

NO-A190 777 COMPUTING BASIC SOLAR AND LUNAR DATA FROM THE AIR
ALMANAC(U) WEATHER WING (5TH) LANGLEY AFB VA
J K SANDERS ET AL DEC 87 5MM-TN-87-001

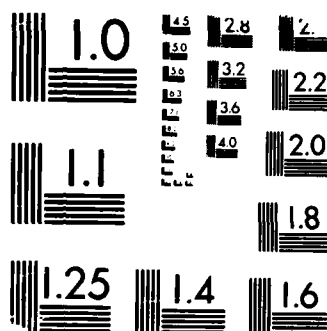
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5TH WEATHER WING TECHNICAL NOTE

COMPUTING BASIC SOLAR AND LUNAR

DATA FROM THE AIR ALMANAC

December 1987

5WW/DNC

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Abstract: This Technical Note provides programmed instruction on the use of the Air Almanac to compute times of sunrise, sunset, moonrise, moonset, and duration of civil twilight for any location between latitudes 60°S and 90°N. Appropriate basic astronomy is included. This Technical Note updates and supersedes 5WW/TN-79/002.

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COMPUTING BASIC LIGHT DATA FROM THE AIR ALMANAC

INTRODUCTION

A pilot comes into your weather office and asks for the time of sunset at his destination; or perhaps you're out in the field and have no access to a computer or some other means of computing astronomical data. How can you provide this information using the Air Almanac?

This Tech Note, which has been reviewed by the Nautical Almanac Office, U.S. Naval Observatory, describes the procedures for extracting these data from the Air Almanac. It will also describe basic theories and laws governing these phenomena. A frame-by-frame programmed learning approach is used.

The Air Almanac is published annually by the Naval Observatory, and is available from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402. Note: AWS units should obtain the Almanac using procedures defined in AWSR 7-1.

The tables and graphs reproduced in this Tech Note are from the Air Almanac 1987 edition; consequently the data, table numbers and page numbers will not necessarily agree with another edition. The procedures for extracting the data are the same, regardless of the edition used.

To complete some of the calculations you will need a few sheets of scratch paper, both to cover the answers (which follow the questions) and to make calculations. A clear plastic straight edge, and in some cases either a pocket calculator or trigonometric tables will also be needed.

The following publications were used in preparing this Tech Note:

- a. AFM 51-40, 1983, Air Navigation, Chaps 9-10.
- b. The Air Almanac, U. S. Naval Observatory, U. S. Government Printing Office, Washington D.C., 1987.

Upon completion of the Program you should be able to extract the data necessary to support your mission directly from the Air Almanac. You can use a worksheet similar to the one provided at the end of this text, to make the extraction of data easier. ED.Note: The worksheet was based on an idea of SMSgt Depew of 25 Wea Sq. He had developed a similar worksheet, which was distributed for use to his subordinate units.

LEARNING OBJECTIVES

1. State the main reason why sunrise, sunset and twilight times change from day-to-day.
2. Name two factors that cause moonrise/set times to change from day to day.
3. Given a date and a position between 72 Deg. N. and 60 Deg. S, obtain the times of sunrise/set, moonrise/set, and morning and evening civil twilights in either Universal Time (Greenwich Mean Time), Local Mean Time, Local Standard and/or Daylight Savings Time, by using the tables in the Air Almanac.
4. Given a date and a position between 65 Deg. N. and 90 Deg. N, obtain the times of sunrise/set, moonrise/set, and morning and evening civil twilights in either Universal Time (Greenwich Mean Time), Local Mean Time, Local Standard and/or Daylight Savings Time, by using the tables in the Air Almanac.
5. Given a location, date and time, calculate the azimuth and altitude of the sun.

PROGRAMMED LEARNING TEXT

FRAME 1

In order to utilize the Air Almanac to find Sunrise/set, and twilight times for your given location you should have some background as to why these times vary both on a daily basis and also latitudinally. The main reason the sun does not rise at the same time every day is the fact that the earth's axis is tilted with respect to it's orbital plane. There are other factors such as, the earth's elliptical orbit and it's wobble at the, poles but this only contributes a few minutes to the annual variation. However, it is the tilt of the axis that causes the seasons and the extremes in the lengths of daylight and darkness.

In the illustration of the earth and its orbit (Figure 1), the 21 December (winter solstice) and 21 June (summer solstice) earth representations have been enlarged to show the extremes in length of daylight caused by first one pole, then the other being tilted toward the sun. Notice in the enlargements that the length of daylight varies with latitude. On 21 June, for example, the length of daylight becomes progressively shorter as you move from north to south.

The axis remains tilted in the same direction as the earth moves in its orbit around the sun. This causes the length of daylight at any one location to vary from day to day. On 21 March (spring equinox) and 21 September (autumnal equinox), the axis' tilt is in a plane perpendicular to the sun's rays, and the durations of daylight and darkness are about 12 hours each for all latitudes.

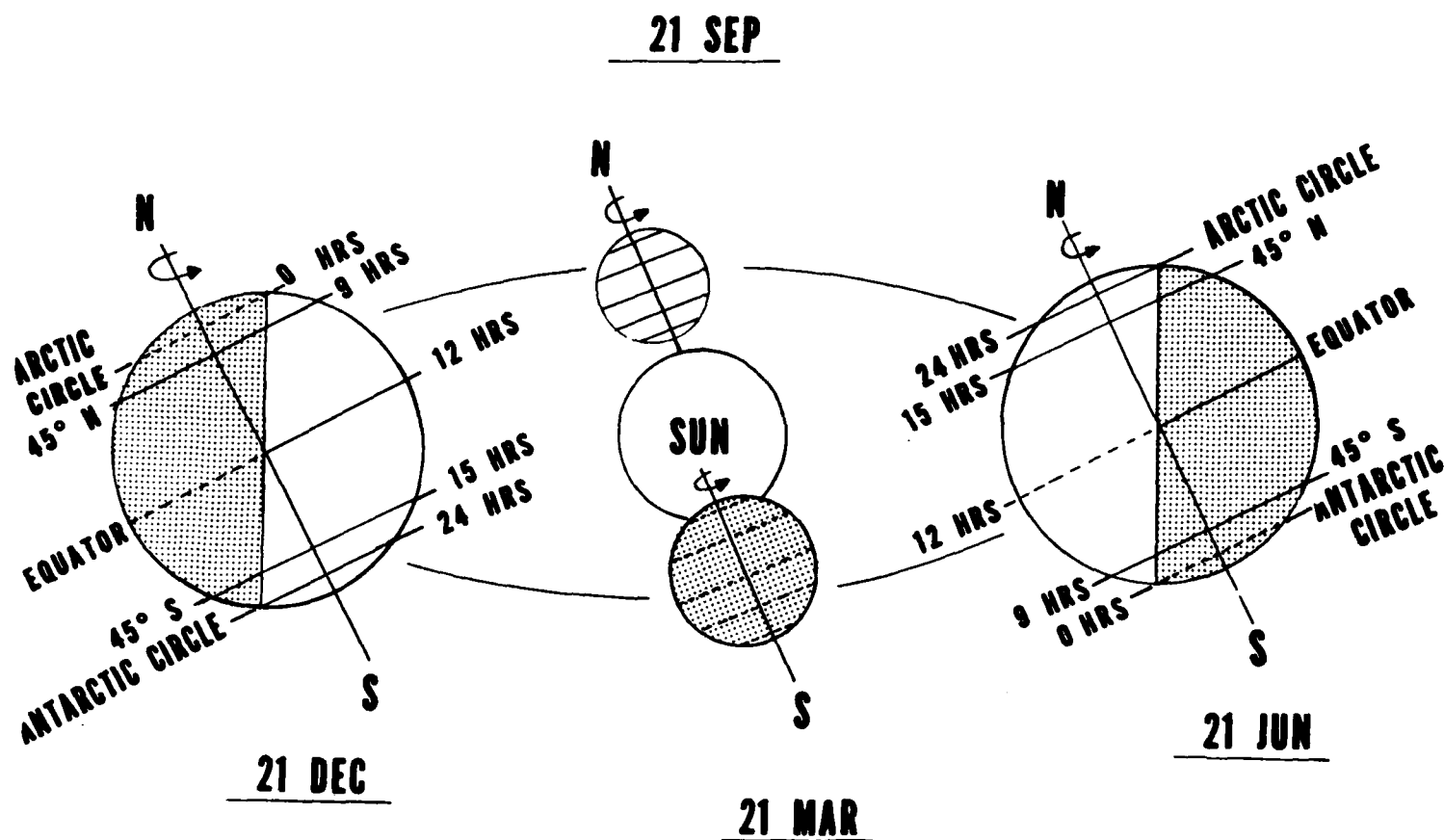


Figure 1. ILLUSTRATION OF EARTH'S ORBIT AND EFFECTS OF TILTED AXIS UPON LENGHT OF DAY (DATES VARY SLIGHTLY FROM YEAR TO YEAR).

Using the illustration, (Figure 1) state the approximate duration of daylight for the latitude 45° N. on the following dates:

- A. 21 December _____
- B. 21 March _____
- C. 21 June _____
- D. 21 September _____

ANSWER:

- A. 9 hours
- B. 12 hours
- C. 15 hours
- D. 12 hours

FRAME 2

The main reason that the times of sunrise/set, and the begin/end times of the twilights vary is because:

- ☐ A. of the obliquity of the ecliptic
- ☐ B. the poles wobble.
- ☐ C. the earth's orbit is an ellipse.
- ☐ D. the earth's axis is tilted 23 1/2° with respect to the plane of the earth's orbit.

ANSWER:

X D.

FRAME 3

The earth's axis tilt and other factors are taken into consideration by the Naval Observatory when they compute the times of sunrise/set and twilights, which are published in the Air Almanac. The published Almanac times are Greenwich Mean Time (GMT) or they are also called Universal Time (UT). "Mean time" is based on the assumption that the earth rotates about its axis at a constant velocity (actual changes from one day to the next are very slight) Because of this assumption, it's possible to establish the following relationship between time and the earth's rotation:

<u>TIME</u>	<u>ARC</u>
24 hours	360°
1 hour	15°
4 minutes	1°

A diagram of a celestial globe with concentric circles representing celestial equator and ecliptic. A vertical line represents the Greenwich meridian, labeled 'GREENWICH' and 'UPPER BR' at the top and 'LOWER BR' at the bottom. A diagonal line represents the observer's meridian, labeled 'OBSERVERS' and 'UPPER BR' at the top and 'LOWER BR' at the bottom. A dashed line represents the ecliptic, labeled 'UPPER BR' and 'LOWER BR' at the top and 'LOWER BR' at the bottom. A small circle with a cross inside represents the 'MEAN SUN' on the ecliptic. A large arrow points from the 'MEAN SUN' towards the bottom right. The labels 'GMT' and 'LMT' are placed near the top of the globe.

LMT is not useful to regulate our daily activities because it varies continuously with longitude since it is based on the position of the observer. LMT is useful in solar calculations because "for all places of the same latitude the corresponding phenomena will occur at approximately the same Local Mean Time (L.M.T.) and this will be approximately the same GMT. tabulated (Ed. Note. in the Air Almanac), since GMT. = L.M.T. at Greenwich. The disadvantage of using LMT to regulate our daily activities was overcome by the introduction of zone time. The world has been divided into 24 zones, each zone being 15° (or one hour) wide. Each zone uses the LMT of its central meridian as the standard time (local standard time (LST)) for the zone.

Below is a a replica of the list of contents (Figure 3) taken from an Air Almanac. The tables and graphs used in this programmed text have been underlined.

LIST OF CONTENTS

Pages	Contents
Inside front cover	Star list (57 stars) and G.H.A. interpolation tables
Daily pages	Ephemerides of Sun, Moon, Aries and planets; <u>moonrise and moonset</u>
F1-F2 (flap)	Star chart
F3 (flap)	Star list (57 stars) and G.H.A. interpolation tables
F4 (flap)	<u>Interpolation of moonrise and moonset for longitude</u> , and star index
A1-A3	Title page, preface, etc.
A4-A17	Explanation
A18-A19	List of symbols and abbreviations
A20-A23	<u>Standard times</u>
A24-A121	Sky diagrams
A122-A124	Planet location diagram
A125	Moonlight interference diagram; planet/star confusion table
A126-A129	Star recognition diagrams for periscopic sextants
A130-A145	<u>Sunrise, sunset and civil twilight</u>
A146-A152	Rising, setting and depression graphs
A153-A156	<u>Semi-duration graphs of sunlight, twilight and moonlight, in high latitudes</u>
A157	<u>Fraction of Moon illuminated</u>
A158-A163	Star list, 173 stars (accuracy 0'.1)
A164-A165	Interpolation of G.H.A. Sun and G.H.A. Aries (accuracy 0'.1)
A166	<u>Conversion of arc to time</u>
A167	<u>Polaris tables</u>
A168	Corrections for (total) refraction and Coriolis (Z) table
Inside back cover	Corrections to marine sextant observations and dome refraction

Figure 3. Air Almanac List of Contents

NO RESPONSE NECESSARY

FRAME 4

In the sunrise/set, and twilight tables the times are listed in Local Mean Time (LMT) for every third day for the specific latitudes shown at the side of the table. When there is less than a three minute change between the days listed, simply use the time listed for the nearest date. If the change is three minutes or more, you must interpolate for the date required. You must also interpolate between latitudes, if your latitude of interest is not listed.

Using the sample sunrise table in Figure 4, find the times (LMT) of sunrise for the following dates and latitudes:

- A. 3 December, 50° N. _____
- B. 13 December, 20° S. _____
- C. 29 November, 59° N. _____
- D. 1 December, 23° N. _____

A144

SUNRISE

Lat.	November				December											Jan.
	19	22	25	28	1	4	7	10	13	16	19	22	25	28	31	3
N 72	10 13	10 38	11 15													
70	09 29	09 43	09 59	10 15	10 32	10 50	11 12									
68	09 00	09 11	09 22	09 33	09 44	09 55	10 04	10 13	10 21	10 28	10 32	10 35	10 35	10 34	10 30	10 26
66	08 38	08 47	08 56	09 05	09 14	09 22	09 29	09 36	09 42	09 46	09 50	09 52	09 53	09 53	09 51	09 48
64	20	29	37	08 44	08 51	08 58	09 04	09 10	09 15	09 19	21	24	25	25	24	22
62	08 06	08 13	08 20	08 27	08 33	08 39	08 45	08 50	08 54	08 57	09 00	09 02	09 03	09 03	09 03	09 02
N 60	07 54	08 00	08 07	08 13	08 18	08 24	08 29	08 33	08 37	08 40	08 43	08 45	08 46	08 46	08 46	08 45
58	43	07 49	07 55	08 00	08 06	08 11	08 15	08 19	08 22	08 25	08 28	08 30	08 31	08 32	08 32	08 31
56	34	39	44	07 50	07 54	07 59	08 03	08 07	08 10	08 13	08 15	08 17	08 18	08 19	08 19	08 19
54	26	31	35	40	44	49	07 52	07 56	07 59	08 02	08 04	08 06	08 07	08 08	08 08	08 08
52	07 18	07 23	07 27	07 32	07 36	07 40	07 43	07 46	07 49	07 52	07 54	07 56	07 57	07 58	07 58	07 58
N 50	07 02	07 06	07 10	07 14	17	21	24	27	29	32	34	35	36	37	38	38
48	06 49	06 52	06 56	07 00	07 02	07 05	07 08	07 10	07 12	15	17	18	20	21	22	22
46	38	40	43	46	06 49	06 51	06 54	06 56	06 59	07 01	07 03	07 04	07 05	07 07	07 08	07 08
44	28	30	33	35	38	40	42	45	47	06 48	06 50	06 52	06 53	06 54	06 55	06 56
42	06 11	06 13	06 14	06 16	06 18	06 20	06 22	06 24	06 26	06 27	06 29	06 31	06 32	06 33	06 35	06 36
N 40	05 56	05 57	05 58	06 00	06 01	06 03	06 04	06 06	06 07	06 09	06 10	06 12	06 13	06 15	06 16	17
38	42	42	43	05 44	05 45	05 46	05 47	05 49	05 50	05 52	05 53	05 55	05 56	05 58	05 59	06 00
S 30	28	28	28	28	29	30	31	32	33	34	35	37	38	40	42	05 43
28	05 12	05 12	05 11	05 11	05 12	05 12	05 12	05 13	05 14	05 15	05 17	05 18	05 20	05 21	23	25
S 30	04 54	04 53	04 52	04 52	04 51	04 51	04 51	04 52	04 52	04 53	04 54	04 56	04 57	04 59	05 01	05 03
35	44	42	41	40	40	39	39	39	40	40	42	43	44	46	04 48	04 51
40	32	30	28	27	26	25	25	25	25	25	26	28	29	31	33	36
45	18	04 15	04 13	04 11	04 09	04 08	04 07	04 07	04 07	04 07	04 08	04 10	04 11	04 13	04 16	04 18
50	04 01	03 57	03 54	03 52	03 49	03 48	03 46	03 45	03 45	03 45	03 46	03 47	03 49	03 51	03 54	03 57
S 52	03 52	03 49	03 45	03 42	03 40	03 38	03 36	03 35	03 34	03 34	03 35	03 36	03 38	03 40	03 43	03 46
54	43	39	35	32	29	26	24	23	22	22	23	24	26	28	31	34
56	33	28	24	20	16	03 13	03 11	03 10	03 09	03 08	03 09	03 10	03 11	03 14	17	20
58	21	16	03 10	03 06	03 02	02 58	02 56	02 54	02 52	02 52	02 52	02 53	02 55	02 57	03 00	03 04
S 60	03 07	03 01	02 55	02 49	02 45	02 40	02 37	02 34	02 32	02 31	02 31	02 32	02 34	02 37	02 40	02 45

FIGURE 4. SAMPLE SUNRISE TABLE

NOTE: For the northernmost latitudes on this and similar tables you will see a number of symbols used. The symbols and their meanings are as follows:

 Sun continuously above the horizon.

 Sun continuously below the horizon.

//// Twilight lasts all night.

