CELESTIAL NAVIGATION

USER`s GUIED
For 14-Software Programs

Captain / ADEL MOSTAFA

To the Student & Navigator

With the hope that this work
will stimulate an interest in Celestial Navigation
and provide an acceptable guide to its software applications.

Contents

Contents (continue)

Introduction

Since the use of the ship's positioning system by GPS, a saying has emerged that *Celestial Navigation* science has ended its era and that the Sextant should be hidden inside museums.

To respond to this statement, we summarize the following:

First: *Celestial Navigation* is not limited to determining the position of the ship, but it goes beyond that limited mission to the following important topics:

1) Compass error setting
    a) Measuring the direction of the sun during theoretical sunrise or sunset
    b) Measure the direction of any low-altitude celestial body
2) Definition of different time measurement systems and the relationship between them.
3) Knowledge of the foundations of the system of rising and setting celestial bodies.
4) Knowledge of the foundations of the annual movement of the sun and its effect on the phenomenon of day and night.
5) Transforming the legal foundations of the times of the call to prayer for the five daily prayers into applied equations.

Second: According to the International Maritime Organization IMO, *Celestial Navigation* is still recognized as a method for determining the observed position of a ship, and determining the ship's position by GPS is a confirmatory system.

Third: The flight of many navigators from the application of *Celestial Navigation* in determining the position of the ship is attributed to several reasons:

1) Unfamiliarity with adjusting the marine sextant.
2) Unskilled in using the marine sextant to measure the altitude of celestial bodies.
3) Awe of the length of the calculations to reach the elements of the position line.
4) Unfamiliarity with determining the most likely observed location after drawing three or more position lines.

To solve this dilemma, many available computer programs only require the navigator to observe stars or planets and enter data to obtain the most likely observed position; thus, the solution can be summarized in that the navigators are trained to control and use the marine sextant.

It is worth noting that one of the most important duties of the navigator is to calculate the time of occurrence of any natural phenomenon for a sailing ship; Therefore, the navigator resorts to applying the method of successive approximation. This method consists of applying the following steps:

1) Calculate the future time of occurrence of the phenomenon using the ship's current position; which is known as the first approximation.
2) Finding the ship's position at the time that was found in the previous step.
3) Using the ship's last position to calculate the time of the future occurrence of the phenomenon again, this is known as the second approximation.

Of course, the mathematical position of the ship can be obtained using the sailing map, or analytically using the following equations:

d. Lat. = dist. Cos T. Co.
dep. = dist. Sin T. Co.
d. Long. = dep. / Cos (mean Lat.)

Natural phenomena that require finding their future time of occurrence while sailing; can be summarized in one sailing day as follows:

1) Morning civil twilight time to prepare for star observations.
2) Sunrise time to check the compass error (amplitude method).
3) The accurate time of the meridian passage of the sun to find the *Observed Latitude* of the ship at noon.
4) Sunset time to check the compass error (amplitude method).
5) Evening civil twilight time to prepare for star observations.

It is obvious that there are many programs that solve these requirements, but alone; any calculation of the time of the morning civil twilight, for example, without preparing the stars chart for observation. So the thought was to design several programs to solve these requirements; these programs are:

A. *The first group to solve general navigation problems:*

1. A program for finding the arrival position with the knowledge of the starting position, the true course and the distance traveled.
2. A program for finding the distance and true course from the departed position to the arrived position.

B. *The second group to solve the problems of daily celestial navigation activities:*

3. A program for finding the time for the next prayer; and the direction of the Qiblah at that time.
4. A program for finding Compass error (*Time Method*).
5. A program for finding Compass error (*Amplitude Method*).
6. A program to prepare for observing the stars (*Star Chart*) during the morning (or evening) twilight.
7. A program to find the time to the nearest second to cross the sun on the ship's meridian.

C. *The third group for solving basic celestial navigation problems:*

8. A Program to solve the observation of the sun.
9. A program to solve two observations of the sun, with a long run in between, in order to obtain the observed (fixed) position.
10. A Program to solve the observation of a star
11. A program for finding the most probable observed position by observing a group of stars simultaneously in a *Universal Method*.
12. A program for finding the most probable observed position by observing a group of stars simultaneously in the *Egyptian Method*.

D. *The fourth group to solve problems related to celestial navigation:*

13. A Program to identify a bright unknown star among the clouds.
14. A program for finding the coordinates of the sun and the point of the vernal equinox, as well as the equation of time.

It should be noted that these programs are available to my sons and fellow naval officers as a science to benefit from.
This is what was agreed upon by the work team, Eng. ***Islam Badawy***, who designed these programs, and my dear son, ***Ahmed Adel***, who designed the required graphics.

In the exercises; you shall use the following equipment’s:

- *Captain Adel Mostafa soft-ware programs which is given free.*
- *Pages of Nautical Almanac Tables for the year 1990 are accompanied for the concerned dates.*
- *Any Nautical Almanac Tables to extract:*
    - *Increments for Sun and Aries.*
    - *Dip angle correction.*
    - *Altitude corrections for sun and stars*

Applications of these Soft-Ware Programs are explained separately in the next pages.

GROUP (1)

ELEMENTARY GENERAL NAVIGATION PROBLEMS

- *Rhumb Line (Lat. & Long.)*
- *Rhumb Line (T. Co & Dist.)*

A. GROUP (1)

1) Rhumb Line (Lat. & Long.)

To apply this software program you must:

Calculate *<u>distance run</u>* in the interval of run.

It is designed to obtain <u>reached position</u> by the knowledge of initial position, true course and distance run.

The screen of the software program is given below

Rhumb Line Sailing (Latitude & Longitude)

DR Latitude
[°] [`] [N / S]
DR Longitude
[°] [`] [E / W]
True Co.
[°]
Distance
[Miles]

Solved Application:

Given:

- ZT_1 2200 Mar. 12^{th};
- DR (31° 07`.1 N; 24° 45`.8 E)
- True Course 153°.0
- Speed 16.4 k

Find DR at ZT_2 0400 Mar.13^{th}.

Procedure of application

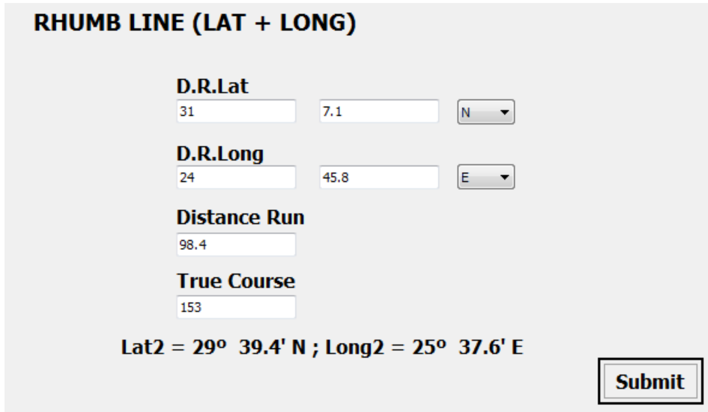
Step (1): Obtaining interval of run

ZT_2	0400 Mar.13^{th}
ZT_1 (-)	2200 Mar. 12^{th}
Interval	6h 00m

Step (2): Obtaining distance run

Distance run = [6h 00m x 16.4k] = <u>98.4 Miles</u>

Step (3): Apply software as follows;



Result obtained DR$_{0400}$March 13th (29° 39`.4 N; 25° 37`.6 E)

TRAINING APPLICATIONS

Application (1)

Given:

- Initial DR (31° 15`.9 N; 115° 44`.7 W)
- Distance runs 167.5 M
- True course to steer 201°.0

Calculate Final DR?

