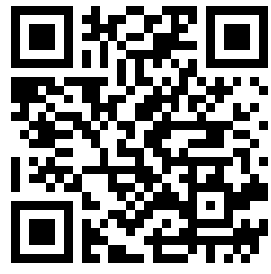

ALMANAC FOR COMPUTERS 1990

Almanac for Computers 1990

Nautical Almanac Office
United States Naval Observatory
Washington, DC 20392

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Section A: EXPLANATION

Introduction

The *Almanac for Computers* provides astronomical data in a form to facilitate the application of small computers and calculators to navigation and positional astronomy. Instead of the fixed-interval tabulations of traditional almanacs, concise mathematical expressions are used to represent the coordinates of celestial bodies for specified intervals of time. These expressions are necessarily approximations, because the fundamental equations of dynamical astronomy are too complex for direct use in the majority of applications. With minimal loss of precision the expressions in this volume will allow direct calculation of astronomical and navigational data for specific times and conditions. Further information concerning precision is given in Tables 1, 2 and 3 (pages A7, A9, A11).

The data in Sections C, D and E are available on magnetic tape and floppy disk. Inquiries should be addressed to The Director, Nautical Almanac Office, U. S. Naval Observatory, Washington, DC 20392.

The first *Almanac for Computers* was produced for the year 1977. During its initial decade the almanac evolved some, without undergoing radical change. Such stability is due in part to the adoption of the almanac in important production programs. Since major modifications would discomfit some users, we have been conservative about introducing new ideas. Furthermore, the format of the *Almanac for Computers* is inconvenient for general use on microcomputers, though it continues to be useful for certain applications.

Specifically designed for microcomputers is the *Floppy Almanac*, an integrated package of software and astronomical data on a floppy disk. It provides high precision astronomical and navigational data for specific times and locations. Like the *Almanac for Computers* it only covers a year at a time. Under development, however, is the *Interactive Computer Ephemeris*, which will cover the years 1800–2050. Versions are being prepared for IBM PCs and clones with at least 384 Kbytes of RAM, the DEC MicroVAX II and IBM 370, 43xx and 30xx computers running under VM/CMS. A version for Macintosh computers with at least 1 Mbyte of RAM is being developed. Information about these may be obtained by writing to the Nautical Almanac Office, Code FA, U. S. Naval Observatory, Washington, DC 20392.

This edition of the *Almanac for Computers* was prepared by LeRoy E. Doggett, William J. Tangren and Stephen P. Panossian.

	JANUARY		FEBRUARY		MARCH		APRIL		MAY		JUNE	
Day of Month	Day of Week	Day of Year	Day of Week	Day of Year	Day of Week	Day of Year	Day of Week	Day of Year	Day of Week	Day of Year	Day of Week	Day of Year
1	Mon.	1	Thu.	32	Thu.	60	Sun.	91	Tue.	121	Fri.	152
2	Tue.	2	Fri.	33	Fri.	61	Mon.	92	Wed.	122	Sat.	153
3	Wed.	3	Sat.	34	Sat.	62	Tue.	93	Thu.	123	Sun.	154
4	Thu.	4	Sun.	35	Sun.	63	Wed.	94	Fri.	124	Mon.	155
5	Fri.	5	Mon.	36	Mon.	64	Thu.	95	Sat.	125	Tue.	156
6	Sat.	6	Tue.	37	Tue.	65	Fri.	96	Sun.	126	Wed.	157
7	Sun.	7	Wed.	38	Wed.	66	Sat.	97	Mon.	127	Thu.	158
8	Mon.	8	Thu.	39	Thu.	67	Sun.	98	Tue.	128	Fri.	159
9	Tue.	9	Fri.	40	Fri.	68	Mon.	99	Wed.	129	Sat.	160
10	Wed.	10	Sat.	41	Sat.	69	Tue.	100	Thu.	130	Sun.	161
11	Thu.	11	Sun.	42	Sun.	70	Wed.	101	Fri.	131	Mon.	162
12	Fri.	12	Mon.	43	Mon.	71	Thu.	102	Sat.	132	Tue.	163
13	Sat.	13	Tue.	44	Tue.	72	Fri.	103	Sun.	133	Wed.	164
14	Sun.	14	Wed.	45	Wed.	73	Sat.	104	Mon.	134	Thu.	165
15	Mon.	15	Thu.	46	Thu.	74	Sun.	105	Tue.	135	Fri.	166
16	Tue.	16	Fri.	47	Fri.	75	Mon.	106	Wed.	136	Sat.	167
17	Wed.	17	Sat.	48	Sat.	76	Tue.	107	Thu.	137	Sun.	168
18	Thu.	18	Sun.	49	Sun.	77	Wed.	108	Fri.	138	Mon.	169
19	Fri.	19	Mon.	50	Mon.	78	Thu.	109	Sat.	139	Tue.	170
20	Sat.	20	Tue.	51	Tue.	79	Fri.	110	Sun.	140	Wed.	171
21	Sun.	21	Wed.	52	Wed.	80	Sat.	111	Mon.	141	Thu.	172
22	Mon.	22	Thu.	53	Thu.	81	Sun.	112	Tue.	142	Fri.	173
23	Tue.	23	Fri.	54	Fri.	82	Mon.	113	Wed.	143	Sat.	174
24	Wed.	24	Sat.	55	Sat.	83	Tue.	114	Thu.	144	Sun.	175
25	Thu.	25	Sun.	56	Sun.	84	Wed.	115	Fri.	145	Mon.	176
26	Fri.	26	Mon.	57	Mon.	85	Thu.	116	Sat.	146	Tue.	177
27	Sat.	27	Tue.	58	Tue.	86	Fri.	117	Sun.	147	Wed.	178
28	Sun.	28	Wed.	59	Wed.	87	Sat.	118	Mon.	148	Thu.	179
29	Mon.	29			Thu.	88	Sun.	119	Tue.	149	Fri.	180
30	Tue.	30			Fri.	89	Mon.	120	Wed.	150	Sat.	181
31	Wed.	31			Sat.	90			Thu.	151		

JULIAN DATE, 1990

0^hUT				0^hUT				0^hUT				0^hUT			
Jan.	0	244	7891·5	Apr.	0	244	7981·5	July	0	244	8072·5	Oct.	0	244	8164·5
Feb.	0	244	7922·5	May	0	244	8011·5	Aug.	0	244	8103·5	Nov.	0	244	8195·5
Mar.	0	244	7950·5	June	0	244	8042·5	Sept.	0	244	8134·5	Dec.	0	244	8225·5

400-day date: JD 244 8000·5 = 1990 Apr. 19·0

	JULY		AUGUST		SEPTEMBER		OCTOBER		NOVEMBER		DECEMBER	
Day of Month	Day of Week	Day of Year	Day of Week	Day of Year	Day of Week	Day of Year	Day of Week	Day of Year	Day of Week	Day of Year	Day of Week	Day of Year
1	Sun.	182	Wed.	213	Sat.	244	Mon.	274	Thu.	305	Sat.	335
2	Mon.	183	Thu.	214	Sun.	245	Tue.	275	Fri.	306	Sun.	336
3	Tue.	184	Fri.	215	Mon.	246	Wed.	276	Sat.	307	Mon.	337
4	Wed.	185	Sat.	216	Tue.	247	Thu.	277	Sun.	308	Tue.	338
5	Thu.	186	Sun.	217	Wed.	248	Fri.	278	Mon.	309	Wed.	339
6	Fri.	187	Mon.	218	Thu.	249	Sat.	279	Tue.	310	Thu.	340
7	Sat.	188	Tue.	219	Fri.	250	Sun.	280	Wed.	311	Fri.	341
8	Sun.	189	Wed.	220	Sat.	251	Mon.	281	Thu.	312	Sat.	342
9	Mon.	190	Thu.	221	Sun.	252	Tue.	282	Fri.	313	Sun.	343
10	Tue.	191	Fri.	222	Mon.	253	Wed.	283	Sat.	314	Mon.	344
11	Wed.	192	Sat.	223	Tue.	254	Thu.	284	Sun.	315	Tue.	345
12	Thu.	193	Sun.	224	Wed.	255	Fri.	285	Mon.	316	Wed.	346
13	Fri.	194	Mon.	225	Thu.	256	Sat.	286	Tue.	317	Thu.	347
14	Sat.	195	Tue.	226	Fri.	257	Sun.	287	Wed.	318	Fri.	348
15	Sun.	196	Wed.	227	Sat.	258	Mon.	288	Thu.	319	Sat.	349
16	Mon.	197	Thu.	228	Sun.	259	Tue.	289	Fri.	320	Sun.	350
17	Tue.	198	Fri.	229	Mon.	260	Wed.	290	Sat.	321	Mon.	351
18	Wed.	199	Sat.	230	Tue.	261	Thu.	291	Sun.	322	Tue.	352
19	Thu.	200	Sun.	231	Wed.	262	Fri.	292	Mon.	323	Wed.	353
20	Fri.	201	Mon.	232	Thu.	263	Sat.	293	Tue.	324	Thu.	354
21	Sat.	202	Tue.	233	Fri.	264	Sun.	294	Wed.	325	Fri.	355
22	Sun.	203	Wed.	234	Sat.	265	Mon.	295	Thu.	326	Sat.	356
23	Mon.	204	Thu.	235	Sun.	266	Tue.	296	Fri.	327	Sun.	357
24	Tue.	205	Fri.	236	Mon.	267	Wed.	297	Sat.	328	Mon.	358
25	Wed.	206	Sat.	237	Tue.	268	Thu.	298	Sun.	329	Tue.	359
26	Thu.	207	Sun.	238	Wed.	269	Fri.	299	Mon.	330	Wed.	360
27	Fri.	208	Mon.	239	Thu.	270	Sat.	300	Tue.	331	Thu.	361
28	Sat.	209	Tue.	240	Fri.	271	Sun.	301	Wed.	332	Fri.	362
29	Sun.	210	Wed.	241	Sat.	272	Mon.	302	Thu.	333	Sat.	363
30	Mon.	211	Thu.	242	Sun.	273	Tue.	303	Fri.	334	Sun.	364
31	Tue.	212	Fri.	243			Wed.	304			Mon.	365

MEAN SIDEREAL TIME, 1990

Greenwich mean sidereal time at 0^hUT

	h		h		h		h
Jan. 0	06·6265	Apr. 0	12·5404	July 0	18·5200	Oct. 0	00·5653
Feb. 0	08·6635	May 0	14·5117	Aug. 0	20·5570	Nov. 0	02·6023
Mar. 0	10·5034	June 0	16·5487	Sept. 0	22·5940	Dec. 0	04·5736

Navigational Tables

Section C contains mathematical representations of the following functions that are tabulated in the *Nautical Almanac* (*NA*): the GHA of Aries, the GHA and declination of the Sun, Moon and navigational planets, the semidiameter of the Sun and Moon, and the horizontal parallax of the Moon. Except in the case of the Moon, each quantity is expressed for a specified time span by a power series of the form

$$f(x) = a_0 + a_1x + a_2x^2 + a_3x^3 + a_4x^4 + a_5x^5.$$

For the Moon there are two additional terms, a_6x^6 and a_7x^7, that must be added to the series. In the series x is a time-like variable that takes on values between –1 and +1 over the specified time span; a_0, a_1, a_2, etc., are coefficients that are tabulated in Section C for the specified time span; and $f(x)$ represents the value of the function (e.g., the GHA of Aries) evaluated at time x.

To evaluate the series for one of the navigational functions, one must first find the set of coefficients in Section C that is applicable for the desired date. Constants A and W are given for the purpose of converting the calendar date and UT (formerly called GMT, see page A7) to the time-like variable x. First compute t, the UT measured in days from the beginning of the month:

$$t = d + \mathrm{UT}/24,$$

where d is the day of the month at Greenwich and UT is expressed in hours. A calendar is provided on pages A2–A3. Once t has been determined, x can be computed from the relation

$$x = ((t - W)/A) - 1.$$

If computed correctly, the value of x will fall in the range $-1 \le x \le +1$.

Example 1: Compute x for later use in computing the position of the Moon on 11 November at $11^h11^m11^s$ UT ($=0^d.4660995$).

$t = 11 + 0.4660995$.

Constants for this date are found on page C18: $A = 4$ and $W = 9$.

Therefore, $x = ((11.4660995 - 9)/4) - 1 = -0.3834751$.

Once the variable x has been computed and the coefficients a_i have been found, the series can be evaluated most efficiently by computing a set of auxiliary variables, b_1, b_2, b_3, b_4, b_5 (with additional variables b_6, b_7 for the Moon), in the following order:

For the Moon: $b_7 = xa_7$

For the Sun, Aries, and planets: $b_5 = xa_5$

$b_6 = x(a_6 + b_7)$

$b_5 = x(a_5 + b_6)$

Then for all objects:

$$b_4 = x(a_4 + b_5)$$
$$b_3 = x(a_3 + b_4)$$
$$b_2 = x(a_2 + b_3)$$
$$b_1 = x(a_1 + b_2)$$
$$f(x) = a_0 + b_1$$

This algorithm evaluates the series in its nested form. For the Sun, Aries and the planets, which have six coefficients per series, this amounts to writing the series in the form

$$f(x) = a_0 + x(a_1 + x(a_2 + x(a_3 + x(a_4 + xa_5)))).$$

Example 2: Compute the declination of the Moon at $11^h11^m11^s$ UT on 11 November 1990.

From the previous example $x = -0.3834751$. The coefficients for the Moon's declination are found on page C16.

$b_7 = -0.3834751\ (-0.0081) = +0.0031$
$b_6 = -0.3834751\ (-0.0430 + 0.0031) = +0.0153$
$b_5 = -0.3834751\ (+0.1202 + 0.0153) = -0.0520$
$b_4 = -0.3834751\ (-0.1058 - 0.0520) = +0.0605$
$b_3 = -0.3834751\ (+1.9701 + 0.0605) = -0.7787$
$b_2 = -0.3834751\ (+2.1641 - 0.7787) = -0.5313$
$b_1 = -0.3834751\ (-21.8514 - 0.5313) = +8.5832$
$f(-0.3834751) = -4.6108 + 8.5832 = +3.9724$
declination $= +3°58'.3$

Example 3: Compute the GHA of Venus on 28 April 1990 at $9^h30^m00^s$ UT.

The constants A and W and the series coefficients are found on page C3.

$x = ((t - W)/A) - 1 = ((28.3958333 - 1)/16) - 1 = +0.7122396$

$b_5 = +0.7122396\ (-0.0003) = -0.0002$
$b_4 = +0.7122396\ (-0.0208 - 0.0002) = -0.0150$
$b_3 = +0.7122396\ (+0.0557 - 0.0150) = +0.0290$
$b_2 = +0.7122396\ (-0.1512 + 0.0290) = -0.0870$
$b_1 = +0.7122396\ (+5759.2595 - 0.0870) = +4101.9106$
$f(+0.7122396) = +5982.1754 + 4101.9106 = +10084.0860$
GHA $= 4°.0860 = 4°05'.2$

Note that when computing the GHA, it may be necessary to reduce the final result to the range 0°–360° by subtracting multiples of 360°.

Although the series are designed to provide precision comparable to that published in the *NA*, there will be small discrepancies between the tabulated values and the values computed from the series. In such cases it should be understood that the *NA* represents the standard. Table 1 lists the largest discrepancies found from evaluating and comparing the series with the data in the *NA*.

Under no circumstances should the series be used to extrapolate data beyond the specified time intervals. Extrapolation will lead to erroneous and useless results.

In accordance with current practice in navigational almanacs, the time argument used in this almanac is UT (universal time), or more specifically UT1, which has replaced the old, ambiguous GMT (Greenwich Mean Time). To obtain full precision in the determined positions, radio time signals in UTC must be corrected to UT1, according to standard procedures. (For details, see the paper by R. L. Duncombe and P. K. Seidelmann, "The New UTC Time Signals," *Navigation*, **24**, 160–165, 1977.)

Beneath each set of coefficients in Section C is printed the sum of the coefficients. As a check on whether the coefficients have been entered accurately into the calculator, it is recommended that the coefficients be summed and that the resulting sum be compared with the printed sum.

Table 1: Comparison of *Almanac for Computers* with *NA*

Function		No. of Terms	Span of Validity	Maximum Error (′)
GHA of Aries		6	32 days	0.1
Sun:	GHA	"	"	0.1
	Declination	"	"	0.1
	Semidiameter	"	"	0.1
Moon:	GHA	8	8 days	0.2
	Declination	"	"	0.1
	Horizontal Parallax	"	"	0.1
	Semidiameter	"	"	0.1
Navigational Planets:	GHA	6	32 days	0.1
	Declination	"	"	0.1

Astronomical Tables

Section D contains mathematical representations of data published in the *Astronomical Almanac* (A^2). Chebyshev expansions have been chosen as the means of representation since they provide efficient and accurate expressions that can be easily evaluated with a small computer. The coefficients a_i of the Chebyshev expansion

$$f(x) = a_0/2 + \sum_{i=1}^{n} a_i T_i(x)$$

are tabulated for prescribed time spans, where $f(x)$ is the function being represented, $T_i(x)$ is the Chebyshev polynomial of the first kind of the *i-th* degree, and x is the normalized time variable. Although Chebyshev polynomials appear in the series expansions, the series can be evaluated without explicitly computing these polynomials. No *a priori* knowledge of Chebyshev analysis is required to use the series in this almanac. Interested readers can find information on Chebyshev analysis in *Applied Analysis* by C. Lanczos and *Chebyshev Polynomials in Numerical Analysis* by L. Fox and I. B. Parker.

It must be emphasized that the series are valid only over the specified time intervals. Attempts to extrapolate data using these series will yield erroneous and useless results.

If precision comparable to that of the A^2 is required, the series on pages D2–D29 should be used. With the exception of the series for the Moon, these series are valid for time spans of approximately three months; for the Moon the span of validity is approximately one month. Table 2 lists the largest errors found by evaluating these series and comparing the results with data printed in the A^2.

It is possible to develop series that are valid for longer time spans if the precision requirements are relaxed. Such series, valid for one full year, are given on pages D30–D33. Precision criteria of these less precise series are summarized in Table 3.

To evaluate a Chebyshev series, one must first normalize the time variable on the interval for which the series is valid. The normalized time x can be determined from the relation

$$x = ((t - W)/A) - 1,$$

where t is reckoned in days and fractions thereof from 0 January. As in previous editions, constants A and W are given for each set of coefficients. If correctly computed, the value of x will fall in the range $-1 \le x \le +1$.

For the functions Apparent Sidereal Time at 0^h UT, Equation of the Equinoxes, Nutation in Longitude and Nutation in Obliquity, the variable t is measured in

Table 2: Comparison of *Almanac for Computers* with A^2 (High Precision Series, pp. D2–D29)

Function		No. of Terms	Span of Validity	Maximum Error
Apparent Sidereal Time at 0^h UT		34	95 days	$0^s.001$
Equation of the Equinoxes		"	"	$0^s.001$
Nutation in Longitude		"	"	$0''.02$
Nutation in Obliquity		"	"	$0''.01$
Sun:	Right Ascension	20	95 days	$0^s.02$
	Declination	"	"	$0''.1$
	Distance	"	"	4×10^{-7} au
	Semidiameter	"	"	$0''.01$
	Ephemeris Transit	"	"	$0^s.01$
Moon:	Right Ascension	34	32 days	$0^s.02$
	Declination	"	"	$0''.1$
	Horizontal Parallax	"	"	$0''.01$
	Geocentric Rectangular Coords.	"	"	1×10^{-6} Earth radii
Mercury:	Right Ascension	32	95 days	$0^s.01$
	Declination	"	"	$0''.1$
	Distance	"	"	1×10^{-6} au
Venus:	Right Ascension	32	95 days	$0^s.01$
	Declination	"	"	$0''.1$
	Distance	"	"	1×10^{-6} au
Mars:	Right Ascension	20	95 days	$0^s.04$
	Declination	"	"	$0''.1$
	Distance	"	"	1×10^{-6} au
Jupiter:	Right Ascension	20	95 days	$0^s.02$
	Declination	"	"	$0''.1$
	Distance	"	"	2×10^{-6} au
Saturn:	Right Ascension	20	95 days	$0^s.02$
	Declination	"	"	$0''.1$
	Distance	"	"	1×10^{-5} au
Uranus:	Right Ascension	20	95 days	$0^s.02$
	Declination	"	"	$0''.2$
	Distance	"	"	1×10^{-5} au
Neptune:	Right Ascension	12	95 days	$0^s.02$
	Declination	"	"	$0''.2$
	Distance	"	"	1×10^{-5} au
Pluto:	Right Ascension (astrometric)	12	95 days	$0^s.01$
	Declination (astrometric)	"	"	$0''.1$
	Distance	"	"	1×10^{-5} au

days of universal time (UT1 to be precise) from 0 January, 0^h UT. For all other functions in Section D, t is measured in days of terrestrial dynamical time (TDT) from 0 January, 0^h TDT. These latter functions can be evaluated for universal time, however, using the normalizing relation $x = (((t' + \Delta t) - W)/A) - 1$, where t' is the universal time measured in days from 0 January, 0^h UT. As this volume goes to press, $\Delta t = 57^s.2$ ($=0^d.000662$) appears to be a reliable value to use in 1990. Care should be taken to verify that the sum $t' + \Delta t$ falls within the time span for which the series is valid; if it falls outside, the series and constants for the next span should be used.

Once the normalized time variable x is determined, the series can be evaluated as follows:

let $b_{n+1} = b_{n+2} = 0,$

compute $b_i = 2xb_{i+1} - b_{i+2} + a_i,$ for $i = n, n-1, \ldots, 0,$

then $f(x) = (b_0 - b_2)/2.$

Example: Compute the nutation in obliquity to a precision of $\pm 0''.3$ on 16 October 1990 at $13^h45^m00^s$ UT.

As shown in Table 3, the low precision series on page D30 provides the required precision. Since universal time is the independent variable for nutation in obliquity,

$t = 289^d + 0^d.572917 = 289^d.572917.$

Constants for the series are $A = 183.0$ and $W = 1$.

$x = (t - W)/A - 1 = (289.572917 - 1)/183.0 - 1 = +0.576901$

$b_{n+2} = b_{11} = 0$

$b_{n+1} = b_{10} = 0$

b_9	$=$	$2xb_{10}$	$- b_{11}$	$+ a_9$	$=$	-0.0266
b_8	$=$	$2xb_9$	$- b_{10}$	$+ a_8$	$=$	-0.0950
b_7	$=$	$2xb_8$	$- b_9$	$+ a_7$	$=$	-0.1831
b_6	$=$	$2xb_7$	$- b_8$	$+ a_6$	$=$	$+0.1778$
b_5	$=$	$2xb_6$	$- b_7$	$+ a_5$	$=$	$+0.4542$
b_4	$=$	$2xb_5$	$- b_6$	$+ a_4$	$=$	-0.0020
b_3	$=$	$2xb_4$	$- b_5$	$+ a_3$	$=$	-0.4258
b_2	$=$	$2xb_3$	$- b_4$	$+ a_2$	$=$	-0.8362
b_1	$=$	$2xb_2$	$- b_3$	$+ a_1$	$=$	-1.8258
b_0	$=$	$2xb_1$	$- b_2$	$+ a_0$	$=$	$+9.9767$

$f(x) = (b_0 - b_2)/2 = (9.9767 + 0.8362)/2$

Nutation in obliquity $= +5''.4$

Beneath each set of coefficients is printed the sum of the coefficients. This may be used as an easy means of verifying the accuracy with which the coefficients have been entered in the computer.

Table 3: Comparison of *Almanac for Computers* with A^2 (Low Precision Series, pp. D30–D33)

Function		No. of Terms	Maximum Error
Apparent Sidereal Time at 0^h UT		10	$0^s.04$
Equation of the Equinoxes		"	$0^s.04$
Nutation in Longitude		"	$0''.6$
Nutation in Obliquity		"	$0''.3$
Sun:	Right Ascension	24	$0^s.5$
	Declination	"	$3''$
	Distance	"	4×10^{-5} au
	Semidiameter	"	$0''.04$
	Ephemeris Transit	"	$0^s.6$
Mercury:	Right Ascension	48	15^s
	Declination	"	$3'$
	Distance	"	4×10^{-4} au
Venus:	Right Ascension	48	$0^s.3$
	Declination	"	$3''$
	Distance	"	2×10^{-6} au
Mars:	Right Ascension	32	1^s
	Declination	"	$3''$
	Distance	"	4×10^{-5} au
Jupiter:	Right Ascension	32	$0^s.1$
	Declination	"	$0''.5$
	Distance	"	4×10^{-5} au
Saturn:	Right Ascension	18	$0^s.1$
	Declination	"	$0''.4$
	Distance	"	4×10^{-5} au
Uranus:	Right Ascension	18	$0^s.05$
	Declination	"	$0''.4$
	Distance	"	4×10^{-5} au
Neptune:	Right Ascension	12	$0^s.05$
	Declination	"	$0''.3$
	Distance	"	7×10^{-5} au
Pluto :	Right Ascension (astrometric)	12	$0^s.04$
	Declination (astrometric)	"	$0''.3$
	Distance	"	7×10^{-5} au

The series for Apparent Sidereal Time are designed to reproduce the table Apparent Sidereal Time at 0^h Universal Time in the A^2. To compute the Greenwich apparent sidereal time for any universal time,

(1) evaluate the series for the desired UT,

(2) add the desired UT to the result of step (1).

Local apparent sidereal time may be obtained by adding the local longitude to the Greenwich apparent sidereal time, where east longitudes are considered positive.

With two exceptions the series in Section D provide data referred to the true equinox and equator of date. The exceptions are

(1) the Moon's geocentric, rectangular coordinates (X, Y, Z), which are referred to the mean equator and equinox of B1950.0;

(2) the right ascension and declination of Pluto, which are astrometric (i.e., free of the effect of stellar aberration) and are referred to the mean equator and equinox of J2000.0.

The unit of distance for the Sun and planets is the astronomical unit; the unit of distance for the Moon is the Earth's equatorial radius.

Stellar Tables

The Stellar Tables (Section E) list the mean places of 176 stars for the current year, along with coefficients for converting from mean to apparent place for any date of the year. The selection of stars is essentially that of the star tables on pages 268–273 of the *Nautical Almanac*. Stars are arranged in order of increasing right ascension (decreasing sidereal hour angle), except where both components of a binary system are listed. For binary stars that can be resolved in small instruments, the position of one or both components is listed rather than the position of the center of gravity or the center of light. When both components are included, the brighter star is listed first. For convenience of navigators the sidereal hour angle (SHA) is tabulated rather than right ascension (RA); right ascension in degree can be obtained from the relation

$$\text{RA} = 360^\circ - \text{SHA}.$$

The quantities tabulated for each star are, from left to right on the page:

1. Identification number.
2. Navigational star number, provided the star is one of the 57 selected navigational stars listed in the *Nautical Almanac* and *Air Almanac*.
3. Star name. The Bayer designation is on the first line and the proper name, if any, is on the second line.
4. Magnitude and spectral type. The visual magnitude is on the first line, and the spectral type is on the second line. A composite spectrum is denoted by *.
5. Mean place of the star for J1990.5. The SHA in degrees is on the first line; the declination in degrees is on the second line.
6. Four coefficients (H, R, S, C) used in computing the apparent place of the star. The coefficients on the first line are for the computation of apparent SHA; these will hereafter be designated H_S, R_S, S_S, C_S. The coefficients on the second line are for the computation of apparent declination; these will be designated with the subscript D: H_D, etc.
7. The sum of the mean SHA or declination and the coefficients in the line. This may be used to verify that the numbers have been entered correctly in the computer.

The mean place of a star is a fundamental reference point with no simple geometric or observational significance. The apparent place of a star is the geocentric position, referred to the true equinox and equator of date, at which the star is observed. Thus the apparent place is the position needed for navigation, calibration of telescope setting circles, computation of transit time, etc. Except for Polaris the tabulated mean places for the middle of the year can be used to an accuracy of $\pm 1'.3$ for any date during the year.

To compute the apparent place of a star for the current year, first determine the parameter τ from the formula

$$\tau = (t - W)/A,$$

where t is the day of the year and the constants A and W are given at the top of page E3. The day of the year may be found from the calendar on pages A2–A3 or calculated from formulas on page B1.

Except for Polaris, star positions accurate to better than $\pm 0'.5$ can be obtained from the following formulas:

$$\text{apparent SHA} = \text{mean SHA} + H_S + R_S\tau$$
$$\text{apparent decl.} = \text{mean decl.} + H_D + R_D\tau$$

Except for Polaris, star positions accurate to better than $\pm 0'.1$ (and usually better than $\pm 0'.05$) can be obtained from the following formulas:

$$\text{apparent SHA} = \text{mean SHA} + H_S + R_S\tau + S_S \sin(360°\tau) + C_S \cos(360°\tau)$$
$$\text{apparent decl.} = \text{mean decl.} + H_D + R_D\tau + S_D \sin(360°\tau) + C_D \cos(360°\tau)$$

To facilitate identification of the 57 standard navigational stars, an index for these stars is provided on page E1.

Example: Compute the apparent place of Spica (α Virginis) on 17 June 1990 to an accuracy of $\pm 0'.1$.

Data for Antares (Nav. No. 33; A/C ID 99) are found on page E6, where it is also found that $A = 365.0$ and $W = 183.5$. From page A2, 17 June is day 168.

$$\tau = (t - W)/A = (168 - 183.5)/365.0 = -0.0425$$

	SHA	decl.
Mean place	$158°.8271$	$-11°.1119$
$+H$	-0.0032	-0.0020
$+R\tau$	$+0.0006$	$+0.0002$
$+S\sin(360°\tau)$	-0.0014	-0.0001
$+C\cos(360°\tau)$	-0.0012	-0.0007
Apparent place	$158°.822$	$-11°.114$

Because of the close proximity of Polaris to the north celestial pole, a small change in the position of Polaris on the celestial sphere causes a large change in the value of the SHA (or right ascension). This is purely due to the nature of the coordinate system rather than to extraordinary physical motion. Though the formulas given above will yield the declination of Polaris to an accuracy comparable to that of other stars, errors in SHA can reach $\pm 1'.2$, even if the more accurate formula is used.

Section B: APPLICATIONS

Note on GMT and UT

Because GMT (Greenwich Mean Time) has accumulated many meanings over the years, it is no longer usable for precision work in astronomy and navigation. Following current practice, it has been replaced by UT (universal time), or more precisely UT1, in this almanac. For detailed information on time systems the reader should consult the Explanation of a current edition of *The Astronomical Almanac*.

Mathematical Functions and Notation

Sign Function. The sign function serves to extract the algebraic sign from a number. The notation $\text{sign}(x)$ is defined to be $\text{sign}(x) = +1$ for $x \geq 0$, $\text{sign}(x) = -1$ for $x < 0$. An equivalent definition is $\text{sign}(x) = x/|x|$ for $x \neq 0$., $\text{sign}(x) = 1$ for $x = 0$.
Examples: $\text{sign}(247) = 1$; $\text{sign}(-6.28) = -1$.

Truncation or largest-integer function. The truncation function extracts the integral part of a number. The algebraic sign of the result is the same as that of the original number. $\langle x \rangle$ is defined to be $\langle x \rangle = \text{sign}(x) \cdot N$, where N is the largest non-negative integer such that $N \leq |x|$.
Examples: $\langle 17.835 \rangle = 17$; $\langle -3.14159 \rangle = -3$.

Modulus or remainder function. The modulus function yields the remainder of the division x/y, when the quotient is constrained to be an integral value. Thus $\text{mod}(x,y)$ is defined to be $\text{mod}(x,y) = x - \langle x/y \rangle \cdot y$.
Examples: $\text{mod}(11,3) = 2$; $\text{mod}(-764.3,360.0) = -44.3$.
Note that $\langle x \rangle = x - \text{mod}(x, 1.0)$. Therefore the truncation function can be defined in terms of the modulus function and *vice versa*. If either modulus or truncation is available on a calculator or computer, the other function can be simply obtained.

Day of the Year

The day of the year N is defined as the integer $N = \langle t \rangle$, where t is the time elapsed in days since 0 January of the current year. Thus N is an integer running from 1 through 365 (or 366 in leap years). The day of the year can be computed from either of the following formulas:

$$N = \langle (275M)/9 \rangle - \langle (M+9)/12 \rangle (1 + \langle (K - 4\langle K/4 \rangle + 2)/3 \rangle) + I - 30$$

$$N = \langle (275M)/9 \rangle - \langle (M+9)/12 \rangle (1 + \langle (\text{mod}(K,4) + 2)/3 \rangle) + I - 30$$

where N is the day of the year, K is the year (e.g., 1987), M is the month ($1 \leq M \leq 12$), and I is the day of the month ($1 \leq I \leq 31$). These formulas make use of the truncation and modulus functions described above.

These formulas are equivalent and are valid for any year, except those centurial years that are not evenly divisible by 400. Therefore the formulas given above are valid for the year 2000, but not for 1900 or 2100. Simplified formulas can be used if leap years and common years are treated separately:

for common years: $N = \langle(275M)/9\rangle - 2\langle(M+9)/12\rangle + I - 30,$

for leap years: $N = \langle(275M)/9\rangle - \langle(M+9)/12\rangle + I - 30,$

where the notation $\langle\ \rangle$ specifies the truncation function described on page B1.

Many expressions in this almanac require the value of t, the time elapsed in days since 0 January, 0^h UT, of the current year. By inverting the definition of N, we obtain $t = N + UT/24$, where UT is the universal time expressed in hours.

Julian Date

The Julian date (JD) is a continuous count of days from 1 January 4713 BC (= −4712 January 1), Greenwich mean noon (= 12^h UT). For example AD 1978 January 1, 0^h UT is JD 2443509.5 and AD 1978 July 21, 15^h UT, is JD 2443711.125. Conversion of Gregorian calendar date to Julian date for years AD 1801–2099 can be carried out with the following formula:

$$\text{JD} = 367K - \langle(7(K + \langle(M+9)/12\rangle))/4\rangle + \langle(275M)/9\rangle + I + 1721013.5 + UT/24 - 0.5\,\text{sign}(100K + M - 190002.5) + 0.5$$

where K is the year ($1801 \le K \le 2099$), M is the month ($1 \le M \le 12$), I is the day of the month ($1 \le I \le 31$), and UT is the universal time in hours. The last two terms in the formula add up to zero for all dates after 1900 February 28, so these two terms can be omitted for subsequent dates. Note that the formula makes use of the truncation and sign functions defined on page B1.

Example: Compute the JD corresponding to 1877 August 11, 7^h30^m UT.

Substituting $K = 1877$, $M = 8$, $I = 11$ and $UT = 7.5$,

$\text{JD} = 688859 - 3286 + 244 + 11 + 1721013.5 + 0.3125 + 0.5 + 0.5$

$= 2406842.8125$

The modified Julian date (MJD) is sometimes used to specify current dates; it is defined as MJD = JD − 2400000.5. Use of the modified Julian date, rather than the Julian date, is recommended with computers and calculators of limited precision. Note that for 0^h UT the Julian date has a fractional part of .5, while the corresponding modified Julian date is an integer.

