CODATA recommended values of the fundamental physical constants : 2002

CODATA RECOMMENDED VALUES OF THE FUNDAMENTAL PHYSICAL CONSTANTS: 2002

NIST SP 961 (Dec/2005) Values from: P. J. Mohr and B. N. Taylor, Rev. Mod. Phys. **77**, 1 (2005).

A more extensive listing of constants is available in the above references and on the NIST Physics Laboratory Web site physics.nist.gov/constants.

The number in parenthesis is the one-standard-deviation uncertainty in the last two digits of the given value.

Quantity	Symbol	Numerical value	Unit
speed of light in vacuum	c, c_0	299 792 458 (exact)	$m\ s^{-1}$
magnetic constant	μ_0	$4\pi \times 10^{-7}$ (exact)	$N\ A^{-2}$
		$= 12.566\,370\,614... \times 10^{-7}$	$N\ A^{-2}$
electric constant $1/\mu_0 c^2$	ϵ_0	$8.854\,187\,817... \times 10^{-12}$	$F\ m^{-1}$
Newtonian constant of gravitation	G	$6.6742(10) \times 10^{-11}$	$m^3\ kg^{-1}\ s^{-2}$
Planck constant	h	$6.626\,0693(11) \times 10^{-34}$	J s
in eV s		$4.135\,667\,43(35) \times 10^{-15}$	eV s
$h/2\pi$	$\hbar$	$1.054\,571\,68(18) \times 10^{-34}$	J s
in eV s		$6.582\,119\,15(56) \times 10^{-16}$	eV s
elementary charge	e	$1.602\,176\,53(14) \times 10^{-19}$	C
magnetic flux quantum $h/2e$	Φ_0	$2.067\,833\,72(18) \times 10^{-15}$	Wb
Josephson constant $2e/h$	K_J	$483\,597.879(41) \times 10^{9}$	$Hz\ V^{-1}$
von Klitzing constant $h/e^2 = \mu_0 c/2\alpha$	R_K	25 812.807 449(86)	Ω
Bohr magneton $e\hbar/2m_e$	μ_B	$927.400\,949(80) \times 10^{-26}$	$J\ T^{-1}$
in eV T^{-1}		$5.788\,381\,804(39) \times 10^{-5}$	$eV\ T^{-1}$
nuclear magneton $e\hbar/2m_p$	μ_N	$5.050\,783\,43(43) \times 10^{-27}$	$J\ T^{-1}$
in eV T^{-1}		$3.152\,451\,259(21) \times 10^{-8}$	$eV\ T^{-1}$
fine-structure constant $e^2/4\pi\epsilon_0\hbar c$	α	$7.297\,352\,568(24) \times 10^{-3}$	
inverse fine-structure constant	α^{-1}	137.035 999 11(46)	
Rydberg constant $\alpha^2 m_e c/2h$	R_∞	10 973 731.568 525(73)	m^{-1}
	$R_\infty c$	$3.289\,841\,960\,360(22) \times 10^{15}$	Hz
energy equivalent in eV	$R_\infty hc$	13.605 6923(12)	eV
Bohr radius $\alpha/4\pi R_\infty = 4\pi\epsilon_0\hbar^2/m_e e^2$	a_0	$0.529\,177\,2108(18) \times 10^{-10}$	m
Hartree energy $e^2/4\pi\epsilon_0 a_0 = 2R_\infty hc = \alpha^2 m_e c^2$	E_h	$4.359\,744\,17(75) \times 10^{-18}$	J
in eV		27.211 3845(23)	eV
electron mass	m_e	$9.109\,3826(16) \times 10^{-31}$	kg
in u		$5.485\,799\,0945(24) \times 10^{-4}$	u
energy equivalent in MeV	$m_e c^2$	0.510 998 918(44)	MeV
electron-muon mass ratio	m_e/m_μ	$4.836\,331\,67(13) \times 10^{-3}$	
electron-proton mass ratio	m_e/m_p	$5.446\,170\,2173(25) \times 10^{-4}$	
electron charge to mass quotient	$-e/m_e$	$-1.758\,820\,12(15) \times 10^{11}$	$C\ kg^{-1}$
Compton wavelength $h/m_e c$	λ_C	$2.426\,310\,238(16) \times 10^{-12}$	m
$\lambda_C/2\pi = \alpha a_0 = \alpha^2/4\pi R_\infty$	$\bar{\lambda}_C$	$386.159\,2678(26) \times 10^{-15}$	m
classical electron radius $\alpha^2 a_0$	r_e	$2.817\,940\,325(28) \times 10^{-15}$	m
Thomson cross section $(8\pi/3)r_e^2$	σ_e	$0.665\,245\,873(13) \times 10^{-28}$	m^2
electron magnetic moment	μ_e	$-928.476\,412(80) \times 10^{-26}$	$J\ T^{-1}$
to Bohr magneton ratio	μ_e/μ_B	$-1.001\,159\,652\,1859(38)$	
to nuclear magneton ratio	μ_e/μ_N	$-1838.281\,971\,07(85)$	
electron magnetic moment anomaly $\lvert\mu_e\rvert/\mu_B - 1$	a_e	$1.159\,652\,1859(38) \times 10^{-3}$	
electron g-factor $-2(1 + a_e)$	g_e	$-2.002\,319\,304\,3718(75)$	
electron-proton magnetic moment ratio	μ_e/μ_p	$-658.210\,6862(66)$	
muon mass in u	m_μ	0.113 428 9264(30)	u
energy equivalent in MeV	$m_\mu c^2$	105.658 3692(94)	MeV
muon-electron mass ratio	m_μ/m_e	206.768 2838(54)	
muon magnetic moment	μ_μ	$-4.490\,447\,99(40) \times 10^{-26}$	$J\ T^{-1}$
to Bohr magneton ratio	μ_μ/μ_B	$-4.841\,970\,45(13) \times 10^{-3}$	
to nuclear magneton ratio	μ_μ/μ_N	$-8.890\,596\,98(23)$	
muon magnetic moment anomaly			
$\lvert\mu_\mu\rvert/(e\hbar/2m_\mu) - 1$	a_μ	$1.165\,919\,81(62) \times 10^{-3}$	

