APPENDIX

UNITS, CONSTANTS, AND CONVERSION FACTORS

THE INTERNATIONAL SYSTEM OF UNITS (SI)[1]

Table A–1. SI base units.

Name	Symbol	Definition
meter	m	"The meter is the length equal to 1 650 763.73 wavelengths in vacuum of the radiation corresponding to the transition between the levels $2p_{10}$ and $5d_5$ of the krypton-86 atom."
kilogram	kg	"The kilogram is the unit of mass; it is equal to the mass of the international prototype of the kilogram [a cylinder of platinum-iridium]."
second	s	"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."
ampere	A	"The ampere is the constant current which, if maintained in two straight parallel conductors of infinite length, of negligible circular cross section, and placed 1 meter apart in vacuum, would produce between these conductors a force equal to 2×10^{-7} newton per meter of length."
kelvin	K	"The kelvin is the fraction 1/273.16 of the thermodynamic temperature of the triple point of water." The "degree Celsius" is defined by the equation $t = T - T_0$, where T is the thermodynamic temperature in kelvins and $T_0 = 273.15$ K.
mole	mol	"The mole is the amount of substance of a system which contains as many elementary entities as there are atoms in 0.012 kilogram of carbon 12."
candela	cd	"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."

Table A–2. SI derived units.

Name	Symbol (dimensions)	Definition	Value in cgs units[a]
Absorbed dose	Gy ($m \cdot s^{-2}$)	The *gray* is the absorbed dose when the energy per unit mass imparted to matter by ionizing radiation is one joule per kilogram. (The gray is also used for the ionizing radiation quantities: specific energy imparted, kerma, and absorbed dose index, which have the SI unit joule per kilogram.) 1 rad = 10^{-2} Gy.	10^4 ergs/gm
Activity	Bq (s^{-1})	The *bequerel* is the activity of a radionuclide decaying at the rate of one spontaneous nuclear transition per second. 1 Ci (curie) = 3.7×10^{10} Bq.	1 sec^{-1}
Dose equivalent	Sv ($m^2 \cdot s^{-2}$)	The *sievert* is the dose equivalent when the absorbed dose of ionizing radiation multiplied by the dimensionless factors Q (quality factor) and N (product of any other multiplying factors) stipulated by the International Commission on Radiological Protection is one joule per kilogram.	10^4 ergs/gm
Electric capacitance	F ($m^{-2} \cdot kg^{-1} \cdot s^4 \cdot A^2$)	The *farad* is the capacitance of a capacitor between the plates of which there appears a difference of potential of one volt when it is charged by a quantity of electricity equal to one coulomb.	8.988×10^{11} esu
Electric conductance	S ($m^{-2} \cdot kg^{-1} \cdot s^3 \cdot A^2$)	The *siemens* is the electric conductance of a conductor in which a current of one ampere is produced by an electric potential difference of one volt.	8.988×10^{11} esu (cm/sec)

1. From *Physics Vade Mecum*, edited by H.L. Anderson, American Institute of Physics, New York, 1981.

Table A–2 (*continued*)

Name	Symbol (dimensions)	Definition	Value in cgs units[a]
Electric inductance	H ($m^2 \cdot kg \cdot s^{-2} \cdot A^{-2}$)	The *henry* is the inductance of a closed circuit in which an electromotive force of one volt is produced when the electric current in the circuit varies uniformly at a rate of one ampere per second.	10^9 emu (cm)
Electric potential difference, electromotive	V ($m^2 \cdot kg \cdot s^{-2} \cdot A^{-1}$)	The *volt* (unit of electric potential difference and electromotive force) is the difference of electric potential between two points of a conductor carrying a constant current of one ampere, when the power dissipated between these points is equal to one watt.	$(1/2.998) \times 10^{-2}$ esu ($cm^{1/2} \cdot gm^{1/2} \cdot sec^{-1}$)
Electric resistance	Ω ($m^2 \cdot kg \cdot s^{-3} \cdot A^{-2}$)	The *ohm* is the electric resistance between two points of a conductor when a constant difference of potential of one volt, applied between these two points, produces in this conductor a current of one ampere, this conductor not being the source of any electromotive force.	$(1/8.988) \times 10^{-11}$ esu ($cm^{-1} \cdot sec$)
Energy	J ($m^2 \cdot kg \cdot s^{-2}$)	The *joule* is the work done when the point of application of a force of one newton is displaced a distance of one meter in the direction of the force.	10^7 ergs ($cm^2 \cdot gm \cdot sec^{-2}$)
Force	N ($m \cdot kg \cdot s^{-2}$)	The *newton* is that force which, when applied to a body having a mass of one kilogram, gives it an acceleration of one meter per second squared.	10^5 dyn ($cm \cdot gm \cdot sec^{-2}$)
Frequency	Hz (s^{-1})	The *hertz* is the frequency of a periodic phenomenon of which the period is one second.	cycles/sec (sec^{-1})
Illuminance	lx ($cd \cdot sr \cdot m^{-2}$)	The *lux* is the illuminance produced by a luminous flux of one lumen uniformly distributed over a surface of one square meter.	
Luminous flux	lm ($cd \cdot sr$)	The *lumen* is the luminous flux emitted in a solid angle of one steradian by a point source having a uniform intensity of one candela.	
Magnetic flux	Wb ($m^2 \cdot kg \cdot s^{-2} \cdot A^{-1}$)	The *weber* is the magnetic flux which, linking a circuit of one turn, produces in it an electromotive force of one volt as it is reduced to zero at a uniform rate in one second.	10^8 Mx ($cm^{3/2} \cdot gm^{1/2} \cdot sec^{-1}$)
Magnetic flux density	T ($kg \cdot s^{-2} \cdot A^{-1}$)	The *tesla* is the magnetic flux density given by a magnetic flux of one weber per square meter.	10^4 Gs ($cm^{-1/2} \cdot gm^{1/2} \cdot sec^{-1}$)
Power	W ($m^2 \cdot kg \cdot s^{-3}$)	The *watt* is the power which gives rise to the production of energy at the rate of one joule per second.	10^7 ergs/sec ($cm^2 \cdot gm \cdot sec^{-2}$)
Pressure or stress	Pa ($m^{-1} \cdot kg \cdot s^{-2}$)	The *pascal* is the pressure or stress of one newton per square meter.	10 dyn/cm^2 ($cm^{-1} \cdot gm \cdot sec^{-2}$)
Quantity of electricity	C	The *coulomb* is the quantity of electricity transported in one second by a current of one ampere.	2.998×10^9 esu ($cm^{3/2} \cdot gm^{1/2} \cdot sec^{-1}$)