ANSWER:

- A. 0739 LMT
- B. 0514 LMT
- C. 0823 LMT
- D. 0624 LMT

CONVERSION OF ARC TO TIME

o	h m	o	h m	o	h m	o	h m	o	h m	o	h m	o	h m
0	0 00	60	4 00	120	8 00	180	12 00	240	16 00	300	20 00	0	0 00
1	0 04	61	4 04	121	8 04	181	12 04	241	16 04	301	20 04	1	0 04
2	0 08	62	4 08	122	8 08	182	12 08	242	16 08	302	20 08	2	0 08
3	0 12	63	4 12	123	8 12	183	12 12	243	16 12	303	20 12	3	0 12
4	0 16	64	4 16	124	8 16	184	12 16	244	16 16	304	20 16	4	0 16
5	0 20	65	4 20	125	8 20	185	12 20	245	16 20	305	20 20	5	0 20
6	0 24	66	4 24	126	8 24	186	12 24	246	16 24	306	20 24	6	0 24
7	0 28	67	4 28	127	8 28	187	12 28	247	16 28	307	20 28	7	0 28
8	0 32	68	4 32	128	8 32	188	12 32	248	16 32	308	20 32	8	0 32
9	0 36	69	4 36	129	8 36	189	12 36	249	16 36	309	20 36	9	0 36
10	0 40	70	4 40	130	8 40	190	12 40	250	16 40	310	20 40	10	0 40
11	0 44	71	4 44	131	8 44	191	12 44	251	16 44	311	20 44	11	0 44
12	0 48	72	4 48	132	8 48	192	12 48	252	16 48	312	20 48	12	0 48
13	0 52	73	4 52	133	8 52	193	12 52	253	16 52	313	20 52	13	0 52
14	0 56	74	4 56	134	8 56	194	12 56	254	16 56	314	20 56	14	0 56
15	1 00	75	5 00	135	9 00	195	13 00	255	17 00	315	21 00	15	1 00
16	1 04	76	5 04	136	9 04	196	13 04	256	17 04	316	21 04	16	1 04
17	1 08	77	5 08	137	9 08	197	13 08	257	17 08	317	21 08	17	1 08
18	1 12	78	5 12	138	9 12	198	13 12	258	17 12	318	21 12	18	1 12
19	1 16	79	5 16	139	9 16	199	13 16	259	17 16	319	21 16	19	1 16
20	1 20	80	5 20	140	9 20	200	13 20	260	17 20	320	21 20	20	1 20
21	1 24	81	5 24	141	9 24	201	13 24	261	17 24	321	21 24	21	1 24
22	1 28	82	5 28	142	9 28	202	13 28	262	17 28	322	21 28	22	1 28
23	1 32	83	5 32	143	9 32	203	13 32	263	17 32	323	21 32	23	1 32
24	1 36	84	5 36	144	9 36	204	13 36	264	17 36	324	21 36	24	1 36
25	1 40	85	5 40	145	9 40	205	13 40	265	17 40	325	21 40	25	1 40
26	1 44	86	5 44	146	9 44	206	13 44	266	17 44	326	21 44	26	1 44
27	1 48	87	5 48	147	9 48	207	13 48	267	17 48	327	21 48	27	1 48
28	1 52	88	5 52	148	9 52	208	13 52	268	17 52	328	21 52	28	1 52
29	1 56	89	5 56	149	9 56	209	13 56	269	17 56	329	21 56	29	1 56
30	2 00	90	6 00	150	10 00	210	14 00	270	18 00	330	22 00	30	2 00
31	2 04	91	6 04	151	10 04	211	14 04	271	18 04	331	22 04	31	2 04
32	2 08	92	6 08	152	10 08	212	14 08	272	18 08	332	22 08	32	2 08
33	2 12	93	6 12	153	10 12	213	14 12	273	18 12	333	22 12	33	2 12
34	2 16	94	6 16	154	10 16	214	14 16	274	18 16	334	22 16	34	2 16
35	2 20	95	6 20	155	10 20	215	14 20	275	18 20	335	22 20	35	2 20
36	2 24	96	6 24	156	10 24	216	14 24	276	18 24	336	22 24	36	2 24
37	2 28	97	6 28	157	10 28	217	14 28	277	18 28	337	22 28	37	2 28
38	2 32	98	6 32	158	10 32	218	14 32	278	18 32	338	22 32	38	2 32
39	2 36	99	6 36	159	10 36	219	14 36	279	18 36	339	22 36	39	2 36
40	2 40	100	6 40	160	10 40	220	14 40	280	18 40	340	22 40	40	2 40
41	2 44	101	6 44	161	10 44	221	14 44	281	18 44	341	22 44	41	2 44
42	2 48	102	6 48	162	10 48	222	14 48	282	18 48	342	22 48	42	2 48
43	2 52	103	6 52	163	10 52	223	14 52	283	18 52	343	22 52	43	2 52
44	2 56	104	6 56	164	10 56	224	14 56	284	18 56	344	22 56	44	2 56
45	3 00	105	7 00	165	11 00	225	15 00	285	19 00	345	23 00	45	3 00
46	3 04	106	7 04	166	11 04	226	15 04	286	19 04	346	23 04	46	3 04
47	3 08	107	7 08	167	11 08	227	15 08	287	19 08	347	23 08	47	3 08
48	3 12	108	7 12	168	11 12	228	15 12	288	19 12	348	23 12	48	3 12
49	3 16	109	7 16	169	11 16	229	15 16	289	19 16	349	23 16	49	3 16
50	3 20	110	7 20	170	11 20	230	15 20	290	19 20	350	23 20	50	3 20
51	3 24	111	7 24	171	11 24	231	15 24	291	19 24	351	23 24	51	3 24
52	3 28	112	7 28	172	11 28	232	15 28	292	19 28	352	23 28	52	3 28
53	3 32	113	7 32	173	11 32	233	15 32	293	19 32	353	23 32	53	3 32
54	3 36	114	7 36	174	11 36	234	15 36	294	19 36	354	23 36	54	3 36
55	3 40	115	7 40	175	11 40	235	15 40	295	19 40	355	23 40	55	3 40
56	3 44	116	7 44	176	11 44	236	15 44	296	19 44	356	23 44	56	3 44
57	3 48	117	7 48	177	11 48	237	15 48	297	19 48	357	23 48	57	3 48
58	3 52	118	7 52	178	11 52	238	15 52	298	19 52	358	23 52	58	3 52
59	3 56	119	7 56	179	11 56	239	15 56	299	19 56	359	23 56	59	3 56

The above table is for converting expressions in arc to their equivalent in time; its main use in this Almanac is for the conversion of longitude for application to L.M.T. (added if west, subtracted if east) to give G.M.T., or vice versa, particularly in the case of sunrise, sunset, etc.

Figure 5. Conversion of Arc To Time Table

FRAME 5

The sunset, and the morning and evening civil twilight tables are read just like the sunrise table. Remember, these times are the Local Mean Time (LMT) for the event, and can be converted to either Local Standard Time or Universal Time (GMT) by using the Conversion of Arc to Time table (Figure 5) of the Almanac. Notice that the conversion factor in the Arc to Time Table is simply 1° of longitude equals 4 minutes time. The first six columns of the table are the hours and minutes conversion, while the last column is the minutes and seconds conversion. For example, (using Figure 5) we will find the time difference corresponding to a longitude difference of $147^\circ 37'$. located 147° in the third column. you will find that 147° equals 9 hr 48 min and the $37' = 2$ min 28 sec. add them together:

$$\begin{array}{r} 9 \text{ hr } 48 \text{ min} \\ + \quad 2 \text{ min } 28 \text{ sec} \\ \hline 9 \text{ hr } 50 \text{ min } 28 \text{ sec} \end{array}$$

In computing these times, you can round off to the nearest minute. thus, the time difference corresponding to a longitude difference of $147^\circ 37'$ is 9 hr. 50 min.

Find the time difference corresponding to the following longitude differences. Round off the time to the nearest minute.

- A. $76^\circ 17'$ _____
- B. $14^\circ 55'$ _____
- C. $122^\circ 39'$ _____
- D. $120^\circ 16'$ _____

ANSWER:

- A. 5 hr 05 min
- B. 1 hr 00 min
- C. 8 hr 11 min
- D. 8 hr 01 min

FRAME 6

Using the Conversion of Arc To Time Table to convert LMT to GMT is fairly simple, since you are simply converting from your longitude position to the 0° Meridian. First, convert your longitude to time; then, add this conversion to LMT if your longitude is west, or subtract it from LMT if your longitude is east.

For example, here is the conversion of 0630 LMT to GMT for Langley AFB, Va, which is located at 76° 21' W.

$$\begin{array}{r} 76^{\circ} = 5 \text{ hr } 04 \text{ min} \\ + \quad 21' = \quad 01 \text{ min } 24 \text{ sec} \\ \hline 5 \text{ hr } 05 \text{ min } 24 \text{ sec} = 5 \text{ hr } 05 \text{ min} \\ \\ 6 \text{ hr } 30 \text{ min LMT} \\ + 5 \text{ hr } 05 \text{ min (added; longitude is west)} \\ \hline 11 \text{ hr } 35 \text{ min} = 1135 \text{ GMT} \end{array}$$

Convert 0630 LMT on 18 May to GMT for the following stations:

- | | | |
|------------------------|-------------|-------|
| A. Fulda, Germany | 9° 41' E. | _____ |
| B. Osan, Korea | 127° 02' E. | _____ |
| C. Brasilia, Brazil | 47° 56' W. | _____ |
| D. Amberley, Australia | 152° 43' E. | _____ |

ANSWER:

- A. 0552 GMT, 18 May
- B. 2202 GMT, 17 May
- C. 0942 GMT, 18 May
- D. 2019 GMT, 17 May

Frame 7

The easiest way to find LST using strictly the Air Almanac and nothing else is to simply find GMT, as you did in Frame 6, and apply the correction to standard time which is indicated in pages A20-A23 of the Air Almanac. NOTE: Standard Time corrections are also located in the Flight Information Publication (FLIP) pertaining to your Area of interest. The Standard Time zones are based on specific Standard Meridians which are normally spaced at 15° of longitude, either east or west, beginning with the Prime Meridian (0°); however, either geographical considerations or local law can be used to adjust Standard Time. Because the LST for your location must be figured using The Standard Meridian for your time zone, which is not necessarily the one closest to it, you must insure that the proper correction is applied. e.g. In eastern and western Kentucky there are 2 different time zones; Newfoundland has a Standard Time correction of +3 hrs 30 Minutes etc.

If you do know the Standard Meridian that is used for your time zone then you simply apply the correction as determined from the Arc to Time Table to the Local Mean Time listed in the Sunrise/set tables. Add the correction if you are west of the Standard Meridian and subtract the correction if you are east. This correction will normally be less than 1 hour, remember, because Standard Meridians are normally 15° apart, and 1° of longitude = 4 minutes time. (See the map on page 49)

Let's use Langley AFB, VA as an example of this last case. Langley, which is located at $37^\circ 05'$ N., $76^\circ 21'$ W. is in the Eastern Standard Time Zone which uses 75° West longitude as it's Standard Meridian. The LMT for sunrise on the 18th of March is 0608 LMT. What time does sunrise (LST) occur at Langley? Langley AFB, VA is located $1^\circ 21'$ West of the Standard Meridian and this equates to a correction of 5 minutes ($1^\circ 21' = 5 \text{ min } 24 \text{ sec}$ which rounds off to 5 min). The correction added to the published LMT, indicates a sunrise time at Langley AFB on 18 March of 0613 LST.

Find time of sunrise (LST) for the following stations using a time of 0630 LMT:

	<u>Standard Meridian</u>	
A. Fulda, Germany (9° 41' E.)	15° E.	_____
B. Osan, Korea (127° 02' E.)	135° E.	_____
C. Brasilia, Brazil (47° 56' W.)	45° W.	_____
D. Amberley, Australia (152° 43' E.)	150° E.	_____

ANSWER:

- A. 0651 LST
- B. 0702 LST
- C. 0642 LST
- D. 0619 LST

FRAME 8

Some locations use Daylight Savings Time (LDT). For an indication of which countries use LDT see the Standard Time tables pp. A20-23 or the applicable Flight information Publication for your area of interest. To convert to Daylight Savings Time (LDT) you just add 1 hour to the LST.

Using the following Figure (Figure 6) and the Conversion of Arc to Time Table (Figure 5), find the LDT of sunset on 11 September for the following stations:

Standard Meridian

- A. Fulda, FRG. (50° 33' N. 9° 41' E.) 15° E. _____
- B. Langley AFB, Va (37° 05' N. 76° 21' W.) 75° W. _____
- C. Brasilia, Bra. (15° 51' S. 47° 56' W.) 45° W. _____
- D. Amberley, Aus. (27° 39' S. 152° 43' E.) 150° E. _____

SUNSET

Lat.	August						September												Oct.
	15	18	21	24	27	30	2	5	8	11	14	17	20	23	26	29	2		
N 72	h m 21 45	h m 21 24	h m 21 04	h m 20 40	h m 20 28	h m 20 11	h m 19 54	h m 19 38	h m 19 22	h m 19 06	h m 18 50	h m 18 34	h m 18 19	h m 18 03	h m 17 48	h m 17 33	h m 17 17		
70	21 13	20 57	20 41	25	20 10	19 50	41	27	12	18 58	44	30	16	02	49	35	21		
68	20 50	30	23	20 10	19 50	44	31	18	19 05	52	39	27	14	02	49	36	24		
66	34	20	20 09	19 57	45	34	22	10	18 59	47	35	24	12	01	49	38	26		
64	18	20 07	19 57	40	30	25	15	19 04	54	43	32	22	11	00	50	39	29		
62	20 06	19 50	47	37	28	18	09	18 59	49	39	29	19	10	18 00	50	40	30		
N 60	19 55	19 47	19 38	19 29	19 21	19 12	19 03	18 54	18 45	18 36	18 27	18 17	18 08	17 59	17 50	17 41	17 32		
58	40	39	31	23	15	06	18 58	50	41	33	24	16	07	59	50	42	34		
56	39	31	24	17	09	19 02	54	46	38	30	22	14	06	58	51	43	35		
54	34	25	18	11	04	18 57	50	43	35	28	21	13	06	58	51	43	36		
52	25	19	13	07	19 00	53	47	40	33	26	19	12	05	58	51	44	37		
N 50	19 20	19 14	19 08	19 02	18 56	18 50	18 44	18 37	18 31	18 24	18 18	18 11	18 04	17 58	17 51	17 45	17 38		
45	19 08	19 03	18 58	18 53	48	44	37	31	26	20	14	09	03	57	52	46	40		
40	18 58	18 54	50	45	41	30	31	26	22	17	12	07	02	57	52	47	42		
35	49	40	42	38	34	31	26	22	18	14	10	05	01	57	52	48	44		
30	14	39	30	33	29	26	22	19	15	11	08	04	18 00	56	53	49	45		
N 20	18 20	18 27	18 25	18 23	18 20	18 18	18 15	18 13	18 10	18 07	18 04	18 02	17 59	17 56	17 53	17 51	17 48		
N 10	18	17	15	14	12	11	09	07	05	03	18 02	18 00	58	56	54	52	50		
0	18 08	18 07	18 07	18 06	18 05	18 04	18 03	18 02	18 01	18 00	17 59	17 58	57	56	55	54	53		
S 10	17 58	17 58	17 58	17 58	17 58	17 58	17 58	17 57	17 57	17 57	57	56	56	56	56	56	55		
20	47	48	49	50	50	51	52	52	53	54	54	55	55	56	57	57	57 58		
S 30	17 35	17 37	17 39	17 40	17 42	17 43	17 45	17 47	17 48	17 50	17 51	17 53	17 55	17 56	17 58	18 00	18 01		
35	28	30	33	35	37	39	41	44	46	48	50	52	54	57	59	01	04		
40	20	23	26	29	32	34	37	40	43	46	48	51	54	57	18 00	03	06		
45	13	15	18	22	25	29	32	36	39	43	46	50	54	57	01	05	08		
50	17 00	05	09	13	18	22	27	31	35	40	44	49	53	58	02	07	12		
S 52	16 55	17 00	17 05	17 09	17 14	17 19	17 24	17 29	17 34	17 38	17 43	17 48	17 53	17 58	18 03	18 08	18 13		
54	50	16 55	17 00	05	11	16	21	26	32	37	42	47	53	58	04	09	15		
56	43	49	16 55	17 01	06	12	18	24	29	35	41	47	53	58	04	10	16		
58	37	43	49	16 55	17 02	08	14	21	27	33	40	46	52	59	05	12	18		
S 60	16 29	16 36	16 42	16 49	16 56	17 03	17 10	17 17	17 24	17 31	17 38	17 45	17 52	17 59	18 06	18 13	18 21		

Figure 6. Sunset Table.

ANSWER:

A. 1946 LDT

B. 1920 LDT

C. 1807 LST

D. 1740 LST

Why not LDT? Because it's not summer in the southern hemisphere! Gotcha!!!!

PROGRESS CHECK

FRAME 9:

Using the extracts from the four sun-event tables provided below and the Conversion of Arc to Time table in figure 5, find the Local Standard Times for the start of morning civil twilight, sunrise, sunset, and the end of civil twilight on 1 January for the following stations:

A. Langley AFB, Va (37° 05' N. 76° 21' W.)

B. Amberley, Aus. (27° 39' S. 152° 43' E.)

AM Twilight

Sunrise

Sunset

PM Twilight

A. _____

B. _____

Lat.	Dec.	30	2
N 72	10 48	10 40	
70	09 52	09 48	
68	09 18	09 10	
66	08 54	08 52	
64	35	34	
62	19	18	
N 60	08 06	08 05	
58	07 54	07 54	
56	44	44	
54	36	35	
52	28	28	
N 50	07 20	07 20	
45	07 04	07 05	
40	06 51	06 52	
35	40	40	
30	29	30	
N 20	06 10	06 11	
N 10	05 53	05 54	
0	30	38	
S 10	05 19	05 20	
20	04 58	05 00	
S 30	04 33	04 36	
35	18	21	
40	04 00	04 03	
45	03 38	03 41	
50	03 09	03 12	
S 52	02 54	02 58	
54	37	40	
56	02 15	02 19	
58	01 46	01 51	
S 60	01 00	01 08	

Lat.	Dec.	30	2
N 72	10 48	10 40	
70	09 52	09 48	
68	09 18	09 10	
66	10 31	10 26	
64	09 51	09 49	
62	24	22	
N 60	09 03	09 02	
58	08 46	08 45	
56	32	31	
54	19	19	
52	08 08	08 08	
N 50	07 58	07 58	
45	38	38	
40	22	22	
35	07 08	07 08	
30	06 55	06 56	
N 20	06 34	06 35	
N 10	06 16	06 17	
0	05 59	06 00	
S 10	42	05 43	
20	23	25	
S 30	05 01	05 03	
35	04 48	04 50	
40	33	36	
45	04 15	04 18	
50	03 53	03 56	
S 52	03 43	03 46	
54	30	34	
56	16	20	
58	03 00	03 04	
S 60	02 40	02 44	

Lat.	Dec.	30	2
N 72	10 48	10 40	
70	09 52	09 48	
68	09 18	09 10	
66	13 34	13 42	
64	14 14	14 20	
62	14 41	14 46	
N 60	15 02	15 06	
58	20	23	
56	34	37	
54	46	15 50	
52	15 57	16 00	
N 50	16 07	16 10	
45	27	30	
40	44	16 41	
35	16 58	17 00	
30	17 10	17 12	
N 20	17 31	17 33	
N 10	17 49	17 51	
0	18 06	18 08	
S 10	24	25	
20	18 42	18 43	
S 30	19 04	19 05	
35	17	18	
40	32	32	
45	19 50	19 50	
50	20 12	20 12	
S 52	20 22	20 22	
54	34	34	
56	20 48	20 47	
58	21 05	21 03	
S 60	21 25	21 23	

Lat.	Dec.	30	2
N 72	13 18	13 20	
70	14 13	14 20	
68	14 47	14 52	
66	15 11	15 16	
64	30	35	
62	46	15 50	
N 60	15 59	16 03	
58	16 11	16 14	
56	21	24	
54	30	33	
52	38	41	
N 50	16 45	16 48	
45	17 01	17 04	
40	15	17	
35	20	23	
30	36	38	
N 20	17 55	17 57	
N 10	18 12	18 14	
0	29	30	
S 10	18 47	18 48	
20	19 07	19 08	
S 30	19 32	19 32	
35	19 47	19 47	
40	20 05	20 05	
45	20 27	20 27	
50	50	20 55	
S 52	21 11	21 10	
54	28	27	
56	21 50	21 48	
58	22 18	22 15	
S 60	23 03	22 57	

Figure 7. Sun Events Tables

ANSWER:

A. 0650,0719,1659,1728

B. 0430,0457,1849,1915

(Answers within one minute of these can be considered correct because of the interpolation involved.)

ONE FINAL NOTE: Nautical and Astronomical Twilight times are not provided in the Air Almanac, but can be estimated by using the time difference between sunrise and start of civil twilight, or sunset and end of civil twilight. Add the difference to end of Civil Twilight to get the end of nautical twilight; add the difference again to get end of astronomical twilight. For corresponding start of twilight times, subtract the difference from starts of civil twilight etc.

So far, you have learned how to find times of sunrise/set, and the twilights between the latitudes of 72° North and 60° South. Although the Air Almanac does not cover the area south of 60° South latitude, it does cover the area north of 72° North. The next few frames will explain these graphs.

****NO RESPONSE NECESSARY****

FRAME 10:

An example of a Semiduration of Sunlight Graph is shown below.

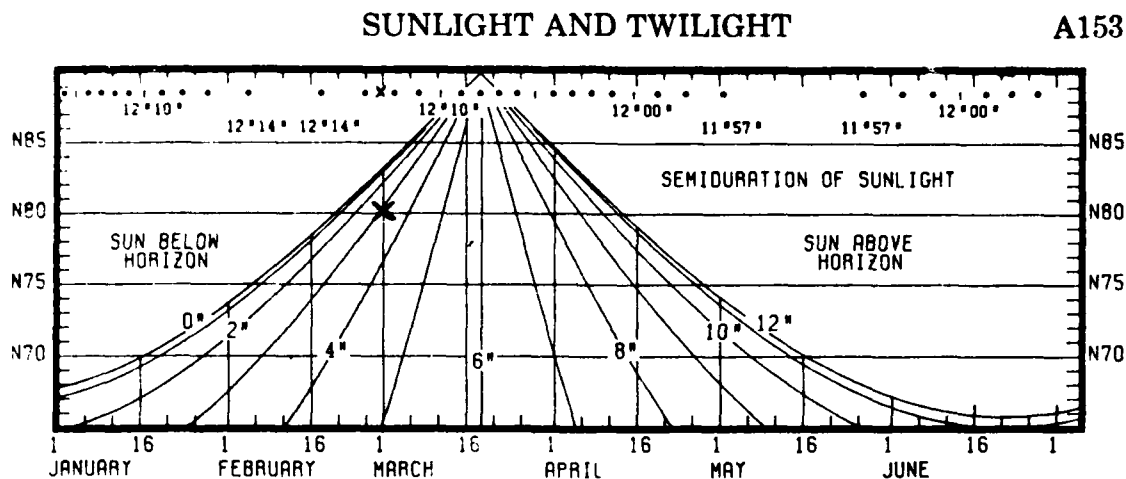


Figure 8. Semiduration of Sunlight

The graph covers a six-month period; the months are indicated across the bottom. Every fifth day there are tick marks; they are depicted along the top and bottom of each chart. The sides of the graph indicate latitudes from 65° North to 90° North. Across the top you also see time in hours and minutes, e.g. 12H 14metc. These times are the times of meridian passage which can be read to the nearest minute for each day. Meridian passage is the time that the sun passes your longitude; i.e. the time of apparent noon during each 24-hour period. The skewed lines on the graph are the semiduration lines. They show the number of hours of sunlight that will occur before and after the meridian passage--hence the term "semiduration". "Sun below horizon" and "Sun above horizon" are self-explanatory. In the regions of the graph that you find difficult to interpret, the phenomena themselves are generally speaking, uncertain.

