

# 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](http://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	Quantity	Symbol	Numerical value	Unit
speed of light in vacuum	$c, c_0$	299 792 458 (exact)	$\text{m s}^{-1}$	muon $g$ -factor $-2(1 + a_\mu)$	$g_\mu$	$-2.002\,331\,8396(12)$	
magnetic constant	$\mu_0$	$4\pi \times 10^{-7}$ (exact)	$\text{N A}^{-2}$	muon-proton magnetic moment ratio	$\mu_\mu/\mu_p$	$-3.183\,345\,118(89)$	
		$= 12.566\,370\,614\dots \times 10^{-7}$	$\text{N A}^{-2}$	proton mass	$m_p$	$1.672\,621\,71(29) \times 10^{-27}$	kg
electric constant $1/\mu_0 c^2$	$\epsilon_0$	$8.854\,187\,817\dots \times 10^{-12}$	$\text{F m}^{-1}$	in u		$1.007\,276\,466\,88(13)$	u
Newtonian constant of gravitation	$G$	$6.6742(10) \times 10^{-11}$	$\text{m}^3 \text{kg}^{-1} \text{s}^{-2}$	energy equivalent in MeV	$m_p c^2$	$938.272\,029(80)$	MeV
Planck constant	$h$	$6.626\,0693(11) \times 10^{-34}$	J s	proton-electron mass ratio	$m_p/m_e$	$1836.152\,672\,61(85)$	
in eV s		$4.135\,667\,43(35) \times 10^{-15}$	eV s	proton magnetic moment	$\mu_p$	$1.410\,606\,71(12) \times 10^{-26}$	$\text{J T}^{-1}$
$h/2\pi$	$\hbar$	$1.054\,571\,68(18) \times 10^{-34}$	J s	to nuclear magneton ratio	$\mu_p/\mu_N$	$2.792\,847\,351(28)$	
in eV s		$6.582\,119\,15(56) \times 10^{-16}$	eV s	proton magnetic shielding correction $1 - \mu'_p/\mu_p$	$\sigma'_p$	$25.689(15) \times 10^{-6}$	
elementary charge	$e$	$1.602\,176\,53(14) \times 10^{-19}$	C	( $\text{H}_2\text{O}$ , sphere, $25^\circ\text{C}$ )			
magnetic flux quantum $h/2e$	$\Phi_0$	$2.067\,833\,72(18) \times 10^{-15}$	Wb	proton gyromagnetic ratio $2\mu_p/\hbar$	$\gamma_p$	$2.675\,222\,05(23) \times 10^8$	$\text{s}^{-1} \text{T}^{-1}$
Josephson constant $2e/h$	$K_J$	$483\,597.879(41) \times 10^9$	$\text{Hz V}^{-1}$		$\gamma_p/2\pi$	$42.577\,4813(37)$	$\text{MHz T}^{-1}$
von Klitzing constant $h/e^2 = \mu_0 c/2\alpha$	$R_K$	$25\,812.807\,449(86)$	$\Omega$	shielded proton gyromagnetic ratio $2\mu'_p/\hbar$	$\gamma'_p$	$2.675\,153\,33(23) \times 10^8$	$\text{s}^{-1} \text{T}^{-1}$
Bohr magneton $e\hbar/2m_e$	$\mu_B$	$927.400\,949(80) \times 10^{-26}$	$\text{J T}^{-1}$	( $\text{H}_2\text{O}$ , sphere, $25^\circ\text{C}$ )			
in eV $\text{T}^{-1}$		$5.788\,381\,804(39) \times 10^{-5}$	$\text{eV T}^{-1}$		$\gamma'_p/2\pi$	$42.576\,3875(37)$	$\text{MHz T}^{-1}$
nuclear magneton $e\hbar/2m_p$	$\mu_N$	$5.050\,783\,43(43) \times 10^{-27}$	$\text{J T}^{-1}$	neutron mass in u	$m_n$	$1.008\,664\,915\,60(55)$	u
in eV $\text{T}^{-1}$		$3.152\,451\,259(21) \times 10^{-8}$	$\text{eV T}^{-1}$	energy equivalent in MeV	$m_n c^2$	$939.565\,360(81)$	MeV
fine-structure constant $e^2/4\pi\epsilon_0\hbar c$	$\alpha$	$7.297\,352\,568(24) \times 10^{-3}$		neutron-proton mass ratio	$m_n/m_p$	$1.001\,378\,418\,70(58)$	
inverse fine-structure constant	$\alpha^{-1}$	137.035 999 11(46)		neutron magnetic moment	$\mu_n$	$-0.966\,236\,45(24) \times 10^{-26}$	$\text{J T}^{-1}$
