1. PHYSICAL CONSTANTS

Table 1.1. Reviewed 2005 by P.J. Mohr and B.N. Taylor (NIST). Based mainly on the "CODATA Recommended Values of the Fundamental Physical Constants: 2002" by P.J. Mohr and B.N. Taylor, Rev. Mod. Phys. **77**, 1 (2005). The last group of constants (beginning with the Fermi coupling constant) comes from the Particle Data Group. 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 2002 CODATA set of constants may be found at `http://physics.nist.gov/constants`

Quantity	Symbol, equation	Value	Uncertainty (ppb)
speed of light in vacuum	c	299 792 458 m s^{-1}	exact*
Planck constant	h	$6.626\ 0693(11)\times10^{-34}$ J s	170
Planck constant, reduced	$\hbar \equiv h/2\pi$	$1.054\ 571\ 68(18)\times10^{-34}$ J s	170
		$= 6.582\ 119\ 15(56)\times10^{-22}$ MeV s	85
electron charge magnitude	e	$1.602\ 176\ 53(14)\times10^{-19}$ C $= 4.803\ 204\ 41(41)\times10^{-10}$ esu	85, 85
conversion constant	$\hbar c$	197.326 968(17) MeV fm	85
conversion constant	$(\hbar c)^2$	0.389 379 323(67) GeV^2 mbarn	170
electron mass	m_e	0.510 998 918(44) $\mathrm{MeV}/c^2 = 9.109\ 3826(16)\times10^{-31}$ kg	86, 170
proton mass	m_p	938.272 029(80) $\mathrm{MeV}/c^2 = 1.672\ 621\ 71(29)\times10^{-27}$ kg	86, 170
		$= 1.007\ 276\ 466\ 88(13)$ u $= 1836.152\ 672\ 61(85)\ m_e$	0.13, 0.46
deuteron mass	m_d	1875.612 82(16) MeV/c^2	86
unified atomic mass unit (u)	(mass ^{12}C atom)/12 = (1 g)/(N_A mol)	931.494 043(80) $\mathrm{MeV}/c^2 = 1.660\ 538\ 86(28)\times10^{-27}$ kg	86, 170
permittivity of free space	$\epsilon_0 = 1/\mu_0 c^2$	$8.854\ 187\ 817\ldots\times10^{-12}$ F m^{-1}	exact
permeability of free space	μ_0	$4\pi\times10^{-7}$ N $\mathrm{A}^{-2} = 12.566\ 370\ 614\ldots\times10^{-7}$ N A^{-2}	exact
fine-structure constant	$\alpha = e^2/4\pi\epsilon_0\hbar c$	$7.297\ 352\ 568(24)\times10^{-3} = 1/137.035\ 999\ 11(46)^{\dagger}$	3.3, 3.3
classical electron radius	$r_e = e^2/4\pi\epsilon_0 m_e c^2$	$2.817\ 940\ 325(28)\times10^{-15}$ m	10
(e^- Compton wavelength)/2π	$\lambda\!\!\!^{-}_e = \hbar/m_e c = r_e\alpha^{-1}$	$3.861\ 592\ 678(26)\times10^{-13}$ m	6.7
Bohr radius ($m_{\mathrm{nucleus}} = \infty$)	$a_\infty = 4\pi\epsilon_0\hbar^2/m_e e^2 = r_e\alpha^{-2}$	$0.529\ 177\ 2108(18)\times10^{-10}$ m	3.3
wavelength of 1 eV/c particle	$hc/(1\ \mathrm{eV})$	$1.239\ 841\ 91(11)\times10^{-6}$ m	85
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 6923(12) eV	85
Thomson cross section	$\sigma_T = 8\pi r_e^2/3$	0.665 245 873(13) barn	20
Bohr magneton	$\mu_B = e\hbar/2m_e$	$5.788\ 381\ 804(39)\times10^{-11}$ MeV T^{-1}	6.7
nuclear magneton	$\mu_N = e\hbar/2m_p$	$3.152\ 451\ 259(21)\times10^{-14}$ MeV T^{-1}	6.7
electron cyclotron freq./field	$\omega^e_{\mathrm{cycl}}/B = e/m_e$	$1.758\ 820\ 12(15)\times10^{11}$ rad s^{-1} T^{-1}	86
proton cyclotron freq./field	$\omega^p_{\mathrm{cycl}}/B = e/m_p$	$9.578\ 833\ 76(82)\times10^{7}$ rad s^{-1} T^{-1}	86
gravitational constant‡	G_N	$6.6742(10)\times10^{-11}$ m^3 kg^{-1} s^{-2}	1.5×10^5
		$= 6.7087(10)\times10^{-39}\ \hbar c\ (\mathrm{GeV}/c^2)^{-2}$	1.5×10^5
standard gravitational accel.	g_n	9.806 65 m s^{-2}	exact
Avogadro constant	N_A	$6.022\ 1415(10)\times10^{23}$ mol^{-1}	170
Boltzmann constant	k	$1.380\ 6505(24)\times10^{-23}$ J K^{-1}	1800
		$= 8.617\ 343(15)\times10^{-5}$ eV K^{-1}	1800
molar volume, ideal gas at STP	$N_A k(273.15\ \mathrm{K})/(101\ 325\ \mathrm{Pa})$	$22.413\ 996(39)\times10^{-3}$ m^3 mol^{-1}	1700
Wien displacement law constant	$b = \lambda_{\mathrm{max}}T$	$2.897\ 7685(51)\times10^{-3}$ m K	1700
Stefan-Boltzmann constant	$\sigma = \pi^2k^4/60\hbar^3c^2$	$5.670\ 400(40)\times10^{-8}$ W m^{-2} K^{-4}	7000
Fermi coupling constant**	$G_F/(\hbar c)^3$	$1.166\ 37(1)\times10^{-5}$ GeV^{-2}	9000
weak-mixing angle	$\sin^2\hat{\theta}(M_Z)$ ($\overline{\mathrm{MS}}$)	$0.23122(15)^{\dagger\dagger}$	6.5×10^5
$W^\pm$ boson mass	m_W	80.403(29) GeV/c^2	3.6×10^5
Z^0 boson mass	m_Z	91.1876(21) GeV/c^2	2.3×10^4
strong coupling constant	$\alpha_s(m_Z)$	0.1176(20)	1.7×10^7

$\pi = 3.141\ 592\ 653\ 589\ 793\ 238$ | 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 $= 1.602\ 176\ 53(14)\times10^{-19}$ J	kT at 300 K $= [38.681\ 684(68)]^{-1}$ eV
1 Å $\equiv$ 0.1 nm	1 dyne $\equiv 10^{-5}$ N	1 eV/$c^2 = 1.782\ 661\ 81(15)\times10^{-36}$ 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 0.23152(14).