Instructions on the use of the *Long Term Almanac*

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Find GHA and declination of the SUN at 15h 52m 25s on July 24, 2009 using the *Long Term Almanac*		
1.	Use Table A1 to find leap year cycles and position	A = 2, B =1
2.	Convert time to decimal hr 15:52:25	= 15.88 hr
3.	Look up (B=1) 00h GHA sun	= 178° 23.0'
	Figure hourly correction -0.01' x 15.88	= -0.2'
	Figure quadrennial correction -0.15 x 2	= -0.3'
	Apply to 00h GHA to find 2009 GHA Sun	= 178° 22.5'
4.	Use Table A2 to find GHA increments for 15h, 52m, 25s	= 238° 06.3'
	Add to 00h 2009 GHA	= 416° 28.8'
	Adjust degrees and minutes	-360°
	GHA Sun	= 56° 28.8'
5.	Look up (B=1) 00h dec	= N 19° 53.7'
	Figure hourly correction -0.53' x 15.88	= - 08.4'
	Figure quadrennial correction -0.44' x 2	= - 00.9'
	Apply to 00h GHA to find 2009 dec sun	= N 19° 44.4'

A short view of the process,

for the SUN

Find GHA and declination of A STAR (*Dubhe*) at 19h 13m 06s on May 12, 2036 using the *Long Term Almanac*		
1.	Use Table A1 to find leap year cycles and position	A = 9, B =0
	Figure years since 2000	= 36
2.	Look up (B=0) 00h GHA Aries	= 230° 04.4'
	Use Table A2 to find GHA increments for 19h, 13m, 06s	= 289° 03.8'
	Use Table A2 to find GHA increments for A = 9	= +16.6'
	Apply to 00h GHA Aries to find 2036 value	= 519° 24.8'
	Adjust degrees and minutes	-360°
	Result is the GHA Aries	= 159° 24.8'
4.	Look up May 2000 SHA *Dubhe*	= 194° 04.1'
	Apply annual correction -0.920' x 36	= - 33.1'
	Find corrected SHA	= 193° 31.0'
	Find GHA *Dubhe* = SHA + GHA Aries	= 352° 55.8'
5.	Look up May 2000 dec Duhbe	= N 61° 45.2'
	Figure annual correction -0.325' x 36	= -00° 11.7'
	Apply to May 2000 dec to find May 2036 dec *Dubhe*	= N 61° 33.5'

A short view of the process,

for a STAR

The Longer View, with Annotations and Tables

The *Long Term Almanac* (LTA) is a small book of about 100 pages by British navigator and engineer Dr. Geoffrey Kolbe that allows you to analyze sextant sights of the sun and selected stars to find your position on earth by standard methods of celestial navigation. No further books are required. The book includes the almanac data, the sextant sight correction tables, and a complete set of concise sight reduction tables.

There is a bit more paperwork to get the answers this way, since we do not have the standard 10 pounds of books to work with, but we will get the answers, well within the required accuracy for routine ocean navigation. The LTA almanac look up process adds only a few minutes to your routine procedures. Work forms are provided for each step of the process to simplify the paper work.

Needless to say, with this book at hand, there would not be a navigation emergency if routine equipment failed underway, because this one book will solve all of the routine computations of celestial navigation as well as compute the bearings to the sun throughout the day or the stars throughout the night for steering without a compass. Even if you do not have a sextant, you can time the sunrise or sunset and call that a sextant height of 0° 0’ and then do a sight reduction with this book for a reasonable line of position. The book can also be used to check your compass or to compute great circle distances and headings to your destination.

The “locations” of the sun and stars needed for celestial navigation are defined as the points on earth directly below the bodies in the sky. These points are called “Geographical Positions” (GP). The longitude equivalent of the GP is called the Greenwich Hour Angle (GHA) and the latitude of the GP is called the declination (dec) The GPs of the sun and stars move westward around the globe at a rate of about 15° of longitude for each hour, because the earth rotates 360° in 24 h, which is the same as 15°/1h. Thus if we know where the GPs are at one time and date we can figure where they will be at a later time and date by advancing them by the elapsed time multiplied by 15°/1h. Since we use the sun to keep time, it is defined as moving at exactly this 15°/1h, but to account for the orbital motion of the earth around the sun, the stars move at a very slightly different rate. The GPs of stars remain at essentially constant latitude, equal to the declination of the star. The latitude of the sun’s GP varies throughout the year between the northern and southern tropics, at 23° 26.4’ N and S.

The *Long Term Almanac* (LTA) tables are based on the fact that the astronomical locations of the sun and stars at any specific time and date essentially repeat themselves every 4 years. Thus we can start with precise base values (00h on Jan 1, 2000, 2001, 2002, and 2003) and then correct for the elapsed time. We also have to correct for the slight changes in this rate, since the positions are not *exactly* the same every 4 years, in part because the earth’s orbit around the sun is changing slightly each year. And finally we need to correct for the position within the leap year cycle, since time keeping gets thrown off by 1 day in each cycle.