FRAME 10 (contd)

Here's an example of how to read the graph to find the sunrise/set times on 1 March at 80° North (using figure 8): first, follow the "1 March" line to the top of meridian passage. An "x" has been placed there, between 12h 14m and 12h 10 m, or approximately 12h 12m. Thus, the meridian passage time on 1 March for any meridian is 12h 12m LMT. Next proceed along the line to your latitude of interest (80° N.). An "x" has also been placed at that point. This point lies approximately on the skewed line labelled "3h." Therefore, the semiduration of sunlight on 1 March at 80° North latitude is 3 hours. With 3 hours sunlight before and after the meridian passage time you can now compute the sunrise to be 0912 LMT (12 - 3h = 0912) and the sunset to be 1512 LMT (12h 12m + 3h = 1512) Now it's your turn! Use figure 8 and find local mean times of sunrise/set for the following dates and latitudes. (A clear straight edge will be useful here.)

		<u>Sunrise</u>	<u>Sunset</u>
A.	16 April, 80° N.	_____	_____
B.	10 February, 70° N.	_____	_____
C.	15 March, 78° N.	_____	_____
D.	1 April, 73° N.	_____	_____

ANSWER:

- A. Sun continuously above horizon.
 B. 0854 LMT 1534 LMT
 C. 0639 LMT 1739 LMT
 D. 0449 LMT 1919 LMT

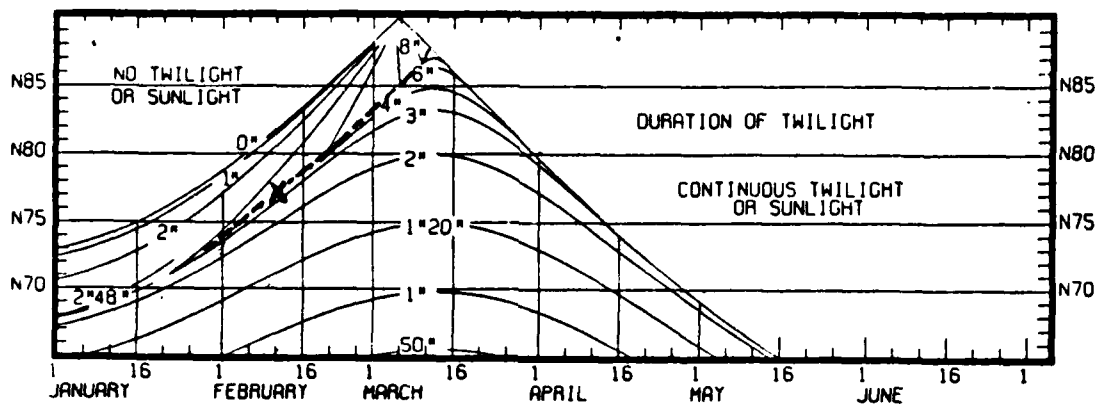


Figure 9. Duration of Twilight Graph

The Duration of Twilight graph (Figure 9) is similar to the Semiduration of Sunlight graph; but notice that the skewed hour lines are not smoothly curved as they are on the sunlight graph. They are kinked in places. These kinks, if superimposed onto the corresponding sunlight graph, would fall on the "0h" line, and along this line the sunrise may or may not occur. We have drawn a dashed line in the example which enables us to define the four areas in the chart as follows:

Area A - No Twilight or sunlight. In this area the sun never gets within 6° of the horizon.

Area B - This is the area where the sun is continuously below the horizon but does get near enough (within 6°) to the horizon during a portion of the day that there is twilight. The value determined in this region of the graph is actually the interval between the beginning of twilight and the time of meridian passage.

Area C - This value when applied to the time of sunrise (-) or sunset (+) gives you the amount of available twilight

Area D - Continuous Twilight or Sunlight - self-explanatory.

FRAME 11 (contd)

Let's work an example to show just how this graph works (see figure 8) on a worst case scenario. We want to find out the amount of twilight available on 11 February at 77° North (Point "x"). As you can see it sits in the heart of the transition zone between sunrise and no sunrise. The first thing we do is draw a dotted line connecting the kinks in the hour lines. Point "x" is located between the "3h" lines, so we must interpolate between the 3h and 4h lines to get a usable value to work with. It is located about 2/3 of the way (2/3 of 60 min = 40 minutes), so the correct value of twilight is 3h 40 min. The sun may or may not rise completely above the horizon on this date at this position. A good light forecast for this date would be 7 hrs 20 minutes of twilight, with the possibility of the sun actually being visible for a few minutes around the time of meridian passage.

Now, you work a few examples. Find the total duration of twilight (using figure 9) for the following dates:

- A. 16 January, 78° N. _____
- B. 1 February, 73° N. _____
- C. 31 March, 80° N. _____
- D. 16 February, 80° N. _____

ANSWER:

- A. No Twilight or sunlight.
- B. 6 hr 00 min.
- C. Continuous twilight or sunlight.
- D. 6 hr 40 min.

FRAME 12

The Duration of Twilight (Figure 11) graph is read in conjunction with the Semiduration of Sunlight graph (Figure 10). Notice that the twilight graph does not have the times for meridian passage on it. However, since the twilight graph is always placed directly underneath the sunlight graph in the Air Almanac, the meridian passage time can be obtained with a straightedge, if necessary.

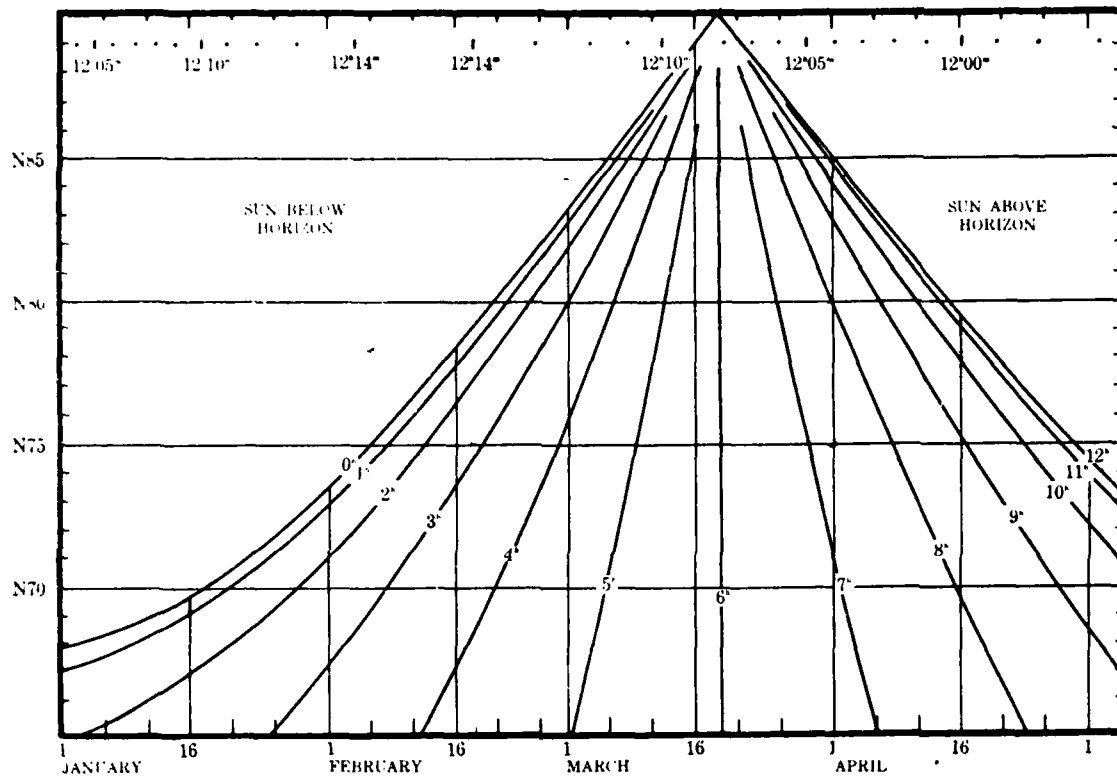


Figure 10. Semiduration of Sunlight

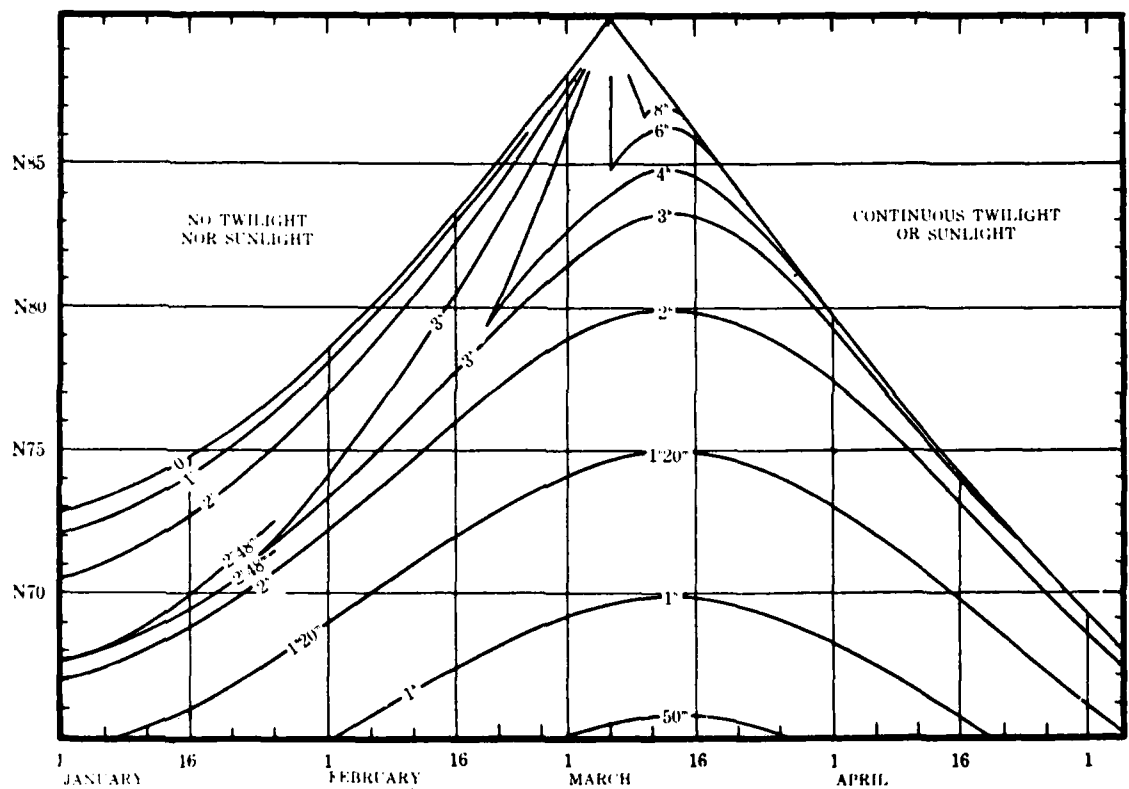


Figure 11. Duration of Twilight

FRAME 12 (contd)

Let's recap the steps for finding the times of sunrise/set, and twilight times in the 65° to 90° North latitude region.

1. Find the time of meridian passage.
2. Find the Semiduration of Sunlight.
3. Apply the value to the meridian passage time for sunrise (subtract) and sunset (add).
4. Find the duration of twilight.
5. Apply the value to the sunrise time (subtract) for begin time of morning twilight and to the sunset (add) to obtain the end of evening twilight.
6. Remember, even if there is no sunrise or sunset there can still be twilight. Subtract the value from the meridian passage time for beginning time; add the value to the meridian time to compute the end time of twilight.

Now let's find the local mean times (using Figures 9 and 10) for all of the events listed below:

	<u>BEGIN TWI</u>	<u>SUNRISE</u>	<u>SUNSET</u>	<u>END TWI</u>
A. 18 February, 75° N.	_____	_____	_____	_____
B. 16 April, 78° N.	_____	_____	_____	_____
C. 1 March, 84° N.	_____	_____	_____	_____
D. 1 April, 75° N.	_____	_____	_____	_____

ANSWER:

- A. 0744, 0924, 1504, 1644
B. Continuous, 0200, 2200, Continuous
C. 0722, None, None, 1702
D. 0304, 0444, 1924, 2104

(Twilight times within 15 minutes of our answers may be considered as correct)

FRAME 13

To compute the sun's azimuth and elevation at a specific time and place, you must use the daily pages and Interpolation of GHA Table in the Air Almanac.

You will need a hand-held calculator; there are numerous programs available for both the TI-59, and HP 41 calculators. Programs are also being developed for microcomputers. See AWS TC 8X/001 for a listing of available programs. They are simple to use; just fill in the values from the Air Almanac, as directed.

NOTE: The time of sunrise/set is given as the time the observer on earth would first see the upper edge of the sun along the horizon. However, solar altitude is determined by the position of the sun's center not it's edge. Consequently, the time that the solar altitude equals 0° may not exactly match the time of sunrise/set.

NO RESPONSE NECESSARY

FRAME 14

You should now be able to calculate sunrise/set, and twilight times for any point North of 60° S. The next few frames will teach you how to find moonrise and moonset times for the same area. Their organization in the Air Almanac is the same as for sun times; there are tables for latitudes between 72° N. and 60° S., and graphs for latitudes between 65° and 90° N. Before discussing how to read these tables and graphs, let's look at some of the reasons that make them necessary.

NO RESPONSE NECESSARY

FRAME 15

The moon revolves around the earth once every 28 days or so. The phases of the moon are caused by its position in its orbit. Using figure 12 you can see how the moon is viewed from earth, by looking at the outer figures at each position. From space the moon can be

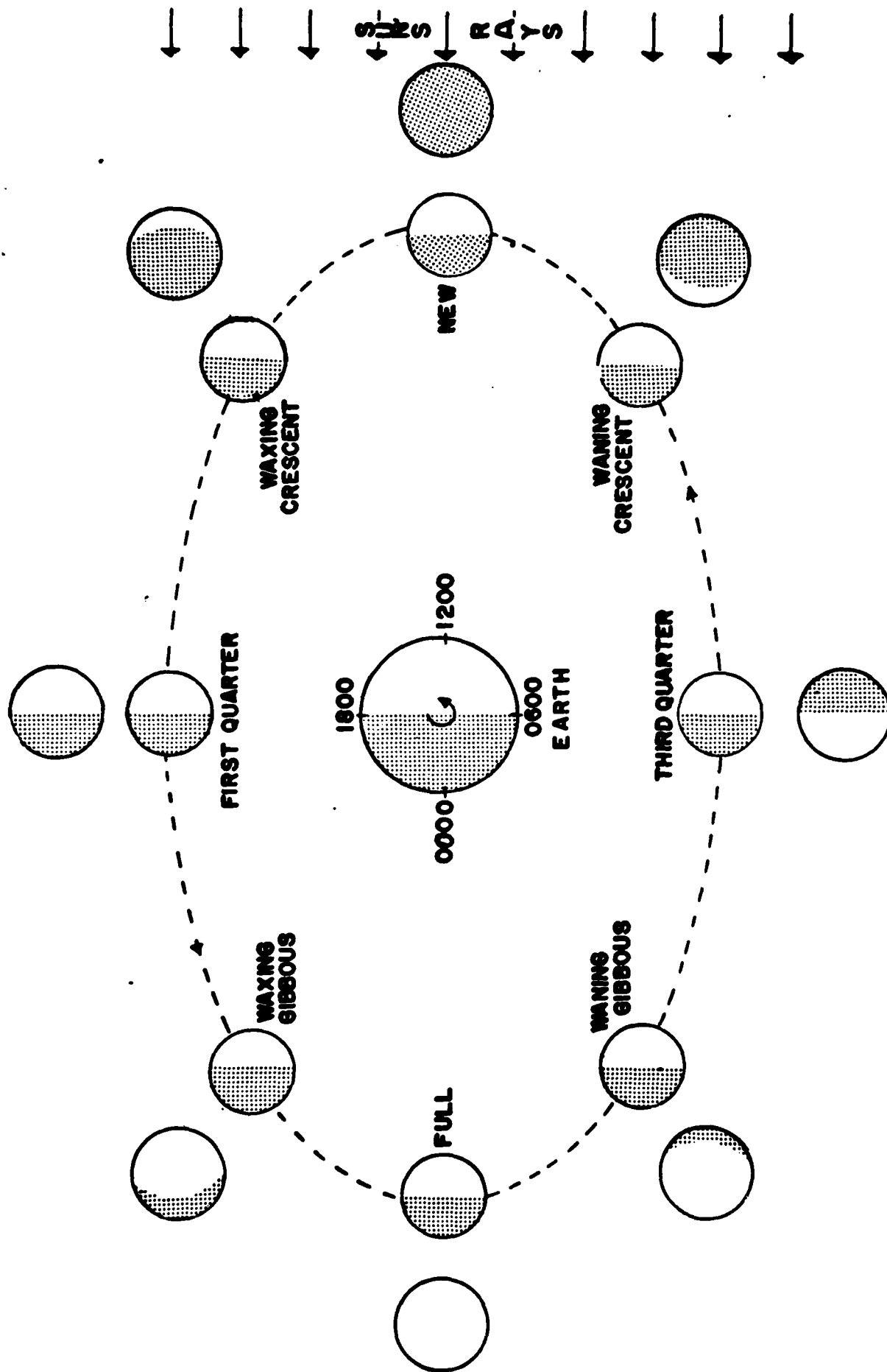


Figure 12. ILLUSTRATION OF LUNAR ORBIT AND PHASES

FRAME 15 (contd)

seen as half-illuminated at all times (the inner figures).

The 24 hour clock face around the earth illustrates to you how you can obtain a rough estimate of the times of moonrise and moonset by the phase of the moon. Look at the full moon portion of the diagram, which is adjacent to 0000 time on the clock face. The full moon crosses the meridian around midnight. Imagine that you are at a point on the right edge of the clock-face earth. As this point turns counter-clockwise (direction of the arrow), the full moon becomes visible as you approach the 1800 position. Moonrise occurs at about 1800 for a full moon. Continuing around the clock face, the moon would recede from your view at about 0600. Moonset occurs around 0600 for a full moon.

In other words, the moon is "full" because it is located on the side of the earth opposite the sun. We tell time on earth by our position in the daily rotation of the earth with respect to the sun. A full moon can only be seen from earth from about 1800 to 0600 because of the mechanics of the situation.

EXCEPTION: In extremely high latitudes, the mechanics get more complicated due to the axis tilt and other irregularities that will be dealt with in succeeding frames.

The other phases of the moon are only visible between certain hours for the same reasons.

