The SI System: FRRB Guide to Scientific Units

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The purpose of this document is to provide an easy reference to some of the language of science. We want you to become familiar with the **International System of Units (SI)** and use them in the preparation of all presentations and documents while a member of FRRB.

Detailed information on SI units can be found at:

http://physics.nist.gov/cuu/Units/

For students, the most common errors are with the following:

1. SI units for time are: s, min, h, d for second(s), minute(s), hour(s) and day(s).

2. Spaces: There is a **space between the numerical value and unit symbol**, even when the value is used in an adjectival sense (except in the case of the angular degree, *e.g.* 90°. (See Table 2, footnote 4 for more examples.)

   Examples are: 10 mM, $k = 1 \times 10^5\ M^{-1}\ s^{-1}$, kiloDaltons would be 33 kDa,

   .

3. The **liter** in Table 2 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.

4 **Molarity** also deserves comment. According to the SI police, molarity is now obsolete. But let's face reality. The world will continue to use M or M or *M* for the foreseeable future. We recommend for simplicity M, mM, μM *etc.*, but efforts should be made to follow the SI approach. Beware of μM and word processors. It can be changed to mM so easily. Always check! If it will be a concern then use uM. (Of course the same problems can occur with μL; it could appear as mL.)

5. Table 2 provides information on how to deal with presenting units and abbreviations in written documents. It should be followed for most presentations, reports, and student theses.

Table 1. NAMES AND SYMBOLS OF SI UNITS

Physical Quantity	Name of unit	Unit symbol
	Basic units	
length	meter	m
mass	kilogram	kg
time	second	s
electric current	ampere	A
temperature	kelvin	K
luminous intensity	candela	cd
amount of substance	mole	mol
	Derived units	
area	square meter	m^2
volume	cubic meter	m^3
frequency	hertz	Hz (s^{-1})
density	kilogram per cubic meter	kg/m^3
speed	meter per second	m/s
angular speed	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 ($kg \bullet m/s^2$)
pressure	pascal	Pa (N/m^2)
kinematic viscosity	sq meter per second	m^2/s
dynamic viscosity	newton-second per sq meter	$N \bullet s/m^2$
work energy, quantity of heat	joule	J (N•m)
power, radiant flux	watt	W (J/s)
fluence	kilojoule per sq meter	kJ/m^2
fluence rate	watt per sq meter	W/m^2
electric charge	coulomb	C (A•s)
voltage, potential difference, electromotive force	volt	V (W/A)

electric field strength	volt per meter	V/m
electric resistance	ohm	Ω (V/A)
electric capacitance	farad	F (A•s/V)
magnetic flux	weber	Wb (V•s)
inductance	henry	H (Wb/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•sr)
luminance	candela per sq meter	cd/m^2
illuminance	lux	lx (lm/m^2)
wave number	reciprocal meter	m^{-1}
entropy	joule per kelvin	J/K
specific heat	joule per kilogram kelvin	J (kg•K)
thermal conductivity	watt per m kelvin	W/(m•K)
radiant intensity	watt per steradian	W/sr
activity (of a radioactive source)	becquerel	Bq (s^{-1})
absorbed dose of ionizing radiation	gray	Gy (J/kg)
	Supplementary units	
plane angle*	radian	rad
solid angle	steradian	sr

Table 2. FREQUENTLY USED SYMBOLS AND ABBREVIATIONS

Symbol or abbreviation	Upper case (uc) or lower case (lc)	Greek (gr), italicized (ital), roman (rom), or script (sc)	Meaning and/or special instructions
c	lc	rom	centi, as in 10 cm
ca.	lc	ital	circa, use period
Chl, Chl *a*, *etc.*	C, uc; h & l, lc	rom	chlorophyll, chlorophyll *a*, *etc.*
cis-	lc	ital	on this side of (isomerism)
Da	D, uc; a, lc	rom	Dalton
Dr., Mr., Ms.	n/a	n/a	most contracted abbreviations
diam.	lc	rom	diameter, use period
et al.	lc	ital	Latin: and others
e.g.	lc	ital	Latin: for example
Eq., Eqs., Fig., Figs.	leading caps	rom	use periods
g	lc	rom	gram
g	lc	ital	gyromagnetic ratio in ESR
g	lc	ital	bold face, meaning gravity, as in centrifugation at 100 000 ***g*** (does not need times sign)
h	lc	rom	hour or hours
i.e.	lc	ital	Latin: that is
in vitro; in vivo; in situ etc.	n/a	ital	Latin is always italicized
J	uc	rom	joule or joules
Jpn., *etc.*	n/a	n/a	use periods
K; °C; °F	uc	rom	degrees Kelvin (no degree sign); degrees Celsius, degrees Fahrenheit (use degree sign)
k	lc	ital	rate constant in units of s^{-1} and/or M^{-1} s^{-1} *etc.*
K, K_a	*K*, uc; a, lc	*K*,ital; a, rom	binding or equilibrium constant
kDa	k, lc; D, uc; a, lc	rom	kilodaltons