Quantity	Symbol	Numerical value	Unit
muon g-factor $-2(1 + a_\mu)$	g_μ	$-2.002\,331\,8396(12)$	
muon-proton magnetic moment ratio	μ_μ/μ_p	$-3.183\,345\,118(89)$	
proton mass	m_p	$1.672\,621\,71(29) \times 10^{-27}$	kg
in u		1.007 276 466 88(13)	u
energy equivalent in MeV	$m_p c^2$	938.272 029(80)	MeV
proton-electron mass ratio	m_p/m_e	1836.152 672 61(85)	
proton magnetic moment	μ_p	$1.410\,606\,71(12) \times 10^{-26}$	$J\ T^{-1}$
to nuclear magneton ratio	μ_p/μ_N	2.792 847 351(28)	
proton magnetic shielding correction $1 - \mu'_p/\mu_p$ (H_2O, sphere, 25 °C)	σ'_p	$25.689(15) \times 10^{-6}$	
proton gyromagnetic ratio $2\mu_p/\hbar$	γ_p	$2.675\,222\,05(23) \times 10^{8}$	$s^{-1}\ T^{-1}$
	$\gamma_p/2\pi$	42.577 4813(37)	$MHz\ T^{-1}$
shielded proton gyromagnetic ratio $2\mu'_p/\hbar$ (H_2O, sphere, 25 °C)	γ'_p	$2.675\,153\,33(23) \times 10^{8}$	$s^{-1}\ T^{-1}$
	$\gamma'_p/2\pi$	42.576 3875(37)	$MHz\ T^{-1}$
neutron mass in u	m_n	1.008 664 915 60(55)	u
energy equivalent in MeV	$m_n c^2$	939.565 360(81)	MeV
neutron-proton mass ratio	m_n/m_p	1.001 378 418 70(58)	
neutron magnetic moment	μ_n	$-0.966\,236\,45(24) \times 10^{-26}$	$J\ T^{-1}$
to nuclear magneton ratio	μ_n/μ_N	$-1.913\,042\,73(45)$	
deuteron mass in u	m_d	2.013 553 212 70(35)	u
energy equivalent in MeV	$m_d c^2$	1875.612 82(16)	MeV
deuteron-proton mass ratio	m_d/m_p	1.999 007 500 82(41)	
deuteron magnetic moment	μ_d	$0.433\,073\,482(38) \times 10^{-26}$	$J\ T^{-1}$
to nuclear magneton ratio	μ_d/μ_N	0.857 438 2329(92)	
helion (^{3}He nucleus) mass in u	m_h	3.014 932 2434(58)	u
energy equivalent in MeV	$m_h c^2$	2808.391 42(24)	MeV
shielded helion magnetic moment (gas, sphere, 25 °C)	μ'_h	$-1.074\,553\,024(93) \times 10^{-26}$	$J\ T^{-1}$
to Bohr magneton ratio	μ'_h/μ_B	$-1.158\,671\,474(14) \times 10^{-3}$	
to nuclear magneton ratio	μ'_h/μ_N	$-2.127\,497\,723(25)$	
alpha particle mass in u	m_α	4.001 506 179 149(56)	u
energy equivalent in MeV	$m_\alpha c^2$	3727.379 17(32)	MeV
Avogadro constant	N_A, L	$6.022\,1415(10) \times 10^{23}$	mol^{-1}
atomic mass constant $\frac{1}{12}m(^{12}C) = 1$ u	m_u	$1.660\,538\,86(28) \times 10^{-27}$	kg
energy equivalent in MeV	$m_u c^2$	931.494 043(80)	MeV
Faraday constant $N_A e$	F	96 485.3383(83)	$C\ mol^{-1}$
molar gas constant	R	8.314 472(15)	$J\ mol^{-1}\ K^{-1}$
Boltzmann constant R/N_A	k	$1.380\,6505(24) \times 10^{-23}$	$J\ K^{-1}$
in eV K^{-1}		$8.617\,343(15) \times 10^{-5}$	$eV\ K^{-1}$
molar volume of ideal gas RT/p ($T = 273.15$ K, $p = 101.325$ kPa)	V_m	$22.413\,996(39) \times 10^{-3}$	$m^3\ mol^{-1}$
Stefan-Boltzmann constant $\pi^2 k^4/60\hbar^3 c^2$	σ	$5.670\,400(40) \times 10^{-8}$	$W\ m^{-2}\ K^{-4}$
first radiation constant $2\pi hc^2$	c_1	$3.741\,771\,38(64) \times 10^{-16}$	$W\ m^2$
second radiation constant hc/k	c_2	$1.438\,7752(25) \times 10^{-2}$	m K
Wien displacement law constant			
$b = \lambda_{max}T = c_2/4.965\,114\,231...$	b	$2.897\,7685(51) \times 10^{-3}$	m K
Cu x unit: $\lambda(Cu\,K\alpha_1)/1\,537.400$	xu(Cu $K\alpha_1$)	$1.002\,077\,10(29) \times 10^{-13}$	m
Mo x unit: $\lambda(Mo\,K\alpha_1)/707.831$	xu(Mo $K\alpha_1$)	$1.002\,099\,66(53) \times 10^{-13}$	m

