1. Physical Constants

Table 1.1: Revised Sept. 2025 by D. Robinson (LBNL) and P.A. Zyla (LBNL). Mainly from "CODATA recommended values of the fundamental physical constants: 2022," P.J. Mohr, D.B. Newell, B.N. Taylor, and E. Tiesinga [1]. The electron charge magnitude e, and the Planck, Boltzmann, and Avogadro constants h, k, and N_A, now join c as having defined values; the free-space permittivity and permeability constants ϵ_0 and μ_0 are no longer exact. These changes affect practically everything else in the Table. Figures in parentheses after the values are the 1-standard-deviation uncertainties in the last digits; the fractional uncertainties in parts per 10^9 (ppb) are in the last column. The full 2022 CODATA Committee on Data for Science and Technology set of constants are found at https://physics.nist.gov/Constants. The last set of constants (beginning with the Fermi coupling constant) comes from the Particle Data Group. See also "The International System of Units (SI)," 9th ed. (2019) of the International Bureau of Weights and Measures (BIPM), https://www.bipm.org/utils/common/pdf/si-brochure/SI-Brochure-9-EN.pdf.

Quantity	Symbol, equation	Value	Uncertainty (ppb)
speed of light in vacuum	c	299 792 458 m s^{-1}	exact
Planck constant	h	$6.626\ 070\ 15\times10^{-34}$ J s (or J/Hz) [§]	exact
Planck constant, reduced	$\hbar \equiv h/2\pi$	$1.054\ 571\ 817\ldots\times10^{-34}$ J s	exact[*]
		$= 6.582\ 119\ 569\ldots\times10^{-22}$ MeV s	exact[*]
electron charge magnitude	e	$1.602\ 176\ 634\times10^{-19}$ C	exact
conversion constant	$\hbar c$	197.326 980 4... MeV fm	exact[*]
conversion constant	$(\hbar c)^2$	0.389 379 372 1... GeV^2 mbarn	exact[*]
electron mass	m_e	0.510 998 950 69(16) MeV/c^2 = $9.109\ 383\ 7139(28)\times10^{-31}$ kg	0.31
proton mass	m_p	938.272 089 43(29) MeV/c^2 = $1.672\ 621\ 925\ 95(52)\times10^{-27}$ kg	0.31
		= 1.007 276 466 5789(83) u =1836.152 673 426(32) m_e	0.0083, 0.017
neutron mass	m_n	939.565 421 94(48) MeV/c^2 = 1.008 664 916 06(40) u	0.51, 0.40
deuteron mass	m_d	1875.612 945 00(58) MeV/c^2	0.31
unified atomic mass unit[**]	u = (mass ^{12}C atom)/12	931.494 103 72(29) MeV/c^2 = $1.660\ 539\ 068\ 92(52)\times10^{-27}$ kg	0.31
permittivity of free space	$\epsilon_0 = 1/\mu_0 c^2$	$8.854\ 187\ 8188(14)\times10^{-12}$ F m^{-1}	0.16
permeability of free space	$\mu_0/(4\pi\times10^{-7})$	0.999 999 999 87(16) N A^{-2}	0.16
fine-structure constant	$\alpha = e^2/4\pi\epsilon_0\hbar c$	$7.297\ 352\ 5643(11)\times10^{-3}$=1/137.035 999 177(21) [†]	0.16
classical electron radius	$r_e = e^2/4\pi\epsilon_0 m_e c^2$	$2.817\ 940\ 3205(13)\times10^{-15}$ m	0.47
(e^- Compton wavelength)/2π	$\lambda\!\!\!^{-}_e = \hbar/m_e c = r_e\alpha^{-1}$	$3.861\ 592\ 6744(12)\times10^{-13}$ m	0.31
Bohr radius ($m_{\rm nucleus} = \infty$)	$a_\infty = 4\pi\epsilon_0\hbar^2/m_e e^2 = r_e\alpha^{-2}$	$0.529\ 177\ 210\ 544(82)\times10^{-10}$ m	0.16
wavelength of 1 eV/c particle	hc/(1 eV)	$1.239\ 841\ 984\ldots\times10^{-6}$ m	exact[*]
Rydberg energy	$hcR_\infty = m_e e^4/2(4\pi\epsilon_0)^2\hbar^2 = m_e c^2\alpha^2/2$	13.605 693 122 990(15) eV	1.1×10^{-3}
Thomson cross section	$\sigma_T = 8\pi r_e^2/3$	0.665 245 870 51(62) barn	0.93
Bohr magneton	$\mu_B = e\hbar/2m_e$	$5.788\ 381\ 7982(18)\times10^{-11}$ MeV T^{-1}	0.31
nuclear magneton	$\mu_N = e\hbar/2m_p$	$3.152\ 451\ 254\ 17(98)\times10^{-14}$ MeV T^{-1}	0.31
electron cyclotron freq./field	$\omega^e_{\rm cycl}/B = e/m_e$	$1.758\ 820\ 008\ 38(55)\times10^{11}$ rad s^{-1} T^{-1}	0.31
proton cyclotron freq./field	$\omega^p_{\rm cycl}/B = e/m_p$	$9.578\ 833\ 1430(30)\times10^{7}$ rad s^{-1} T^{-1}	0.31
gravitational constant[‡]	G_N	$6.674\ 30(15)\times10^{-11}$ m^3 kg^{-1} s^{-2}	2.2×10^4
		= $6.708\ 83(15)\times10^{-39}$ $\hbar c$ $(\mathrm{GeV}/c^2)^{-2}$	2.2×10^4
standard gravitational accel.	g_N	9.806 65 m s^{-2}	exact
Avogadro constant	N_A	$6.022\ 140\ 76\times10^{23}$ mol^{-1}	exact
Boltzmann constant	k	$1.380\ 649\times10^{-23}$ J K^{-1}	exact
		= $8.617\ 333\ 262\ldots\times10^{-5}$ eV K^{-1}	exact[*]
molar volume, ideal gas at STP	$N_A k$ (273.15 K)/(101 325 Pa)	$22.413\ 969\ 54\ldots\times10^{-3}$ m^3 mol^{-1}	exact[*]
Wien displacement law constant	$b = \lambda_{\rm max}T$	$2.897\ 771\ 955\ldots\times10^{-3}$ m K	exact[*]
Stefan-Boltzmann constant	$\sigma = \pi^2 k^4/60\hbar^3 c^2$	$5.670\ 374\ 419\ldots\times10^{-8}$ W m^{-2} K^{-4}	exact[*]
Fermi coupling constant[‡‡]	$G_F/(\hbar c)^3$	$1.166\ 378\ 5(6)\times10^{-5}$ GeV^{-2}	514
weak-mixing angle[‡‡]	$\sin^2\widehat{\theta}(M_Z)$ $(\overline{\rm MS})$	0.231 22(6)[††]	2.6×10^5
$W^\pm$ boson mass	m_W	80.3692(133) GeV/c^2 [¶]	1.7×10^5
Z^0 boson mass	m_Z	91.1880(20) GeV/c^2 [‖]	2.2×10^4
strong coupling constant	$\alpha_s(m_Z)$	0.1180(9)	7.6×10^6