[a]For more precise work use 2.997 924 58 for 2.998 and 8.987 551 79 for 8.988.

Table A–3. SI prefixes.

Factor	Prefix	Symbol	Factor	Prefix	Symbol
10^{18}	exa	E	10^{-1}	deci	d
10^{15}	peta	P	10^{-2}	centi	c
10^{12}	tera	T	10^{-3}	milli	m
10^9	giga	G	10^{-6}	micro	μ
10^6	mega	M	10^{-9}	nano	n
10^3	kilo	k	10^{-12}	pico	p
10^2	hecto	h	10^{-15}	femto	f
10^1	deka	da	10^{-18}	atto	a

Table A–4. Conversion to SI units.

1. Acceleration

The gal is a special unit employed in geodesy and geophysics to express the acceleration due to gravity.

1 ft/s^2	$= 0.30480^*$ m/s^2	1 gal	$= 0.01000^*$ m/s^2
Standard gravity (g)	$= 9.8067$ m/s^2	Sun's surface	$= 274.0$ m/s^2
		1 AU from Sun	$= 0.005931$ m/s^2

2. Angle

1 degree (°)	$= 1.7453\times10^{-2}$ rad	1 second (″)	$= 4.8481\times10^{-6}$ rad
1 minute (′)	$= 2.9089\times10^{-4}$ rad		

3. Area

The darcy is a unit for measuring the permeability of porous solids.

1 acre	$= 4046.9$ m^2	1 in.^{2}	$= 6.4516^*\times10^{-4}$ m^2
1 are	$= 100.00^*$ m^2	1 square mile (international)	$= 2.5900\times10^6$ m^2
1 barn (b)	$= 1.0000^*\times10^{-28}$ m^2	1 square mile (statute)[t]	$= 2.5900\times10^6$ m^2
1 circular mil	$= 5.0671\times10^{-10}$ m^2	1 square (building)	$= 9.2903$ m^2
1 darcy	$= 9.8692\times10^{-13}$ m^2	1 square rod (rd^2), square pole, or square perch	$= 25.293$ m^2
1 ft^2	$= 0.092\,903$ m^2	1 square yard (yd^2)	$= 0.83613$ m^2
1 hectare	$= 10\,000^*$ m^2		

4. Density

1 grain/gal (U.S. liquid)	$= 0.017118$ kg/m^3	1 ton (short)/yd^3	$= 1186.6$ kg/m^3
1 oz (avoirdupois)/in.^{3}	$= 1730.0$ kg/m^3	Density of water (4°C)	$= 999.97$ kg/m^3
1 lb/ft^3	$= 16.018$ kg/m^3	Density of mercury (0°C)	$= 13595$ kg/m^3
1 lb/in.^{3}	$= 27680$ kg/m^3	Solar mass/cubic parsec	$= 6.770\times10^{-20}$ kg/m^3
1 lb/gal (U.S. liquid)	$= 119.83$ kg/m^3	STP gas density for molecular weight M_0	$= 0.044615M_0$ kg/m^3
1 ton (long)/yd^3	$= 1328.9$ kg/m^3		

5. Electricity and magnetism

A = ampere, C = coulomb, F = farad, H = henry, Ω = ohm, S = siemens, V = volt, T = tesla, Wb = weber, * = exact value.