Sidereal Time

The following formulas are relevant to the computation of sidereal time:

(1) $\text{GMST} = 6^h.6265313 + 0.0657098242\,N + 1.00273791\,UT$

(2) $\text{GMST} = 6^h.69737456 + 2400.051336\,T_0 + 0.0000258622\,T_0^2 + 1.002737909\,UT$

(3) $\Omega = 318^\circ.5111 - 0.0529538\ (N + \text{UT}/24)$

(4) $\Omega = 125^\circ.04452 - 1934.13626\,T + 0.002071\,T^2$

(5) $E = -0^h.00029 \sin\Omega$

(6) GAST = GMST + E

(7) GAST = $\Sigma(t_0)$ + 1.002737909UT = $\Sigma(t)$ + UT

(8) LAST = GAST + $\lambda/15$

where

GMST is the Greenwich mean sidereal time in hours;

Ω is the mean longitude of the ascending node of the Moon's orbit, measured in degrees;

E is the equation of the equinoxes in hours;

GAST is the Greenwich apparent sidereal time in hours;

LAST is the local apparent sidereal time in hours;

N is the day of the year ($1 \le N \le 365$ or $1 \le N \le 366$, during a leap year);

T_0 and T are time intervals in Julian centuries from J2000.0:

$T_0 = (JD_0 - 2451545.0)/36525$ $T = (JD - 2451545.0)/36525$;

UT is the universal time in hours;

JD_0 and JD are the Julian dates at 0^h UT and at an arbitrary time of the day, respectively;

$\Sigma(t_0)$ and $\Sigma(t)$ are values obtained by evaluating the Chebyshev series for apparent sidereal time (pages D2–D5 or D30) at 0^h UT and at an arbitrary time of day, respectively; (see page A12 for notes about evaluating the series for sidereal time);

λ is the local longitude in degrees (east is positive; west is negative).

When using the formulas given above, it may be necessary to reduce the results to the range 0^h–24^h by adding or subracting multiples of 24^h.

Eqs. (1) and (3) are specifically for the current year; the other formulas are valid at least over the latter half of this century. Eq. (5) is an approximation that is accurate to about $\pm 0^s.2$. If more accuracy is required, the Chebyshev series for the equation of the equinoxes (pages D2–D5 or D30) can be used in place of eq. (5). If sidereal time is to be computed to an accuracy better than $\pm 0^s.2$ (rarely justified for practical applications), then either the Chebyshev series for the equation of the equinoxes should be used in place of eq. (5), or eq. (7) should be used in place of eq. (6).

Hour Angles

The following formulas are useful if astronomical data, such as that given in Sections D and E, are applied to navigational purposes:

GHA = 15 (GAST − RA)

LHA = 15 (LAST − RA) = GHA + λ

GHA Aries = 15 GAST

$$SHA = 360° - 15\,RA$$

$$GHA = GHA\ Aries + SHA$$

where

GHA is the Greenwich hour angle in degrees;
LHA is the local hour angle in degrees;
GHA Aries is the Greenwich hour angle of the First Point of Aries (the origin of right ascension) in degrees;
SHA is the sidereal hour angle in degrees;
RA is the apparent right ascension (referred to the true equator and equinox of date) in hours;
λ is the local longitude in degrees (east is positive; west is negative);
GAST is the Greenwich apparent sidereal time in hours;
LAST is the local apparent sidereal time in hours.

When using these formulas it may be necessary to add or subtract 360° to reduce the resulting hour angles to the range 0°–360°. Often local hour angle values are reduced to the range –180° to +180°, in which case they are called meridian angles. In all cases positive hour angles are measured westward from the meridian.

Altitude and Azimuth

The following formulas can be used to compute the altitude a and azimuth A of a celestial body:

(1) $$\sin a = \cos z = \sin\varphi \sin\delta + \cos\varphi \cos\delta \cos LHA$$

(2) $$x = \tan A = \sin LHA / (\cos LHA \sin\varphi - \tan\delta \cos\varphi)$$

Formula (2) is most efficiently evaluated using a rectangular to polar coordinate conversion function, with the numerator and denominator being the rectangular coordinates. If this is not available, some care must be taken in determining the proper quadrant for A. Since computers and calculators normally give the arctangent in the range –90° to +90°, the correct quadrant for A can be selected according to the following rules:

If $0° \le LHA \le 180°$,
  $A = 180° + \arctan x$, if x is positive,
  $A = 360° + \arctan x$, if x is negative.
If $180° \le LHA \le 360°$,
  $A = \arctan x$, if x is positive,
  $A = 180° + \arctan x$, if x is negative.

Notation:

a: altitude of body above horizon (if $\sin a$ is negative, the body is below the horizon);

A: azimuth of body measured eastward from north over the range $0° \le A \le 360°$;
φ: latitude of observer (north is positive; south is negative);
δ: declination of body (north is positive; south is negative);
LHA: local hour angle of body;
z: zenith distance of body ($z = 90° - a$).

In standard navigational notation, altitude and azimuth are denoted Hc and Zn, respectively. Formulas (1) and (2) are the basic formulas used in preparing sight reduction tables; they do not include the effect of refraction.

Example: Compute the altitude and azimuth of the Sun at 18^h00^m UT on 16 August at Punxsutawney, Pennsylvania.

Latitude: $\varphi = +40°.95$ $\sin\varphi = +0.65540$ $\cos\varphi = +0.75528$
Longitude: $\lambda = -78°.97$
Using the power series on page C4, the Sun's GHA and δ are found to be
GHA $= 88°.937$ hence LHA $= 9°.967$
$\sin\text{LHA} = +0.17308$ $\cos\text{LHA} = +0.98491$
$\delta = +13°.652$ $\sin\delta = +0.23602$ $\cos\delta = +0.97175$ $\tan\delta = +0.24289$
$\sin a = (0.65540)(0.23602) + (0.75528)(0.97175)(0.98491)$
$= +0.87756$
$a = 61°.3$
$x = \tan A = 0.17308/((0.98491)(0.65540) - (0.24289)(0.75528))$
$= +0.37458$
$\arctan x = +20°.5$
Since LHA is less than 180°, and since x is positive,
$A = 180° + 20°.5 = 200°.5$

Sunrise, Sunset and Twilight

For location between latitudes 65° North and 65° South, the following algorithm provides times of sunrise, sunset and twilight to an accuracy of $\pm 2^m$, for any date in the latter half of the twentieth century. Because the phenomena depend on local meteorological conditions, attempts to attain higher accuracy are seldom justified. Although the algorithm can be used at higher latitudes, its accuracy deteriorates near dates on which the Sun remains above or below the horizon for more than twenty-four hours.

Notation:

φ: latitude of observer (north is positive; south is negative)
λ: longitude of observer (east is positive; west is negative)
M: Sun's mean anomaly
L: Sun's true longitude
RA: Sun's right ascension

δ: Sun's declination
H: Sun's local hour angle
z: Sun's zenith distance at rise, set or twilight*
t: approximate time of phenomenon in days since 0 January, 0^h UT
T: local mean time of phenomenon
UT: universal time of phenomenon

*The proper value of z should be chosen from the following:

	z	$\cos z$
Sunrise and Sunset	90°50′	−0.01454
Civil Twilight	96°	−0.10453
Nautical Twilight	102°	−0.20791
Astronomical Twilight	108°	−0.30902

Formulas:

(1) $M = 0.^\circ 985600\, t - 3.^\circ 289$
(2) $L = M + 1.^\circ 916 \sin M + 0.^\circ 020 \sin 2M + 282.^\circ 634$
(3) $\tan RA = 0.91746 \tan L$
(4) $\sin\delta = 0.39782 \sin L$
(5) $x = \cos H = (\cos z - \sin\delta \sin\varphi)/(\cos\delta \cos\varphi)$
(6) $T = H + RA - 0.^h 065710\, t - 6.^h 622$
(7) $UT = T - \lambda$

Procedure:

1. With an initial value of t, compute M from eq. (1) and then L from eq. (2). If a morning phenomenon (sunrise or the beginning of morning twilight) is being computed, construct an initial value of t from the formula
$$t = N + (6^h - \lambda)/24,$$
where N is the day of the year (see the calendar on pages A2–A3 or the formulas on page B1) and λ is the observer's longitude expressed in hours. If an evening phenomenon is being computed, use
$$t = N + (18^h - \lambda)/24.$$
2. Solve eq. (3) for RA, noting that RA is in the same quadrant as L. Transform RA to hours for later use in eq. (6).
3. Solve eq. (4) for $\sin\delta$, which appears in eq. (5); $\cos\delta$, which also is required in eq. (5), should be determined from $\sin\delta$. While $\sin\delta$ may be positive or negative, $\cos\delta$ is always positive.
4. Solve eq. (5) for H. Since computers and calculators normally give the arccosine in the range 0°–180°, the correct quadrant for H can be selected according to the following rules:
rising phenomena: $H = 360^\circ - \arccos x$;
setting phenomena: $H = \arccos x$.

In other words, for rising phenomena H must be either in quadrant 3 or 4 (depending on the sign of $\cos H$), whereas H must be either in quadrant 1 or 2 for setting phenomena. Convert H from degrees to hours for use in eq. (6).

5. Compute T from eq. (6), recalling that H and RA must be expressed in hours. If T is negative or greater than 24^h, it should be converted to the range 0^h–24^h by adding or subtracting multiples of 24^h.
6. Compute UT from eq. (7), where λ must be expressed in hours. UT is an approximation to the time of the desired rising or setting phenomenon, referred to the Greenwich meridian. If UT is greater than 24^h, the phenomenon occurs on the following day, Greenwich time. If UT is negative, the phenomenon occurs on the previous day, Greenwich time.

To ensure that precision is not lost during the computations, t should be carried to three decimal places. Angles should be expressed to three decimals of a degree and, upon conversion, to three decimals of an hour. Five significant digits should be carried for the trigonometric functions.

Under certain conditions, eq. (5) will yield a value of $|\cos H| > 1$, indicating the absence of the phenomenon on that day. At far northern latitudes, for example, there is continuous illumination during certain summer days and continuous darkness during winter days.

Example: Compute the time of sunrise on 25 June at Wayne, New Jersey.

Latitude: $40^\circ.9$ North $\varphi = +40^\circ.9$ $\sin\varphi = +0.65474$ $\cos\varphi = +0.75585$

Longitude: $74^\circ.3$ West $\lambda = -74^\circ.3/15 = -4^h.953$

For sunrise: $z = 90°50'$ $\cos z = -0.01454$

$t = 176^d + (6^h + 4^h.953)/24 = 176^d.456$

$M = 0^\circ.985600(176^d.456) - 3^\circ.289 = 170^\circ.626$

$L = 170^\circ.626 + 1^\circ.916(0.16288) + 0^\circ.020(-0.32141) + 282^\circ.634$
$= 453^\circ.566 = 93^\circ.566$

$\tan RA = 0.91746(-16.046) = -14.722$

Since L is in quadrant 2, so is RA: $RA = 93^\circ.886/15 = 6^h.259$

$\sin\delta = 0.39782(0.99806) = 0.39705$

$\cos\delta = 0.91780$

$x = \cos H = (-0.01454 - (0.39705)(0.65474))/((0.91780)(0.75585))$
$= -0.39570$ $\arccos x = 113^\circ.310$

Since sunrise is being computed, $H = 360° - 113^\circ.310 = 246^\circ.690$

$H = 246^\circ.690/15 = 16^h.446$

$T = 16^h.446 + 6^h.259 - 0^h.065710(176^d.456) - 6^h.622 = 4^h.488$

$UT = 4^h.488 + 4^h.953 = 9^h.441$

Sunrise occurs at 9^h26^m UT = 5^h26^m EDT

Solar Coordinates

The true geocentric longitude of the Sun L can be computed to an accuracy of ± 1 minute of arc from the following formulas:

$$M = 357^\circ.528 + 35999^\circ.050\,T$$
$$\Lambda = 280^\circ.460 + 36000^\circ.772\,T$$
$$L = \Lambda + (1^\circ.915 - 0^\circ.0048\,T)\sin M + 0^\circ.020\sin 2M$$

where $T = (\text{JD} - 2451545.0)/36525$ and JD is the Julian date (see page B2).

If we consider the Sun's latitude to be identically zero, the right ascension RA and declination δ of the Sun can also be computed to ±1 minute of arc from

$$\tan RA = \cos\varepsilon \tan L$$
$$\sin\delta = \sin\varepsilon \sin L$$

where ε, the obliquity of the ecliptic, can be computed from $\varepsilon = 23^\circ.439 - 0^\circ.013T$. The right ascension is always in the same quadrant as the true longitude.

Because the obliquity varies slowly, a single value can be used for an extended period of time. During the last quarter of the twentieth century, $\varepsilon = 23^\circ.441$ is sufficiently accurate. Similarly the coefficient of $\sin M$ in the equation for L changes slowly; for the last half of the twentieth century a value of $1^\circ.916$ can be used.

Although there is no rigorous limit on the time span for which these formulas are valid, their accuracy gradually deteriorates for values of T greater than a couple of centuries.

Equation of Time and Time of Solar Transit

The equation of time EqT is the hour angle of the true Sun minus the hour angle of the mean sun. Thus it is the difference: apparent solar (sundial) time minus mean solar (clock) time.

For the current year EqT can be computed to an accuracy of ±0.8 minute from the following formula:

(1) $$EqT = -7^m.66\sin(0^\circ.9856t - 3^\circ.80) - 9^m.78\sin(1^\circ.9712t + 17^\circ.96)$$

where t is the number of days since 0 January, 0^h UT.

If higher accuracy is required the following formulas will give EqT to an accuracy of ±2 seconds during the current year:

(2) $$\theta = 9^\circ.397 + 0^\circ.98561t + 1^\circ.915\sin(0^\circ.9856t - 3^\circ.798) + 0^\circ.014\cos(0^\circ.9856t - 3^\circ.798) + 0^\circ.020\sin(1^\circ.9712t - 7^\circ.596)$$

(3) $$EqT = 37^m.589 + 3^m.94244t - 4^m.0\arctan((\tan\theta)/0.91747)$$

where t is the number of days since 0 January, 0^h UT. In eq. (3) the arctangent should yield a result in degrees that is in the same quadrant as θ. Near the end of the year θ becomes greater than 360°. When this occurs the arctangent in eq. (3) should also be greater than 360°.

Eqs. (2) and (3) can be used to compute the time at which the Sun transits the

local meridian. First use eqs. (2) and (3) to compute EqT for $t = N + (12^h - \lambda)/24$, where N is the day of the year (see the calendar on pages A2–A3 or the formulas on pages B1–B2) and λ is the longitude (east positive, west negative) expressed in hours. Then the local mean time (LMT) of transit is given to an accuracy of ±2 seconds by $LMT = 12^h - EqT$. The universal time of local transit is then obtained from $UT = LMT - \lambda$.

Example: Compute the time of solar transit at longitude 73°58′ West on 17 June 1990.

$\lambda = -73^\circ.967/15 = -4^h.9311 = -4^h56^m.87$

For solar transit: $t = 168^d + (12^h + 4^h.9311)/24 = 168^d.7055$

$\theta = 9^\circ.397 + 0^\circ.98561(168^d.7055) + 1^\circ.915(0.3010) +$
$0^\circ.014(-0.9536) + 0^\circ.020(-0.5742) = 176^\circ.226$

$EqT = 37^m.589 + 3^m.94244(168^d.7055) - 4^m.0\arctan(-0.06596/0.91747)$
$= 37^m.589 + 665^m.111 - 4^m.0(175^\circ.888) = -0^m.85$

$LMT = 12^h00^m + 0^m.85 = 12^h00^m.85$

$UT = 12^h00^m.85 + 4^h56^m.87 = 16^h57^m.72$ UT

Moonrise and Moonset

Times of moonrise and moonset can be computed for specified locations using the following algorithm. Between latitudes 60° North and 60° South, the phenomena can be computed to an accuracy of ±3 minutes. Although the algorithm can be used at higher latitudes, its accuracy deteriorates near dates on which the Moon remains above or below the horizon for more than twenty-four hours.

Notation:

- φ: latitude of observer (north is positive; south is negative)
- λ: longitude of observer (east is positive; west is negative)
- t_i: *i-th* approximation of universal time of phenomenon, expressed as the fraction of a day from 0^h UT
- GHA_i: Moon's GHA at time t_i
- δ_i: Moon's declination at time t_i (north is positive; south is negative)
- τ_i: *i-th* correction to t_0, thus $t_i = t_0 + \tau_i$
- H_i: *i-th* approximation to Moon's LHA at time or rise or set
- ΔH_i: *i-th* approximation to Moon's daily rate of change in GHA

Formulas:

(1) $\Delta H_i = (GHA_i - GHA_0)/\tau_i$ for $i = 0$, let $\Delta H_0 = 347^\circ.81$

(2) $x_{i+1} = \cos H_{i+1} = (0.00233 - \sin\varphi \sin\delta_i)/(\cos\varphi \cos\delta_i)$

(3) $\tau_{i+1} = (H_{i+1} - H_0)/\Delta H_i$

(4) $t_{i+1} = t_0 + \tau_{i+1}$

Procedure:

1. Let $t_0 = (12^h - \lambda)/24$, where λ is the observer's longitude expressed in hours. Set $i = 0$ and begin the following iterative process.
2. For some t_i compute the Moon's GHA and declination to navigational precision (about $\pm 0'.1$). Label these quantities GHA_i and δ_i, respectively, where i specifies the iteration number. For $i = 0$, compute $H_0 = GHA_0 + \lambda$.
3. If $i = 0$, let $\Delta H_0 = 347°.81$. Otherwise compute ΔH_i from eq. (1). If $\Delta H_i < 0$, add $360°/|\tau_i|$ to ΔH_i.
4. Solve eq. (2) for H_{i+1}. Since computers and calculators normally give the arccosine in the range 0°–180°, the correct quadrant for H_{i+1} can be selected according to the following rules:
   (a) moonrise: $H_{i+1} = 360° - \arccos x_{i+1}$;
   (b) moonset: $H_{i+1} = \arccos x_{i+1}$.
   In other words, near the time of moonrise H_{i+1} must be in quadrant 3 or 4 (depending on the sign of $\cos H_{i+1}$); near moonset H_{i+1} must be in quadrant 1 or 2. For latitudes higher than 60° (i.e, $|\varphi| > 60°$), the condition $|\cos H_{i+1}| > 1$ can occur, thereby indicating the absence of the phenomenon on that day.
5. Compute τ_{i+1} from eq. (3). If $|\tau_{i+1}| < 0^d.5$, proceed to Step 6. If $|\tau_{i+1}| > 0^d.5$, the phenomenon occurs on the day prior to the day desired (if τ_{i+1} is negative) or on the day following the day desired (if τ_{i+1} is positive). Normally the phenomenon on the desired day can be obtained by adding to τ_{i+1} (if τ_{i+1} is negative), or subtracting from τ_{i+1} (if τ_{i+1} is positive), $360°/\Delta H_i$. If successful, this technique will produce a new value of τ_{i+1} in the required range. However, two conditions may prevent the reduction to $|\tau_{i+1}| < 0^d.5$:
   (a) for low values of i, τ_{i+1} may be a fairly crude approximation to the ultimate value, τ_n;
   (b) each month there is one day (near last quarter) on which there is no moonrise, and another day (near first quarter) when there is no moonset.
   If $|\tau_{i+1}| \approx 0^d.5$, it is probably worth attempting another iteration to see if $|\tau_{i+2}| < 0^d.5$.
6. Compute t_{i+1} from eq. (4). If $|t_{i+1} - t_i| < 0^d.01$, t_{i+1} is accurate to $\pm 3^m$. Otherwise it is necessary to iterate the solution by setting $i = i + 1$ and executing Steps 2 through 6 again.

Example: Compute moonset on 5 March 1990 at Yonkers, New York.

$\varphi = +40°.94$ $\quad \sin\varphi = +0.65527$ $\quad \cos\varphi = +0.75540$

$\lambda = -73°.87 = -4^h.925$

$t_0 = (12^h + 4^h.925)/24 = +0^d.70521$

$i = 0$: Evaluating the power series on page C10 for t_0 on 5 March,

$GHA_0 = 320°.743$ $\quad \delta_0 = +26°.726$

$H_0 = 320^\circ.743 - 73^\circ.87 = +246^\circ.873$
$\Delta H_0 = 347^\circ.81$
$x_1 = \cos H_1 = (0.00233 - (0.65527)(0.44972))/((0.75540)(0.89317))$
$= -0.43332 \qquad \arccos x_1 = 115^\circ.678$
Since moonset is sought, H_1 is in quadrant 1 or 2:
$H_1 = 115^\circ.678$
$\tau_1 = (115.678 - 246.873)/347.81 = -0^d.37720$
Since $|\tau_1| < 0.5$,
$t_1 = 0^d.70521 - 0^d.37720 = 0^d.32801$

$i = 1$: Evaluating the power series on page C10 for t_1 on 5 March,
$GHA_1 = 190^\circ.354 \qquad \delta_1 = +27^\circ.192$
$\Delta H_1 = (190.354 - 320.743)/(-0.37720) = +345^\circ.676$
$x_2 = \cos H_2 = (0.00233 - (0.65527)(0.45697))/((0.75540)(0.88948))$
$= -0.44218 \qquad \arccos x_2 = 116^\circ.243$
Since moonset is sought, H_2 is in quadrant 1 or 2:
$H_2 = 116^\circ.243$
$\tau_2 = (116.243 - 246.873)/345.676 = -0^d.37790$
Since $|\tau_2| < 0.5$,
$t_2 = 0^d.70521 - 0^d.37790 = 0^d.32731 = 07^h51^m$ UT on 5 March
$|t_2 - t_1| = 0^d.0007 < 0^d.01$

The extremely rapid convergence illustrated in this example occurs frequently but not invariably. Although the first approximation (t_1) will often give adequate precision for most purposes, it is recommended that the solution be iterated and that the convergence criterion ($|t_{i+1} - t_i| < 0^d.01$) be tested.

Polaris (Pole Star)

The following formulas are relevant to observations of Polaris:

(1) $\varphi = a - p\cos h + 0.5p\sin p \sin^2 h \tan\varphi$

(2) $A\cos\varphi = -p\sin h - p\sin p \sin h \cos h \tan\varphi$

where p is the polar distance of Polaris: $p = 90° -$ declination of Polaris;
h is the LHA of Polaris: $h =$ GHA Aries + SHA Polaris + east (–west) longitude of observer;
φ is the observer's latitude;
A is the azimuth of Polaris;
a is the corrected altitude of Polaris.

Eq. (1) permits the observer's latitude to be determined from an observation of the altitude of Polaris (corrected for refraction, dip, etc.). Assumed values of the observer's latitude and longitude can be used for the right side of eq. (1). Eq. (2) yields the azimuth of Polaris if the observer's position is known. These expressions are accurate only for Polaris, since they depend on p being a small quantity.

The SHA and declination of Polaris to be used in these formulas should be referred to the true equator and equinox of date; i.e., the apparent place of Polaris should be computed (see Section E where Polaris is star number 17).

Equation of Position Line

The following formula can be used to obtain a line of position (LOP) directly from an observation of the altitude of a celestial body:

$$\lambda = \text{GHA} \pm \arccos((\sin a - \sin\varphi \sin d)/\cos\varphi \cos d)$$

where λ is the computed longitude;
GHA is the GHA of the body for the time of observation;
a is the corrected altitude of the body;
d is the declination of the body for the time of observation;
φ is an estimate of the observer's latitude.

North latitudes and west longitudes are positive; south latitudes and east longitudes are negative. Longitudes with absolute values greater than 180° may be encountered. In using the plus-or-minus option in the formula, + is used for bodies east of the meridian (rising) and – for bodies west of the meridian (setting).

The formula gives the longitude λ at which the position line crosses the parallel of latitude φ. Repeated application of the formula using different values of latitude yields a locus of points all lying in the LOP. Note that no assumed position is necessary, although an estimate of the observer's latitude is helpful in reducing the number of times the formula is applied.

The formula becomes indeterminate at the transit time of a body and for latitudes that the position line does not cross at any point.

Motion of Body and Motion of Observer

During the time interval Δt (e.g., the interval between a sextant observation and the time of a fix), the rotation of the Earth causes a change in the altitude of a celestial body. To permit the use of a common assumed position and LHA Aries for observations made at different times, the following correction can be applied to the observed altitude:

$$\text{MOB} = 15.04\, \Delta t \cos\varphi \sin A$$

where MOB is the altitude correction in minutes of arc, Δt is the time difference in minutes, φ is the latitude of the observer, and A is the azimuth of the observed body. If the time of the fix is later than the time of observation, MOB should be added to the observed altitude. It should be noted that the formula for MOB is an approximation that becomes unreliable for values of Δt greater than 5 minutes.

The following formula gives the change of altitude of a celestial body due to

the motion of the observer in the time interval Δt (e.g., the interval between a sextant observation and the time of a fix). Although this formula is only an approximation to the physical phenomenon, it is the exact mathematical equivalent of advancing or retiring a line of position.

$$\text{MOO} = (v\,\Delta t/60)\cos(A-C)$$

where MOO is the altitude correction in minutes of arc, Δt is the time difference in minutes, A is the azimuth of the observed body, C is the track/course angle, and v is the ground speed in knots. If the time of the fix is later than the time of observation, MOO should be added to the observed altitude.

Sextant Altitude Corrections

Several corrections must be applied to a sextant altitude (hs) in order to obtain a corrected altitude (Ho). Ho can then be either compared with the computed altitude (Hc) to obtain the altitude difference (Δa), or used in the "Equation of Position Line" (see page B12) to obtain directly the location of the LOP for the sight.

The corrections, in the order in which they should be applied, are

(1) instrument and/or index correction, IC;
(2) dip of horizon, D (marine sextant), or coriolis correction, Δz (bubble sextant);
(3) atmospheric refraction, R;
(4) semidiameter, SD (marine sextant, Sun and Moon observations);
(5) parallax in altitude, PA (Moon, Venus and Mars observations).

In mathematical notation:

$$\text{Ho} = \text{hs} + \text{IC} + (\text{D or } \Delta z) - \text{R} + \text{SD} + \text{PA}$$

Descriptions and formulas for D, Δz, R, SD and PA are given on the following pages.

Dip of Horizon

The dip of the apparent horizon from a horizontal plane is given by

$$\text{D} = -0.97\sqrt{h}$$

where h is the height of eye level of the observer in feet and D is the dip of the horizon in minutes of arc. For observations of a celestial body made with a marine sextant or similar instrument, D should be added to the observed altitude. This formula is an approximation; the apparent dip varies with atmospheric conditions.

Coriolis Correction

Any object moving across or above the surface of the rotating Earth is subject to an apparent force which tends to push the object to the right in the northern hemisphere and to the left in the southern hemisphere. This coriolis acceleration manifests itself as a deflection of the apparent vertical by an amount Z:

(1) $$Z = 2.62\,V\sin\varphi + 0.146\,V^2\sin C\tan\varphi - 5.25\,VC'$$

where Z is the deflection in minutes of arc;
V is the speed in hundreds of knots;
φ is the latitude;
C is the true track/course angle;
C' is the rate of change of true track/course angle in degrees per minute of time.

The "Coriolis (Z) Correction" tabulated in the Air Almanac consists of only the first term in eq. (1). The second term is known as "Rhumb Line Correction," and the third term is the "Wander Correction." Usually only the first term is significant.

Observations of the altitudes of celestial bodies made with bubble sextants or similar artificial horizon instruments must be corrected for the coriolis effect. The correction Δz, which can be added to the observed (e.g., bubble sextant) altitude, is given approximately by

(2) $$\Delta z = Z\sin(A - C)$$

where Δz is the altitude correction in minutes of arc;
Z is the deflection of the vertical determined from eq. (1);
A is the azimuth of the observed body;
C is the true track/course angle.

In the northern hemisphere the correction Δz is positive for stars on the right and negative for stars on the left of the aircraft. In the southern hemisphere the correction is negative for stars on the right and positive for stars on the left.

Atmospheric Refraction

The Earth's atmosphere refracts light in such a way that celestial bodies appear slightly higher in the sky then they would if there were no atmosphere. The formulas below can be used to determine R, the angle of refraction. R should be subtracted from an observed (e.g., sextant) altitude to obtain the corrected altitude.

(1) $$R' = \cot(a + (7.31/(a + 4.4)))$$

(2) $$R = R' - 0.06\sin(14.7R' + 13)$$

where R is the refraction correction in minutes of arc and a is the observed altitude. At sea level, with air temperature of 10°C and pressure of 1010 mb, R′ of eq. (1) is accurate to 0′.07, and R of eq. (2) is accurate to 0′.015 for an altitude range of 0°–90°.

For nonstandard conditions the following formula is accurate to about 0.′2 for temperatures in the range −20° to +40° C and pressures of 970–1050 mb.

(3) $$R = R'((P - 80)/930)/(1 + 8\times10^{-5}(R' + 39)(T - 10))$$

where T is the temperature in degrees Celsius;
P is the atmospheric pressure in millibars;
R' is the refraction for standard conditions from eq. (1).

For surface observations under standard atmospheric conditions, the following Chebyshev series represents refraction for altitudes from 0°–90° with errors not exceeding 0.′05:

$$f(x) = a_0/2 + \sum_{i=1}^{12} a_i T_i(x)$$

where x is related to the observed altitude by $x = 0.442837 \log_e(a + 1.5) - 1$. The coefficients a_i in the series are

$a_0 = +28.891741$	$a_5 = +0.340097$	$a_{10} = +0.007814$
$a_1 = -20.516167$	$a_6 = -0.024576$	$a_{11} = -0.009707$
$a_2 = +7.291562$	$a_7 = -0.050041$	$a_{12} = +0.001271$
$a_3 = -0.813492$	$a_8 = +0.023252$	
$a_4 = -0.690042$	$a_9 = -0.009406$	

The sum of these coefficients is +14.442306.

For a given value of the altitude a, compute x. Then the series can be evaluated as follows:

let $b_{13} = b_{14} = 0$,
compute $b_i = 2xb_{i+1} - b_{i+2} + a_i$, for $i = 12, 11, \ldots, 0$,
then $f(x) = (b_0 - b_2)/2$.

Example: A star is observed from the Earth's surface under standard atmospheric conditions to be at altitude 10.°0. Use the Chebyshev series to compute the refraction correction.

$a = 10.°0$ $\quad x = 0.442837 \log_e(10.0 + 1.5) - 1 = +0.081562$

$b_{13} = b_{14} = 0$

b_{12}	=	0.0	−	0.0	+	0.001271	=	+ 0.001271
b_{11}	=	+0.000207	−	0.0	−	0.009707	=	− 0.009500
b_{10}	=	−0.001550	−	0.001271	+	0.007814	=	+ 0.004993
b_9	=	+0.000815	+	0.009500	−	0.009406	=	+ 0.000909
b_8	=	+0.000148	−	0.004993	+	0.023252	=	+ 0.018407
b_7	=	+0.003003	−	0.000909	−	0.050041	=	− 0.047947
b_6	=	−0.007821	−	0.018407	−	0.024576	=	− 0.050804
b_5	=	−0.008287	+	0.047947	+	0.340097	=	+ 0.379757
b_4	=	+0.061947	+	0.050804	−	0.690042	=	− 0.577291
b_3	=	−0.094170	−	0.379757	−	0.813492	=	− 1.287419

$$b_2 = -0.210009 + 0.577291 + 7.291562 = +7.658844$$
$$b_1 = +1.249341 + 1.287419 - 20.516167 = -17.979407$$
$$b_0 = -2.932873 - 7.658844 + 28.891741 = +18.300024$$
$$R = (18.300024 - 7.658844)/2 = 5'.3$$

Semidiameter of the Sun and Planets

The semidiameters of the Sun and planets can be computed from

$$SD = S/d = S\pi/8.794$$

where SD is the semidiameter in seconds of arc;
S is the semidiameter at unit distance (1 au) in seconds of arc;
d is the geocentric distance in astronomical units;
π is the horizontal parallax in seconds of arc.

The following values of S should be used:

Sun	959".63	Jupiter	98".47
Mercury	3.34	Saturn	83.33
Venus	8.41	Uranus	34.28
Mars	4.68	Neptune	36.56

These values apply to the equatorial dimensions of the bodies and do not include any adjustments for irradiation.

Semidiameter of the Moon

The geocentric semidiameter of the Moon can be computed from

(1) $$SD = 56204.92/d = 0.272476\,\pi$$

where SD is the geocentric semidiameter in seconds of arc, d is the geocentric distance of the Moon in units of the Earth's equatorial radius, and π is the horizontal parallax of the Moon in seconds of arc.

Since observations are made from the Earth's surface rather than from its center, the observed, topocentric semidiameter is slightly greater than the geocentric semidiameter. For navigation and certain other purposes the augmented semidiameter of the Moon should be used:

(2) $$SD_{aug} = SD\,(1 + (\sin a)/d)$$

where SD_{aug} is the augmented semidiameter in seconds of arc, a is the altitude of the Moon (for navigational purposes a = Ho, but hs or Hc can be used instead with negligible error), d is the geocentric distance of the Moon in units of the Earth's equatorial radius, and SD is the geocentric semidiameter computed from eq. (1). For navigational purposes a constant value of $d = 60.27$ gives sufficient accuracy. The increase in the Moon's semidiameter due to augmentation is zero when the Moon is on the horizon and is about 0'.3 when the Moon is at the zenith.

