mole per cubic meter	mol/m^3
current density	ampere per square meter	A/m^2
density (mass density)	kilogram per cubic meter	kg/m^3
electric charge density	coulomb per cubic meter	C/m^3
electric field strength	volt per meter	V/m
electric flux density	coulomb per square meter	C/m^2
energy density	joule per cubic meter	J/m^3
entropy	joule per kelvin	J/K
exposure (x and gamma rays)	coulomb per kilogram	C/kg
heat capacity	joule per kelvin	J/K
heat flux density, irradiance	watt per square meter	W/m^2
luminance	candela per square meter	cd/m^2
magnetic field strength	ampere per meter	A/m
molar energy	joule per mole	J/mol
molar entropy	joule per mole kelvin	J/(mol•K)
molar heat capacity	joule per mole kelvin	J/(mol•K)
moment of force	newton meter	N•m
permeability (magnetic)	henry per meter	H/m
permittivity	farad per meter	F/m
power density	watt per square meter	W/m^2
radiance	watt per square meter steradian	$W/(m^2 \cdot sr)$
radiant intensity	watt per steradian	W/sr
specific heat capacity	joule per kilogram kelvin	J/(kg•K)
specific energy	joule per kilogram	J/kg
specific entropy	joule per kilogram kelvin	J/(kg•K)
specific volume	cubic meter per kilogram	m^3/kg
surface tension	newton per meter	N/m
thermal conductivity	watt per meter kelvin	W/(m•K)
velocity	meter per second	m/s
viscosity, dynamic	pascal second	Pa•s
viscosity, kinematic	square meter per second	m^2/s
volume	cubic meter	m^3
wave number	1 per meter	1/m

Unit of mass

Among the base and derived units of SI, the unit of mass (kilogram) is the only one whose name, for historical reasons, contains a prefix. Names and symbols of decimal multiples and submultiples of the unit of mass are formed by attaching prefixes to the word gram or prefix symbols to the symbol g.

Other units

Units from other systems

To preserve the advantage of SI as a coherent system, minimize the use of units from other systems with SI. Such use should be limited to those listed in Table 2-7.

TABLE 2-7 UNITS IN USE WITH SI (ANSI SI 10)

Quantity	Unit	Symbol	Value in SI units
time[1]	minute	min	1 min = 60 s
	hour	h	1 h = 60 min = 3600 s
	day	d	1 d = 24 h = 86 400 s
	week, month, etc.		
plane angle	degree	°	1° = (π/180) rad
	minute	'	1' = (1/60)° = (π/10 800) rad
	second	"	1" = (1/60)' = (π/648 000) rad
volume	liter	L, l	1 L = 1 dm^3 = 10^{-3} m^3
mass	metric ton or tonne	t	1 t = 1 Mg = 10^3 kg
energy	electronvolt	eV	1 eV = 1.602 177 33(49) x 10^{-19} J
mass	unified atomic mass unit	u	1 u = 1.660 540 2(10) x 10^{-27} kg

NOTE:

1. TIME: The international (military) designation is: 13:32 (instead of 1:32 p.m.); 11:15 (instead of 11:15 a.m.)

DATE: The all-numeric writing of dates varies in different parts of the world. The date April 2, 2012 is written as follows;

ISO 8601 : 2012-04-02
. USA : 4-2-2012
Europe : 2-4-2012

EU and many other countries have adopted the ISO standard for the writing of all-numeric dates in their standards, and it is recommended for use in all international communications.

use of second (s) – the SI base unit s (second) is recommended in all applications where energy or power might be calculated (torque, flow, speed).

Time

The SI unit for time is the second (s), which should be used in technical calculations. However, where time relates to life customs or calendar cycles, the minute, hour, day, and other calendar units may be necessary. For example, vehicle speed is often expressed in unit kilometer per hour (km/h)

Plane angle

The SI unit for plane angle is the number 1, which is also called by its special name radian (rad). Use of the degree and its decimal submultiples is permissible when the radian is not a convenient value. Do not use the minute and second except for special fields such as astronomy and cartography.

Volume

The SI unit for volume is the cubic meter (m^3). Use this unit, or a multiple or submultiple of it such as cubic kilometer (km^3), cubic centimeter (cm^3), etc. The liter (L) has the exact volume of one cubic decimeter (dm^3). The name liter with its new symbol and SI prefixes are easy to write and speak, and the author recommend its use in USA.

Mass

The SI unit for mass is the kilogram (kg). This unit, or a multiple or submultiple formed by attaching a SI prefix to gram (g), is preferred in all applications. The name “ton” has been given to several large mass units that are widely used in commerce and technology: the long ton of 2240 lb, the short ton of 2000 lb, and the metric ton of 1000 kg, which is almost 2205 lb. None of these terms is SI. The terms “metric ton” and “tonne” are restricted to commercial usage. The ton is also used for volume (register ton) and power ratings (air conditioning). The author therefore recommends using the SI prefix mega with gram, thus 1 Mg = 1000 kg.

Energy

The SI unit of energy, the joule, together with its multiples and submultiples, is preferred for all applications. The kilowatthour is widely used as a measure of electric energy. This unit should not be introduced into any new fields, and eventually it should be replaced. The unit to use is the megajoule.

Units in use temporarily with SI

Units in use temporarily with SI are shown in Table 2-8. These units should not be introduced where they are not presently used.