Application (2)

Given:

- Initial DR (37° 15`.9 S; 177° 41`.7 W)
- Distance runs 367.8 M
- True course to steer 259°.0

Calculate Final DR?

Application (3)

Given:

- Initial DR (01° 15`.9 N; 077° 51`.3 E)
- Distance runs 452.6 M
- True course to steer 169°.0

Calculate Final DR?

Application (4)

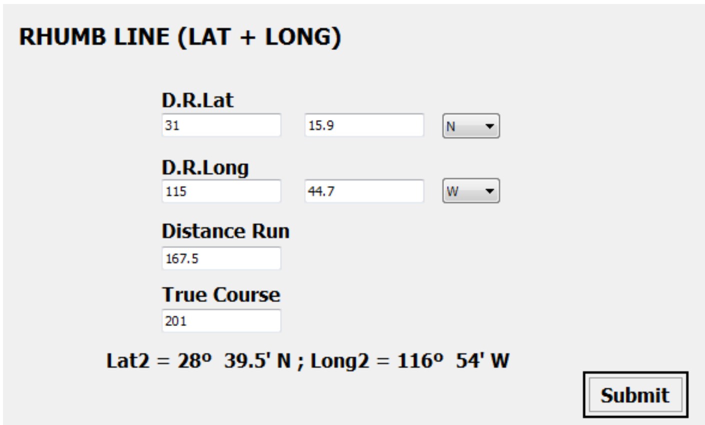
Given:

- Initial DR (00° 10`.5 S; 179° 55`.0 E)
- Distance runs 76.0 M
- True course to steer 066°.0

Calculate Final DR?

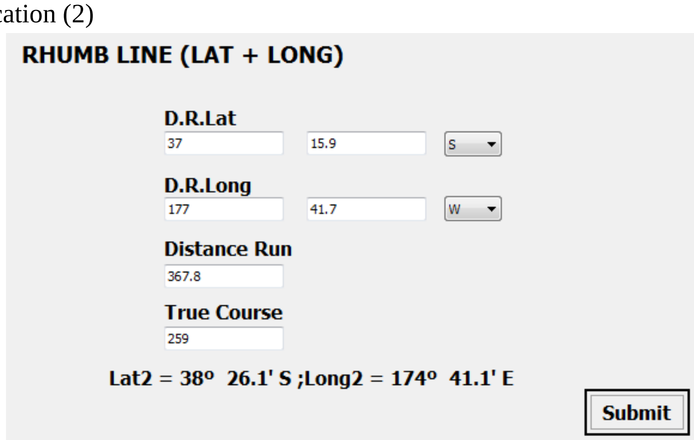
ANSWERS

Application (1)



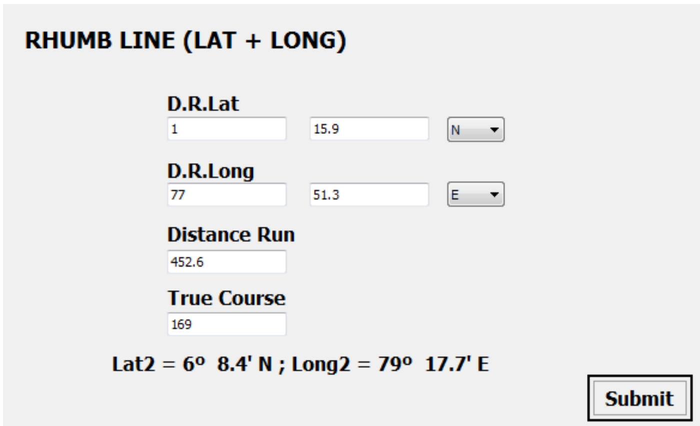
Result obtained (28°39`.5 N; 116° 54`.0 W)

Application (2)



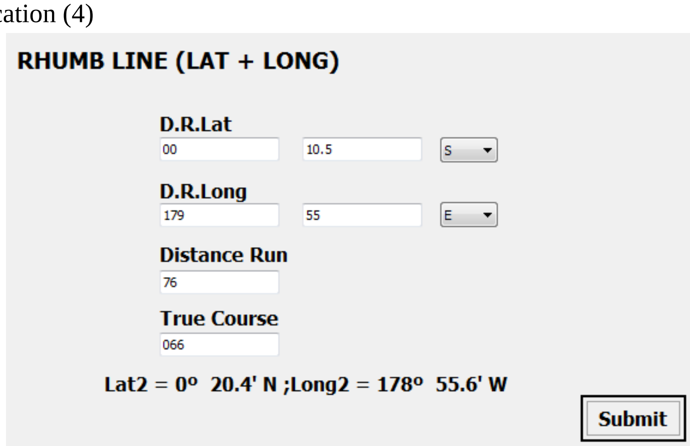
Result obtained (38°26`.1 S; 174° 41`.1 E)

Application (3)



Result obtained (6°08`.4 S; 079° 17`.7 E)

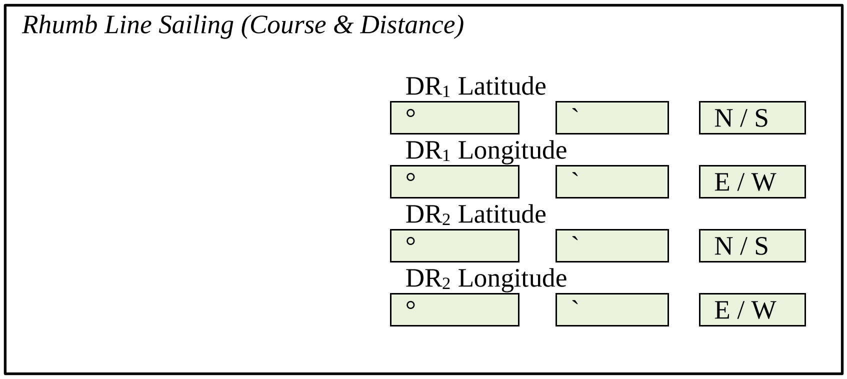
Application (4)



Result obtained (00°20`.4 N; 178° 55`.6 W)

2) *Rhumb Line (T. Co & Dist.)*

To apply this software program no previous calculations is needed:
It is designed to obtain *__true course__* and *__distance run__* from the initial position to the reached position.
The screen of the software program is given below



Solved Application (1):

Given:

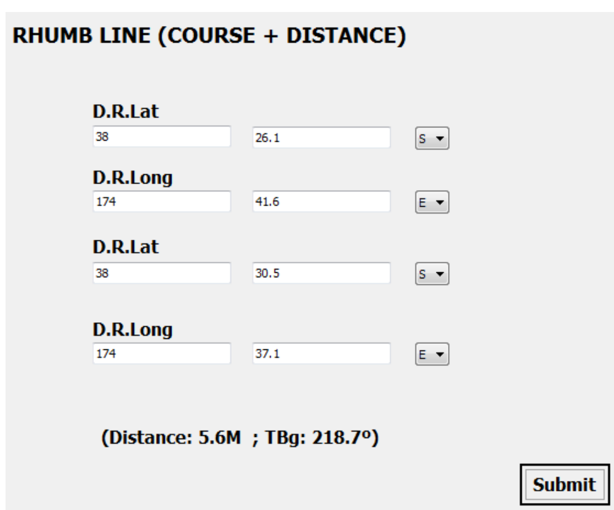
DR position (38°26`.1 S; 174° 41`.6 E)

Observed position (38°30`.5 S; 174° 37`.1 E)

Calculate the shift and bearing of the observed position from the DR position.

