Selected Astronomical Constants

Units:

The units meter (m), kilogram (kg), and SI second (s) are the units of length, mass and time in the International System of Units (SI).

The astronomical unit of time is a time interval of one day (D) of 86400 seconds. An interval of 36525 days is one Julian century. The astronomical unit of mass is the mass of the Sun (S). The astronomical unit of length is that length (A) for which the Gaussian gravitational constant (k) takes the value 0·017 202 098 95 when the units of measurement are the astronomical units of length, mass and time. The dimensions of k^2 are those of the constant of gravitation (G), i.e., $A^3 S^{-1} D^{-2}$.

Some constants from the JPL DE405 ephemeris are consistent with TDB seconds (see page L2). For these quantities both TDB and SI values are given.

	Quantity	Symbol, Value(s), [Uncertainty]	Refs.
Defining constants:			
1	Gaussian gravitational constant	$k = 0{\cdot}017\ 202\ 098\ 95$	I*
2	Speed of light	$c = 299\ 792\ 458\ \mathrm{m\,s^{-1}}$	C E J A
3	L_G	$L_G = 6{\cdot}969\ 290\ 134 \times 10^{-10}$	I E
Other constants:			
4	L_C	$L_C = 1{\cdot}480\ 826\ 867\ 41 \times 10^{-8}$ $[2 \times 10^{-17}]$	I E
5	$L_B = L_G + L_C - L_G L_C$	$L_B = 1{\cdot}550\ 519\ 767\ 72 \times 10^{-8}$ $[2 \times 10^{-17}]$	I E
6	Light-time for unit distance	$\tau_A = 499^{s}{\cdot}004\ 783\ 806\ 1$ (TDB) $= 499^{s}{\cdot}004\ 786\ 385\ 2$ (SI) $[2^{s} \times 10^{-8}]$ $1/\tau_A = 173{\cdot}144\ 632\ 684\ 7$ au/d (TDB)	J E A
7	Unit distance, astronomical unit in metres	$A = c\tau_A$ $= 1{\cdot}495\ 978\ 706\ 91 \times 10^{11}$ m (TDB) $= 1{\cdot}495\ 978\ 714\ 64 \times 10^{11}$ m (SI) [6]	J E
8	Equatorial radius for Earth	$a_e = 6\ 378\ 136{\cdot}6$ m [0·10]	G E A
9	Flattening factor for Earth	$f = 0{\cdot}003\ 352\ 8197 = 1/298{\cdot}256\ 42$ [1/0·00001]	G E A
10	Dynamical form-factor for the Earth	$J_2 = 0{\cdot}001\ 082\ 635\ 9$ $[1{\cdot}0 \times 10^{-10}]$	G E
11	Nominal mean angular velocity of Earth rotation	$\omega = 7{\cdot}292\ 115 \times 10^{-5}\ \mathrm{rad\,s^{-1}}$ [variable]	I E G A
12	Potential of the geoid	$W_0 = 6{\cdot}263\ 685\ 60 \times 10^{7}\ \mathrm{m^2\,s^{-2}}$ [0·5]	G E
13	Geocentric gravitational constant	$GE = 3{\cdot}986\ 004\ 33 \times 10^{14}\ \mathrm{m^3\,s^{-2}}$ (TDB) $= 3{\cdot}986\ 004\ 39 \times 10^{14}\ \mathrm{m^3\,s^{-2}}$ (SI) $= 3{\cdot}986\ 004\ 418 \times 10^{14}\ \mathrm{m^3\,s^{-2}}$ $[8 \times 10^{5}]$	J A G E
14	Heliocentric gravitational constant	$GS = A^3 k^2 / D^2$ $= 1{\cdot}327\ 124\ 400\ 179\ 87 \times 10^{20}\ \mathrm{m^3\,s^{-2}}$ (TDB) $= 1{\cdot}327\ 124\ 420\ 76 \times 10^{20}\ \mathrm{m^3\,s^{-2}}$ (SI) $[5 \times 10^{10}]$	J A E
15	Constant of gravitation	$G = 6{\cdot}6742 \times 10^{-11}\ \mathrm{m^3\,kg^{-1}\,s^{-2}}$ $= 6{\cdot}673 \times 10^{-11}\ \mathrm{m^3\,kg^{-1}\,s^{-2}}$ $[1{\cdot}0 \times 10^{-13}]$	C E

Selected Astronomical Constants (continued)