TABLE 2-8 UNITS IN USE TEMPORARILY WITH SI (ANSI SI 10)

Name	Symbol	Value in SI units
nautical mile		1 nautical mile = 1852 m
knot		1 nautical mile per hour = (1852/3600) m/s
hectare	ha	1 ha = 1 $hm^2 = 10^4 m^2$
bar	bar	1 bar = 100 kPa
barn	b	1 b = 100 $fm^2 = 10^{-28} m^2$
curie	Ci	1 Ci = 3.7×10^{10} Bq
roentgen	R	1 R = 2.58×10^{-4} C/kg
rad	rad, rd	1 rad = 1 cGy = 10^{-2} Gy
rem	rem	1 rem = 1 cSv = 10^{-2} Sv

Length

The International nautical mile is now defined as 1852 m long, and it is used in nautical and aerial navigation to express distance and speed.

Area

The SI unit for area is the square meter (m^2). The hectare (ha) is a special name for the square hectometer (hm^2). Large land or water areas are generally expressed in hectares or in square kilometers (km^2).

Pressure, stress and vacuum

The SI unit for pressure and stress is the pascal (newton per square meter), and with proper SI prefixes it should be used in all applications. Do not use old metric units for pressure and stress such as kilogram-force per square centimeter (kgf/cm^2), or other non-SI units, such as torr and millimeter of mercury, for pressure. Because one bar equals 10^5 Pa, the millibar should be called by its SI name, the hectopascal (1 mbar = 1 hPa).

Pressure and vacuum . Gage pressure is absolute pressure minus ambient pressure (usually atmospheric pressure). Both gage pressure and absolute pressure are expressed in pascals, using SI prefixes as appropriate. Gage pressure is positive if above ambient pressure and negative if below. Pressure below ambient is often called vacuum; if the term “vacuum” is applied to numerical measure it should be made clear whether negative gage pressure or absolute gage pressure is meant. See Editorial guide, Attachments to unit symbols for methods of designating gage pressure and absolute pressure.

Centimeter-gram-second (cgs) units

Avoid all units with special names peculiar to the various cgs systems (measurement systems constructed by using the centimeter, gram, and second as base units). Among these units are the following, defined for mechanics, fluid mechanics, and photometry: the erg, dyne, gal, poise, stokes, stilb, phot, and lambert.

Further, avoid the cgs units for electricity and magnetism. This statement applies to the units designated by the general abbreviation “esu” (for electrostatic cgs unit) and “emu” (for electromagnetic cgs unit), including those units that have been given special names – gauss, oersted, maxwell, gilbert, biot, and franklin. It also applies to the unit names formed with the prefixes ab and stat, for example, the abampere and statvolt.

Units and names that are not to be used

Table 2-9 lists deprecated units and, in many cases, units with which they may be replaced. These are examples of several metric and related units other than those of SI that have been defined over the years. These include all units defined only in the cgs, esu, and emu systems. Some of these are used only in special fields; others have found broad application outside the USA. Except for the special cases discussed in the previous text, do not use units that are not part of SI (as well as non-SI names for multiples and submultiples of SI units, such as micron for micrometer).

TABLE 2-9 EXAMPLES OF UNITS AND NAMES THAT ARE NOT TO BE USED (ANSI SI 10)

Name	Symbol	Value in SI units
ångström	Å	1 Å = 0.1 nm = 10^{-10} m
are	a	1 a = 1 dam^2 = 100 m^2
atmosphere, standard	atm	1 atm = 101.325 kPa
atmosphere, technical	at	1 at = 98.0665 kPa
calorie (physics)	cal	1 cal = 4.184 J
calorie (nutrition)	Cal	1 Cal = 4.184 kJ
candle		1 cd
candlepower	cp	1 cp = 1 cd
dyne	dyn	1 dyn = 10^{-5} N
erg	erg	1 erg = 10^{-7} J
fermi	fermi	1 fm = 10^{-15} m
G, *g* (as a unit)		1 *g* = 9.806 65 m/s^2
gal	Gal	1 Gal = cm/s^2 = 10^{-2} m/s^2
gamma	γ	1 γ = 1 nT = 10^{-9} T
gauss	G	1 G = 10^{-4} T
gon, grad, grade	gon	1 gon = (π/200) rad
kilocalorie	kcal	1 kcal = 4.184 kJ
kilogram-force	kgf	1 kgf = 9.806 65 N
langley	cal/cm^2	1 cal/cm^2 = 41.84 kJ/m^2 = 4.184 x 10^4 J/m^2
maxwell	Mx	1 Mx = 10^{-8} Wb
metric carat		1 carat = 200 mg = 2 x 10^{-4} kg
metric horsepower	75 kgf•m/s	1 hp_m = 735.5 W
micron	µ	1 µm = 10^{-6} m
millimeter of mercury	mmHg	1 mmHg = 133.3 Pa
mm, cm, or m of water	mmH_2O, etc.	1 mmH_2O = 9.806 65 Pa, etc.
millimicron	mµ	1 mµ = 1 nm = 10^{-9} m
mho	mho	1 mho = 1 S
oersted	Oe	1 Oe = (1000/4π) A/m
phot	ph	1 ph = 10^4 lx
poise	P	1 P = dyn•s/cm^2 = 0.1 Pa•s
stere	st	1 st = 1 m^3
stilb	sb	1 sb = 1 cd/cm^2 = 10^4 cd/m^2
stokes	St	1 St = cm^2/s = 10^{-4} m^2/s
torr	Torr	1Torr = (101 325/760) Pa
x unit		1 x unit = 1.0021 x 10^{-13} m
γ (mass)	γ	1 γ = µg = 10^{-9} kg
λ (volume)	λ	1 λ = mm^3 = 10^{-9} m^3

Some comments concerning quantities and units

Mass, force and weight

For a discussion of the treatment of these and related quantities in SI, see note (1) Table 2-1.