Using Figure 12, state the approximate times of moonrise and moonset for:

	<u>MOONRISE</u>	<u>MOONSET</u>
A. Third Quarter Moon	_____	_____
B. Full Moon	_____	_____
C. First Quarter Moon	_____	_____

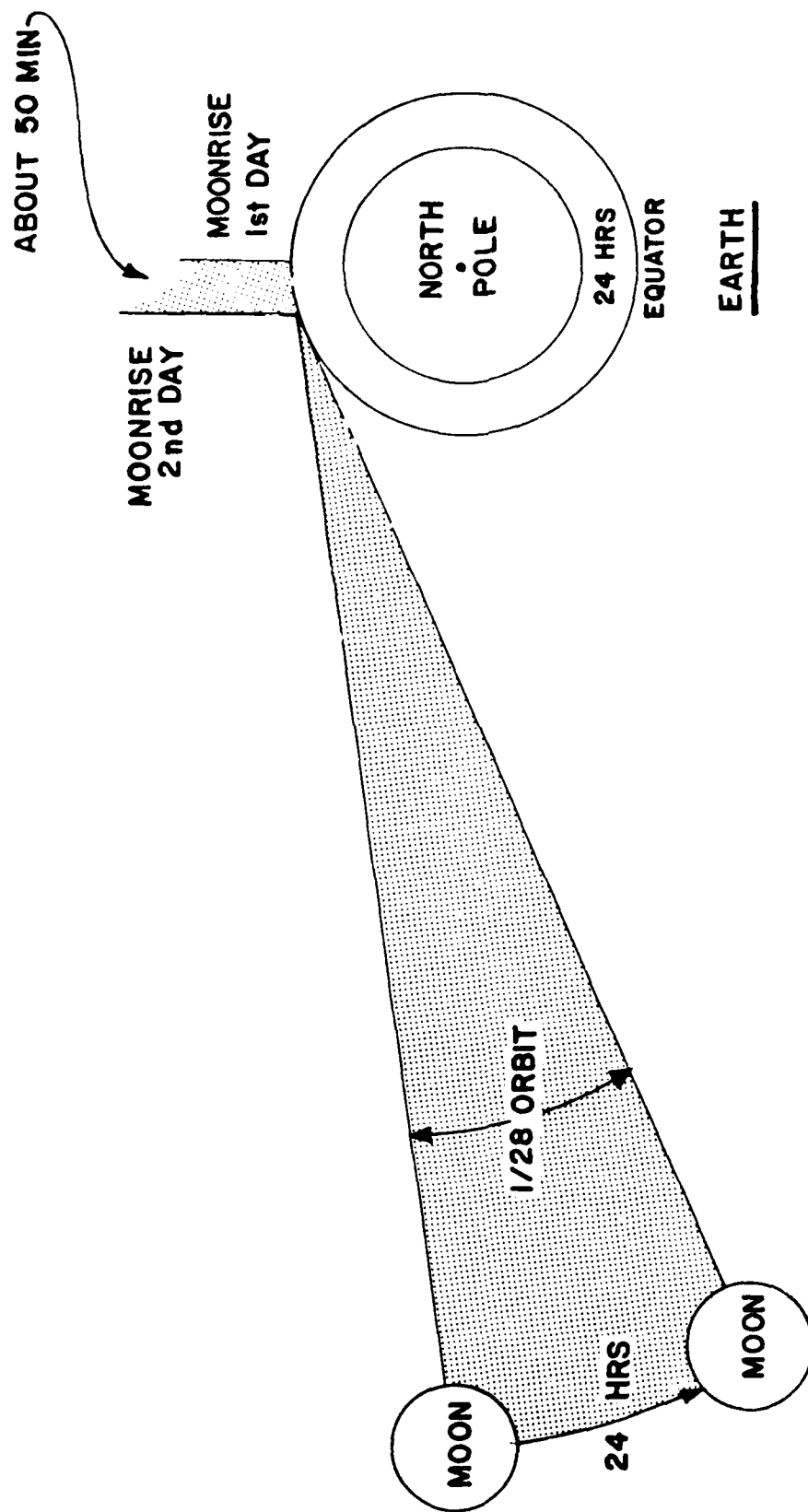


Figure 13. ILLUSTRATION OF HOW CONSTANT ORBITAL SPEED AND ZERO ORBITAL ANGLE WOULD AFFECT MOONRISE TIMES

ANSWER:

- A. 0000 1200
- B. 1200 0600
- C. 1200 0000

FRAME 16

Two factors cause moonrise and moonset times to change from day to day. They are the moon's orbital speed and its orbital angle. Let's see if we can explain that more fully. Assume that both the moon's orbital speed and angle are constant. This would result from the idealized situation of the moon being in a circular orbit directly above the equator. The moon orbits the earth once every 28 days; this equates to $1/28$ of its orbit being completed every 24 hours. $1/28$ of 24 hours equals approximately 51 minutes. Now, with the moon making a circular orbit in the same direction that the earth turns this would mean that the moonrise/set would occur about 51 minutes later each day (See Figure 13).

The exaggerated illustration in Figure 12 looks down on the earth at the North Pole with the equator the edge of the circle. The earth is rotating clockwise and the moon is orbiting in the same direction. Therefore, each day (24 hours) when a standard meridian on earth makes a complete revolution, it must continue on for 51 more minutes for the moon to come in view. Consequently, moonrise occurs 51 minutes later each day.

Because of it's orbital speed, the moon would rise about 51 minutes later each day if the moon's orbit was:

- A. Elliptical and inclined to the equator.
- B. Circular, and directly above the equator.

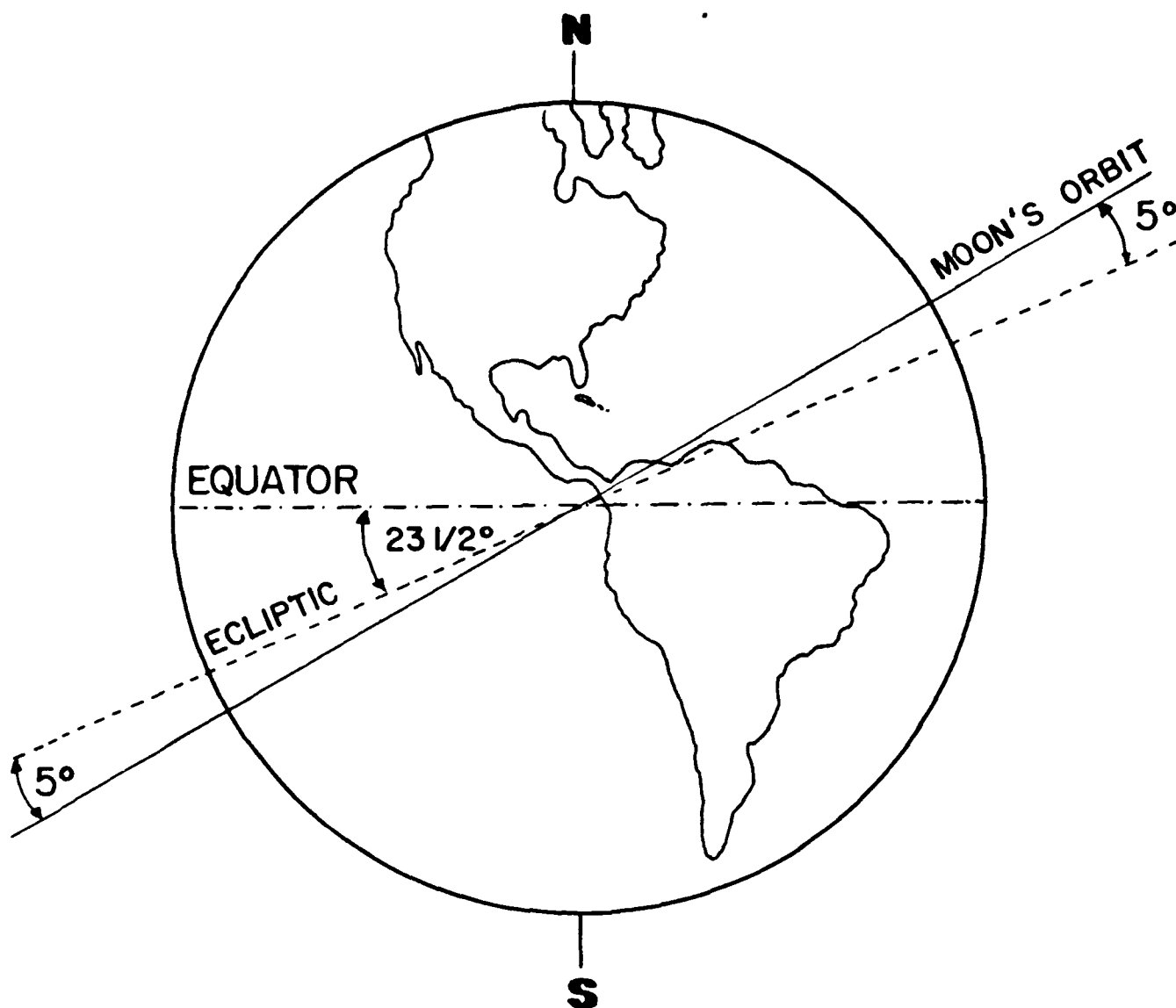


Figure 14. ECLIPTIC AND ORBITAL PATH OF MOON RELATIVE TO EQUATORIAL PLANE OF EARTH

ANSWER:

A. Circular and directly above the equator.

FRAME 17

With the moon in a circular orbit above the equator, moonrise would occur about 51 minutes later each day for all positions on the earth (except the poles). However, the moon is, in fact, neither in a circular orbit, nor does it orbit directly over the equator. What does this mean? Well, for any one position in the low and mid latitudes the moon does rise about 51 minutes later each day, but the difference along a single meridian longitude can vary more than 6 hours between 60° S. and 72° N. This is mainly because of the moon's orbital angle. Rather than orbiting directly above the equator the moon moves both north and south of the equator during each orbit. When the moon is in the northern part of its orbit, it can be seen earlier by northern observers than by those to the south, and vice versa.

Earlier, you learned that the sun moves $23\frac{1}{2}^{\circ}$ north and south of the equator during the course of a year because of the earth's axis tilt. The apparent path of the sun across the sky is called the ecliptic. The ecliptic crosses the equator at an angle of $23\frac{1}{2}^{\circ}$. The moon's path crosses the ecliptic at an angle of 5° . The point where they intersect moves around the ecliptic in a little more than 18 years, causing the angle at which the moon crosses the equator to vary between $18\frac{1}{2}^{\circ}$ and $28\frac{1}{2}^{\circ}$. These apparent paths are illustrated in Figure 14.

Moonrise varies by latitude along a particular meridian of longitude mainly because of the moon's:

- A. orbital speed.
- B. orbital angle.
- C. elliptical orbit
- D. circular orbit.

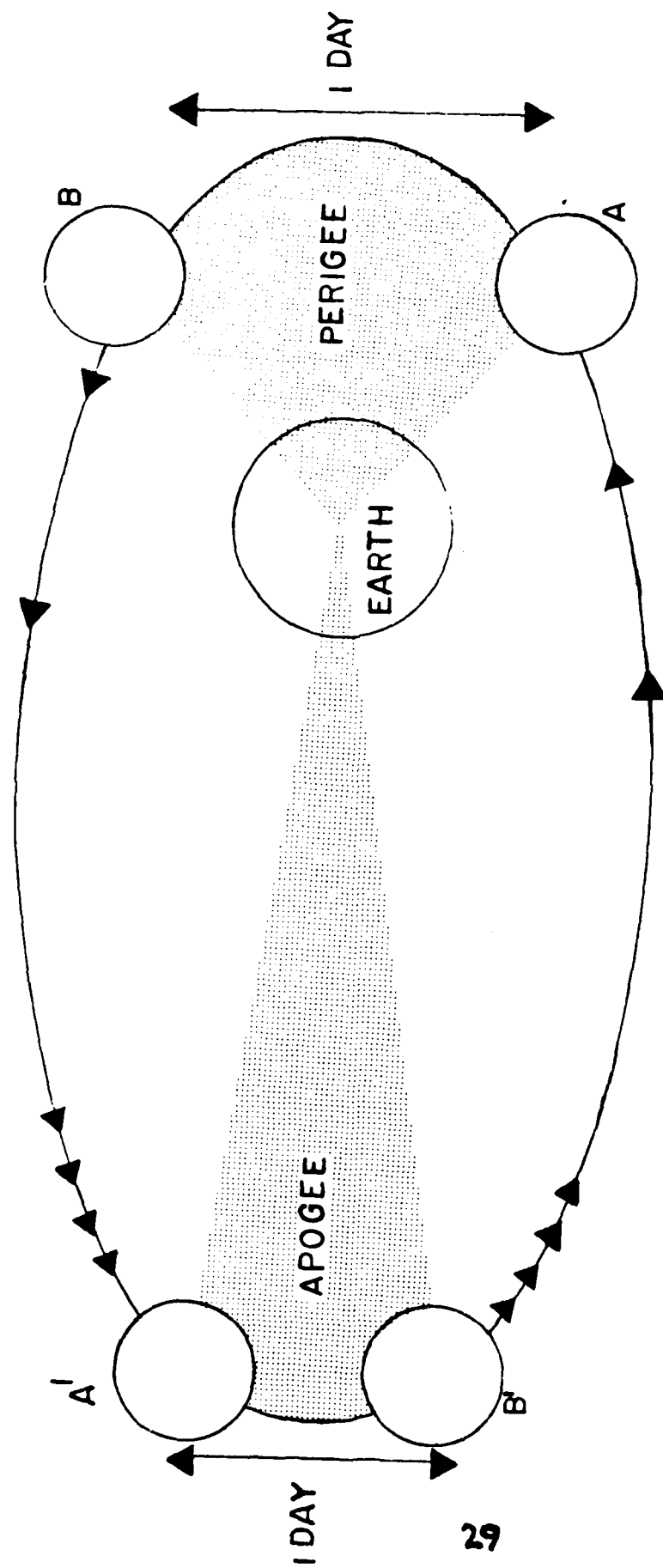


FIGURE 15. ILLUSTRATION OF NON-UNIFORM ORBITAL SPEED OF MOON

FRANK: _____

ANSWER:

F: _____

First, the orbit is not perfectly circular, it is elliptical. This means that the moon is closer at times (perigee) and farther away at times (apogee). The Law of Equal Areas, which is part of Kepler's Laws, states that the moon moves faster in its orbit when it is closer to the earth and slower when it is farther away. This much is understood. It is stated the moon's non-uniform orbital speed is due to its elliptical orbit. The distance from A to B represents one day at perigee, the distance from A' to B' represents one day at Apogee.

Kepler's Law states that equal orbital areas are swept out in equal amounts of time. In other words, the two triangles have equal areas but are of different shapes. The moon is moving faster from A to B than from A' to B'. Moonrise at B would be more than 50 minutes later than at A, because the earth would have to turn farther. Conversely moonrise at B' would occur less than 50 minutes later than at A', because the earth would not have to turn so far. The moon's elliptical orbit causes it's orbital speed to be:
A. Faster at perigee than at apogee.
B. Slower at perigee than at apogee.

AN: WFL:

A: Faster.

FRANK: _____

When we talk about the moon's day to day motion, it is mostly because of the moon's _____ and orbital _____.

ANSWER:

Speed; Angle (either order)

FRAME 19

The last few frames have shown that, although you can get a rough idea of moonrise/set times by the phases of the moon, specific times can only be obtained by considerations and calculations of data which include the moon's orbital speed and orbital angle. Next we will cover calculating the moonrise/set data from the Air Almanac. It is true that the data from the Almanac seems a little complicated, you should now have some appreciation for the calculations involved. NOTE: Although it requires no calculation, Fractional Illumination data is provided in the Air Almanac. See the index for the exact page number.

****NO RESPONSE NECESSARY****

FRAME 20

To find moonrise/set times between 60° S. and 72° N. from the Air Almanac, you must use three different sets of tables. They are:

- a. Moonrise, Moonset data (Daily Pages).
- b. Interpolation of Moonrise, Moonset for Longitude.
- c. Conversion of Arc to Time Table.

The moonset and moonrise tables are found in the upper right hand corner of each daily page. They alternate, with moonset on the left page and moonrise on the right page of each opening. The next two pages (Figures 16 and 17) are excerpts of complete daily pages with the moonrise and moonset tables circled.

NO RESPONSE NECESSARY

GMT (UT)	SUN		ARIES		VENUS-3.9		MARS 1.7		JUPITER-2.8		MOON		lat	Moon- rise	Diff
	GHA	Dec	GHA	Dec	GHA	Dec	GHA	Dec	GHA	Dec	GHA	Dec			
00 00	183 35.4	S19 44.8	59 27.8	159 07	S24 07	213 13	S10 01	39 42	N 6 44	188 19	S22 54	N			
10	186 05.4	44.9	61 58.2	161 37		215 43		42 12		190 43	56	72			
20	188 35.4	45.0	64 28.6	164 06		218 13		44 43		193 08	58	70			
30	191 05.4	45.1	66 59.0	166 36		220 44		47 13		195 32	22 59	68			
40	193 35.3	45.2	69 29.5	169 06		223 14		49 44		197 57	23 01	66			
50	196 05.3	45.2	71 59.9	171 36		225 44		52 14		200 21	03	64	10 35		
01 00	198 35.3	S19 45.3	74 30.3	174 06	S24 08	228 14	S10 01	54 44	N 6 44	202 45	S23 04	62	09 48	+69	
10	201 05.3	45.4	77 00.7	176 36		230 44		57 15		205 10	06	60	09 17	56	
20	203 35.2	45.5	79 31.1	179 05		233 14		59 45		207 34	08	58	08 54	51	
30	206 05.2	45.6	82 01.5	181 35		235 45		62 16		209 58	10	56	08 36	48	
40	208 35.2	45.7	84 31.9	184 05		238 15		64 46		212 23	11	54	08 21	46	
50	211 05.2	45.8	87 02.3	186 35		240 45		67 17		214 47	13	52	08 07	44	
02 00	213 35.1	S19 45.9	89 32.7	189 05	S24 08	243 15	S10 02	69 47	N 6 44	217 12	S23 15	50	07 55	42	
10	216 05.1	46.0	92 03.2	191 35		245 45		72 18		219 36	16	45	07 31	40	
20	218 35.1	46.1	94 33.6	194 04		248 15		74 48		222 00	18	40	07 12	38	
30	221 05.1	46.2	97 04.0	196 34		250 45		77 19		224 25	20	35	06 56	36	
40	223 35.0	46.3	99 34.4	199 04		253 16		79 49		226 49	22	30	06 42	34	
50	226 05.0	46.4	102 04.8	201 34		255 46		82 19		229 13	23	20	06 19	32	
03 00	228 35.0	S19 46.5	104 35.2	204 04	S24 08	258 16	S10 02	84 50	N 6 44	231 38	S23 25	10	05 59	30	
10	231 05.0	46.6	107 05.6	206 34		260 46		87 20		234 02	27	0	05 40	28	
20	233 34.9	46.7	109 36.0	209 04		263 16		89 51		236 26	28	10	05 22	27	
30	236 04.9	46.7	112 06.4	211 33		265 46		92 21		238 50	30	20	05 02	25	
40	238 34.9	46.8	114 36.8	214 03		268 16		94 52		241 15	32	30	04 39	23	
50	241 04.9	46.9	117 07.3	216 33		270 47		97 22		243 39	33	35	04 26	21	
04 00	243 34.8	S19 47.0	119 37.7	219 03	S24 09	273 17	S10 03	99 53	N 6 44	246 03	S23 35	40	04 11	20	
10	246 04.8	47.1	122 08.1	221 33		275 47		102 23		248 28	37	45	03 53	18	
20	248 34.8	47.2	124 38.5	224 03		278 17		104 53		250 52	38	50	03 31	15	
30	251 04.8	47.3	127 08.9	226 33		280 47		107 24		253 16	40	52	03 20	13	
40	253 34.7	47.4	129 39.3	229 02		283 17		109 54		255 41	42	54	03 09	12	
50	256 04.7	47.5	132 09.7	231 32		285 48		112 25		258 05	43	56	02 55	10	
05 00	258 34.7	S19 47.6	134 40.1	234 02	S24 09	288 18	S10 04	114 55	N 6 44	260 29	S23 45	58	02 40	06	
10	261 04.7	47.7	137 10.5	236 32		290 48		117 26		262 53	46	60	02 21	03	
20	263 34.6	47.8	139 41.0	239 02		293 18		119 56		265 18	48				
30	266 04.6	47.9	142 11.4	241 32		295 48		122 26		267 42	50				
40	268 34.6	48.0	144 41.8	244 01		298 18		124 57		270 06	51				
50	271 04.5	48.1	147 12.2	246 31		300 49		127 27		272 31	53				
06 00	273 34.5	S19 48.1	149 42.6	249 01	S24 09	303 19	S10 04	129 58	N 6 44	274 55	S23 55	Moon's P. in A.			
10	276 04.5	48.2	152 13.0	251 31		305 49		132 28		277 19	56	A	C	A	C
20	278 34.5	48.3	154 43.4	254 01		308 19		134 59		279 43	58	I	O	I	O
30	281 04.4	48.4	157 13.8	256 31		310 49		137 29		282 08	23 59				
40	283 34.4	48.5	159 44.2	259 00		313 19		140 00		284 32	24 01				
50	286 04.4	48.6	162 14.7	261 30		315 49		142 30		286 56	03	0	59	54	59
07 00	288 34.4	S19 48.7	164 45.1	264 00	S24 09	318 20	S10 05	145 00	N 6 43	289 20	S24 04	5	58	55	33
10	291 04.3	48.8	167 15.5	266 30		320 50		147 31		291 45	06	12	57	57	32
20	293 34.3	48.9	169 45.9	269 00		323 20		150 01		294 09	07	16	56	58	31
30	296 04.3	49.0	172 16.3	271 30		325 50		152 32		296 33	09	19	55	58	30
40	298 34.3	49.1	174 46.7	274 00		328 20		155 02		298 57	10	22	54	59	29
50	301 04.2	49.2	177 17.1	276 29		330 50		157 33		301 22	12	24	53	61	28
08 00	303 34.2	S19 49.3	179 47.5	278 59	S24 10	333 20	S10 06	160 03	N 6 43	303 46	S24 14	26	52	62	27
10	306 04.2	49.4	182 17.9	281 29		335 51		162 34		306 10	15	28	51	63	26
20	308 34.2	49.5	184 48.3	283 59		338 21		165 04		308 34	17	30	50	64	25
30	311 04.1	49.6	187 18.8	286 29		340 51		167 34		310 58	18	32	49	65	24
40	313 34.1	49.6	189 49.2	288 59		343 21		170 05		313 23	20	34	48	66	23
50	316 04.1	49.7	192 19.6	291 28		345 51		172 35		315 47	21	36	47	67	22
09 00	318 34.1	S19 49.8	194 50.0	293 58	S24 10	348 21	S10 06	175 06	N 6 43	318 11	S24 23	37	46	68	21
10	321 04.0	49.9	197 20.4	296 28		350 52		177 36		320 35	25	39	45	69	20
20	323 34.0	50.0	199 50.8	298 58		353 22		180 07		322 59	26	40	44	70	19
30	326 04.0	50.1	202 21.2	301 28		355 52		182 37		325 24	28	42	43	71	18
40	328 34.0	50.2	204 51.6	303 58		358 22		185 07		327 48	29	43	42	72	17
50	331 04.0	50.3	207 22.0	306 28		0 52		187 38		330 12	31	45	41	73	16
10 00	333 33.9	S19 50.4	209 52.5	308 57	S24 10	3 22	S10 07	190 08	N 6 43	332 36	S24 32	46	40	74	15
10	336 03.9	50.5	212 22.9	311 27		5 53		192 39		335 00	34	47	39	75	14
20	338 33.9	50.6	214 53.3	313 57		8 23		195 09		337 25	35	49	38	76	13
30	341 03.8	50.7	217 23.7	316 27		10 53		197 40		339 49	37	50	37	77	12
40	343 33.8	50.8	219 54.1	318 57		13 23		200 10		342 13	38	51	36	78	11
50	346 03.8	50.9	222 24.5	321 27		15 53		202 41		344 37	40	52	35	79	10
11 00	348 33.8	S19 50.9	224 54.9	323 56	S24 11	18 23	S10 07	205 11	N 6 43	347 01	S24 41	54	34	80	10
10	351 03.7	51.0	227 25.3	326 26		20 53		207 42		349 25	43	55			
20	353 33.7	51.1	229 55.7	328 56		23 24		210 12		351 50	44				
30	356 03.7	51.2	232 26.2	331 26		25 54		212 42		354 14	46				
40	358 33.6	51.3	234 56.6	333 56		28 24		215 13		356 38	47				
50	361 03.6	51.4	237 27.0	336 26		30 54		217 43		359 02	49				
													Sun SD 16'2		
													Moon SD 16'		
													Age 0d		

