

## 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 compatible values are given, which are indicated in brackets.

	Quantity	Symbol, Value(s), [Uncertainty]	Refs.
<b>Defining constants:</b>			
1	Gaussian gravitational constant	$k = 0.017\ 202\ 098\ 95$	I*
2	Speed of light	$c = 299\ 792\ 458\ \text{m s}^{-1}$	C E J A
3	$L_G$	$L_G = 6.969\ 290\ 134 \times 10^{-10}$	I E
4	$L_B$	$L_B = 1.550\ 519\ 767\ 72 \times 10^{-8}$	I <sub>06</sub> E
<b>Other constants and quantities:</b>			
5	$L_C$	$L_C = 1.480\ 826\ 867\ 41 \times 10^{-8}$ [ $2 \times 10^{-17}$ ]	I E
6	Light-time for unit distance	$\tau_A = 499^{\text{s}}004\ 783\ 806\ 1$ (TDB) $= 499^{\text{s}}004\ 786\ 385\ 2$ (SI) [ $2 \times 10^{-8}$ ] $1/\tau_A = 173.144\ 632\ 684\ 7$ au/d (TDB)	J E A
7	Unit distance, astronomical unit in metres	$A = c\tau_A$ $= 149\ 597\ 870\ 691$ m (TDB) $= 149\ 597\ 871\ 464$ m (SI) [6]	J E
8	Equatorial radius for Earth	$a_e = 6\ 378\ 136.6$ m [0.10]	G E A
9	Flattening factor for Earth	$f = 0.003\ 352\ 8197 = 1/298.256\ 42$ [1/0.00001]	G E A
10	Dynamical form-factor for the Earth	$J_2 = 0.001\ 082\ 635\ 9$ [ $1 \times 10^{-10}$ ]	G E
11	Nominal mean angular velocity of Earth rotation	$\omega = 7.292\ 115 \times 10^{-5}$ rad s <sup>-1</sup> [variable]	I E G
12	Potential of the geoid	$W_0 = 6.263\ 685\ 60 \times 10^7$ m <sup>2</sup> s <sup>-2</sup> [0.5]	G E
13	Geocentric gravitational constant	$GE = 3.986\ 004\ 329 \times 10^{14}$ m <sup>3</sup> s <sup>-2</sup> (TDB) $= 3.986\ 004\ 391 \times 10^{14}$ m <sup>3</sup> s <sup>-2</sup> (SI) $= 3.986\ 004\ 418 \times 10^{14}$ m <sup>3</sup> s <sup>-2</sup> [ $8 \times 10^5$ ]	J A G E
14	Heliocentric gravitational constant	$GS = A^3 k^2 / D^2$ $= 1.327\ 124\ 400\ 179\ 87 \times 10^{20}$ m <sup>3</sup> s <sup>-2</sup> (TDB) $= 1.327\ 124\ 420\ 76 \times 10^{20}$ m <sup>3</sup> s <sup>-2</sup> (SI) [ $5 \times 10^{10}$ ]	J A E
15	Constant of gravitation	$G = 6.674\ 28 \times 10^{-11}$ m <sup>3</sup> kg <sup>-1</sup> s <sup>-2</sup> $= 6.673 \times 10^{-11}$ m <sup>3</sup> kg <sup>-1</sup> s <sup>-2</sup> [ $0.067 \times 10^{-13}$ ] and [ $1.0 \times 10^{-13}$ ], respectively	C E

**Selected Astronomical Constants (continued)**

	Quantity	Symbol, Value(s), [Uncertainty]	Refs.
<b>Other constants (continued):</b>			
16	General precession in longitude at J2000-0	$p_A = 5028''.796\ 195$ per Julian century $= 5028''.796\ 95$ per Julian century	I <sub>06</sub> A P P I E
17	Mean obliquity of the ecliptic at J2000-0	$\epsilon_0 = 23^\circ\ 26'\ 21''.406 = 84\ 381''.406$ [0''.0001] $= 23^\circ\ 26'\ 21''.4059 = 84\ 381''.4059$ $= 23^\circ\ 26'\ 21''.448 = 84\ 381''.448$	I <sub>06</sub> A  E I* I
18	Ratio: mass of Moon to that of the Earth	$\mu = 1/81.300\ 56 = 0.012\ 300\ 0383$ [ $5 \times 10^{-10}$ ]	E J
19	Ratio: mass of Sun to that of the Earth	$S/E = GS/GE = 332\ 946.050\ 895$	J
20	Ratio: mass of Sun to that of the Earth + Moon	$(S/E)/(1 + \mu)$ $= 328\ 900.561\ 400$	J
21	Mass of the Sun	$S = (GS)/G = 1.9884 \times 10^{30}$ 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 Venus 408 523.71 Earth + Moon 328 900.561 400 Mars 3 098 708	Jupiter 1 047.3486 Saturn 3 497.898 Uranus 22 902.98 Neptune 19 412.24	Pluto 135 200 000
26	Minor planet masses: mass in solar mass		
	Hilton (H)		JPL DE405 (J)
	1 Ceres $4.39 \times 10^{-10} \pm 0.04$		$4.7 \times 10^{-10}$
	2 Pallas $1.59 \times 10^{-10} \pm 0.05$		$1.0 \times 10^{-10}$
	4 Vesta $1.69 \times 10^{-10} \pm 0.11$		$1.3 \times 10^{-10}$
27	Masses of the larger natural satellites: mass satellite/mass of the planet (see pages F3, F5)		
	<b>Jupiter</b> Io $4.70 \times 10^{-5}$ Europa $2.53 \times 10^{-5}$ Ganymede $7.80 \times 10^{-5}$ Callisto $5.67 \times 10^{-5}$	<b>Saturn</b> Titan $2.37 \times 10^{-4}$ <b>Uranus</b> Titania $4.06 \times 10^{-5}$ Oberon $3.47 \times 10^{-5}$ <b>Neptune</b> Triton $2.09 \times 10^{-4}$	
28	Equatorial radii in km: <i>Cartographic Coordinates</i> (CC) and JPL DE405 Ephemeris (J)		
	CC A Mercury 2 439.7 ± 1.0 Venus 6 051.8 ± 1.0 Earth 6 378.14 ± 0.01 Mars 3 396.19 ± 0.1	JPL 2 439.76 6 052.3 6 378.137 3 397.515	CC A Jupiter 71 492 ± 4 Saturn 60 268 ± 4 Uranus 25 559 ± 4 Neptune 24 764 ± 15 Pluto 1 195 ± 5 Moon (mean) 1 737.4 ± 1 Sun (I*) 696 000

The list below gives the references (Refs.) which indicate where the constants has been used, quoted or derived from. The full references may be found at the end of Section L *Notes and References*, as well as on AsA-Online.

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|----|-------------------------------------|-----------------|----------------------------|
| A  | Constants used in this publication. |                 |                            |
| C  | CODATA 2006.                        | I <sub>06</sub> | IAU XXV GA 2006.           |
| CC | IAU/IAG WGCCRE 2007.                | I               | IAU XXIV GA 2000.          |
| E  | IERS Conventions 2003 (IAU 2000).   | I*              | IAU 1976.                  |
| G  | IAG XXII GA 1999, SC3.              | J               | JPL DE405/LE405 Ephemeris. |
| H  | Hilton, ApJ., 1999.                 | P               | Capitaine, A&A 2003.       |