kT	k, lc; T, uc	rom	k, Boltzmann's constant; T, temperature
L	uc	rom	liter, as in 100 L or 100 mL (See Table Footnote)
m	lc	rom	milli- and/or meter, as in 100 mm
M	uc	ital	refers to concentration, *e.g.* 0.5 *M* or *0.5* m*M* (See Table Footnote)
mol wt	lc	rom	molecular weight, no periods
No.	N, uc; o, lc	rom	number, do not use #, follow 'o' with period
P	uc	ital	probability, appears as an inequlity, *e.g.* ($P > 0.05$)
pH	p, lc; H, uc	rom	negative log of H^+
p*K*, pK_a	p & a, lc; *K*, uc	p & a, rom; *K*, ital	negative log of *K*; K_a
s; ns; ps; *etc*.	lc	rom	second, seconds; nanosecond; picosecond, *etc.*
trans-	lc	ital	across or over (isomerism)
µ	lc	gr	mu, or micro
USA, DNA, UK, *etc*.	uc	n/a	no periods with most acronyms
V	uc	rom	volt or volts
vol/vol, wt/vol, wt/wt, *etc*.	lc	rom	volume/volume; weight/volume; weight/weight, *etc.* Do not use v/v, w/v, w/w, *etc*.
W	uc	rom	watt or watts
x	n/a	n/a	a cross signifying multiplication

Footnote 1: 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.

Footnote 2: **Molarity** also deserves comment. According to the SI police, molarity is now obsolete. But let's face reality. The world will continue to use M or M or *M* for the foreseeable future. We recommend for simplicity M, mM, μM *etc.* But beware of μM and word processors. It can be changed to mM so easily. Always check! If it will be a concern then use uM. (Of course the same problems can occur with μL; it too can appear as mL.)

Footnote 3: Journals often have their own rules and idiosyncrasies. Check the *Notes to Contributors* for each specific journal when preparing work for publication.

Footnote 4: **Spacing:** There is a **space between the numerical value and unit symbol**, even when the value is used in an adjectival sense, except in the case of superscript units.

A space or half-high dot is used to signify the multiplication of units. A solidus (*i.e.,* slash), horizontal line, or negative exponent is used to signify the division of units. The solidus must not be repeated on the same line unless parentheses are used.

For Example:

proper: The speed of sound is about 344 $m{\cdot}s^{-1}$ (meters per second)
The decay rate of ^{113}Cs is about 21 ms^{-1} (reciprocal milliseconds)
m/s, $m{\cdot}s^{-2}$, $m{\cdot}kg/(s^3{\cdot}A)$, $m{\cdot}kg{\cdot}s^{-3}{\cdot}A^{-1}$
m/s, $m\ s^{-2}$, $m\ kg/(s^3\ A)$, $m\ kg\ s^{-3}\ A^{-1}$

improper: The speed of sound is about 344 ms^{-1} (reciprocal milliseconds ?)
The decay rate of ^{113}Cs is about 21 $m{\cdot}s^{-1}$ (meters per second ?)
$m \div s$, $m/s/s$, $m{\cdot}kg/s^3/A$???

Thesis Format:

We expect students to use standard units, nomenclature, and abbreviations.

Table 3. CONVERSION FACTORS (Alphabetical listing)

To convert from	to	Multiply by
acre	$meter^2$	4.406×10^3
angstrom	meter	1×10^{-10}
atmosphere	Pa ($newton/meter^2$)	1.013×10^5
calorie (thermochemical)	joule	4.184
centipoise	newton $second/m^2$	1.0×10^{-3}
curie	disintegration/second	3.7×10^{10}
day (mean solar)	second (mean solar)	8.64×10^4
degree (plane angle)	radian	1.745×10^{-2}
dyne	newton	1×10^{-5}
electron volt	joule	1.602×10^{-19}
erg	joule	1.0×10^{-7}
erg/cm^2s	$watt/m^2$	1.0×10^{-3}
fahrenheit (temperature)	kelvin	$T_k = (5/9)\,(T_F + 459.67)$
faraday	coulomb	9.649×10^4
foot	meter	3.048×10^{-1}
foot-candle	lumen/meter	1.076×10^1
gallon (U.K. liquid)	$meter^3$	4.546×10^{-3}
gallon (U.S. liquid)	$meter^3$	3.785×10^{-3}
gauss	tesla	1.0×10^{-4}
inch	meter	2.54×10^{-2}
kayser	reciprocal meter	1.0×10^2
kilocalorie (thermochemical)	joule	4.184×10^3
lux	$lumen/meter^2$	1.00
millibar	Pa ($newton/meter^2$)	1.0×10^2
millimeter of mercury (at 0 °C)	Pa ($newton/meter^2$)	1.333×10^2
minute (plane angle)	radian	2.909×10^{-4}
pint (U.S. liquid)	$meter^3$	4.732×10^{-4}
poise	newton $second/meter^2$	0.10

psi	Pa (newton/m^2)	6.894×10^{3}
rad (radiation dose absorbed)	Gy (joule/kilogram)	1.0×10^{-2}
roentgen	coulomb/kilogram	2.5798×10^{-4}
second (plane angle)	radian	4.848×10^{-6}
torr (at 0 °C)	Pa (newton/m^2)	1.333×10^{2}
watt/cm^2	watt/m^2	1.0×10^{4}
yard	meter	9.144×10^{-1}

End 04/18/2007