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., $A^3S^{-1}D^{-2}$.

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.
Defining constants:			
1	Speed of light	$c = 299\,792\,458$ m s^{-1}	C E J A
2	Gaussian gravitational constant	$k = 0{\cdot}017\,202\,098\,95$	I* A
3	L_G	$L_G = 6{\cdot}969\,290\,134 \times 10^{-10}$	I E
4	L_B	$L_B = 1{\cdot}550\,519\,768 \times 10^{-8}$	I_{06}
5	Rate of advance of Earth rotation angle (ERA)	$\dot{\theta} = 1{\cdot}002\,737\,811\,911\,354\,48$ revolutions per UT1 day	I A
Other constants and quantities:			
6	L_C	$L_C = 1{\cdot}480\,826\,867\,41 \times 10^{-8}$ [2×10^{-17}]	I E
7	Light-time for unit distance	$\tau_A = 499^s{\cdot}004\,783\,806\,1$ (TDB) $= 499^s{\cdot}004\,786\,385\,2$ (SI) [2×10^{-8}] $1/\tau_A = 173{\cdot}144\,632\,684\,7$ au/d (TDB)	J E A
8	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
9	Equatorial radius for Earth	$a_e = 6\,378\,136{\cdot}6$ m [0·10]	G E A
10	Flattening factor for Earth	$f = 0{\cdot}003\,352\,8197 = 1/298{\cdot}256\,42$ [1/0·00001]	G E A
11	Dynamical form-factor for the Earth	$J_2 = 0{\cdot}001\,082\,635\,9$ [1×10^{-10}]	G E
12	Nominal mean angular velocity of Earth rotation	$\omega = 7{\cdot}292\,115 \times 10^{-5}$ rad s^{-1}	I E G
13	Potential of the geoid	$W_0 = 6{\cdot}263\,685\,60 \times 10^7$ m^2 s^{-2} [0·5]	G E
14	Geocentric gravitational constant	$GE = 3{\cdot}986\,004\,329 \times 10^{14}$ m^3 s^{-2} (TDB) $= 3{\cdot}986\,004\,391 \times 10^{14}$ m^3 s^{-2} (SI) $= 3{\cdot}986\,004\,418 \times 10^{14}$ m^3 s^{-2} (SI) [8×10^5]	J A G E
15	Heliocentric gravitational constant	$GS = A^3k^2/D^2$ $= 1{\cdot}327\,124\,400\,179\,87 \times 10^{20}$ m^3 s^{-2} (TDB) $= 1{\cdot}327\,124\,420\,76 \times 10^{20}$ m^3 s^{-2} (SI) [5×10^{10}]	J A E
16	Constant of gravitation	$G = 6{\cdot}674\,28 \times 10^{-11}$ m^3 kg^{-1} s^{-2} $= 6{\cdot}673 \times 10^{-11}$ m^3 kg^{-1} s^{-2} [$0{\cdot}067 \times 10^{-13}$] and [$1{\cdot}0 \times 10^{-13}$], respectively	C E

Selected Astronomical Constants (continued)

	Quantity	Symbol, Value(s), [Uncertainty]	Refs.
Other constants (continued):			
17	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
18	Ratio: mass of Sun to that of the Earth	$S/E = GS/GE = 332\ 946{\cdot}050\ 895$	J
19	Ratio: mass of Sun to that of the Earth + Moon	$(S/E)/(1+\mu)$ $= 328\ 900{\cdot}561\ 400$	J
20	Mass of the Sun	$S = GS/G = 1{\cdot}9884 \times 10^{30}$ kg	J
21	Mass of the Earth	$E = GE/G = 5{\cdot}972\ 1986 \times 10^{24}$ kg	J
22	Mean obliquity of the ecliptic at J2000	$\epsilon_0 = 23^\circ\ 26'\ 21\overset{''}{.}406 = 84\ 381\overset{''}{.}406$	I_{06} A
23	Rates of precession (TDB) at J2000·0		I_{06} A
	General precession in longitude	$p_A = 5028\overset{''}{.}796\ 195$ per Julian century	
	Rate of change in obliquity	$\dot{\epsilon} = -46\overset{''}{.}836\ 769$ per Julian century	
	Precession of the equator in longitude	$\dot{\psi} = 5038\overset{''}{.}481\ 507$ per Julian century	
	Precession of the equator in obliquity	$\dot{\omega} = -0\overset{''}{.}025\ 754$ per Julian century	
24	Constant of nutation	$N = 9\overset{''}{.}2052\ 331$ at epoch J2000	I
25	Solar parallax	$\pi_\odot = \sin^{-1}(a_e/A) = 8\overset{''}{.}794\ 143$	A
26	Constant of aberration	$\kappa = 20\overset{''}{.}495\ 51$ at epoch J2000	

27 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		

28 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	$1{\cdot}3 \times 10^{-10}$

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

Jupiter	Io	$4{\cdot}704 \times 10^{-5}$	**Saturn**	Titan	$2{\cdot}366 \times 10^{-4}$
	Europa	$2{\cdot}528 \times 10^{-5}$	**Uranus**	Titania	$4{\cdot}06 \times 10^{-5}$
	Ganymede	$7{\cdot}805 \times 10^{-5}$		Oberon	$3{\cdot}47 \times 10^{-5}$
	Callisto	$5{\cdot}667 \times 10^{-5}$	**Neptune**	Triton	$2{\cdot}089 \times 10^{-4}$

30 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 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 *The Astronomical Almanac Online*. The IAU WG on Numerical Standards for Fundamental Astronomy is developing a list of "Current Best Estimates" (see http://maia.usno.navy.mil/NSFA.html) where some of these and other constants make be found.

A	Constants used in this publication.	H	Hilton, AJ, 1999.
C	CODATA 2006.	I_{06}	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.