1 abampere	$= 10.000^*$ A	1 ohm centimeter	$= 1.0000^*\times10^{-2}$ $\Omega\cdot m$
1 abcoulomb	$= 10.000^*$ C	1 ohm circular-mil per foot	$= 1.6624\times10^{-9}$ $\Omega\cdot m$
1 abfarad	$= 1.0000^*\times10^{9}$ F	1 statampere	$= 3.3356\times10^{-10}$ A
1 abhenry	$= 1.0000^*\times10^{-9}$ H	1 statcoulomb	$= 3.3356\times10^{-10}$ C
1 abmho	$= 1.0000^*\times10^{9}$ S	1 statfarad	$= 1.1127\times10^{-12}$ F
1 abohm	$= 1.0000^*\times10^{-9}$ Ω	1 stathenry	$= 8.9876\times10^{11}$ H
1 abvolt	$= 1.0000^*\times10^{-8}$ V	1 statmho	$= 1.1127\times10^{-12}$ S
1 ampere hour	$= 3600^*$ C	1 statohm	$= 8.9876\times10^{11}$ Ω
1 emu of capacitance	$= 1.0000^*\times10^{9}$ F	1 statvolt	$= 299.79$ V
1 emu of current	$= 10.000^*$ A	1 unit pole	$= 1.2566\times10^{-7}$ Wb
1 emu of electric potential	$= 1.0000^*\times10^{-8}$ V	Potential of electron at 1st Bohr orbit	$= 27.212$ V
1 emu of inductance	$= 1.0000^*\times10^{-9}$ H	Ionization potential from 1st Bohr orbit	$= 13.606$ V
1 emu of resistance	$= 1.0000^*\times10^{-9}$ Ω	Nuclear electric field at 1st Bohr orbit	$= 5.140\times10^{11}$ V/m
1 esu of capacitance	$= 1.1127\times10^{-12}$ F	Current in 1st Bohr orbit	$= 1.054\times10^{-3}$ A
1 esu of current	$= 3.3356\times10^{-10}$ A	Dipole moment of nucleus and electron in 1st Bohr orbit	$= 0.8478\times10^{-29}$ C·m
1 esu of electric potential	$= 2.9979\times10^{2}$ V	Magnetic field, atomic unit	$= 1715$ T
1 esu of inductance	$= 8.9876\times10^{11}$ H	Field at nucleus due to electron in 1st Bohr orbit	$= 9.9551\times10^{6}$ A/m
1 esu of resistance	$= 8.9876\times10^{11}$ Ω	Magnetic moment, atomic unit	$= 2.542\times10^{-21}$ J/T
1 faraday (based on ^{12}C)	$= 9.6487\times10^{4}$ C	Earth magnetic moment	$= 7.98\times10^{22}$ J/T
1 faraday (chemical)	$= 9.6496\times10^{4}$ C		
1 faraday (physical)	$= 9.6522\times10^{4}$ C		
1 gamma	$= 1.0000^*\times10^{-9}$ T		
1 gauss	$= 1.0000^*\times10^{-4}$ T		
1 gilbert	$= 7.9577\times10^{-1}$ A (amp. turns)		
1 maxwell	$= 1.0000^*\times10^{-8}$ Wb		
1 mho	$= 1.0000^*$ S		
1 oersted	$= 79.577$ A/m		

6. Energy

Btu = British thermal unit (thermochemical), 1 Btu (International Table) = 1.000 67 Btu (thermochemical); cal = calorie (thermochemical), 1 cal (International Table) = 1.000 67 cal (thermochemical); J = joule; W = watt.

1 Btu	$= 1054.4$ J	1 foot-poundal	$= 0.042140$ J
1 Btu (mean)	$= 1055.9$ J	1 kilowatt hour (kW·h)	$= 3.6000^*\times10^{6}$ J
1 Btu (39°F)	$= 1059.7$ J	1 therm	$= 1.0551\times10^{8}$ J

Table A–4 (*continued*)

1 Btu (60°F)	= 1054.7 J	1 ton (nuclear equivalent of TNT)	= 4.184×10^{9} J
1 calorie	= 4.1840* J	1 watt hour (W·h)	= 3600* J
1 calorie (mean)	= 4.1900 J	1 watt second (W·s)	= 1.0000* J
1 calorie (15°C)	= 4.1858 J	Energy of unit wave number (hc)	= 1.9865×10^{-25} J
1 calorie (20°C)	= 4.1819 J	Mass energy of unit atomic weight	= 1.4924×10^{-10} J
1 kilocalorie	= 4184.0* J		
1 electron volt (eV)	= 1.6022×10^{-19} J		
1 erg	= $1.0000^{*}\times10^{-7}$ J		
1 foot-pound (ft·lbf)	= 1.3558 J		

Note: 1 quad = 10^{15} Btu
1 quad per year = 0.472 million barrels of oil per day (1 barrel = 42 gallons)
= 1 trillion cubic feet of gas per year
= 44.4 million tons of coal per year (for medium heating value coal at 22.5 Btu/ton)
= 33.4 million kilowatts of electricity
= 293 billion kilowatt-hours of electricity per year at 100% efficiency
= 95.2 billion kilowatt-hours of electricity per year at 32.5% efficiency

See Chaps. 10.00 (Energy Demand) and 11.00 (Energy Supply).

7. Force

1 dyne	= $1.0000^{*}\times10^{-5}$ N	1 lbf/lb (thrust/weight [mass] ratio)	= 9.8067 N
1 kilogram-force	= 9.8067 N	1 poundal	= 0.13825 N
1 kip (1000 lbf)	= 4448.2 N	1 ton-force (2000 lbf)	= 8896.4 N
1 ounce-force	= 0.27801 N	Proton-electron attraction at distance a_0	= 8.238×10^{-8} N
1 pound-force (lbf)	= 4.4482 N		

8. Frequency

1 hertz (Hz)	= 1 cycle/s	Frequency of free electron in magnetic field H	= $2.7993\times10^{10}H$ Hz·T^{-1}
1 kayser	= 3×10^{10} Hz		
Rydberg frequency (cR_∞)	= 3.2898×10^{15} Hz	Plasma frequency associated with electron density N_e	= $8.979N_e^{1/2}$ Hz (N_e in m^{-3})
Frequency of 1st Bohr orbit ($2cR_\infty$)	= 6.5797×10^{15} Hz		

9. Heat

Btu = British thermal unit (thermochemical), 1 Btu (International Table) = 1.000 67 Btu (thermochemical); cal = calorie (thermochemical), 1 cal (International Table) = 1.000 67 cal (thermochemical); J = joule, K = kelvin; W = watt; h = hour.