Figure 16 SAMPLE TABLE

650 (DAY 325) GREENWICH P. M. 1987 NOVEMBER 21 (SATURDAY)

GMT (UT)	SUN		ARIES		VENUS-3.9		MARS 1.7		JUPITER-2.8		MOON		Lat	Moon- set	Diff.	
	GHA	Dec	GHA	Dec	GHA	Dec	GHA	Dec	GHA	Dec	GHA	Dec				
12 00	3 33.6	519 51.5	239 57.4	338 55	S24 11	33 24	510 08	220 14	N 6 43	1 26	S24 50		N			
10	0 03.6	51.6	242 27.8	341 25		35 54		222 44		3 50	51	72				
20	8 33.5	51.7	244 58.2	343 55		38 24		225 15		6 14	53	70				
30	11 03.5	51.8	247 28.6	346 25		40 55		227 45		8 39	54	68				
40	13 33.5	51.9	249 59.0	348 55		43 25		230 15		11 03	56	66				
50	16 03.5	52.0	252 29.4	351 25		45 55		232 46		13 27	57	64	13 01			
13 00	18 33.4	519 52.1	254 59.8	353 55	S24 11	48 25	510 08	235 16	N 6 43	15 51	S24 59	62	13 49	-08		
10	21 03.4	52.1	257 30.3	356 24		50 55		237 47		18 15	25 00	60	14 20	+04		
20	23 33.4	52.2	260 00.7	358 54		53 25		240 17		20 39	02	58	14 43	09		
30	26 03.4	52.3	262 31.1	1 24		55 55		242 48		23 03	03	56	15 02	12		
40	28 33.3	52.4	265 01.5	3 54		58 26		245 18		25 27	04	54	15 18	14		
50	31 03.3	52.5	267 31.9	6 24		60 56		247 49		27 52	06	52	15 32	16		
14 00	33 33.3	519 52.6	270 02.3	8 54	S24 11	63 26	510 09	250 19	N 6 43	30 16	S25 07	50	15 44	18		
10	36 03.3	52.7	272 32.7	11 24		65 56		252 50		32 40	09	45	16 09	20		
20	38 33.2	52.8	275 03.1	13 53		68 26		255 20		35 04	10	40	16 30	22		
30	41 03.2	52.9	277 33.5	16 23		70 56		257 50		37 28	12	35	16 47	23		
40	43 33.2	53.0	280 04.0	18 53		73 27		260 21		39 52	13	30	17 01	25		
50	46 03.2	53.1	282 34.4	21 23		75 57		262 51		42 16	14	20	17 26	26		
15 00	48 33.1	519 53.2	285 04.8	23 53	S24 12	78 27	510 10	265 22	N 6 43	44 40	S25 16	10	17 48	28		
10	51 03.1	53.3	287 35.2	26 23		80 57		267 52		47 04	17	0	18 08	30		
20	53 33.1	53.3	290 05.6	28 52		83 27		270 23		49 28	19	10	18 28	31		
30	56 03.1	53.4	292 36.0	31 22		85 57		272 53		51 52	20	20	18 50	33		
40	58 33.0	53.5	295 06.4	33 52		88 28		275 23		54 17	21	30	19 15	35		
50	61 03.0	53.6	297 36.8	36 22		90 58		277 54		56 41	23	35	19 30	36		
16 00	63 33.0	519 53.7	300 07.2	38 52	S24 12	93 28	510 10	280 24	N 6 43	59 05	S25 24	40	19 48	37		
10	66 02.9	53.8	302 37.7	41 22		95 58		282 55		61 29	25	45	20 09	39		
20	68 32.9	53.9	305 08.1	43 51		98 28		285 25		63 53	27	50	20 35	41		
30	71 02.9	54.0	307 38.5	46 21		100 58		287 56		66 17	28	52	20 48	42		
40	73 32.9	54.1	310 08.9	48 51		103 28		290 26		68 41	29	54	21 03	44		
50	76 02.8	54.2	312 39.3	51 21		105 59		292 57		71 05	31	56	21 21	46		
17 00	78 32.8	519 54.3	315 09.7	53 51	S24 12	108 29	510 11	295 27	N 6 43	73 29	S25 32	58	21 42	49		
10	81 02.8	54.4	317 40.1	56 21		110 59		297 57		75 53	34	60	22 09	54		
20	83 32.8	54.5	320 10.5	58 51		113 29		300 28		78 17	35					
30	86 02.7	54.5	322 40.9	61 20		115 59		302 58		80 41	36	S				
40	88 32.7	54.6	325 11.3	63 50		118 29		305 29		83 05	38					
50	91 02.7	54.7	327 41.8	66 20		121 00		307 59		85 29	39					
18 00	93 32.7	519 54.8	330 12.2	68 50	S24 13	123 30	510 11	310 30	N 6 43	87 53	S25 40		Moon's P. in A.			
10	96 02.6	54.9	332 42.6	71 20		126 00		313 00		90 17	41	A	C	A	C	
20	98 32.6	55.0	335 13.0	73 50		128 30		315 31		92 41	43	I	O	I	O	
30	101 02.6	55.1	337 43.4	76 19		131 00		318 01		95 05	44					
40	103 32.6	55.2	340 13.8	78 49		133 30		320 31		97 29	45					
50	106 02.5	55.3	342 44.2	81 19		136 00		323 02		99 53	47	0	+	+	+	
19 00	108 32.5	519 55.4	345 14.6	83 49	S24 13	138 31	510 12	325 32	N 6 43	102 17	S25 48	7	59	54	34	
10	111 02.5	55.5	347 45.0	86 19		141 01		328 03		104 41	49	12	58	56	33	
20	113 32.4	55.6	350 15.5	88 49		143 31		330 33		107 05	50	16	57	57	32	
30	116 02.4	55.6	352 45.9	91 18		146 01		333 04		109 29	52	19	56	58	31	
40	118 32.4	55.7	355 16.3	93 48		148 31		335 34		111 53	53	22	55	59	30	
50	121 02.4	55.8	357 46.7	96 18		151 01		338 05		114 17	54	24	54	61	29	
20 00	123 32.3	519 55.9	0 17.1	98 48	S24 13	153 32	510 13	340 35	N 6 43	116 41	S25 56	27	53	62	27	
10	126 02.3	56.0	2 47.5	101 18		156 02		343 05		119 05	57	29	52	63	26	
20	128 32.3	56.1	5 17.9	103 48		158 32		345 36		121 29	58	31	51	64	25	
30	131 02.3	56.2	7 48.3	106 18		161 02		348 06		123 53	25 59	32	50	65	24	
40	133 32.2	56.3	10 18.7	108 47		163 32		350 37		126 17	26 01	34	49	66	23	
50	136 02.2	56.4	12 49.2	111 17		166 02		353 07		128 41	02	36	47	67	22	
21 00	138 32.2	519 56.5	15 19.6	113 47	S24 13	168 32	510 13	355 38	N 6 43	131 05	S26 03	37	47	68	21	
10	141 02.2	56.6	17 50.0	116 17		171 03		358 08		133 29	04	39	46	69	20	
20	143 32.1	56.7	20 20.4	118 47		173 33		0 38		135 53	05	41	45	70	19	
30	146 02.1	56.8	22 50.8	121 17		176 03		3 09		138 17	07	42	44	71	18	
40	148 32.1	56.8	25 21.2	123 46		178 33		5 39		140 41	08	43	43	72	17	
50	151 02.1	56.9	27 51.6	126 16		181 03		8 10		143 05	09	45	42	73	16	
22 00	153 32.0	519 57.0	30 22.0	128 46	S24 14	183 33	510 14	10 40	N 6 42	145 29	S26 10	46	41	74	15	
10	156 02.0	57.1	32 52.4	131 16		186 04		13 11		147 53	12	47	40	75	14	
20	158 32.0	57.2	35 22.8	133 46		188 34		15 41		150 17	13	49	39	76	13	
30	161 01.9	57.3	37 53.3	136 16		191 04		18 12		152 41	14	50	38	77	12	
40	163 31.9	57.4	40 23.7	138 46		193 34		20 42		155 05	15	51	37	78	11	
50	166 01.9	57.5	42 54.1	141 15		196 04		23 12		157 29	16	53	36	79	10	
23 00	168 31.9	519 57.6	45 24.5	143 45	S24 14	198 34	510 14	25 43	N 6 42	159 53	S26 17	54	35	80		
10	171 01.8	57.7	47 54.9	146 15		201 04		28 13		162 17	19	55	34			
20	173 31.8	57.8	50 25.3	148 45		203 35		30 44		164 41	20					
30	176 01.8	57.8	52 55.7	151 15		206 05		33 14		167 05	21					
40	178 31.8	57.9	55 26.1	153 45		208 35		35 45		169 29	22					
50	181 01.7	58.0	57 56.5	156 15		211 05		38 15		171 52	23					
Rate	14 59.8	50 00.6				14 59.1	50 00.3	15 00.9	50 00.6	15 02.6	50 00.1	14 24.2	50 07.9			
														Sun SD	16.2	
														Moon SD	16'	
														Age Od		

Figure 17: SAMPLE TABLE

FRAME 111

Figure 12 contains moonrise and moonset tables which were taken from the daily pages. The first column of each shows the same latitudes as the sun tables. The second column gives the times of moonrise and moonset in LMT on the 15° meridian for those latitudes. Notice that there is more than six hours difference between the northernmost and southernmost times listed. This is because of the moon's orbital angle.

Because of the variability of the moon's orbital speed, there is a column to account for this difference labelled "Diff." Diff. is the half-daily difference (minutes) in local mean time for the phenomena. In simpler terms, this correction when applied to the published moonrise or set values will give you the LMT time that these events will occur at 180° longitude. NOTE: An Asterisk (*) is entered in the Diff. Column under extreme conditions where an interpolation cannot be made.

Lat	Moonrise	Diff	Lat	Moonset	Diff
N			N		
72	h m	*	72	h m	*
70	10 10	32	70	12 29	15
68	09 23	32	68	13 10	20
66	08 52	32	66	13 38	22
64	08 29	32	64	13 59	23
62	08 11	32	62	14 16	24
60	07 55	32	60	14 31	25
58	07 43	32	58	14 43	25
56	07 31	31	56	14 54	26
54	07 22	32	54	15 03	26
52	07 13	32	52	15 11	27
50	07 05	31	50	15 19	27
45	06 48	31	45	15 35	28
40	06 35	31	40	15 48	28
35	06 23	31	35	15 59	28
30	06 13	31	30	16 09	29
20	05 56	31	20	16 26	29
10	05 41	31	10	16 41	30
0	05 27	31	0	16 55	30
10	05 13	31	10	17 08	31
20	04 58	30	20	17 23	31
30	04 41	30	30	17 40	31
35	04 31	30	35	17 50	32
40	04 19	30	40	18 01	32
45	04 06	30	45	18 14	33
50	03 50	29	50	18 30	33
52	03 42	29	52	18 38	33
54	03 33	29	54	18 46	33
56	03 24	29	56	18 56	34
58	03 13	29	58	19 06	34
60	03 01	29	60	19 18	34
S			S		

Figure 12. JAN. 1. MOONRISE/SET TABLES

FRAME 21 (cont)

From the moonrise table (figure 18), list the LMT of moonrise at 0° and 180° longitude for the following latitudes:

	<u>0°</u>	<u>180°</u>
A. 70° N.	_____	_____
B. 50° S.	_____	_____
C. 30° N.	_____	_____
D. 39° N.	_____	_____

ANSWER:

- A. 1010, 1042
- B. 0342, 0411
- C. 0613, 0644
- D. 0633, 0704

FRAME 22

Now you know how to find the LMT of Moonrise/set at 0° and 180° longitude. What happens if you are located somewhere in between? You can either divide the Diff. by 180 to find the correction for each 1° or just use the table that's provided. That's right! There is a table provided in the Air Almanac to assist you in interpolating for longitudes other than 0° and 180°. An example of this table, entitled Interpolation of Moonrise, Moonset for Longitudes is reproduced in Figure 19.

Notice that the table actually consists of 3 vertically stacked sections. The top table lists Diff. values from 5-30, the mid level 35-60, and finally values from 65-90. The longitudes are listed along the left side. The 0° longitude value will always be zero and the value at 180° will always be the same as the value at the head of the column.

FRAME 22 (contd)

To obtain the time difference for your location, use the Diff. value you derived from the moonrise/set tables and the longitude value nearest your location the correction amount is accurate enough so that further interpolation is not necessary.

F4 INTERPOLATION OF MOONRISE, MOONSET FOR LONGITUDE

Add if longitude west
Subtract if longitude east

Longi- tude	Diff *					
	05	10	15	20	25	30
0	00	00	00	00	00	00
20	01	01	02	02	03	03
40	01	02	03	04	05	07
60	02	03	05	07	08	10
80	02	04	07	09	11	13
100	03	06	08	11	14	17
120	03	07	10	13	17	20
140	04	08	12	16	19	23
160	04	09	13	18	22	27
180	05	10	15	20	25	30

Longi- tude	Diff *					
	35	40	45	50	55	60
0	00	00	00	00	00	00
15	03	03	04	04	05	06
30	06	07	08	08	09	10
45	09	10	11	12	14	15
60	12	13	15	17	18	20
75	15	17	19	21	23	25
90	18	20	22	25	28	30
105	20	23	26	29	32	35
120	23	27	30	33	37	40
135	26	30	34	38	41	45
150	29	33	38	42	46	50
165	32	37	41	46	50	55
180	35	40	45	50	55	60

Longi- tude	Diff *					
	65	70	75	80	85	90
0	00	00	00	00	00	00
10	04	04	04	04	05	05
20	07	08	08	09	09	10
30	11	12	12	13	14	15
40	14	16	17	18	19	20
50	18	19	21	22	24	25
60	22	23	25	27	28	30
70	25	27	29	31	33	35
80	29	31	33	36	38	40
90	32	35	38	40	42	45
100	36	39	42	44	47	50
110	40	43	46	49	52	55
120	43	47	50	53	57	60
130	47	51	54	58	61	65
140	51	54	58	62	66	70
150	54	58	62	67	71	75
160	58	62	67	71	76	80
170	61	66	71	76	80	85
180	65	70	75	80	85	90

* When negative subtract correction if longitude west and add if east.

For example, if your Diff. value from the daily pages was 37 and your longitude was 87° West, you would use a Diff. value of 35 and enter the table at 90° longitude to get a correction of + 18 minutes. It is "+" because you're at West Longitude. Select the correction factor from the interpolation table for the following Diff. values and longitudes. When the daily tables indicate a "POSITIVE" Diff. value indicate "+" if the correction is West/ "-" if the correction is East.

EXCEPTION: If the Diff. value in the daily tables is negative "-" then you subtract the correction from the LMT when you are at West longitude and add it if you are East.

DIFF. LONG. CORR.

- A. 25 100 W.
- B. -7 68 W.
- C. 42 122 E.
- D. -16 15 E.

ANSWER:

- A. +14 C. -27
- B. -2 D. +2

Figure 19. Interpolation of Moonrise, Moonset for Longitude.

FRAME 23

To complete the process of obtaining moonrise/set times, use the Conversion of Arc to Time Table from the Almanac (or Figure 5) to convert to LST, at your position, as you did for sun times.

NOTE: Each month there is one day near the first quarter without a moonset and one day near the last quarter without a moonrise. The tabulated times may indicate more than 24 hours (e.g. 14hr 38 min.), or, after conversion, the LST may be over 24 hours (i.e. the next day).

****NO RESPONSE NECESSARY****

FRAME 24

Using the moonrise and moonset tables for 21 November, shown in pages 31 and 32, the Interpolation for Moonrise, Moonset for Longitude table (Figure 19), the Conversion of Arc to Time Table (Figure 5), and the conversion tables for Standard time (Air Almanac) find moonrise/set times for the following stations in LST.

			<u>Moonrise/Set</u>
A. Langley AFB, Va	(37° 05' N.	76° 21' W.)	<u> / </u>
B. Fulda, FRG	(50° 33' N.	9° 41' E.)	<u> / </u>
C. Osan, Korea	(37° 06' N.	127° 02' E.)	<u> / </u>

ANSWER:

- A. 0724/1655
- B. 0818/1601
- C. 0709/1657

FRAME 25

Moon phase data are shown at the top of the daily pages in the Almanac. The symbols are related to the phase symbols in Figure 12. At the bottom right of each daily page, the number of days since the last New Moon are given as "Age(#)d." Finally, Fractional Illumination data are also provided in the Air Almanac (see List of Contents).

****NO RESPONSE NECESSARY****

FRAME 26

For latitudes between 65° and 90° North, Semiduration of Moonlight graphs are provided in the Almanac. These tables are very similar to the Semiduration of Sunlight graphs. Each 'moon' has its own graph.

FRAME 26 (CONTD.)

A December 1987 graph is shown in Figure 20. Dates are shown across the bottom and top and meridian passage times are indicated near the top of the chart by dots (•) at one hour intervals. The skewed semiduration lines are similar to those in the sunlight graph, as are the moon above and moon below horizon portions of the graph. Moon phases are indicated on their date of occurrence. Note that the phases correspond to meridian passage times (6 hours apart) and are the same as illustrated in Figure 12. You'll need to keep Figure 12 in mind to ensure the rise/set times are figured for the "correct" day. For example, on 6 December there is a full moon. As depicted in Fig. 12 a full moon passes the meridian near midnight. At 70° North on 6 December, Fig. 20 shows that the moon is (continuously) above the horizon. There is, therefore, neither rise nor set on 6 December, but there is continuous moonlight. On 13 December the moon is near third quarter (figs. 12 and 20) and so it passes the meridian near 0600. From Fig. 20, the semiduration of moonlight for latitude 75° North on 13 December is approximately 8 hours. Thus, moonrise is on December 12 at approximately 2200 and moonset on 13 December is approximately at 1400 for latitude 75°.