Procedure of application

Apply software as follows



Result obtained:

Shift of the observed position from DR position is5.6 Miles in the direction 218°.7

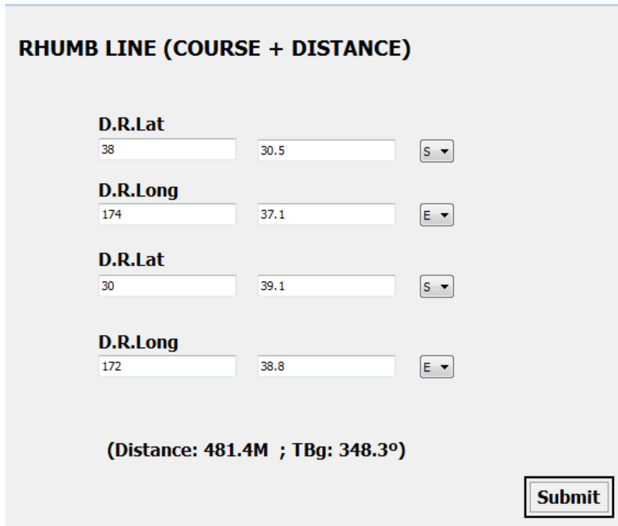
Solved Application (2):

Given:

Your vessel in DR position (38°30`.5 S; 174° 37`.1 E) received SOS signal from a ship in DR position (30°39`.1 S; 172° 38`.8 E).

Calculate distance run and true course to steer to arrive to that ship?

Apply software as follows



Result obtained:

Distance 481.4 Miles; True course to steer 348°.3

TRAINING APPLICATIONS

Application (1)

Given:

DR position (28°23`.5N; 170° 13`.7 E)

Observed position (28°32`.2N; 170° 17`.3 E)

Calculate the shift and bearing of the observed position from the DR position.

Application (2)

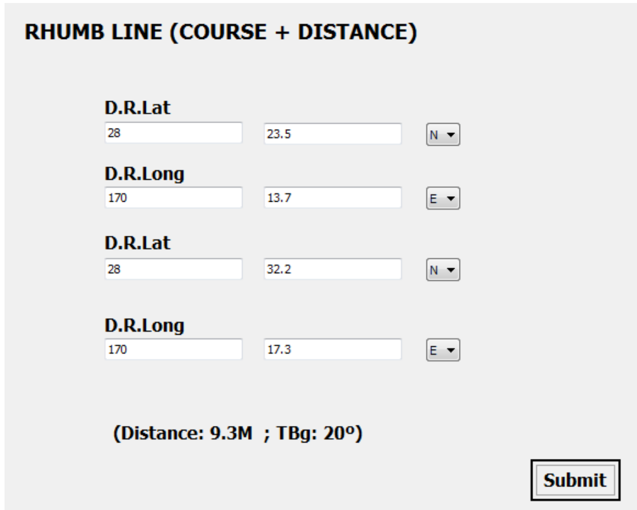
Given:

Your vessel in DR position (42°39`.5 N; 174° 08`.1 W) received SOS signal from a ship in DR position (37°09`.1 N; 172° 38`.8 W).

Calculate distance run and true course to steer to arrive to that ship?

ANSWERS

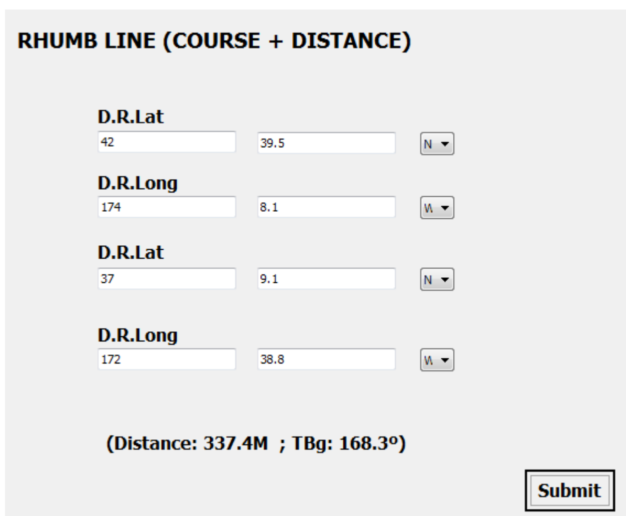
Application (1)



Result obtained:

Shift of the observed position from DR position is9.3 Miles in the direction 020°.0

Application (2)



Result obtained:

Distance 337.4 Miles; True course to steer 168°.3

GROUP (2)

DAILY CELESTIAL NAVIGATION ACTIVITIES

- *Prayer Times*
- *Compass Error (Time Method)*
- *Compass Error (Amplitude Method):*
- *Star Chart*
- *Meridian Passage*

B. GROUP (2)

3) *Prayer Times*

To apply this software programs you can proceed without any previous calculations.

The software program is designed to obtain:

- El-Fagr Time and El-Qibla direction
- El-Sherouk Time (Sun rise)
- El-Zohr Time (Noon) and El-Qibla direction
- El-Asr Time and El-Qibla direction
- El-Maghrib Time (Sun set) and El-Qibla direction
- El-Esha Time and El-Qibla direction

The screen of the software program is given below

Prayer Times and El-Qibla Direction

ZT

h	m	s

Date

D	M	Y

DR Latitude

°	\`	N / S

DR Longitude

°	\`	E / W

True Co.	Speed	Prayer
°	knots	

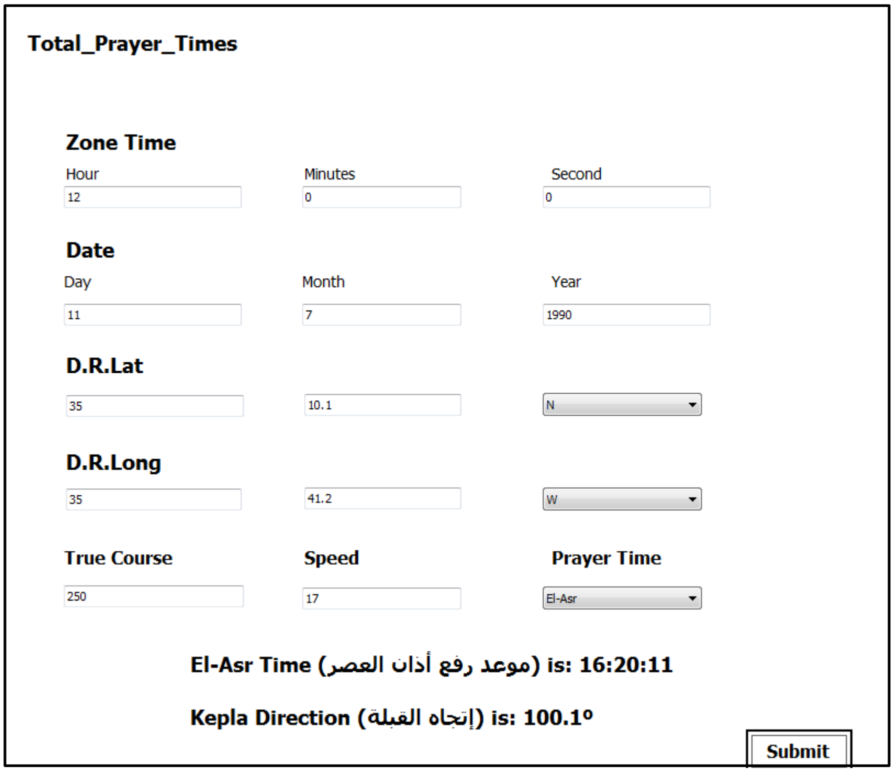
Solved Application (1):