Parallax in Altitude

The finite size of the Earth causes a parallactic shift in the apparent positions of nearby celestial objects. The resulting parallax in altitude can be computed from

$$\sin \mathrm{PA} = \sin\pi \cos a$$

where PA is the parallax in altitude, π is the horizontal parallax, and a is the observed altitude. When the horizontal parallax of a body is not available, it can be computed from the relation $\pi = 8''.794/d$, where d is the geocentric distance of the body in astronomical units. Except for the Moon, parallax in altitude does not exceed $1'$. Since parallax tends to decrease the apparent altitude of a body, the quantity PA should be added to an observed (e.g., sextant) altitude to obtain the corrected altitude. To a reasonable approximation, PA can also be computed from

$$\mathrm{PA} = \pi \cos a.$$

Section C: NAVIGATIONAL TABLES

Dates: Jan. 1 – Jan. 31

A = 16.0 W = 1

Term	Aries GHA °	Sun GHA °	Sun Dec. °	Sun S.D. °
0	6236.1571	6297.5226	–20.8369	0.2717
1	5775.7698	5758.6591	3.1056	0.0000
2	–0.0002	0.3644	0.8503	0.0000
3	0.0024	0.0461	–0.0598	0.0000
4	–0.0002	–0.0067	–0.0094	0.0000
5	–0.0021	–0.0005	0.0003	0.0000
Sums	12011.9268	12056.5850	–16.9499	0.2717

Dates: Feb. 1 – Feb. 28

A = 16.0 W = 1

Term	Aries GHA °	Sun GHA °	Sun Dec. °	Sun S.D. °
0	5906.7127	5936.4840	–12.1502	0.2698
1	5775.7708	5760.2687	5.5773	0.0004
2	–0.0036	0.3668	0.4118	0.0027
3	–0.0029	–0.0395	–0.0814	–0.0046
4	0.0032	–0.0009	0.0030	–0.0017
5	0.0026	0.0024	0.0030	0.0036
Sums	11682.4828	11697.0815	–6.2365	0.2702

Dates: Mar. 1 – Mar. 31

A = 16.0 W = 1

Term	Aries GHA °	Sun GHA °	Sun Dec. °	Sun S.D. °
0	5934.3104	5937.8604	–1.5375	0.2681
1	5775.7695	5761.1476	6.3216	0.0000
2	–0.0005	0.0999	0.0283	0.0041
3	0.0025	–0.0570	–0.0623	–0.0022
4	0.0001	0.0044	–0.0041	–0.0039
5	–0.0020	–0.0023	–0.0041	0.0004
Sums	11710.0800	11699.0530	4.7419	0.2665

Dates: Apr. 1 – Apr. 30

A = 16.0 W = 1

Term	Aries GHA °	Sun GHA °	Sun Dec. °	Sun S.D. °
0	5964.8661	5940.0739	10.3064	0.2665
1	5775.7708	5760.9377	5.6504	–0.0019
2	–0.0036	–0.2112	–0.3625	–0.0026
3	–0.0029	–0.0442	–0.0587	0.0016
4	0.0032	0.0115	0.0007	0.0020
5	0.0026	0.0023	–0.0031	–0.0005
Sums	11740.6362	11700.7700	15.5332	0.2651

Dates: Jan. 1 – Jan. 31

A = 16.0 W = 1

Term	Venus GHA °	Venus Dec. °	Mars GHA °	Mars Dec. °	Jupiter GHA °	Jupiter Dec. °	Saturn GHA °	Saturn Dec. °
0	6295.4494	–14.5993	6335.9910	–23.3445	6142.6806	23.3249	6307.2386	–22.0250
1	5786.2689	1.2860	5763.3886	–0.9633	5777.7618	0.0839	5773.7570	0.2226
2	0.5502	–1.1462	–0.1713	0.4678	–0.2752	–0.0198	0.0309	0.0073
3	–2.9013	0.0300	0.0321	0.0170	–0.0624	0.0014	0.0074	0.0065
4	–0.0935	0.0752	0.0033	0.0019	0.0060	0.0018	–0.0012	0.0022
5	0.3485	–0.0028	–0.0029	–0.0021	0.0026	–0.0002	0.0052	–0.0068
Sums	12079.6222	–14.3571	12099.2408	–23.8232	11920.1134	23.3920	12081.0379	–21.7932

Dates: Feb. 1 – Feb. 28

A = 16.0 W = 1

Term	Venus GHA °	Venus Dec. °	Mars GHA °	Mars Dec. °	Jupiter GHA °	Jupiter Dec. °	Saturn GHA °	Saturn Dec. °
0	5973.6681	–15.1892	5982.1513	–23.3678	5815.7204	23.4335	5974.1027	–21.5705
1	5770.3194	–0.8657	5763.0928	0.9590	5776.2247	0.0373	5774.0246	0.2347
2	–4.3626	0.3098	0.0183	0.4992	–0.4618	–0.0059	0.1081	–0.0050
3	0.7990	0.2729	0.0320	–0.0085	–0.0111	0.0017	0.0177	–0.0041
4	0.0765	–0.0401	0.0000	–0.0025	0.0042	–0.0005	0.0001	–0.0004
5	–0.0862	–0.0064	0.0013	0.0021	0.0037	0.0002	–0.0039	0.0017
Sums	11740.4142	–15.5187	11745.2957	–21.9185	11591.4801	23.4663	11748.2493	–21.3436

Dates: Mar. 1 – Mar. 31

A = 16.0 W = 1

Term	Venus GHA °	Venus Dec. °	Mars GHA °	Mars Dec. °	Jupiter GHA °	Jupiter Dec. °	Saturn GHA °	Saturn Dec. °
0	5982.2718	–14.7046	5987.7903	–20.2168	5842.7045	23.4844	5999.0470	–21.1930
1	5761.3201	1.8248	5763.4288	2.5958	5774.6472	0.0186	5774.5190	0.1862
2	–1.2389	1.0168	0.1522	0.4214	–0.4128	–0.0123	0.1692	–0.0230
3	0.3663	0.0145	0.0227	–0.0218	0.0139	–0.0046	0.0063	–0.0064
4	–0.0480	–0.0327	–0.0007	–0.0026	–0.0006	0.0013	0.0008	0.0001
5	0.0035	0.0039	–0.0047	–0.0003	0.0031	0.0006	0.0029	0.0032
Sums	11742.6748	–11.8773	11751.3886	–17.2243	11616.9553	23.4880	11773.7452	–21.0329

Dates: Apr. 1 – Apr. 30

A = 16.0 W = 1

Term	Venus GHA °	Venus Dec. °	Mars GHA °	Mars Dec. °	Jupiter GHA °	Jupiter Dec. °	Saturn GHA °	Saturn Dec. °
0	5982.1754	–7.5713	5995.0979	–13.7994	5869.6773	23.4585	6027.8799	–20.9376
1	5759.2595	5.3166	5764.1276	3.9174	5773.2851	–0.0579	5775.2746	0.0708
2	–0.1512	0.6775	0.1860	0.2524	–0.2834	–0.0317	0.2129	–0.0361
3	0.0557	–0.1113	0.0044	–0.0276	0.0175	–0.0017	0.0036	–0.0075
4	–0.0208	–0.0061	–0.0042	–0.0007	–0.0008	0.0013	0.0012	–0.0009
5	–0.0003	0.0062	–0.0054	–0.0038	0.0036	–0.0019	0.0008	0.0044
Sums	11741.3183	–1.6884	11759.4063	–9.6617	11642.6993	23.3666	11803.3730	–20.9069

Dates: May 1 – May 31

A = 16.0 W = 1

Term	Aries GHA °	Sun GHA °	Sun Dec. °	Sun S.D. °
0	5994.4350	5940.9204	19.2200	0.2642
1	5775.7720	5759.9029	3.6480	–0.0033
2	0.0001	–0.3085	–0.6925	0.0000
3	–0.0030	0.0137	–0.0550	0.0061
4	0.0000	0.0144	0.0015	0.0000
5	0.0014	–0.0017	0.0040	–0.0037
Sums	11770.2055	11700.5412	22.1260	0.2633

Dates: June 1 – June 30

A = 16.0 W = 1

Term	Aries GHA °	Sun GHA °	Sun Dec. °	Sun S.D. °
0	6024.9900	5939.8243	23.3679	0.2633
1	5775.7720	5759.1349	0.5121	0.0000
2	0.0000	–0.0515	–0.8827	0.0000
3	–0.0028	0.0704	–0.0076	0.0000
4	0.0000	0.0085	0.0099	0.0000
5	0.0013	–0.0044	0.0005	0.0000
Sums	11800.7605	11698.9822	23.0001	0.2633

Dates: July 1 – July 31

A = 16.0 W = 1

Term	Aries GHA °	Sun GHA °	Sun Dec. °	Sun S.D. °
0	6054.5590	5938.4848	21.2799	0.2633
1	5775.7708	5759.6377	–2.6705	0.0000
2	0.0036	0.2689	–0.7715	0.0000
3	–0.0028	0.0393	0.0460	0.0000
4	–0.0032	–0.0019	0.0053	0.0000
5	0.0026	–0.0023	–0.0029	0.0000
Sums	11830.3300	11698.4265	17.8863	0.2633

Dates: Aug. 1 – Aug. 31

A = 16.0 W = 1

Term	Aries GHA °	Sun GHA °	Sun Dec. °	Sun S.D. °
0	6085.1140	5938.9501	13.5728	0.2633
1	5775.7707	5760.8321	–5.0836	–0.0007
2	0.0027	0.2708	–0.4579	0.0004
3	–0.0012	–0.0242	0.0607	0.0031
4	–0.0018	–0.0038	–0.0011	0.0006
5	0.0006	–0.0017	–0.0012	–0.0015
Sums	11860.8850	11700.0233	8.0897	0.2652

Dates: May 1 – May 31

A = 16.0 W = 1

Term	Venus GHA °	Venus Dec. °	Mars GHA °	Mars Dec. °	Jupiter GHA °	Jupiter Dec. °	Saturn GHA °	Saturn Dec. °
0	5980.3439	4.0312	6003.4454	–5.7832	5893.7320	23.2218	6057.2881	–20.9435
1	5758.6969	6.6478	5764.7379	4.5120	5772.4523	–0.2034	5776.0918	–0.0748
2	–0.2691	0.0177	0.1318	0.0636	–0.1647	–0.0441	0.2114	–0.0334
3	–0.0633	–0.1243	–0.0058	–0.0286	0.0142	–0.0060	–0.0065	0.0023
4	–0.0015	–0.0023	0.0027	–0.0004	0.0005	–0.0015	–0.0021	–0.0028
5	0.0029	–0.0019	–0.0023	–0.0040	0.0038	0.0037	0.0003	–0.0002
Sums	11738.7098	10.5682	11768.3097	–1.2406	11666.0381	22.9705	11833.5830	–21.0524

Dates: June 1 – June 30

A = 16.0 W = 1

Term	Venus GHA °	Venus Dec. °	Mars GHA °	Mars Dec. °	Jupiter GHA °	Jupiter Dec. °	Saturn GHA °	Saturn Dec. °
0	5976.3563	16.0382	6013.0667	2.9544	5917.3783	22.6441	6089.1858	–21.2076
1	5756.9562	5.2595	5765.1575	4.3871	5772.0227	–0.3957	5776.7828	–0.1875
2	–0.5998	–0.7367	0.0943	–0.1226	–0.0615	–0.0500	0.1293	–0.0212
3	–0.0113	–0.1307	0.0139	–0.0369	0.0182	–0.0023	–0.0203	0.0038
4	0.0192	0.0001	0.0016	–0.0015	–0.0001	–0.0010	0.0003	0.0024
5	–0.0038	–0.0006	–0.0077	0.0048	–0.0011	0.0024	–0.0010	0.0002
Sums	11732.7168	20.4298	11778.3263	7.1853	11689.3565	22.1975	11866.0769	–21.4099

Dates: July 1 – July 31

A = 16.0 W = 1

Term	Venus GHA °	Venus Dec. °	Mars GHA °	Mars Dec. °	Jupiter GHA °	Jupiter Dec. °	Saturn GHA °	Saturn Dec. °
0	5968.6597	22.4941	6023.1081	10.5537	5939.8104	21.7283	6120.9611	–21.5973
1	5755.0140	1.2491	5765.5792	3.6311	5771.9545	–0.5739	5777.0224	–0.2121
2	–0.2938	–1.3315	0.1576	–0.2686	0.0227	–0.0398	–0.0102	0.0066
3	0.1374	–0.0549	0.0400	–0.0149	0.0155	0.0062	–0.0264	0.0089
4	0.0136	0.0190	0.0041	0.0042	–0.0010	–0.0004	0.0011	–0.0009
5	–0.0072	–0.0011	–0.0076	–0.0032	–0.0006	–0.0029	–0.0003	–0.0046
Sums	11723.5237	22.3747	11788.8814	13.9023	11711.8015	21.1175	11897.9477	–21.7994

Dates: Aug. 1 – Aug. 31

A = 16.0 W = 1

Term	Venus GHA °	Venus Dec. °	Mars GHA °	Mars Dec. °	Jupiter GHA °	Jupiter Dec. °	Saturn GHA °	Saturn Dec. °
0	5958.9162	19.7841	6034.7721	16.4856	5963.1603	20.4896	5793.7159	–21.9585
1	5755.4107	–3.9670	5766.6237	2.4585	5772.2008	–0.6893	5776.6935	–0.1515
2	0.4296	–1.2149	0.4331	–0.3192	0.1036	–0.0178	–0.1526	0.0258
3	0.0633	0.0862	0.0853	–0.0026	0.0107	0.0045	–0.0111	0.0057
4	–0.0239	0.0140	0.0045	0.0038	0.0013	0.0018	0.0026	–0.0023
5	0.0022	0.0011	–0.0075	0.0045	0.0038	–0.0001	–0.0069	–0.0020
Sums	11714.7981	14.7035	11801.9112	18.6306	11735.4805	19.7887	11570.2414	–22.0828

Dates: Sept. 1 – Sept. 30

A = 16.0 W = 1

Term	Aries GHA °	Sun GHA °	Sun Dec. °	Sun S.D. °
0	6115.6696	5941.3140	2.4408	0.2651
1	5775.7697	5761.4241	–6.1805	0.0019
2	0.0001	–0.0001	–0.1047	0.0026
3	0.0024	–0.0541	0.0667	–0.0016
4	0.0003	0.0006	0.0021	–0.0020
5	–0.0020	0.0003	–0.0010	0.0005
Sums	11891.4401	11702.6848	–3.7766	0.2665

Dates: Oct. 1 – Oct. 31

A = 16.0 W = 1

Term	Aries GHA °	Sun GHA °	Sun Dec. °	Sun S.D. °
0	6145.2391	5943.6213	–9.0764	0.2675
1	5775.7686	5760.8306	–5.8722	0.0033
2	0.0001	–0.3154	0.2763	0.0000
3	0.0043	–0.0419	0.0765	–0.0061
4	–0.0001	0.0063	0.0013	0.0000
5	–0.0027	–0.0012	–0.0019	0.0037
Sums	11921.0093	11704.0997	–14.5964	0.2684

Dates: Nov. 1 – Nov. 30

A = 16.0 W = 1

Term	Aries GHA °	Sun GHA °	Sun Dec. °	Sun S.D. °
0	5815.7941	5943.7875	–18.8655	0.2701
1	5775.7697	5759.2416	–3.9475	–0.0007
2	0.0018	–0.4480	0.7143	–0.0004
3	0.0028	0.0185	0.0658	0.0031
4	–0.0016	0.0135	–0.0029	–0.0006
5	–0.0020	0.0001	0.0041	–0.0015
Sums	11591.5648	11702.6132	–22.0317	0.2700

Dates: Dec. 1 – Dec. 31

A = 16.0 W = 0

Term	Aries GHA °	Sun GHA °	Sun Dec. °	Sun S.D. °
0	5844.3783	5941.1743	–23.2941	0.2718
1	5775.7720	5758.0644	–0.7646	–0.0004
2	0.0001	–0.1322	0.9900	–0.0027
3	–0.0030	0.0935	0.0138	0.0046
4	0.0000	0.0071	–0.0088	0.0017
5	0.0014	0.0001	0.0036	–0.0036
Sums	11620.1488	11699.2072	–23.0601	0.2714

Dates: Sept. 1 – Sept. 30

A = 16.0 W = 1

Term	Venus GHA °	Venus Dec. °	Mars GHA °	Mars Dec. °	Jupiter GHA °	Jupiter Dec. °	Saturn GHA °	Saturn Dec. °
0	5951.7911	8.3352	6049.8560	20.1123	5987.2992	19.1348	5825.3777	–22.1498
1	5757.1512	–7.3870	5769.3315	1.3414	5772.7755	–0.6837	5775.9430	–0.0411
2	0.3126	–0.5094	1.0493	–0.2299	0.1944	0.0205	–0.2230	0.0322
3	–0.0817	0.1328	0.1460	0.0297	0.0150	0.0108	–0.0073	–0.0070
4	–0.0083	0.0019	0.0009	–0.0014	0.0012	0.0022	0.0026	–0.0029
5	–0.0005	0.0017	–0.0024	–0.0038	0.0024	–0.0026	0.0015	0.0046
Sums	11709.1644	0.5752	11820.3813	21.2483	11760.2877	18.4820	11601.0945	–22.1640

Dates: Oct. 1 – Oct. 31

A = 16.0 W = 1

Term	Venus GHA °	Venus Dec. °	Mars GHA °	Mars Dec. °	Jupiter GHA °	Jupiter Dec. °	Saturn GHA °	Saturn Dec. °
0	5946.8944	–6.3979	6072.0332	21.9814	6012.0572	17.9875	5854.4779	–22.1271
1	5757.2308	–7.8376	5774.9037	0.7268	5773.6979	–0.5090	5775.1044	0.0684
2	–0.2971	0.2793	1.9549	–0.1229	0.3006	0.0696	–0.2144	0.0301
3	–0.1091	0.1504	0.1260	–0.0050	0.0209	0.0046	0.0072	–0.0024
4	0.0051	0.0015	–0.0486	–0.0075	–0.0010	0.0012	0.0011	0.0004
5	0.0026	–0.0026	–0.0116	0.0024	–0.0010	0.0031	–0.0018	0.0027
Sums	11703.7267	–13.8069	11848.9576	22.5752	11786.0746	17.5570	11629.3744	–22.0279

Dates: Nov. 1 – Nov. 30

A = 16.0 W = 1

Term	Venus GHA °	Venus Dec. °	Mars GHA °	Mars Dec. °	Jupiter GHA °	Jupiter Dec. °	Saturn GHA °	Saturn Dec. °
0	5939.7446	–19.4476	6108.2541	22.7775	6039.8599	17.3270	5882.9986	–21.8820
1	5755.1425	–5.0690	5781.9035	–0.0353	5775.0685	–0.1433	5774.3751	0.1835
2	–0.6481	1.1491	0.9502	–0.2843	0.4015	0.1176	–0.1535	0.0288
3	0.0323	0.1402	–0.5921	0.0057	0.0103	0.0083	0.0103	0.0027
4	0.0282	–0.0085	–0.0760	0.0272	–0.0020	–0.0039	–0.0032	–0.0001
5	–0.0028	–0.0013	0.0358	0.0033	0.0021	–0.0024	0.0016	–0.0028
Sums	11694.2967	–23.2371	11890.4755	22.4941	11815.3403	17.3033	11657.2289	–21.6699

Dates: Dec. 1 – Dec. 31

A = 16.0 W = 0

Term	Venus GHA °	Venus Dec. °	Mars GHA °	Mars Dec. °	Jupiter GHA °	Jupiter Dec. °	Saturn GHA °	Saturn Dec. °
0	5929.2910	–24.1622	6147.4523	22.1087	6068.5387	17.4621	5908.6141	–21.4572
1	5753.7439	0.1462	5779.6401	–0.4059	5776.5812	0.2872	5773.9358	0.2802
2	0.0324	1.5962	–1.7729	0.1677	0.4065	0.1109	–0.0838	0.0227
3	0.1918	–0.0041	–0.1973	0.0947	–0.0132	0.0027	0.0136	0.0014
4	0.0019	–0.0250	0.1047	–0.0185	–0.0060	–0.0006	0.0004	0.0011
5	–0.0092	0.0030	0.0014	–0.0080	–0.0024	–0.0073	0.0000	–0.0017
Sums	11683.2518	–22.4459	11925.2283	21.9387	11845.5048	17.8550	11682.4801	–21.1535

Dates: Jan. 1 – Jan. 8

A = 4.0 W = 1

Term	GHA °	Dec. °	H.P. °	S.D. °
0	1886.1136	12.8073	0.9875	0.2691
1	1391.1624	23.4578	0.0225	0.0061
2	–6.1424	–4.7180	–0.0077	–0.0021
3	–2.7097	–3.9812	–0.0106	–0.0029
4	1.0417	–0.5029	–0.0066	–0.0018
5	0.8360	0.0772	0.0118	0.0032
6	0.0988	0.1875	0.0032	0.0009
7	–0.0824	0.0604	–0.0070	–0.0019
Sums	3270.3180	27.3881	0.9931	0.2706

Dates: Jan. 9 – Jan. 16

A = 4.0 W = 9

Term	GHA °	Dec. °	H.P. °	S.D. °
0	1414.4819	16.3845	0.9586	0.2612
1	1392.2310	–20.4080	–0.0481	–0.0131
2	8.2767	–5.2130	–0.0052	–0.0014
3	–2.0179	4.0149	0.0018	0.0005
4	–1.4270	–0.7181	–0.0013	–0.0004
5	0.9154	–0.2987	0.0147	0.0040
6	–0.0252	0.2308	0.0017	0.0005
7	–0.1379	–0.0130	–0.0081	–0.0022
Sums	2812.2970	–6.0206	0.9141	0.2491

Dates: Jan. 17 – Jan. 24

A = 4.0 W = 17

Term	GHA °	Dec. °	H.P. °	S.D. °
0	1690.2583	–23.7362	0.9063	0.2469
1	1393.5400	–11.7497	0.0149	0.0041
2	–5.5465	7.9430	0.0200	0.0055
3	–0.0704	2.1320	0.0059	0.0016
4	1.3973	0.0132	0.0008	0.0002
5	0.2911	–0.2435	–0.0235	–0.0064
6	–0.1428	–0.0858	–0.0014	–0.0004
7	–0.0923	0.0172	0.0149	0.0041
Sums	3079.6347	–25.7098	0.9379	0.2556

Dates: Jan. 25 – Jan. 31

A = 4.0 W = 25

Term	GHA °	Dec. °	H.P. °	S.D. °
0	1590.4940	–7.4837	0.9743	0.2655
1	1393.8812	24.7877	0.0254	0.0069
2	1.6508	3.4210	–0.0123	–0.0034
3	–2.3978	–3.3963	0.0044	0.0012
4	–0.6897	–0.1197	0.0000	0.0000
5	0.3441	0.0633	–0.0094	–0.0025
6	0.0011	–0.0612	0.0002	0.0001
7	–0.0063	0.0110	0.0039	0.0011
Sums	2983.2774	17.2221	0.9865	0.2689

Dates: Feb. 1 – Feb. 8

A = 4.0 W = 1

Term	GHA °	Dec. °	H.P. °	S.D. °
0	1501.5666	27.2255	0.9818	0.2675
1	1381.0106	3.9612	–0.0143	–0.0039
2	–1.5062	–14.0895	–0.0096	–0.0026
3	5.5021	–0.8293	–0.0003	–0.0001
4	1.0604	2.0480	–0.0022	–0.0006
5	–1.6201	0.2800	0.0014	0.0004
6	–0.2496	–0.2683	0.0020	0.0005
7	0.2944	–0.0626	–0.0016	–0.0004
Sums	2886.0582	18.2650	0.9572	0.2608

Dates: Feb. 9 – Feb. 16

A = 4.0 W = 9

Term	GHA °	Dec. °	H.P. °	S.D. °
0	1762.9158	–4.0083	0.9194	0.2505
1	1399.9947	–22.5560	–0.0322	–0.0088
2	0.5289	2.0760	0.0128	0.0035
3	–2.5414	1.9676	–0.0004	–0.0001
4	0.1851	–0.2816	–0.0025	–0.0007
5	0.0787	0.1151	0.0154	0.0042
6	–0.0135	0.0074	0.0005	0.0001
7	0.0254	0.0020	–0.0096	–0.0026
Sums	3161.1737	–22.6778	0.9034	0.2461

Dates: Feb. 17 – Feb. 24

A = 4.0 W = 17

Term	GHA °	Dec. °	H.P. °	S.D. °
0	1671.6525	–26.4664	0.9315	0.2538
1	1388.1481	6.7551	0.0464	0.0127
2	0.2582	11.1905	0.0107	0.0029
3	2.7522	–0.2435	–0.0030	–0.0008
4	–0.5177	–1.0307	0.0028	0.0007
5	–0.6830	–0.0569	–0.0140	–0.0038
6	0.0849	0.0830	–0.0028	–0.0008
7	0.0871	0.0003	0.0096	0.0026
Sums	3061.7823	–9.7686	0.9812	0.2673

Dates: Feb. 25 – Feb. 28

A = 4.0 W = 25

Term	GHA °	Dec. °	H.P. °	S.D. °
0	1573.4604	15.7698	0.9985	0.2721
1	1388.3190	22.4626	–0.0055	–0.0015
2	–5.5333	–7.3367	–0.0230	–0.0063
3	–1.2900	–4.2243	–0.0125	–0.0034
4	1.5859	0.3067	0.0055	0.0015
5	0.7342	0.3564	0.0337	0.0092
6	–0.1083	0.0786	–0.0027	–0.0007
7	–0.1407	–0.0077	–0.0187	–0.0051
Sums	2957.0272	27.4054	0.9753	0.2658

Dates: Mar. 1 – Mar. 8

A = 4.0 W = 1

Term	GHA °	Dec. °	H.P. °	S.D. °
0	1517.0275	27.4045	0.9751	0.2657
1	1381.7425	–1.4748	–0.0333	–0.0091
2	2.7211	–13.7379	–0.0001	0.0000
3	5.0639	1.2615	0.0184	0.0050
4	–0.8938	1.8012	–0.0081	–0.0022
5	–1.4566	–0.3723	–0.0323	–0.0088
6	0.2219	–0.2163	0.0039	0.0011
7	0.2665	0.0675	0.0197	0.0054
Sums	2904.6930	14.7334	0.9433	0.2571

Dates: Mar. 9 – Mar. 16

A = 4.0 W = 9

Term	GHA °	Dec. °	H.P. °	S.D. °
0	1423.1590	–7.6477	0.9127	0.2487
1	1399.8481	–21.6702	–0.0243	–0.0066
2	–0.9718	2.8879	0.0099	0.0027
3	–2.1584	1.9623	0.0024	0.0007
4	0.2809	–0.1315	–0.0003	–0.0001
5	0.0882	0.0910	0.0049	0.0013
6	0.0173	–0.0068	0.0000	0.0000
7	0.0155	–0.0150	–0.0036	–0.0010
Sums	2820.2788	–24.5300	0.9017	0.2457

Dates: Mar. 17 – Mar. 24

A = 4.0 W = 17

Term	GHA °	Dec. °	H.P. °	S.D. °
0	1690.6361	–25.0271	0.9317	0.2539
1	1389.5874	9.9367	0.0482	0.0131
2	1.3735	10.4214	0.0163	0.0044
3	1.6650	–0.7739	0.0048	0.0013
4	–0.9645	–0.7619	–0.0002	–0.0001
5	–0.3867	0.0392	–0.0201	–0.0055
6	0.1429	0.0209	–0.0019	–0.0005
7	0.0438	–0.0186	0.0104	0.0028
Sums	3082.0975	–6.1633	0.9892	0.2694

Dates: Mar. 25 – Mar. 31

A = 4.0 W = 25

Term	GHA °	Dec. °	H.P. °	S.D. °
0	1591.7458	19.1227	1.0128	0.2760
1	1384.4193	20.2745	–0.0125	–0.0034
2	–6.4126	–9.8996	–0.0358	–0.0098
3	0.6220	–4.6309	0.0014	0.0004
4	2.5404	0.9071	0.0059	0.0016
5	0.5132	0.7682	0.0133	0.0036
6	–0.3952	0.0129	–0.0001	0.0000
7	–0.1725	–0.1057	–0.0080	–0.0022
Sums	2972.8604	26.4492	0.9770	0.2662

Dates: Apr. 1 – Apr. 8

A = 4.0 W = 1

Term	GHA °	Dec. °	H.P. °	S.D. °
0	1494.2510	15.7968	0.9421	0.2567
1	1394.3810	–19.7582	–0.0403	–0.0110
2	6.7856	–4.8298	0.0107	0.0029
3	–2.2929	3.1284	0.0066	0.0018
4	–0.7394	–0.5082	–0.0045	–0.0012
5	0.5981	–0.0208	–0.0143	–0.0039
6	–0.1045	0.1153	0.0013	0.0004
7	–0.0411	–0.0381	0.0099	0.0027
Sums	2892.8378	–6.1146	0.9115	0.2484

Dates: Apr. 9 – Apr. 16

A = 4.0 W = 9

Term	GHA °	Dec. °	H.P. °	S.D. °
0	1770.4492	–23.6028	0.8999	0.2452
1	1393.8208	–11.2872	–0.0013	–0.0003
2	–4.1892	8.0940	0.0193	0.0053
3	0.5872	1.7444	0.0186	0.0051
4	1.0848	–0.2838	–0.0124	–0.0034
5	–0.0313	–0.1763	–0.0318	–0.0087
6	–0.1372	–0.0225	0.0087	0.0024
7	–0.0077	0.0190	0.0181	0.0049
Sums	3161.5766	–25.5152	0.9191	0.2505

Dates: Apr. 17 – Apr. 24

A = 4.0 W = 17

Term	GHA °	Dec. °	H.P. °	S.D. °
0	1674.0809	–8.6147	0.9733	0.2652
1	1393.8575	23.9611	0.0640	0.0174
2	–0.3069	4.8930	0.0027	0.0007
3	–2.4883	–2.6932	–0.0144	–0.0039
4	–0.6354	–0.6716	–0.0118	–0.0032
5	0.2257	–0.1894	0.0055	0.0015
6	0.0559	0.0038	0.0058	0.0016
7	0.0239	0.0476	–0.0041	–0.0011
Sums	3064.8133	16.7366	1.0210	0.2782

Dates: Apr. 25 – Apr. 30

A = 4.0 W = 25

Term	GHA °	Dec. °	H.P. °	S.D. °
0	1564.4438	26.6666	0.9960	0.2714
1	1379.6274	–4.7592	–0.0558	–0.0152
2	6.3408	–14.2234	–0.0116	–0.0032
3	5.4115	3.0988	0.0131	0.0036
4	–2.7011	1.9562	–0.0110	–0.0030
5	–1.2601	–1.1000	0.0142	0.0039
6	0.6652	–0.2062	0.0071	0.0019
7	0.1546	0.2179	–0.0128	–0.0035
Sums	2952.6821	11.6507	0.9392	0.2559

Dates: May 1 – May 8

A = 4.0 W = 1

Term	GHA °	Dec. °	H.P. °	S.D. °
0	1492.0205	0.6049	0.9189	0.2504
1	1400.1975	–22.3202	–0.0360	–0.0098
2	1.5909	0.5660	0.0194	0.0053
3	–2.7660	1.9087	0.0156	0.0043
4	0.2848	–0.1920	–0.0102	–0.0028
5	0.0521	0.1763	–0.0293	–0.0080
6	–0.0437	–0.0256	0.0050	0.0014
7	0.0453	–0.0162	0.0166	0.0045
Sums	2891.3814	–19.2981	0.9000	0.2453

Dates: May 9 – May 16

A = 4.0 W = 9

Term	GHA °	Dec. °	H.P. °	S.D. °
0	1764.0400	–26.8696	0.9063	0.2469
1	1390.2851	1.8532	0.0177	0.0048
2	–0.0554	10.1880	0.0161	0.0044
3	2.6793	–0.0070	0.0149	0.0041
4	–0.2688	–0.8317	–0.0028	–0.0008
5	–0.6892	0.0278	–0.0304	–0.0083
6	0.0440	0.0839	0.0011	0.0003
7	0.1032	–0.0046	0.0186	0.0051
Sums	3156.1382	–15.5600	0.9415	0.2565

Dates: May 17 – May 24

A = 4.0 W = 17

Term	GHA °	Dec. °	H.P. °	S.D. °
0	1670.5028	8.1736	0.9991	0.2722
1	1391.1849	25.2140	0.0565	0.0154
2	–6.3844	–1.9989	–0.0182	–0.0050
3	–3.1618	–4.3650	–0.0345	–0.0094
4	0.6405	–1.0064	0.0002	0.0000
5	0.8293	0.0057	0.0348	0.0095
6	0.1923	0.2217	–0.0003	–0.0001
7	–0.0391	0.0960	–0.0170	–0.0046
Sums	3053.7645	26.3407	1.0206	0.2780

Dates: May 25 – May 31

A = 4.0 W = 25

Term	GHA °	Dec. °	H.P. °	S.D. °
0	1554.9104	18.0611	0.9717	0.2648
1	1389.9535	–19.0116	–0.0652	–0.0178
2	9.6016	–6.2141	–0.0048	–0.0013
3	–2.0769	4.3386	0.0122	0.0033
4	–1.8662	–0.8403	0.0067	0.0018
5	1.2616	–0.3035	0.0084	0.0023
6	0.0134	0.2971	–0.0046	–0.0012
7	–0.2422	–0.0601	–0.0066	–0.0018
Sums	2951.5552	–3.7328	0.9178	0.2501

Dates: June 1 – June 8

A = 4.0 W = 1

Term	GHA °	Dec. °	H.P. °	S.D. °
0	1480.9850	–18.3951	0.9007	0.2454
1	1397.0687	–16.1795	–0.0079	–0.0022
2	–4.1395	5.8600	0.0173	0.0047
3	–1.0878	1.9039	–0.0090	–0.0024
4	0.9444	0.0885	0.0000	0.0000
5	0.2399	–0.0726	0.0118	0.0032
6	–0.0252	–0.0680	–0.0012	–0.0003
7	–0.0360	–0.0107	–0.0060	–0.0016
Sums	2873.9495	–26.8735	0.9057	0.2468

Dates: June 9 – June 16

A = 4.0 W = 9

Term	GHA °	Dec. °	H.P. °	S.D. °
0	1745.7631	–16.5082	0.9330	0.2542
1	1394.7863	18.6160	0.0384	0.0105
2	2.9497	6.4383	0.0143	0.0039
3	–1.2810	–2.0798	–0.0017	–0.0005
4	–1.0993	–0.1317	–0.0084	–0.0023
5	0.2685	0.0602	0.0003	0.0001
6	0.0548	–0.0747	0.0041	0.0011
7	–0.0557	0.0011	–0.0003	–0.0001
Sums	3141.3864	6.3212	0.9797	0.2669

Dates: June 17 – June 24

A = 4.0 W = 17

Term	GHA °	Dec. °	H.P. °	S.D. °
0	1647.6265	25.5406	1.0144	0.2764
1	1378.1527	9.1387	0.0093	0.0025
2	–5.6498	–14.6012	–0.0349	–0.0095
3	6.0336	–3.2663	–0.0073	–0.0020
4	3.0766	2.4521	0.0006	0.0002
5	–1.5199	1.1032	0.0029	0.0008
6	–0.7750	–0.3306	0.0031	0.0008
7	0.2271	–0.2366	–0.0013	–0.0004
Sums	3027.1718	19.7999	0.9868	0.2688

Dates: June 25 – June 30

A = 4.0 W = 25

Term	GHA °	Dec. °	H.P. °	S.D. °
0	1541.6151	–2.2036	0.9299	0.2534
1	1399.2470	–22.6118	–0.0477	–0.0130
2	1.6964	1.8731	0.0134	0.0037
3	–2.9738	1.9003	0.0018	0.0005
4	0.3204	–0.3775	0.0093	0.0025
5	0.1030	0.1842	0.0049	0.0013
6	–0.0539	–0.0110	–0.0082	–0.0022
7	0.0288	0.0081	–0.0018	–0.0005
Sums	2939.9830	–21.2382	0.9016	0.2457