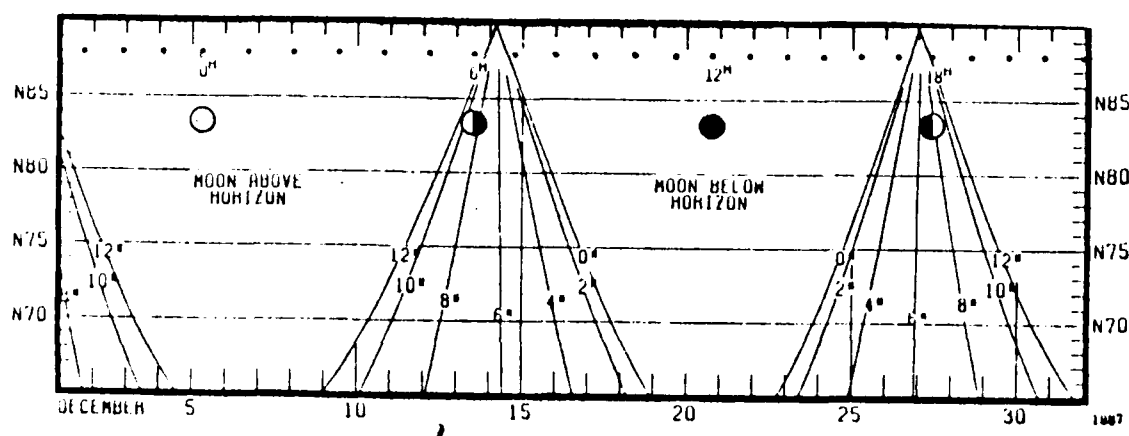


Figure 20. Semiduration of Moonlight

FRAME 26 (CONTD)

Find the LMT of moonrise and moonset for the following dates and latitudes:

	<u>MOONRISE/MOONSET</u>
A. 10 Dec, 74° N.	_____ / _____
B. 25 Dec, 80° N.	_____ / _____
C. 27 Dec, 70° N.	_____ / _____
D. 17 Dec, 69° N.	_____ / _____

ANSWER:

- A. moon above the horizon.
- B. moon below the horizon.
- C. 1130, 2330
- D. 0559, 1159

TEST QUESTIONS

The following test is provided so you can determine whether or not you reached the objectives stated in the beginning of this Tech Note. Tables and graphs to be used for this test are located on the following pages.

1. State the main reason that sunrise, sunset, and twilight times change from day-to-day.

2. Langley AFB, VA is located at $37^{\circ} 05' N$, $76^{\circ} 21' N$. List the Local Standard Time on 15 April that the following events will occur:

<u>AM Civ Twilight</u>	<u>Sunrise</u>	<u>Sunset</u>	<u>PM Civ Twilight</u>

3. State the Local Mean Time of occurrence at $75^{\circ} N$. on 1 April for the following events:

<u>AM Civ Twilight</u>	<u>Sunrise</u>	<u>Sunset</u>	<u>PM Civ Twilight</u>

4. Name two factors that cause moonrise/set times to change from day to day.

A.

B.

5. Fulda Gap, FRG is located at $50^{\circ} 33' N$, $9^{\circ} 41' E$. Figure the time of occurrence of the following events on 15 Apr 87.

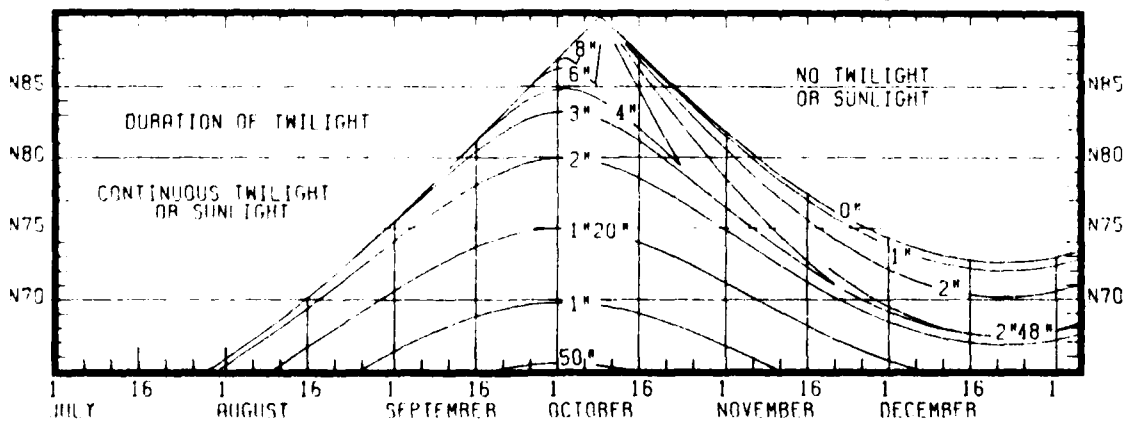
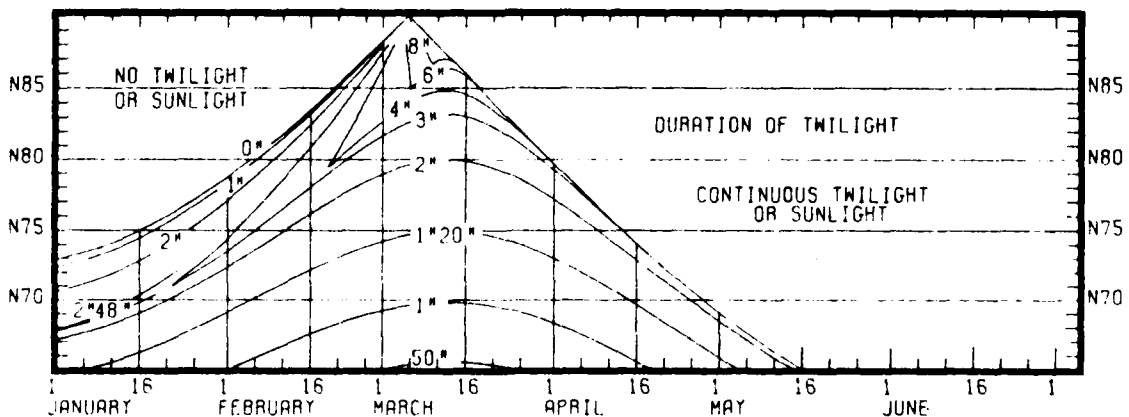
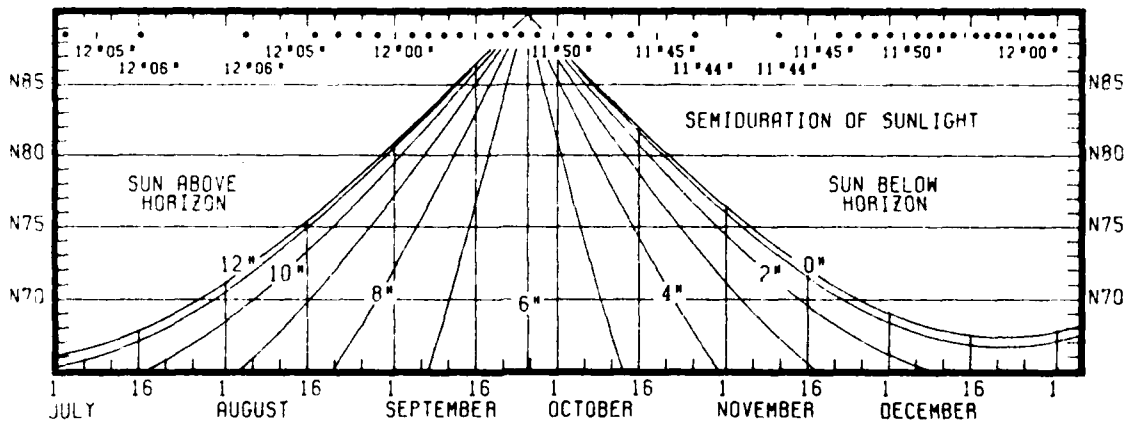
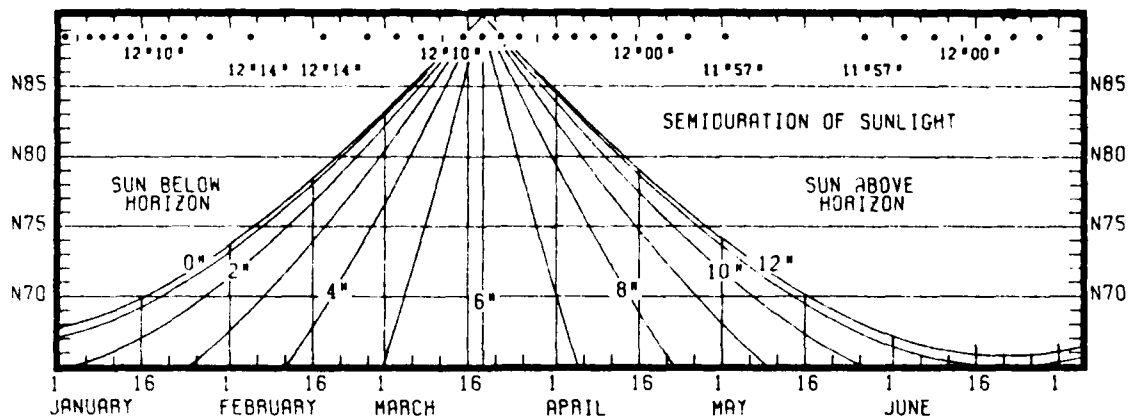
<u>Moonrise</u>	<u>Moonset</u>
<u>GMT</u>	<u>GMT</u>
<u>LST</u>	<u>LST</u>

6. State the Local Mean Time of moonrise and set at $75^{\circ} N$. on 7 May 87

<u>Moonrise</u>	<u>Moonset</u>

SUNLIGHT AND TWILIGHT

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CONVERSION OF ARC TO TIME

s	m	s	m	s	m	s	m	s	m	s	m	s	m	s	m
0	0 00	60	4 00	120	8 00	180	12 00	240	16 00	300	20 00	0	0 00		
1	0 04	61	4 04	121	8 04	181	12 04	241	16 04	301	20 04	1	0 04		
2	0 08	62	4 08	122	8 08	182	12 08	242	16 08	302	20 08	2	0 08		
3	0 12	63	4 12	123	8 12	183	12 12	243	16 12	303	20 12	3	0 12		
4	0 16	64	4 16	124	8 16	184	12 16	244	16 16	304	20 16	4	0 16		
5	0 20	65	4 20	125	8 20	185	12 20	245	16 20	305	20 20	5	0 20		
6	0 24	66	4 24	126	8 24	186	12 24	246	16 24	306	20 24	6	0 24		
7	0 28	67	4 28	127	8 28	187	12 28	247	16 28	307	20 28	7	0 28		
8	0 32	68	4 32	128	8 32	188	12 32	248	16 32	308	20 32	8	0 32		
9	0 36	69	4 36	129	8 36	189	12 36	249	16 36	309	20 36	9	0 36		
10	0 40	70	4 40	130	8 40	190	12 40	250	16 40	310	20 40	10	0 40		
11	0 44	71	4 44	131	8 44	191	12 44	251	16 44	311	20 44	11	0 44		
12	0 48	72	4 48	132	8 48	192	12 48	252	16 48	312	20 48	12	0 48		
13	0 52	73	4 52	133	8 52	193	12 52	253	16 52	313	20 52	13	0 52		
14	0 56	74	4 56	134	8 56	194	12 56	254	16 56	314	20 56	14	0 56		
15	1 00	75	5 00	135	9 00	195	13 00	255	17 00	315	21 00	15	1 00		
16	1 04	76	5 04	136	9 04	196	13 04	256	17 04	316	21 04	16	1 04		
17	1 08	77	5 08	137	9 08	197	13 08	257	17 08	317	21 08	17	1 08		
18	1 12	78	5 12	138	9 12	198	13 12	258	17 12	318	21 12	18	1 12		
19	1 16	79	5 16	139	9 16	199	13 16	259	17 16	319	21 16	19	1 16		
20	1 20	80	5 20	140	9 20	200	13 20	260	17 20	320	21 20	20	1 20		
21	1 24	81	5 24	141	9 24	201	13 24	261	17 24	321	21 24	21	1 24		
22	1 28	82	5 28	142	9 28	202	13 28	262	17 28	322	21 28	22	1 28		
23	1 32	83	5 32	143	9 32	203	13 32	263	17 32	323	21 32	23	1 32		
24	1 36	84	5 36	144	9 36	204	13 36	264	17 36	324	21 36	24	1 36		
25	1 40	85	5 40	145	9 40	205	13 40	265	17 40	325	21 40	25	1 40		
26	1 44	86	5 44	146	9 44	206	13 44	266	17 44	326	21 44	26	1 44		
27	1 48	87	5 48	147	9 48	207	13 48	267	17 48	327	21 48	27	1 48		
28	1 52	88	5 52	148	9 52	208	13 52	268	17 52	328	21 52	28	1 52		
29	1 56	89	5 56	149	9 56	209	13 56	269	17 56	329	21 56	29	1 56		
30	2 00	90	6 00	150	10 00	210	14 00	270	18 00	330	22 00	30	2 00		
31	2 04	91	6 04	151	10 04	211	14 04	271	18 04	331	22 04	31	2 04		
32	2 08	92	6 08	152	10 08	212	14 08	272	18 08	332	22 08	32	2 08		
33	2 12	93	6 12	153	10 12	213	14 12	273	18 12	333	22 12	33	2 12		
34	2 16	94	6 16	154	10 16	214	14 16	274	18 16	334	22 16	34	2 16		
35	2 20	95	6 20	155	10 20	215	14 20	275	18 20	335	22 20	35	2 20		
36	2 24	96	6 24	156	10 24	216	14 24	276	18 24	336	22 24	36	2 24		
37	2 28	97	6 28	157	10 28	217	14 28	277	18 28	337	22 28	37	2 28		
38	2 32	98	6 32	158	10 32	218	14 32	278	18 32	338	22 32	38	2 32		
39	2 36	99	6 36	159	10 36	219	14 36	279	18 36	339	22 36	39	2 36		
40	2 40	100	6 40	160	10 40	220	14 40	280	18 40	340	22 40	40	2 40		
41	2 44	101	6 44	161	10 44	221	14 44	281	18 44	341	22 44	41	2 44		
42	2 48	102	6 48	162	10 48	222	14 48	282	18 48	342	22 48	42	2 48		
43	2 52	103	6 52	163	10 52	223	14 52	283	18 52	343	22 52	43	2 52		
44	2 56	104	6 56	164	10 56	224	14 56	284	18 56	344	22 56	44	2 56		
45	3 00	105	7 00	165	11 00	225	15 00	285	19 00	345	23 00	45	3 00		
46	3 04	106	7 04	166	11 04	226	15 04	286	19 04	346	23 04	46	3 04		
47	3 08	107	7 08	167	11 08	227	15 08	287	19 08	347	23 08	47	3 08		
48	3 12	108	7 12	168	11 12	228	15 12	288	19 12	348	23 12	48	3 12		
49	3 16	109	7 16	169	11 16	229	15 16	289	19 16	349	23 16	49	3 16		
50	3 20	110	7 20	170	11 20	230	15 20	290	19 20	350	23 20	50	3 20		
51	3 24	111	7 24	171	11 24	231	15 24	291	19 24	351	23 24	51	3 24		
52	3 28	112	7 28	172	11 28	232	15 28	292	19 28	352	23 28	52	3 28		
53	3 32	113	7 32	173	11 32	233	15 32	293	19 32	353	23 32	53	3 32		
54	3 36	114	7 36	174	11 36	234	15 36	294	19 36	354	23 36	54	3 36		
55	3 40	115	7 40	175	11 40	235	15 40	295	19 40	355	23 40	55	3 40		
56	3 44	116	7 44	176	11 44	236	15 44	296	19 44	356	23 44	56	3 44		
57	3 48	117	7 48	177	11 48	237	15 48	297	19 48	357	23 48	57	3 48		
58	3 52	118	7 52	178	11 52	238	15 52	298	19 52	358	23 52	58	3 52		
59	3 56	119	7 56	179	11 56	239	15 56	299	19 56	359	23 56	59	3 56		

The above table is for converting expressions in arc to their equivalent in time; its main use in this Almanac is for the conversion of longitude for application to L.M.T. (added if west, subtracted if east) to give G.M.T., or vice versa, particularly in the case of sunrise, sunset, etc.

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SUNRISE

Lat.	April										May					
	2	5	8	11	14	17	20	23	26	29	2	5	8	11	14	17
N 72	04 55	04 39	04 23	04 06	03 49	03 32	03 14	02 55	02 35	02 14	01 50	01 22	00 41	00 11	00 00	00 00
70	05 02	04 45	04 28	04 10	03 52	03 34	03 15	02 56	02 36	02 15	01 51	01 22	00 41	00 11	00 00	00 00
68	05 08	04 50	04 33	04 14	03 56	03 37	03 18	02 58	02 38	02 17	01 52	01 23	00 42	00 12	00 01	00 00
66	05 14	04 56	04 39	04 20	04 01	03 42	03 23	03 03	02 43	02 22	01 57	01 27	00 46	00 15	00 04	00 00
64	05 18	04 59	04 42	04 22	04 03	03 44	03 25	03 05	02 45	02 24	01 59	01 29	00 48	00 17	00 06	00 00
62	05 22	05 02	04 45	04 25	04 06	03 47	03 28	03 08	02 48	02 27	02 01	01 31	00 50	00 19	00 08	00 00
N 60	05 25	05 10	04 53	04 33	04 14	03 54	03 35	03 15	02 55	02 34	02 08	01 38	00 57	00 26	00 15	00 00
58	05 28	05 11	04 54	04 34	04 15	03 55	03 36	03 16	02 56	02 35	02 09	01 39	00 58	00 27	00 16	00 00
56	05 30	05 12	04 56	04 36	04 17	03 57	03 38	03 18	02 58	02 37	02 11	01 41	01 00	00 29	00 18	00 00
54	05 32	05 13	04 58	04 38	04 19	03 59	03 40	03 20	03 00	02 39	02 13	01 43	01 02	00 31	00 20	00 00
52	05 34	05 14	05 00	04 40	04 21	04 01	03 42	03 22	03 02	02 41	02 15	01 45	01 04	00 33	00 22	00 00
N 50	05 36	05 16	05 01	04 41	04 22	04 02	03 43	03 23	03 03	02 42	02 16	01 46	01 05	00 34	00 23	00 00
45	05 40	05 19	05 04	04 44	04 25	04 05	03 46	03 26	03 06	02 45	02 19	01 49	01 08	00 37	00 26	00 00
40	05 44	05 22	05 07	04 48	04 29	04 09	03 49	03 29	03 09	02 48	02 22	01 52	01 11	00 41	00 30	00 00
35	05 47	05 25	05 10	04 51	04 32	04 12	03 52	03 32	03 12	02 51	02 25	01 55	01 14	00 44	00 33	00 00
30	05 49	05 27	05 12	04 53	04 34	04 14	03 54	03 34	03 14	02 53	02 27	01 57	01 16	00 46	00 35	00 00
N 20	05 53	05 31	05 16	04 57	04 38	04 18	03 58	03 38	03 18	02 57	02 31	01 61	01 20	00 50	00 39	00 00
N 10	05 57	05 35	05 20	05 01	04 42	04 22	04 02	03 42	03 22	03 01	02 40	02 14	01 44	01 03	00 52	00 00
0	06 01	05 39	05 24	05 05	04 46	04 26	04 06	03 46	03 26	03 05	02 44	02 18	01 48	01 07	00 56	00 00
S 10	06 04	05 42	05 27	05 08	04 49	04 29	04 09	03 49	03 29	03 08	02 47	02 21	01 51	01 10	00 59	00 00
20	06 07	05 45	05 30	05 11	04 52	04 32	04 12	03 52	03 32	03 11	02 50	02 24	01 54	01 13	00 62	00 00
S 30	06 11	05 49	05 34	05 15	04 56	04 36	04 16	03 56	03 36	03 15	02 54	02 28	01 58	01 17	00 66	00 00
35	06 13	05 51	05 36	05 17	04 58	04 38	04 18	03 58	03 38	03 17	02 56	02 30	02 00	01 19	00 70	00 00
40	06 15	05 53	05 38	05 19	05 00	04 40	04 20	04 00	03 40	03 20	02 59	02 33	02 03	01 22	00 72	00 00
45	06 18	05 56	05 41	05 22	05 03	04 43	04 23	04 03	03 43	03 23	03 02	02 36	02 06	01 25	00 75	00 00
50	06 21	05 59	05 44	05 25	05 06	04 46	04 26	04 06	03 46	03 26	03 05	02 39	02 09	01 28	00 78	00 00
S 52	06 22	06 00	05 45	05 26	05 07	04 47	04 27	04 07	03 47	03 27	03 06	02 40	02 10	01 29	00 81	00 00
54	06 24	06 02	05 47	05 28	05 09	04 49	04 29	04 09	03 49	03 29	03 08	02 42	02 12	01 31	00 83	00 00
56	06 26	06 04	05 49	05 30	05 11	04 51	04 31	04 11	03 51	03 31	03 10	02 44	02 14	01 33	00 86	00 00
58	06 28	06 06	05 51	05 32	05 13	04 53	04 33	04 13	03 53	03 33	03 12	02 46	02 16	01 35	00 89	00 00
S 60	06 30	06 08	05 53	05 34	05 15	04 55	04 35	04 15	03 55	03 35	03 14	02 48	02 18	01 37	00 92	00 00