Thermal conductivity k:			
1 Btu·ft/h·ft²·°F	= 1.7296 W/m·K	1 Btu·in./s·ft²·°F	= 518.87 W/m·K
Thermal conductance C:			
1 Btu/h·ft²·°F	= 5.6745 W/m²·K		
Heat capacity:			
1 Btu/lb·°F	= 4184.0* J/kg·K	1 cal/s	= 4.1840* W
1 cal/g·°C	= 4184.0* J/kg·K		
Thermal resistance R:		Thermal resistivity:	
1 °F·h·ft²/Btu	= 0.176 23 K·m²/W	1 °F·h·ft²/Btu·in.	= 6.9381 K·m/W
1 clo	= 0.20037 K·m²/W		
Thermal diffusivity:			
1 ft²/h	= 2.5806×10^{-5} m²/s		

10. Length

1 angstrom (Å)	= $1.0000^{*}\times10^{-10}$ m	1 microinch	= $2.5400^{*}\times10^{-8}$ m
1 atomic unit (a_0)	= $0.529\,18\times10^{-10}$ m	1 micron (μm)	= $1.0000^{*}\times10^{-6}$ m
1 astronomical unit (AU)	= 1.4960×10^{11} m	1 mil	= $2.5400^{*}\times10^{-5}$ m
1 cable's length	= 219 m	1 mile (int. nautical)	= 1852.0* m
1 chain	= 20.117 m	1 mile (U.S. nautical)	= 1852.0* m
1 electron radius (r_e)	= 2.818×10^{-15} m	1 mile (international)	= 1609.3 m
1 fathom	= 1.8288 m	1 mile (U.S. statute)	= 1609.3 m
1 fermi (femtometer) (fm)	= $1.0000^{*}\times10^{-15}$ m	1 parsec (pc)	= 3.0857×10^{16} m
1 foot (ft)	= 0.30480* m	1 pica (printer's)	= 4.2175×10^{-3} m
1 foot (U.S. survey)	= 0.30480 m	1 point (printer's)	= 3.5146×10^{-4} m
1 furlong	= 201.17 m	1 rod	= 5.0292 m
1 hand	= 0.10160 m	1 solar radius ($R_\odot$)	= 6.960×10^{8} m
1 inch (in.)	= 0.02540* m	Wavelength of 1-eV photon (hc/eV)	= 1.2399×10^{-6} m
1 league (land)	= 4828 m		

Table A–4 (*continued*)

1 light year (ly)	$= 9.4606 \times 10^{15}$ m	1 x unit	$= 1.002 \times 10^{-13}$ m
1 link (Gunther's or surveyors')	= 0.20117 m	1 yard	= 0.91440* m

11. Light

cd = candela, lm = lumen, [1 lumen = flux from $(1/60\pi)$ cm² of blackbody at 2044K], lx = lux.

1 apostilb	= 1 lm/m² for perfectly diffusing surface	1 lambert	= 3183.1 cd/m²
1 cd/in.²	= 1550.0 cd/m²	1 lumen of maximum-visibility radiation (5550 Å)	$= 1.470 \times 10^{-3}$ W
1 foot-candle	= 10.764 lx	1 stilb (sb)	= 10 000* cd/m²
1 foot-lambert	= 3.4263 cd/m²	1 phot	= 10 000* lx

12. Mass

1 atomic unit (electron) (m_e)	$= 9.1095 \times 10^{-34}$ kg	1 ounce (avoirdupois)	$= 2.8350 \times 10^{-2}$ kg
1 atomic mass unit (^{12}C scale) (amu)	$= 1.660\,57 \times 10^{-27}$ kg	1 ounce (troy or apothecary)	$= 3.1103 \times 10^{-2}$ kg
1 carat (metric)	$= 2.0000^* \times 10^{-4}$ kg	1 pennyweight (troy)	$= 1.5552 \times 10^{-3}$ kg
1 dram, apothecary	$= 3.8879 \times 10^{-3}$ kg	1 pound (lb avoirdupois)	= 0.45359 kg
1 dram, avoirdupois	$= 1.7718 \times 10^{-3}$ kg	1 pound (troy or apothecary)	= 0.37324 kg
1 gamma	$= 1.0000^* \times 10^{-9}$ kg	1 quintal (q)	= 100.00 kg
1 grain	$= 6.4799 \times 10^{-5}$ kg	1 scruple	$= 1.2960 \times 10^{-3}$ kg
1 hundredweight (gross or long)	= 50.802 kg	1 slug	= 14.594 kg
1 hundred weight (net or short)	= 45.359 kg	1 ton (assay)	= 0.029167 kg
1 kgf·s²/m	= 9.8067 kg	1 ton (long, 2240 lb)	= 1016.0 kg
		1 ton (short, 2000 lb)	= 907.18 kg
		1 ton (metric ton)	= 1.0000* kg

13. Mass per unit length

1 denier	$= 1.1111 \times 10^{-7}$ kg/m	1 tex	$= 1.0000^* \times 10^{-6}$ kg/m

14. Mass per unit time

1 perm (0°C)	$= 5.7214 \times 10^{-11}$ kg/Pa·s·m²	1 lb/hp·h	$= 1.6897 \times 10^{-7}$ kg/J
1 perm·in. (0°C)	$= 1.4532 \times 10^{-12}$ kg/Pa·s·m	1 ton (short)/h	= 0.25200 kg/s
1 lb/h	$= 1.2600 \times 10^{-4}$ kg/s		