Energy equivalents

$(1\ m^{-1})c = 299\,792\,458$ Hz	$(1\ Hz)h/k = 4.799\,2374(84) \times 10^{-11}$ K	$(1\ J) = 6.241\,509\,47(53) \times 10^{18}$ eV	$(1\ eV)/c^2 = 1.073\,544\,171(92) \times 10^{-9}$ u
$(1\ m^{-1})hc/k = 1.438\,7752(25) \times 10^{-2}$ K	$(1\ Hz)h = 4.135\,667\,43(35) \times 10^{-15}$ eV	$(1\ eV) = 1.602\,176\,53(14) \times 10^{-19}$ J	$(1\ kg) = 6.022\,1415(10) \times 10^{26}$ u
$(1\ m^{-1})hc = 1.239\,841\,91(11) \times 10^{-6}$ eV	$(1\ K)k/hc = 69.503\,56(12)\ m^{-1}$	$(1\ eV)/hc = 8.065\,544\,45(69) \times 10^{5}\ m^{-1}$	$(1\ u) = 1.660\,538\,86(28) \times 10^{-27}$ kg
$(1\ m^{-1})h/c = 1.331\,025\,0506(89) \times 10^{-15}$ u	$(1\ K)k/h = 2.083\,6644(36) \times 10^{10}$ Hz	$(1\ eV)/h = 2.417\,989\,40(21) \times 10^{14}$ Hz	$(1\ u)c/h = 7.513\,006\,608(50) \times 10^{14}\ m^{-1}$
$(1\ Hz)/c = 3.335\,640\,951 \ldots \times 10^{-9}\ m^{-1}$	$(1\ K)k = 8.617\,343(15) \times 10^{-5}$ eV	$(1\ eV)/k = 1.160\,4505(20) \times 10^{4}$ K	$(1\ u)c^2 = 931.494\,043(80) \times 10^{6}$ eV