Rydberg constant $\alpha^2 m_e c/2h$	$R_\infty$	$10\,973\,731.568\,525(73)$	$\text{m}^{-1}$	to nuclear magneton ratio	$\mu_n/\mu_N$	$-1.913\,042\,73(45)$	
	$R_\infty c$	$3.289\,841\,960\,360(22) \times 10^{15}$	Hz	deuteron mass in u	$m_d$	$2.013\,553\,212\,70(35)$	u
energy equivalent in eV	$R_\infty hc$	13.605 6923(12)	eV	energy equivalent in MeV	$m_d c^2$	$1875.612\,82(16)$	MeV
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	deuteron-proton mass ratio	$m_d/m_p$	$1.999\,007\,500\,82(41)$	
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	deuteron magnetic moment	$\mu_d$	$0.433\,073\,482(38) \times 10^{-26}$	$\text{J T}^{-1}$
in eV		27.211 3845(23)	eV	to nuclear magneton ratio	$\mu_d/\mu_N$	$0.857\,438\,2329(92)$	
electron mass	$m_e$	$9.109\,3826(16) \times 10^{-31}$	kg	helion ( $^3\text{He}$ nucleus) mass in u	$m_h$	$3.014\,932\,2434(58)$	u
in u		$5.485\,799\,0945(24) \times 10^{-4}$	u	energy equivalent in MeV	$m_h c^2$	$2808.391\,42(24)$	MeV
energy equivalent in MeV	$m_e c^2$	0.510 998 918(44)	MeV	shielded helion magnetic moment	$\mu_h$	$-1.074\,553\,024(93) \times 10^{-26}$	$\text{J T}^{-1}$
electron-muon mass ratio	$m_e/m_\mu$	$4.836\,331\,67(13) \times 10^{-3}$		(gas, sphere, $25^\circ\text{C}$ )			
electron-proton mass ratio	$m_e/m_p$	$5.446\,170\,2173(25) \times 10^{-4}$		to Bohr magneton ratio	$\mu'_h/\mu_B$	$-1.158\,671\,474(14) \times 10^{-3}$	
electron charge to mass quotient	$-e/m_e$	$-1.758\,820\,12(15) \times 10^{11}$	$\text{C kg}^{-1}$	to nuclear magneton ratio	$\mu'_h/\mu_N$	$-2.127\,497\,723(25)$	
Compton wavelength $h/m_e c$	$\lambda_C$	$2.426\,310\,238(16) \times 10^{-12}$	m	alpha particle mass in u	$m_\alpha$	$4.001\,506\,179\,149(56)$	u
$\lambda_C/2\pi = \alpha a_0 = \alpha^2/4\pi R_\infty$	$\lambda_C$	$386.159\,2678(26) \times 10^{-15}$	m	energy equivalent in MeV	$m_\alpha c^2$	$3727.379\,17(32)$	MeV
classical electron radius $\alpha^2 a_0$	$r_e$	$2.817\,940\,325(28) \times 10^{-15}$	m	Avogadro constant	$N_A, L$	$6.022\,1415(10) \times 10^{23}$	$\text{mol}^{-1}$
Thomson cross section $(8\pi/3)r_e^2$	$\sigma_e$	$0.665\,245\,873(13) \times 10^{-28}$	$\text{m}^2$	atomic mass constant $\frac{1}{12}m(^{12}\text{C}) = 1 \text{ u}$	$m_u$	$1.660\,538\,86(28) \times 10^{-27}$	kg
electron magnetic moment	$\mu_e$	$-928.476\,412(80) \times 10^{-26}$	$\text{J T}^{-1}$	energy equivalent in MeV	$m_u c^2$	$931.494\,043(80)$	MeV
to Bohr magneton ratio	$\mu_e/\mu_B$	$-1.001\,159\,652\,1859(38)$		Faraday constant $N_A e$	$F$	$96\,485.3383(83)$	$\text{C mol}^{-1}$
to nuclear magneton ratio	$\mu_e/\mu_N$	$-1838.281\,971\,07(85)$		molar gas constant	$R$	$8.314\,472(15)$	$\text{J mol}^{-1} \text{K}^{-1}$
electron magnetic moment anomaly $ \mu_e /\mu_B - 1$	$a_e$	$1.159\,652\,1859(38) \times 10^{-3}$		Boltzmann constant $R/N_A$	$k$	$1.380\,6505(24) \times 10^{-23}$	$\text{J K}^{-1}$