Dates: July 1 – July 8

A = 4.0 W = 1

Term	GHA °	Dec. °	H.P. °	S.D. °
0	1476.5989	–26.1596	0.9040	0.2463
1	1391.2293	–5.4668	0.0097	0.0026
2	–3.3105	9.5236	0.0080	0.0022
3	2.0012	1.3130	0.0079	0.0022
4	1.0981	–0.6030	0.0156	0.0043
5	–0.3730	–0.2584	–0.0248	–0.0067
6	–0.1875	0.0354	–0.0095	–0.0026
7	0.0282	0.0304	0.0152	0.0042
Sums	2867.0847	–21.5854	0.9261	0.2525

Dates: July 9 – July 16

A = 4.0 W = 9

Term	GHA °	Dec. °	H.P. °	S.D. °
0	1742.1160	–1.1342	0.9592	0.2614
1	1396.1868	24.2424	0.0395	0.0108
2	–1.2412	1.2286	0.0052	0.0014
3	–2.9174	–2.7315	–0.0220	–0.0060
4	–0.3394	–0.2624	–0.0091	–0.0025
5	0.1817	–0.1396	0.0365	0.0099
6	0.0480	–0.0239	0.0048	0.0013
7	0.0481	0.0221	–0.0204	–0.0056
Sums	3134.0826	21.2015	0.9937	0.2707

Dates: July 17 – July 24

A = 4.0 W = 17

Term	GHA °	Dec. °	H.P. °	S.D. °
0	1634.2310	24.9822	0.9979	0.2719
1	1380.7601	–10.5473	–0.0233	–0.0063
2	6.6501	–13.1250	–0.0246	–0.0067
3	4.5204	3.6524	0.0158	0.0043
4	–2.9897	1.7944	–0.0031	–0.0008
5	–0.8332	–1.0571	–0.0272	–0.0074
6	0.7059	–0.1897	0.0040	0.0011
7	0.0651	0.2117	0.0161	0.0044
Sums	3023.1097	5.7216	0.9556	0.2605

Dates: July 25 – July 31

A = 4.0 W = 25

Term	GHA °	Dec. °	H.P. °	S.D. °
0	1541.1949	–16.0634	0.9113	0.2483
1	1397.5029	–17.9697	–0.0281	–0.0077
2	–2.8060	5.5374	0.0233	0.0064
3	–1.7306	1.6177	0.0051	0.0014
4	0.6632	0.0301	–0.0051	–0.0014
5	0.2051	0.0959	–0.0003	–0.0001
6	0.0180	–0.0687	0.0010	0.0003
7	–0.0154	–0.0297	–0.0007	–0.0002
Sums	2935.0321	–26.8504	0.9065	0.2470

Dates: Aug. 1 – Aug. 8

A = 4.0 W = 1

Term	GHA °	Dec. °	H.P. °	S.D. °
0	1457.6572	–22.6322	0.9273	0.2527
1	1391.3014	13.0546	0.0357	0.0097
2	2.8759	9.1063	0.0058	0.0016
3	1.0455	–1.6577	–0.0032	–0.0009
4	–1.2215	–0.6686	0.0024	0.0007
5	–0.1168	0.1907	–0.0121	–0.0033
6	0.1689	0.0181	–0.0021	–0.0006
7	–0.0233	–0.0365	0.0090	0.0025
Sums	2851.6873	–2.6253	0.9628	0.2624

Dates: Aug. 9 – Aug. 16

A = 4.0 W = 9

Term	GHA °	Dec. °	H.P. °	S.D. °
0	1724.1006	20.1910	0.9849	0.2684
1	1386.8407	17.6411	0.0137	0.0037
2	–7.2139	–9.0044	–0.0049	–0.0013
3	–0.1765	–3.9419	0.0006	0.0002
4	2.2559	0.2479	–0.0116	–0.0032
5	0.7183	0.5389	–0.0018	–0.0005
6	–0.2737	0.1278	0.0071	0.0019
7	–0.2014	–0.0502	0.0001	0.0000
Sums	3106.0500	25.7502	0.9881	0.2692

Dates: Aug. 17 – Aug. 24

A = 4.0 W = 17

Term	GHA °	Dec. °	H.P. °	S.D. °
0	1614.3831	8.0078	0.9591	0.2613
1	1395.0455	–23.3972	–0.0430	–0.0117
2	4.9927	–1.8143	–0.0109	–0.0030
3	–2.5901	3.3660	0.0141	0.0038
4	–0.2932	–0.6330	0.0078	0.0021
5	0.4332	–0.0163	–0.0131	–0.0036
6	–0.1439	0.1125	–0.0034	–0.0009
7	0.0001	–0.0302	0.0064	0.0017
Sums	3011.8274	–14.4047	0.9170	0.2497

Dates: Aug. 25 – Aug. 31

A = 4.0 W = 25

Term	GHA °	Dec. °	H.P. °	S.D. °
0	1526.0986	–26.5468	0.9057	0.2468
1	1391.0355	–3.6883	0.0066	0.0018
2	–2.3385	9.7149	0.0187	0.0051
3	1.8257	0.8885	0.0138	0.0038
4	0.6953	–0.5235	0.0078	0.0021
5	–0.3797	–0.1438	–0.0202	–0.0055
6	–0.1114	0.0181	–0.0064	–0.0017
7	0.0344	0.0119	0.0085	0.0023
Sums	2916.8599	–20.2690	0.9345	0.2547

Dates: Sept. 1 – Sept. 8

A = 4.0 W = 1

Term	GHA °	Dec. °	H.P. °	S.D. °
0	1442.2529	–4.6400	0.9693	0.2641
1	1394.6569	24.4735	0.0411	0.0112
2	–0.3639	2.7146	–0.0173	–0.0047
3	–2.3191	–3.1526	–0.0105	–0.0029
4	–0.4137	–0.4158	0.0111	0.0030
5	0.1909	–0.0082	0.0052	0.0014
6	0.0390	0.0062	–0.0049	–0.0013
7	0.0408	0.0205	–0.0022	–0.0006
Sums	2834.0838	18.9982	0.9918	0.2702

Dates: Sept. 9 – Sept. 16

A = 4.0 W = 9

Term	GHA °	Dec. °	H.P. °	S.D. °
0	1696.4585	26.0789	0.9815	0.2674
1	1382.0115	–6.3210	–0.0174	–0.0047
2	4.4942	–13.0814	–0.0040	–0.0011
3	4.2829	2.2209	–0.0152	–0.0041
4	–1.8513	1.5852	–0.0103	–0.0028
5	–0.9648	–0.5715	0.0270	0.0074
6	0.4305	–0.1540	0.0059	0.0016
7	0.1176	0.1026	–0.0130	–0.0035
Sums	3084.9791	9.8597	0.9545	0.2602

Dates: Sept. 17 – Sept. 24

A = 4.0 W = 17

Term	GHA °	Dec. °	H.P. °	S.D. °
0	1602.3826	–12.6325	0.9199	0.2506
1	1397.5189	–19.9466	–0.0297	–0.0081
2	–1.9261	4.7691	0.0069	0.0019
3	–1.6321	2.0163	–0.0030	–0.0008
4	0.5422	–0.1828	0.0061	0.0017
5	0.1450	–0.0162	0.0135	0.0037
6	0.0063	–0.0240	–0.0042	–0.0011
7	–0.0048	0.0160	–0.0063	–0.0017
Sums	2997.0320	–26.0007	0.9032	0.2462

Dates: Sept. 25 – Sept. 30

A = 4.0 W = 25

Term	GHA °	Dec. °	H.P. °	S.D. °
0	1508.3494	–21.5127	0.9265	0.2524
1	1392.6106	13.8874	0.0461	0.0125
2	2.2992	8.5394	0.0136	0.0037
3	0.1061	–1.3521	–0.0100	–0.0027
4	–1.0400	–0.4416	0.0050	0.0014
5	–0.0194	0.0298	0.0046	0.0012
6	0.1140	–0.0239	–0.0036	–0.0010
7	–0.0063	–0.0033	–0.0026	–0.0007
Sums	2902.4136	–0.8770	0.9796	0.2668

Dates: Oct. 1 – Oct. 8

A = 4.0 W = 1

Term	GHA °	Dec. °	H.P. °	S.D. °
0	1438.4214	11.6304	0.9993	0.2723
1	1389.5163	23.8768	0.0260	0.0071
2	–6.1763	–4.4893	–0.0229	–0.0063
3	–1.9512	–4.6793	0.0096	0.0026
4	1.1766	–0.3585	–0.0126	–0.0034
5	0.8111	0.3637	–0.0281	–0.0077
6	0.0209	0.1602	0.0115	0.0031
7	–0.1132	0.0121	0.0156	0.0043
Sums	2821.7056	26.5161	0.9984	0.2720

Dates: Oct. 9 – Oct. 16

A = 4.0 W = 9

Term	GHA °	Dec. °	H.P. °	S.D. °
0	1686.2888	16.2734	0.9608	0.2618
1	1391.9232	–19.5030	–0.0408	–0.0111
2	7.1391	–5.6077	0.0019	0.0005
3	–2.0168	3.5039	0.0142	0.0039
4	–1.1018	–0.4610	–0.0016	–0.0004
5	0.7850	–0.1036	–0.0196	–0.0053
6	–0.0470	0.1601	0.0009	0.0002
7	–0.1164	–0.0489	0.0106	0.0029
Sums	3082.8541	–5.7868	0.9264	0.2525

Dates: Oct. 17 – Oct. 24

A = 4.0 W = 17

Term	GHA °	Dec. °	H.P. °	S.D. °
0	1599.3781	–23.1762	0.9030	0.2460
1	1393.4429	–10.8785	–0.0150	–0.0041
2	–3.2263	8.2751	0.0155	0.0042
3	0.8292	1.4729	0.0091	0.0025
4	1.0016	–0.4315	–0.0063	–0.0017
5	–0.1060	–0.1621	–0.0012	–0.0003
6	–0.1414	0.0079	0.0044	0.0012
7	–0.0082	0.0291	–0.0026	–0.0007
Sums	2991.1699	–24.8633	0.9069	0.2471

Dates: Oct. 25 – Oct. 31

A = 4.0 W = 25

Term	GHA °	Dec. °	H.P. °	S.D. °
0	1505.4852	–9.1476	0.9515	0.2593
1	1395.7422	22.1401	0.0613	0.0167
2	–0.2528	4.6613	0.0109	0.0030
3	–2.3906	–2.0954	–0.0032	–0.0009
4	–0.5548	–0.4798	–0.0083	–0.0023
5	0.1631	–0.2028	–0.0204	–0.0056
6	0.0251	–0.0229	0.0041	0.0011
7	0.0175	0.0336	0.0131	0.0036
Sums	2898.2349	14.8865	1.0090	0.2749

Dates: Nov. 1 – Nov. 8

A = 4.0 W = 1

Term	GHA °	Dec. °	H.P. °	S.D. °
0	1414.1264	26.0108	1.0161	0.2769
1	1377.1817	4.8768	–0.0208	–0.0057
2	–1.1923	–15.4380	–0.0367	–0.0100
3	7.2714	–0.9322	0.0131	0.0036
4	0.8864	3.0071	0.0066	0.0018
5	–2.3492	0.1924	–0.0090	–0.0024
6	–0.2412	–0.4958	–0.0016	–0.0004
7	0.4652	–0.0485	0.0043	0.0012
Sums	2796.1484	17.1726	0.9720	0.2650

Dates: Nov. 9 – Nov. 16

A = 4.0 W = 9

Term	GHA °	Dec. °	H.P. °	S.D. °
0	1672.2322	–4.6108	0.9249	0.2520
1	1399.0021	–21.8514	–0.0361	–0.0098
2	0.1065	2.1641	0.0199	0.0054
3	–2.5115	1.9701	0.0076	0.0021
4	0.4208	–0.1058	–0.0172	–0.0047
5	0.0879	0.1202	–0.0126	–0.0034
6	–0.0030	–0.0430	0.0094	0.0026
7	0.0299	–0.0081	0.0068	0.0019
Sums	3069.3649	–22.3647	0.9027	0.2461

Dates: Nov. 17 – Nov. 24

A = 4.0 W = 17

Term	GHA °	Dec. °	H.P. °	S.D. °
0	1581.3232	–25.1382	0.9019	0.2457
1	1392.0682	6.6399	0.0147	0.0040
2	2.2593	9.1227	0.0174	0.0048
3	1.6379	–0.9712	–0.0034	–0.0009
4	–0.9524	–0.5356	–0.0017	–0.0005
5	–0.3189	0.1939	0.0087	0.0024
6	0.1432	0.0183	0.0003	0.0001
7	0.0218	–0.0311	–0.0039	–0.0011
Sums	2976.1823	–10.7013	0.9340	0.2545

Dates: Nov. 25 – Nov. 30

A = 4.0 W = 25

Term	GHA °	Dec. °	H.P. °	S.D. °
0	1491.2027	12.4406	0.9953	0.2712
1	1389.8745	22.8240	0.0603	0.0164
2	–8.2866	–3.9190	–0.0195	–0.0053
3	–2.6993	–4.6047	–0.0167	–0.0046
4	1.3206	–1.0208	0.0059	0.0016
5	1.1400	0.1992	0.0008	0.0002
6	0.1049	0.2943	–0.0024	–0.0007
7	–0.1562	0.0783	0.0011	0.0003
Sums	2872.5006	26.2919	1.0248	0.2791

Dates: Dec. 1 – Dec. 8

A = 4.0 W = 1

Term	GHA °	Dec. °	H.P. °	S.D. °
0	1401.4708	22.6771	1.0070	0.2744
1	1381.7207	–13.9821	–0.0496	–0.0135
2	9.6459	–11.3201	–0.0203	–0.0055
3	2.2397	5.1003	0.0113	0.0031
4	–3.8788	0.7599	–0.0128	–0.0035
5	0.4752	–1.3666	0.0072	0.0020
6	0.7790	0.1061	0.0091	0.0025
7	–0.2705	0.2261	–0.0050	–0.0014
Sums	2792.1820	2.2007	0.9469	0.2581

Dates: Dec. 9 – Dec. 16

A = 4.0 W = 9

Term	GHA °	Dec. °	H.P. °	S.D. °
0	1670.2208	–18.1209	0.9070	0.2471
1	1396.4036	–15.8999	–0.0210	–0.0057
2	–3.3712	6.1642	0.0195	0.0053
3	–0.9769	1.7534	–0.0116	–0.0032
4	0.9606	–0.0110	–0.0102	–0.0028
5	0.2188	–0.0969	0.0144	0.0039
6	–0.0315	–0.0632	0.0070	0.0019
7	–0.0491	0.0129	–0.0049	–0.0013
Sums	3063.3751	–26.2614	0.9002	0.2452

Dates: Dec. 17 – Dec. 24

A = 4.0 W = 17

Term	GHA °	Dec. °	H.P. °	S.D. °
0	1576.5813	–16.4963	0.9156	0.2495
1	1396.3111	17.3258	0.0252	0.0069
2	3.0020	5.8642	0.0133	0.0036
3	–1.1860	–1.8710	0.0160	0.0044
4	–0.9375	–0.0355	–0.0028	–0.0008
5	0.2115	0.0860	–0.0189	–0.0052
6	0.0272	–0.0692	0.0031	0.0009
7	–0.0384	–0.0155	0.0067	0.0018
Sums	2973.9712	4.7885	0.9582	0.2611

Dates: Dec. 24 – Dec. 31

A = 4.0 W = 24

Term	GHA °	Dec. °	H.P. °	S.D. °
0	1497.1834	20.6079	1.0003	0.2725
1	1384.4846	16.7250	0.0483	0.0132
2	–9.7590	–9.2943	–0.0222	–0.0060
3	0.2186	–5.0369	0.0000	0.0000
4	3.2486	0.0122	0.0087	0.0024
5	1.0745	0.9753	–0.0259	–0.0071
6	–0.4816	0.2388	–0.0052	–0.0014
7	–0.3435	–0.1011	0.0150	0.0041
Sums	2875.6256	24.1269	1.0190	0.2777

Section D: ASTRONOMICAL TABLES

With two exceptions the series in this section provide data referred to the true equator and equinox of date. The exceptions are

1. the Moon's geocentric, rectangular coordinates (X, Y, Z), which are referred to the mean equator and equinox of B1950.0 (JD 2433282.423);
2. the right ascension and declination of Pluto, which are astrometric (i.e., free from stellar aberration) and are referred to the mean equator and equinox of J2000.0 (JD 2451545.0).

The unit of distance for the Sun and planets is the astronomical unit (au); the unit of distance for the Moon is the Earth's equatorial radius.

Chebyshev Series for Sidereal Time and Nutation, 1990

Days: 1–95 JD 2447892.5 – 2447987.5 Dates: Jan. 1 – Apr. 5

A = 47.5 W = 1

Term	Apparent Sid. Time h	Equation of Equinoxes s	Nutation in Longitude ″	Nutation in Obliquity ″
0	19.62733594	1.5134	24.7426	13.4454
1	3.12121669	0.0001	0.0021	0.2981
2	–0.00001021	–0.0367	–0.6007	–0.1296
3	0.00000272	0.0098	0.1599	–0.1019
4	0.00000194	0.0070	0.1144	0.0300
5	0.00000061	0.0022	0.0357	–0.0051
6	0.00000112	0.0040	0.0659	0.0217
7	–0.00000035	–0.0013	–0.0208	0.0099
8	0.00000077	0.0028	0.0451	0.0178
9	–0.00000143	–0.0051	–0.0839	0.0288
10	0.00000049	0.0018	0.0287	0.0010
11	–0.00000037	–0.0013	–0.0221	0.0350
12	–0.00000130	–0.0047	–0.0767	–0.0197
13	–0.00000015	–0.0005	–0.0089	0.0021
14	–0.00000128	–0.0046	–0.0750	–0.0222
15	0.00000099	0.0036	0.0582	–0.0398
16	0.00000077	0.0028	0.0455	0.0121
17	0.00000025	0.0009	0.0150	–0.0108
18	0.00000139	0.0050	0.0820	0.0232
19	–0.00000101	–0.0036	–0.0593	0.0464
20	–0.00000173	–0.0062	–0.1016	–0.0259
21	0.00000075	0.0027	0.0441	–0.0361
22	0.00000106	0.0038	0.0621	0.0167
23	–0.00000050	–0.0018	–0.0296	0.0200
24	–0.00000058	–0.0021	–0.0342	–0.0112
25	0.00000030	0.0011	0.0175	–0.0103
26	0.00000023	0.0008	0.0138	0.0042
27	–0.00000002	–0.0001	–0.0011	0.0021
28	0.00000004	0.0001	0.0024	0.0022
29	–0.00000014	–0.0005	–0.0081	0.0026
30	–0.00000013	–0.0005	–0.0076	–0.0040
31	0.00000014	0.0005	0.0082	–0.0029
32	0.00000009	0.0003	0.0054	0.0031
33	–0.00000010	–0.0004	–0.0057	0.0017
Sums	22.74854699	1.4933	24.4133	13.6046

Days: 91–185 JD 2447982.5 – 2448077.5 Dates: Apr. 1 – July 4

A = 47.5 W = 91

Term	Apparent Sid. Time h	Equation of Equinoxes s	Nutation in Longitude ″	Nutation in Obliquity ″
0	31.45510163	1.5037	24.5852	11.9162
1	3.12123265	0.0576	0.9413	–0.8770
2	0.00001017	0.0366	0.5986	0.0923
3	–0.00000257	–0.0093	–0.1514	0.0850
4	–0.00000070	–0.0025	–0.0411	–0.0386
5	–0.00000079	–0.0029	–0.0467	0.0059
6	–0.00000086	–0.0031	–0.0505	–0.0359
7	0.00000017	0.0006	0.0098	0.0014
8	–0.00000127	–0.0046	–0.0745	–0.0299
9	0.00000155	0.0056	0.0914	–0.0087
10	0.00000052	0.0019	0.0306	–0.0061
11	0.00000108	0.0039	0.0635	–0.0147
12	0.00000020	0.0007	0.0117	0.0283
13	0.00000025	0.0009	0.0146	–0.0001
14	0.00000050	0.0018	0.0297	0.0327
15	–0.00000151	–0.0054	–0.0889	0.0159
16	–0.00000049	–0.0018	–0.0289	–0.0206
17	–0.00000037	–0.0013	–0.0217	–0.0001
18	–0.00000052	–0.0019	–0.0305	–0.0340
19	0.00000187	0.0067	0.1099	–0.0243
20	0.00000110	0.0040	0.0646	0.0483
21	–0.00000158	–0.0057	–0.0929	0.0244
22	–0.00000064	–0.0023	–0.0374	–0.0300
23	0.00000079	0.0028	0.0463	–0.0071
24	0.00000003	0.0001	0.0020	0.0130
25	–0.00000032	–0.0011	–0.0187	–0.0017
26	0.00000002	0.0001	0.0011	–0.0046
27	0.00000008	0.0003	0.0047	–0.0024
28	0.00000021	0.0007	0.0122	0.0001
29	0.00000004	0.0002	0.0026	0.0072
30	–0.00000029	–0.0011	–0.0172	0.0013
31	–0.00000004	–0.0001	–0.0024	–0.0068
32	0.00000021	0.0008	0.0124	–0.0002
33	–0.00000001	0.0000	–0.0008	0.0040
Sums	34.57634111	1.5859	25.9286	11.1332

Chebyshev Series for Sidereal Time and Nutation, 1990

Days: 182–276 JD 2448073.5 – 2448168.5 Dates: July 1 – Oct. 3

A = 47.5 W = 182

Term	Apparent Sid. Time h	Equation of Equinoxes s	Nutation in Longitude ″	Nutation in Obliquity ″
0	43.41435101	1.7246	28.1968	11.1421
1	3.12121545	–0.0043	–0.0707	0.3124
2	–0.00001126	–0.0405	–0.6625	–0.0713
3	0.00000146	0.0053	0.0859	–0.0601
4	0.00000006	0.0002	0.0036	0.0298
5	0.00000012	0.0004	0.0073	0.0142
6	–0.00000037	–0.0013	–0.0215	0.0322
7	–0.00000019	–0.0007	–0.0110	–0.0007
8	–0.00000036	–0.0013	–0.0214	0.0297
9	–0.00000061	–0.0022	–0.0358	–0.0153
10	–0.00000060	–0.0021	–0.0351	0.0056
11	–0.00000154	–0.0056	–0.0909	–0.0174
12	0.00000071	0.0025	0.0415	–0.0256
13	–0.00000004	–0.0001	–0.0024	–0.0025
14	0.00000053	0.0019	0.0314	–0.0293
15	0.00000135	0.0049	0.0797	0.0204
16	–0.00000050	–0.0018	–0.0294	0.0190
17	0.00000029	0.0010	0.0168	0.0017
18	–0.00000060	–0.0022	–0.0354	0.0304
19	–0.00000174	–0.0063	–0.1027	–0.0286
20	0.00000118	0.0042	0.0694	–0.0459
21	0.00000157	0.0057	0.0924	0.0287
22	–0.00000076	–0.0027	–0.0447	0.0290
23	–0.00000073	–0.0026	–0.0431	–0.0116
24	0.00000016	0.0006	0.0093	–0.0103
25	0.00000020	0.0007	0.0119	0.0004
26	0.00000002	0.0001	0.0013	0.0028
27	–0.00000008	–0.0003	–0.0048	–0.0006
28	0.00000010	0.0003	0.0057	–0.0020
29	0.00000009	0.0003	0.0051	0.0042
30	–0.00000020	–0.0007	–0.0116	0.0018
31	–0.00000007	–0.0002	–0.0039	–0.0052
32	0.00000017	0.0006	0.0101	–0.0011
33	0.00000003	0.0001	0.0019	0.0034
Sums	46.53555485	1.6785	27.4432	11.3803

Days: 274–368 JD 2448165.5 – 2448260.5 Dates: Oct. 1 – Jan. 3

A = 47.5 W = 274

Term	Apparent Sid. Time h	Equation of Equinoxes s	Nutation in Longitude ″	Nutation in Obliquity ″
0	7.50495164	1.6993	27.7822	9.5414
1	3.12123459	0.0646	1.0558	–0.9818
2	0.00001278	0.0460	0.7525	0.1141
3	–0.00000030	–0.0011	–0.0174	0.0700
4	0.00000045	0.0016	0.0263	0.0107
5	0.00000093	0.0033	0.0546	–0.0134
6	0.00000153	0.0055	0.0900	0.0167
7	0.00000020	0.0007	0.0115	0.0090
8	0.00000128	0.0046	0.0753	0.0144
9	–0.00000141	–0.0051	–0.0831	0.0336
10	0.00000012	0.0004	0.0071	0.0060
11	–0.00000029	–0.0010	–0.0170	0.0379
12	–0.00000126	–0.0045	–0.0739	–0.0170
13	–0.00000027	–0.0010	–0.0157	0.0039
14	–0.00000145	–0.0052	–0.0852	–0.0177
15	0.00000078	0.0028	0.0458	–0.0402
16	0.00000069	0.0025	0.0406	0.0096
17	0.00000026	0.0009	0.0152	–0.0140
18	0.00000143	0.0051	0.0840	0.0177
19	–0.00000092	–0.0033	–0.0544	0.0437
20	–0.00000163	–0.0059	–0.0962	–0.0235
21	0.00000080	0.0029	0.0469	–0.0349
22	0.00000115	0.0041	0.0674	0.0162
23	–0.00000045	–0.0016	–0.0265	0.0231
24	–0.00000068	–0.0025	–0.0403	–0.0078
25	0.00000017	0.0006	0.0100	–0.0110
26	0.00000020	0.0007	0.0116	0.0021
27	–0.00000001	0.0000	–0.0005	0.0001
28	0.00000013	0.0005	0.0076	0.0009
29	–0.00000006	–0.0002	–0.0034	0.0053
30	–0.00000024	–0.0009	–0.0142	0.0018
31	0.00000007	0.0002	0.0040	0.0062
32	0.00000022	0.0008	0.0131	0.0016
33	–0.00000005	–0.0002	–0.0027	0.0047
Sums	10.62620040	1.8146	29.6710	8.8134

Days: 1–95 JD 2447892.5 – 2447987.5 Dates: Jan. 1 – Apr. 5

A = 47.5 W = 1

Term	R.A. h	Dec. °	Distance AU	S.D. ′	Ephem. Tran. h
0	43.9018609	–20.359985	1.98024345	32.36036	24.2748358
1	3.1042432	15.140065	0.00893278	–0.14571	–0.0205212
2	–0.0923471	1.796111	0.00187920	–0.03010	–0.0916280
3	0.0121500	–0.489025	–0.00028173	0.00487	0.0125183
4	0.0043393	–0.000803	–0.00002641	0.00042	0.0042541
5	–0.0007684	0.005146	–0.00001227	0.00019	–0.0007786
6	–0.0000103	–0.001322	0.00000018	–0.00001	–0.0000067
7	0.0000280	–0.000022	–0.00001257	0.00021	0.0000221
8	–0.0000782	–0.000396	–0.00000030	0.00001	–0.0000794
9	–0.0000025	–0.000031	0.00001842	–0.00030	0.0000065
10	0.0000482	0.000352	0.00000035	0.00000	0.0000476
11	–0.0000015	0.000024	–0.00000772	0.00013	–0.0000038
12	–0.0000152	–0.000127	–0.00000009	0.00000	–0.0000136
13	0.0000010	–0.000016	0.00000210	–0.00003	0.0000019
14	0.0000025	0.000031	–0.00000008	0.00000	0.0000033
15	0.0000008	0.000010	–0.00000056	0.00001	–0.0000004
16	0.0000003	–0.000007	–0.00000004	0.00000	–0.0000003
17	–0.0000003	0.000004	–0.00000015	0.00000	–0.0000009
18	0.0000001	–0.000001	0.00000012	0.00000	–0.0000010
19	–0.0000004	–0.000007	0.00000035	–0.00001	0.0000009
Sums	46.9294504	–3.909999	1.99073503	32.19004	24.1786566

Days: 91–185 JD 2447982.5 – 2448077.5 Dates: Apr. 1 – July 4

A = 47.5 W = 91

Term	R.A. h	Dec. °	Distance AU	S.D. ′	Ephem. Tran. h
0	7.4754516	33.076788	2.01942167	31.73251	24.0201455
1	3.1307437	9.525933	0.00898227	–0.14139	0.0118718
2	0.0655886	–2.981254	–0.00180617	0.02898	0.0651485
3	–0.0067688	–0.293642	–0.00024881	0.00366	–0.0071598
4	–0.0049094	0.036675	0.00002220	–0.00036	–0.0049002
5	0.0000723	0.005815	–0.00001281	0.00021	0.0000852
6	0.0001466	0.000249	0.00000066	–0.00001	0.0001500
7	–0.0000008	–0.000068	–0.00001142	0.00018	–0.0000058
8	–0.0000768	–0.000222	0.00000553	–0.00009	–0.0000724
9	0.0000184	0.000179	0.00001768	–0.00028	0.0000244
10	0.0000540	0.000097	–0.00000342	0.00005	0.0000525
11	–0.0000042	–0.000154	–0.00000802	0.00013	–0.0000090
12	–0.0000171	–0.000032	0.00000115	–0.00002	–0.0000170
13	0.0000025	0.000058	0.00000173	–0.00003	0.0000027
14	0.0000029	0.000011	–0.00000051	0.00001	0.0000022
15	–0.0000024	–0.000009	–0.00000019	0.00000	–0.0000012
16	–0.0000015	0.000001	–0.00000005	0.00000	–0.0000013
17	–0.0000014	–0.000005	0.00000023	0.00000	–0.0000010
18	0.0000007	–0.000012	0.00000040	–0.00001	0.0000015
19	0.0000038	0.000005	–0.00000027	0.00000	0.0000016
Sums	10.6603027	39.370413	2.02636185	31.62354	24.0853182

Days: 182–276 JD 2448073.5 – 2448168.5 Dates: July 1 – Oct. 3

A = 47.5 W = 182

Term	R.A. h	Dec. °	Distance AU	S.D. ′	Ephem. Tran. h
0	19.4137088	22.881647	2.02082933	31.71024	23.9972041
1	2.9879295	–14.027862	–0.00833673	0.13106	–0.1356760
2	–0.0648381	–1.963069	–0.00193612	0.03089	–0.0641570
3	0.0109835	0.378148	0.00022169	–0.00323	0.0112944
4	0.0038036	0.010730	0.00001770	–0.00027	0.0037480
5	–0.0005000	–0.002422	–0.00001156	0.00017	–0.0005076
6	–0.0000262	0.000915	0.00000162	–0.00002	–0.0000227
7	–0.0000157	0.000198	–0.00000804	0.00012	–0.0000193
8	–0.0000530	0.000218	0.00001402	–0.00022	–0.0000471
9	0.0000489	–0.000307	0.00001231	–0.00019	0.0000538
10	0.0000312	–0.000227	–0.00001026	0.00016	0.0000273
11	–0.0000253	0.000157	–0.00000547	0.00009	–0.0000257
12	–0.0000080	0.000094	0.00000333	–0.00005	–0.0000072
13	0.0000046	–0.000034	0.00000132	–0.00002	0.0000050
14	0.0000020	–0.000035	–0.00000033	0.00000	0.0000011
15	0.0000013	–0.000001	–0.00000021	0.00000	0.0000000
16	–0.0000009	0.000001	0.00000004	0.00000	–0.0000003
17	0.0000010	–0.000008	0.00000006	0.00000	0.0000009
18	–0.0000003	0.000014	–0.00000031	0.00000	0.0000004
19	–0.0000034	0.000013	–0.00000004	0.00000	–0.0000015
Sums	22.3510435	7.278170	2.01079235	31.86873	23.8118706

Days: 274–368 JD 2448165.5 – 2448260.5 Dates: Oct. 1 – Jan. 3

A = 47.5 W = 274

Term	R.A. h	Dec. °	Distance AU	S.D. ′	Ephem. Tran. h
0	31.2211178	–31.815214	1.98100673	32.34798	23.7184048
1	3.2519059	–10.298649	–0.00926378	0.15101	0.1344088
2	0.1021979	3.045892	0.00178600	–0.02850	0.1016550
3	–0.0084079	0.412059	0.00028645	–0.00494	–0.0089225
4	–0.0066455	–0.036001	–0.00003788	0.00060	–0.0066686
5	–0.0002215	–0.010820	–0.00000329	0.00007	–0.0001980
6	0.0002194	–0.000941	0.00000231	–0.00004	0.0002247
7	–0.0000109	0.000433	–0.00000009	0.00000	–0.0000110
8	–0.0000036	0.000034	0.00001967	–0.00032	0.0000039
9	0.0000701	–0.000201	0.00000015	0.00000	0.0000708
10	0.0000034	0.000147	–0.00001288	0.00021	–0.0000020
11	–0.0000327	0.000088	0.00000007	0.00000	–0.0000325
12	–0.0000034	–0.000076	0.00000419	–0.00007	0.0000000
13	0.0000092	–0.000034	0.00000006	0.00000	0.0000098
14	–0.0000004	0.000034	–0.00000116	0.00002	0.0000002
15	–0.0000010	0.000012	–0.00000007	0.00000	–0.0000020
16	0.0000006	–0.000007	–0.00000004	0.00000	–0.0000002
17	–0.0000008	0.000007	–0.00000006	0.00000	–0.0000010
18	0.0000013	–0.000008	0.00000046	–0.00001	–0.0000002
19	0.0000008	–0.000008	0.00000010	0.00000	0.0000018
Sums	34.5601987	–38.703253	1.97378694	32.46601	23.9389418

