1. Physical Constants

Table 1.1. Reviewed 2015 by P.J. Mohr and D.B. Newell (NIST). Mainly from the "CODATA Recommended Values of the Fundamental Physical Constants: 2014" by P.J. Mohr, D.B. Newell, and B.N. Taylor in arXiv:1507.07956 (2015) and RMP (to be submitted). The last set of constants (beginning with the Fermi coupling constant) comes from the Particle Data Group and is the only set updated for this 2018 edition. The figures in parentheses after the values give the 1-standard-deviation uncertainties in the last digits; the corresponding fractional uncertainties in parts per 10^9 (ppb) are given in the last column. This set of constants (aside from the last group) is recommended for international use by CODATA (the Committee on Data for Science and Technology). The full 2014 CODATA set of constants may be found at `http://physics.nist.gov/constants`. See also P.J. Mohr and D.B. Newell, "Resource Letter FC-1: The Physics of Fundamental Constants," Am. J. Phys. **78**, 338 (2010).

Quantity	Symbol, equation	Value	Uncertainty (ppb)
speed of light in vacuum	c	299 792 458 m s^{-1}	exact*
Planck constant	h	$6.626\ 070\ 040(81)\times10^{-34}$ J s	12
Planck constant, reduced	$\hbar \equiv h/2\pi$	$1.054\ 571\ 800(13)\times10^{-34}$ J s	12
		$= 6.582\ 119\ 514(40)\times10^{-22}$ MeV s	6.1
electron charge magnitude	e	$1.602\ 176\ 6208(98)\times10^{-19}$ C $= 4.803\ 204\ 673(30)\times10^{-10}$ esu	6.1, 6.1
conversion constant	$\hbar c$	197.326 9788(12) MeV fm	6.1
conversion constant	$(\hbar c)^2$	0.389 379 3656(48) GeV^2 mbarn	12
electron mass	m_e	$0.510\ 998\ 9461(31)$ MeV/c^2 $= 9.109\ 383\ 56(11)\times10^{-31}$ kg	6.2, 12
proton mass	m_p	938.272 0813(58) MeV/c^2 $= 1.672\ 621\ 898(21)\times10^{-27}$ kg	6.2, 12
		$= 1.007\ 276\ 466\ 879(91)$ u $= 1836.152\ 673\ 89(17)\ m_e$	0.090, 0.095
deuteron mass	m_d	1875.612 928(12) MeV/c^2	6.2
unified atomic mass unit (u)	(mass ^{12}C atom)/12 = (1 g)/(N_A mol)	931.494 0954(57) MeV/c^2 $= 1.660\ 539\ 040(20)\times10^{-27}$ kg	6.2, 12
permittivity of free space	$\epsilon_0 = 1/\mu_0 c^2$	8.854 187 817 ... $\times10^{-12}$ F m^{-1}	exact
permeability of free space	μ_0	$4\pi \times 10^{-7}$ N A^{-2} $= 12.566\ 370\ 614\ ... \times10^{-7}$ N A^{-2}	exact
fine-structure constant	$\alpha = e^2/4\pi\epsilon_0\hbar c$	$7.297\ 352\ 5664(17)\times10^{-3} = 1/137.035\ 999\ 139(31)^\dagger$	0.23, 0.23
classical electron radius	$r_e = e^2/4\pi\epsilon_0 m_e c^2$	$2.817\ 940\ 3227(19)\times10^{-15}$ m	0.68
(e^- Compton wavelength)/2π	$\lambda\!\!\!^{-}_e = \hbar/m_e c = r_e\alpha^{-1}$	$3.861\ 592\ 6764(18)\times10^{-13}$ m	0.45
Bohr radius ($m_{\rm nucleus} = \infty$)	$a_\infty = 4\pi\epsilon_0\hbar^2/m_e e^2 = r_e\alpha^{-2}$	$0.529\ 177\ 210\ 67(12)\times10^{-10}$ m	0.23
wavelength of 1 eV/c particle	hc/(1 eV)	$1.239\ 841\ 9739(76)\times10^{-6}$ m	6.1
Rydberg energy	$hcR_\infty = m_e e^4/2(4\pi\epsilon_0)^2\hbar^2 = m_e c^2\alpha^2/2$	13.605 693 009(84) eV	6.1
Thomson cross section	$\sigma_T = 8\pi r_e^2/3$	0.665 245 871 58(91) barn	1.4
Bohr magneton	$\mu_B = e\hbar/2m_e$	$5.788\ 381\ 8012(26)\times10^{-11}$ MeV T^{-1}	0.45
nuclear magneton	$\mu_N = e\hbar/2m_p$	$3.152\ 451\ 2550(15)\times10^{-14}$ MeV T^{-1}	0.46
electron cyclotron freq./field	$\omega^e_{\rm cycl}/B = e/m_e$	$1.758\ 820\ 024(11)\times10^{11}$ rad s^{-1} T^{-1}	6.2
proton cyclotron freq./field	$\omega^p_{\rm cycl}/B = e/m_p$	$9.578\ 833\ 226(59)\times10^{7}$ rad s^{-1} T^{-1}	6.2
gravitational constant‡	G_N	$6.674\ 08(31)\times10^{-11}$ m^3 kg^{-1} s^{-2}	4.7×10^4
		$= 6.708\ 61(31)\times10^{-39}$ $\hbar c$ $(\mathrm{GeV}/c^2)^{-2}$	4.7×10^4
standard gravitational accel.	g_N	9.806 65 m s^{-2}	exact
Avogadro constant	N_A	$6.022\ 140\ 857(74)\times10^{23}$ mol^{-1}	12
Boltzmann constant	k	$1.380\ 648\ 52(79)\times10^{-23}$ J K^{-1}	570
		$= 8.617\ 3303(50)\times10^{-5}$ eV K^{-1}	570
molar volume, ideal gas at STP	$N_A k$(273.15 K)/(101 325 Pa)	$22.413\ 962(13)\times10^{-3}$ m^3 mol^{-1}	570
Wien displacement law constant	$b = \lambda_{\rm max}T$	$2.897\ 7729(17)\times10^{-3}$ m K	570
Stefan-Boltzmann constant	$\sigma = \pi^2 k^4/60\hbar^3 c^2$	$5.670\ 367(13)\times10^{-8}$ W m^{-2} K^{-4}	2300
Fermi coupling constant**	$G_F/(\hbar c)^3$	$1.166\ 378\ 7(6)\times10^{-5}$ GeV^{-2}	510
weak-mixing angle	$\sin^2\widehat{\theta}(M_Z)$ ($\overline{\rm MS}$)	0.231 22(4)††	1.7×10^5
$W^\pm$ boson mass	m_W	80.379(12) GeV/c^2	1.5×10^5
Z^0 boson mass	m_Z	91.1876(21) GeV/c^2	2.3×10^4
strong coupling constant	$\alpha_s(m_Z)$	0.1181(11)	9.3×10^6