Temperature

The SI unit of thermodynamic temperature is the kelvin (K). Use this unit to express thermodynamic temperature and temperature intervals. Wide use is also made of the degree Celsius (^{o}C), which is equal to the unit kelvin; it is a special name for expressing Celsius temperature and temperature intervals. Celsius temperature *t* (which replace centigrade temperature) is related to thermodynamic temperature *T* by the equation

$t = T - T_o$, where T_o = 273.15 K by definition.

In practice, the International Temperature Scale of 1990(ITS-90) serves as the basis for high-accuracy temperature measurements in science and technology.

Nominal dimensions

Many dimensions used to identify commercial products are nominal values – values like “2 by 4” lumber and one-inch pipe that exist in name only and are used for the purpose of convenient designation. Others, like the inch-based trade sizes of nuts and bolts, designate one of the critical dimensions of the product. Although individuals should not convert such designations into SI units, trade associations and other organizations that are responsible for standardizing such products may adopt, without changing the product, nominal metric designations as deemed appropriate.

Quantities and units used in rotational machines

Angle, angular velocity, and angular acceleration

The coherent SI unit of plane angle is the number one; thus the SI units of the quantities of angle, angular velocity, and angular acceleration are, respectively, 1, 1/s, and 1/s^2. However, it is often convenient to use the special name “radian” (rad), instead of the number 1 when expressing the values of these quantities. Thus, for clarity, the unit rad, rad/s, and rad/s^2 are usually used, as shown in Table 6. Similar comments apply to solid angle; its coherent SI unit is also the number 1, which has the special name “steradian” (sr).

Moment of force (bending moment)

Because moment of force (bending moment) and torque are equal to a force times a distance (moment arm or lever arm), their SI unit is N•m. The joule (J = N•m), which is a special name for the SI unit of energy and work, shall not be used as a name for the unit of moment of force or of torque.

Moment of inertia

This quantity (I) is a property of the mass distribution of a body about an axis ($I = \sum m \cdot r^2$); its SI unit is kg•m^2.

Angular momentum

Angular momentum (moment of momentum) is linear momentum (SI unit kg•m/s) times moment arm; its SI unit is kg•m^2/s. The total angular momentum of a body of moment of inertia I (SI unit kg•m^2) rotating with angular velocity ω (SI unit 1/s) is $I \cdot \omega$ (SI unit kg•m^2/s).

Kinetic energy

The kinetic energy of a body of moment of inertia I (SI unit kg•m^2) rotating with angular velocity ω (SI unit 1/s) is $I \cdot \omega^2/2$; its SI unit is joule.

Work

The work done by a moment of force or by a torque (SI unit N•m) in a rotation through an angle (SI unit 1) is moment of force or torque times angle of rotation; its SI unit is joule.

Note that if the unit of rotational work is written as N•m rather than as J, possible confusion may occur because in its form it appears identical to the unit of moment of force or torque. In vector algebraic expressions or vector diagrams, the distinction between work and moment of force or torque is obvious because work is the scalar product of force and displacement while moment of force or torque involves the vector product of force and moment arm, but no such distinction is possible in the associated units.

Impact energy absorption

This quantity, often incorrectly called “impact resistance” or “impact strength”, is measured in terms of work required to break a standard specimen; the SI unit is joule.

Editorial guide

Introduction

The metric system is the international language of measurement. Its symbols are identical in all languages. Just as the English language is governed by rules of spelling, punctuation and pronunciation, so is the language of measurement. Uniformity of usage facilitates comprehension and leads to clarity in communications.

This Editorial guide is a recommended practice intended to serve as a guide to accepted and consistent USA usage of the metric system, and does not constitute a standard.

Rules for writing SI unit symbols

Recommended use of SI units with names and symbols are shown in Table 2-1 and prefixes in Table 2-2.

Symbols. The short form for metric units and prefixes are called symbols. The first letter of a symbol is capitalized when the name of the unit is derived from the name of a person. Other symbols are generally lower case*.

Examples:

Unit Name	Symbol
meter	m
liter	L*
kilogram	kg
newton	N
pascal	Pa

*In 1979. the CGPM approved "L" and "l" as alternative symbols for liter. Since the letter symbol "l" can easily be confused with the numeral "1", the symbol "L" is recommended for USA use. Any use of the script "ell" as a symbol for liter is deprecated.

1. Print unit symbols in upright type regardless of the typestyle used in the surrounding text. Italic letters are reserved for quantity symbols, such as *A* for area, *m* for mass, *g* for gravity acceleration and *t* for time. In typewriting or longhand, underlining may be used as a substitute for italics.
2. Do not alter unit symbols in the plural. Examples: 1 m, 100 m. Plural name usage. Names of units may be plural for numeric values greater than 1, equal to 0 or less than -1. All other values take only the singular form of the unit name.