Chebyshev Series for the Moon, 1990

Days: 1–32 JD 2447892.5 – 2447924.5 Dates: Jan. 1 – Feb. 1

A = 16.0 W = 1

Term	R.A. h	Dec. °	H.P. ′	*X* Earth Rad.	*Y* Earth Rad.	*Z* Earth Rad.
0	72.00417728	1.2659491	115.5600661	42.5674288	–5.1088477	0.3977185
1	14.00302241	–2.9770814	–0.1404109	0.1531425	–5.9432161	–3.0007594
2	–0.20399859	3.6024000	1.4671618	52.6190261	–0.0478185	3.7449189
3	0.11075335	22.1643840	1.3877189	–0.8672096	43.8603935	22.5051372
4	0.10291241	–2.1319444	–1.0923020	–27.9499489	–0.1858684	–2.0881964
5	–0.21265240	–4.7740458	–0.5217729	0.8497308	–9.9207197	–5.0536243
6	0.01904002	0.7810345	0.3170988	3.2206196	0.5865929	0.5315566
7	0.13312697	–0.1316490	0.0934215	–0.5299159	0.4650046	0.2030927
8	–0.02481118	–0.2050073	–0.0650373	0.1205323	–0.2863226	–0.1388176
9	–0.02780295	0.3689792	0.0093464	0.1596193	0.1359766	0.0812932
10	0.01028393	–0.0173006	0.0070242	–0.0941866	0.0627393	0.0256007
11	–0.00506605	–0.1432640	–0.0106878	–0.0223082	–0.0391742	–0.0217662
12	–0.00082762	0.0388344	0.0009485	0.0184930	–0.0040720	–0.0007852
13	0.00606614	0.0191019	0.0028846	–0.0016775	0.0060555	0.0030011
14	–0.00165465	–0.0156483	–0.0008389	–0.0020370	–0.0020922	–0.0012211
15	–0.00209332	0.0096030	–0.0002640	0.0017368	–0.0003838	–0.0000741
16	0.00107528	0.0011591	0.0002991	–0.0001054	0.0008678	0.0004394
17	0.00002687	–0.0067475	–0.0000916	–0.0004514	–0.0001439	–0.0001064
18	–0.00025950	0.0020886	–0.0000631	0.0001355	–0.0001579	–0.0000716
19	0.00033062	0.0016719	0.0000488	0.0000476	0.0000723	0.0000408
20	–0.00007413	–0.0012284	0.0000022	–0.0000437	0.0000030	–0.0000016
21	–0.00016271	0.0002441	–0.0000119	0.0000092	–0.0000184	–0.0000089
22	0.00009314	0.0002431	0.0000041	0.0000080	0.0000075	0.0000044
23	0.00002091	–0.0003725	0.0000012	–0.0000057	0.0000023	0.0000008
24	–0.00003598	0.0000992	–0.0000018	–0.0000001	–0.0000026	–0.0000012
25	0.00001895	0.0001338	0.0000004	0.0000014	0.0000004	0.0000003
26	0.00000078	–0.0000951	0.0000004	–0.0000004	0.0000005	0.0000001
27	–0.00001311	–0.0000009	–0.0000002	–0.0000001	–0.0000003	–0.0000002
28	0.00000688	0.0000304	0.0000000	0.0000002	0.0000001	–0.0000001
29	0.00000292	–0.0000228	0.0000001	–0.0000001	0.0000000	0.0000000
30	–0.00000390	0.0000023	0.0000002	0.0000000	–0.0000001	–0.0000001
31	0.00000105	0.0000114	0.0000000	0.0000000	0.0000000	0.0000000
32	0.00000073	–0.0000069	0.0000000	0.0000000	0.0000000	0.0000000
33	–0.00000110	–0.0000013	0.0000001	0.0000000	0.0000001	0.0000000
Sums	85.91150345	17.8515538	117.0145450	70.2426405	23.5788780	17.1873703

Days: 32–63 JD 2447923.5 – 2447955.5 Dates: Feb. 1 – Mar. 4

A = 16.0 W = 32

Term	R.A. h	Dec. °	H.P. ′	*X* Earth Rad.	*Y* Earth Rad.	*Z* Earth Rad.
0	30.63239732	17.3177551	115.9924484	24.1395900	28.6624656	16.4688509
1	14.06915202	–1.5934649	0.2045059	4.8131304	–4.1038862	–1.7966722
2	0.00734882	20.5346036	1.9502169	33.6064050	35.5143758	20.6848001
3	0.32628908	12.0493406	–0.5734387	–37.9170752	29.0929768	12.2335874
4	–0.06555636	–10.6134822	–1.4140650	–17.9322559	–18.6129142	–10.8707319
5	–0.02922407	–2.5625911	–0.0108286	8.2035161	–6.6568864	–2.8282015
6	0.14867459	0.6552917	0.3777078	2.1390733	1.8419256	1.1040632
7	–0.03512256	0.0396964	0.0694603	–0.1431475	0.3251932	0.1561962
8	–0.05455262	0.3418517	–0.0447099	0.0736560	0.1925564	0.1040576
9	0.00712367	–0.0589879	–0.0163087	–0.1662324	0.1035274	0.0412766
10	0.00367596	–0.1066519	–0.0101733	–0.0704252	–0.0672243	–0.0396549
11	0.00413689	0.0583000	–0.0004830	0.0266573	–0.0313003	–0.0141627
12	0.00002354	0.0137315	0.0052108	0.0135331	0.0046289	0.0033629
13	–0.00340602	–0.0090759	0.0012958	0.0006960	0.0034882	0.0018412
14	0.00101510	–0.0019237	–0.0006951	–0.0003618	0.0014215	0.0007038
15	0.00108594	–0.0032660	–0.0003523	–0.0010752	0.0005247	0.0001925
16	–0.00028565	0.0025726	–0.0001235	–0.0005371	–0.0004405	–0.0002652
17	–0.00015592	0.0013453	0.0000101	0.0001780	–0.0002930	–0.0001379
18	–0.00012997	–0.0014250	0.0000703	0.0001492	0.0000243	0.0000233
19	0.00004983	–0.0001561	0.0000222	0.0000130	0.0000458	0.0000245
20	0.00010512	0.0002451	–0.0000105	–0.0000097	0.0000157	0.0000074
21	–0.00004095	0.0000990	–0.0000070	–0.0000110	0.0000035	0.0000010
22	–0.00003072	0.0000534	–0.0000015	–0.0000053	–0.0000042	–0.0000025
23	0.00000994	–0.0001022	0.0000005	0.0000015	–0.0000033	–0.0000014
24	0.00000632	–0.0000255	0.0000010	0.0000020	0.0000000	0.0000000
25	0.00000412	0.0000439	0.0000003	0.0000003	0.0000006	0.0000002
26	–0.00000327	0.0000035	–0.0000002	–0.0000002	0.0000002	0.0000001
27	–0.00000333	–0.0000071	–0.0000001	–0.0000002	0.0000000	0.0000000
28	0.00000183	–0.0000041	0.0000000	0.0000000	–0.0000001	–0.0000001
29	0.00000101	–0.0000009	–0.0000001	0.0000001	0.0000000	0.0000000
30	–0.00000039	0.0000038	0.0000000	0.0000000	0.0000001	0.0000000
31	–0.00000029	0.0000004	0.0000000	0.0000000	0.0000000	–0.0000001
32	–0.00000014	–0.0000014	0.0000001	0.0000000	–0.0000001	–0.0000001
33	0.00000016	–0.0000001	–0.0000001	–0.0000001	0.0000002	0.0000000
Sums	45.01258900	36.0637716	116.5297528	16.7854645	66.2702219	35.2491584

Chebyshev Series for the Moon, 1990

Days: 60–91 JD 2447951.5 – 2447983.5 Dates: Mar. 1 – Apr. 1

A = 16.0 W = 60

Term	R.A. h	Dec. °	H.P. ′	*X* Earth Rad.	*Y* Earth Rad.	*Z* Earth Rad.
0	31.93034144	18.7680807	116.2216260	16.3193450	32.3610939	17.7373801
1	14.06005780	–1.4736611	0.4389766	5.5624988	–3.9365573	–1.7097731
2	0.12824954	22.3108672	2.2925486	26.4237364	40.1398822	22.4086440
3	0.38342500	8.8052871	–1.1109289	–42.4462888	23.7661884	9.1233766
4	–0.08486472	–11.3759133	–1.4081633	–14.3392731	–20.8490320	–11.7115237
5	0.01983105	–2.1414385	–0.1408486	8.9548523	–5.6567910	–2.2391398
6	0.10249687	0.5208646	0.2744435	1.9403466	1.9133351	1.1233787
7	–0.07122531	0.1778224	0.1822062	–0.0713456	0.3930888	0.1940066
8	–0.03916128	0.2903466	–0.0055099	0.0026451	0.2346019	0.1196667
9	0.00986393	–0.0576062	–0.0287132	–0.1706809	0.0791271	0.0282049
10	0.00487829	–0.0098231	–0.0148262	–0.0677993	–0.0565350	–0.0337865
11	0.00379172	0.0397689	–0.0056094	0.0138771	–0.0345523	–0.0166419
12	–0.00196399	–0.0117830	0.0029491	0.0166696	–0.0026468	–0.0001414
13	–0.00121300	–0.0087481	0.0030385	0.0044191	0.0044426	0.0025871
14	0.00162156	–0.0025947	0.0005870	–0.0004357	0.0024670	0.0012269
15	0.00019266	0.0008950	–0.0003508	–0.0011343	0.0007322	0.0002926
16	–0.00040457	0.0026042	–0.0003261	–0.0007214	–0.0002134	–0.0001609
17	–0.00016095	–0.0008259	–0.0001143	–0.0000582	–0.0003529	–0.0001847
18	–0.00000873	–0.0007500	0.0000209	0.0001543	–0.0001036	–0.0000418
19	0.00011065	0.0003308	0.0000474	0.0000782	0.0000272	0.0000196
20	0.00000245	0.0001873	0.0000195	0.0000088	0.0000331	0.0000175
21	–0.00004362	0.0000337	–0.0000021	–0.0000118	0.0000134	0.0000059
22	0.00000550	–0.0000801	–0.0000057	–0.0000098	–0.0000001	–0.0000006
23	0.00001173	–0.0000459	–0.0000028	–0.0000026	–0.0000039	–0.0000020
24	0.00000276	0.0000352	–0.0000001	0.0000013	–0.0000021	–0.0000011
25	–0.00000322	0.0000103	0.0000008	0.0000015	–0.0000001	0.0000001
26	–0.00000328	–0.0000099	0.0000004	0.0000004	0.0000005	0.0000002
27	0.00000132	–0.0000034	–0.0000001	–0.0000002	0.0000002	0.0000001
28	0.00000120	0.0000013	0.0000000	–0.0000001	0.0000000	0.0000000
29	–0.00000046	0.0000029	–0.0000001	0.0000000	0.0000000	0.0000001
30	–0.00000035	–0.0000001	0.0000001	–0.0000001	0.0000000	0.0000001
31	–0.00000002	–0.0000015	–0.0000001	0.0000000	–0.0000001	0.0000000
32	0.00000018	–0.0000001	–0.0000001	0.0000000	0.0000000	–0.0000001
33	0.00000005	0.0000003	0.0000001	0.0000000	0.0000000	0.0000001
Sums	46.44583220	35.8338536	116.7010629	2.1408726	68.3582430	35.0274103

Days: 91–122 JD 2447982.5 – 2448014.5 Dates: Apr. 1 – May 2

A = 16.0 W = 91

Term	R.A. h	Dec. °	H.P. ′	*X* Earth Rad.	*Y* Earth Rad.	*Z* Earth Rad.
0	38.77086222	16.6393653	114.9201947	–24.1164877	34.9598182	15.9954538
1	14.05737408	0.7276910	0.7032295	7.0063054	0.9601590	0.8465525
2	0.50505284	20.8541555	0.9088262	–16.9341994	45.0320953	21.5866947
3	0.17889467	–10.1441868	–2.6138616	–46.3775238	–12.4705745	–9.6915277
4	–0.16698367	–11.3505616	–0.8821518	8.1687032	–24.1283395	–11.6413473
5	0.00736351	1.0684759	0.3965126	11.0963730	1.7068474	1.6951062
6	–0.12126333	1.7057577	0.4564721	0.1556216	3.2681400	1.6692738
7	–0.05256682	0.6645742	0.1002298	–0.8963689	0.6210466	0.2458398
8	0.04957618	0.0030484	–0.1069716	–0.4843313	–0.0627533	–0.0676036
9	0.02974738	–0.0702701	–0.0614590	–0.0913761	–0.2127793	–0.1143343
10	–0.00026820	–0.0856141	–0.0033396	0.0883866	–0.0856226	–0.0367919
11	–0.00671376	–0.0783483	0.0148999	0.0597007	0.0156466	0.0123260
12	–0.00164452	0.0022394	0.0092552	0.0038430	0.0272656	0.0140801
13	–0.00105621	0.0304001	–0.0000572	–0.0126410	0.0074790	0.0028506
14	–0.00122972	0.0138411	–0.0027729	–0.0061106	–0.0031532	–0.0020472
15	0.00054472	–0.0022263	–0.0013057	0.0001908	–0.0031281	–0.0015691
16	0.00103417	–0.0035101	0.0001833	0.0016017	–0.0007220	–0.0002471
17	0.00024855	–0.0010542	0.0004645	0.0007270	0.0004744	0.0002946
18	–0.00025279	–0.0007723	0.0001747	–0.0000875	0.0004172	0.0002046
19	–0.00015628	–0.0002973	–0.0000496	–0.0002339	0.0000663	0.0000158
20	–0.00001788	0.0004351	–0.0000772	–0.0000846	–0.0000802	–0.0000468
21	–0.00000862	0.0004466	–0.0000236	0.0000231	–0.0000550	–0.0000262
22	0.00000599	0.0000510	0.0000115	0.0000337	–0.0000041	0.0000003
23	0.00002797	–0.0001149	0.0000128	0.0000095	0.0000132	0.0000074
24	0.00001603	–0.0000589	0.0000029	–0.0000049	0.0000073	0.0000034
25	–0.00000576	–0.0000148	–0.0000025	–0.0000048	–0.0000003	–0.0000006
26	–0.00000894	–0.0000062	–0.0000020	–0.0000009	–0.0000021	–0.0000012
27	–0.00000215	0.0000073	–0.0000004	0.0000008	–0.0000009	–0.0000004
28	0.00000081	0.0000140	0.0000002	0.0000006	0.0000001	0.0000002
29	0.00000063	0.0000056	0.0000004	0.0000002	0.0000003	0.0000003
30	0.00000071	–0.0000030	0.0000001	–0.0000001	0.0000002	0.0000001
31	0.00000061	–0.0000034	0.0000000	–0.0000001	–0.0000001	0.0000000
32	–0.00000006	–0.0000007	–0.0000001	0.0000000	–0.0000002	–0.0000001
33	–0.00000036	0.0000001	–0.0000001	0.0000000	–0.0000001	0.0000000
Sums	53.24857200	19.9734653	113.8383955	–62.3379347	49.6322612	20.5131607

Chebyshev Series for the Moon, 1990

Days: 121–152 JD 2448012.5 – 2448044.5 Dates: May 1 – June 1

A = 16.0 W = 121

Term	R.A. h	Dec. °	H.P. ′	*X* Earth Rad.	*Y* Earth Rad.	*Z* Earth Rad.
0	43.48051081	6.2713485	113.6891934	–46.0649974	18.1793782	5.6778341
1	14.02352948	2.6142908	0.7822697	5.1202077	4.6337113	2.5627825
2	0.52017050	10.2637055	–0.3931348	–42.2989598	28.7061692	11.2210809
3	–0.10510692	–19.0971391	–2.8645829	–28.5640890	–34.2185209	–19.3670275
4	–0.18573290	–6.2828667	–0.1888830	22.1413185	–16.0530063	–6.3868565
5	–0.11258823	4.1794153	0.6572905	8.0950331	7.4468751	4.3796508
6	–0.09290355	2.0236368	0.4117453	–2.3530625	3.2240655	1.4407083
7	0.08617505	0.0132151	–0.0290144	–1.4752838	–0.1623854	–0.1974257
8	0.07162064	–0.3607971	–0.1561142	–0.2242427	–0.5212158	–0.2792617
9	–0.01155814	–0.2544515	–0.0419132	0.2018995	–0.2031539	–0.0864125
10	–0.02403596	–0.1111083	0.0249127	0.1375354	0.0357240	0.0285830
11	–0.00609747	0.0780473	0.0222636	0.0078283	0.0640478	0.0327785
12	0.00116584	0.0972053	0.0025738	–0.0321717	0.0170031	0.0060609
13	0.00279653	0.0089314	–0.0055795	–0.0144588	–0.0101536	–0.0062166
14	0.00323055	–0.0290970	–0.0032224	0.0028019	–0.0080847	–0.0038467
15	0.00046084	–0.0150440	0.0003079	0.0046702	–0.0005283	0.0000949
16	–0.00162430	–0.0000631	0.0011260	0.0011398	0.0018387	0.0010125
17	–0.00093260	0.0042534	0.0003840	–0.0007541	0.0008880	0.0003877
18	0.00020026	0.0038183	–0.0001780	–0.0006158	–0.0001259	–0.0001113
19	0.00038502	0.0009154	–0.0001936	–0.0000492	–0.0002940	–0.0001512
20	0.00016920	–0.0014122	–0.0000299	0.0001496	–0.0000867	–0.0000319
21	–0.00000150	–0.0012128	0.0000467	0.0000753	0.0000465	0.0000291
22	–0.00009404	–0.0000541	0.0000297	–0.0000115	0.0000432	0.0000208
23	–0.00007729	0.0004021	–0.0000017	–0.0000257	0.0000042	0.0000002
24	0.00000235	0.0002502	–0.0000099	–0.0000069	–0.0000102	–0.0000057
25	0.00003858	0.0000279	–0.0000038	0.0000043	–0.0000053	–0.0000023
26	0.00001938	–0.0000854	0.0000015	0.0000035	0.0000006	0.0000006
27	–0.00000385	–0.0000816	0.0000019	0.0000004	0.0000018	0.0000009
28	–0.00000944	–0.0000139	0.0000003	–0.0000009	0.0000006	0.0000002
29	–0.00000536	0.0000303	–0.0000004	–0.0000006	–0.0000003	–0.0000002
30	0.00000023	0.0000235	–0.0000004	0.0000001	–0.0000003	–0.0000001
31	0.00000303	0.0000014	0.0000001	0.0000003	–0.0000001	0.0000000
32	0.00000200	–0.0000082	0.0000002	0.0000000	0.0000001	0.0000000
33	–0.00000025	–0.0000063	0.0000001	–0.0000001	0.0000000	0.0000000
Sums	57.64970849	–0.5939228	111.9092853	–85.3160626	11.1322262	–0.9763240

Days: 152–183 JD 2448043.5 – 2448075.5 Dates: June 1 – July 2

A = 16.0 W = 152

Term	R.A. h	Dec. °	H.P. ′	*X* Earth Rad.	*Y* Earth Rad.	*Z* Earth Rad.
0	49.62800022	–10.5662054	112.1878650	–51.2423289	–15.9842042	–12.0702796
1	14.06968123	3.2635149	0.6036017	–0.9568410	6.7293146	3.1828347
2	0.21082373	–8.1092489	–2.0589120	–50.4878955	–7.9933623	–8.0140037
3	–0.30852415	–19.5712861	–1.9369099	10.2394753	–42.4025207	–20.4138051
4	–0.17123965	4.0799561	0.8550778	27.6533630	3.8215752	4.1324554
5	–0.05664879	5.7658899	0.7376995	–1.6206433	11.0799213	5.4313607
6	0.13896571	–0.1882970	0.0890975	–4.8520160	0.1742858	–0.3044555
7	0.10112744	–1.1597288	–0.2292852	–0.4167282	–1.6047009	–0.8390538
8	–0.05656491	–0.3778764	–0.1043337	0.6703008	–0.3566493	–0.1245674
9	–0.04691191	0.1382635	0.0473223	0.2468440	0.2037839	0.1221175
10	0.00936216	0.2705475	0.0420682	–0.0707760	0.1310401	0.0599559
11	0.01602718	0.0541573	–0.0022741	–0.0774933	–0.0078083	–0.0101706
12	0.00443367	–0.1119746	–0.0128308	–0.0059325	–0.0349669	–0.0179994
13	–0.00392335	–0.0519976	–0.0031156	0.0185257	–0.0081687	–0.0025998
14	–0.00495305	0.0274716	0.0028783	0.0066802	0.0070028	0.0040476
15	0.00004186	0.0267760	0.0018353	–0.0030942	0.0040270	0.0017688
16	0.00258748	0.0006959	–0.0003216	–0.0025860	–0.0007618	–0.0005903
17	0.00075561	–0.0101785	–0.0006680	0.0001120	–0.0012718	–0.0006283
18	–0.00084542	–0.0052043	–0.0001014	0.0007215	–0.0001508	–0.0000174
19	–0.00061210	0.0025192	0.0001773	0.0001742	0.0003015	0.0001649
20	0.00008551	0.0034312	0.0000845	–0.0001483	0.0001277	0.0000520
21	0.00032037	0.0001012	–0.0000300	–0.0000908	–0.0000473	–0.0000308
22	0.00011217	–0.0014372	–0.0000352	0.0000155	–0.0000490	–0.0000234
23	–0.00011487	–0.0005798	–0.0000012	0.0000297	–0.0000007	0.0000019
24	–0.00010210	0.0003726	0.0000105	0.0000042	0.0000134	0.0000072
25	0.00001667	0.0004136	0.0000036	–0.0000070	0.0000041	0.0000015
26	0.00005355	0.0000106	–0.0000021	–0.0000033	–0.0000024	–0.0000015
27	0.00001369	–0.0001900	–0.0000018	0.0000010	–0.0000021	–0.0000009
28	–0.00001882	–0.0000825	0.0000000	0.0000012	0.0000001	0.0000002
29	–0.00001480	0.0000557	0.0000008	0.0000000	0.0000006	0.0000003
30	0.00000267	0.0000599	0.0000000	–0.0000003	0.0000002	0.0000000
31	0.00000849	–0.0000013	–0.0000002	–0.0000002	–0.0000002	–0.0000001
32	0.00000222	–0.0000278	–0.0000001	0.0000001	–0.0000001	0.0000000
33	–0.00000324	–0.0000111	0.0000001	0.0000001	0.0000000	0.0000000
Sums	63.53194447	–26.5200906	110.2188995	–70.9003363	–46.2432692	–28.8634590

Chebyshev Series for the Moon, 1990

Days: 182–213 JD 2448073.5 – 2448105.5 Dates: July 1 – Aug. 1

A = 16.0 W = 182

Term	R.A. h	Dec. °	H.P. ′	*X* Earth Rad.	*Y* Earth Rad.	*Z* Earth Rad.
0	54.14743471	–19.6764102	111.7944838	–35.7779949	–37.4628078	–21.6870821
1	14.11098802	1.9401691	0.3048811	–5.4438728	5.0349155	2.0329223
2	0.00079915	–18.5409473	–2.4673952	–35.2591572	–32.4442504	–19.1356362
3	–0.25624974	–11.7998582	–0.6771848	35.2485873	–30.3088322	–12.2758118
4	–0.08514932	10.2915056	1.2067200	19.4405084	17.6209522	10.4294799
5	0.10377768	3.4555055	0.4127658	–8.9308192	8.1930621	3.3705579
6	0.16433745	–2.0285960	–0.0951472	–3.6734651	–2.8765225	–1.7455849
7	–0.04266170	–0.8645896	–0.1875841	1.1539818	–1.3868919	–0.5999199
8	–0.08241766	0.2850429	–0.0276220	0.6545794	0.3185662	0.2138264
9	0.01310685	0.3770582	0.0576822	–0.1096511	0.2679021	0.1252019
10	0.02765900	0.0205814	0.0176132	–0.1346312	–0.0125700	–0.0174325
11	0.00021214	–0.1726108	–0.0138550	–0.0072489	–0.0543855	–0.0278515
12	–0.00984104	–0.0387489	–0.0072558	0.0270999	–0.0108580	–0.0031991
13	–0.00347888	0.0644947	0.0024629	0.0087417	0.0102188	0.0058424
14	0.00397551	0.0234546	0.0024611	–0.0048411	0.0052404	0.0022256
15	0.00264181	–0.0198133	–0.0001342	–0.0033333	–0.0015485	–0.0010513
16	–0.00149291	–0.0131486	–0.0007219	0.0006074	–0.0016761	–0.0007900
17	–0.00141591	0.0049210	–0.0001329	0.0009774	0.0000838	0.0001227
18	0.00040825	0.0068824	0.0001816	0.0000276	0.0004453	0.0002254
19	0.00069078	–0.0007128	0.0000813	–0.0002438	0.0000639	0.0000119
20	–0.00002121	–0.0032122	–0.0000363	–0.0000553	–0.0001009	–0.0000552
21	–0.00032614	–0.0002749	–0.0000319	0.0000512	–0.0000371	–0.0000143
22	–0.00006653	0.0013398	0.0000039	0.0000252	0.0000183	0.0000113
23	0.00014400	0.0003828	0.0000101	–0.0000080	0.0000137	0.0000063
24	0.00006107	–0.0005057	0.0000011	–0.0000085	–0.0000017	–0.0000016
25	–0.00005617	–0.0002801	–0.0000028	0.0000002	–0.0000042	–0.0000021
26	–0.00003993	0.0001691	–0.0000010	0.0000024	–0.0000004	–0.0000002
27	0.00001789	0.0001643	0.0000006	0.0000005	0.0000011	0.0000005
28	0.00002274	–0.0000441	0.0000004	–0.0000006	0.0000004	0.0000001
29	–0.00000352	–0.0000847	–0.0000001	–0.0000003	–0.0000001	–0.0000002
30	–0.00001173	0.0000028	–0.0000002	0.0000002	–0.0000002	0.0000000
31	–0.00000088	0.0000395	0.0000001	0.0000001	0.0000000	0.0000001
32	0.00000551	0.0000069	–0.0000001	0.0000000	0.0000000	0.0000000
33	0.00000159	–0.0000167	0.0000001	0.0000001	–0.0000001	0.0000000
Sums	68.09305088	–36.6881335	110.3222438	–32.8101405	–73.1090038	–39.3139982

Days: 213–244 JD 2448104.5 – 2448136.5 Dates: Aug. 1 – Sept. 1

A = 16.0 W = 213

Term	R.A. h	Dec. °	H.P. ′	*X* Earth Rad.	*Y* Earth Rad.	*Z* Earth Rad.
0	60.54664663	–22.4607533	112.3065184	0.0996479	–48.7718927	–24.3783503
1	14.11411953	–0.9567059	–0.1134533	–7.8136557	–0.6047815	–0.9124206
2	–0.11906651	–21.9936621	–1.8816003	3.9476468	–46.0600999	–22.7302600
3	–0.13737517	5.0214590	1.1823401	48.0915855	2.4547034	5.1920707
4	0.08781313	12.0628757	1.0386227	–2.5289995	25.1001218	12.3445368
5	0.16950990	–1.7622595	–0.0829416	–12.2759532	–1.0589603	–1.5489636
6	–0.06290828	–2.1775595	–0.1573230	0.9184808	–4.2163745	–2.0331747
7	–0.10930810	0.5702460	–0.0869724	1.6851467	0.4211498	0.3509866
8	0.03321756	0.4698569	0.0262459	–0.2652873	0.5694065	0.2629362
9	0.03558549	–0.2015064	0.0356846	–0.2419617	–0.0952497	–0.0677502
10	–0.01413773	–0.1803220	–0.0094934	0.0408103	–0.0875189	–0.0403950
11	–0.01020681	0.0795677	–0.0105711	0.0386239	0.0083058	0.0073608
12	0.00671468	0.0665402	0.0029384	–0.0006929	0.0143521	0.0071193
13	0.00404244	–0.0337380	0.0026994	–0.0069744	0.0016645	0.0002537
14	–0.00340584	–0.0212387	–0.0006432	–0.0015591	–0.0028636	–0.0015613
15	–0.00165254	0.0147883	–0.0006347	0.0015892	–0.0010022	–0.0003694
16	0.00163541	0.0068659	0.0000869	0.0006240	0.0006898	0.0003969
17	0.00056671	–0.0066905	0.0001558	–0.0003930	0.0003185	0.0001266
18	–0.00076017	–0.0023151	0.0000044	–0.0001768	–0.0001655	–0.0000975
19	–0.00017441	0.0030308	–0.0000414	0.0000903	–0.0000832	–0.0000340
20	0.00035719	0.0007159	–0.0000077	0.0000446	0.0000356	0.0000214
21	0.00004891	–0.0013525	0.0000112	–0.0000182	0.0000207	0.0000087
22	–0.00016802	–0.0001779	0.0000034	–0.0000112	–0.0000064	–0.0000042
23	–0.00000838	0.0005999	–0.0000030	0.0000030	–0.0000054	–0.0000023
24	0.00007774	0.0000226	–0.0000012	0.0000031	0.0000008	0.0000007
25	–0.00000314	–0.0002656	0.0000008	–0.0000004	0.0000014	0.0000007
26	–0.00003548	0.0000133	0.0000004	–0.0000009	–0.0000001	–0.0000001
27	0.00000464	0.0001168	–0.0000001	0.0000000	–0.0000004	–0.0000002
28	0.00001607	–0.0000164	–0.0000001	0.0000003	0.0000001	0.0000000
29	–0.00000359	–0.0000509	–0.0000002	0.0000002	0.0000001	0.0000001
30	–0.00000719	0.0000119	0.0000000	–0.0000001	0.0000000	0.0000000
31	0.00000231	0.0000218	0.0000000	0.0000000	0.0000000	0.0000000
32	0.00000314	–0.0000074	–0.0000001	0.0000000	0.0000000	–0.0000001
33	–0.00000137	–0.0000094	0.0000000	0.0000000	0.0000000	0.0000000
Sums	74.54113875	–31.5018984	112.2516256	31.6886122	–72.3282334	–33.5475643

Days: 244–275 JD 2448135.5 – 2448167.5 Dates: Sept. 1 – Oct. 2

A = 16.0 W = 244

Term	R.A. h	Dec. °	H.P. ′	X Earth Rad.	Y Earth Rad.	Z Earth Rad.
0	66.93947515	–12.5343187	113.9699570	33.0862668	–33.4587601	–13.9167400
1	14.00705815	–3.2022462	–0.3110912	–4.4157102	–5.9321738	–3.2418490
2	–0.22548140	–11.1365614	–0.0058121	41.0452490	–29.4778801	–11.3629874
3	–0.05694796	18.8925804	2.3082881	29.1993583	34.4042379	19.4886067
4	0.17597393	5.4542413	0.1808369	–22.4259309	15.3576985	5.7855097
5	–0.05768473	–4.9728497	–0.2905446	–6.1426649	–8.7980329	–4.8880235
6	–0.12902582	–0.1039299	–0.0575927	3.7884159	–1.4882431	–0.4247035
7	0.06385309	0.7682107	–0.0797575	0.0685155	1.2312601	0.6197540
8	0.04813308	–0.3419477	0.0255233	–0.4864966	–0.1305999	–0.1053937
9	–0.02771906	–0.0852218	0.0209878	0.1086181	–0.1524196	–0.0669243
10	–0.00557145	0.1633002	–0.0146824	0.0495513	0.0379446	0.0230192
11	0.00953393	–0.0191640	–0.0007792	–0.0120358	0.0108869	0.0044044
12	–0.00359857	–0.0534835	0.0043716	–0.0018545	–0.0008442	–0.0005822
13	–0.00280537	0.0206876	–0.0006476	–0.0014185	–0.0003145	–0.0002700
14	0.00302108	0.0101435	–0.0006277	0.0005151	–0.0011767	–0.0005429
15	0.00038626	–0.0109244	0.0001950	0.0007516	0.0004758	0.0002984
16	–0.00135370	0.0011264	0.0000301	–0.0004251	0.0003243	0.0001265
17	0.00027691	0.0042447	–0.0000085	–0.0001268	–0.0002269	–0.0001233
18	0.00039920	–0.0021423	–0.0000032	0.0001327	–0.0000325	–0.0000054
19	–0.00028480	–0.0010753	–0.0000105	0.0000000	0.0000534	0.0000268
20	–0.00004536	0.0012210	0.0000053	–0.0000238	–0.0000048	–0.0000041
21	0.00015249	–0.0000046	0.0000031	0.0000044	–0.0000075	–0.0000035
22	–0.00003790	–0.0004756	–0.0000025	0.0000025	0.0000019	0.0000010
23	–0.00005407	0.0001937	–0.0000003	–0.0000008	0.0000006	0.0000004
24	0.00003562	0.0001216	0.0000006	–0.0000003	–0.0000002	0.0000000
25	0.00000924	–0.0001325	–0.0000002	0.0000000	–0.0000003	–0.0000001
26	–0.00001883	–0.0000016	0.0000000	0.0000002	–0.0000001	0.0000000
27	0.00000377	0.0000572	0.0000001	0.0000000	0.0000001	0.0000001
28	0.00000692	–0.0000206	0.0000000	–0.0000001	0.0000000	0.0000000
29	–0.00000452	–0.0000159	0.0000000	0.0000000	0.0000001	0.0000000
30	–0.00000136	0.0000148	–0.0000001	0.0000000	–0.0000001	0.0000000
31	0.00000253	0.0000007	0.0000000	0.0000001	0.0000000	–0.0000001
32	–0.00000039	–0.0000070	0.0000000	0.0000001	0.0000000	0.0000000
33	–0.00000099	0.0000027	–0.0000001	0.0000000	0.0000000	0.0000000
Sums	80.73768507	–7.1483762	115.7486385	73.8606933	–28.3978331	–8.0864058

Days: 274–305 JD 2448165.5 – 2448197.5 Dates: Oct. 1 – Nov. 1

A = 16.0 W = 274

Term	R.A. h	Dec. °	H.P. ′	*X* Earth Rad.	*Y* Earth Rad.	*Z* Earth Rad.
0	71.52518225	–0.4706995	115.4546355	42.5646147	–10.5801506	–1.6744751
1	13.93620946	–3.3676279	–0.3433996	0.3858283	–7.3794290	–3.5217470
2	–0.34671053	2.4268108	1.6762679	52.0876852	–3.3102450	2.5740241
3	0.08705265	21.4925329	2.3619796	1.1333656	44.4873782	21.9867438
4	0.13569213	–1.9080117	–0.5799552	–27.4967886	1.1405312	–1.7332044
5	–0.15530523	–4.5139145	–0.1761160	0.8382299	–10.0011503	–4.8658973
6	0.04081559	1.1050252	–0.0274800	3.2630619	0.7871615	0.6660297
7	0.10292568	0.0001605	–0.1450889	–0.7381540	0.6087015	0.2405066
8	–0.03519058	–0.2370250	0.0424296	–0.0182306	–0.3433402	–0.1714490
9	–0.02070380	0.2127200	0.0208419	0.1425763	0.0440380	0.0336246
10	0.01283053	–0.0663781	–0.0157844	–0.0299522	0.0280143	0.0113654
11	–0.00346786	–0.0737190	0.0048818	0.0049935	–0.0081795	–0.0036740
12	–0.00076544	0.0530482	0.0024441	0.0000734	0.0076986	0.0038029
13	0.00373942	0.0037658	–0.0015638	–0.0047130	–0.0018054	–0.0012783
14	–0.00190220	–0.0140582	0.0003474	0.0019395	–0.0014329	–0.0005470
15	–0.00105267	0.0074167	–0.0000003	0.0001098	0.0010389	0.0005219
16	0.00110297	–0.0006836	–0.0001462	–0.0005284	–0.0001989	–0.0001427
17	–0.00012074	–0.0032958	0.0000852	0.0002065	–0.0001626	–0.0000631
18	–0.00023497	0.0023199	–0.0000151	0.0000245	0.0000945	0.0000494
19	0.00021324	0.0003010	–0.0000171	–0.0000388	–0.0000136	–0.0000101
20	–0.00007214	–0.0009798	0.0000141	0.0000167	–0.0000068	–0.0000025
21	–0.00006977	0.0003651	–0.0000018	–0.0000028	0.0000078	0.0000038
22	0.00007693	0.0001049	–0.0000021	–0.0000028	–0.0000035	–0.0000017
23	–0.00000690	–0.0002057	0.0000015	0.0000024	–0.0000002	0.0000000
24	–0.00002550	0.0001034	–0.0000003	–0.0000005	0.0000010	0.0000004
25	0.00001596	0.0000311	–0.0000001	–0.0000005	–0.0000003	–0.0000001
26	–0.00000095	–0.0000651	0.0000001	0.0000001	0.0000000	–0.0000001
27	–0.00000620	0.0000210	–0.0000001	–0.0000001	0.0000000	0.0000001
28	0.00000495	0.0000135	–0.0000001	0.0000000	0.0000000	–0.0000001
29	–0.00000008	–0.0000153	0.0000001	0.0000000	0.0000002	0.0000001
30	–0.00000224	0.0000046	0.0000000	0.0000000	0.0000000	0.0000000
31	0.00000123	0.0000036	–0.0000001	0.0000001	0.0000000	0.0000000
32	0.00000018	–0.0000042	0.0000000	0.0000000	0.0000000	0.0000001
33	–0.00000061	0.0000011	0.0000001	0.0000001	–0.0000001	0.0000001
Sums	85.28022476	14.6480659	118.2743577	72.1343162	15.4785468	13.5441805