SUNSET

Lat.	April										May					
	2	5	8	11	14	17	20	23	26	29	2	5	8	11	14	17
N 72	19 19	19 39	19 45	20 00	20 16	20 32	20 48	21 00	21 20	21 47	22 11	22 41	23 35	23 52	24 00	24 00
70	08 08	08 21	08 33	19 46	20 00	20 13	20 27	20 42	20 57	21 12	21 29	21 47	22 07	22 31	23 01	23 00
68	19 02	19 13	19 24	19 35	19 47	19 59	20 11	20 23	20 35	20 48	21 01	21 15	21 30	21 45	22 01	22 18
66	18 36	18 46	18 56	19 07	19 17	19 27	19 37	19 47	19 57	20 08	20 18	20 29	20 40	20 52	21 03	21 15
64	18 30	18 40	18 50	19 01	19 11	19 21	19 31	19 41	19 51	20 01	20 11	20 21	20 32	20 43	20 54	21 05
62	18 24	18 34	18 44	18 54	19 04	19 14	19 24	19 34	19 44	19 54	20 04	20 14	20 24	20 35	20 45	20 55
N 60	18 41	18 52	19 02	19 12	19 22	19 32	19 42	19 52	20 02	20 12	20 22	20 32	20 42	20 52	21 02	21 12
58	18 41	18 52	19 02	19 12	19 22	19 32	19 42	19 52	20 02	20 12	20 22	20 32	20 42	20 52	21 02	21 12
56	18 39	18 50	19 00	19 10	19 20	19 30	19 40	19 50	20 00	20 10	20 20	20 30	20 40	20 50	21 00	21 10
54	18 36	18 47	18 57	19 07	19 17	19 27	19 37	19 47	19 57	20 07	20 17	20 27	20 37	20 47	20 57	21 07
52	18 34	18 45	18 55	19 05	19 15	19 25	19 35	19 45	19 55	20 05	20 15	20 25	20 35	20 45	20 55	21 05
N 50	18 32	18 43	18 53	19 03	19 13	19 23	19 33	19 43	19 53	20 03	20 13	20 23	20 33	20 43	20 53	21 03
45	18 28	18 39	18 49	18 59	19 09	19 19	19 29	19 39	19 49	19 59	20 09	20 19	20 29	20 39	20 49	20 59
40	18 24	18 35	18 45	18 55	19 05	19 15	19 25	19 35	19 45	19 55	20 05	20 15	20 25	20 35	20 45	20 55
35	18 20	18 31	18 41	18 51	19 01	19 11	19 21	19 31	19 41	19 51	20 01	20 11	20 21	20 31	20 41	20 51
30	18 16	18 27	18 37	18 47	18 57	19 07	19 17	19 27	19 37	19 47	19 57	20 07	20 17	20 27	20 37	20 47
N 20	18 14	18 25	18 35	18 45	18 55	19 05	19 15	19 25	19 35	19 45	19 55	20 05	20 15	20 25	20 35	20 45
N 10	18 10	18 21	18 31	18 41	18 51	19 01	19 11	19 21	19 31	19 41	19 51	20 01	20 11	20 21	20 31	20 41
0	18 07	18 18	18 28	18 38	18 48	18 58	19 08	19 18	19 28	19 38	19 48	19 58	20 08	20 18	20 28	20 38
S 10	18 04	18 15	18 25	18 35	18 45	18 55	19 05	19 15	19 25	19 35	19 45	19 55	20 05	20 15	20 25	20 35
20	18 00	18 11	18 21	18 31	18 41	18 51	19 01	19 11	19 21	19 31	19 41	19 51	20 01	20 11	20 21	20 31
S 30	17 59	18 10	18 20	18 30	18 40	18 50	19 00	19 10	19 20	19 30	19 40	19 50	20 00	20 10	20 20	20 30
35	17 54	18 05	18 15	18 25	18 35	18 45	18 55	19 05	19 15	19 25	19 35	19 45	19 55	20 05	20 15	20 25
40	17 49	18 00	18 10	18 20	18 30	18 40	18 50	19 00	19 10	19 20	19 30	19 40	19 50	20 00	20 10	20 20
45	17 44	17 55	18 05	18 15	18 25	18 35	18 45	18 55	19 05	19 15	19 25	19 35	19 45	19 55	20 05	20 15
50	17 40	17 51	18 01	18 11	18 21	18 31	18 41	18 51	19 01	19 11	19 21	19 31	19 41	19 51	20 01	20 11
S 52	17 41	17 52	18 02	18 12	18 22	18 32	18 42	18 52	19 02	19 12	19 22	19 32	19 42	19 52	20 02	20 12
54	17 38	17 49	17 59	18 09	18 19	18 29	18 39	18 49	18 59	19 09	19 19	19 29	19 39	19 49	19 59	20 09
56	17 34	17 45	17 55	18 05	18 15	18 25	18 35	18 45	18 55	19 05	19 15	19 25	19 35	19 45	19 55	20 05
58	17 30	17 41	17 51	18 01	18 11	18 21	18 31	18 41	18 51	19 01	19 11	19 21	19 31	19 41	19 51	20 01
S 60	17 27	17 38	17 48	17 58	18 08	18 18	18 28	18 38	18 48	18 58	19 08	19 18	19 28	19 38	19 48	19 58

MORNING CIVIL TWILIGHT

A135

Lat.	April										May					
	2	5	8	11	14	17	20	23	26	29	2	5	8	11	14	17
N 72	01 47	01 21	01 00	02 48	02 14	01 45	01 08									
70	01 50	01 10	01 23	01 08	02 40	02 20	02 03	01 37	01 03							
68	01 00	01 33	01 40	01 28	01 00	02 53	30	02 17	01 57	01 33	01 04	00 02	01 01			
66	21	10 07	01 54	41	27	01 11	02 59	02 44	02 28	02 12	01 51	01 34	01 10	00 37		
64	28	17	01 05	01 53	41	20	01 17	01 01	02 51	38	02 24	02 10	01 54	01 38	01 20	00 50
62	30	28	18	01 01	01 53	42	31	20	03 00	02 58	02 40	35	02 23	02 11	01 50	01 40
N 60	01 42	01 42	01 23	01 13	01 03	01 53	03 44	03 34	03 21	03 14	03 04	02 51	02 44	02 35	02 25	02 15
58	47	39	30	21	12	01 03	03 54	45	39	27	19	03 10	03 02	02 53	02 45	3
56	52	44	35	27	19	11	01 03	03 55	47	30	31	23	16	03 00	03 01	02 45
54	01 50	40	41	33	20	18	11	01 03	03 50	49	42	35	28	22	13	04 00
52	05 00	51	40	30	31	25	18	11	01 04	03 58	51	45	30	33	27	22
N 50	05 04	04 57	04 50	04 44	04 37	04 30	04 21	04 18	04 11	04 05	03 59	03 54	03 48	03 43	03 38	03 33
45	11	05 05	04 59	04 51	48	43	37	32	27	22	04 17	04 12	04 07	04 03	03 50	03 55
40	10	12	05 07	05 02	04 57	04 52	48	43	39	35	31	27	23	19	04 10	04 13
35	21	17	13	00	05 04	05 00	04 57	04 53	49	45	42	39	30	33	30	27
30	25	21	18	14	11	07	05 04	05 01	04 58	04 55	04 52	04 49	04 46	04 44	04 42	04 40
N 20	05 31	05 20	05 20	05 24	05 21	05 19	05 19	05 14	05 12	05 10	05 08	05 06	05 04	05 03	05 01	05 00
N 10	10	31	33	31	20	28	20	25	23	22	21	20	19	18	17	16
0	40	30	38	37	30	35	35	34	33	33	32	32	31	31	31	31
S 10	43	43	43	42	42	42	42	42	42	43	43	43	43	43	44	44
20	45	40	47	47	48	49	50	51	05 51	05 52	05 53	05 54	05 55	05 50	05 57	05 58
S 30	05 47	05 40	05 50	05 52	05 54	05 50	05 57	05 50	06 01	06 03	06 04	06 06	06 08	06 10	06 11	06 13
35	48	50	52	51	05 57	05 50	06 01	06 04	06	08	10	12	15	17	19	21
40	48	51	54	05 57	06 00	06 03	06	08	11	14	17	20	22	25	27	30
45	48	52	50	06 00	03	07	10	14	17	21	24	28	31	34	37	40
50	40	53	58	02	07	11	16	20	24	28	33	37	41	45	49	52
S 52	05 49	05 54	05 50	06 04	06 08	06 13	06 18	06 23	06 27	06 32	06 37	06 41	06 45	06 50	06 54	06 58
54	49	54	06 00	05	10	15	21	26	31	36	41	46	50	06 55	06 50	07 04
56	49	55	06	06	12	18	23	29	34	40	45	51	06 50	07 01	07 00	10
58	48	55	01	08	14	20	26	32	38	44	50	06 50	07 02	07	13	18
S 60	05 48	05 55	06 02	06 09	06 16	06 23	06 30	06 36	06 43	06 49	06 56	07 02	07 08	07 14	07 20	07 26

EVENING CIVIL TWILIGHT

Lat.	April										May					
	2	5	8	11	14	17	20	23	26	29	2	5	8	11	14	17
N 72	20 32	20 50	21 00	21 31	21 55	22 24	23 06	23 07	23 07	23 07	23 07	23 07	23 07	23 07	23 07	23 07
70	15	30	20 45	21 02	21 20	21 39	22 02	22 28	23 07	23 07	23 07	23 07	23 07	23 07	23 07	23 07
68	20 02	14	28	20 41	20 50	21 11	21 27	21 45	22 05	22 29	23 01	23 01	23 01	23 01	23 01	23 01
66	19 51	20 02	13	25	37	20 50	21 03	21 17	21 32	21 48	22 06	22 26	22 51	23 33	23 01	23 01
64	42	19 52	20 02	12	22	33	20 44	20 50	21 08	21	21 34	21 48	22 03	22 20	22 39	23 02
62	34	43	19 52	20 01	10	20	29	30	20 49	21 00	21 11	22	21 33	21 45	21 58	22 11
N 60	19 28	19 36	19 44	19 52	20 00	20 08	20 17	20 25	20 34	20 43	20 53	21 02	21 11	21 21	21 30	21 40
58	22	20	36	44	19 51	19 59	20 06	14	22	30	38	20 45	20 54	21 02	21 10	18
56	17	23	30	37	43	50	19 57	20 04	11	18	25	32	39	20 40	20 53	21 00
54	13	18	24	30	36	43	49	19 55	20 01	20 08	14	20	26	33	39	20 45
52	09	14	20	25	31	36	42	47	19 53	19 59	20 04	10	16	21	27	32
N 50	19 05	19 10	19 15	19 20	19 25	19 30	19 35	19 40	19 46	19 51	19 56	20 01	20 06	20 11	20 16	20 21
45	18 58	19 02	19 06	10	14	18	22	26	30	34	38	19 42	19 46	19 50	19 54	19 58
40	52	18 55	18 58	19 02	09 05	08	11	14	18	21	24	28	31	34	37	40
35	47	49	52	18 54	18 57	19 00	19 02	19 05	19 07	10	13	15	18	21	23	26
30	43	45	47	49	51	18 53	18 55	18 57	18 59	19 01	19 03	19 05	19 07	19 09	19 11	19 13
N 20	18 37	18 37	18 38	18 39	18 40	18 41	18 42	18 43	18 44	18 40	18 47	18 48	18 40	18 50	18 52	18 53
N 10	32	32	32	32	32	32	32	32	33	33	33	34	34	35	36	36
0	28	27	26	25	25	24	23	23	23	22	22	22	22	22	22	22
S 10	25	23	22	20	19	17	16	14	13	12	11	18 10	18 00	18 09	18 08	18 08
20	22	20	17	15	13	10	08	18 06	18 04	18 02	18 01	17 59	17 58	17 50	17 55	17 54
S 30	18 20	18 17	18 13	18 10	18 07	18 03	18 00	17 58	17 55	17 52	17 49	17 47	17 45	17 43	17 41	17 30
35	19	15	11	07	04	18 00	17 50	53	50	46	43	41	38	35	33	31
40	19	14	06	05	18 00	17 50	52	18	44	40	37	34	30	27	25	22
45	18	13	07	18 02	17 57	52	47	42	38	33	29	25	22	18	15	12
50	18	12	06	17 59	53	47	42	39	31	26	21	16	12	07	17 03	17 00
S 52	18 18	18 11	18 04	17 58	17 52	17 45	17 39	17 33	17 28	17 22	17 17	17 12	17 07	17 02	16 58	16 54
54	18	11	04	57	50	43	37	30	21	18	13	07	17 02	16 57	52	48
56	18	10	03	55	48	41	34	27	20	14	08	17 02	16 50	51	46	42
58	18	10	02	54	46	38	31	24	16	10	17 03	16 57	51	45	39	34
S 60	18 18	18 09	18 01	17 52	17 44	17 35	17 27	17 20	17 12	17 05	16 57	16 50	16 44	16 38	16 32	16 26

GMT UT	SUN	ARIES	VENUS-4.0	MARS 1.5	JUPITER-2.0	MOON	Lat	Moon rise	Diff
	GHA Dec	GHA Dec	GHA Dec	GHA Dec	GHA Dec	GHA Dec			
00 00	179 55.7 N 9 29.9	202 37.2	210 35 S 4 52	138 26 N22 14	192 38 N 3 07	349 44 S15 35	N		
10	180 25.7	205 07.6	213 05	140 57	195 09	352 09	72		
20	181 55.7	207 38.0	215 15	143 27	197 39	354 34	70		
30	183 25.8	210 08.5	218 05	145 57	200 09	356 59	68	24 24	.91
40	184 55.8	212 38.9	220 35	148 27	202 40	359 24	66	23 27	
50	186 25.8	215 09.3	223 05	150 57	205 10	1 48	64	22 54	.74
01 00	187 55.8 N 9 30.7	217 39.7	225 35 S 4 51	153 27 N22 14	207 40 N 3 07	4 13 S15 49	62	22 30	.62
10	189 25.9	220 10.1	228 05	155 57	210 11	6 38	60	22 11	.56
20	190 55.9	222 40.5	230 35	158 27	212 41	9 03	58	21 55	.52
30	192 25.9	225 10.9	233 04	160 58	215 11	11 28	56	21 42	.49
40	193 55.9	227 41.3	235 34	163 28	217 41	13 53	54	21 31	.47
50	195 26.0	230 11.7	238 04	165 58	220 12	16 18	52	21 20	.45
02 00	196 56.0 N 9 31.6	232 42.1	240 34 S 4 50	168 28 N22 15	222 42 N 3 07	18 43 S16 03	50	21 11	.44
10	198 26.0	235 12.6	243 04	170 58	225 13	21 08	48	20 53	.40
20	199 56.0	237 43.0	245 34	173 28	227 43	23 32	46	20 37	.38
30	201 26.1	240 13.4	248 04	175 58	230 13	25 57	44	20 24	.36
40	202 56.1	242 43.8	250 34	178 28	232 43	28 22	42	20 13	.34
50	204 26.1	245 14.2	253 04	180 58	235 14	30 47	40	19 54	.32
03 00	205 56.1 N 9 32.5	247 44.6	255 34 S 4 49	183 29 N22 15	237 44 N 3 08	33 12 S16 18	38	19 38	.29
10	207 26.2	250 15.0	258 04	185 59	240 14	35 37	36	19 22	.27
20	208 56.2	252 45.4	260 34	188 29	242 45	38 02	34	19 07	.25
30	210 26.2	255 15.8	263 04	190 59	245 15	40 27	32	18 51	.22
40	211 56.2	257 46.3	265 34	193 29	247 45	42 51	30	18 33	.20
50	213 26.3	260 16.7	268 04	195 59	250 16	45 16	28	18 22	.18
04 00	214 56.3 N 9 33.4	262 47.1	270 34 S 4 48	198 29 N22 15	252 46 N 3 08	47 41 S16 32	26	18 10	.16
10	216 26.3	265 17.5	273 04	200 59	255 16	50 06	24	17 56	.14
20	217 56.4	267 47.9	275 34	203 29	257 47	52 31	22	17 39	.11
30	219 26.4	270 18.3	278 03	206 00	260 17	54 56	20	17 31	.10
40	220 56.4	272 48.7	280 33	208 30	262 47	57 21	18	17 22	.08
50	222 26.4	275 19.1	283 03	211 00	265 18	59 45	16	17 12	.06
05 00	223 56.5 N 9 34.3	277 49.5	285 33 S 4 47	213 30 N22 16	267 48 N 3 08	62 10 S16 46	14	17 01	.04
10	225 26.5	280 20.0	288 03	216 00	270 18	64 35	12	16 48	.01
20	226 56.5	282 50.4	290 33	218 30	272 48	67 00	10		
30	228 26.5	285 20.8	293 03	221 00	275 19	69 25	8		
40	229 56.6	287 51.2	295 33	223 30	277 49	71 50	6		
50	231 26.6	290 21.6	298 03	226 01	280 19	74 14	4		
06 00	232 56.6 N 9 35.2	292 52.0	300 33 S 4 46	228 31 N22 16	282 50 N 3 08	76 39 S17 00	2		
10	234 26.6	295 22.4	303 03	231 01	285 20	79 04	0		
20	235 56.7	297 52.8	305 33	233 31	287 50	81 29	0		
30	237 26.7	300 23.2	308 03	236 01	290 21	83 54	0		
40	238 56.7	302 53.6	310 33	238 31	292 51	86 18	0		
50	240 26.7	305 24.1	313 03	241 01	295 21	88 43	0		
07 00	241 56.8 N 9 36.1	307 54.5	315 33 S 4 44	243 31 N22 16	297 52 N 3 08	91 08 S17 13	0		
10	243 26.8	310 24.9	318 03	246 01	300 22	93 33	0		
20	244 56.8	312 55.3	320 33	248 31	302 52	95 58	0		
30	246 26.8	315 25.7	323 03	251 02	305 23	98 22	0		
40	247 56.9	317 56.1	325 32	253 32	307 53	100 47	0		
50	249 26.9	320 26.5	328 02	256 02	310 23	103 12	0		
08 00	250 56.9 N 9 37.0	322 56.9	330 32 S 4 43	258 32 N22 16	312 54 N 3 09	105 37 S17 27	0		
10	252 26.9	325 27.3	333 02	261 02	315 24	108 02	0		
20	253 57.0	327 57.8	335 32	263 32	317 54	110 26	0		
30	255 27.0	330 28.2	338 02	266 02	320 25	112 51	0		
40	256 57.0	332 58.6	340 32	268 33	322 55	115 16	0		
50	258 27.0	335 29.0	343 02	271 03	325 25	117 41	0		
09 00	259 57.1 N 9 37.9	337 59.4	345 32 S 4 42	273 33 N22 17	327 56 N 3 09	120 05 S17 41	0		
10	261 27.1	340 29.8	348 02	276 03	330 26	122 30	0		
20	262 57.1	343 00.2	350 32	278 33	332 56	124 55	0		
30	264 27.1	345 30.6	353 02	281 03	335 27	127 20	0		
40	265 57.2	348 01.0	355 32	283 33	337 57	129 44	0		
50	267 27.2	350 31.4	358 02	286 03	340 27	132 09	0		
10 00	268 57.2 N 9 38.8	353 01.9	0 32 S 4 41	288 33 N22 17	342 57 N 3 09	134 34 S17 54	0		
10	270 27.3	355 32.3	3 02	291 04	345 28	136 59	0		
20	271 57.3	358 02.7	5 32	293 34	347 58	139 23	0		
30	273 27.3	0 33.1	8 02	296 04	350 28	141 48	0		
40	274 57.3	3 03.5	10 31	298 34	352 59	144 13	0		
50	276 27.4	5 33.9	13 01	301 04	355 29	146 38	0		
11 00	277 57.4 N 9 39.7	8 04.3	15 31 S 4 40	303 34 N22 17	357 59 N 3 09	149 02 S18 08	0		
10	279 27.4	10 34.7	18 01	306 04	0 30	151 27	0		
20	280 57.4	13 05.1	20 31	308 34	3 00	153 52	0		
30	282 27.5	15 35.6	23 01	311 05	5 30	156 17	0		
40	283 57.5	18 06.0	25 31	313 35	8 01	158 41	0		
50	285 27.5	20 36.4	28 01	316 05	10 31	161 06	0		
Rate	15 00.2 NO 00.9		14 59.7 NO 01.1	15 00.7 NO 01.3	15 01.9 NO 02.2	14 28.9 NO 13.9			

Moon's P in A.