Examples: 100 meters, 1.1 meters, 0 degrees Celsius, -4 degrees Celsius or
1.1 meter, 0 degree Celsius, 0.5 meter, ½ liter, -0.2 degree Celsius, -1 degree Celsius.

3. Do not follow unit symbols by a period except when used at the end of a sentence.

Examples: When you add 15 g of salt … The length of the field is 350 m.

4. Write letter unit symbols in lowercase (e.g., cd) unless the unit name has been derived from a proper name, in which case the first letter of the symbol is capitalized (e.g., W, Pa). The exception is the symbol for liter, L. Prefix symbols use either lowercase or uppercase letters as shown in Table 2-7. The importance of precise use of capital and lowercase letters is shown by the following examples.

Examples:
G stands for giga; g for gram
K for kelvin; k for kilo
M for mega; m for milli
N for newton; n for nano

Names of units and prefixes are not capitalized except at the beginning of a sentence and in those titles, headings and other instances in which all main words are capitalized.
Example: Meter is the unit used for some Olympic events. Force is measured in newtons.

Note: In "degree Celsius", "degree" is lower case and "Celsius" is capitalized; "degree centigrade" is obsolete. Unit symbols retain their prescribed form regardless of the surrounding typography.

5. If the value of a quantity is expressed as a numerical value and a unit symbol, a space shall be left between them. For example, write 35 mm, *not* 35mm, 2.37 lm (for 2.37 lumens), *not* 2.37lm, and 20 ^{o}C, *not* 20^{o}C.

EXCEPTION – No space is left between the number and the symbol for degree, minute, and second of plain angle.

6. Do not leave any space between the prefix and unit symbols.

7. Use symbols, not abbreviations, for units. For example, use "A", and not "amp", for ampere.

Rules for writing unit names

The handling of unit names varies internationally because of language differences. The following rules should be followed in USA:

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.

2. Use plurals as required by the rules of English grammar, for example, henries for the plural of henry.

EXCEPTION – The names for hertz, lux and siemens remain unchanged in plural.

3. Do not leave a space or place a hyphen between the prefix and unit name.

In three cases, the final vowel in the prefix is commonly omitted: "megohm," "kilohm," and "hectare." In all other cases where the unit name begins with a vowel, both vowels are retained and both are pronounced.

Units formed by multiplication and division

Unit names

1. *Product.* Use a space (preferred) or a hyphen:
Examples: newton meter or newton-meter
In the case of watt hour the space may be omitted, thus:
Examples: watthour
2. *Quotient*. Use the word "per" and not a solidus:
Examples: meter per second, not meter/second
3. *Powers*. Use the modifier "squared" or "cubed" placed after the unit name:
Examples: meter per second squared
In case of area or volume, a modifier may be placed before the unit name:
Examples: square millimeters, cubic meter, watt per square meter
4. *Symbols.* To avoid ambiguity in complicated expressions, unit symbols are preferred over unit names.

Unit symbols

The symbol for a compound unit that is the product of two or more units is indicated by either a raised dot, which is preferred, or by a space; thus, for newton meter

Examples: N•m *or* N m

For limited character sets where the raised dot is not possible, use a space. In the case of kW•h, kilowatthour (a non-SI unit), the raised dot is often omitted, as is the space; thus, kWh.

The symbol for a quotient of two or more units is indicated in one of the following ways:

Examples: m/s *or* $\mathrm{m{\bullet}s^{-1}}$ *or* $\frac{\mathrm{m}}{\mathrm{s}}$

Do not use more than one solidus in the same expression unless parentheses are inserted to avoid ambiguity.

Examples: J/(mol•K) *or* $\mathrm{J{\bullet}mol^{-1}{\bullet}K^{-1}}$ *or* (J/mol)/K, but *not* J/mol/K

Mixtures

Do not mix symbols and unit names in the same expression.

Examples: joules per kilogram or J/kg

Do not write: joules/kilogram *nor* joules/kg *nor* $\mathrm{joules{\bullet}kg^{-1}}$

Attachments to unit symbols

Attachment of letters to a unit symbol as a means of giving information about the nature of the quantity under consideration is incorrect. Thus, do not use MWe, Vac, VAC, kJt, "megawatt electrical (power)," "volts ac," nor kilojoules thermal (energy)." If the context leaves any doubt as to what is meant, qualify the name of the quantity appropriately. For example, " … an electric power of 1.4 MW."

For the same reason, do not attempt to construct SI equivalents of the abbreviations "psia" (pounds per square inch, absolute) and "psig," which are often used to distinguish between absolute and gage pressure. Use instead " … at a gage pressure of 13 kPa" or " … at an absolute pressure of 13 kPa."

Where space is limited, such as on gages, nameplates, graph labels, and in table headings, the use of a modifier in parentheses, such as "kPa (gage)," "kPa (absolute)," or "V (ac)," is permitted.

Rules for writing SI prefixes

In general, use the SI prefixes to indicate orders of magnitude. Thus, one can eliminate zeros (i.e., 12 300 m becomes 12.3 km) and leading zeros in decimal numbers (i.e., 0.001 23 µm becomes 1.23 nm). SI prefixes, therefore, provide a convenient alternative to powers-of-ten notation preferred in computation (i.e., 12.3 x 10^3 m becomes 12.3 km). Never use prefix alone.