Chebyshev Series for the Moon, 1990

Days: 305–336 JD 2448196.5 – 2448228.5 Dates: Nov. 1 – Dec. 2

A = 16.0 W = 305

Term	R.A. h	Dec. °	H.P. ′	*X* Earth Rad.	*Y* Earth Rad.	*Z* Earth Rad.
0	30.06622026	14.7303610	117.0778143	28.3194618	21.6910374	13.0236033
1	13.95459665	–1.5558672	–0.1099443	6.1802061	–5.0824202	–1.9235083
2	–0.23219342	19.3170988	3.4668480	35.6817239	33.5659251	19.3182290
3	0.41143161	12.2983061	1.0289383	–36.8168306	31.7831962	12.3414346
4	0.03084152	–9.8666199	–1.2361041	–18.3210872	–17.5810287	–10.1712038
5	0.01460816	–1.7173136	–0.0442826	7.9799506	–6.3132438	–2.3968581
6	0.15153025	0.6929278	–0.2117061	1.3739778	1.9101987	1.0602764
7	–0.06147069	–0.3481097	–0.0784365	–0.3333308	–0.0965184	–0.0754948
8	–0.04750008	0.1563165	0.0929400	0.2460532	0.0348862	0.0374523
9	0.01676256	–0.1187626	0.0009144	–0.0497674	0.0975353	0.0434441
10	–0.00126783	–0.0111390	0.0003065	–0.0142420	–0.0119350	–0.0071570
11	0.00092192	0.1059909	0.0058311	–0.0021977	0.0116682	0.0054801
12	–0.00081791	–0.0184463	–0.0027856	–0.0113297	–0.0037918	–0.0028136
13	–0.00243455	–0.0122678	–0.0001895	0.0029675	–0.0044995	–0.0019448
14	0.00218889	0.0047306	–0.0001523	0.0009778	0.0011455	0.0006458
15	0.00046634	–0.0027102	–0.0003435	–0.0004140	–0.0002552	–0.0001587
16	–0.00065699	0.0029128	0.0001707	0.0003663	–0.0000735	–0.0000037
17	0.00010528	–0.0007221	0.0000100	–0.0000233	0.0001522	0.0000722
18	–0.00002718	–0.0016883	–0.0000093	–0.0000305	–0.0000221	–0.0000142
19	0.00005322	0.0009071	0.0000212	0.0000125	0.0000138	0.0000078
20	0.00004018	0.0001148	–0.0000061	–0.0000173	0.0000023	–0.0000001
21	–0.00007715	–0.0001353	–0.0000007	0.0000017	–0.0000074	–0.0000036
22	0.00001003	0.0000477	0.0000009	0.0000017	0.0000022	0.0000011
23	0.00002042	–0.0000778	–0.0000012	–0.0000016	–0.0000005	–0.0000004
24	–0.00000742	0.0000471	0.0000002	0.0000007	–0.0000008	–0.0000004
25	0.00000099	0.0000276	0.0000001	0.0000005	0.0000003	0.0000003
26	–0.00000232	–0.0000326	–0.0000001	–0.0000002	0.0000003	0.0000001
27	–0.00000002	0.0000039	0.0000001	–0.0000002	–0.0000001	–0.0000001
28	0.00000250	0.0000037	0.0000001	0.0000001	–0.0000001	–0.0000002
29	–0.00000112	–0.0000010	–0.0000001	0.0000000	0.0000001	0.0000000
30	–0.00000045	0.0000022	0.0000001	–0.0000001	0.0000000	0.0000001
31	0.00000038	–0.0000021	0.0000001	0.0000001	–0.0000001	0.0000001
32	–0.00000006	–0.0000004	0.0000001	–0.0000001	0.0000000	0.0000000
33	0.00000006	0.0000010	0.0000000	0.0000000	0.0000000	0.0000000
Sums	44.30334403	33.6559037	119.9898342	24.2364296	60.0019666	31.2514855

Days: 335–366 JD 2448226.5 – 2448258.5 Dates: Dec. 1 – Jan. 1

A = 16.0 W = 335

Term	R.A. h	Dec. °	H.P. ′	*X* Earth Rad.	*Y* Earth Rad.	*Z* Earth Rad.
0	35.03246300	18.2832112	117.2897304	3.4932688	33.1228323	16.4096013
1	13.98406819	0.1250791	–0.0105626	8.1815733	–1.1774992	0.1639087
2	0.04810468	23.2997194	3.7101850	6.4862844	46.8698948	23.2712662
3	0.50340649	–1.1579494	–0.3015482	–49.7105084	7.2625442	–0.9139614
4	–0.01985647	–11.6320291	–1.3140103	–3.4056812	–24.2514297	–12.0990766
5	0.10575806	0.0716622	0.0577028	10.2229159	–1.6065048	0.1363187
6	–0.01477908	0.3581376	–0.2491454	0.4291788	2.1485410	1.0888438
7	–0.12554000	0.0980912	0.0056267	–0.0925612	0.1010507	0.0401057
8	0.00330207	0.0964062	0.0994961	–0.0243683	0.2075957	0.0982451
9	0.01567994	0.0079644	0.0006263	–0.1120354	–0.0026973	–0.0113153
10	0.00152899	0.1589060	0.0045518	0.0036936	–0.0141858	–0.0066402
11	0.00027354	–0.0110638	–0.0014102	–0.0141272	0.0023749	–0.0001004
12	0.00020857	–0.0466951	–0.0034399	–0.0010812	–0.0114103	–0.0056355
13	0.00312242	–0.0015742	0.0001722	0.0056137	–0.0006582	0.0001823
14	–0.00038169	0.0001869	–0.0004870	0.0002355	0.0011383	0.0005775
15	–0.00133279	0.0007090	0.0000436	0.0001967	0.0000899	0.0000620
16	–0.00000388	–0.0019544	0.0002155	–0.0000461	0.0003009	0.0001415
17	0.00012336	0.0004546	0.0000004	–0.0001509	–0.0000097	–0.0000186
18	0.00001949	0.0018591	0.0000167	0.0000040	–0.0000206	–0.0000096
19	–0.00007266	–0.0000988	–0.0000049	–0.0000193	0.0000007	–0.0000013
20	0.00001792	–0.0003413	–0.0000086	0.0000004	–0.0000159	–0.0000077
21	0.00006706	–0.0000376	0.0000002	0.0000076	–0.0000002	0.0000006
22	–0.00000632	0.0000453	–0.0000016	0.0000003	0.0000009	0.0000005
23	–0.00001777	–0.0000066	0.0000004	0.0000010	0.0000003	0.0000002
24	–0.00000090	–0.0000596	0.0000007	–0.0000003	0.0000009	0.0000005
25	0.00000329	0.0000096	–0.0000002	–0.0000005	–0.0000002	–0.0000002
26	–0.00000033	0.0000252	0.0000000	0.0000000	–0.0000003	–0.0000001
27	–0.00000270	–0.0000002	0.0000001	0.0000001	0.0000001	0.0000002
28	0.00000054	–0.0000045	0.0000000	–0.0000002	0.0000000	0.0000000
29	0.00000131	–0.0000004	–0.0000001	0.0000000	0.0000000	–0.0000001
30	–0.00000005	0.0000018	0.0000001	0.0000000	0.0000000	0.0000000
31	–0.00000031	–0.0000003	0.0000001	0.0000000	0.0000000	0.0000001
32	0.00000001	–0.0000014	–0.0000001	0.0000000	0.0000001	–0.0000001
33	0.00000012	0.0000001	–0.0000001	0.0000001	–0.0000001	–0.0000001
Sums	49.53615410	29.6506522	119.2877499	–24.5376060	62.6519334	28.1724877

Chebyshev Series for Mercury and Venus, 1990

Days: 1–95 JD 2447892.5 – 2447987.5 Dates: Jan. 1 – Apr. 5

A = 47.5 W = 1

Term	Mercury R.A. h	Mercury Dec. °	Mercury Distance AU	Venus R.A. h	Venus Dec. °	Venus Distance AU
0	43.4693190	–20.454355	2.0921934	41.0858537	–28.884703	0.8972879
1	3.4604673	16.188965	0.2849142	0.7632130	1.849362	0.2324112
2	1.1942929	8.308064	–0.1570952	0.8889290	0.613393	0.0710512
3	–0.4649057	1.125995	–0.1214820	–0.0285631	1.297890	–0.0206476
4	0.0922804	–1.251537	0.0322014	–0.1121150	–0.124408	0.0018123
5	0.0422853	0.016013	–0.0263670	0.0471085	–0.094704	0.0013402
6	–0.0854173	–0.109391	0.0064877	–0.0017046	0.029851	–0.0007695
7	0.0454573	–0.066020	0.0036213	–0.0075045	0.001024	0.0001156
8	–0.0206037	0.020597	–0.0021631	0.0036385	–0.004508	0.0000787
9	0.0009993	–0.001405	0.0023687	–0.0001891	0.001143	–0.0000341
10	0.0063417	0.002738	–0.0007930	–0.0005157	0.001047	0.0000022
11	–0.0057672	0.004128	0.0000223	0.0002724	–0.000443	–0.0000040
12	0.0034085	0.000091	0.0001467	–0.0000732	–0.000265	–0.0000002
13	–0.0009390	–0.000977	–0.0002181	–0.0000189	0.000127	0.0000032
14	–0.0003366	0.000963	0.0001045	0.0000370	0.000051	–0.0000010
15	0.0006592	–0.000761	–0.0000349	–0.0000159	–0.000020	–0.0000009
16	–0.0005140	0.000026	–0.0000041	–0.0000022	–0.000009	0.0000004
17	0.0002299	0.000217	0.0000193	0.0000051	0.000009	0.0000000
18	–0.0000273	–0.000262	–0.0000132	–0.0000024	–0.000011	0.0000002
19	–0.0000623	0.000169	0.0000072	0.0000012	–0.000009	0.0000003
20	0.0000694	–0.000049	–0.0000014	0.0000008	0.000016	–0.0000003
21	–0.0000432	–0.000014	–0.0000016	–0.0000021	0.000004	–0.0000002
22	0.0000157	0.000043	0.0000017	0.0000005	–0.000010	0.0000002
23	0.0000027	–0.000040	–0.0000010	0.0000010	–0.000002	0.0000001
24	–0.0000091	0.000019	0.0000003	–0.0000006	0.000004	–0.0000001
25	0.0000073	0.000000	0.0000000	–0.0000003	0.000001	0.0000000
26	–0.0000034	–0.000007	–0.0000001	0.0000002	–0.000002	0.0000000
27	0.0000006	0.000007	0.0000002	0.0000002	0.000000	0.0000000
28	0.0000009	–0.000004	–0.0000001	0.0000002	0.000001	0.0000000
29	–0.0000011	0.000000	0.0000000	–0.0000002	–0.000001	0.0000000
30	0.0000006	0.000001	0.0000000	–0.0000003	0.000000	0.0000000
31	–0.0000001	0.000001	0.0000000	0.0000001	0.000001	0.0000000
Sums	47.7372080	3.783215	2.1139141	42.6383533	–25.315171	1.1826458

Days: 91–185 JD 2447982.5 – 2448077.5 Dates: Apr. 1 – July 4

A = 47.5 W = 91

Term	Mercury R.A. h	Mercury Dec. °	Mercury Distance AU	Venus R.A. h	Venus Dec. °	Venus Distance AU
0	7.2486312	34.843234	1.9672794	50.2729403	9.047803	2.0948387
1	2.2419529	4.717373	0.1671083	3.4549660	17.282496	0.3421183
2	0.8680355	2.209702	0.3192733	0.0927577	–0.145644	–0.0126952
3	0.6476592	2.909621	–0.1045842	0.0186141	–0.811935	–0.0020153
4	–0.2412931	–3.130528	–0.0408606	0.0025805	–0.015038	0.0000551
5	–0.0326535	–0.535401	0.0096242	–0.0021030	0.003381	–0.0000179
6	0.0590345	0.602272	–0.0072441	0.0000197	0.000001	0.0000047
7	–0.0287728	–0.085727	–0.0007002	–0.0000508	0.000357	–0.0000080
8	–0.0148632	–0.132813	0.0018836	–0.0000395	–0.000189	0.0000167
9	0.0105480	0.081047	0.0007701	0.0000561	0.000404	0.0000098
10	0.0014800	0.039569	–0.0001398	0.0000234	0.000039	–0.0000107
11	–0.0031149	–0.035266	–0.0000626	–0.0000201	–0.000216	–0.0000042
12	0.0010186	–0.002266	0.0001019	–0.0000049	0.000009	0.0000033
13	0.0008995	0.012540	–0.0000751	0.0000051	0.000070	0.0000006
14	–0.0006269	–0.004374	–0.0000429	0.0000000	–0.000006	–0.0000007
15	–0.0001155	–0.003457	0.0000210	–0.0000022	–0.000013	0.0000000
16	0.0002156	0.002578	0.0000025	–0.0000011	–0.000001	0.0000001
17	–0.0000556	0.000428	–0.0000041	–0.0000007	–0.000009	0.0000004
18	–0.0000583	–0.001025	0.0000030	0.0000012	0.000001	0.0000001
19	0.0000439	0.000224	0.0000019	0.0000024	0.000010	–0.0000005
20	0.0000083	0.000325	–0.0000015	–0.0000003	–0.000001	–0.0000001
21	–0.0000186	–0.000194	–0.0000002	–0.0000018	–0.000004	0.0000003
22	0.0000038	–0.000057	0.0000005	0.0000000	0.000002	0.0000000
23	0.0000058	0.000092	–0.0000003	0.0000008	0.000001	–0.0000001
24	–0.0000036	–0.000012	–0.0000002	–0.0000001	–0.000001	0.0000000
25	–0.0000010	–0.000032	0.0000002	–0.0000004	–0.000001	0.0000000
26	0.0000016	0.000015	0.0000000	0.0000001	0.000000	0.0000000
27	–0.0000001	0.000006	0.0000000	0.0000002	0.000000	0.0000000
28	–0.0000001	–0.000008	0.0000000	0.0000002	0.000001	0.0000000
29	0.0000001	0.000001	0.0000000	–0.0000001	0.000000	0.0000000
30	–0.0000003	0.000001	0.0000000	–0.0000003	–0.000001	0.0000000
31	0.0000000	–0.000002	0.0000000	0.0000001	0.000000	0.0000000
Sums	10.7579610	41.487866	2.3123541	53.8397426	25.361516	2.4222954

Chebyshev Series for Mercury and Venus, 1990

Days: 182–276 JD 2448073.5 – 2448168.5 Dates: July 1 – Oct. 3

A = 47.5 W = 182

Term	Mercury R.A. h	Mercury Dec. °	Mercury Distance AU	Venus R.A. h	Venus Dec. °	Venus Distance AU
0	19.9699567	21.075658	2.0851010	16.7324360	29.445450	3.1075651
1	2.1763977	–10.366376	–0.1815627	3.9505300	–10.429484	0.1743731
2	–1.0472245	6.192563	0.2434550	–0.0776433	–4.812362	–0.0285445
3	0.4839162	0.248794	0.1445465	–0.0227855	0.491301	–0.0004353
4	0.3046097	–3.416156	–0.0068365	0.0110434	0.122715	0.0001519
5	0.0781624	–1.033599	–0.0208336	0.0010797	–0.018744	–0.0000043
6	–0.0553752	0.187563	–0.0195404	–0.0006405	–0.001087	–0.0000020
7	–0.0673347	0.528169	–0.0024004	–0.0000165	0.001202	–0.0000055
8	–0.0132136	0.232436	0.0034840	0.0000140	0.000015	0.0000181
9	0.0133543	–0.064123	0.0024469	0.0000350	–0.000221	0.0000066
10	0.0126772	–0.110785	0.0005369	0.0000063	–0.000093	–0.0000118
11	0.0021764	–0.040160	–0.0005168	–0.0000190	0.000096	–0.0000026
12	–0.0033474	0.020628	–0.0003519	–0.0000002	0.000052	0.0000035
13	–0.0024750	0.025822	–0.0000332	0.0000033	–0.000026	0.0000007
14	–0.0001471	0.005789	0.0000883	0.0000006	–0.000024	–0.0000004
15	0.0008405	–0.006966	0.0000498	0.0000013	0.000003	–0.0000001
16	0.0004895	–0.006159	–0.0000105	–0.0000007	–0.000001	0.0000001
17	–0.0000576	–0.000506	–0.0000216	0.0000011	–0.000003	0.0000000
18	–0.0002173	0.002268	–0.0000069	–0.0000007	0.000015	–0.0000003
19	–0.0000971	0.001491	0.0000056	–0.0000029	0.000003	0.0000001
20	0.0000359	–0.000124	0.0000062	0.0000014	–0.000014	0.0000003
21	0.0000589	–0.000704	0.0000010	0.0000023	–0.000003	–0.0000001
22	0.0000165	–0.000341	–0.0000021	–0.0000010	0.000006	–0.0000002
23	–0.0000145	0.000102	–0.0000016	–0.0000010	0.000002	0.0000000
24	–0.0000143	0.000202	–0.0000001	0.0000002	–0.000001	0.0000001
25	–0.0000023	0.000072	0.0000006	0.0000003	–0.000001	0.0000000
26	0.0000045	–0.000043	0.0000004	0.0000001	0.000000	0.0000000
27	0.0000034	–0.000056	0.0000000	–0.0000001	0.000000	0.0000000
28	0.0000002	–0.000014	–0.0000002	0.0000001	–0.000001	0.0000000
29	–0.0000012	0.000016	–0.0000001	0.0000001	0.000001	0.0000000
30	–0.0000010	0.000016	0.0000000	–0.0000002	0.000001	0.0000000
31	0.0000001	0.000002	0.0000000	–0.0000001	–0.000001	0.0000000
Sums	21.8531773	13.475479	2.2476036	20.5940435	14.798796	3.2531125

Days: 274–368 JD 2448165.5 – 2448260.5 Dates: Oct. 1 – Jan. 3

A = 47.5 W = 274

Term	Mercury R.A. h	Mercury Dec. °	Mercury Distance AU	Venus R.A. h	Venus Dec. °	Venus Distance AU
0	31.2617268	–29.367328	2.1968239	31.8382769	–29.519735	3.3697415
1	3.3752036	–12.349350	–0.3115358	4.0455407	–12.412805	–0.0347228
2	–1.0905973	8.176862	–0.1798381	0.1241227	4.749475	–0.0234393
3	–0.5233581	0.006972	0.1265852	–0.0153915	0.757486	0.0007158
4	–0.1008539	–1.151475	0.0567149	–0.0145847	–0.096797	–0.0000752
5	0.1061027	–0.274641	0.0284883	–0.0001648	–0.027678	–0.0000134
6	0.1251688	–0.129811	–0.0006193	0.0007862	–0.001743	0.0000002
7	0.0587607	0.045150	–0.0084311	0.0000989	0.001287	–0.0000011
8	0.0093893	0.012918	–0.0060553	–0.0000284	0.000241	0.0000200
9	–0.0158804	0.007553	–0.0024915	0.0000254	–0.000118	0.0000013
10	–0.0169033	0.003786	0.0002570	0.0000039	0.000075	–0.0000117
11	–0.0090802	0.005573	0.0009827	–0.0000160	0.000030	–0.0000004
12	–0.0013423	0.006151	0.0007654	–0.0000033	–0.000047	0.0000037
13	0.0024714	0.003153	0.0002795	0.0000044	–0.000015	0.0000002
14	0.0027727	–0.000057	–0.0000419	–0.0000005	0.000024	–0.0000010
15	0.0015218	–0.002061	–0.0001367	–0.0000002	0.000005	–0.0000001
16	0.0002390	–0.002122	–0.0001037	0.0000005	0.000000	–0.0000001
17	–0.0004153	–0.001099	–0.0000380	–0.0000002	0.000007	–0.0000001
18	–0.0004818	–0.000055	0.0000065	0.0000012	–0.000014	0.0000004
19	–0.0002717	0.000502	0.0000201	–0.0000003	–0.000008	0.0000001
20	–0.0000482	0.000545	0.0000150	–0.0000014	0.000013	–0.0000004
21	0.0000724	0.000288	0.0000057	0.0000004	0.000005	–0.0000001
22	0.0000881	0.000012	–0.0000006	0.0000010	–0.000007	0.0000002
23	0.0000504	–0.000118	–0.0000030	–0.0000002	–0.000003	0.0000000
24	0.0000093	–0.000120	–0.0000025	–0.0000006	0.000003	–0.0000001
25	–0.0000126	–0.000064	–0.0000010	0.0000000	0.000000	0.0000000
26	–0.0000160	–0.000005	0.0000001	0.0000002	0.000001	0.0000000
27	–0.0000098	0.000025	0.0000005	0.0000000	0.000001	0.0000000
28	–0.0000021	0.000025	0.0000004	0.0000001	–0.000002	0.0000000
29	0.0000023	0.000014	0.0000002	–0.0000001	–0.000001	0.0000000
30	0.0000029	0.000003	0.0000000	–0.0000002	0.000002	0.0000000
31	0.0000019	–0.000004	–0.0000001	0.0000001	0.000000	0.0000000
Sums	33.1843111	–35.008778	1.9016468	35.9786702	–36.550318	3.3122176

Days: 1–95 JD 2447892.5 – 2447987.5 Dates: Jan. 1 – Apr. 5

A = 47.5 W = 1

Term	Mars R.A. h	Mars Dec. °	Mars Distance AU	Jupiter R.A. h	Jupiter Dec. °	Jupiter Distance AU
0	37.9844019	–42.431545	4.0191941	12.3819797	46.795277	9.3130084
1	2.4689724	2.819904	–0.3070466	–0.0731261	0.127999	0.5899736
2	–0.0042525	2.095770	–0.0039427	0.1223213	–0.040904	0.0846581
3	–0.0127337	–0.038466	0.0021336	0.0042171	0.004396	–0.0201307
4	0.0006883	–0.025796	–0.0001041	–0.0034469	–0.003863	–0.0003439
5	0.0002868	0.000416	–0.0000265	0.0003560	–0.000667	0.0003535
6	–0.0000317	0.000230	0.0000042	0.0000519	0.000284	–0.0000450
7	–0.0000226	–0.000108	–0.0000070	–0.0000174	–0.000005	–0.0000018
8	–0.0000256	–0.000064	0.0000132	0.0000107	–0.000026	–0.0000110
9	0.0000246	0.000038	0.0000138	–0.0000156	0.000018	–0.0000112
10	0.0000228	0.000098	–0.0000099	–0.0000081	0.000021	0.0000143
11	–0.0000121	–0.000008	–0.0000064	0.0000089	0.000005	0.0000067
12	–0.0000089	–0.000041	0.0000033	0.0000016	–0.000013	–0.0000059
13	0.0000033	–0.000010	0.0000017	–0.0000033	0.000002	–0.0000020
14	0.0000004	0.000017	–0.0000010	–0.0000023	–0.000004	0.0000018
15	0.0000000	0.000010	–0.0000005	0.0000021	–0.000012	0.0000005
16	0.0000004	–0.000005	0.0000001	0.0000011	0.000003	–0.0000004
17	0.0000000	0.000007	0.0000000	0.0000003	–0.000003	–0.0000001
18	0.0000015	–0.000004	0.0000003	0.0000017	0.000006	–0.0000002
19	–0.0000004	–0.000013	0.0000002	–0.0000015	0.000013	–0.0000001
Sums	40.4373149	–37.579570	3.7102198	12.4323312	46.882527	9.9674646

Days: 91–185 JD 2447982.5 – 2448077.5 Dates: Apr. 1 – July 4

A = 47.5 W = 91

Term	Mars R.A. h	Mars Dec. °	Mars Distance AU	Jupiter R.A. h	Jupiter Dec. °	Jupiter Distance AU
0	46.8577071	–10.236433	2.8915414	13.5633863	46.009543	11.6229671
1	2.1897653	12.776108	–0.2802743	0.6375689	–0.666239	0.5038556
2	–0.0394959	0.243619	0.0065880	0.0476461	–0.195447	–0.0844770
3	0.0035258	–0.216513	–0.0004560	–0.0084624	–0.011546	–0.0074418
4	–0.0002171	0.001975	–0.0001736	0.0003275	0.002686	0.0009007
5	–0.0002526	0.000798	0.0000099	0.0000031	0.000137	–0.0000516
6	–0.0000076	–0.000041	0.0000065	–0.0000137	–0.000026	–0.0000031
7	–0.0000253	–0.000134	–0.0000010	0.0000032	0.000010	–0.0000033
8	–0.0000067	0.000031	0.0000186	–0.0000115	0.000012	–0.0000072
9	0.0000470	0.000347	0.0000022	–0.0000044	0.000016	0.0000172
10	0.0000094	0.000012	–0.0000145	0.0000110	–0.000022	0.0000078
11	–0.0000196	–0.000172	–0.0000014	0.0000048	–0.000021	–0.0000101
12	–0.0000033	–0.000012	0.0000049	–0.0000039	0.000013	–0.0000032
13	0.0000048	0.000054	0.0000000	–0.0000004	0.000004	0.0000030
14	0.0000004	0.000000	–0.0000009	0.0000017	0.000007	0.0000003
15	–0.0000023	–0.000016	0.0000002	–0.0000018	0.000006	–0.0000006
16	–0.0000007	–0.000002	0.0000002	–0.0000008	–0.000004	0.0000000
17	0.0000001	–0.000003	0.0000003	–0.0000006	0.000002	0.0000001
18	0.0000006	0.000004	–0.0000001	–0.0000007	–0.000009	0.0000004
19	0.0000017	0.000011	–0.0000005	0.0000025	–0.000010	0.0000001
Sums	49.0110311	2.569633	2.6172499	14.2404549	45.139112	12.0357544

Days: 182–276 JD 2448073.5 – 2448168.5 Dates: July 1 – Oct. 3

A = 47.5 W = 182

Term	Mars R.A. h	Mars Dec. °	Mars Distance AU	Jupiter R.A. h	Jupiter Dec. °	Jupiter Distance AU
0	6.4657183	30.496385	1.8627603	16.2125466	40.812706	12.0678080
1	1.7057044	7.295691	–0.2627420	0.6859974	–1.943207	–0.2856996
2	–0.1471022	–1.284670	–0.0003590	–0.0315743	–0.058365	–0.1032474
3	–0.0332373	0.020467	0.0007969	–0.0064787	0.036116	0.0039226
4	–0.0049067	0.029012	0.0005195	–0.0001304	0.003112	0.0007968
5	–0.0003422	0.000159	0.0000984	–0.0000362	0.000014	0.0000257
6	0.0000170	–0.000397	0.0000136	–0.0000017	0.000016	0.0000123
7	0.0000019	–0.000197	0.0000074	–0.0000024	0.000002	–0.0000013
8	0.0000663	0.000218	0.0000112	–0.0000034	0.000027	0.0000151
9	0.0000552	0.000050	–0.0000149	0.0000107	–0.000057	0.0000057
10	–0.0000450	–0.000258	–0.0000098	0.0000031	–0.000016	–0.0000159
11	–0.0000350	–0.000019	0.0000078	–0.0000090	0.000040	–0.0000032
12	0.0000142	0.000107	0.0000036	–0.0000006	–0.000007	0.0000064
13	0.0000103	–0.000005	–0.0000018	0.0000022	–0.000005	0.0000010
14	–0.0000002	–0.000026	–0.0000008	0.0000004	–0.000009	–0.0000012
15	–0.0000003	0.000007	0.0000001	0.0000016	–0.000007	–0.0000003
16	–0.0000008	0.000004	0.0000001	–0.0000005	0.000014	0.0000001
17	0.0000003	0.000006	–0.0000001	0.0000001	–0.000004	0.0000000
18	–0.0000020	0.000000	0.0000000	–0.0000003	0.000007	–0.0000003
19	–0.0000019	–0.000012	0.0000003	–0.0000025	0.000008	0.0000001
Sums	7.9859143	36.556522	1.6010908	16.8603221	38.850385	11.6836246

Days: 274–368 JD 2448165.5 – 2448260.5 Dates: Oct. 1 – Jan. 3

A = 47.5 W = 274

Term	Mars R.A. h	Mars Dec. °	Mars Distance AU	Jupiter R.A. h	Jupiter Dec. °	Jupiter Distance AU
0	8.6336760	44.099006	1.2170955	17.8996726	35.598524	10.0210863
1	–0.6659317	0.254005	0.0008386	0.1206602	–0.326040	–0.6658151
2	–0.1503066	–0.595171	0.0873189	–0.1123690	0.465708	0.0328902
3	0.1587948	0.160601	0.0070001	–0.0038924	0.022218	0.0198671
4	0.0192950	0.109723	–0.0033701	0.0015761	–0.010944	0.0007186
5	–0.0138306	0.008982	–0.0005923	0.0003313	–0.001789	–0.0001596
6	–0.0028493	–0.018703	0.0002090	0.0000323	–0.000052	–0.0000365
7	0.0013936	–0.003476	0.0000632	–0.0000026	0.000035	0.0000007
8	0.0004589	0.002391	–0.0000299	0.0000111	–0.000053	–0.0000030
9	–0.0002762	0.000502	–0.0000118	–0.0000045	0.000036	–0.0000192
10	–0.0000958	–0.000265	0.0000183	–0.0000123	0.000070	0.0000035
11	0.0001096	0.000010	0.0000040	0.0000010	–0.000001	0.0000114
12	0.0000251	0.000044	–0.0000079	0.0000037	–0.000028	–0.0000014
13	–0.0000402	–0.000019	–0.0000014	–0.0000005	0.000005	–0.0000038
14	–0.0000105	–0.000031	0.0000025	–0.0000032	0.000012	0.0000003
15	0.0000132	–0.000003	0.0000005	0.0000006	–0.000012	0.0000011
16	0.0000035	0.000017	–0.0000005	0.0000011	–0.000003	0.0000000
17	–0.0000007	0.000003	0.0000000	0.0000003	–0.000004	0.0000001
18	0.0000021	0.000003	–0.0000003	0.0000019	–0.000005	0.0000000
19	–0.0000039	0.000002	–0.0000002	–0.0000008	0.000013	–0.0000005
Sums	7.9804263	44.017621	1.3085362	17.9060069	35.747690	9.4085402

Days: 1–95 JD 2447892.5 – 2447987.5 Dates: Jan. 1 – Apr. 5

A = 47.5 W = 1

Term	Saturn R.A. h	Saturn Dec. °	Saturn Distance AU	Uranus R.A. h	Uranus Dec. °	Uranus Distance AU
0	38.9583273	–43.182070	21.3501624	37.1615196	–46.954121	39.8131178
1	0.3273617	0.637477	–0.4524018	0.1411109	0.099876	–0.5655524
2	–0.0315897	–0.028621	–0.1123197	–0.0240032	–0.014679	–0.0976868
3	–0.0054768	–0.019389	0.0107410	–0.0029272	–0.004632	0.0158115
4	0.0001763	–0.000551	0.0013769	0.0002577	0.000143	0.0013781
5	0.0000180	0.000212	–0.0000636	0.0000229	0.000096	–0.0001283
6	0.0000001	–0.000010	0.0000028	–0.0000003	–0.000008	0.0000016
7	–0.0000009	0.000003	–0.0000024	–0.0000009	–0.000004	–0.0000013
8	–0.0000041	–0.000028	0.0000094	–0.0000012	–0.000009	0.0000117
9	0.0000033	0.000006	0.0000157	0.0000014	–0.000005	0.0000128
10	0.0000051	0.000019	–0.0000100	0.0000030	0.000006	–0.0000129
11	–0.0000023	–0.000018	–0.0000093	–0.0000021	–0.000012	–0.0000077
12	–0.0000039	0.000000	0.0000039	–0.0000025	0.000001	0.0000052
13	0.0000006	–0.000010	0.0000028	0.0000004	0.000000	0.0000025
14	–0.0000008	0.000015	–0.0000012	–0.0000013	0.000006	–0.0000016
15	0.0000004	0.000004	–0.0000008	0.0000010	0.000012	–0.0000008
16	0.0000012	0.000002	0.0000003	0.0000009	–0.000003	0.0000004
17	–0.0000001	0.000005	0.0000001	0.0000003	0.000003	0.0000001
18	0.0000019	–0.000008	0.0000002	0.0000017	–0.000005	0.0000002
19	–0.0000010	–0.000005	0.0000002	–0.0000010	–0.000014	0.0000001
Sums	39.2488163	–42.592967	20.7975069	37.2759801	–46.873349	39.1669502