In this book, the change in rate of motion is called “Hourly Acceleration” (HRLY ACCN) for the Greenwich hour angle (GHA) and called “Hourly Rate” (HRLY RATE) for the changes in declination (dec). In each case, the leap year correction is called “Quadrennial Correction” (QUAD CORR).

To Find the Greenwich Hour Angle (GHA) and declination (dec) of the SUN

There are detailed instructions in the book, but in summary you can think of the process of finding the sun’s GHA and Dec for any time and date as a sequence of 5 short steps, which can be expedited using what we call here work form A3. You can follow this example with the Form A3, on page 4 below. (There is also a form of different design in the LTA book on page 65.)

Step 1. First compute how many leap year cycles took place since the year 2000 (that number is called “A”), and then determine which year you are within that 4-yr cycle, which for mathematical reasons are numbered 0, 1, 2, or 3. That number is called “B.”

Table A1 is one easy to figure A and B for any given year in the range 2000 to 2050. This table is in the LTA book on page 61.

The main almanac data in the book are organized according to the B value for your date. Thus there are 12 monthly pages for each value of B, and on

Table A1 — Leap year locators, A and B					
		B = Location within the leap year cycle			
	A	*B = 0*	*B = 1*	*B = 2*	*B = 3*
A = Number of leap year cycles past 2000	*0*	2000	2001	2002	2003
	1	2004	2005	2006	2007
	2	2008	2009	2010	2111
	3	2012	2013	2014	2015
	4	2016	2017	2018	2019
	5	2020	2021	2022	2023
	6	2024	2025	2026	2027
	7	2028	2029	2030	2031
	8	2032	2033	2034	2035
	9	2036	2037	2038	2039
	10	2040	2041	2042	2043
	11	2044	2045	2046	2047
	12	2048	2049	2050	2051
	13	2052	2053	2054	2055

Examples: For 2009, A = 2, B = 1. For 2014 A = 3, B =2.

each of these there is data for each day of that month. The values given on these pages were valid at 00h in the year 2000.

Step 2. Convert your sight time from hours, minutes, and seconds (hh mm ss) to decimal hours. You can do this manually with a calculator or use the equivalent of what we call here Table A2, which is also in the LTA book on page 62.

Table A2 is likely the quickest approach, but the manual method would be for a time (h, m, s), such as 15:52:25, with h = 15, m = 52, and s = 25:

T (h.h) = h + { [(s / 60) + m] / 60 } = 15 + { [(25/60) + 52] / 60 }
= 15 + 0.874 = 15.87 h.

Table A2 gives a value of 15.88, but this difference is not significant in this process.

Step 3. This is where you look up and record the value of the GHA at 00h on the month and day of your sight back in the year 2000. The value depends on B (location in the leap year cycle), the month, and the date of your sight time. The B values are shown prominently on each of the data pages (page 4 to 51 in the LTA book). The LTA page for July 24, 2009 is shown below on page 4. The year 2000 GHA value for 00h was 178° 23.0'. This is recorded in the third line of Box 3 in Form A4. This value then has to be corrected for the Hourly Acceleration and the Quadrennial Correction. So we start by going to the right page and copying these 3 numbers into the first 3 lines of box 3 of the form.

If you want to at this point, you could look ahead to Step 5 and note that you will need the corresponding values for the declination and record them now in the first 3 lines of Box 5. This is then all we need from the LTA book and you could put it away at this point. This shows how simple the process really is. For any desired date and time, we only need 6 numbers easily found in the LTA book, and their is a logical place in the work form to record them.

The final part of Step 3 is to apply the corrections needed to end up with the GHA value at 00h on the date and year of your sight. This process is illustrated in the A4 form on page 4.

Step 4. At the end of Step 3 we found that the GHA at 00h on the day of our site (July 24, 2009 in this example) was 178° 22.5'. The task of Box 4 is to apply the GHA increments to correct this for the time of day. This can be done with the time listed in Box 1 and Table A3 for the increments. (Note that this table is just the reverse of the Arc to Time table we use in routine celestial navigation.) The final answer should be a GHA with degrees less than 360 and minutes less than 60. See Form A4 and Table A3 for details.

After cleaning up the degrees and minutes you are done with the GHA.

Step 5. This is the near identical procedure for finding the declination, but it is shorter because the declination changes more slowly. Apply the two corrections (HR and QC) to the 00h value and you have the final declination, as shown in Box 5 of Form A3 on page 4, below.

Practice Finding Sun's GHA and dec.

After following through the example given, find GHA and declination of the sun for these times and dates, all GMT = UTC. You will notice that the format of the "helper" tables are somewhat different in these instructions than in the LTA book itself, so it will pay to identify the ones in the book and practice with those as well. You will soon note which pages you need to tab for quick reference. *Remember that even though these instructions are long, once you see the process it takes just seconds to get a GHA and dec with these tables.*

(1) 17h 36m 27s on July 4, 2012 (2) 03h 56m 05s on Dec 19, 2013 (3) 23h 34m 24s on Jan 13, 2014

(4) 05h 35m 56s on Mar 21, 2015

Find these on your own, then compare with final answer. If they agree, fine. If not check your work again before referring to the full answers. If you can't find the error, check the full answers to see what step when wrong.