ZT 1200; Z.N. (+2); Jul. 11^{th}, 1990

- DR (35° 10`.1 N; 35° 41`.2 W)
- True Course 250°.0
- Speed 17 k
- Calculate El-Asr Time and El-Qibla direction

Solution

Apply software as follows;



ANSWER

El-Asr time 16h 20m 11s

Kepla Direction 100°.1

TRAINING APPLICATIONS

Application (1)
ZT 0000; Z.N. (-9); August 3rd, 1990

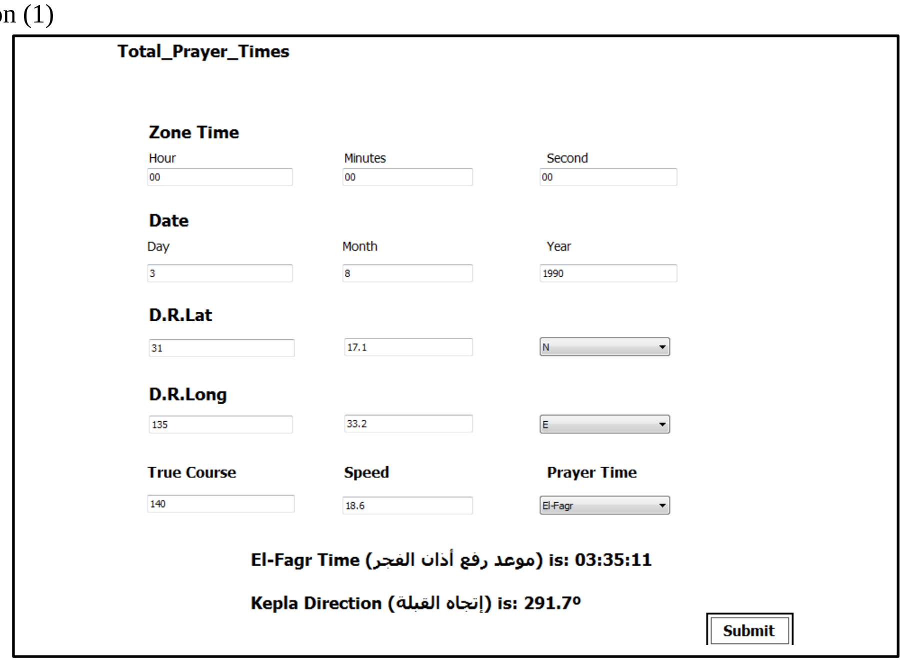
- DR (31° 17`.1 N; 135° 33`.2 E)
- True Course 140°.0
- Speed 18.6 k
- Calculate El-Fagr Time and El-Qibla direction

Application (2)
ZT 1600; Z.N. (+9); October 2nd, 1990

- DR (41° 53`.1 S; 139° 53`.2 W)
- True Course 020°.0
- Speed 19.5 k
- Calculate El-Maghreb Time and El-Qibla direction

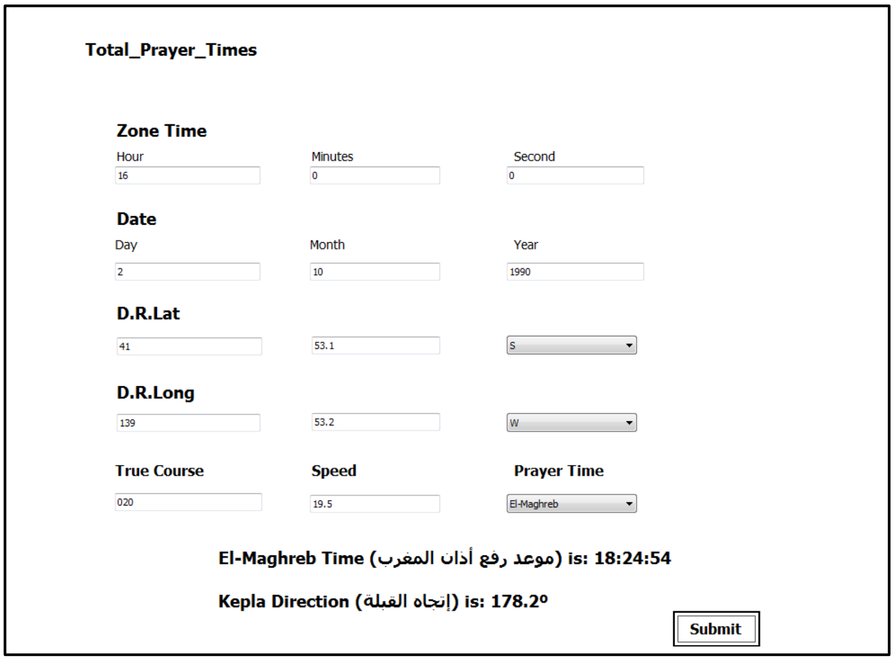
ANSWERS

Application (1)



El-Fagr time 03h 35m 11s
Kepla Direction 291°.7

Application (2)



El-Maghreb time 18h 24m 54s
Kepla Direction 178°.2

4) Compass Error (Time Method)

To apply this software program:

In case of a star you must:

- Calculate [GHA_{star}] at GMT of taking compass or gyro bearing or both.
- Extract [$Dec._{star}$]

In case of Sun you must:

- Calculate [GHA_{sun}] at GMT of taking compass or gyro bearing or both.
- Calculate [$Dec._{sun}$]

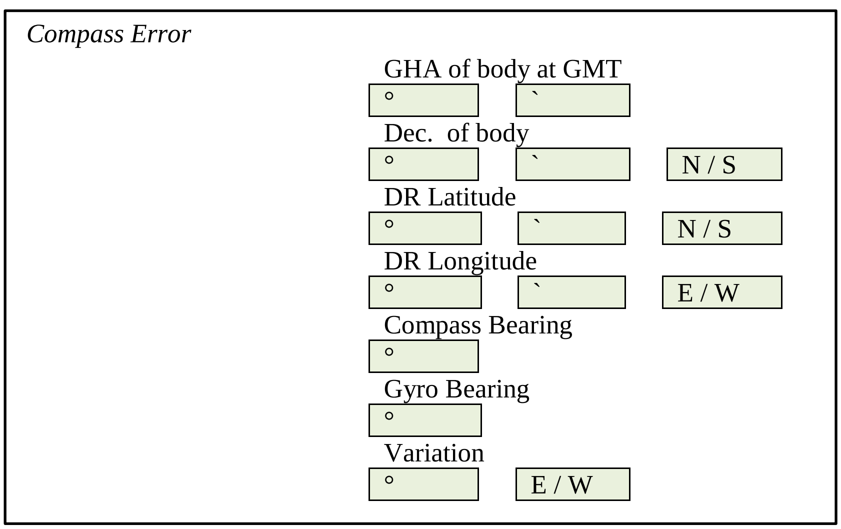
In both cases:

- Correct variation to *year 1990* for exercises; (*practically in deep sea it is corrected to the current year of sailing).*

The software program is designed to obtain;

- Compass Error
- Gyro Compass Error
- Deviation

The screen of the software program is given below



Solved Application (1):

The star *Dubhe* was seen at low altitude on the western horizon.
It is required to check the error of the compasses.
The following data were recorded;

- GMT: 23h 40m 40s on August 23rd ; 1990
- DR: 29º 30`.0 N; 46º 40`.0 W
- Compass Bearing 330º.0
- Gyro Bearing 332°.0
- Variation (1978) 3º.0 E (decreasing 5` annually)

Calculate the error of each compass and the deviation.

Solution;

Step (1) Extract G.H.A.* & Dec*

G.H.A. γ	316° 58`.4		
Incr.	10° 11`.7		
SHA	194° 12`.9	Dec	61° 48`.2 N
G.H.A.*	161° 23`.0		

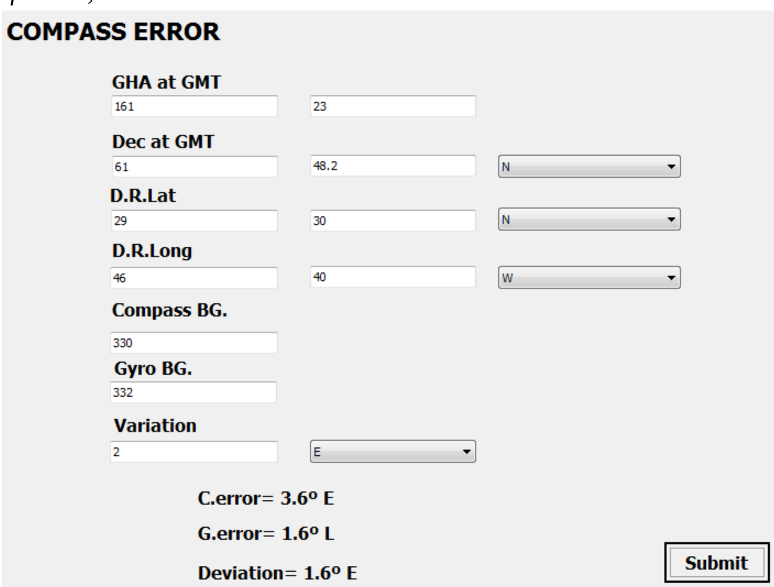
Step (2)

Calculate Var_{1990};

$Var._{1990}$ =$Var._{1978}$ - (5x12) =3º.0 E - 1º.0 = 2º.0 E

Step (3)

Apply software as follows;



Answers: Compass Error [3°.6 E] & Deviation [1°.6 E]
Gyro Error [1°.6 Low]

Solved Application (2):

Sun was seen at low altitude on the western horizon.
It is required to check the error of the compasses.
The following data were recorded;

- GMT: 01h 24m 28s on January 2nd ; 1990
- DR: 31º 15`.0 S; 125º 22`.0 W
- Compass Bearing 259º.0
- Gyro Bearing 255°.5
- Variation (1986) 1º.4 E (decreasing 6` annually)

Calculate the error of each compass and the deviation.

Solution;

Step (1) Extract G.H.A.* & Dec*

G.H.A.	194° 03`.1	Dec.	22° 57`.4 S
Incr.	06° 07`.0	d. Corr.	0`.1
G.H.A.	200° 10`.1	C. Dec	22° 57`.3 S

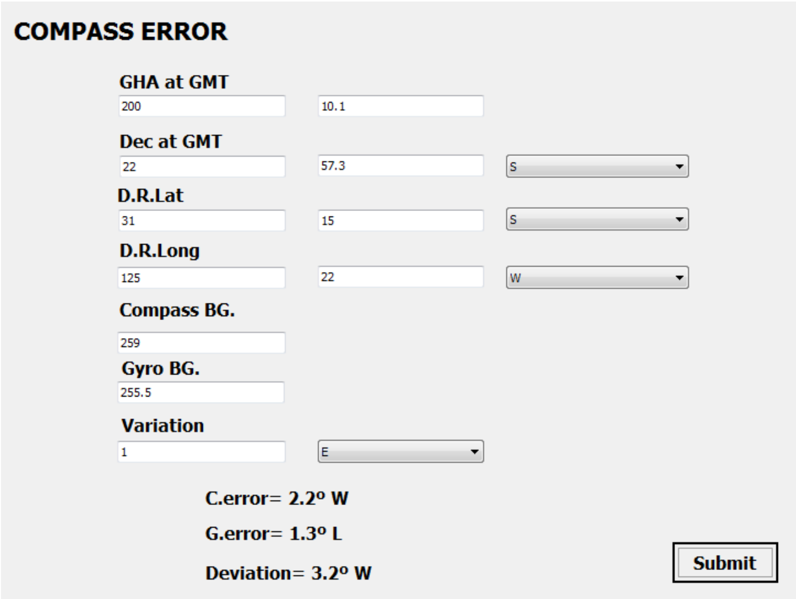
Step (2)

Calculate Var_{1990};

$$Var._{1990} = Var._{1986} - (6`x4) = \mathbf{1}º.4\ E - 0º.4 = 1º.0\ E$$

Step (3)

Apply software as follows;



Answers: Compass Error [2°.2 W] & Deviation [3°.2 W]
Gyro Error [1°.3 Low]

TRAINING APPLICATIONS

Application (1)

The star *Altair* was seen at low altitude on the western horizon.
It is required to check the error of the compasses.
The following data were recorded;

- GMT: 19h 31m 29s on June 17th; 1990
- DR: 34º 10`.0 S; 144º 35`.0 E
- Compass Bearing 312º.0
- Gyro Bearing 308°.0
- Variation (1980) 3º.0 E (decreasing 3` annually)

Calculate the error of each compass and the deviation.

Application (2)

The star *Hadar* was seen at low altitude on the eastern horizon.
It is required to check the error of the compasses.
The following data were recorded;

- GMT: 7h 32m 40s on February 17th; 1990
- DR: 41º 20`.0 S; 171º 20`.0 E
- Compass Bearing 155º.0
- Gyro Bearing 159°.5
- Variation (1986) 1º.5 W (increasing 15` annually)

Calculate the error of each compass and the deviation.

Application (3)

Sun was seen at low altitude on the eastern horizon.
It is required to check the error of the compasses.
The following data were recorded;

- GMT: 14h 42m 14s on June 17th; 1990
- DR: 21º 10`.0 N; 125º 00`.0 W
- Compass Bearing 065º.5
- Gyro Bearing 069°.0
- Variation (1975) 0º.5 W (decreasing 4` annually)

Calculate the error of each compass and the deviation.