Days: 91–185 JD 2447982.5 – 2448077.5 Dates: Apr. 1 – July 4

A = 47.5 W = 91

Term	Saturn R.A. h	Saturn Dec. °	Saturn Distance AU	Uranus R.A. h	Uranus Dec. °	Uranus Distance AU
0	39.4991900	–42.197005	19.0496531	37.2760160	–46.925280	37.5147251
1	–0.0616561	–0.208295	–0.6161213	–0.0808141	–0.087374	–0.4863230
2	–0.0569496	–0.144376	0.0824498	–0.0238532	–0.017877	0.1167746
3	0.0033296	0.010614	0.0183714	0.0034510	0.004790	0.0146002
4	0.0010920	0.003816	–0.0008513	0.0004298	0.000385	–0.0016415
5	0.0000272	–0.000114	–0.0001890	–0.0000305	–0.000121	–0.0001290
6	–0.0000092	–0.000052	0.0000029	–0.0000037	0.000007	0.0000136
7	–0.0000018	–0.000004	0.0000028	0.0000001	0.000001	0.0000026
8	0.0000032	0.000021	0.0000097	0.0000014	0.000012	0.0000061
9	0.0000070	0.000029	–0.0000145	0.0000037	0.000010	–0.0000173
10	–0.0000047	–0.000016	–0.0000117	–0.0000028	–0.000003	–0.0000078
11	–0.0000025	–0.000009	0.0000090	0.0000000	0.000001	0.0000109
12	0.0000025	0.000001	0.0000051	0.0000017	–0.000005	0.0000034
13	0.0000014	0.000006	–0.0000029	0.0000007	0.000001	–0.0000035
14	0.0000001	–0.000009	–0.0000009	0.0000003	–0.000009	–0.0000005
15	–0.0000018	–0.000009	0.0000007	–0.0000018	–0.000006	0.0000007
16	–0.0000005	0.000005	0.0000001	–0.0000006	0.000005	0.0000000
17	–0.0000003	0.000000	0.0000000	–0.0000004	–0.000001	–0.0000001
18	–0.0000006	0.000007	–0.0000004	–0.0000007	0.000009	–0.0000003
19	0.0000018	0.000011	–0.0000002	0.0000021	0.000009	–0.0000001
Sums	39.3850277	–42.535379	18.5333124	37.1751990	–47.025446	37.1580141

Days: 182–276 JD 2448073.5 – 2448168.5 Dates: July 1 – Oct. 3

A = 47.5 W = 182

Term	Saturn R.A. h	Saturn Dec. °	Saturn Distance AU	Uranus R.A. h	Uranus Dec. °	Uranus Distance AU
0	38.9332646	–43.731311	18.5761041	36.9163363	–47.232252	37.6782037
1	–0.1568520	–0.402320	0.4058335	–0.0678237	–0.043077	0.5613892
2	0.0409330	0.094843	0.1293228	0.0263513	0.020542	0.1036403
3	0.0079772	0.012777	–0.0130955	0.0029619	0.000391	–0.0162225
4	–0.0010102	–0.002478	–0.0018877	–0.0004637	–0.000230	–0.0013893
5	–0.0000822	0.000166	0.0001859	–0.0000161	0.000072	0.0001529
6	0.0000207	0.000042	0.0000003	0.0000043	–0.000010	–0.0000060
7	0.0000009	–0.000008	–0.0000027	0.0000001	–0.000001	–0.0000015
8	0.0000004	–0.000002	–0.0000139	–0.0000006	–0.000007	–0.0000142
9	–0.0000089	–0.000024	–0.0000026	–0.0000049	–0.000004	0.0000020
10	–0.0000017	–0.000009	0.0000172	–0.0000004	–0.000003	0.0000173
11	0.0000037	0.000019	0.0000014	0.0000009	0.000009	–0.0000016
12	0.0000011	0.000010	–0.0000076	0.0000006	0.000008	–0.0000074
13	–0.0000018	–0.000005	–0.0000005	–0.0000009	–0.000001	0.0000005
14	0.0000004	0.000008	0.0000016	0.0000006	0.000008	0.0000016
15	0.0000019	–0.000001	0.0000002	0.0000017	–0.000004	0.0000001
16	–0.0000005	–0.000006	–0.0000001	–0.0000005	–0.000006	–0.0000001
17	0.0000003	0.000000	0.0000000	0.0000003	0.000000	0.0000001
18	–0.0000006	–0.000009	0.0000002	–0.0000007	–0.000009	0.0000002
19	–0.0000020	0.000004	–0.0000001	–0.0000020	0.000006	–0.0000003
Sums	38.8242443	–44.028304	19.0964565	36.8773445	–47.254568	38.3257650

Days: 274–368 JD 2448165.5 – 2448260.5 Dates: Oct. 1 – Jan. 3

A = 47.5 W = 274

Term	Saturn R.A. h	Saturn Dec. °	Saturn Distance AU	Uranus R.A. h	Uranus Dec. °	Uranus Distance AU
0	39.1349646	–43.502773	20.8627964	37.0954914	–47.075443	40.0844779
1	0.2625441	0.540652	0.6088568	0.1555068	0.125893	0.5096327
2	0.0445604	0.123953	–0.0795395	0.0206408	0.022599	–0.1124772
3	–0.0051469	–0.003725	–0.0152616	–0.0032436	–0.000490	–0.0137734
4	–0.0002969	–0.000940	0.0011767	–0.0002103	–0.000353	0.0015243
5	0.0000480	–0.000108	0.0000646	0.0000218	–0.000049	0.0000916
6	–0.0000057	–0.000015	–0.0000001	–0.0000008	0.000001	0.0000015
7	0.0000000	–0.000001	–0.0000025	–0.0000006	0.000006	–0.0000022
8	–0.0000036	–0.000018	0.0000083	–0.0000008	0.000002	0.0000110
9	0.0000025	0.000001	0.0000166	0.0000014	0.000004	0.0000134
10	0.0000055	0.000018	–0.0000092	0.0000030	0.000013	–0.0000124
11	–0.0000027	–0.000018	–0.0000095	–0.0000014	–0.000007	–0.0000079
12	–0.0000036	–0.000007	0.0000038	–0.0000017	0.000005	0.0000051
13	0.0000006	0.000000	0.0000031	0.0000010	0.000000	0.0000025
14	–0.0000011	0.000003	–0.0000011	–0.0000007	0.000002	–0.0000015
15	0.0000006	0.000012	–0.0000009	0.0000013	0.000006	–0.0000007
16	0.0000007	–0.000001	0.0000001	0.0000011	–0.000009	0.0000002
17	0.0000003	0.000004	–0.0000001	0.0000003	–0.000003	–0.0000001
18	0.0000016	–0.000001	0.0000001	0.0000014	–0.000010	0.0000001
19	–0.0000009	–0.000014	0.0000004	–0.0000015	–0.000018	0.0000003
Sums	39.4366675	–42.842978	21.3781024	37.2682089	–46.927851	40.4694852

Days: 1–95 JD 2447892.5 – 2447987.5 Dates: Jan. 1 – Apr. 5

A = 47.5 W = 1

Term	Neptune R.A. h	Neptune Dec. °	Neptune Distance AU	Pluto R.A.* h	Pluto Dec.* °	Pluto Distance AU
0	37.9399091	–43.819902	61.5785189	30.5961045	–4.093021	58.9859550
1	0.0922622	0.135104	–0.5279529	0.0098322	0.317732	–0.7127658
2	–0.0143927	–0.014008	–0.1105824	–0.0199055	0.070694	0.0293259
3	–0.0020444	–0.004167	0.0151417	0.0001459	–0.013016	0.0213030
4	0.0001817	0.000153	0.0015448	0.0003100	–0.001215	–0.0003977
5	0.0000147	0.000051	–0.0001408	0.0000019	0.000116	–0.0002054
6	0.0000005	–0.000005	0.0000001	–0.0000022	0.000003	0.0000128
7	–0.0000015	–0.000002	–0.0000011	–0.0000004	0.000000	0.0000015
8	0.0000002	–0.000013	0.0000105	0.0000002	–0.000011	0.0000139
9	–0.0000005	0.000000	0.0000139	0.0000025	–0.000008	–0.0000031
10	0.0000028	–0.000004	–0.0000118	–0.0000001	0.000013	–0.0000161
11	–0.0000016	–0.000001	–0.0000085	–0.0000015	0.000005	0.0000016
Sums	38.0159305	–43.702794	60.9565324	30.5864875	–3.718708	58.3232256

Days: 91–185 JD 2447982.5 – 2448077.5 Dates: Apr. 1 – July 4

A = 47.5 W = 91

Term	Neptune R.A. h	Neptune Dec. °	Neptune Distance AU	Pluto R.A.* h	Pluto Dec.* °	Pluto Distance AU
0	38.0251765	–43.663931	59.2326841	30.4426290	–2.877914	57.7076262
1	–0.0485979	–0.061827	–0.5471296	–0.0739969	0.197739	0.1277570
2	–0.0160826	–0.025788	0.1063511	0.0023779	–0.095821	0.1485745
3	0.0019458	0.002861	0.0156759	0.0028303	–0.009173	–0.0044952
4	0.0002530	0.000448	–0.0014857	–0.0000659	0.001608	–0.0021052
5	–0.0000169	–0.000054	–0.0001193	–0.0000279	0.000058	0.0000807
6	–0.0000018	0.000007	0.0000135	0.0000026	–0.000017	0.0000070
7	0.0000001	0.000000	0.0000023	0.0000003	–0.000001	0.0000006
8	0.0000002	0.000009	0.0000075	0.0000017	–0.000002	–0.0000062
9	0.0000032	0.000010	–0.0000164	–0.0000010	0.000017	–0.0000158
10	–0.0000013	–0.000002	–0.0000090	–0.0000021	0.000003	0.0000071
11	0.0000003	0.000003	0.0000102	0.0000006	–0.000011	0.0000103
Sums	37.9626786	–43.748264	58.8059846	30.3737486	–2.783514	57.9774410

*Astrometric Position, equinox and equator of J2000.0.

Days: 182–276 JD 2448073.5 – 2448168.5 Dates: July 1 – Oct. 3

A = 47.5 W = 182

Term	Neptune R.A. h	Neptune Dec. °	Neptune Distance AU	Pluto R.A.* h	Pluto Dec.* °	Pluto Distance AU
0	37.7805267	–44.025430	59.1293240	30.3306239	–3.607207	59.5556981
1	–0.0551634	–0.093773	0.5003385	0.0280685	–0.552811	0.7044461
2	0.0147799	0.016797	0.1156209	0.0187301	–0.063677	–0.0227359
3	0.0021837	0.002730	–0.0143889	–0.0003630	0.012210	–0.0192519
4	–0.0002369	–0.000277	–0.0016165	–0.0002327	0.000664	0.0003443
5	–0.0000163	0.000004	0.0001223	0.0000082	–0.000093	0.0001189
6	0.0000018	–0.000006	–0.0000032	–0.0000005	0.000010	–0.0000086
7	0.0000001	0.000000	–0.0000007	0.0000001	0.000000	–0.0000021
8	–0.0000003	–0.000007	–0.0000144	–0.0000014	0.000012	–0.0000077
9	–0.0000033	–0.000004	–0.0000001	–0.0000016	–0.000005	0.0000153
10	–0.0000007	–0.000004	0.0000172	0.0000016	–0.000013	0.0000088
11	–0.0000002	0.000007	–0.0000002	0.0000009	0.000004	–0.0000100
Sums	37.7420711	–44.099963	59.7293989	30.3768341	–4.210906	60.2186153

Days: 274–368 JD 2448165.5 – 2448260.5 Dates: Oct. 1 – Jan. 3

A = 47.5 W = 274

Term	Neptune R.A. h	Neptune Dec. °	Neptune Distance AU	Pluto R.A.* h	Pluto Dec.* °	Pluto Distance AU
0	37.8450011	–44.033230	61.5058103	30.6304757	–5.782565	60.9245481
1	0.0886378	0.096733	0.5515391	0.1112856	–0.453586	–0.0969601
2	0.0151266	0.025721	–0.1050028	–0.0008630	0.084238	–0.1478756
3	–0.0019788	–0.001337	–0.0158963	–0.0024887	0.009257	0.0019553
4	–0.0001868	–0.000332	0.0014675	–0.0000146	–0.000999	0.0020472
5	0.0000169	–0.000005	0.0001241	0.0000146	–0.000072	0.0000145
6	0.0000014	–0.000001	0.0000002	0.0000007	–0.000006	0.0000004
7	0.0000002	0.000001	–0.0000025	–0.0000003	0.000002	–0.0000003
8	0.0000002	–0.000004	0.0000099	0.0000000	–0.000009	0.0000143
9	0.0000002	–0.000006	0.0000147	0.0000024	–0.000008	–0.0000019
10	0.0000020	0.000006	–0.0000111	–0.0000001	0.000011	–0.0000157
11	–0.0000012	–0.000011	–0.0000086	–0.0000014	0.000004	0.0000013
Sums	37.9466196	–43.912465	61.9380445	30.7384109	–6.143733	60.6837275

*Astrometric Position, equinox and equator of J2000.0.

Chebyshev Series for Sidereal Time and Nutation, 1990

Days: 1–366 JD 2447892.5 – 2448258.5 Dates: Jan. 1 – Jan. 1

A = 183.0 W = 1

Term	Apparent Sid.Time h	Equation of Equinoxes s	Nutation in Longitude ″	Nutation in Obliquity ″
0	37.43472829	1.6213	26.5070	11.2471
1	12.02491879	0.0754	1.2328	–1.2868
2	0.00000373	0.0134	0.2193	–0.3469
3	–0.00000031	–0.0011	–0.0184	0.0307
4	0.00000479	0.0172	0.2817	–0.3482
5	0.00001635	0.0588	0.9621	0.0659
6	–0.00000308	–0.0111	–0.1814	0.2941
7	–0.00000598	–0.0215	–0.3518	–0.1001
8	–0.00000087	–0.0031	–0.0514	–0.0643
9	0.00000071	0.0025	0.0416	–0.0266
Sums	49.45966242	1.7518	28.6415	9.4649

Chebyshev Series for Solar Coordinates, 1990

Days: 1–366 JD 2447892.5 – 2448258.5 Dates: Jan. 1 – Jan. 1

A = 183.0 W = 1

Term	R.A. h	Dec. °	Distance AU	S.D. ′	Ephem. Tran. h
0	61.4587431	–13.460672	1.99000540	32.20493	24.0259229
1	11.8887704	–2.505273	0.00034551	–0.00560	–0.1357043
2	0.0299280	–22.470167	–0.01627003	0.26198	0.0325747
3	0.0727323	2.888544	–0.00040692	0.00651	0.0728332
4	0.0419206	6.644198	0.00497913	–0.07834	0.0433777
5	0.1039747	–0.389476	0.00005064	–0.00069	0.1031517
6	–0.0323844	–0.498213	–0.00041267	0.00539	–0.0337501
7	–0.0438820	0.067698	–0.00000681	0.00006	–0.0435936
8	0.0075637	0.071751	0.00000242	0.00025	0.0078506
9	0.0073753	–0.040589	–0.00000729	0.00013	0.0072973
10	–0.0021185	–0.035491	0.00000240	–0.00007	–0.0021903
11	–0.0017201	0.012646	–0.00000641	0.00011	–0.0016801
12	0.0010317	0.008579	0.00000278	–0.00005	0.0010707
13	0.0006592	–0.003182	–0.00000322	0.00005	0.0006387
14	–0.0004044	–0.001743	0.00000436	–0.00007	–0.0004157
15	–0.0001840	0.001196	0.00000140	–0.00002	–0.0001773
16	0.0000947	0.000403	0.00000343	–0.00006	0.0000983
17	0.0000595	–0.000365	0.00000653	–0.00011	0.0000596
18	–0.0000422	–0.000181	0.00000014	0.00000	–0.0000440
19	0.0000046	0.000120	0.00000622	–0.00010	0.0000086
20	0.0000406	0.000060	–0.00000382	0.00006	0.0000398
21	0.0000039	–0.000138	0.00000023	0.00000	0.0000039
22	0.0000200	0.000084	–0.00000387	0.00006	0.0000169
23	–0.0000170	–0.000051	–0.00000663	0.00011	–0.0000196
Sums	73.5321697	–29.710262	1.97828292	32.39453	24.0773696

Days: 1–366 JD 2447892.5 – 2448258.5 Dates: Jan. 1 – Jan. 1

A = 183.0 W = 1

Term	Mercury R.A. h	Mercury Dec. °	Mercury Distance AU	Venus R.A. h	Venus Dec. °	Venus Distance AU
0	61.4007114	–15.520541	1.9314712	60.0266328	–16.098211	2.2328225
1	12.2323981	–2.362546	0.0300156	12.6026674	–1.492990	0.7913898
2	–0.0718059	–20.214835	–0.1225795	1.7910380	–17.916585	–0.2042583
3	–0.4020675	3.014639	–0.0326237	–0.9214596	–5.070758	–0.1104423
4	0.1240792	7.519549	–0.2175022	0.4843584	8.260102	0.0503934
5	–0.5822485	–1.598363	–0.0029397	–0.0920073	4.297006	–0.0163766
6	0.0084297	2.875320	–0.0220487	0.0515535	–2.145150	0.0086782
7	–0.9427167	1.436497	–0.0212666	0.0185105	–0.292224	–0.0039953
8	–0.0963172	–1.966345	0.2446877	–0.1210886	0.190982	0.0002397
9	0.6519789	0.102418	0.0301764	0.0631247	0.003809	0.0009857
10	0.0457363	–2.562844	–0.1195047	–0.0107348	0.041952	–0.0010493
11	–0.3439905	–0.842460	–0.0132614	0.0059710	–0.100611	0.0007813
12	–0.0107308	3.309281	0.0672489	–0.0022125	0.012718	–0.0004545
13	0.2497836	0.760923	0.0035002	–0.0052567	0.028148	0.0001789
14	0.0081145	–2.481492	–0.0063501	0.0073990	–0.001318	–0.0000139
15	0.0625501	–0.525482	–0.0004861	–0.0039083	–0.003960	–0.0000559
16	0.0193249	1.100693	–0.0241764	0.0015608	–0.004757	0.0000758
17	–0.0874040	0.187242	–0.0048355	–0.0010348	0.004294	–0.0000522
18	–0.0314830	0.012725	0.0093234	0.0000578	0.000268	0.0000358
19	0.0565636	0.087180	0.0054157	0.0007453	–0.001008	–0.0000078
20	0.0253972	–0.414368	0.0023722	–0.0006824	0.000081	–0.0000021
21	–0.0170998	–0.245369	–0.0047314	0.0003715	–0.000442	0.0000066
22	–0.0194917	0.305232	–0.0106172	–0.0001652	0.000757	–0.0000116
23	–0.0401076	0.266834	0.0030757	0.0000502	–0.000313	–0.0000001
24	0.0036287	–0.040903	0.0105415	0.0000511	–0.000055	–0.0000031
25	0.0414889	–0.172818	–0.0000739	–0.0000966	0.000180	–0.0000038
26	0.0075930	–0.136707	–0.0047039	0.0000310	–0.000190	0.0000067
27	–0.0285751	0.044964	–0.0013625	0.0000020	0.000244	0.0000026
28	–0.0098909	0.177920	0.0008508	–0.0000119	–0.000213	0.0000026
29	0.0116318	0.059631	0.0012958	0.0000167	–0.000053	0.0000049
30	0.0071753	–0.119172	0.0007459	0.0000230	0.000132	–0.0000081
31	0.0035679	–0.097395	–0.0002530	–0.0000308	–0.000182	–0.0000040
32	0.0000341	0.045276	–0.0004108	0.0000150	0.000226	0.0000010
33	–0.0059984	0.071209	–0.0009308	–0.0000078	0.000106	–0.0000031
34	–0.0052528	–0.000035	–0.0005093	–0.0000304	–0.000264	0.0000086
35	0.0040366	–0.018650	0.0012851	0.0000396	0.000069	0.0000060
36	0.0063965	–0.015094	0.0008089	0.0000132	0.000046	–0.0000111
37	–0.0004267	–0.026926	–0.0009274	–0.0000302	–0.000118	–0.0000049
38	–0.0045908	0.008850	–0.0006628	–0.0000052	0.000113	0.0000081
39	–0.0024822	0.044111	0.0003155	0.0000170	0.000080	0.0000030
40	0.0012867	0.001343	0.0003488	0.0000034	–0.000138	–0.0000042
41	0.0028179	–0.034885	0.0001183	–0.0000094	–0.000048	–0.0000012
42	0.0010358	–0.007960	–0.0001279	–0.0000017	0.000098	0.0000017
43	–0.0021074	0.014585	–0.0001835	0.0000035	0.000017	0.0000004
44	–0.0016739	0.010156	0.0000779	0.0000015	–0.000045	–0.0000006
45	0.0009491	0.003151	0.0000352	–0.0000023	0.000000	–0.0000003
46	0.0010887	–0.008132	–0.0000831	–0.0000005	0.000018	0.0000002
47	–0.0000033	–0.010813	0.0001204	0.0000014	0.000007	0.0000000
Sums	72.2713338	–27.964406	1.7306790	73.8954823	–30.288180	2.7488692

Chebyshev Sereis for Mars and Jupiter, 1990

Days: 1–366 JD 2447892.5 – 2448258.5 Dates: Jan. 1 – Jan. 1

A = 183.0 W = 1

Term	Mars R.A. h	Mars Dec. °	Mars Distance AU	Jupiter R.A. h	Jupiter Dec. °	Jupiter Distance AU
0	47.7779270	3.340895	2.5970292	15.0978223	41.818303	10.1396461
1	6.0366130	27.021062	–0.9112416	1.6926094	–3.456391	0.2166010
2	–1.8326824	–3.328876	0.1571704	0.1308392	–0.761541	–0.9661567
3	–0.6208445	–5.540926	0.0791579	–0.4104462	0.776270	–0.0979240
4	–0.0987821	1.859836	0.0446482	0.0019488	0.470506	0.1873808
5	0.1019299	0.408072	0.0252040	0.0065146	0.020993	0.0010588
6	0.1459972	–0.281172	0.0007206	–0.0074204	–0.061472	0.0026596
7	0.0651585	–0.001488	–0.0046978	0.0067368	–0.005634	0.0014846
8	0.0079121	0.084924	–0.0032629	–0.0003988	–0.004469	–0.0016808
9	–0.0118108	0.072751	–0.0014228	0.0003602	–0.003138	0.0001441
10	–0.0145814	0.026113	–0.0002015	0.0001924	0.001264	–0.0001197
11	–0.0087712	–0.012021	0.0002908	–0.0001389	–0.000130	–0.0000171
12	–0.0023881	–0.020820	0.0003227	0.0000391	0.000114	0.0000176
13	0.0011521	–0.014387	0.0001693	–0.0000176	0.000095	–0.0000004
14	0.0020784	–0.005050	0.0000420	0.0000024	–0.000061	0.0000020
15	0.0014780	0.001513	–0.0000335	0.0000034	0.000001	0.0000026
16	0.0005118	0.003661	–0.0000402	0.0000063	–0.000031	–0.0000028
17	–0.0001123	0.002866	–0.0000285	–0.0000012	–0.000009	–0.0000029
18	–0.0003413	0.001152	–0.0000115	0.0000056	–0.000008	–0.0000019
19	–0.0002724	–0.000182	0.0000045	–0.0000025	0.000003	–0.0000074
20	–0.0001353	–0.000695	0.0000019	–0.0000007	0.000014	0.0000006
21	–0.0000209	–0.000612	0.0000104	–0.0000018	0.000019	–0.0000059
22	0.0000457	–0.000253	0.0000024	–0.0000064	0.000023	0.0000027
23	0.0000436	0.000017	0.0000041	0.0000018	0.000014	0.0000019
24	0.0000527	0.000185	0.0000042	–0.0000047	0.000006	0.0000020
25	0.0000315	0.000164	–0.0000041	0.0000027	–0.000001	0.0000079
26	0.0000168	0.000084	0.0000020	0.0000024	–0.000019	–0.0000016
27	0.0000117	0.000022	–0.0000061	0.0000005	–0.000011	0.0000027
28	–0.0000272	–0.000085	–0.0000053	0.0000055	–0.000014	–0.0000030
29	–0.0000284	–0.000059	0.0000018	–0.0000031	0.000002	–0.0000078
30	–0.0000311	–0.000042	–0.0000037	–0.0000030	0.000020	0.0000011
31	–0.0000260	–0.000047	0.0000060	–0.0000005	0.000010	–0.0000037
Sums	51.5501046	23.616602	1.9838329	16.5186476	38.794728	9.4830804

Chebyshev Series for Saturn and Uranus, 1990

Days: 1–366 JD 2447892.5 – 2448258.5 Dates: Jan. 1 – Jan. 1

A = 183.0 W = 1

Term	Saturn R.A. h	Saturn Dec. °	Saturn Distance AU	Uranus R.A. h	Uranus Dec. °	Uranus Distance AU
0	39.0804106	–43.258567	20.5596584	37.1160822	–47.034897	39.3895826
1	0.1491189	0.086354	–0.1351098	0.0273595	–0.001302	0.0643781
2	–0.0717034	–0.141872	0.9459206	0.0105157	0.024394	0.9680226
3	0.2562369	0.567507	0.1215185	0.1410199	0.112359	–0.0360240
4	0.0256541	0.085550	–0.2827389	–0.0037702	–0.005379	–0.2967943
5	–0.0477979	–0.119320	–0.0227983	–0.0241798	–0.018366	0.0063911
6	–0.0060520	0.003223	0.0322954	0.0005816	0.007710	0.0300125
7	0.0068934	0.022293	0.0034305	0.0025565	0.001503	–0.0007603
8	0.0014903	–0.004013	–0.0033613	–0.0000899	–0.002540	–0.0020175
9	–0.0011662	–0.004860	–0.0006460	–0.0003106	–0.000118	0.0000940
10	–0.0003518	0.000929	0.0004811	0.0000132	0.000476	0.0001815
11	0.0002093	0.001130	0.0001238	0.0000429	0.000005	–0.0000206
12	0.0000840	–0.000182	–0.0000797	–0.0000011	–0.000084	–0.0000223
13	–0.0000395	–0.000258	–0.0000323	–0.0000077	–0.000010	–0.0000020
14	–0.0000205	0.000013	0.0000167	–0.0000010	0.000007	0.0000079
15	0.0000068	0.000077	0.0000051	0.0000005	0.000010	–0.0000007
16	0.0000031	–0.000013	0.0000003	–0.0000007	–0.000005	0.0000036
17	–0.0000005	–0.000012	0.0000038	–0.0000002	–0.000002	0.0000047
Sums	39.3929756	–42.762021	21.2186879	37.2698108	–46.916239	40.1230369

Chebyshev Series for Neptune and Pluto, 1990

Days: 1–366 JD 2447892.5 – 2448258.5 Dates: Jan. 1 – Jan. 1

A = 183.0 W = 1

Term	Neptune R.A. h	Neptune Dec. °	Neptune Distance AU	Pluto R.A.* h	Pluto Dec.* °	Pluto Distance AU
0	37.8922864	–43.911172	60.9797745	30.5569856	–4.531730	59.6556281
1	0.0001572	–0.027833	–0.0283872	0.0294342	–0.534758	0.4579032
2	–0.0056564	–0.035745	0.9705361	0.0915360	–0.695370	0.5552613
3	0.0899870	0.122219	0.0278269	0.0532689	0.065470	–0.5158500
4	0.0018478	0.011453	–0.2989683	–0.0291005	0.214756	–0.1645001
5	–0.0147014	–0.020458	–0.0043301	–0.0073824	–0.017887	0.0803794
6	–0.0002688	0.001399	0.0284135	0.0033332	–0.020205	0.0120009
7	0.0012460	0.001895	0.0002827	0.0001492	0.003695	–0.0054714
8	0.0000390	–0.000756	–0.0013940	–0.0002897	0.000808	0.0003032
9	–0.0001061	–0.000192	–0.0000190	0.0000604	–0.000596	0.0002360
10	–0.0000013	0.000143	0.0000671	0.0000239	0.000028	–0.0001277
11	0.0000116	0.000037	–0.0000007	–0.0000113	0.000072	–0.0000078
Sums	37.9648410	–43.859010	61.6738015	30.6980075	–5.515717	60.0757551

*Astrometric Position, equinox and equator of J2000.0.

Section E: STELLAR TABLES

Index of Standard Navigation Stars

	Nav. No.	A/C ID
Acamar	7	18
Achernar	5	11
Acrux	30	86
Adhara	19	50
Aldebaran	10	26
Alioth	32	94
Alkaid	34	101
Al Na'ir	55	170
Alnilam	15	37
Alphard	25	71
Alphecca	41	120
Alpheratz	1	1
Altair	51	160
Ankaa	2	5
Antares	42	128
Arcturus	37	106
Atria	43	133
Avior	22	64
Bellatrix	13	31
Betelgeuse	16	42
Canopus	17	46
Capella	12	30
Deneb	53	164
Denebola	28	82
Diphda	4	7
Dubhe	27	79
Elnath	14	32
Eltanin	47	147
Enif	54	168
Fomalhaut	56	173
Gacrux	31	88
Gienah	29	85
Hadar	35	104
Hamal	6	15
Kaus Australis	48	150
Kochab	40	114
Markab	57	175
Menkar	8	19
Menkent	36	105
Miaplacidus	24	68
Mirfak	9	21
Nunki	50	153
Peacock	52	162
Pollux	21	60
Procyon	20	59
Rasalhague	46	143
Regulus	26	74
Rigel	11	29
Rigil Kentaurus	38	109
Sabik	44	136
Schedar	3	6
Shaula	45	142
Sirius	18	48
Spica	33	99
Suhail	23	67
Vega	49	152
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Polaris	—	17

Days: 1 – 365 JD 2447892.5 – 2448257.5 Dates: Jan. 1 – Dec. 31

A = 365.0 W = 183.5

A/C ID	Nav. No.	Name	Magnitude & Spec.		Mean Place (J1990.5)	*H*	*R*	*S*	*C*	Sum
					°	°	°	°	°	°
1	1	α And	2.06	SHA	358.0262	–0.0026	–0.0142	–0.0059	–0.0008	358.0027
		Alpheratz	B9	Dec.	29.0380	0.0015	0.0059	0.0023	–0.0024	29.0453
2		β Cas	2.27	SHA	357.8332	–0.0008	–0.0152	–0.0101	–0.0013	357.8058
		Caph	F2	Dec.	59.0974	0.0015	0.0059	0.0018	–0.0046	59.1020
3		γ Peg	2.83	SHA	356.8135	–0.0030	–0.0140	–0.0054	–0.0006	356.7905
		Algenib	B2	Dec.	15.1308	0.0016	0.0059	0.0023	–0.0011	15.1395
4		β Hyi	2.80	SHA	353.6833	–0.0098	–0.0079	–0.0238	–0.0012	353.6406
			G1	Dec.	–77.3077	0.0016	0.0059	0.0001	0.0056	–77.2945
5	2	α Phe	2.39	SHA	353.5459	–0.0047	–0.0125	–0.0071	–0.0003	353.5213
		Ankaa	K0	Dec.	–42.3576	0.0017	0.0059	0.0014	0.0041	–42.3445
6	3	α Cas	2.23	SHA	350.0090	–0.0014	–0.0163	–0.0095	0.0002	349.9820
		Schedar	K0	Dec.	56.4854	0.0017	0.0058	0.0013	–0.0045	56.4897
7	4	β Cet	2.04	SHA	349.2217	–0.0038	–0.0132	–0.0055	0.0002	349.1994
		Diphda	K1	Dec.	–18.0387	0.0018	0.0057	0.0021	0.0021	–18.0270
8		γ Cas	2.47	SHA	345.9677	–0.0013	–0.0175	–0.0107	0.0010	345.9392
			B0	Dec.	60.6654	0.0018	0.0056	0.0008	–0.0047	60.6689
9		β And	2.06	SHA	342.7005	–0.0026	–0.0155	–0.0064	0.0010	342.6770
		Mirach	M0	Dec.	35.5703	0.0019	0.0055	0.0015	–0.0030	35.5762
10		δ Cas	2.68	SHA	338.7029	–0.0017	–0.0186	–0.0104	0.0024	338.6746
		Ruchbah	A5	Dec.	60.1862	0.0020	0.0053	0.0003	–0.0046	60.1892
11	5	α Eri	0.46	SHA	335.6593	–0.0047	–0.0090	–0.0094	0.0028	335.6390
		Achernar	B3	Dec.	–57.2848	0.0020	0.0052	0.0023	0.0048	–57.2705
12		β Ari	2.64	SHA	331.4716	–0.0031	–0.0150	–0.0053	0.0020	331.4502
		Sheratan	A5	Dec.	20.7618	0.0021	0.0049	0.0015	–0.0015	20.7688
13		α Hyi	2.86	SHA	330.3820	–0.0046	–0.0072	–0.0104	0.0042	330.3640
			F0	Dec.	–61.6159	0.0021	0.0049	0.0026	0.0049	–61.6014
14		γ^1 And	2.26	SHA	329.1717	–0.0029	–0.0170	–0.0066	0.0029	329.1481
		Almak	K3	Dec.	42.2845	0.0021	0.0048	0.0004	–0.0033	42.2885
15	6	α Ari	2.00	SHA	328.3410	–0.0032	–0.0153	–0.0053	0.0024	328.3196
		Hamal	K2	Dec.	23.4178	0.0021	0.0047	0.0013	–0.0017	23.4242
16		β Tri	3.00	SHA	327.7561	–0.0030	–0.0164	–0.0059	0.0027	327.7335
			A5	Dec.	34.9427	0.0021	0.0047	0.0007	–0.0027	34.9475
17		α UMi	2.02	SHA	324.5649	0.0295	–0.3088	–0.3500	0.1863	324.1219
		Polaris	F8	Dec.	89.2217	0.0021	0.0045	–0.0022	–0.0051	89.2210
18	7	θ Eri	2.91	SHA	315.5248	–0.0035	–0.0098	–0.0057	0.0043	315.5101
		Acamar	A5	Dec.	–40.3425	0.0022	0.0038	0.0036	0.0033	–40.3296
19	8	α Cet	2.53	SHA	314.5545	–0.0034	–0.0141	–0.0043	0.0034	314.5361
		Menkar	M1	Dec.	4.0529	0.0022	0.0037	0.0020	0.0001	4.0609
20		β Per	2.12	SHA	313.1131	–0.0034	–0.0179	–0.0056	0.0046	313.0908
		Algol	B8	Dec.	40.9196	0.0022	0.0036	–0.0003	–0.0026	40.9225