Remember. You know roughly what the declination of the sun is on any date before you begin, so that is your first reality check on your answer. If you get N 15° on Dec 20 that is wrong! You also know that the GHA of the sun is roughly 0° at 12h UTC (±16 m to account for the Equation of Time), and it is roughly 180° at 00h ±16m.

The Analemma shown in Figure 1 is a good way to recall the limiting values of the declination and GHA, and how they vary throughout the year.

Table A2 — Conversion of Time from hours, minutes, seconds (h,m,s) to decimal hours (h.h)											
Minutes	*Seconds*					*Minutes*	*Seconds*				
	0	*15*	*30*	*45*	*60*		*0*	*15*	*30*	*45*	*60*
0	0.00	0.00	0.01	0.01	0.02	*30*	0.50	0.50	0.51	0.51	0.52
1	0.02	0.02	0.03	0.03	0.03	*31*	0.52	0.52	0.53	0.53	0.53
2	0.03	0.04	0.04	0.05	0.05	*32*	0.53	0.54	0.54	0.55	0.55
3	0.05	0.05	0.06	0.06	0.07	*33*	0.55	0.55	0.56	0.56	0.57
4	0.07	0.07	0.08	0.08	0.08	*34*	0.57	0.57	0.58	0.58	0.58
5	0.08	0.09	0.09	0.10	0.10	*35*	0.58	0.59	0.59	0.60	0.60
6	0.10	0.10	0.11	0.11	0.12	*36*	0.60	0.60	0.61	0.61	0.62
7	0.12	0.12	0.13	0.13	0.13	*37*	0.62	0.62	0.63	0.63	0.63
8	0.13	0.14	0.14	0.15	0.15	*38*	0.63	0.64	0.64	0.65	0.65
9	0.15	0.15	0.16	0.16	0.17	*39*	0.65	0.65	0.66	0.66	0.67
10	0.17	0.17	0.18	0.18	0.18	*40*	0.67	0.67	0.68	0.68	0.68
11	0.18	0.19	0.19	0.20	0.20	*41*	0.68	0.69	0.68	0.70	0.70
12	0.20	0.20	0.21	0.21	0.22	*42*	0.70	0.70	0.71	0.71	0.72
13	0.22	0.22	0.23	0.23	0.23	*43*	0.72	0.72	0.73	0.73	0.73
14	0.23	0.24	0.24	0.25	0.25	*44*	0.73	0.74	0.74	0.75	0.75
15	0.25	0.25	0.26	0.26	0.27	*45*	0.75	0.75	0.76	0.76	0.77
16	0.27	0.27	0.28	0.28	0.28	*46*	0.77	0.77	0.78	0.78	0.78
17	0.28	0.29	0.29	0.30	0.30	*47*	0.78	0.79	0.79	0.80	0.80
18	0.30	0.30	0.31	0.31	0.32	*48*	0.80	0.80	0.81	0.81	0.82
19	0.32	0.32	0.33	0.33	0.33	*49*	0.82	0.82	0.83	0.83	0.83
20	0.33	0.34	0.34	0.35	0.35	*50*	0.83	0.84	0.84	0.85	0.85
21	0.35	0.35	0.36	0.36	0.37	*51*	0.85	0.85	0.86	0.86	0.87
22	0.37	0.37	0.38	0.38	0.38	*52*	0.87	0.87	0.88	0.88	0.88
23	0.38	0.39	0.39	0.40	0.40	*53*	0.88	0.89	0.89	0.90	0.90
24	0.40	0.40	0.41	0.41	0.42	*54*	0.90	0.90	0.91	0.91	0.92
25	0.42	0.42	0.43	0.43	0.43	*55*	0.92	0.92	0.93	0.93	0.93
26	0.43	0.44	0.44	0.45	0.45	*56*	0.93	0.94	0.94	0.95	0.95
27	0.45	0.45	0.46	0.46	0.47	*57*	0.95	0.95	0.96	0.96	0.97
28	0.47	0.47	0.48	0.48	0.48	*58*	0.97	0.97	0.98	0.98	0.98
29	0.48	0.49	0.49	0.50	0.50	*59*	0.98	0.99	0.99	1.00	1.00

Examples: 15h 52m 25s = 15h + 0.88h (using 30s as the closest tabulated value) = 15.88h. And 04h 09m 13s = 04h + 0.15h (using 15s as the closest tabulated value) = 4.15h

Example 1.
The form below can be used to extract the GHA and declination of the sun for July 24, 2009, using the Long Term Almanac.