π = 3.141 592 653 589 793 238 ...		e = 2.718 281 828 459 045 235...	γ = 0.577 215 664 901 532 860...
1 in ≡ 0.0254 m	1 G ≡ 10^{-4} T	1 eV = $1.602\ 176\ 634\times10^{-19}$ J (exact)	kT at 300 K = $[38.681\ 727\ 0718\ldots]^{-1}$eV (exact[*])
1 Å ≡ 0.1 nm	1 dyne ≡ 10^{-5} N	$(1\ \mathrm{kg})c^2 = 5.609\ 588\ 603\ldots\times10^{35}$ eV(exact[*])	0 °C ≡ 273.15K
1 barn ≡ 10^{-28} m^2	1 erg ≡ 10^{-7} J	1 C = $2.997\ 924\ 58\times10^9$ esu	1 atmosphere ≡ 760 Torr ≡ 101 325Pa

[§] CODATA recommends that the unit be J/Hz to stress that in $h = E/\nu$ the frequency ν is in cycles/sec (Hz), not radians/sec.
[*] These are calculated from exact values and are exact to the number of places given (*i.e.* no rounding).
[**] The molar mass of ^{12}C is 12.000 000 0126(37) g.
[†] CODATA recommended value at $Q^2 = 0$. At $Q^2 \approx m_W^2$ the value is ∼ 1/128. A world average of the latest data yields α^{-1} = 137.035 999 178(8). [‡‡]
[‡] Absolute laboratory measurements of G_N have been made only on scales of about 1 cm to 1 m.
[‡‡] See the discussion in "Electroweak model and constraints on new physics" review.
[††] Derived from $\sin^2\theta$ for the effective angle $\bar{s}^2_\ell = 0.23154(6)$.
[¶] See the "Mass and width of the W boson" and "Electroweak model and constraints on new physics" reviews.
[‖] See the "Z boson" and "Electroweak model and constraints on new physics" reviews.

References

[1] P. J. Mohr *et al.*, Rev. Mod. Phys. **97**, 2, 025002 (2025), [arXiv:2409.03787].