A common unit-multiple is preferable even when some of the numerical values may require up to five or six digits before the decimal point.

Examples:

mm	for dimensions on engineering drawings
MPa	for stress, except in very weak materials, for which kPa may be more convenient
GPa	for modulus of elasticity in most materials, except elastomers
kg/m^3	for mass density

In a table of values for the same quantity, or in a discussion of such values within a given context, the same unit multiple should be used for all items even when some of the numerical values may require up to five or six digits before the decimal point.

Mixing prefixes should be avoided unless the difference in size is extreme.
Examples: 40 mm wide and 1500 mm long*, not* 40 mm wide and 1.5 m long; *but* 1500 meters of 2-mm diameter wire.

Two units should not be used for one quantity.
Examples: 3.5 m, *not* 3 m 50 cm or 3 m 500 mm; 13.58 L, *not* 13 L 580 mL

Slang. A prefix should not be used without a unit.
Examples: kilogram, *not* kilo; 10 kilometer run or 10 km run, *not* 10 K run.

Roman numerals. Do not use M to indicate thousands (as in MCF for thousands of cubic feet or in MCM for thousands of circular mills) nor MM to indicate millions, nor C to indicate hundreds, etc., because of conflicts with the SI prefixes.

Selection

When expressing a quantity by a numerical value and a unit, give preference to a prefix that yields a numerical value between 0.1 and 1000. For simplicity, give preference to prefixes representing 1000 raised to a positive or negative integral power. However, the following factors may justify deviation from these prefixes:

1. In expressing area and volume, the prefixes hecto, deka, deci and centi may be required; for example, cubic decimeter, square hectometer, cubic centimeter.
2. In tables of values of the same quantity, or in a discussion of such values within a given context, it is preferable to use the same unit multiple throughout.
3. For certain quantities in particular applications, one particular multiple or submultiple is often used. For example, the millimeter is used for linear dimensions in engineering drawings even when the values lie far outside the range of 0.1 mm to 1000 mm; the centimeter is usually used for body measurements and clothing sizes.

Prefixes in compound units

A compound unit is a derived unit that is expressed in terms of two or more units, rather than by a single special name. Ordinarily, only one prefix should be used in forming a multiple or submultiple of a compound unit. Normally the prefix should be attached to a unit in the numerator. An exception to this is when the kilogram occurs in the denominator.

Examples: kV/m is usually preferable to V/mm
MJ/kg is usually preferable to kJ/g
kg/m^3 is usually preferable to g/cm^3 (NOTE – 1000 kg/m^3 = 1 kg/dm^3 = 1 g/cm^3)

Compound prefixes

Do not use prefixes formed by the juxtaposition of two or more SI prefixes.
Examples: 1.3 nm, *not* 1.3 mμm
2.4 pF, *not* 2.4 μμF

If a value is required outside the range covered by the prefixes, express it by using a power of ten applied to the unit.
Examples: 2 MJ = 2 x 10^6 J

Powers of units

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

Examples: $1\ \mathrm{cm}^3 = (10^{-2}\ \mathrm{m})^3 = 10^{-6}\ \mathrm{m}^3$
$2.5\ \mathrm{ns}^{-1} = 2.5(10^{-9}\ \mathrm{s})^{-1} = 2.5 \times 10^9\ \mathrm{s}^{-1}$
$7\ \mathrm{mm}^2/\mathrm{s} = 7(10^{-3}\ \mathrm{m})^2/\mathrm{s} = 7 \times 10^{-6}\ \mathrm{m}^2/\mathrm{s}$

Prefixes defined as powers of two

In the computer field the SI prefixes kilo, mega, giga, etc. have sometimes been defined as powers of two. That is, kilo has been used to mean 1024 (i.e., 2^{10}), mega has been used to mean 1048 576 (i.e., 2^{20}), etc. This practice frequently leads to confusion and is deprecated.

Numbers

Decimal marker

In the USA, the decimal marker is a dot on the line. When writing numbers less than one, write a zero before the decimal marker.

Outside the USA, the comma is widely used as the decimal marker. In some applications, therefore, the common practice in the USA of using a comma to separate digits into groups of three (as in 23,478; EU use 23.478) may cause ambiguity. To avoid this potential source of confusion, recommended international practice calls for separating the digits into groups of three, counting from the decimal marker toward the left and the right, and using a thin, fixed space to separate the groups. In numbers of four digits on either side of the decimal marker the space is usually not necessary, except for uniformity in tables.

Examples: 2.141 596 73 722 0.1334

Where this practice is followed, the width of the space should be constant even if, as is often the case in printing, justified spacing is used between words. In certain special applications, such as in engineering drawings and financial statements, the practice of inserting spaces to separate groups of numbers is not customary.

Decimal notation is preferred with metric measurements, but simple fractions are acceptable (except on engineering drawings), such as those where the denominator is 2, 3 or 4.

Examples: 0.5 g, 1.75 kg and 0.7 L are preferred;
½ g, is acceptable (except on engineering drawings)

Nonsignificant zeros are normally not used.

Examples: 25 *not* 25.0

EXCEPTION – Uniformity of inscription on drawings with limit dimensions.

Examples: 25.00 25
not
24.46 24.46

Hyphens are used when a quantity is placed in an adjectival sense.

