Appendix A: SI Units

"SI" is an abbreviation for Le Système International d'Unités, an international system of units adopted by many national and international authorities, associations, professional societies, and agencies. SI is closely related to but not identical with the former cgs, mks, and mksa systems of metric units. Official information, development history, and more detail on SI can be found in Bureau of Standards Special Publication 330 (1974) and in the SEG Subcommittee on Metrification (1981) publication.

SI is based on seven **base units** listed in Table 1 and two **supplementary units** (the last two).

SI **derived units** are formed by combining the base and supplementary units. Some of the derived units are listed in Table 2.

Table 3 shows how larger or smaller units can be made by adding prefixes. When prefixes are used, the first syllable is accented. Note that k and M stand for 10^3 and 10^6, whereas M and MM (or m and mm) are sometimes used in the oil industry for designating thousands and millions (of gas volumes). Prefixes are raised to the power of the unit employed; for example, km^3 means cubic kilometers, not thousands of cubic meters. Prefixes are not compounded (GW rather than kMW).

SEG allows the forms in Table 4 in addition to those in Tables 1 to 3.

Table 5 relates cgs electromagnetic and electrostatic units to SI units; see also Figure E-8. Figure M-1 relates cgs and SI magnetic units.

Rules about writing units

Symbols are written in Roman (not italics) type. They are never pluralized.

Unit names, including prefixes, are not capitalized except at the beginning of a sentence or in titles. Unit names are pluralized in the usual manner, as 100 meters, 70 henries, except for lux, hertz, and siemens. Fractional values require the singular form.

Periods are not used after symbols, that is, symbols are not abbreviations.

Symbols are lower case except when named for a person (exception: L for liter).

A space separates a numerical value and the unit symbol (except for °C); thus, 10 m, 0.112 s, 1.5 g/cm^3, 20°C. A hyphen separates value and symbol when used as an adjective; thus, 35-mm film. No space separates a prefix and the symbol; thus, ms for milliseconds, kW for kilowatt.

The symbols "/" or "." are used to indicate the compounding of symbols (for example, km/s or N.m for kilometers per second and newton-meter), but are not used when units are written out. Where symbols are compounded, parentheses should be used to avoid ambiguity, as W/(m.k). "P" is not acceptable as an abbreviation for "per." "Per" should not be compounded; thus, "meters per second squared," not "meters per second per second." Use $\times$ rather than $\cdot$ for products of numbers; thus 6.2×5, not 6.2.5. A space should be used on each side of symbols for multiplication, addition, subtraction, convolution ($\times$, $+$, $-$, *) and for the division symbol $\div$ but not for /.

Numbers with many decimal places should be grouped by threes separated by a space rather than by a comma (which Europeans read as a decimal point); thus, 4 720 525 or 0.528 75. For numbers smaller than one, a zero should be shown in the units place. A space is not necessary for four-digit numbers.

Table 1. SI base and supplementary units.

Quantity	SI unit	symbol
Length	meter or metre	m
Mass	kilogram	kg
Time	second	s
Electric current	ampere	A
Thermodynamic temperature	kelvin	K
Amount of substance	mole	mol
Luminous intensity	candela	cd
Plane angle	radian	rad
Solid angle	steradian	sr

Note that the kilogram is not a unit of force (weight). The word *weight* is often ambiguous and its use should be avoided. The temperature unit kelvin is not *degree kelvin*.

Squared or *cubed* should follow unit names except for areas and volumes; thus, meter per second squared, square meter, watt per cubic meter.

The spellings *metre* and *litre* are preferred but *meter* and *liter* are the official U.S. forms of spelling. The use of *liter* as a cubic decimeter is discouraged.

Table 2. SI derived units.