Days: 1 – 365 JD 2447892.5 – 2448257.5 Dates: Jan. 1 – Dec. 31

A = 365.0 W = 183.5

A/C ID	Nav. No.	Name	Magnitude & Spec.		Mean Place (J1990.5)	*H*	*R*	*S*	*C*	Sum
					°	°	°	°	°	°
21	9	α Per	1.80	SHA	309.0898	–0.0036	–0.0197	–0.0062	0.0059	309.0662
		Mirfak	F5	Dec.	49.8280	0.0022	0.0032	–0.0011	–0.0030	49.8293
22		η Tau	2.87	SHA	303.2704	–0.0036	–0.0161	–0.0040	0.0046	303.2513
		Alcyone	B7	Dec.	24.0763	0.0022	0.0027	0.0005	–0.0012	24.0805
23		ζ Per	2.85	SHA	301.6168	–0.0037	–0.0171	–0.0041	0.0051	301.5970
			B1	Dec.	31.8560	0.0021	0.0026	–0.0002	–0.0016	31.8589
24		ε Per	2.89	SHA	300.6966	–0.0038	–0.0183	–0.0045	0.0057	300.6757
			B0	Dec.	39.9833	0.0021	0.0025	–0.0008	–0.0020	39.9851
25		γ Eri	2.95	SHA	300.6036	–0.0033	–0.0124	–0.0036	0.0045	300.5888
			M1	Dec.	–13.5351	0.0021	0.0025	0.0031	0.0012	–13.5262
26	10	α Tau	0.85	SHA	291.1563	–0.0037	–0.0155	–0.0029	0.0051	291.1393
		Aldebaran	K5	Dec.	16.4907	0.0020	0.0015	0.0009	–0.0004	16.4947
27		ι Aur	2.69	SHA	285.9066	–0.0041	–0.0176	–0.0028	0.0062	285.8883
			K3	Dec.	33.1517	0.0019	0.0010	–0.0007	–0.0010	33.1529
28		β Eri	2.79	SHA	283.1546	–0.0033	–0.0132	–0.0021	0.0053	283.1413
			A3	Dec.	–5.0982	0.0019	0.0007	0.0026	0.0006	–5.0924
29	11	β Ori	0.12	SHA	281.4798	–0.0033	–0.0129	–0.0020	0.0054	281.4670
		Rigel	B8	Dec.	–8.2122	0.0019	0.0005	0.0029	0.0007	–8.2062
30	12	α Aur	0.08	SHA	281.0035	–0.0046	–0.0199	–0.0028	0.0077	280.9839
		Capella	G8	Dec.	45.9892	0.0019	0.0005	–0.0020	–0.0011	45.9885
31	13	γ Ori	1.64	SHA	278.8448	–0.0036	–0.0144	–0.0018	0.0054	278.8304
		Bellatrix	B2	Dec.	6.3416	0.0018	0.0003	0.0017	0.0002	6.3456
32	14	β Tau	1.65	SHA	278.5773	–0.0041	–0.0170	–0.0020	0.0062	278.5604
		Elnath	B7	Dec.	28.6000	0.0018	0.0002	–0.0004	–0.0005	28.6011
33		β Lep	2.84	SHA	278.0405	–0.0029	–0.0115	–0.0018	0.0058	278.0301
			G5	Dec.	–20.7667	0.0018	0.0002	0.0038	0.0009	–20.7600
34		δ Ori	2.23	SHA	277.1198	–0.0034	–0.0137	–0.0016	0.0055	277.1066
			O9	Dec.	–0.3056	0.0018	0.0001	0.0023	0.0004	–0.3010
35		α Lep	2.58	SHA	276.9224	–0.0030	–0.0118	–0.0017	0.0057	276.9116
			F0	Dec.	–17.8286	0.0018	0.0001	0.0037	0.0008	–17.8222
36		ι Ori	2.76	SHA	276.2581	–0.0033	–0.0131	–0.0015	0.0055	276.2457
			O9	Dec.	–5.9156	0.0018	0.0000	0.0027	0.0005	–5.9106
37	15	ε Ori	1.70	SHA	276.0673	–0.0034	–0.0136	–0.0015	0.0055	276.0543
		Alnilam	B0	Dec.	–1.2075	0.0017	0.0000	0.0023	0.0004	–1.2031
38		ζ Tau	3.00	SHA	275.7309	–0.0039	–0.0161	–0.0016	0.0059	275.7152
			B1	Dec.	21.1373	0.0017	–0.0001	0.0003	–0.0002	21.1390
39		α Col	2.64	SHA	275.1738	–0.0025	–0.0097	–0.0017	0.0066	275.1665
		Phact	B7	Dec.	–34.0789	0.0017	–0.0001	0.0047	0.0011	–34.0715
40		ζ Ori	1.77	SHA	274.9303	–0.0034	–0.0135	–0.0014	0.0055	274.9175
		Alnitak	O9	Dec.	–1.9471	0.0017	–0.0002	0.0024	0.0004	–1.9428

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41		κ Ori	2.06	SHA	273.1737	–0.0032	–0.0127	–0.0013	0.0056	273.1621
			B0	Dec.	–9.6726	0.0017	–0.0003	0.0031	0.0006	–9.6675
42	16	α Ori	0.50	SHA	271.3357	–0.0036	–0.0145	–0.0011	0.0056	271.3221
		Betelgeuse	M2	Dec.	7.4059	0.0016	–0.0005	0.0016	0.0003	7.4089
43		β Aur	1.90	SHA	270.2921	–0.0049	–0.0197	–0.0014	0.0079	270.2740
		Menkalinan	A2	Dec.	44.9472	0.0016	–0.0006	–0.0021	–0.0004	44.9457
44		θ Aur	2.62	SHA	270.2316	–0.0045	–0.0183	–0.0012	0.0070	270.2146
			B9	Dec.	37.2125	0.0016	–0.0006	–0.0013	–0.0002	37.2120
45		β CMa	1.98	SHA	264.4298	–0.0029	–0.0118	–0.0005	0.0060	264.4206
		Mirzam	B1	Dec.	–17.9508	0.0015	–0.0012	0.0037	0.0005	–17.9463
46	17	α Car	–0.72	SHA	264.0645	–0.0013	–0.0060	–0.0007	0.0094	264.0659
		Canopus	F0	Dec.	–52.6902	0.0014	–0.0013	0.0055	0.0005	–52.6841
47		γ Gem	1.93	SHA	260.7092	–0.0039	–0.0154	–0.0001	0.0059	260.6957
		Alhena	A0	Dec.	16.4080	0.0013	–0.0016	0.0007	0.0004	16.4088
48	18	α CMa A	–1.46	SHA	258.8175	–0.0029	–0.0120	0.0001	0.0059	258.8086
		Sirius	A1	Dec.	–16.7027	0.0013	–0.0018	0.0036	0.0003	–16.6993
49		τ Pup	2.93	SHA	257.5749	–0.0012	–0.0068	0.0003	0.0089	257.5761
			K1	Dec.	–50.6032	0.0012	–0.0019	0.0055	0.0000	–50.5984
50	19	ε CMa	1.50	SHA	255.4369	–0.0024	–0.0106	0.0004	0.0065	255.4308
		Adhara	B2	Dec.	–28.9588	0.0012	–0.0022	0.0045	0.0001	–28.9552
51		o^2 CMa	3.03	SHA	254.3431	–0.0026	–0.0113	0.0005	0.0062	254.3359
			B3	Dec.	–23.8191	0.0011	–0.0023	0.0041	0.0001	–23.8161
52		δ CMa	1.86	SHA	252.9988	–0.0025	–0.0110	0.0006	0.0063	252.9922
		Wezen	F8	Dec.	–26.3777	0.0011	–0.0024	0.0043	0.0000	–26.3747
53		π Pup	2.70	SHA	250.7982	–0.0020	–0.0096	0.0010	0.0070	250.7946
			K4	Dec.	–37.0801	0.0010	–0.0026	0.0049	–0.0003	–37.0771
54		η CMa	2.44	SHA	249.0703	–0.0023	–0.0107	0.0011	0.0064	249.0648
			B5	Dec.	–29.2842	0.0010	–0.0028	0.0045	–0.0002	–29.2817
55		β CMi	2.90	SHA	248.3411	–0.0037	–0.0145	0.0010	0.0056	248.3295
			B7	Dec.	8.3090	0.0009	–0.0028	0.0015	0.0006	8.3092
56		σ Pup	3.25	SHA	247.7677	–0.0016	–0.0088	0.0014	0.0076	247.7663
			K5	Dec.	–43.2819	0.0009	–0.0029	0.0051	–0.0006	–43.2794
57		α Gem A	2.85	SHA	246.5019	–0.0047	–0.0170	0.0014	0.0065	246.4881
		Castor	A5	Dec.	31.9098	0.0009	–0.0030	–0.0008	0.0011	31.9080
58		α Gem B	1.99	SHA	246.5009	–0.0047	–0.0170	0.0014	0.0065	246.4871
			A1	Dec.	31.9100	0.0009	–0.0030	–0.0008	0.0011	31.9082
59	20	α CMi A	0.38	SHA	245.2988	–0.0036	–0.0142	0.0013	0.0055	245.2878
		Procyon	F5	Dec.	5.2499	0.0008	–0.0031	0.0018	0.0005	5.2499
60	21	β Gem	1.14	SHA	243.8162	–0.0045	–0.0164	0.0016	0.0061	243.8030
		Pollux	K0	Dec.	28.0497	0.0008	–0.0032	–0.0004	0.0011	28.0480

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61		ζ Pup	2.25	SHA	239.1874	–0.0017	–0.0097	0.0024	0.0069	239.1853
			O5	Dec.	–39.9761	0.0006	–0.0036	0.0049	–0.0011	–39.9753
62		ρ Pup	2.81	SHA	238.2152	–0.0025	–0.0116	0.0021	0.0057	238.2089
			F5	Dec.	–24.2765	0.0006	–0.0037	0.0040	–0.0006	–24.2762
63		γ^2 Vel	1.78	SHA	237.6900	–0.0011	–0.0087	0.0029	0.0077	237.6908
			WC	Dec.	–47.3084	0.0006	–0.0038	0.0051	–0.0014	–47.3079
64	22	ε Car	1.86	SHA	234.4199	0.0002	–0.0062	0.0043	0.0100	234.4282
		Avior	K3	Dec.	–59.4788	0.0004	–0.0040	0.0052	–0.0020	–59.4792
65		δ Vel	1.96	SHA	228.8895	–0.0004	–0.0080	0.0046	0.0083	228.8940
			A0	Dec.	–54.6733	0.0002	–0.0044	0.0050	–0.0022	–54.6747
66		ι UMa	3.14	SHA	225.3599	–0.0058	–0.0179	0.0044	0.0069	225.3475
			A7	Dec.	48.0794	0.0001	–0.0047	–0.0017	0.0027	48.0758
67	23	λ Vel	2.21	SHA	223.0884	–0.0014	–0.0103	0.0043	0.0062	223.0872
		Suhail	K4	Dec.	–43.3939	0.0000	–0.0048	0.0045	–0.0021	–43.3963
68	24	β Car	1.68	SHA	221.7247	0.0025	–0.0044	0.0092	0.0127	221.7447
		Miaplacidus	A1	Dec.	–69.6780	0.0000	–0.0049	0.0047	–0.0032	–69.6814
69		ι Car	2.25	SHA	220.7909	0.0002	–0.0080	0.0064	0.0085	220.7980
			A9	Dec.	–59.2353	–0.0001	–0.0050	0.0047	–0.0030	–59.2387
70		κ Vel	2.50	SHA	219.5451	–0.0003	–0.0091	0.0058	0.0074	219.5489
			B2	Dec.	–54.9699	–0.0001	–0.0050	0.0046	–0.0029	–54.9733
71	25	α Hya	1.98	SHA	218.2199	–0.0031	–0.0133	0.0035	0.0042	218.2112
		Alphard	K3	Dec.	–8.6172	–0.0002	–0.0051	0.0028	–0.0002	–8.6199
72		N Vel	3.13	SHA	217.2668	–0.0001	–0.0090	0.0064	0.0075	217.2716
			K5	Dec.	–56.9923	–0.0002	–0.0052	0.0045	–0.0031	–56.9963
73		ε Leo	2.98	SHA	213.6717	–0.0044	–0.0150	0.0041	0.0042	213.6606
			G1	Dec.	23.8183	–0.0003	–0.0053	0.0006	0.0020	23.8153
74	26	α Leo	1.35	SHA	208.0333	–0.0039	–0.0142	0.0042	0.0035	208.0229
		Regulus	B7	Dec.	12.0139	–0.0006	–0.0056	0.0015	0.0013	12.0105
75		γ^1 Leo	1.99	SHA	205.1375	–0.0042	–0.0144	0.0045	0.0034	205.1268
		Algeiba	K0	Dec.	19.8899	–0.0007	–0.0057	0.0011	0.0020	19.8866
76		θ Car	2.76	SHA	199.3460	0.0008	–0.0109	0.0105	0.0062	199.3526
			B0	Dec.	–64.3445	–0.0009	–0.0059	0.0033	–0.0043	–64.3523
77		μ VeL	2.69	SHA	198.4101	–0.0011	–0.0123	0.0070	0.0040	198.4077
			G5	Dec.	–49.3697	–0.0009	–0.0059	0.0034	–0.0036	–49.3767
78		β UMa	2.37	SHA	194.6819	–0.0063	–0.0150	0.0086	0.0041	194.6733
		Merak	A1	Dec.	56.4335	–0.0010	–0.0059	–0.0006	0.0045	56.4305
79	27	α UMa	1.79	SHA	194.2131	–0.0070	–0.0153	0.0101	0.0047	194.2056
		Dubhe	K0	Dec.	61.8024	–0.0010	–0.0060	–0.0009	0.0048	61.7993
80		ψ UMa	3.01	SHA	192.7171	–0.0053	–0.0144	0.0067	0.0029	192.7070
			K1	Dec.	44.5502	–0.0011	–0.0060	0.0001	0.0040	44.5472

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81		δ Leo	2.56	SHA	191.5990	–0.0041	–0.0139	0.0052	0.0021	191.5883
			A4	Dec.	20.5758	–0.0011	–0.0060	0.0014	0.0022	20.5723
82	28	β Leo	2.14	SHA	182.8561	–0.0039	–0.0136	0.0053	0.0012	182.8451
		Denebola	A3	Dec.	14.6252	–0.0014	–0.0060	0.0019	0.0018	14.6215
83		γ UMa	2.44	SHA	181.6665	–0.0057	–0.0131	0.0087	0.0018	181.6582
		Phecda	A0	Dec.	53.7476	–0.0014	–0.0060	0.0004	0.0047	53.7453
84		δ Cen	2.60	SHA	178.0341	–0.0015	–0.0148	0.0082	0.0011	178.0271
			B2	Dec.	–50.6695	–0.0015	–0.0059	0.0020	–0.0041	–50.6790
85	29	γ Crv	2.59	SHA	176.1709	–0.0029	–0.0141	0.0055	0.0005	176.1599
		Gienah	B8	Dec.	–17.4892	–0.0016	–0.0059	0.0023	–0.0013	–17.4957
86	30	α Cru A	1.58	SHA	173.4835	–0.0006	–0.0164	0.0115	0.0005	173.4785
		Acrux	B0	Dec.	–63.0465	–0.0017	–0.0059	0.0013	–0.0049	–63.0577
87		α Cru B	2.09	SHA	173.4810	–0.0006	–0.0164	0.0115	0.0005	173.4760
			B1	Dec.	–63.0459	–0.0017	–0.0059	0.0013	–0.0049	–63.0571
88	31	γ Cru	1.63	SHA	172.3413	–0.0013	–0.0160	0.0096	0.0002	172.3338
		Gacrux	M4	Dec.	–57.0601	–0.0017	–0.0058	0.0014	–0.0046	–57.0708
89		β Crv	2.65	SHA	171.5283	–0.0028	–0.0144	0.0057	0.0001	171.5169
			G5	Dec.	–23.3443	–0.0017	–0.0058	0.0021	–0.0019	–23.3516
90		α Mus	2.69	SHA	170.8475	0.0001	–0.0180	0.0147	0.0000	170.8443
			B2	Dec.	–69.0833	–0.0017	–0.0058	0.0009	–0.0052	–69.0951
91		γ Cen	2.17	SHA	169.7526	–0.0019	–0.0157	0.0080	–0.0002	169.7428
		Muhlifain	A0	Dec.	–48.9076	–0.0017	–0.0058	0.0015	–0.0040	–48.9176
92		γ Vir	2.75	SHA	169.7055	–0.0034	–0.0138	0.0052	–0.0001	169.6934
			F0	Dec.	–1.3974	–0.0017	–0.0058	0.0022	0.0002	–1.4025
93		β Cru	1.25	SHA	168.2096	–0.0013	–0.0169	0.0104	–0.0006	168.2012
		Mimosa	B0	Dec.	–59.6369	–0.0018	–0.0057	0.0010	–0.0047	–59.6481
94	32	ε UMa	1.77	SHA	166.5967	–0.0052	–0.0107	0.0094	–0.0008	166.5894
		Alioth	A0	Dec.	56.0113	–0.0018	–0.0057	0.0015	0.0049	56.0102
95		α^2 CVn	2.90	SHA	166.1039	–0.0044	–0.0121	0.0067	–0.0006	166.0935
		Cor Caroli	B9	Dec.	38.3696	–0.0018	–0.0056	0.0019	0.0038	38.3679
96		ε Vir	2.83	SHA	164.5741	–0.0036	–0.0133	0.0053	–0.0006	164.5619
			G8	Dec.	11.0101	–0.0019	–0.0056	0.0023	0.0015	11.0064
97		ι Cen	2.75	SHA	159.9848	–0.0027	–0.0157	0.0064	–0.0014	159.9714
			A2	Dec.	–36.6624	–0.0019	–0.0054	0.0013	–0.0030	–36.6714
98		ζ UMa	2.05	SHA	159.1139	–0.0048	–0.0098	0.0090	–0.0020	159.1063
		Mizar	A2	Dec.	54.9748	–0.0020	–0.0053	0.0020	0.0048	54.9743
99	33	α Vir	0.97	SHA	158.8271	–0.0032	–0.0143	0.0052	–0.0012	158.8136
		Spica	B1	Dec.	–11.1119	–0.0020	–0.0053	0.0020	–0.0007	–11.1179
100		ε Cen	2.30	SHA	155.1796	–0.0023	–0.0179	0.0085	–0.0026	155.1653
			B1	Dec.	–53.4183	–0.0020	–0.0051	0.0003	–0.0042	–53.4293

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101	34	η UMa	1.86	SHA	153.2083	–0.0043	–0.0099	0.0077	–0.0027	153.1991
		Alkaid	B3	Dec.	49.3606	–0.0020	–0.0050	0.0026	0.0044	49.3606
102		η Boo	2.68	SHA	151.4419	–0.0036	–0.0126	0.0053	–0.0020	151.4290
			G0	Dec.	18.4451	–0.0021	–0.0049	0.0026	0.0021	18.4428
103		ζ Cen	2.55	SHA	151.2642	–0.0027	–0.0175	0.0073	–0.0028	151.2485
			B2	Dec.	–47.2419	–0.0021	–0.0049	0.0003	–0.0037	–47.2523
104	35	β Cen	0.61	SHA	149.2130	–0.0023	–0.0201	0.0099	–0.0043	149.1962
		Hadar	B1	Dec.	–60.3275	–0.0021	–0.0048	–0.0005	–0.0044	–60.3393
105	36	θ Cen	2.06	SHA	148.4698	–0.0030	–0.0165	0.0061	–0.0027	148.4537
		Menkent	K0	Dec.	–36.3236	–0.0021	–0.0047	0.0007	–0.0028	–36.3325
106	37	α Boo	–0.04	SHA	146.1930	–0.0036	–0.0124	0.0051	–0.0025	146.1796
		Arcturus	K2	Dec.	19.2316	–0.0021	–0.0046	0.0028	0.0021	19.2298
107		γ Boo	3.03	SHA	142.0761	–0.0037	–0.0104	0.0059	–0.0035	142.0644
			A7	Dec.	38.3495	–0.0022	–0.0043	0.0032	0.0034	38.3496
108		η Cen	2.31	SHA	141.2748	–0.0031	–0.0176	0.0062	–0.0038	141.2565
			B1	Dec.	–42.1165	–0.0022	–0.0042	0.0000	–0.0030	–42.1259
109	38	α Cen A	0.33	SHA	140.2591	–0.0029	–0.0215	0.0094	–0.0060	140.2381
		Rigil Kent.	G2	Dec.	–60.7946	–0.0022	–0.0042	–0.0011	–0.0041	–60.8062
110		α Cen B	1.70	SHA	140.2655	–0.0029	–0.0215	0.0094	–0.0060	140.2445
			K1	Dec.	–60.7991	–0.0022	–0.0042	–0.0011	–0.0041	–60.8107
111		α Lup	2.30	SHA	139.6764	–0.0031	–0.0185	0.0067	–0.0044	139.6571
			B1	Dec.	–47.3478	–0.0022	–0.0041	–0.0004	–0.0033	–47.3578
112		ε Boo	2.40	SHA	138.8569	–0.0035	–0.0115	0.0051	–0.0034	138.8436
			K0	Dec.	27.1140	–0.0022	–0.0041	0.0032	0.0025	27.1134
113	39	α^2 Lib	2.75	SHA	137.4121	–0.0034	–0.0150	0.0046	–0.0033	137.3950
		Zubenelgenubi	A2	Dec.	–16.0027	–0.0022	–0.0039	0.0014	–0.0009	–16.0083
114	40	β UMi	2.08	SHA	137.3185	–0.0040	0.0023	0.0163	–0.0116	137.3215
		Kochab	K4	Dec.	74.1944	–0.0022	–0.0039	0.0033	0.0047	74.1963
115		β Lup	2.68	SHA	135.5234	–0.0033	–0.0181	0.0060	–0.0045	135.5035
			B2	Dec.	–43.0962	–0.0022	–0.0038	–0.0004	–0.0029	–43.1055
116		β Lib	2.61	SHA	130.8763	–0.0034	–0.0146	0.0042	–0.0037	130.8588
			B8	Dec.	–9.3483	–0.0022	–0.0034	0.0017	–0.0003	–9.3525
117		γ TrA	2.89	SHA	130.4966	–0.0036	–0.0265	0.0112	–0.0101	130.4676
			A0	Dec.	–68.6451	–0.0022	–0.0034	–0.0022	–0.0039	–68.6568
118		γ UMi	3.05	SHA	129.8156	–0.0031	0.0016	0.0130	–0.0120	129.8151
			A3	Dec.	71.8679	–0.0022	–0.0033	0.0039	0.0042	71.8705
119		γ Lup	2.78	SHA	126.3737	–0.0036	–0.0183	0.0051	–0.0053	126.3516
			B2	Dec.	–41.1354	–0.0022	–0.0030	–0.0007	–0.0024	–41.1437
120	41	α CrB	2.23	SHA	126.4286	–0.0033	–0.0111	0.0043	–0.0045	126.4140
		Alphecca	A0	Dec.	26.7463	–0.0022	–0.0030	0.0036	0.0022	26.7469

Days: 1 – 365 JD 2447892.5 – 2448257.5 Dates: Jan. 1 – Dec. 31

A = 365.0 W = 183.5

A/C ID	Nav. No.	Name	Magnitude & Spec.		Mean Place (J1990.5)	*H*	*R*	*S*	*C*	Sum
					°	°	°	°	°	°
121		α Ser	2.65	SHA	124.0501	–0.0034	–0.0131	0.0037	–0.0042	124.0331
			K2	Dec.	6.4551	–0.0022	–0.0028	0.0026	0.0008	6.4535
122		β TrA	2.85	SHA	121.4251	–0.0043	–0.0246	0.0078	–0.0097	121.3943
			F2	Dec.	–63.4021	–0.0021	–0.0025	–0.0025	–0.0031	–63.4123
123		π Sco	2.89	SHA	120.4310	–0.0036	–0.0164	0.0038	–0.0049	120.4099
			B1	Dec.	–26.0873	–0.0021	–0.0024	0.0003	–0.0012	–26.0927
124		δ Sco	2.32	SHA	120.0574	–0.0036	–0.0160	0.0037	–0.0048	120.0367
		Dschubba	B0	Dec.	–22.5952	–0.0021	–0.0024	0.0005	–0.0010	–22.6002
125		β^1 Sco	2.62	SHA	118.7791	–0.0036	–0.0157	0.0035	–0.0048	118.7585
			B0	Dec.	–19.7799	–0.0021	–0.0023	0.0007	–0.0008	–19.7844
126		δ Oph	2.74	SHA	116.5382	–0.0035	–0.0141	0.0032	–0.0046	116.5192
			M0	Dec.	–3.6704	–0.0021	–0.0021	0.0020	0.0002	–3.6724
127		η Dra	2.74	SHA	114.0348	–0.0021	–0.0032	0.0063	–0.0100	114.0258
			G8	Dec.	61.5356	–0.0021	–0.0018	0.0049	0.0029	61.5395
128	42	α Sco A	0.96	SHA	112.7940	–0.0038	–0.0166	0.0032	–0.0054	112.7714
		Antares	M1	Dec.	–26.4115	–0.0021	–0.0017	0.0001	–0.0010	–26.4162
129		β Her	2.77	SHA	112.5472	–0.0031	–0.0115	0.0031	–0.0052	112.5305
			G8	Dec.	21.5099	–0.0020	–0.0017	0.0037	0.0014	21.5113
130		τ Sco	2.82	SHA	111.1775	–0.0038	–0.0169	0.0031	–0.0056	111.1543
			B0	Dec.	–28.1969	–0.0020	–0.0015	–0.0001	–0.0010	–28.2015
131		ζ Oph	2.56	SHA	110.8412	–0.0036	–0.0148	0.0028	–0.0050	110.8206
			O9	Dec.	–10.5484	–0.0020	–0.0015	0.0014	–0.0001	–10.5506
132		ζ Her	2.81	SHA	109.7679	–0.0029	–0.0101	0.0031	–0.0058	109.7522
			G1	Dec.	31.6197	–0.0020	–0.0014	0.0043	0.0018	31.6224
133	43	α TrA	1.92	SHA	108.0863	–0.0058	–0.0291	0.0070	–0.0141	108.0443
		Atria	K2	Dec.	–69.0113	–0.0020	–0.0012	–0.0035	–0.0023	–69.0203
134		ε Sco	2.29	SHA	107.6132	–0.0040	–0.0178	0.0030	–0.0061	107.5883
			K2	Dec.	–34.2767	–0.0020	–0.0012	–0.0008	–0.0011	–34.2818
135		ζ Ara	3.13	SHA	105.5420	–0.0049	–0.0225	0.0041	–0.0092	105.5095
			K3	Dec.	–55.9759	–0.0019	–0.0010	–0.0026	–0.0017	–55.9831
136	44	η Oph	2.43	SHA	102.5418	–0.0037	–0.0154	0.0021	–0.0055	102.5193
		Sabik	A2	Dec.	–15.7137	–0.0019	–0.0006	0.0008	–0.0002	–15.7156
137		α Her	3.08	SHA	101.4464	–0.0031	–0.0122	0.0020	–0.0055	101.4276
			M5	Dec.	14.4007	–0.0019	–0.0005	0.0034	0.0009	14.4026
138		β Ara	2.85	SHA	98.8727	–0.0052	–0.0225	0.0031	–0.0096	98.8385
			K3	Dec.	–55.5217	–0.0018	–0.0003	–0.0028	–0.0012	–55.5278
139		υ Sco	2.69	SHA	97.4707	–0.0044	–0.0183	0.0020	–0.0068	97.4432
			B2	Dec.	–37.2890	–0.0018	–0.0001	–0.0012	–0.0007	–37.2928
140		β Dra	2.79	SHA	97.4457	–0.0018	–0.0060	0.0027	–0.0089	97.4317
			G2	Dec.	52.3082	–0.0018	–0.0001	0.0053	0.0015	52.3131

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					°	°	°	°	°	°
141		α Ara	2.95	SHA	97.2232	–0.0049	–0.0209	0.0025	–0.0085	97.1914
			B2	Dec.	–49.8695	–0.0018	–0.0001	–0.0024	–0.0010	–49.8748
142	45	λ Sco	1.63	SHA	96.7592	–0.0044	–0.0183	0.0020	–0.0069	96.7316
		Shaula	B1	Dec.	–37.0976	–0.0018	0.0000	–0.0012	–0.0006	–37.1012
143	46	α Oph	2.08	SHA	96.3767	–0.0031	–0.0124	0.0016	–0.0056	96.3572
		Rasalhague	A5	Dec.	12.5665	–0.0018	0.0000	0.0033	0.0007	12.5687
144		θ Sco	1.87	SHA	95.8411	–0.0046	–0.0193	0.0020	–0.0075	95.8117
			F0	Dec.	–42.9925	–0.0017	0.0001	–0.0018	–0.0007	–42.9966
145		κ Sco	2.41	SHA	94.5425	–0.0045	–0.0186	0.0018	–0.0071	94.5141
			B1	Dec.	–39.0259	–0.0017	0.0002	–0.0014	–0.0005	–39.0293
146		β Oph	2.77	SHA	94.2492	–0.0033	–0.0133	0.0013	–0.0055	94.2284
			K2	Dec.	4.5707	–0.0017	0.0002	0.0026	0.0005	4.5723
147	47	γ Dra	2.23	SHA	90.9037	–0.0016	–0.0062	0.0017	–0.0090	90.8886
		Eltanin	K5	Dec.	51.4898	–0.0016	0.0006	0.0054	0.0010	51.4952
148		γ Sgr	2.99	SHA	88.7006	–0.0043	–0.0172	0.0010	–0.0065	88.6736
			K0	Dec.	–30.4249	–0.0016	0.0008	–0.0007	–0.0001	–30.4265
149		δ Sgr	2.70	SHA	84.9034	–0.0043	–0.0171	0.0006	–0.0065	84.8761
			K2	Dec.	–29.8329	–0.0015	0.0012	–0.0007	0.0001	–29.8338
150	48	ε Sgr	1.85	SHA	84.1144	–0.0045	–0.0178	0.0005	–0.0069	84.0857
		Kaus Aust.	A0	Dec.	–34.3899	–0.0014	0.0013	–0.0011	0.0001	–34.3910
151		λ Sgr	2.81	SHA	83.1538	–0.0042	–0.0165	0.0004	–0.0063	83.1272
			K2	Dec.	–25.4276	–0.0014	0.0014	–0.0002	0.0003	–25.4275
152	49	α Lyr	0.03	SHA	80.8457	–0.0020	–0.0091	0.0002	–0.0073	80.8275
		Vega	A0	Dec.	38.7744	–0.0013	0.0016	0.0050	0.0003	38.7800
153	50	σ Sgr	2.02	SHA	76.3308	–0.0043	–0.0165	–0.0003	–0.0063	76.3034
		Nunki	B2	Dec.	–26.3092	–0.0012	0.0021	–0.0003	0.0006	–26.3080
154		ζ Sgr	2.60	SHA	74.4980	–0.0045	–0.0169	–0.0005	–0.0065	74.4696
			A2	Dec.	–29.8945	–0.0011	0.0022	–0.0007	0.0007	–29.8934
155		ζ Aql	2.99	SHA	73.7566	–0.0030	–0.0124	–0.0005	–0.0058	73.7349
			A0	Dec.	13.8489	–0.0011	0.0023	0.0034	0.0002	13.8537
156		π Sgr	2.89	SHA	72.7002	–0.0041	–0.0159	–0.0007	–0.0060	72.6735
			F2	Dec.	–21.0393	–0.0011	0.0024	0.0002	0.0007	–21.0371
157		β^1 Cyg	3.08	SHA	67.4154	–0.0024	–0.0110	–0.0012	–0.0062	67.3946
		Albireo	K3	Dec.	27.9393	–0.0009	0.0029	0.0044	–0.0003	27.9454
158		δ Cyg	2.87	SHA	63.8304	–0.0014	–0.0087	–0.0020	–0.0077	63.8106
			B9	Dec.	45.1073	–0.0008	0.0032	0.0052	–0.0009	45.1140
159		γ Aql	2.72	SHA	63.5479	–0.0030	–0.0128	–0.0015	–0.0055	63.5251
			K3	Dec.	10.5897	–0.0008	0.0033	0.0031	0.0001	10.5954
160	51	α Aql	0.77	SHA	62.4200	–0.0031	–0.0130	–0.0015	–0.0054	62.3970
		Altair	A7	Dec.	8.8428	–0.0007	0.0034	0.0030	0.0001	8.8486

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					°	°	°	°	°	°
161		γ Cyg	2.20	SHA	54.5282	–0.0016	–0.0100	–0.0029	–0.0067	54.5070
			F8	Dec.	40.2260	–0.0004	0.0040	0.0048	–0.0013	40.2331
162	52	α Pav	1.94	SHA	53.7747	–0.0067	–0.0205	–0.0041	–0.0092	53.7342
		Peacock	B2	Dec.	–56.7662	–0.0004	0.0041	–0.0027	0.0024	–56.7628
163		α Ind	3.11	SHA	50.7744	–0.0058	–0.0183	–0.0037	–0.0072	50.7394
			K0	Dec.	–47.3252	–0.0003	0.0043	–0.0019	0.0024	–47.3207
164	53	α Cyg	1.25	SHA	49.7230	–0.0012	–0.0096	–0.0037	–0.0069	49.7016
		Deneb	A2	Dec.	45.2461	–0.0003	0.0044	0.0048	–0.0018	45.2532
165		ε Cyg	2.46	SHA	48.5433	–0.0020	–0.0110	–0.0032	–0.0058	48.5213
			K0	Dec.	33.9343	–0.0002	0.0045	0.0044	–0.0014	33.9416
166		α Cep	2.44	SHA	40.4116	0.0008	–0.0073	–0.0071	–0.0094	40.3886
		Alderamin	A7	Dec.	62.5452	0.0001	0.0050	0.0046	–0.0031	62.5518
167		β Aqr	2.91	SHA	37.2352	–0.0036	–0.0140	–0.0035	–0.0041	37.2100
			G0	Dec.	–5.6133	0.0002	0.0052	0.0018	0.0008	–5.6053
168	54	ε Peg	2.39	SHA	34.0701	–0.0030	–0.0133	–0.0038	–0.0039	34.0461
		Enif	K2	Dec.	9.8312	0.0003	0.0053	0.0028	–0.0003	9.8393
169		δ Cap	2.87	SHA	33.3706	–0.0040	–0.0145	–0.0039	–0.0040	33.3442
			Am	Dec.	–16.1707	0.0004	0.0054	0.0011	0.0015	–16.1623
170	55	α Gru	1.74	SHA	28.0905	–0.0057	–0.0161	–0.0060	–0.0050	28.0577
		Al Na'ir	B7	Dec.	–47.0073	0.0006	0.0056	–0.0009	0.0036	–46.9984
171		α Tuc	2.86	SHA	25.5352	–0.0071	–0.0172	–0.0085	–0.0065	25.4959
			K3	Dec.	–60.3073	0.0006	0.0057	–0.0016	0.0043	–60.2983
172		β Gru	2.11	SHA	19.4741	–0.0056	–0.0152	–0.0066	–0.0040	19.4427
			M5	Dec.	–46.9346	0.0009	0.0059	–0.0004	0.0039	–46.9243
173	56	α PsA	1.16	SHA	15.7180	–0.0045	–0.0143	–0.0054	–0.0027	15.6911
		Fomalhaut	A3	Dec.	–29.6728	0.0010	0.0059	0.0008	0.0029	–29.6622
174		β Peg	2.42	SHA	14.1718	–0.0024	–0.0133	–0.0054	–0.0025	14.1482
		Scheat	M2	Dec.	28.0312	0.0010	0.0060	0.0030	–0.0021	28.0391
175	57	α Peg	2.49	SHA	13.9282	–0.0029	–0.0135	–0.0049	–0.0023	13.9046
		Markab	B9	Dec.	15.1540	0.0011	0.0060	0.0027	–0.0010	15.1628
176		γ Cep	3.21	SHA	5.2621	0.0044	–0.0143	–0.0234	–0.0065	5.2223
			K1	Dec.	77.5794	0.0013	0.0060	0.0019	–0.0053	77.5833

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