Form A4 — Find GHA and Declination for the Sun

1	*Month, day*	July 24		← *Sight month and day*
	Year, 20xx	2009		← *Sight year*
	No. of cycles, A	2		← *Number of leap year cycles past 2000. A From Table A1.*
	Cycle position, B	1		← *Position within the leap year cycle. B From Table A1.*
2	*Sight Time, h*	15		← *Hour part of sight time*
	Sight Time, m	52		← *Minutes part of sight time*
	Sight Time, s	25		← *Seconds part of sight time*
	T (hh.hh)	15.88		← *Sight time converted to decimal hours. Use Table A2.*
3	*HA_GHA*	-0.01'		← *Hourly acceleration of the GHA. From B=1, July, page 22*
	QC_GHA	-0.15'		← *Quadrennial correction. From B=1, July, page 22*
	GHA 00h (B)	178°	23.0'	← *Base GHA value from 00h for B=1, July, page 22*
	T x HA_GHA		-0.2'	← *15.88 x (-0.01')*
	A x QC_GHA		-0.3'	← *2 x (-0.15')*
	GHA 00h, 20xx	178°	22.5'	← *Sum of base plus two corrections (22.5' - 0.2' - 0.3')*
4	*+ GHA-h inc*	225°		← *Table A3 for h = 15*
	+ GHA-m inc	13°		← *Table A3 for m = 52*
	+ GHA-s inc		+6.3'	← *Table A3 for s = 25*
	GHA hms, 20xx	416°	28.8'	← *00h value plus 3 GHA inc corrections*
	Adjust degrees and minutes as needed			← *use this line when GHA minutes are greater than 60*
		-360°		← *subtract 360*
	GHA=	56°	28.8'	← *Final sun GHA for 15h 52m 25s on July 24, 2009*
5	*HR_dec*	-0.53'		← *Hourly rate of declination change. From B=1, July, page 22*
	QC_dec	-0.44'		← *Quadrennial correction. From B=1, July, page 22*
	dec 00h (B)	19°	53.7'	← *Base declination for 00h for B=1, July, page 22*
	T x HR_dec		-8.4'	← *15.88 x (-0.53')*
	A x QG_dec		-0.9'	← *2 x (-0.44')*
	dec =	19°	44.4'	← *Sum of base plus two corrections (53.7' - 8.4' - 0.9')*
	dec =	19°	44.4'	← *Final sun declination for 15h 52m 25s on July 24, 2009*

QC_GHA QC_dec

HA_GHA HR_dec

GHA 00h, 2000 dec 00h, 2000

B = **1** **JULY** **1**

DAY	GHA SUN	HRLY ACCN	QUAD CORR	DEC SUN	HRLY RATE	QUAD CORR	GHA ARIES
01	179°03.9′	−0.12′	−0.22′	N 23°06.8′	−0.17′	−0.15′	279°06.9′
02	179 01.0	−0.12	−0.21	23 02.7	−0.19	−0.17	280 06.1
03	178 58.1	−0.11	−0.21	22 58.1	−0.20	−0.18	281 05.2
04	178 55.4	−0.11	−0.20	22 53.2	−0.23	−0.20	282 04.4
05	178 52.7	−0.11	−0.20	22 47.8	−0.24	−0.21	283 03.5
06	178 50.1	−0.10	−0.19	22 42.0	−0.25	−0.23	284 02.6
07	178 47.6	−0.10	−0.19	22 35.9	−0.28	−0.24	285 01.8
08	178 45.2	−0.10	−0.19	22 29.2	−0.29	−0.25	286 00.9
09	178 42.9	−0.09	−0.18	22 22.3	−0.30	−0.26	287 00.1
10	178 40.7	−0.09	−0.18	22 15.0	−0.32	−0.27	287 59.2
11	178 38.6	−0.08	−0.18	22 07.3	−0.34	−0.28	288 58.3
12	178 36.6	−0.08	−0.17	21 59.2	−0.35	−0.30	289 57.5
13	178 34.7	−0.07	−0.17	21 50.7	−0.37	−0.31	290 56.6
14	178 33.0	−0.07	−0.17	21 41.9	−0.38	−0.32	291 55.7
15	178 31.4	−0.06	−0.17	21 32.7	−0.40	−0.33	292 54.9
16	178 29.9	−0.05	−0.17	21 23.1	−0.42	−0.34	293 54.0
17	178 28.6	−0.05	−0.17	21 13.1	−0.43	−0.36	294 53.2
18	178 27.4	−0.05	−0.17	21 02.8	−0.44	−0.37	295 52.3
19	178 26.3	−0.04	−0.17	20 52.2	−0.46	−0.39	296 51.4
20	178 25.3	−0.03	−0.17	20 41.2	−0.48	−0.40	297 50.6
21	178 24.5	−0.03	−0.16	20 29.8	−0.49	−0.40	298 49.7
22	178 23.9	−0.02	−0.16	20 18.1	−0.50	−0.41	299 48.9
23	178 23.4	−0.02	−0.16	20 06.1	−0.52	−0.42	300 48.0
24	178 23.0	−0.01	−0.15	19 53.7	−0.53	−0.44	301 47.1
25	178 22.8	0.00	−0.15	19 40.9	−0.54	−0.45	302 46.3
26	178 22.8	0.00	−0.14	19 27.9	−0.55	−0.46	303 45.4
27	178 22.8	+0.01	−0.14	19 14.6	−0.57	−0.47	304 44.6
28	178 23.0	+0.01	−0.13	19 00.9	−0.58	−0.48	305 43.7
29	178 23.3	+0.02	−0.13	18 46.9	−0.60	−0.49	306 42.8
30	178 23.8	+0.03	−0.12	18 32.6	−0.61	−0.50	307 42.0
31	178 24.5	+0.03	−0.11	18 18.0	−0.62	−0.51	308 41.1