15. Power

1 Btu (int.)/h	= 0.29307 W	1 horsepower (boiler)	= 9809.5 W
1 Btu (int.)/s	= 1055.1 W	1 horsepower (electric)	= 746.00* W
1 Btu (thermochem.)/h	= 0.292 88 W	1 horsepower (metric)	= 735.50 W
1 cal (thermochem.)/s	= 4.1840* W	1 horsepower (water)	= 746.04 W
1 force de cheval	= 735.5 W	1 horsepower (U.K.)	= 745.70 W
1 erg/s	$= 1.0000^* \times 10^{-7}$ W	1 ton (refrigeration)	= 3516.8 W
1 ft·lbf/h	$= 3.7662 \times 10^{-4}$ W	Star, $M_{bol} = 0$ radiation	$= 2.97 \times 10^{28}$ W
1 horsepower (550 ft·lbf/s)	= 745.70 W	Solar luminosity	$= 3.826 \times 10^{26}$ W

16. Pressure or stress (force per unit area)

1 atmosphere (standard)	= 101 325* Pa	1 inch of water (39.2°F)	= 249.08 Pa
1 atmosphere (technical = 1 kgf/cm²)	= 98 066.5* Pa	1 kgf/cm²	= 98 066.5* Pa
1 bar	= 100 000* Pa	1 kip/in.² (ksi)	$= 6.8948 \times 10^{6}$ Pa
1 cm Hg(0°C)	= 1333.2 Pa	1 millibar	= 100.00* Pa
1 centimeter of water (4°C)	= 98.064 Pa	1 newton/cm²	= 10000* Pa
1 dyne/cm²	= 0.100 00* Pa	1 poundal/ft²	= 1.4882 Pa
1 foot of water (39.2°F)	= 2989.0 Pa	1 lbf/ft²	= 47.880 Pa
1 gf/cm²	= 98.0665* Pa	1 lbf/in.² (psi)	= 6894.8 Pa
1 inch of mercury (32°F)	= 3386.4 Pa	1 torr (mm Hg, 0°C)	= 133.32 Pa

17. Temperature

Degree Celsius	$T_K = t_C + 273.15$	Triple point of natural water	= 273.16 K
Degree Fahrenheit	$t_C = (t_F - 32)/1.8$	Elementary temperature ($c\hbar/r_e k$)	$= 8.1262 \times 10^{11}$ K
Degree Fahrenheit	$T_K = (t_F + 459.67)/1.8$	Temperature of 1 eV	= 11 605 K
Degree Rankine	$T_K = T_R/1.8$		
Kelvin	$t_C = T_K - 273.15$		

18. Time

1 day	= 86400* s	1 year (sidereal)	$= 3.1558 \times 10^{7}$ s
1 day (sidereal)	= 86164 s	1 year (tropical)	$= 3.1557 \times 10^{7}$ s
1 hour	= 3600.0* s	1 atomic second (s_A)	= 9192631770 ^{133}Cs cycles
1 hour (sidereal)	= 3590.2 s		

Table A-4 (*continued*)

1 minute	$= 60.000^{*}$ s
1 second (sidereal)	$= 0.99727$ s
1 year (365 days)	$= 3.1536^{*} \times 10^{7}$ s
1 atomic unit (1st Bohr orbit/2π) (τ_0)	$= 2.4189 \times 10^{-17}$ s
Jordan's elementary time (r_e/c)	$= 9.3996 \times 10^{-24}$ s

19. Torque

1 dyne·cm	$= 1.0000^{*} \times 10^{-7}$ N·m
1 kgf·m	$= 9.8067$ N·m
1 ozf·in.	$= 0.0070616$ N·m
1 lbf·in.	$= 0.11298$ N·m
1 lbf·ft	$= 1.3558$ N·m

20. Velocity

1 ft/s	$= 0.30480^{*}$ m/s
1 in./s	$= 0.02540^{*}$ m/s
1 km/h	$= 0.27778$ m/s
1 knot (international)	$= 0.51444$ m/s
1 mi/h (international)	$= 0.44704^{*}$ m/s
1 mi/s (international)	$= 1609.3$ m/s
1 mi/h (international)	$= 1.6093$ km/h
Velocity of light (c)	$= 2.9979 \times 10^{8}$ m/s
1 AU per year	$= 4.7406$ km/s
1 parsec per year	$= 9.7781 \times 10^{8}$ m/s
Electron in Bohr orbit	$= 2.1877 \times 10^{6}$ m/s
1-eV electron	$= 5.9309 \times 10^{5}$ m/s
Angular velocity of Earth on its axis	$= 7.2921 \times 10^{-5}$ rad/s
Mean angular velocity of Earth in its orbit	$= 1.9910 \times 10^{-7}$ rad/s

21. Viscosity

1 centipoise	$= 1.0000^{*} \times 10^{-3}$ Pa·s
1 centistokes	$= 1.0000^{*} \times 10^{-6}$ m²/s
1 ft²/s	$= 0.092030$ m²/s
1 poise	$= 0.10000^{*}$ Pa·s
1 poundal·s/ft²	$= 1.4882$ Pa·s
1 lb/ft·h	$= 4.1338 \times 10^{-4}$ Pa·s
1 lb/ft·s	$= 1.4882$ Pa·s
1 lbf·s/ft²	$= 47.880$ Pa·s
1 lbf·s/in.²	$= 6894.8$ Pa·s
1 rhe	$= 10.000^{*}$ (Pa·s)$^{-1}$
1 slug/ft·s	$= 47.880$ Pa·s
1 stokes	$= 1.0000^{*} \times 10^{-4}$ m²/s

