CODATA RECOMMENDED VALUES OF THE FUNDAMENTAL PHYSICAL CONSTANTS: 2018

NIST SP 961 (May 2019)

An extensive list of constants is available on the NIST Physics Laboratory Web site physics.nist.gov/constants. For numerical values a number in parentheses, if present, is the one-standard-deviation uncertainty in the last two digits. For units with square brackets the full descriptions of m^{-1} and m are cycles per meter and meter per cycle, respectively. For the first radiation constant the full description of m^2 is m^{-2} $(m/cycle)^4$.

Quantity	Symbol	Numerical value	Unit
speed of light in vacuum	c	299 792 458 (exact)	m s^{-1}
Newtonian constant of gravitation	G	$6.674\,30(15) \times 10^{-11}$	m^3 kg^{-1} s^{-2}
Planck constant	h	$6.626\,070\,15 \times 10^{-34}$ (exact)	J Hz^{-1}
in eV s		$4.135\,667\,696\ldots \times 10^{-15}$	eV Hz^{-1}
	$\hbar$	$1.054\,571\,817\ldots \times 10^{-34}$	J s
in eV s		$6.582\,119\,569\ldots \times 10^{-16}$	eV s
elementary charge	e	$1.602\,176\,634 \times 10^{-19}$ (exact)	C
vacuum magnetic permeability $4\pi\alpha\hbar/e^2c$	μ_0	$1.256\,637\,062\,12(19) \times 10^{-6}$	N A^{-2}
$\mu_0/(4\pi \times 10^{-7})$		1.000 000 000 55(15)	N A^{-2}
vacuum electric permittivity $1/\mu_0 c^2$	ϵ_0	$8.854\,187\,8128(13) \times 10^{-12}$	F m^{-1}
Josephson constant $2e/h$	K_J	$483\,597.848\,4\ldots \times 10^9$	Hz V^{-1}
von Klitzing constant $\mu_0 c/2\alpha = 2\pi\hbar/e^2$	R_K	25 812.807 45 ...	Ω
magnetic flux quantum $2\pi\hbar/(2e)$	Φ_0	$2.067\,833\,848\ldots \times 10^{-15}$	Wb
Bohr magneton $e\hbar/2m_e$	μ_B	$9.274\,010\,0783(28) \times 10^{-24}$	J T^{-1}
in eV T^{-1}		$5.788\,381\,8060(17) \times 10^{-5}$	eV T^{-1}
nuclear magneton $e\hbar/2m_p$	μ_N	$5.050\,783\,7461(15) \times 10^{-27}$	J T^{-1}
in eV T^{-1}		$3.152\,451\,258\,44(96) \times 10^{-8}$	eV T^{-1}
fine-structure constant $e^2/4\pi\epsilon_0\hbar c$	α	$7.297\,352\,5693(11) \times 10^{-3}$	
inverse fine-structure constant	α^{-1}	137.035 999 084(21)	
Rydberg frequency $\alpha^2 m_e c^2/2h = E_h/2h$	cR_∞	$3.289\,841\,960\,2508(64) \times 10^{15}$	Hz
energy equivalent in eV		13.605 693 122 994(26)	eV
Rydberg constant	R_∞	10 973 731.568 160(21)	$[m^{-1}]$
Bohr radius $\hbar/\alpha m_e c = 4\pi\epsilon_0\hbar^2/m_e e^2$	a_0	$5.291\,772\,109\,03(80) \times 10^{-11}$	m
Hartree energy $\alpha^2 m_e c^2 = e^2/4\pi\epsilon_0 a_0 = 2(cR_\infty)h$	E_h	$4.359\,744\,722\,2071(85) \times 10^{-18}$	J
in eV		27.211 386 245 988(53)	eV
electron mass	m_e	$9.109\,383\,7015(28) \times 10^{-31}$	kg
in u		$5.485\,799\,090\,65(16) \times 10^{-4}$	u
energy equivalent in MeV	$m_e c^2$	0.510 998 950 00(15)	MeV
electron-muon mass ratio	m_e/m_μ	$4.836\,331\,69(11) \times 10^{-3}$	
electron-proton mass ratio	m_e/m_p	$5.446\,170\,214\,87(33) \times 10^{-4}$	
electron charge to mass quotient	$-e/m_e$	$-1.758\,820\,010\,76(53) \times 10^{11}$	C kg^{-1}
reduced Compton wavelength $\hbar/m_e c = \alpha a_0$	$\lambda\!\!\!^{-}_C$	$3.861\,592\,6796(12) \times 10^{-13}$	m
Compton wavelength	λ_C	$2.426\,310\,238\,67(73) \times 10^{-12}$	[m]
classical electron radius $\alpha^2 a_0$	r_e	$2.817\,940\,3262(13) \times 10^{-15}$	m
Thomson cross section $(8\pi/3)r_e^2$	σ_e	$6.652\,458\,7321(60) \times 10^{-29}$	m^2
electron magnetic moment	μ_e	$-9.284\,764\,7043(28) \times 10^{-24}$	J T^{-1}
to Bohr magneton ratio	μ_e/μ_B	−1.001 159 652 181 28(18)	
to nuclear magneton ratio	μ_e/μ_N	−1838.281 971 88(11)	
electron magnetic moment anomaly $\lvert\mu_e\rvert/\mu_B - 1$	a_e	$1.159\,652\,181\,28(18) \times 10^{-3}$	
electron g-factor $-2(1 + a_e)$	g_e	−2.002 319 304 362 56(35)	
electron-proton magnetic moment ratio	μ_e/μ_p	−658.210 687 89(20)	
muon mass in u	m_μ	0.113 428 9259(25)	u
energy equivalent in MeV	$m_\mu c^2$	105.658 3755(23)	MeV
muon-electron mass ratio	m_μ/m_e	206.768 2830(46)	
muon magnetic moment	μ_μ	$-4.490\,448\,30(10) \times 10^{-26}$	J T^{-1}
to Bohr magneton ratio	μ_μ/μ_B	$-4.841\,970\,47(11) \times 10^{-3}$	
to nuclear magneton ratio	μ_μ/μ_N	−8.890 597 03(20)	
muon magnetic moment anomaly $\lvert\mu_\mu\rvert/(e\hbar/2m_\mu) - 1$	a_μ	$1.165\,920\,89(63) \times 10^{-3}$	