VALID FOR THE YEARS	
2001	For an *Explanation of Daily tables*, see page 60
2005	For the *Tables of GHA increments*, see page 63
2009	
2013	*Another way to check that you have the right B section is to find your year in this column*
2017	
2021	
2025	
2029	
2033	
2037	
2041	
2045	
2049	

Table A3 GHA Increments for the SUN					
Time h	*GHA-h inc*	*Time m*	*GHA-m inc*	*Time s*	*GHA-s inc*
1h	15°	*1m*	0° 15’	*1s*	0.3’
2h	30°	*2m*	0° 30’	*2s*	0.5’
3h	45°	*3m*	0° 45’	*3s*	0.8’
4h	60°	*4m*	1° 0’	*4s*	1.0’
5h	75°	*5m*	1° 15’	*5s*	1.3’
6h	90°	*6m*	1° 30’	*6s*	1.5’
7h	105°	*7m*	1° 45’	*7s*	1.8’
8h	120°	*8m*	2° 0’	*8s*	2.0’
9h	135°	*9m*	2° 15’	*9s*	2.3’
10h	150°	*10m*	2° 30’	*10s*	2.5’
11h	165°	*11m*	2° 45’	*11s*	2.8’
12h	180°	*12m*	3° 0’	*12s*	3.0’
13h	195°	*13m*	3° 15’	*13s*	3.3’
14h	210°	*14m*	3° 30’	*14s*	3.5’
15h	225°	*15m*	3° 45’	*15s*	3.8’
16h	240°	*16m*	4° 0’	*16s*	4.0’
17h	255°	*17m*	4° 15’	*17s*	4.3’
18h	270°	*18m*	4° 30’	*18s*	4.5’
19h	285°	*19m*	4° 45’	*19s*	4.8’
20h	300°	*20m*	5° 0’	*20s*	5.0’
21h	315°	*21m*	5° 15’	*21s*	5.3’
22h	330°	*22m*	5° 30’	*22s*	5.5’
23h	345°	*23m*	5° 45’	*23s*	5.8
24h	360°	*24m*	6° 0’	*24s*	6.0’
		25m	6° 15’	*25s*	6.3’
		26m	6° 30’	*26s*	6.5’
		27m	6° 45’	*27s*	6.8’
		28m	7° 0’	*28s*	7.0’
		29m	7° 15’	*29s*	7.3’
		30m	7° 30’	*30s*	7.5’

Table A3 Continued			
Time m	*GHA-m inc*	*Time s*	*GHA-s inc*
31m	7° 45’	*31s*	7.8’
32m	8° 0’	*32s*	8.0’
33m	8° 15’	*33s*	8.3’
34m	8° 30’	*34s*	8.5’
35m	8° 45’	*35s*	8.8’
36m	9° 0’	*36s*	9.0’
37m	9° 15’	*37s*	9.3’
38m	9° 30’	*38s*	9.5’
39m	9° 45’	*39s*	9.8’
40m	10° 0’	*40s*	10.0’
41m	10° 15’	*41s*	10.3’
42m	10 30’	*42s*	10.5’
43m	10° 45’	*43s*	10.8’
44m	11° 0’	*44s*	11.0’
45m	11° 15’	*45s*	11.3’
46m	11° 30’	*46s*	11.5’
47m	11° 45’	*47s*	11.8’
48m	12° 0’	*48s*	12.0’
49m	12° 15’	*49s*	12.3’
50m	12° 30’	*50s*	12.5’
51m	12° 45’	*51s*	12.8’
52m	13° 0’	*52s*	13.0’
53m	13° 15’	*53s*	13.3’
54m	13° 30’	*54s*	13.5’
55m	13° 45	*55s*	13.8’
56m	14° 0’	*56s*	14.0’
57m	14° 15’	*57s*	14.3’
58m	14° 30’	*58s*	14.5’
59m	14° 45’	*59s*	14.8’
60m	15° 0’	*60s*	15.0’

Examples. Sun’s GHA increment for 15h 52m 25 s = 225° + 13° 0’ + 0° 6.3’ = 238° 6.3’. For 04h 09m 13s the result is 60° + 2° 15’ + 3.3 ‘ = 62° 18.3’.