22. Volume

1 acre-foot	$= 1233.5$ m³
1 barrel (oil, 42 gal)	$= 0.15899$ m³
1 barrel (bbl), liquid	= 31 to 42 gallons
1 barrel (bbl), standard for fruits, vegetables, and other dry commodities except cranberries	= 7056 cubic inches = 105 dry quarts = 3.281 bushels, struck measure
1 barrel (bbl), standard, cranberry	= 5826 cubic inches = $86\frac{45}{64}$ dry quarts = 2.709 bushels, struck measure
1 board foot	$= 2.3597 \times 10^{-3}$ m³
1 bushel (U.S.)	$= 3.5239 \times 10^{-2}$ m³
1 bushel (bu), struck measure (U.S.)	$= 2150.42^{*}$ in.³
1 bushel, heaped (U.S.)	= 1.278 bushels, struck measure
1 bushel (bu), struck measure (British Imperial)	= 1.032 U.S. bushels, struck measure
1 cord (cd) (firewood)	$= 128^{*}$ ft³
1 cup (measuring)	$= 2.3659 \times 10^{-4}$ m³
1 dram (U.S. fluid)	$= 3.6967 \times 10^{-6}$ m³
1 drachm (U.K. fluid)	$= 3.5516 \times 10^{-6}$ m³
1 fluid ounce (U.S.)	$= 2.9574 \times 10^{-5}$ m³

1 ft³	$= 0.028\,317$ m³
1 gallon (Canadian liquid)	$= 4.5461 \times 10^{-3}$ m³
1 gallon (U.K. liquid)	$= 4.5461 \times 10^{-3}$ m³
1 gallon (U.S. dry)	$= 4.4049 \times 10^{-3}$ m³
1 gallon (U.S. liquid)	$= 3.7854 \times 10^{-3}$ m³
1 gill (U.K.)	$= 1.4207 \times 10^{-4}$ m³
1 gill (U.S.)	$= 1.1829 \times 10^{-4}$ m³
1 in.³	$= 1.6387 \times 10^{-5}$ m³
1 liter	$= 1.0000^{*} \times 10^{-3}$ m³
1 ounce (U.K. fluid)	$= 2.8413 \times 10^{-5}$ m³
1 ounce (U.S. fluid)	$= 2.9574 \times 10^{-5}$ m³
1 cubic parsec	$= 2.9380 \times 10^{49}$ m³
1 peck (U.S.)	$= 8.8098 \times 10^{-3}$ m³
1 pint (U.S. dry)	$= 5.5061 \times 10^{-4}$ m³
1 pint (U.S. liquid)	$= 4.7318 \times 10^{-4}$ m³
1 quart (U.S. dry)	$= 1.1012 \times 10^{-3}$ m³
1 quart (U.S. liquid)	$= 9.4635 \times 10^{-4}$ m³
1 stere	$= 1.0000^{*}$ m³
Solar volume ($4\pi R_{\odot}^{3}/3$)	$= 1.4122 \times 10^{27}$ m³
1 tablespoon	$= 1.4787 \times 10^{-5}$ m³
1 teaspoon	$= 4.9289 \times 10^{-6}$ m³
1 ton (register)	$= 2.8317$ m³
1 yd³	$= 0.764\,55$ m²

Table A–5. Precise physical constants.[1]