Quantity	Derived unit, symbol	Quantity	Derived unit, symbol
Absorbed dose	gray, Gy=J/kg	Luminous flux	lumen, lm=cd.sr
Acceleration	meters per second squared, m/s^2	Magnetizing force	ampere per meter, A/m
Activity (of radionuclides)	becquerel, Bq=l/s	Magnetic flux	weber, Wb=V.s
Angular acceleration	radian per second squared, rad/s^2	Magnetic flux density	tesla, T=Wb/m^2
Angular velocity	radian per second, rad/s	Potential difference	volt, V=W/A
Area	square meter, m^2	Power	watt, W=J/s
Density	kilogram per cubic meter, kg/m^3	Pressure	pascal, Pa=N/m^2
Electric capacitance	farad, F=A.s/V =C/V	Quantity of electricity	coulomb, C=A.s
Electric charge	coulomb, C=A/s	Quantity of heat	joule, J=N.m
Electrical conductance	siemens, S=A/V	Radiant flux	watt, W=J/s
Electric field strength	volt per meter, V/m	Radiant intensity	watt per steradian, W/sr
Electric inductance	henry, H=V.s/A= Wb/A	Specific heat capacity	joule per kilogram kelvin, J/kg.K
Electric potential	volt, V=W/A	Stress	pascal, Pa=N/m^2
Electric resistance	ohm, Ω=V/A	Thermal conductivity	watt per meter kelvin, W/m.K
Electromotive force	volt, V=W/A	Torque	newton meter (not joule)
Energy	joule, J=N.m	Velocity	meter per second, m/s
Entropy	joule per kelvin, J/K	Viscosity, dynamic	pascal second, Pa.s
Force	newton, N=kg.m/s^2	Viscosity, kinematic	square meter per second, m^2/s
Frequency	hertz, Hz=l/s	Voltage	volt, V=W/A
Illuminance	lux, lx=lm/m^2	Volume	cubic meter, m^3
Luminance	candela per square meter, cd/m^2	Wavenumber	per meter, l/m
		Work	joule, J=N.m

Table 3. SI prefixes

Multiplier	Prefix, symbol
10^{24}	yotta, Y
10^{21}	zetta, Z
10^{18}	exa, E
10^{15}	peta, P
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
10^{-21}	zepto, z
10^{-24}	yocto, y

When prefixes are used, the first syllable is accented.

Table 4. Additional units allowed by SEG

Quantity	Unit and equivalence
Acceleration	milligal, mGal$=10^{-5}$ m/s^2
Angular velocity	revolutions per minute, rad/2π min, revolutions per second, rad/2π s
Area	hectare, ha$=10^4$ m^2
Calorific value	kilowatt hour per kilogram
Energy	kilowatt hour, kw.h$=(1/3600)$J
Energy unit	electron volt, eV
Length	centimeter, cm$=10^{-2}$ m
Magnetic flux density	gamma$=$nT
Mass	tonne$=10^3$ kg
Plane angle	degree$=0.017\ 453\ 29$ rad
Pressure	bar$=100$ kPa
Temperature	degree Celsius, °C$=$K-273.15
Time	minute, min$=60$ s
	hour h$=3600$ s
	day, d
	year, a
Volume	liter or litre, L$=$dm^3
	hectare meter, ha.m$=10^4$ m^3
Yield	liter/tonne

Note that *degree* in *degree Celsius* is lowercase. *Centigrade* is now obsolete. The symbol ° to indicate degree is not used when temperature is expressed in kelvin.

Table 5. SI equivalents of cgs units

Quantity	SI unit	cgs-emu	cgs-esu
Length	meter	$=10^2$ centimeter	
Mass	kilogram	$=10^3$ gram	
Force	newton	$=10^5$ dyne	
Energy (work)	joule	$=10^7$ erg	
Current	ampere	$=10^{-1}$ abampere	$=$ 3×10^9 statampere
Charge	coulomb	$=10^{-1}$ abcoulomb	$=$ 3×10^9 statcoulomb
Electrical potential	volt	$=10^8$ abvolt	$=$ (1/300) statvolt
Resistance	ohm	$=10^9$ abohm	$=$ $(9\times10^{11})^{-1}$ statohm
Capacitance	farad	$=10^{-9}$ abfarad	$=$ 9×10^{11} statfarad
Magnetic flux density	tesla	$=10^4$ gauss	
Magnetic flux	weber	$=10^8$ maxwell	
Magnetizing force	ampere turn/m	$=4\pi\times10^3$ oersted	
Inductance	henry	$=10^9$ abhenry	

For some of the above units, magnitude depends on the speed of light, here taken as 3×10^8 m/s (actually $2.997\ 9246\times10^8$ m/s).