D.2   Planetary Constants

Besides defining the Earth's physical parameters, it's also useful to define constants for the remaining planets and the Sun. Table D-3 shows data for the Sun.

TABLE D-3.   Solar Constants. These solar constants are from Seidelmann (1992, 696–697, 700). The value for the semimajor axis, $a_\oplus$, of the Earth's orbit and the time-unit value for the Sun are derived quantities.

Distance			Speed		
$(R_\odot)$ 1.0 SR	696,000.000	km	1.0 AU/ $TU_\odot$	29.784 691 674 9	km /solar s
1.0 AU	149,597,870.0	km	**Gravitational Parameter**		
$a_\oplus$	149,598,023.0	km	$(\mu_\odot)$ 1.0 $AU^3/TU^2_\odot$	1.327 124 28×10^{11}	km^3/(solar s)^2
Shape			**Rotation**		
Mass	332,946 Earth masses			25.38	solar days
	1.9891×10^{30}	kg	**Time**		
			1.0 TU	58.132 440 906	solar days

Table D-4 and Table D-5 list data for the planets. Notice that using canonical units allows identical routines for the Earth, as well as other planets. Once we've found the defining physical parameters, the equations and routines are exactly the same, except for the gravitational potential. I discuss a way to obtain planetary positions in Sec. 5.3.1. Knowing the orbital elements for each planet is important when analyzing interplanetary problems. Many algorithms require knowing the physical parameters of the Sun, Moon, and planets.

TABLE D-4. Mean Planetary Constants For Epoch J2000. All values for the top section are from Seidelmann (1992, 704). Values for the lower section are from Seidelmann (1992, 706). The values for gravitational parameters come from Seidelmann (1992, 700).

	Moon	Mercury	Venus	Earth	Mars
Symbol	$\mathbb{C}$	$\male$... ☿	♀	$\oplus$	♂
Semimajor axis, AU*	60.27 ER	0.387 098 309	0.723 329 82	1.000 001 017 8	1.523 679 34
km	384,400	57,909,083	108,208,601	149,598,023	227,939,186
Eccentricity	0.054 90	0.205 631 752	0.006 771 882	0.016 708 617	0.093 400 620
Inclination (°)	5.145 396	7.004 986 25	3.394 466 19	0.000 000 00	1.849 726 48
Longitude of ascending node (°)	0.0	48.330 893 04	76.679 920 19	0.000 000 00	49.558 093 21
Longitude of perihelion (°)	0.0	77.456 119 04	131.563 707 24	102.937 348 08	336.060 233 98
True longitude (°)	0.0	252.250 905 51	181.979 800 84	100.466 448 51	355.433 274 63
Orbital period (yrs)	0.0	0.240 844 45	0.615 182 57	0.999 978 62 / 365.242 189 7 dy	1.880 711 05
Orbital velocity (km/s)	0.0	47.8725	35.0214	29.7859	24.1309
Equatorial radius (km)	1738.	2439.	6052.	6378.1363	3397.2
Reciprocal flattening				0.003 353 813 1	0.006 476 30
Gravitational parameter (km^3/s^2)	4902.799	2.2032×10^4	3.257×10^5	$3.986\ 004\ 415\times10^5$	4.305×10^4
Mass ($m_\oplus =1$)	0.012 30	0.055 274 3	0.8150	1.0	0.107 44
Mass (kg)	7.3483×10^{22}	3.3022×10^{23}	4.869×10^{24}	5.9742×10^{24}	6.4191×10^{23}
Rotation (days)	27.321 66	58.6462	−243.01	0.997 269 68	1.025 956 75
Inclination of Equator to orbit (°)	6.68	0.0	177.3	23.45	25.19
J_2	0.000 202 7	0.000 06	0.000 027	0.001 082 626 9	0.001 964
J_3				−0.000 002 532 3	0.000 036
J_4				−0.000 001 620 4	
Density (gm/cm^3)	3.34	5.43	5.24	5.515	3.94

* 1 AU = 149,597,870 km.

TABLE D-5. Mean Planetary Constants For Epoch J2000. All values for the top section are from Seidelmann (1992, 704). Values for the lower section are from Seidelmann (1992, 706). The values for gravitational parameters come from Seidelmann (1992, 700).