Quantity	Symbol	Numerical value	Unit
muon g-factor $-2(1 + a_\mu)$	g_μ	−2.002 331 8418(13)	
muon-proton magnetic moment ratio	μ_μ/μ_p	−3.183 345 142(71)	
proton mass	m_p	$1.672\,621\,923\,69(51) \times 10^{-27}$	kg
in u		1.007 276 466 621(53)	u
energy equivalent in MeV	$m_p c^2$	938.272 088 16(29)	MeV
proton-electron mass ratio	m_p/m_e	1836.152 673 43(11)	
proton magnetic moment	μ_p	$1.410\,606\,797\,36(60) \times 10^{-26}$	J T^{-1}
to nuclear magneton ratio	μ_p/μ_N	2.792 847 344 63(82)	
proton magnetic shielding correction $1-\mu'_p/\mu_p$ (H_2O, sphere, 25 °C)	σ'_p	$2.5689(11) \times 10^{-5}$	
proton gyromagnetic ratio $2\mu_p/\hbar$	γ_p	$2.675\,221\,8744(11) \times 10^8$	s^{-1} T^{-1}
		42.577 478 518(18)	MHz T^{-1}
shielded proton gyromagnetic ratio $2\mu'_p/\hbar$ (H_2O, sphere, 25 °C)	γ'_p	$2.675\,153\,151(29) \times 10^8$	s^{-1} T^{-1}
		42.576 384 74(46)	MHz T^{-1}
neutron mass in u	m_n	1.008 664 915 95(49)	u
energy equivalent in MeV	$m_n c^2$	939.565 420 52(54)	MeV
neutron-proton mass ratio	m_n/m_p	1.001 378 419 31(49)	
neutron magnetic moment	μ_n	$-9.662\,3651(23) \times 10^{-27}$	J T^{-1}
to nuclear magneton ratio	μ_n/μ_N	−1.913 042 73(45)	
deuteron mass in u	m_d	2.013 553 212 745(40)	u
energy equivalent in MeV	$m_d c^2$	1875.612 942 57(57)	MeV
deuteron-proton mass ratio	m_d/m_p	1.999 007 501 39(11)	
deuteron magnetic moment	μ_d	$4.330\,735\,094(11) \times 10^{-27}$	J T^{-1}
to nuclear magneton ratio	μ_d/μ_N	0.857 438 2338(22)	
helion (^{3}He nucleus) mass in u	m_h	3.014 932 247 175(97)	u
energy equivalent in MeV	$m_h c^2$	2808.391 607 43(85)	MeV
shielded helion magnetic moment (gas, sphere, 25 °C)	μ'_h	$-1.074\,553\,090(13) \times 10^{-26}$	J T^{-1}
to Bohr magneton ratio	μ'_h/μ_B	$-1.158\,671\,471(14) \times 10^{-3}$	
to nuclear magneton ratio	μ'_h/μ_N	−2.127 497 719(25)	
alpha particle mass in u	m_α	4.001 506 179 127(63)	u
energy equivalent in MeV	$m_\alpha c^2$	3727.379 4066(11)	MeV
Boltzmann constant	k	$1.380\,649 \times 10^{-23}$ (exact)	J K^{-1}
Avogadro constant	N_A	$6.022\,140\,76 \times 10^{23}$ (exact)	mol^{-1}
atomic mass constant $\frac{1}{12}m(^{12}C) = 1$ u	m_u	$1.660\,539\,066\,60(50) \times 10^{-27}$	kg
energy equivalent in MeV	$m_u c^2$	931.494 102 42(28)	MeV
Faraday constant $N_A e$	F	96 485.332 12 ...	C mol^{-1}
molar gas constant $N_A k$	R	8.314 462 618 ...	J mol^{-1} K^{-1}
in eV K^{-1}		$8.617\,333\,262\ldots \times 10^{-5}$	eV K^{-1}
molar volume of ideal gas RT/p (T = 273.15 K, p = 101.325 kPa)	V_m	$22.413\,969\,54\ldots \times 10^{-3}$	m^3 mol^{-1}
Stefan-Boltzmann constant $\pi^2 k^4/60\hbar^3 c^2$	σ	$5.670\,374\,419\ldots \times 10^{-8}$	W m^{-2} K^{-4}
first radiation constant $2\pi hc^2$	c_1	$3.741\,771\,852\ldots \times 10^{-16}$	$[W\ m^2]$
second radiation constant hc/k	c_2	$1.438\,776\,877\ldots \times 10^{-2}$	[m K]
Wien displacement law constant $b = \lambda_{max}T = c_2/4.965\,114\,231\ldots$	b	$2.897\,771\,955\ldots \times 10^{-3}$	[m K]
Cu x unit: $\lambda(\mathrm{Cu\ K}\alpha_1)/1\,537.400$	xu(Cu Kα$_1$)	$1.002\,076\,97(28) \times 10^{-13}$	m
Mo x unit: $\lambda(\mathrm{Mo\ K}\alpha_1)/707.831$	xu(Mo Kα$_1$)	$1.002\,099\,52(53) \times 10^{-13}$	m