Application (4)

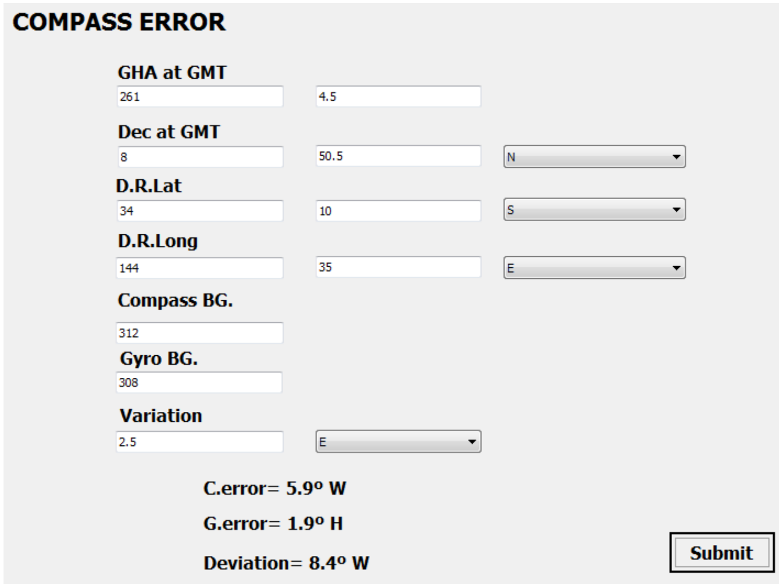
Sun was seen at low altitude on the eastern horizon.
It is required to check the error of the compasses.
The following data were recorded;

- GMT: 22h 35m 10s on August 23rd ; 1990
- DR: 22º 05`.0 N; 120º 30`.0 E
- Compass Bearing 085º.0
- Gyro Bearing 083°.0
- Variation (1978) 1º.5 W (increasing 5` annually)

Calculate the error of each compass and the deviation.

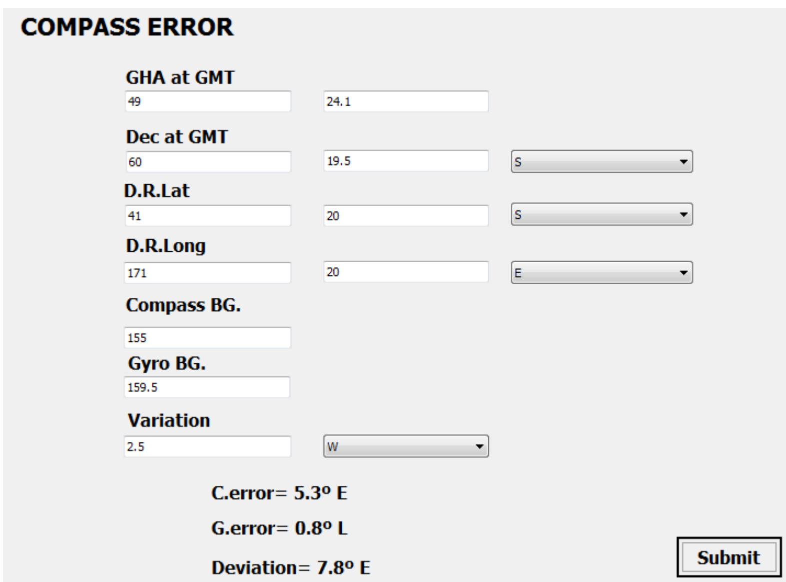
ANSWERS

Application (1)



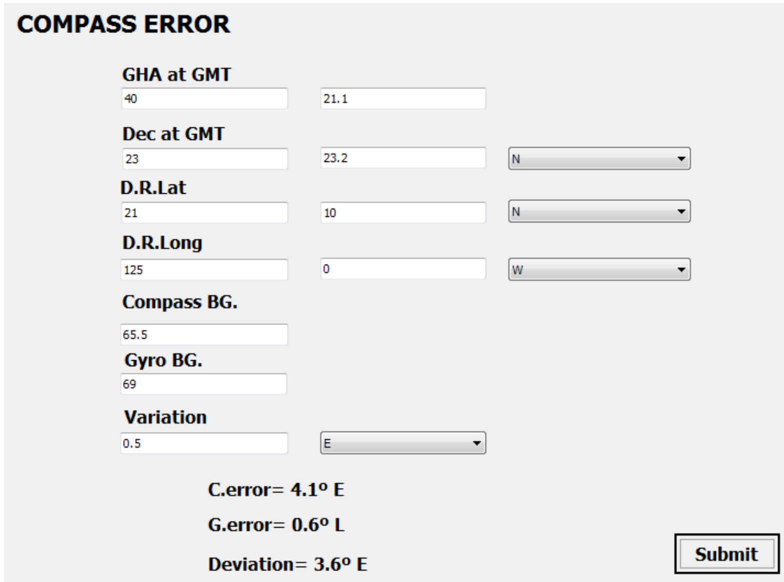
Answers: Compass Error [5°.9 W] & Deviation [8°.4 W]
Gyro Error [1°.9 H]

Application (2)



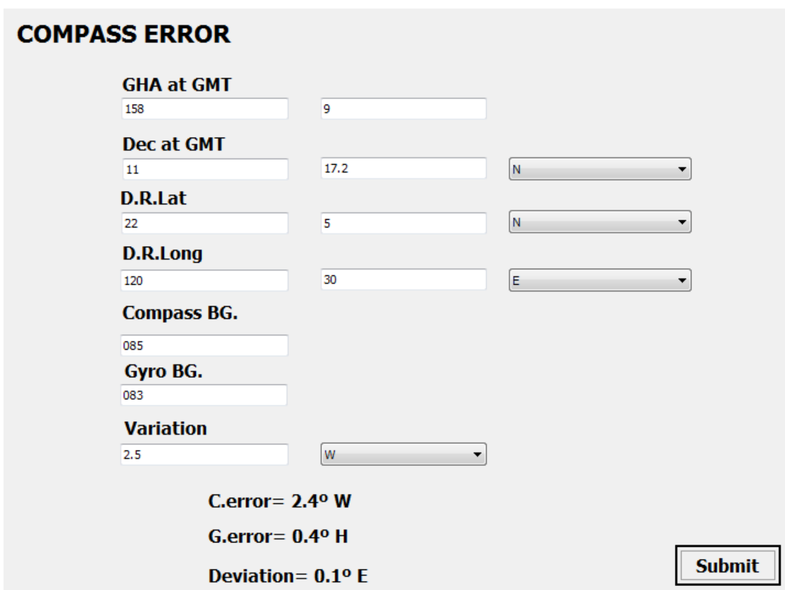
Answers: Compass Error [5°.3 E] & Deviation [7°.8 E]
Gyro Error [0°.8 Low]

Application (3)



Answers: Compass Error [4°.1 E] & Deviation [3°.6 E]
Gyro Error [0°.6 Low]

Application (4)



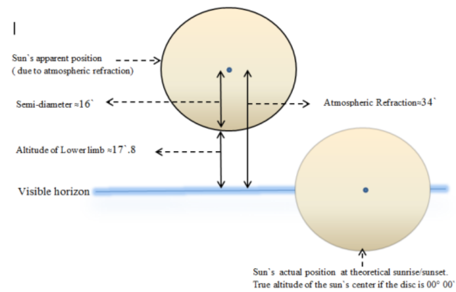
Answers: Compass Error [2°.4 W] & Deviation [0°.1 E]
Gyro Error [0°.4 H]

5) *Compass Error (Amplitude Method):*

It is a chance to check compasses and deviation at theoretical sunrise or sunset. The sun`s bearing must be taken a certain situation of the sun`s disc. This is correct only when the altitude of the lower limb of the sun`s disc is nearly equals its semi-diameter.
Practically the navigator must calculate the *True Bearing* of the sun`s disc at the phenomena *in-advance*. At the moment when he observes the compass bearing, he can obtain the compass error directly.