$\pi = 3.141\ 592\ 653\ 589\ 793\ 238$ e $= 2.718\ 281\ 828\ 459\ 045\ 235$ $\gamma = 0.577\ 215\ 664\ 901\ 532\ 861$

1 in $\equiv 0.0254$ m 1 G $\equiv 10^{-4}$ T 1 eV $= 1.602\ 176\ 6208(98)\times10^{-19}$ J kT at 300 K $= [38.681\ 740(22)]^{-1}$ eV

1 Å $\equiv 0.1$ nm 1 dyne $\equiv 10^{-5}$ N 1 eV/c^2 $= 1.782\ 661\ 907(11)\times10^{-36}$ kg 0 °C $\equiv 273.15$ K

1 barn $\equiv 10^{-28}$ m^2 1 erg $\equiv 10^{-7}$ J $2.997\ 924\ 58\times10^9$ esu $= 1$ C 1 atmosphere $\equiv 760$ Torr $\equiv 101\ 325$ Pa

* 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.
† At $Q^2 = 0$. At $Q^2 \approx m_W^2$ the value is $\sim 1/128$.
‡ Absolute lab measurements of G_N have been made only on scales of about 1 cm to 1 m.
** See the discussion in Sec. 10, "Electroweak model and constraints on new physics."
†† The corresponding $\sin^2\theta$ for the effective angle is 0.23155(4).