Examples: A 3-meter pole … The length is 3 meters.
A 35-mm film … The width is 35 mm.

Billion . Because billion means a thousand million in the USA but a million million in most other countries, avoid the term and similar terms for large numbers in international communications. How the terms billion, trillion, etc. relate throughout the world is well outlined at the following site: http://www.jimloy.com/math/billion.htm.

Examples:

Multiplication factor	Prefix	Symbol	Term	
			USA	Other countries
$1\ 000\ 000\ 000\ 000 = 10^{12}$	tera	T	trillion	billion
$1\ 000\ 000\ 000 = 10^{9}$	giga	G	billion	milliard

Quantities expressed as pure numbers

Certain so-called dimensionless quantities, as for example refractive index, relative permeability, relative mass density, or the friction factor, are defined as the ratio of two compatible quantities. Such quantities have a dimensional product – or dimension – equal to 1 and are therefore expressed by pure numbers. The coherent SI unit is then the ratio of two identical SI units and may be expressed by the number one (for example, m/m = 1). More generally, a quantity of dimension one may be expressed by the ratio of units (for example, mm/m = 10^{-3}). The number one is generally not written out explicitly when a quantity of dimension one is expressed numerically.

The percent symbol (%) may be used for the number 0.01. Avoid, however, the abbreviations ppm for parts per million and ppb for parts per billion. Because the names for numbers one billion and larger are not uniform worldwide, do not use terms such as parts per billion and parts per trillion.

When expressing the values of quantities of dimension one, the meaning has to be clear. Expressions like "The mass fraction of Pt in the sample is 90% (or 0.9)," "the volume fraction of CO_2 in the sample is 1.2×10^{-6}," or "the amount-of-substance fraction Pb in the sample is 2.7×10^{-3}," are permissible; but they would not be permissible if the words "mass", "volume," and "amount of substance," respectively, were not in the three expressions. These three fractions can also be expressed as 0.9 kg/kg, 1.2 cm^3/m^3, and 2.7 mmol/mol, respectively, which are more understandable and, therefore, preferred.

History

Development of the International System of Units (SI)

The decimal system of units was conceived in the 16th century, when there was a great confusion and a jumble of units of weights and measures. It was not until 1790, however, that the French National Assembly requested the French Academy of Sciences to work out a system of units suitable for adoption by the entire world. This system was based on the meter as a unit of length. The mass of a cubic centimeter of water, the gram, was adopted as a practical measure to benefit industry and commerce. Physicists soon realized the system's advantages, and it was adopted also in scientific and technical circles. The importance of the regulation of weights and measures was recognized in Article 1, Section 8, when the United States Constitution was written in 1787. The metric system was legalized in this country in 1866. In 1893, the international meter and kilogram became the fundamental standards of length and mass in the United States, both for metric and customary weights and measures.

Meanwhile, international standardization began with an 1870 meeting of 17 nations in Paris that lead to the May 20, 1875 Convention du Mètre and the establishment of a permanent International Bureau of Weights and Measures near Paris. A General Conference on Weights and Measures (CGPM) was also constituted to handle all international matters concerning the metric system. The CGPM meets at least every six years in Paris and controls the International Bureau of Weights and Measures, which in turn preserves the metric standards, compares national standards with them, and conducts research to establish new standards. The National Institute of Standards and Technology (NIST) represents the United States in these activities.

The metric system of 1875 provide a set of units for the measurement of length, area, volume, capacity, and mass. Measurement of additional quantities required for science and commerce has necessitated development of additional fundamental and derived units. Numerous other systems based on the meter and gram have been used. A unit of time was added to produce the centimeter-gram-second (CGS) system, adopted in 1881 by the International Electrical Congress. About the year 1900, practical measurements in metric units began to be based on the meter-kilogram-second (MKS) system. In 1935, the International Electrotechnical Commission (IEC) acted favorably on a proposal originally made by Professor Giovanni Giorgi in 1901 and recommended that the MKS system of mechanics be linked with the electromagnetic system of units by adoption of one of the units-ampere, coulomb, ohm, or volt-for a fourth base unit. Subsequently the ampere, the unit of electric current, was selected as a base unit, thus defining the MKSA system.

The 10th CGPM in 1954 adopted a rationalized and coherent system of units based on the four MKSA units, plus the Kelvin as the unit of temperature and the candela as the unit of luminous intensity. The 11th CGPM in 1960 formally gave it the full title, International System of Units, for which the abbreviation is "SI" in all languages. Thirty-six countries, including the United States, participated in this conference. The 12th CGPM in 1964 made some refinements, and the 13th CGPM in 1967 redefined the second, renamed the unit of temperature as the kelvin (K), and revised the definition of the candela. The 14th CGPM in 1971 added a seventh base unit, the mole, and approved the pascal (Pa) as a special name for the SI unit of pressure or stress, the newton per square meter, and the siemens (S) as a special name for the unit of electric conductance, the recipocal ohm or the ampere per volt.

The 15th CGPM in 1975 added prefixes for 10^{18} and 10^{15}, exa (E) and peta (P) respectively, and approved two special names: the gray (Gy) as a special name for the SI unit of absorbed dose, the joule per kilogram; and the becquerel (Bq) as a special name for the SI unit of activity of a radionuclide, one per second.