The software program is designed to obtain;

- True Bearing
- Compass Error
- Gyro Compass Error
- Deviation



The screen of the software program is given below

Compass Error (Amplitude)

ZT
h | m | s
Date
D | M | Y
Phenomena
Sunrise / Sunset
DR Latitude
° | ` | N / S
DR Longitude
° | ` | E / W
True Co. | Speed
° | knots
Compass Bearing
°
Gyro Bearing
°
Variation
° | E / W

Solved Application

ZT 0400 April 2nd 1990;

- DR (30° 10`.1 N; 25° 19`.6 E)
- True Course 153°
- Speed 16 k
- Variation$_{1990}$ 1°.3E

In order to check the compasses at theoretical sunrise phenomena; calculate the True Bearing of the sun at the phenomena in-advance.

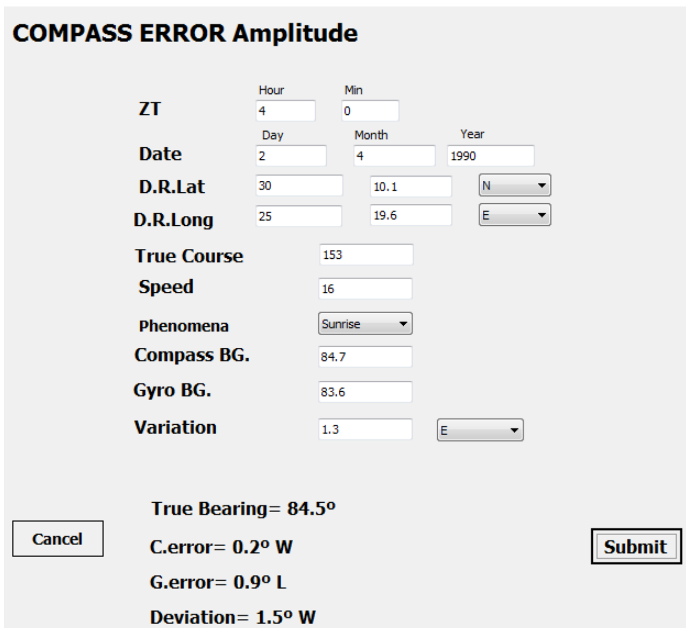
At theoretical Sun Rise:

- Compass bearing was 094°.7
- Gyro bearing was 093°.6

Calculate the error of each compass and the deviation.

Solution;

Apply software as follows;



Answer:
True Bearing at Sunrise 084°.5
Compass Error 0°.2 W
Gyro Error 0°.9 Low
Deviation 1°.5W

TRAINING APPLICATIONS

Application (1)

ZT 0400 August 23th 1990;

- DR (44° 11`.1 S; 30° 57`.8 E)
- True Course 100°
- Speed 16 k
- Variation_{1990} 2°.1E

In order to check the compasses at theoretical sunrise phenomena; calculate the True Bearing of the sun at the phenomena in-advance.

At theoretical Sun Rise:

- Compass bearing was 073°.0
- Gyro bearing was 074°.0

Calculate the error of each compass and the deviation.

Application (2)

ZT 1600 October 15th 1990;

- DR (39° 15`.4 N; 179° 31`.0 E)
- True Course 085°
- Speed 22 k
- Variation_{1990} 3°.0W

In order to check the compasses at theoretical sunrise phenomena; calculate the True Bearing of the sun at the phenomena in-advance.

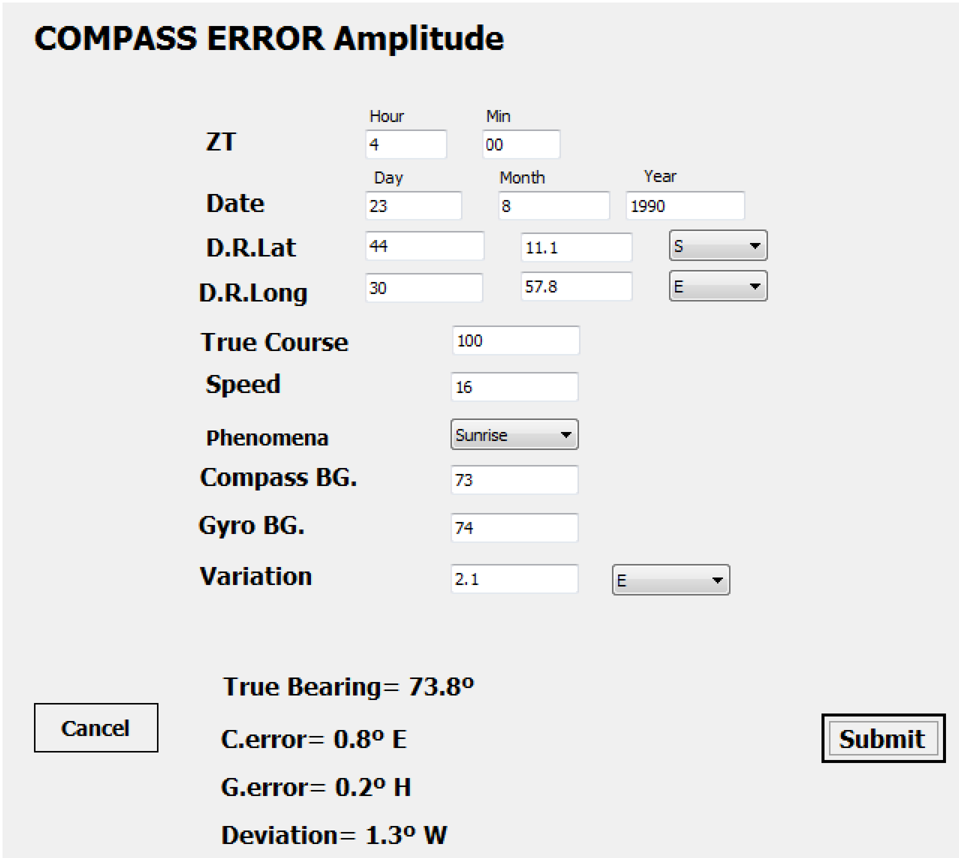
At theoretical Sun Rise:

- Compass bearing was 261°.1
- Gyro bearing was 260°.7

Calculate the error of each compass and the deviation.

