

Astronomical and physical constants

Norman Gray

2022 October 21, from guexam-1.3.6

The constants for astronomy exams, and some physics exams, are maintained in the repository in the file `physical-constants.csv`, so that they are consistent across all of the exams. This is a CSV file – if it is convenient to edit this by importing it into a spreadsheet, be careful to interpret the numeric columns as *text*, and not as numbers.

The numerical values of physical values, and in some cases the form of the names of the constants, currently come from CODATA 2010.¹ For the (new) exact SI values, see Resolution 1 of the 26th CGPM² (in force from 2019 May 20).

For layout prescriptions, see ISO 80000-1:2009, Sect. 7. In particular:

7.1.2 Subscripts. When, in a given context, different quantities have the same letter symbol or when, for one quantity, different applications or different values are of interest, a distinction can be made by use of subscripts. The following principles for the printing of subscripts apply.

- A subscript that represents a physical quantity or a mathematical variable, such as a running number, is printed in italic (sloping) type.
- Other subscripts, such as those representing words or fixed numbers, are printed in roman (upright) type.

Therefore the Boltzmann constant and the Bohr magneton, and the electron and proton masses, which represent ‘fixed numbers’, should have upright subscripts, not sloping.

If you spot any transcription or layout errors, please let Norman know.

¹See <http://asa.usno.navy.mil/> and <http://physics.nist.gov/cuu/pdf/RevModPhysCODATA2010.pdf>.

²<https://www.bipm.org/en/committees/cg/cgpm/26-2018/resolution-1>

P1 constants:

acceleration due to gravity	g	9.807 m s^{-2}
speed of light in vacuum	c	$2.998 \times 10^8 \text{ m s}^{-1}$
gravitational constant	G	$6.674 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2}$
Planck constant	h	$6.626 \times 10^{-34} \text{ J s}$
permeability of vacuum	μ_0	$4\pi \times 10^{-7} \text{ H m}^{-1}$
permittivity of vacuum	ϵ_0	$8.854 \times 10^{-12} \text{ F m}^{-1}$
Boltzmann constant	k_B	$1.381 \times 10^{-23} \text{ J K}^{-1}$
Stefan-Boltzmann constant	σ	$5.670 \times 10^{-8} \text{ W m}^{-2} \text{ K}^{-4}$
Avogadro constant	N_A	$6.022 \times 10^{23} \text{ mol}^{-1}$
molar gas constant	R	$8.314 \text{ J mol}^{-1} \text{ K}^{-1}$
proton mass	m_p	$1.673 \times 10^{-27} \text{ kg}$
electron mass	m_e	$9.109 \times 10^{-31} \text{ kg}$
elementary charge	e	$1.602 \times 10^{-19} \text{ C}$

P2 constants:

acceleration due to gravity	g	9.807 m s^{-2}
speed of light in vacuum	c	$2.998 \times 10^8 \text{ m s}^{-1}$
permeability of vacuum	μ_0	$4\pi \times 10^{-7} \text{ H m}^{-1}$
permittivity of vacuum	ϵ_0	$8.854 \times 10^{-12} \text{ F m}^{-1}$
Boltzmann constant	k_B	$1.381 \times 10^{-23} \text{ J K}^{-1}$
Avogadro constant	N_A	$6.022 \times 10^{23} \text{ mol}^{-1}$
molar gas constant	R	$8.314 \text{ J mol}^{-1} \text{ K}^{-1}$
proton mass	m_p	$1.673 \times 10^{-27} \text{ kg}$
electron mass	m_e	$9.109 \times 10^{-31} \text{ kg}$
elementary charge	e	$1.602 \times 10^{-19} \text{ C}$