Because of the experimental difficulties in realizing a Planck radiator at high temperatures and the new possibilities offered by radiometry, i.e., the measurement of optical radiation power, the 16th CGPM in 1979 adopted a new definition of the SI base unit candela. It also adopted a special name sievert (Sv) for the SI unit of dose equivalent in the field of radioprotection. In order to increase the precision of realization of the SI base unit meter, the definition based upon the wavelength of a krypton-86 radiation was replaced by one based on the speed of light by the 17th CGPM in 1983. The 19th CGPM in 1991 added the prefix zetta (Z) for 10^{21}, zepto (z) for 10^{-21}, yotta (Y) for 10^{24}, and yocto (y) for 10^{-24}.

When SI was established by the 11th CGPM in 1960, it had three classes of units; base units, derived units, and supplementary units. The class of supplementary units contained two units: the radian (rad) for plane angle and the steradian (sr) for solid angle (see Table 3). However, at the time of the introduction of the International System, the 11th CGPM left open the question of the nature of these supplementary units. Considering that plane angle is generally expressed as the ratio between two lengths and a solid angle as the ratio between an area and the square of a length, in 1980 the CIPM (the International Committee for Weights and Measures of the CGPM) specified that in the International System the supplementary units radian and steradian are dimensionless derived units that may be used or omitted in expressing the values of physical quantities. This implies that the quantities plane angle and solid angle are considered dimensionless derived quantities.

Because of this interpretation, the 20th CGPM in 1995 eliminated supplementary units as a separate class in SI. Since then, SI consists of only two classes of units: base units and derived units, with the radian and steradian classified as derived units. The option of using them or not using them in expressions for other SI derived units, as is convenient, remain unchanged,

The International Bureau of Weights and Measures (BIPM)

The International Bureau of Weights and Measures (BIPM, Bureau International des Poids et Mesures) has its headquarter near Paris, in the grounds of the Pavillon de Breteuil (parc de Saint-Cloud), placed at its disposal by the French Government; its upkeep is financed jointly by the member nations of the Convention du Mètre.

In October 1995, 48 nations were members of this Convention: Argentina (Republic of), Australia, Austria, Belgium, Brazil, Bulgaria, Cameroon, Canada, Chile, China (People's Republic of), Czech Republic, Denmark, Dominican Republic Egypt, Finland, France, Germany, Hungary, India, Indonesia, Iran, Ireland, Israel, Italy, Japan, Korea (Democratic People's Republic of), Korea (Republic of), Mexico, Netherlands, New Zealand, Norway, Pakistan, Poland, Portugal, Romania, Russian Federation, Singapore, Slovak Republic, South Africa, Spain, Sweden, Switzerland, Thailand, Turkey, United Kingdom, the United States of America, Uruguay, Venezuela.

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 international standards;
- Ensuring the coordination of corresponding measuring techniques;
- Carrying out and coordinating the determinations relating to the fundamental physical constants that are involved in the above-mentioned activities.

The BIPM operates under the exclusive supervision of the International Committee for Weight and Measures (CIPM, Comité, International des Poids et Mesures), which itself comes under the authority of the General Conference on Weights and Measures (CGPM, Conférence Générale des Poids et Mesures).

The General Conference consists of delegates from all the member nations of the Convention du Mètre meets at present every four years. At each meeting it receives the Report of the International Committee on the work accomplished, and it is responsible for

- Discussing and instigating the arrangements required to ensure the propagation and improvement of the International System of Units (SI, Système International d'Unités), which is the modern form of the metric system;
- Confirming the results of new fundamental metrological determinations and the various scientific resolutions of international scope;
- Adopting the important decisions concerning the organization and development of the BIPM.

STANDARD CONDITIONS AND PHYSICAL CONSTANTS

STANDARD CONDITIONS

Standard gravity acceleration $g = 9.80665\ m/s^2 = 32.1740\ ft/s^2$
Absolute temperature (Thermodynamic temperature)
K (kelvin) = (^oC + 273.15) = (Celsius degrees + 273.15 exactly)

MISCELLANEOUS PRESSURE BASES

International standard atmosphere
= 0.101325 MPa (megapascal)
= 1.01325 bar
= $1.01325\ 10^5\ N/m^2$
= $1.0332\ kgf/cm^2$
= $14.697\ lbf/in^2$.

1 technical atmospheric pressure[1] = 1 at
= 0.98067 bar
= $1\ kgf/cm^2$
= $1\ kp/cm^2$
= $14.223\ lbf/in^2$
= 735.6 mm Hg
= 28.96 in Hg

absolute pressure = atmospheric pressure + recorded pressure
ata = at + atü (gauge)
atü = atmospheric overpressure (Germany)

NOTE 1. The technical atmospheric pressure is defined in the German standard DIN 1314 as 1 kg-force/cm^2, and it approximates the barometric pressure at sea level.

Definition of SI Base Units

Translation of the original French definitions of the seven base units of the International System are given in the following item 1 through 7.