Quantity	Symbol (expression)	Value in SI (cgs) units	Error (ppm)
1. Speed of light in vacuum	c	$2.997\,924\,58 \times 10^{8}$ m·s^{-1} (10^{10} cm·sec^{-1})	0.004
2. Elementary charge	e	$1.602\,189\,2 \times 10^{-19}$ C (10^{-20} emu)	2.9
		($4.803\,242 \times 10^{-10}$ esu)	2.9
3. Planck's constant	h	$6.626\,176 \times 10^{-34}$ J·s (10^{-27} erg·sec)	5.4
	$\hbar = h/2\pi$	$1.054\,588\,7 \times 10^{-34}$ J·s (10^{-27} erg·sec)	5.4
4. Electron rest mass	m_e	$0.910\,953\,4 \times 10^{-30}$ kg (10^{-27} gm)	5.1
5. Avogadro constant	N_A	6.022045×10^{23} mol^{-1} (10^{23} mol^{-1})	5.1
recent value		$6.022\,097\,8 \times 10^{23}$ mol^{-1} (10^{23} mol^{-1})	1.0
6. Molar gas constant	R	$8.314\,41 \times 10^{0}$ J·mol^{-1}·K^{-1} (10^{7} erg·mol^{-1}·°K^{-1})	31
7. Boltzmann constant	$k = R/N_A$	$1.380\,662 \times 10^{-23}$ J·K^{-1} (10^{-16} erg·°K^{-1})	32
8. Gravitational constant	G	$6.672\,0 \times 10^{-11}$ N·m^{2}·kg^{-2} (10^{-8} dyn·cm^{2}·gm^{-2})	615
9. Molar volume (273.15 °K, $p_0 = 1$ atm)	$V_m = RT_0/p_0$	$22.413\,83 \times 10^{-3}$ m^{3}·mol^{-1} (10^{3} cm^{3}·mol^{-1})	31
10. Faraday constant	$F = N_A e$	$9.648\,456 \times 10^{4}$ C·mol^{-1} (10^{3} emu·mol^{-1})	2.8
11. Rydberg constant	$R_\infty = [4\pi\epsilon_0]^{-2}(m_e e^4/4\pi\hbar^3 c)$	$1.097\,373\,177 \times 10^{7}$ m^{-1} (10^{5} cm^{-1})	0.07
recent value		$1.097\,373\,147\,6 \times 10^{7}$ m^{-1} (10^{5} cm^{-1})	0.0003
12. Fine structure constant	$\alpha^{-1} = [4\pi\epsilon_0](\hbar c/e^2)$	137.036 04	0.11
recent value		137.035 963	
13. Classical electron radius	$r_e = [4\pi\epsilon_0]^{-1}(e^2/m_e c^2)$	$2.817\,938\,0 \times 10^{-15}$ m (10^{-13} cm)	2.5
14. Specific electron charge	e/m_e	$1.758\,804\,7 \times 10^{11}$ C·kg^{-1} (10^{7} emu·gm^{-1})	2.8
15. Electron Compton wavelength	$\lambda_c = \hbar/m_e c = \alpha^{-1} r_e$	$3.861\,590\,5 \times 10^{-13}$ m (10^{-11} cm)	1.6
16. Bohr radius	$a_0 = \alpha^{-2} r_e$	$0.529\,177\,06 \times 10^{-10}$ m (10^{-8} cm)	0.82
17. Magnetic flux quantum	$\Phi_0 = [c]^{-1}(hc/2e)$	$2.067\,850\,6 \times 10^{-15}$ T·m^{2} (10^{-7} Gs·cm^{2})	2.6
	h/e	$4.135\,701 \times 10^{-15}$ J·s·C^{-1} (10^{-7} erg·sec·emu^{-1})	2.6
18. Quantum of circulation	$h/2m_e$	$3.636\,945\,5 \times 10^{-4}$ J·Hz^{-1}·kg^{-1} (10^{0} erg·sec·gm^{-1})	1.6
19. Atomic mass unit	$1\ \mathrm{u} = \mathrm{gm{\cdot}mol^{-1}}/N_A$	$1.660\,565\,5 \times 10^{-27}$ kg (10^{-24} gm)	5.1
20. Proton rest mass	m_p	$1.672\,648\,5 \times 10^{-27}$ kg (10^{-24} gm)	5.1
		1.007 276 470 u (amu)	0.011
	m_p/m_e	1836.151 52	0.38
21. Neutron rest mass	m_n	$1.674\,954\,3 \times 10^{-27}$ kg (10^{-24} gm)	5.1
		1.008 665 012 u (amu)	0.037
22. Electron g factor	$\frac{1}{2}g_e = \mu_e/\mu_B$	1.001 159 656 7	0.0035
recent value		1.001 159 652 200	0.0004
23. Bohr magneton	$\mu_B = [c](e\hbar/2m_e c)$	$9.274\,078 \times 10^{-24}$ J·T^{-1} (10^{-21} erg·Gs^{-1})	3.9
24. Nuclear magneton	$\mu_N = [c](e\hbar/2m_p c)$	$5.050\,824 \times 10^{-27}$ J·T^{-1} (10^{-24} erg·Gs^{-1})	3.9
25. Electron magnetic moment	μ_e	$9.284\,832 \times 10^{-24}$ J·T^{-1} (10^{-21} erg·Gs^{-1})	3.9
26. Proton magnetic moment	μ_p	$1.410\,617\,1 \times 10^{-26}$ J·T^{-1} (10^{-23} erg·Gs^{-1})	3.9
	μ_e/μ_p	658.210 688 0	0.010
27. Proton gyromagnetic ratio	γ_p	$2.675\,198\,7 \times 10^{8}$ rad·s^{-1}·T^{-1} (10^{4} rad·sec^{-1}·Gs^{-1})	2.8
28. Stefan-Boltzmann constant	$\sigma = (\pi^2/60)k^4/\hbar^3 c^2$	$5.670\,32 \times 10^{-8}$ W·m^{-2}·K^{-4} (10^{-5} erg·sec^{-1}·cm^{-2}·°K^{-4})	125
29. First radiation constant	$c_1 = 2\pi hc^2$	$3.741\,832 \times 10^{-16}$ W·m^{2} (10^{-5} erg·sec^{-1}·cm^{2})	5.4
30. Second radiation constant	$c_2 = hc/k$	$1.438\,786 \times 10^{-2}$ m·K (10^{0} cm·°K)	31

Energy equivalents

Quantity	Symbol (expression)	Value	Error (ppm)
Atomic mass unit	u	931.501 6 MeV	2.8
Proton mass	m_p	938.279 6 MeV	2.8
Neutron mass	m_n	939.573 1 MeV	2.8
Electron mass	m_e	0.511 003 4 MeV	2.8
Electron volt	1 eV/k	11 604.50 K	31
	1 eV/hc	8 065.479 cm^{-1}	2.6
	1 eV/h	$2.417\,969\,6 \times 10^{14}$ Hz	2.6
	1 eV	$1.602\,189\,2 \times 10^{-12}$ ergs	2.9
Planck's constant	$\hbar$	$6.582\,173 \times 10^{-22}$ MeV·sec	2.6
	$\hbar c$	$1.973\,285\,8 \times 10^{-11}$ MeV·cm	2.6
	$(\hbar c)^2$	0.389 385 7 GeV^{2}·mb	5.2
Rydberg constant	$R_\infty hc$	13.605 804 eV	2.6
Voltage-wavelength product	$V\lambda$	12 398.520 eV·Å	2.6
Gas constant	R	1.987 19 cal·mol^{-1}·°K^{-1}	31