Energy equivalents

$[1\ m^{-1}]c = 299\,792\,458$ Hz	(1 Hz)$h/k = 4.799\,243\,073\ldots \times 10^{-11}$ K	(1 J) $= 6.241\,509\,074\ldots \times 10^{18}$ eV	(1 eV)$/c^2 = 1.073\,544\,102\,33(32) \times 10^{-9}$ u
$[1\ m^{-1}]hc/k = 1.438\,776\,877\ldots \times 10^{-2}$ K	(1 Hz)$h = 4.135\,667\,696\ldots \times 10^{-15}$ eV	(1 eV) $= 1.602\,176\,634 \times 10^{-19}$ J	(1 kg) $= 6.022\,140\,7621(18) \times 10^{26}$ u
$[1\ m^{-1}hc = 1.239\,841\,984\ldots \times 10^{-6}$ eV	(1 K)$k/hc = 69.503\,480\,04\ldots$ $[m^{-1}]$	(1 eV)$/hc = 8.065\,543\,937\ldots \times 10^5$ $[m^{-1}]$	(1 u) $= 1.660\,539\,066\,60(50) \times 10^{-27}$ kg
$[1\ m^{-1}]h/c = 1.331\,025\,050\,10(40) \times 10^{-15}$ u	(1 K)$k/h = 2.083\,661\,912\ldots \times 10^{10}$ Hz	(1 eV)$/h = 2.417\,989\,242\ldots \times 10^{14}$ Hz	(1 u)$c/h = 7.513\,006\,6104(23) \times 10^{14}$ $[m^{-1}]$
(1 Hz)$/c = 3.335\,640\,951\ldots \times 10^{-9}$ $[m^{-1}]$	(1 K)$k = 8.617\,333\,262\ldots \times 10^{-5}$ eV	(1 eV)$/k = 1.160\,451\,812\ldots \times 10^4$ K	(1 u)$c^2 = 9.314\,941\,0242(28) \times 10^8$ eV

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