A1 constants:

speed of light in vacuum	c	$2.998 \times 10^8 \text{ m s}^{-1}$
gravitational constant	G	$6.674 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2}$
Planck constant	h	$6.626 \times 10^{-34} \text{ J s}$
Boltzmann constant	k_{B}	$1.381 \times 10^{-23} \text{ J K}^{-1}$
Stefan-Boltzmann constant	σ	$5.670 \times 10^{-8} \text{ W m}^{-2} \text{ K}^{-4}$
Rydberg constant	R_{∞}	$1.097 \times 10^7 \text{ m}^{-1}$
Avogadro constant	N_{A}	$6.022 \times 10^{23} \text{ mol}^{-1}$
molar gas constant	R	$8.314 \text{ J mol}^{-1} \text{ K}^{-1}$
proton mass	m_{p}	$1.673 \times 10^{-27} \text{ kg}$
electron mass	m_{e}	$9.109 \times 10^{-31} \text{ kg}$
elementary charge	e	$1.602 \times 10^{-19} \text{ C}$
electronvolt	eV	$1.602 \times 10^{-19} \text{ J}$
astronomical unit	au	$1.496 \times 10^{11} \text{ m}$
parsec	pc	$3.086 \times 10^{16} \text{ m}$
light year	ly	$9.461 \times 10^{15} \text{ m}$
Earth mass	M_{\oplus}	$5.972 \times 10^{24} \text{ kg}$
Earth equatorial radius	R_{\oplus}	$6.378 \times 10^6 \text{ m}$
Solar mass	M_{\odot}	$1.988 \times 10^{30} \text{ kg}$
Solar equatorial radius	R_{\odot}	$6.957 \times 10^8 \text{ m}$
Solar luminosity	L_{\odot}	$3.828 \times 10^{26} \text{ W}$
Solar absolute bolometric magnitude		+4.74
obliquity of the ecliptic	ϵ	$23^{\circ}26'$

A2 constants:

speed of light in vacuum	c	$2.998 \times 10^8 \text{ m s}^{-1}$
gravitational constant	G	$6.674 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2}$
Planck constant	h	$6.626 \times 10^{-34} \text{ J s}$
Boltzmann constant	k_{B}	$1.381 \times 10^{-23} \text{ J K}^{-1}$
Stefan-Boltzmann constant	σ	$5.670 \times 10^{-8} \text{ W m}^{-2} \text{ K}^{-4}$
Rydberg constant	R_{∞}	$1.097 \times 10^7 \text{ m}^{-1}$
Avogadro constant	N_{A}	$6.022 \times 10^{23} \text{ mol}^{-1}$
molar gas constant	R	$8.314 \text{ J mol}^{-1} \text{ K}^{-1}$
proton mass	m_{p}	$1.673 \times 10^{-27} \text{ kg}$
electron mass	m_{e}	$9.109 \times 10^{-31} \text{ kg}$
elementary charge	e	$1.602 \times 10^{-19} \text{ C}$
electronvolt	eV	$1.602 \times 10^{-19} \text{ J}$
astronomical unit	au	$1.496 \times 10^{11} \text{ m}$
parsec	pc	$3.086 \times 10^{16} \text{ m}$
light year	ly	$9.461 \times 10^{15} \text{ m}$
jansky	Jy	$1 \times 10^{-26} \text{ W m}^{-2} \text{ Hz}^{-1}$
Earth mass	M_{\oplus}	$5.972 \times 10^{24} \text{ kg}$
Earth equatorial radius	R_{\oplus}	$6.378 \times 10^6 \text{ m}$
Solar mass	M_{\odot}	$1.988 \times 10^{30} \text{ kg}$
Solar equatorial radius	R_{\odot}	$6.957 \times 10^8 \text{ m}$
Solar luminosity	L_{\odot}	$3.828 \times 10^{26} \text{ W}$
Solar absolute bolometric magnitude		$+4.74$
obliquity of the ecliptic	ϵ	$23^{\circ}26'$

A345 constants: The values of GM , R , and L below are the IAU's ‘conversion constants’ (see <https://arxiv.org/abs/1510.07674>), with GM converted to M using the value $G = 6.67408(31) \times 10^{-11} \text{ m}^3 \text{ kg}^{-1} \text{ s}^{-2}$ (CODATA 2014). According to that document, each of these should properly be cursive and labelled with a superscript N, but that seems merely confusing in this context.