This table in a condensed form appears on page 63 of LTA

Table A5 GHA Increments for ARIES					
Time h	*GHA-h inc*	*Time m*	*GHA-m inc*	*Time s*	*GHA-s inc*
1h	15° 02.5'	*1m*	0° 15.0'	*1s*	0.3’
2h	30° 04.9'	*2m*	0° 30.1'	*2s*	0.5’
3h	45° 07.4'	*3m*	0° 45.1'	*3s*	0.8’
4h	60° 09.8'	*4m*	1° 00.2'	*4s*	1.0’
5h	75° 12.3'	*5m*	1° 15.2'	*5s*	1.3’
6h	90° 14.8'	*6m*	1° 30.2'	*6s*	1.5’
7h	105° 17.2'	*7m*	1° 45.3'	*7s*	1.8’
8h	120° 19.7'	*8m*	2° 00.3'	*8s*	2.0’
9h	135° 22.1'	*9m*	2° 15.4'	*9s*	2.3’
10h	150° 24.6'	*10m*	2° 30.4'	*10s*	2.5’
11h	165° 27.1'	*11m*	2° 45.5'	*11s*	2.8’
12h	180° 29.5'	*12m*	3° 00.5'	*12s*	3.0’
13h	195° 32.0'	*13m*	3° 15.5'	*13s*	3.3’
14h	210° 34.4'	*14m*	3° 30.6'	*14s*	3.5’
15h	225° 36.9'	*15m*	3° 45.6'	*15s*	3.8’
16h	240° 39.4'	*16m*	4° 00.7'	*16s*	4.0’
17h	255° 41.8'	*17m*	4° 15.7'	*17s*	4.3’
18h	270° 44.3'	*18m*	4° 30.7'	*18s*	4.5’
19h	285° 46.7'	*19m*	4° 45.8'	*19s*	4.8’
20h	300° 49.2'	*20m*	5° 00.8'	*20s*	5.0’
21h	315° 51.7'	*21m*	5° 15.9'	*21s*	5.3’
22h	330° 54.1'	*22m*	5° 30.9'	*22s*	5.5’
23h	345° 56.6'	*23m*	5° 45.9'	*23s*	5.8
24h	360° 59.0'	*24m*	6° 01.0'	*24s*	6.0’
		25m	6° 16.00'	*25s*	6.3’
		26m	6° 31.1'	*26s*	6.5’
		27m	6° 46.1'	*27s*	6.8’
		28m	7° 01.1'	*28s*	7.0’
		29m	7° 16.2'	*29s*	7.3’
		30m	7° 31.2'	*30s*	7.5’

Table A5 Continued			
Time m	*GHA-m inc*	*Time s*	*GHA-s inc*
31m	7° 46.3'	*31s*	7.8’
32m	8° 01.3'	*32s*	8.0’
33m	8° 16.4'	*33s*	8.3’
34m	8° 31.4'	*34s*	8.5’
35m	8° 46.4'	*35s*	8.8’
36m	9° 01.5'	*36s*	9.0’
37m	9° 16.5'	*37s*	9.3’
38m	9° 31.6'	*38s*	9.5’
39m	9° 46.6'	*39s*	9.8’
40m	10° 01.6'	*40s*	10.0’
41m	10° 16.7'	*41s*	10.3’
42m	10 31.7'	*42s*	10.5’
43m	10° 46.8'	*43s*	10.8’
44m	11° 01.8'	*44s*	11.0’
45m	11° 16.8'	*45s*	11.3’
46m	11° 31.9'	*46s*	11.5’
47m	11° 46.9'	*47s*	11.8’
48m	12° 2.00'	*48s*	12.0’
49m	12° 17.0'	*49s*	12.3’
50m	12° 32.1'	*50s*	12.5’
51m	12° 47.1'	*51s*	12.8’
52m	13° 02.1'	*52s*	13.0’
53m	13° 17.2'	*53s*	13.3’
54m	13° 32.2'	*54s*	13.5’
55m	13° 47.3'	*55s*	13.8’
56m	14° 02.3'	*56s*	14.0’
57m	14° 17.3'	*57s*	14.3’
58m	14° 32.4'	*58s*	14.5’
59m	14° 47.4'	*59s*	14.8’
60m	15° 02.5'	*60s*	15.0’

Table A5 Cont.	
A	*GHA-A inc*
1	*1.8’*
2	*3.7’*
3	*5.5’*
4	*7.4’*
5	*9.2’*
6	*11.0’*
7	*12.9’*
8	*14.7’*
9	*16.6’*
10	*18.4’*
11	*20.2’*
12	*22.1’*
13	*23.9’*
14	*25.8’*
15	*27.6’*

This table in a condensed form appears on page 63 of LTA

To Find the Greenwich Hour Angle (GHA) and declination (dec) of a STAR

Again, there are detailed instructions in the book, but this annotated summary may make it easier to follow. We use work form A6 for stars. That form is used to illustrate the steps below.

Step 1. Same as with the sun, use Table A1 to find A and B and fill in Box 1 with the time. For star sights we *do not* need to figure the decimal hours.

Step 2. Find the GHA of Aries (γ) from the daily pages of LTA corresponding to your B value. Then using the time of your sight, figure the GHA Aries increments, just as done for the sun. Note there is one extra factor here, which is a GHA increment based on the A value.