A C O A C O

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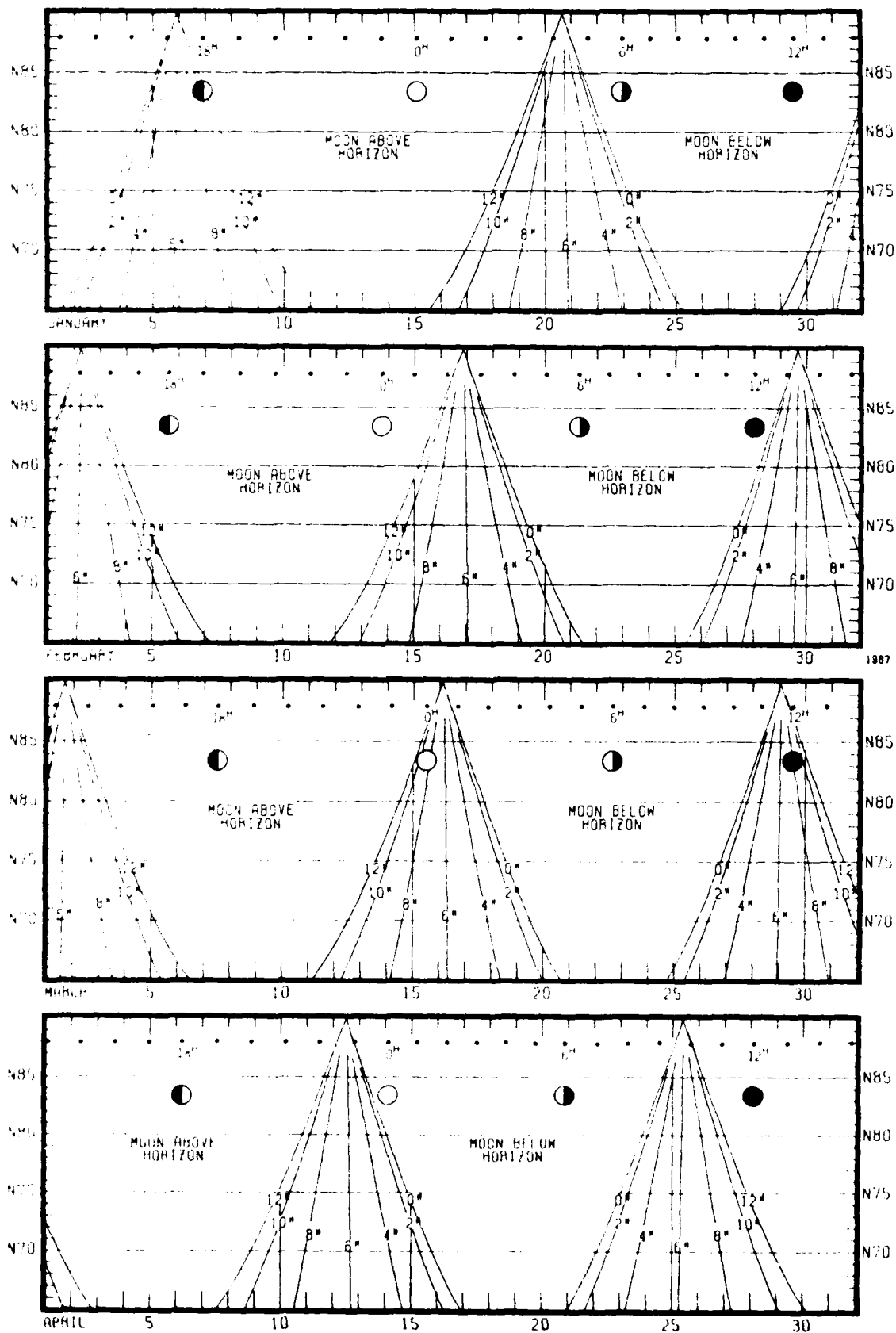
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GMT UT	SUN		ARIES		VENUS-4.0		MARS 15		JUPITER-2.0		MOON		Lat	Moon- set	Diff.
	GHA	Dec	GHA	Dec	GHA	Dec	GHA	Dec	GHA	Dec	GHA	Dec			
12 00	354 50.6	N 9 40.6	23 06.6	30 31.5	4 39	318 35	N22 18	13 01	N 3 10	163 31	S18 21	N			
10	2 27.6	40.7	25 37.6	31 01	321 04	15 31	165 55	23	72	02 30					
20	4 57.6	40.9	26 07.6	31 31	323 35	18 02	168 20	26	70	03 10					
30	7 27.6	41.1	30 38.3	36 01	426 05	20 32	170 45	28	68	03 39	-26				
40	9 57.6	41.3	33 06.4	40 31	428 35	23 03	173 10	30	66	04 00	14				
50	12 27.7	41.5	35 36.6	43 01	431 05	25 33	175 34	32	64	04 18	-08				
13 00	14 57.7	N 9 41.7	36 04.3	45 31.5	4 38	333 36	N22 18	28 03	N 3 10	177 58	S18 35				
10	17 27.7	41.9	41 34.7	48 01	336 06	30 33	180 24	37	62	04 32	03				
20	19 57.7	42.1	43 10.1	50 31	338 36	33 04	182 48	39	60	04 44	00				
30	22 27.8	42.3	44 40.5	53 00	341 06	35 34	185 13	41	58	04 55	+03				
40	24 57.8	42.5	46 10.4	55 30	343 36	38 04	187 38	43	56	05 04	05				
50	27 27.8	42.7	50 41.3	58 00	346 06	40 35	190 02	46	54	05 12	07				
14 00	29 57.8	N 9 42.4	53 11.7	60 30.5	4 37	348 36	N22 18	43 05	N 3 10	192 27	S18 48				
10	32 27.9	42.5	55 42.1	63 00	351 06	45 35	194 52	50	50	05 27	10				
20	34 57.9	42.7	58 12.5	65 30	353 36	48 06	197 16	52	45	05 41	12				
30	37 27.9	42.8	60 42.9	68 00	356 07	50 36	199 41	54	40	05 53	15				
40	39 57.9	43.0	63 13.4	70 30	358 37	53 06	202 06	56	35	06 03	16				
50	42 28.0	43.1	65 43.8	73 00	1 07	55 37	204 30	18 59	30	06 12	18				
15 00	44 58.0	N 9 43.3	68 14.2	75 30.5	4 35	3 37	N22 19	58 07	N 3 10	206 55	S19 01				
10	47 28.0	43.4	70 44.6	78 00	6 07	60 37	209 20	03	20	06 42	24				
20	49 58.0	43.6	73 15.0	80 30	8 37	63 08	211 44	05	10	06 55	26				
30	52 28.1	43.7	75 45.4	83 00	11 07	65 38	214 09	07	10	07 08	28				
40	54 58.1	43.9	78 15.8	85 30	13 37	68 08	216 34	09	20	07 22	31				
50	57 28.1	44.0	80 46.2	88 00	16 07	70 39	218 58	12	30	07 38	34				
16 00	59 58.1	N 9 44.2	83 16.6	90 30.5	4 34	18 38	N22 19	73 09	N 3 11	221 23	S19 14				
10	62 28.2	44.3	85 47.1	93 00	21 08	75 39	223 48	16	40	07 58	37				
20	64 58.2	44.5	88 17.5	95 30	23 38	78 10	226 12	18	50	08 10	40				
30	67 28.2	44.6	90 47.9	97 59	26 08	80 40	228 37	20	50	08 26	43				
40	69 58.3	44.8	93 18.3	100 29	28 38	83 10	231 01	22	52	08 33	44				
50	72 28.3	44.9	95 48.7	102 59	31 08	85 41	233 26	25	54	08 41	46				
17 00	74 58.3	N 9 45.1	98 19.1	105 29.5	4 33	33 38	N22 19	88 11	N 3 11	235 51	S19 27				
10	77 28.3	45.2	100 49.5	107 59	36 08	90 41	238 15	29	58	09 01	50				
20	79 58.4	45.4	103 19.9	110 29	38 38	93 11	240 40	31	60	09 13	54				
30	82 28.4	45.5	105 50.3	112 59	41 09	95 42	243 05	33	S						
40	84 58.4	45.6	108 20.8	115 29	43 39	98 12	245 29	35							
50	87 28.4	45.8	110 51.2	117 59	46 09	100 42	247 54	37							
18 00	89 58.5	N 9 45.9	113 21.6	120 29.5	4 32	48 39	N22 19	103 13	N 3 11	250 18	S19 39	Moon's P. in A			
10	92 28.5	46.1	115 52.0	122 59	51 09	105 43	252 43	42	A	C	A	C			
20	94 58.5	46.2	118 22.4	125 29	53 39	108 13	255 08	44	I	O	I	O			
30	97 28.5	46.4	120 52.8	127 59	56 09	110 44	257 32	46	t	r	t	r			
40	99 58.6	46.5	123 23.2	130 29	58 39	113 14	259 57	48							
50	102 28.6	46.7	125 53.6	132 59	61 10	115 44	262 21	50	0	59	54				
19 00	104 58.6	N 9 46.8	128 24.0	135 29.5	4 31	63 40	N22 20	118 15	N 3 11	264 46	S19 52				
10	107 28.6	47.0	130 54.4	137 59	66 10	120 45	267 11	54	6	58	55				
20	109 58.7	47.1	133 24.9	140 29	68 40	123 15	269 35	56	12	57	57				
30	112 28.7	47.3	135 55.3	142 58	71 10	125 46	272 00	19 58	16	56	58				
40	114 58.7	47.4	138 25.7	145 28	73 40	128 16	274 24	20 01	19	55	59				
50	117 28.7	47.6	140 56.1	147 58	76 10	130 46	276 49	03 24	22	54	61				
20 00	119 58.8	N 9 47.7	143 26.5	150 28.5	4 30	78 40	N22 20	133 17	N 3 11	279 13	S20 05				
10	122 28.8	47.9	145 56.9	152 58	81 10	135 47	281 38	07	26	52	62				
20	124 58.8	48.0	148 27.3	155 28	83 41	138 17	284 03	09	29	51	63				
30	127 28.8	48.2	150 57.7	157 58	86 11	140 47	286 27	11	30	50	64				
40	129 58.9	48.3	153 28.1	160 28	88 41	143 18	288 52	13	32	49	65				
50	132 28.9	48.5	155 58.6	162 58	91 11	145 48	291 16	15	34	48	66				
21 00	134 58.9	N 9 48.6	158 29.0	165 28.5	4 29	93 41	N22 20	148 18	N 3 12	293 41	S20 17				
10	137 28.9	48.8	160 59.4	167 58	96 11	150 49	296 05	19	36	47	67				
20	139 59.0	48.9	163 29.8	170 28	98 41	153 19	298 30	21	37	46	68				
30	142 29.0	49.1	166 00.2	172 58	101 11	155 49	300 54	23	39	45	69				
40	144 59.0	49.2	168 30.6	175 28	103 42	158 20	303 19	26	40	44	70				
50	147 29.0	49.4	171 01.0	177 58	106 12	160 50	305 43	28	42	43	71				
22 00	149 59.1	N 9 49.5	173 31.4	180 28.5	4 28	108 42	N22 21	163 20	N 3 12	308 08	S20 30				
10	152 29.1	49.7	176 01.8	182 58	111 12	165 51	310 33	32	44	42	73				
20	154 59.1	49.8	178 32.3	185 27	113 42	168 21	312 57	34	46	40	74				
30	157 29.1	50.0	181 02.7	187 57	116 12	170 51	315 22	36	47	39	75				
40	159 59.2	50.1	183 33.1	190 27	118 42	173 22	317 46	38	49	38	76				
50	162 29.2	50.3	186 03.5	192 57	121 12	175 52	320 11	40	50	37	77				
23 00	164 59.2	N 9 50.4	188 33.9	195 27.5	4 27	123 42	N22 21	178 22	N 3 12	322 35	S20 42				
10	167 29.2	50.6	191 04.3	197 57	126 13	180 53	325 00	44	51	36	78				
20	169 59.3	50.7	193 34.7	200 27	128 43	183 23	327 24	46	52	35	79				
30	172 29.3	50.9	196 05.1	202 57	131 13	185 53	329 49	48	53	34	80				
40	174 59.3	51.0	198 35.5	205 27	133 43	188 24	332 13	50	Sun SD	16.0					
50	177 29.3	51.2	201 05.9	207 57	136 13	190 54	334 39	52	Moon SD	16'					
Rate	15 00.2	N 00 00.9	14 59.7	N 00 01.1	15 00.7	N 00 00.3	15 01.9	N 00 00.2	14 27.8	S 00 12.7	Age 17d				

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SEMIDURATION OF MOONLIGHT



F4 INTERPOLATION OF MOONRISE, MOONSET

FOR LONGITUDE

Add if longitude west
Subtract if longitude east

Longi- tude	Diff.*					
	05	10	15	20	25	30
•	m	m	m	m	m	m
0	00	00	00	00	00	00
20	01	01	02	02	03	03
40	01	02	03	04	06	07
60	02	03	05	07	08	10
80	02	04	07	09	11	13
100	03	06	08	11	14	17
120	03	07	10	13	17	20
140	04	08	12	16	19	23
160	04	09	13	18	22	27
180	05	10	15	20	25	30
Longi- tude	Diff.*					
	35	40	45	50	55	60
•	m	m	m	m	m	m
0	00	00	00	00	00	00
15	03	03	04	04	05	05
30	06	07	08	08	09	10
45	09	10	11	12	14	15
60	12	13	15	17	18	20
75	15	17	19	21	23	25
90	18	20	22	25	28	30
105	20	23	26	29	32	35
120	23	27	30	33	37	40
135	26	30	34	38	41	45
150	29	33	38	42	46	50
165	32	37	41	46	50	55
180	35	40	45	50	55	60
Longi- tude	Diff.*					
	65	70	75	80	85	90
•	m	m	m	m	m	m
0	00	00	00	00	00	00
10	04	04	04	04	05	05
20	07	08	08	09	09	10
30	11	12	12	13	14	15
40	14	16	17	18	19	20
50	18	19	21	22	24	25
60	22	23	25	27	28	30
70	25	27	29	31	33	35
80	29	31	33	36	38	40
90	32	35	38	40	42	45
100	36	39	42	44	47	50
110	40	43	46	49	52	55
120	43	47	50	53	57	60
130	47	51	54	58	61	65
140	51	54	58	62	66	70
150	54	58	62	67	71	75
160	58	62	67	71	76	80
170	61	66	71	76	80	85
180	65	70	75	80	85	90

* When negative subtract correction if longitude west, and add if east.

Sunrise/Sunset Calculations Worksheet

I. Obtain Local Mean Time (LMT) from the tables contained in the Air Almanac, pp A130-A145. You will need the date, and the latitude of the location you desire. Some interpolation may be required.

II. Next convert the LMT from Step I to GMT by using the Conversion of Arc to Time chart on page A166. The whole degrees (°) of longitude will be converted into hours and minutes using the left portion of the chart and the minutes (') of longitude will be converted into minutes and seconds using the right hand column. The times are then added (for West Longitude) to the LMT obtained in step one. The result is the time of the event in GMT.

III. Convert GMT to LST using standard correction obtained from pages A20-A23.

1. Date: _____
 2. Latitude: _____
 3. Longitude: _____ (°) _____ (') _____ (")
 4. Standard Time Correction +/- _____ hrs _____ min

5. In appropriate page from A130 -A145, At the intersection of items 1 and 2 read the Local Mean Time and enter below:

<u>BEGIN CIVIL TWILIGHT</u>	<u>SUNRISE</u>	<u>SUNSET</u>	<u>End Civil Twilight</u>
_____ LMT	_____ LMT	_____ LMT	_____ LMT

6. From The Arc to Time Table, on page A166: Determine the GMT Conversion _____ hrs _____ min based on whole (°) longitude. Last column _____ min _____ sec based on minutes and seconds of longitude. Combining the two and rounding off seconds to minutes will give you the Total GMT Conversion (7).

7. Total GMT conversion = +/- _____ Hrs _____ Min
 * correction for West Longitude / - Correction for East Longitude)

8. DIFF IN GMT-(add 5 and 7)

(5)		Hrs	Min	
(7)	+/-	Hrs	Min	
		Hrs	Min	Z

9. DIFF IN LST-apply standard
 cor.(4) to (8)

(8)		Hrs	Min	
(4)	+/-	Hrs	Min	
		Hrs	Min	LST

* Civil Twilight can be computed in steps 8 and 9 using data from Civil Twilight tables. NOTE. **Nautical Twilight Time** can be estimated by subtracting the difference between civil twilight time and sunrise from Begin civil Twilight, and adding the difference between civil twilight time and sunset to the end civil twilight time.

MOONRISE/MOONSET CALCULATIONS WORKSHEET

I. Enter the Date, and the latitude/longitude of the location in question on the worksheet below.

II. Using the information from step I determine the Moonrise/set time from the appropriate Air Almanac table (pp 1-732) for the date in question. Some interpolation will be required. This is the Local Mean Time of the event at 0° Longitude. At the same time, copy down the DIFF value from the latitude closest to your location.

III. To convert to local mean time for your location, Enter page F4, using the longitude and the Diff from step II to determine the correction to be applied to LMT. After applying the correction and you will have the local mean time of the event for your location.

IV. Convert to GMT using the procedures below in para 9.

V. Convert to LST using the procedures in para 10 (The Standard Correction (5) obtained from pages A20-A23 of the Air Almanac.

1. Date: _____
2. Latitude: _____
3. Longitude: _____ (°) _____ (') _____ (")
4. Diff value(s) _____ / _____ minutes
5. Standard Time Correction _____ +/- hrs

6. Using 1 and 2 determine moonrise/set times at 0° Longitude from pp 1-732. MR: _____ /MS: _____.

7. Using 3 and 4 determine the correction for your longitude and apply to the time arrived at in 6. MR _____ /MS _____.

8. From The Arc to Time Table, on page A166: Determine the GMT Conversion on the left side of the chart _____ hrs _____ min based on whole (°) longitude. From the last column determine the _____ min _____ sec based on minutes and seconds of longitude. Combining the two and rounding off seconds to minutes will give you the Total GMT Conversion (8).

9. Total GMT conversion = +/- _____ Hrs _____ Min
(Use a + correction for West Longitude ; a - Correction for East Longitude)

10. MR/MS IN GMT-(add 7 and 9)

(7)		Hrs	Min
(9)	+/-	Hrs	Min
		Hrs	Min

11. MS/MS IN LST-apply standard (10)
cor. to (10)

(5)	+/-	Hrs	Min
		Hrs	Min

PREPARATION OF ASTRONOMICAL DATA - TEST ANSWERS

1. The earth's axis is not perpendicular to the plane of it's orbit. It is tilted $23\frac{1}{2}^\circ$. (or words to that effect.)

2. AM Civ Twilight	Sunrise	Sunset	PM Civ Twilight
0505	0532	1840	1907

3. AM Civ Twilight	Sunrise	Sunset	PM Civ Twilight
0304	0444	1924	2104

4. A. The moon's orbital speed
B. The moon's orbital angle (in either order)

5. Moonrise	Moonset
2035 GMT	0449 GMT
2135 LST	0549 LST

6. Moonrise	Moonset
7 May /0645	8 May /0645

If you missed any of these questions, go back and reread the appropriate sections of this Tech Note.

END

DATE

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