Since the IAU recommends the ‘year’ as being the julian year of 365.25 days,³ the light-year is in principle exact, but to more digits than is interesting.

speed of light in vacuum	c	2.997 924 58	$\times 10^8 \text{ m s}^{-1}$ (exact)
gravitational constant	G	6.673 84(80)	$\times 10^{-11} \text{ N m}^2 \text{ kg}^{-2}$
Planck constant	h	6.626 070 15	$\times 10^{-34} \text{ J s}$ (exact)
$h/(2\pi)$	\hbar	1.054 571 82	$\times 10^{-34} \text{ J s}$
permeability of vacuum	μ_0	4π	$\times 10^{-7} \text{ H m}^{-1}$ (1 in 2.3×10^{-10})
permittivity of vacuum	ϵ_0	8.854 187 817	$\times 10^{-12} \text{ F m}^{-1}$
Boltzmann constant	k_B	1.380 649	$\times 10^{-23} \text{ J K}^{-1}$ (exact)
Stefan-Boltzmann constant	σ	5.670 373(21)	$\times 10^{-8} \text{ W m}^{-2} \text{ K}^{-4}$
Thomson cross section (e)	σ_T	6.652 458 715 8(91)	$\times 10^{-29} \text{ m}^2$
Rydberg constant	R_∞	1.097 373 156 853 9(55)	$\times 10^7 \text{ m}^{-1}$
Bohr magneton	μ_B	9.274 008 99(37)	$\times 10^{-24} \text{ J T}^{-1}$
Avogadro constant	N_A	6.022 140 76	$\times 10^{23} \text{ mol}^{-1}$ (exact)
molar gas constant	R	8.314 462 1(75)	$\text{J mol}^{-1} \text{ K}^{-1}$
proton mass	m_p	1.672 621 777(74)	$\times 10^{-27} \text{ kg}$
unified atomic mass unit	u	1.660 538 921(73)	$\times 10^{-27} \text{ kg}$
electron mass	m_e	9.109 382 91(40)	$\times 10^{-31} \text{ kg}$
elementary charge	e	1.602 176 634	$\times 10^{-19} \text{ C}$
electronvolt	eV	1.602 176 565(35)	$\times 10^{-19} \text{ J}$
fine-structure constant	α	7.297 352 569 8(24)	$\times 10^{-3}$
astronomical unit	au	1.495 978 707	$\times 10^{11} \text{ m}$
parsec	pc	3.085 677 6	$\times 10^{16} \text{ m}$
light year	ly	9.460 730 472	$\times 10^{15} \text{ m}$
jansky	Jy	1	$\times 10^{-26} \text{ W m}^{-2} \text{ Hz}^{-1}$
Earth mass	M_\oplus	5.972 36(28)	$\times 10^{24} \text{ kg}$
Earth mass parameter	$(GM)_\oplus$	3.986 004	$\times 10^{14} \text{ m}^3 \text{ s}^{-2}$ (nominal)
Earth equatorial radius	R_\oplus	6.3781	$\times 10^6 \text{ m}$ (nominal)
Solar mass	M_\odot	1.988 475(92)	$\times 10^{30} \text{ kg}$
Solar mass parameter	$(GM)_\odot$	1.327 124 4	$\times 10^{20} \text{ m}^3 \text{ s}^{-2}$ (nominal)
Solar equatorial radius	R_\odot	6.957	$\times 10^8 \text{ m}$ (nominal)
Solar luminosity	L_\odot	3.828	$\times 10^{26} \text{ W}$ (nominal)
Solar absolute bolometric magnitude		+4.74	

³https://www.iau.org/publications/proceedings_rules/units/