Step 3. Turn to the Year 2000 Star Positions (LTA pages 54-59) to find and record the SHA for your star on your month. Also record the annual correction in Box 3. Figure the number of years past 2000 and multiply that times the SHA correction and apply it as shown in Form A6. then add the SHA to the GHA Aries to get the GHA of the star: GHA star = GHA Aries + SHA star.

Step 4. Same as Step 3 for the declination. Record year 2000 value, record and apply the annual correction, and you are done.

In practice you will typically do Step 3 and Step 4 at the same time.

Practice finding GHA and dec of a star. All times are GMT = UT

(1) 04h 32m 13s, Jan 12, 2009, Kochab

(2) 16h 44m 58s, Feb 22, 2010, Alkaid

(3) 22h 05m, 10s, Jun 03, 2030, Spica

(4) 09h 39m 05s, Mar 22, 2015, Fomalhaut

	Exact Star answers	LTA answers
(1) KOCHAB	317° 11.7, N74° 06.7’	______________________
(2) ALKAID	196° 43.9’, N49° 15.4’	______________________
(3) SPICA	021° 59.4’, S11° 19.3’	______________________
(4) FOMALHAUT	339° 44.0’, S29° 32.5’	______________________

		Exact Sun answers	LTA answers
(1) 17h 36m 27s on July 4, 2012	SUN	82° 58.8’ , N22° 47.3’	______________________
(2) 03h 56m 05s on Dec 19, 2013	SUN	239° 46.3’, S23° 24.6’	______________________
(3) 23h 34m 24s on Jan 13, 2014	SUN	171° 23.3’, S21° 21.3’	______________________
(4) 05h 35m 56s on Mar 21, 2015	SUN	262° 09.0’, N 0° 06.8’	______________________

Form A6 — Find GHA and Declination for a STAR using the *Long Term Almanac*				
1	*Month, day*	May 12		← *Sight month and day*
	Year, 20xx	2036		← *Sight year*
	No. of cycles, A	9		← *Number of leap year cycles past 2000. A From Table A1.*
	Cycle position, B	0		← *Position within the leap year cycle. B From Table A1.*
	Sight Time, h, m, s	19h 13m 6s		← *Sight time*
2	*GHA γ 00h, 2000*	230°	4.4'	← *Base GHA γ value from 00h, 2000. (page 8 in LTA)*
	+ GHA-h inc	+285°	+46.8'	← *Table A5 for h = 19 (page 63 in LTA)*
	+ GHA-m inc	+3°	+15.5'	← *Table A5 for m = 13 (page 63 in LTA)*
	+ GHA-s inc		+1.5'	← *Table A5 for s = 6 (page 63 in LTA)*
	+ GHA-A inc		+16.6'	← *Table A5 for A = 9 (page 63 in LTA)*
	GHA γ hms, 20xx	518°	84.8'	← *00h value plus 4 GHA γ increment corrections*
	Adjust degrees and minutes as needed	519°	24.8	← *84.8' = 1° 24.8'*
		-360°		← *subtract 360*
	GHA γ =	159°	24.8'	← *Final GHA γ for 19h 13m 6s on May 12, 2036*
3	*(month, 2000) SHA✶*	194°	04.1'	← *SHA for May, 2000 (page 56 in LTA)*
	SHA Annual Correction	-0.920'		← *Annual correction to the SHA (page 56 in LTA)*
	Years since 2000	36		← *2036 - 2000*
	Years x SHA Corr.		-33.1'	← *36 x (-0.920')*
	Corrected SHA✶	193°	31.0'	← *194° 04.1' - 33.1'*
	GHA✶ = GHA γ + SHA✶	352°	55.8'	← *Sum of base plus two corrections (53.7' - 8.4' - 0.9')*
	Adjust deg and min			
4	*(month, 2000) dec✶*	N 61°	45.2'	← *dec for May, 2000 (page 56 in LTA)*
	dec Annual Correction	-0.325'		← *Annual correction to the SHA (page 56 in LTA)*
	Years since 2000	36		← *2036 - 2000*
	Years x dec Corr.		-11.7'	← *36 x (-0.325')*
	Corrected dec✶	N 61°	33.5'	← *N 61° 45.2' - 11.7'*
	Adjust deg and min			

