1.5 Fundamental physical constants

The following values were recommended by the CODATA Task Group on Fundamental Constants in 1986. For each constant the standard deviation uncertainty in the least significant digits is given in parentheses.

Quantity	*Symbol*	*Value*
permeability of vacuum[1]	μ_0	$4\pi\times10^{-7}$ H m^{-1} (defined)
speed of light in vacuum	c_0	299 792 458 m s^{-1} (defined)
permittivity of vacuum[1]	$\varepsilon_0 = 1/\mu_0 c_0^2$	8.854 187 816 ...$\times10^{-12}$ F m^{-1}
Planck constant	h	6.626 075 5(40) $\times10^{-34}$ J s
	$\hbar = h / 2\pi$	1.054 572 66(63)$\times10^{-34}$ J s
elementary charge	e	1.602 177 33(49)$\times10^{-19}$ C
electron rest mass	m_e	9.109 389 7(54)$\times10^{-31}$ kg
proton rest mass	m_p	1.672 623 1(10)$\times10^{-27}$ kg
neutron rest mass	m_n	1.674 928 6(10)$\times10^{-27}$ kg
atomic mass constant, (unified atomic mass unit)	m_u = 1 u	1.660 540 2(10)$\times10^{-27}$ kg
Avogadro constant	L, N_A	6.022 136 7(36)$\times10^{23}$ mol^{-1}
Boltzmann constant	k	1.380 658 (12)$\times10^{-23}$ J K^{-1}
Faraday constant	F	9.648 530 9(29)$\times10^{4}$ C mol^{-1}
gas constant	R	8.314 510 (70) J K^{-1} mol^{-1}
zero of the Celsius scale		273.15 K (defined)
molar volume, ideal gas, p = 1 bar, θ = 0 °C		22.711 08(19) L mol^{-1}
standard atmosphere	atm	101 325 Pa (defined)
Bohr radius	$a_0 = 4\pi\varepsilon_0 h^2/m_e e^2$	5.291 772 49(24)$\times10^{-11}$ m
Rydberg constant	$R_\infty = E_h/2hc_0$	1.097 373 153 4(13)$\times10^{7}$ m^{-1}
Bohr magneton	$\mu_B = eh/2m_e$	9.274 015 4(31)$\times10^{-24}$ J T^{-1}
electron magnetic moment	μ_e	9.284 770 1(31)$\times10^{-24}$ J T^{-1}

(1) H m^{-1} = N A^{-2} = N s^2 C^{-2}; F m^{-1} = C^2 J^{-1} m^{-1}; ε_0 may be calculated exactly from the defined values of μ_0 and c_0.

Quantity	*Symbol*	*Value*
Landé *g*-factor for free electron	$g_e = 2\mu_e/\mu_B$	2.002 319 304 386 (20)
nuclear magneton	$\mu_N = (m_e/m_p)\mu_B$	$5.050\ 786\ 6(17)\times10^{-27}$ J T^{-1}
proton magnetic moment	μ_p	$1.410\ 607\ 61(47)\times10^{-26}$ J T^{-1}
proton magnetogyric ratio	γ_p	$2.675\ 221\ 28(81)\times10^{8}$ s^{-1} T^{-1}
magnetic moment of protons in H_2O, μ'_p	μ'_p/μ_B	$1.520\ 993\ 129(17)\times10^{-3}$
proton resonance frequency per field in H_2O	γ'_p	42.576 375(13) MHz T^{-1}
Stefan-Boltzmann constant	$\sigma / 2\pi^5k^4/15h^3c_0^2$	$5.670\ 51(19)\times10^{-8}$ W m^{-2} K^{-4}
first radiation constant	$c_1 = 2\pi hc_0^2$	$3.741\ 774\ 9(22)\times10^{-16}$ W m^2
second radiation constant	$c_2 = hc_0/k$	$1.438\ 769(12)\times10^{-2}$ m K
gravitational constant	G	$6.672\ 59(85)\times10^{-11}$ m^3 kg^{-1} s^{-2}
standard acceleration of free fall	g_n	9.806 65 m s^{-2} (defined)

Values of common mathematical constants

Mathematical constant	*Symbol*	*Value*
ratio of circumference to diameter of a circle	π	3.141 592 653 59
base of natural logarithms	e	2.718 281 828 46
natural logarithm of 10	ln 10	2.302 585 092 99

Reference: Cohen, E.R. and Taylor, B.N., The 1986 Adjustment of the Fundamental Physical Constants, CODATA Bull. 63 (1986) 1-49.