	Jupiter	Saturn	Uranus	Neptune	Pluto
Symbol	♃	♄	♅	♆	♇
Semimajor axis, AU*	5.202 603 191	9.554 909 595	19.218 446 061	30.110 386 87	39.544 674
km	778,298,361	1,429,394,133	2,875,038,615	4,504,449,769	5,915,799,000
Eccentricity	0.0484 948 51	0.055 508 622	0.046 295 898	0.008 988 095	0.249 050
Inclination (°)	1.303 269 66	2.488 878 10	0.773 196 17	1.769 952 21	17.142 166 67
Longitude of ascending node (°)	100.464 440 64	113.665 523 70	74.005 947 23	131.784 057 02	110.297 138 89
Longitude of perihelion (°)	14.331 309 24	93.056 787 28	173.005 159 22	48.123 690 50	224.134 861 11
True longitude (°)	34.351 483 92	50.077 471 38	314.055 005 11	304.348 665 48	238.743 944 44
Orbital period (yrs)	11.856 525	29.423 519	83.747 406	163.723 2045	248.020 8
Orbital velocity (km/s)	13.0697	9.6724	6.835 24	5.4778	4.7490
Equatorial radius (km)	71,492.	60,268.	25,559.	24,764.	1151.
Reciprocal flattening	0.064 874 4	0.097 962 4	0.022 927 3	0.0171	0.0
Gravitational parameter (km^3/s^2)	1.268×10^8	3.794×10^7	5.794×10^6	6.809×10^6	9.00×10^2
Mass ($m_\oplus$ =1)	318.0	95.159	14.4998	17.203	0.00251
Mass (kg)	1.8988×10^{27}	5.685×10^{26}	8.6625×10^{25}	1.0278×10^{26}	1.5×10^{22}
Rotation (days)	0.413 54	0.4375	−0.65	0.768	−6.3867
Inclination of Equator to orbit (°)	3.12	26.73	97.86	29.56	118.0
J_2	0.014 75	0.016 45	0.012	0.004	
J_3	−0.000 58	−0.001			
J_4					
Density (gm/cm^3)	1.33	0.70	1.30	1.76	1.1

* 1 AU = 149,597,870 km.

JGM-2 Constants & Conversions

We can use the four fundamental defining parameters (shaded cells) to recalculate this table as newer coefficients are determined. Underlined digits indicate extra precision in the conversion beyond the significant digits contained in the base values.

Mean Equatorial Radius			Shape	
$(R_\oplus)$ 1.0 ER	6,378.1363	km	Mass	5.973 332 8x10^{24} kg
	20,925,644.028 871 3	ft	$(b_\oplus)$ Semi-minor axis	6,356.751 600 562 9 km
	3963.190 156 983	miles	$(e_\oplus)$ Earth eccentricity	0.081 819 221 456
	3443.918 088 553	nm	$e_\oplus^2$	0.006 694 385 000
Time				
1.0 TU	13.446 849 855 11	solar min	(f) Earth flattening	1.0 / 298.257
	806.810 991 306 73	solar s	J_2	0.001 082 626 9
	0.009 338 090 177 16	solar day	J_3	−0.000 002 532 3
	0.009 363 657 021 58	sidereal days	J_4	−0.000 001 620 4
1.0 Solar Day	1.002 737 909 350 795	sidereal days	$\bar{C}_{2,0}$	−484.165 466 3x10^{-6}
Speed				
1.0 ER/TU	25,936.240 649 101 294	ft / solar s		
	7.905 366 149 846	km / solar s		
Gravitational Parameter			**Conversions & Constants**	
(μ) 1.0 ER^3/TU^2	398,600.441 5	km^3 / (solar s)^2	1.0 ft	0.304 8 m exact
	14,076,441,746,610,709.60	ft^3 / (solar s)^2	1.0 mile	1.609 344 km exact
Rotation			1.0 mile	5280 ft exact
$\omega_\oplus$	0.000 072 921 158 553 0	rad / solar sec	1.0 nm	1.852 km exact
	0.058 833 599 801 549 19	rad / TU	$\pi/2$	1.570 796 326 794 90
	0.250 684 477 337 462 15	deg / solar min	π	3.141 592 653 589 79
1.0°/ solar s	1.0/0.071 015 111 031 520 1	rad / TU	2π	6.283 185 307 179 59
	6.300 388 098 665 74	rad / solar day	1.0 radian	57.295 779 513 082 30°