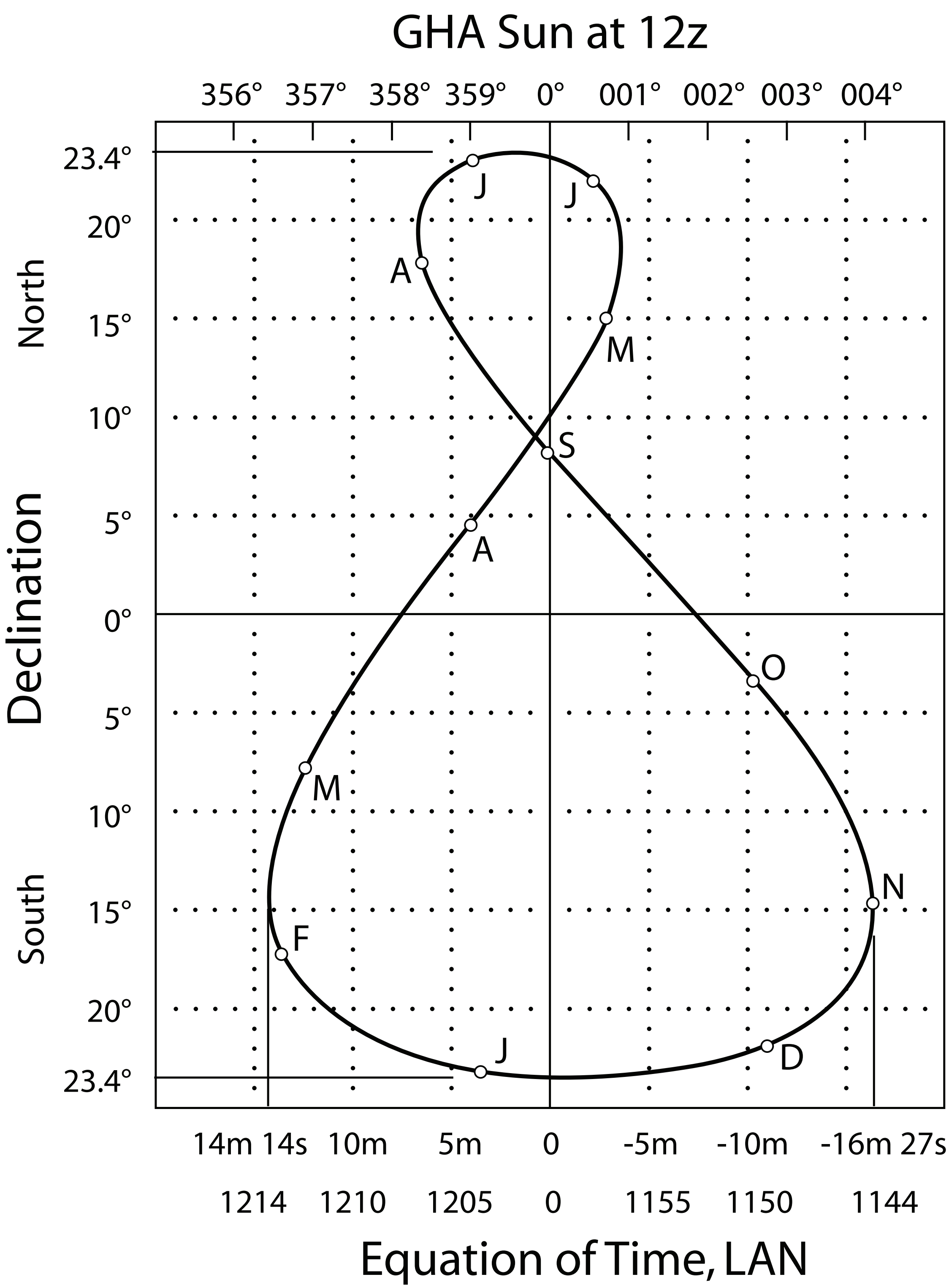

Figure 1. This diagram is called the *Analemma*. It displays the annual progression of the sun's GHA and declination. It pays to keep this in mind so you have a rough feeling for what these values are at any time of year. The use of these ideas is discussed in detail in the book *Emergency Navigation*, from which we have adapted this diagram.

Form A4 — Find GHA and Declination for the Sun using the *Long Term Almanac*

1	*Month, day*								
	Year, 20xx								
	No. of cycles, A								
	Cycle position, B								
2	*Sight Time, h*								
	Sight Time, m								
	Sight Time, s								
	T (hh.hh)								
3	*HA_GHA*								
	QC_GHA								
	GHA 00h (B)								
	T x HA_GHA								
	A x QC_GHA								
	GHA 00h, 20xx								
4	*+ GHA-h inc*								
	+ GHA-m inc								
	+ GHA-s inc								
	GHA hms, 20xx								
	Adjust degrees and minutes as needed								
	GHA=								
5	*HR_dec*								
	QC_dec								
	dec 00h (B)								
	T x HR_dec								
	A x QG_dec								
	dec =								
	dec =								

Form A6 — Find GHA and Declination for a STAR using the *Long Term Almanac*									
1	*Month, day*								
	Year, 20xx								
	No. of cycles, A								
	Cycle position, B								
	Sight Time, h, m, s								
2	*GHA γ 00h (B)*								
	+ GHA-h inc								
	+ GHA-m inc								
	+ GHA-s inc								
	+ GHA-A inc								
	GHA γ hms, 20xx								
	Adjust degrees and minutes as needed								
	GHA γ =								
3	*(month, 2000) SHA✶*								
	SHA Annual Correction								
	Years since 2000								
	Years x SHA Corr.								
	Corrected SHA✶								
	GHA✶ = GHA γ + SHA✶								
	Adjust deg and min								
4	*(month, 2000) dec✶*								
	dec Annual Correction								
	Years since 2000								
	Years x dec Corr.								
	Corrected dec✶								
	Adjust deg and min								