electron $g$ -factor $-2(1 + a_e)$	$g_e$	$-2.002\,319\,304\,3718(75)$		in $\text{eV K}^{-1}$		$8.617\,343(15) \times 10^{-5}$	$\text{eV K}^{-1}$
electron-proton magnetic moment ratio	$\mu_e/\mu_p$	$-658.210\,6862(66)$		molar volume of ideal gas $RT/p$	$V_m$	$22.413\,996(39) \times 10^{-3}$	$\text{m}^3 \text{mol}^{-1}$
muon mass in u	$m_\mu$	$0.113\,428\,9264(30)$	u	( $T = 273.15 \text{ K}$ , $p = 101.325 \text{ kPa}$ )			
energy equivalent in MeV	$m_\mu c^2$	$105.658\,3692(94)$	MeV	Stefan-Boltzmann constant $\pi^2 k^4/60\hbar^3 c^2$	$\sigma$	$5.670\,400(40) \times 10^{-8}$	$\text{W m}^{-2} \text{K}^{-4}$
muon-electron mass ratio	$m_\mu/m_e$	$206.768\,2838(54)$		first radiation constant $2\pi^5 \hbar c^2$	$c_1$	$3.741\,771\,38(64) \times 10^{-16}$	$\text{W m}^2$
muon magnetic moment	$\mu_\mu$	$-4.490\,447\,99(40) \times 10^{-26}$	$\text{J T}^{-1}$	second radiation constant $\hbar c/k$	$c_2$	$1.438\,7752(25) \times 10^{-2}$	$\text{m K}$
to Bohr magneton ratio	$\mu_\mu/\mu_B$	$-4.841\,970\,45(13) \times 10^{-3}$		Wien displacement law constant			
to nuclear magneton ratio	$\mu_\mu/\mu_N$	$-8.890\,596\,98(23)$		$b = \lambda_{\text{max}} T = c_2/4.965\,114\,231\dots$	$b$	$2.897\,7685(51) \times 10^{-3}$	$\text{m K}$
muon magnetic moment anomaly				Cu x unit: $\lambda(\text{Cu K}\alpha_1)/1\,537.400$	$xu(\text{Cu K}\alpha_1)$	$1.002\,077\,10(29) \times 10^{-13}$	m
$ \mu_\mu /(e\hbar/2m_\mu) - 1$	$a_\mu$	$1.165\,919\,81(62) \times 10^{-3}$		Mo x unit: $\lambda(\text{Mo K}\alpha_1)/707.831$	$xu(\text{Mo K}\alpha_1)$	$1.002\,099\,66(53) \times 10^{-13}$	m
Energy equivalents							
$(1 \text{ m}^{-1})c = 299\,792\,458 \text{ Hz}$		$(1 \text{ Hz})h/k = 4.799\,2374(84) \times 10^{-11} \text{ K}$		$(1 \text{ J}) = 6.241\,509\,47(53) \times 10^{18} \text{ eV}$		$(1 \text{ eV})/c^2 = 1.073\,544\,171(92) \times 10^{-9} \text{ u}$	
$(1 \text{ m}^{-1})hc/k = 1.438\,7752(25) \times 10^{-2} \text{ K}$		$(1 \text{ Hz})h = 4.135\,667\,43(35) \times 10^{-15} \text{ eV}$		$(1 \text{ eV})/hc = 1.602\,176\,53(14) \times 10^{-19} \text{ J}$		$(1 \text{ kg}) = 6.022\,1415(10) \times 10^{26} \text{ u}$	
$(1 \text{ m}^{-1})hc = 1.239\,841\,91(11) \times 10^{-6} \text{ eV}$		$(1 \text{ K})k/hc = 69.503\,56(12) \text{ m}^{-1}$		$(1 \text{ eV})/hc = 8.065\,544\,45(69) \times 10^5 \text{ m}^{-1}$		$(1 \text{ u}) = 1.660\,538\,86(28) \times 10^{-27} \text{ kg}$	
$(1 \text{ m}^{-1})h/c = 1.331\,025\,0506(89) \times 10^{-15} \text{ u}$		$(1 \text{ K})k/h = 2.083\,6644(36) \times 10^{10} \text{ Hz}$		$(1 \text{ eV})/h = 2.417\,989\,40(21) \times 10^{14} \text{ Hz}$		$(1 \text{ u})c/h = 7.513\,006\,608(50) \times 10^{14} \text{ m}^{-1}$	
$(1 \text{ Hz})/c = 3.335\,640\,951\dots \times 10^{-9} \text{ m}^{-1}$		$(1 \text{ K})k = 8.617\,343(15) \times 10^{-5} \text{ eV}$		$(1 \text{ eV})/k = 1.160\,4505(20) \times 10^4 \text{ K}$		$(1 \text{ u})c^2 = 931.494\,043(80) \times 10^6 \text{ eV}$	