1. **meter:** The meter is the length of the path traveled by light in vacuum during a time interval of 1/299 792 458 of a second. (Adopted by the 17th CGPM in 1983.)
2. **kilogram:** The kilogram is the unit of mass; it is equal to the mass of the international prototype of the kilogram. (Adopted by the 1st and 3rd CGPMs in 1889 and 1901.)
3. **second:** 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. (Adopted by the 13th CGPM in 1967.)
4. **ampere:** The ampere is that constant current that, if maintained in two straight parallel conductors of infinite length, of negligible circular cross section, and placed one meter apart in vacuum, would produce between these conductors a force equal to 2×10^{-7} newtons per meter of length. (Adopted by the 9th CGPM in 1948.)
5. **kelvin:** The kelvin, unit of thermodynamic temperature, is the fraction 1/273.16 of the thermodynamic temperature of the triple point of water. (Adopted by the 13th CGPM in 1967.) NOTE-It follows from this definition that the temperature of the triple point of water is 273.16 K (0.01 ^{o}C). The freezing point of water at standard atmospheric pressure is approximately 0.01 K below the triple point of water.
6. **mole:** The mole is the amount of substance of a system that contains as many elementary entries as there are atoms in 0.012 kilogram of carbon-12. (Adopted by the 14th CGPM in 1971.) When the mole is used, the elementary entries must be specified and may be atoms, molecules, ions, electrons, other particles, or specified groups of such particles.
7. **candela:** The candela is the luminous intensity, in a given direction, of a source that emits monochromatic radiation of frequency 540×10^{12} hertz and that has a radiant intensity in that direction of 1/683 watt per steradian. (Adopted by the 16th CGPM in 1979.)

The metric system is covered in national standards as shown in Table 2-10.

TABLE 2-10 SI SYSTEM STANDARDS

Global	ISO	1000
USA	ANSI	SI 10
Japan	JIS	Z8203
Germany	DIN	1301
France	NF	X02-004
UK	BS	3763
Italy	UNI	10003
Canada	CSA	Z234.2
Australia	AS	1000

RELATED ISO STANDARDS

TC 12 - Quantities and units

ISO 80000-1:2009 Quantities and units -- Part 1: General
ISO 80000-2:2009 Quantities and units -- Part 2: Mathematical signs and symbols to be used in the natural sciences and technology
ISO 80000-3:2006 Quantities and units -- Part 3: Space and time
ISO 80000-4:2006 Quantities and units -- Part 4: Mechanics
ISO 80000-5:2007 Quantities and units -- Part 5: Thermodynamics
IEC 80000-6:2008 Quantities and units -- Part 6: Electromagnetism
ISO 80000-7:2008 Quantities and units -- Part 7: Light
ISO 80000-8:2007 Quantities and units -- Part 8: Acoustics
ISO 80000-9:2009 Quantities and units -- Part 9: Physical chemistry and molecular physics
ISO 80000-10:2009 Quantities and units -- Part 10: Atomic and nuclear physics
ISO 80000-11:2008 Quantities and units -- Part 11: Characteristic numbers
ISO 80000-12:2009 Quantities and units -- Part 12: Solid state physics
IEC 80000-13:2008 Quantities and units -- Part 13: Information science and technology
IEC 80000-14:2008 Quantities and units -- Part 14: Telebiometrics related to human physiology
IEC/NP 80003-1 Physiological quantities and their units -- Part 1: Modalities
ISO/CD 80003-2 Physiological quantities and their units -- Part 2: Physics
ISO/CD 80003-3 Physiological quantities and their units -- Part 3: Chemistry
IEC/NP 80003-4 Physiological quantities and their units -- Part 4: Biology
IEC/NP 80003-5 Physiological quantities and their units -- Part 5: Culturology
IEC/NP 80003-6 Physiological quantities and their units -- Part 6: Psychology

National USA

ANMC Metric Editorial Guide, 1993 Fifth Edition
ANSI/IEEE/ASTM SI 10-2010 Standard for Use of the International System of Units (SI): The Modern Metric System
ANSI/IEEE Std 260.1-1993 American National Standard Letter Symbols for Units of Measurement (SI Units, Customary Inch-Pound Units, and Certain Other Units)
AS 1000 Metric (SI) System (Australia)
ASTM E 29-93a, Using Significant Digits in Test Data to Determine Conformance with Specifications
BIPM. 1991 Le Systeme International d'Unites (SI), 6th edition. (This publication is in two parts: the official French text followed by an English-language translation.)
BS 3763 Metric (SI) System (UK)
CSA Z234.2 Metric (SI) System (Canada)
DIN 1301 Metric (SI) System (Germany)
JIS Z8203 Metric (SI) System (Japan)
NF X02-004 Metric (SI) System (France)
NIST Special Publication 304, 1991 Edition, The Modernized Metric System – International System of Units.
NIST Special Publication 330, 1991 Edition, The International System of Units (SI).
NIST Special Publication 811, 1995 Edition, Guide for the Use of the International System of Units (SI).
NIST Special Publication 814, 1992 Edition, Interpretation of SI for the United States and Metric Conversion Policy for Federal Agencies.
NIST Technical Note 1265, Guidelines for Realizing the International Temperature Scale of 990 (ITS-90).
UNI 10003 Metric (SI) System (Italy)

RELATED PUBLICATIONS

ISO STANDARDS HANDBOOK Quantities and units

SI units and recommendations for the use of their multiples and of certain other units, general principles concerning quantities, units and symbols. Individual standards dealing with quantities in space and time, periodic phenomena, mechanics, heat, electricity and magnetism, electromagnetic radiation, chemistry, molecular physics, nuclear physics, etc. 1993 3rd Ed 345 p ISBN 92-67-10185-4