Table A–6. Mathematical constants.[1]

Constant	Number	Log
π	3.141 592 653 6	0.497 149 872 7
2π	6.283 185 307 2	0.798 179 868 4
4π	12.566 370 614 4	1.099 209 864 0
π^2	9.869 604 401 1	0.994 299 745 4
$\sqrt{\pi}$	1.772 453 850 9	0.248 574 936 3
e	2.718 281 828 5	0.434 294 481 9
mod $= M = \log e$	0.434 294 481 9	$\bar{1}$.637 784 311 3
$1/M = \ln 10$	2.302 585 093 0	0.362 215 688 7
2	2.000 000 000 0	0.301 029 995 7
$\sqrt{2}$	1.414 213 562 4	0.150 514 997 8
$\sqrt{3}$	1.732 050 807 6	0.238 560 627 4
$\sqrt{10}$	3.162 277 660 2	0.500 000 000 0
$\ln\pi$	1.144 729 885 8	0.058 703 021 2
e^{π}	23.140 692 632 8	1.364 376 353 8
Euler constant γ	0.577 215 664 9	$\bar{1}$.761 338 108 8
1 radian	57°.295 779 513 1	1.758 122 632 4
	3437′.746 770 78	3.536 273 882 8
	206 264″.806 25	5.314 425 133 2
1°	0′.017 453 292 5	$\bar{2}$.241 877 367 6
1′	0′.000 290 888 2	$\bar{4}$.463 726 117 2
1″	0′.000 004 848 1	$\bar{6}$.685 574 866 8

Square degrees on a sphere = 129 600/π = 41 252.961 24
Square degrees in a steradian = 32 400/π^2 = 3282.806 35
For Gaussian distribution $(1/\sigma\sqrt{2\pi})\exp(-x^2/2\sigma^2)$
Probable error/standard error = r/σ = 0.674 489 750 2
Probable error/average error = r/η = 0.845 347 539 4
σ/η = 1.253 314 137, $\rho = (r/\sigma)/\sqrt{2}$ = 0.476 936 276 2

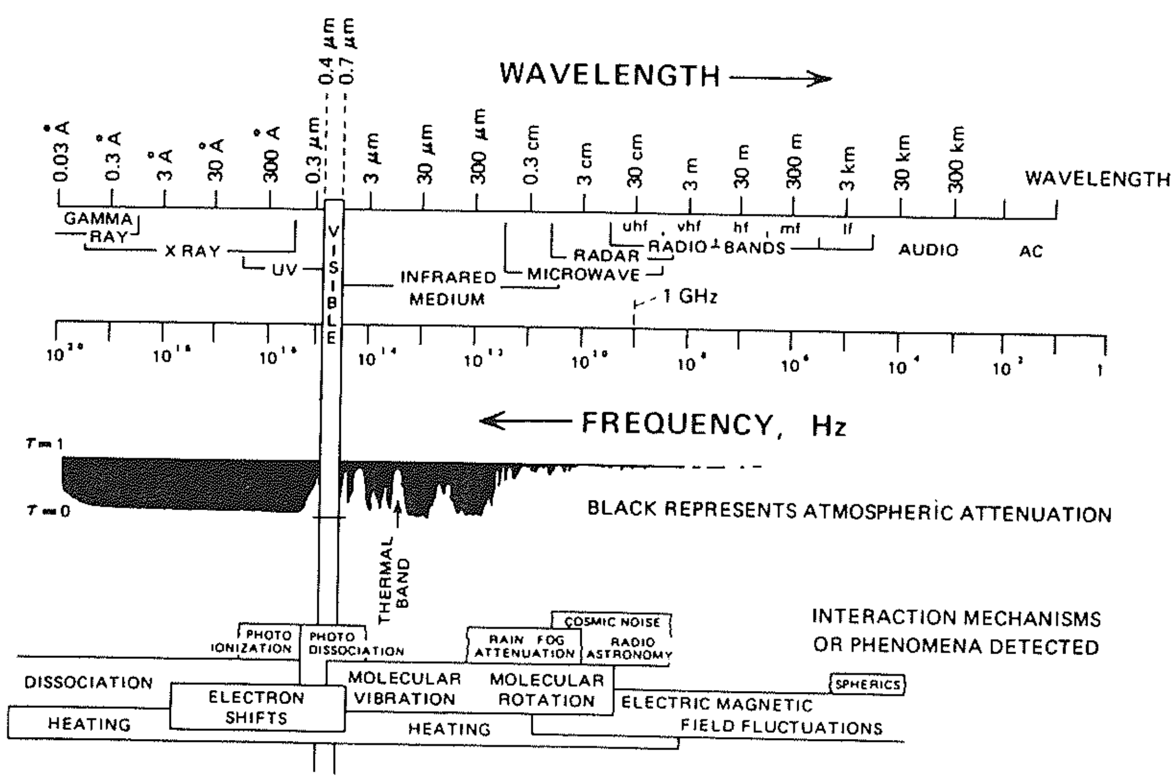

Figure A–1 Electromagnetic spectrum.[1]