	Quantity	Symbol, Value(s), [Uncertainty]	Refs.
Other constants (continued):			
16	General precession in longitude at J2000·0	$p_A = 5028''.796\ 95$ per Julian century, IAU2000A/IERS $= 5028''.796\ 195$ per Julian century, P03 solution	P P
17	Obliquity of the ecliptic at J2000·0	$\epsilon_0 = 23^\circ\ 26'\ 21''.448 = 84\ 381''.448$ $= 23^\circ\ 26'\ 21''.4059 = 84\ 381''.4059$ $= 23^\circ\ 26'\ 21''.406 = 84\ 381''.406$ $[0''.0003]$	I* I A E P
18	Ratio: mass of Moon to that of the Earth	$\mu = 1/81{\cdot}300\ 56 = 0{\cdot}012\ 300\ 0383$ $[5 \times 10^{-10}]$	E J
19	Ratio: mass of Sun to that of the Earth	$S/E = GS/GE = 332\ 946{\cdot}050\ 895$	J
20	Ratio: mass of Sun to that of the Earth + Moon	$(S/E)/(1+\mu)$ $= 328\ 900{\cdot}561\ 400$	J
21	Mass of the Sun	$S = (GS)/G = 1{\cdot}9884 \times 10^{30}$ kg	
22	Constant of nutation	$N = 9''.2052\ 331$ at epoch J2000·0	I
23	Solar parallax	$\pi_\odot = \sin^{-1}(a_e/A) = 8''.794\ 143$	
24	Constant of aberration	$\kappa = 20''.495\ 51$ at epoch J2000·0	

25 Ratios of mass of Sun to masses of the planets: JPL DE405 Ephemeris (J)

Mercury	6 023 600	Jupiter	1 047·3486	Pluto	135 200 000
Venus	408 523·71	Saturn	3 497·898		
Earth + Moon	328 900·561 400	Uranus	22 902·98		
Mars	3 098 708	Neptune	19 412·24		

26 Minor planet masses: mass in solar mass

	Hilton (H)		JPL DE405 (J)
1 Ceres	$4{\cdot}39 \times 10^{-10}$	±0·04	$4{\cdot}7 \times 10^{-10}$
2 Pallas	$1{\cdot}59 \times 10^{-10}$	±0·05	$1{\cdot}0 \times 10^{-10}$
4 Vesta	$1{\cdot}69 \times 10^{-10}$	±0·11	$1{\cdot}3 \times 10^{-10}$

27 Masses of the larger natural satellites: mass satellite/mass of the planet (see pages F3, F5)

Jupiter	Io	$4{\cdot}70 \times 10^{-5}$	**Saturn**	Titan	$2{\cdot}37 \times 10^{-4}$
	Europa	$2{\cdot}53 \times 10^{-5}$	**Uranus**	Titania	$4{\cdot}06 \times 10^{-5}$
	Ganymede	$7{\cdot}80 \times 10^{-5}$		Oberon	$3{\cdot}47 \times 10^{-5}$
	Callisto	$5{\cdot}67 \times 10^{-5}$	**Neptune**	Triton	$2{\cdot}09 \times 10^{-4}$

28 Equatorial radii in km: *Cartographic Coordinates* (CC) and JPL DE405 Ephemeris (J)

	CC A	JPL		CC A		CC A
Mercury	2 439·7 ± 1·0	2 439·76	Jupiter	71 492 ± 4	Pluto	1 195 ± 5
Venus	6 051·8 ± 1·0	6 052·3	Saturn	60 268 ± 4		
Earth	6 378·14 ± 0·01	6 378·137	Uranus	25 559 ± 4	Moon (mean)	1 737·4 ± 1
Mars	3 396·19 ± 0·1	3 397·515	Neptune	24 764 ± 15	Sun (I*)	696 000

The references (Refs.) indicate where the constant has been used, quoted or derived from:

A	Constants used in this publication.
C	CODATA 2002, http://physics.nist.gov/constants, page 1.
CC	Report of the IAU/IAG Working Group on Cartographic Coordinates & Rotational Elements of Planets and Satellites: 2000 Seidelmann *et al.*, *Celest. Mech.*, **82**, 83-111, 2002, & 2003 report in press 2005.
E	IERS *Conventions 2003*, Technical Note 32, Chapter 1.
G	IAG XXII GA, Special Commission SC3, Fundamental Constants, Groten, E., 1999.
H	Hilton, *Astrophysical Journal*, **117**, 1077-1086, 1999.
I	IAU XXIV General Assembly (2000), resolutions B1.5, B1.6, B1.9, & IAU2000A precession-nutation.
I*	IAU (1976) System of Astronomical Constants.
J	JPL IOM 312.F-98-048, Standish, E.M., 1998 (DE405/LE405 Ephemeris).
P	Capitaine *et al.*, *Astronomy & Astrophysics*, **412**, 567-586, 2003.