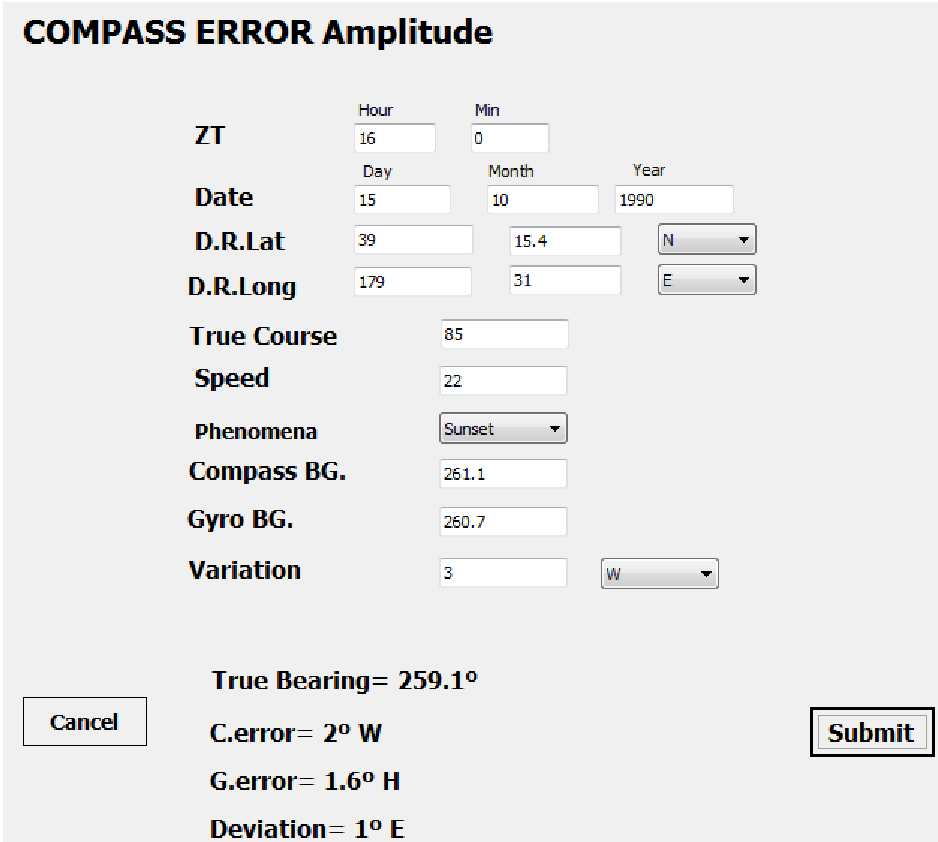
ANSWERS

Application (1)



Answer:
True Bearing at Sunrise 073°.8
Compass Error 0°.8 E
Gyro Error 0°.2 H
Deviation 1°.3 W

Application (2)



Answer:
True Bearing at Sunrise 259°.1
Compass Error 2°.0W
Gyro Error 1°.6 High
Deviation 1°.0 E

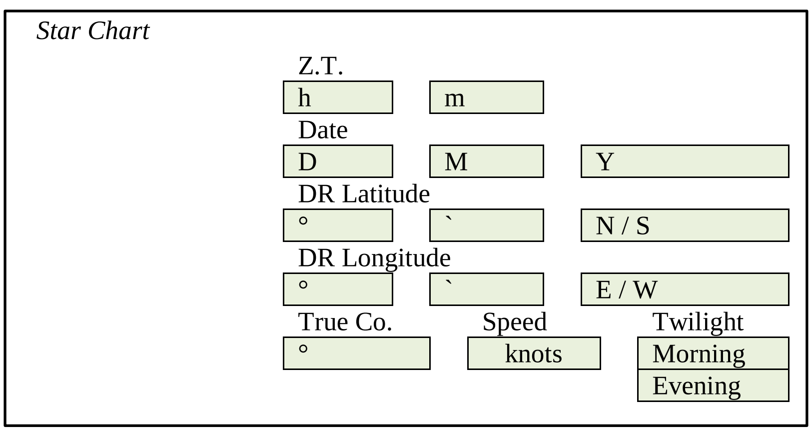
6) *Star Chart*

To apply this software programs you can proceed without any previous calculations.

The software program is designed to obtain:
Star Chart at <u>*Evening or Morning civil twilight*</u> (the middle time of taking star sights),
Accompanied with a table of suitable stars to be observed:

Star Name	altitude	True Bg.
↓	↓	↓

The screen of the software program is given below



Solved Application

At Z.T. 0005 January 2nd; 1990.

Ship was in DR Position (32° 45`.0 S; 173° 20`.0 E)

- Steaming Speed 19.5 K
- Steering true course 333°.0

Calculate:

- Choose and name (7) suitable stars for observation at the morning twilight; referring to the *Air Navigation Tables* as a guide, giving their predicted altitudes & bearings (to the nearest degree).
- Draw a figure showing the horizon, true course of the ship and the chosen stars as a guide for observation.

Manual Calculations:

To find G.M.T. of The Morning Civil Twilight:

Z.T.	0005 Jan.2nd
Z.N. (-)	12
G.D.	1205 Jan. 1st

1st *Approximation*

L.M.T.	0436 Jan. 2nd
Lat. Corr^{n}	8
L.M.T.	0428 Jan. 2nd
± Long. w/ E	1133
G.M.T.$_1$	1655 Jan. 1st
G.D.	1205 Jan. 1st
Interval	0450

Distance Run = (04h 50m) x 19.5 k = 94.3 **M**

True Course to steer **333.0**

d. Lat.	**dep.**	M. latitude	**d. Long.**
84`.0 N	42`.8 W	32°.15	50`.5 W

DR$_1$	Lat.	32° 45`.0 S	Long.	173° 20.0 E
	d. Lat.	1° 24`.0 N	d. Long.	0° 50`.5 W
DR$_2$	Lat.	31° 21`.0 S	Long.	172° 29.5 E

2nd *Approximation*

L.M.T.	0436 Jan. 2nd
Lat. Corr^{n}	4
L.M.T.	0432 Jan. 2nd
± Long. w/ E	1130
G.M.T.$_2$	1702 Jan. 1st
G.M.T.$_1$	1655 Jan. 1st
Interval	0007 (+)

Distance Run = (00h 07m) x 19.5 k = 2.3 **M**

True Course to steer **333.0**

d. Lat.	**dep.**	M. latitude	**d. Long.**
2`.0 N	1`.0 W	31°.3	1`.2 W

DR$_2$	Lat.	31° 21.0 S	Long.	172° 29`.5 E
	d. Lat.	2.0 N	d. Long.	1`.2 W
DR$_3$	Lat.	31° 19.0 S	Long.	172° 28`.3 E

Calculating LHA γ (At G.M.T.$_2$)

G.H.A. γ	356° 05`.1
Incr.	0° 30`.1
G.H.A. γ	356° 35`.2
± Long. E/ W	172° 28`.3
L.H.A. γ	169° 03`.5

Extract The 7-Recommended Stars

	Star Name	Altitude	True Bearing
1	*Arcturus*	24°	047°
2	*Antares*	22°.5	108°
3	*Acrux*	56°	166°
4	*Canopus*	34°	224°
5	*Sirius*	27°.5	266°
6	*Procyon*	27°	295°
7	*Regulus*	44°	337°

Procedure of application

A. Application of the soft-ware program;

ZT		
00	05	
Date		
2	1	1990
DR Latitude		
32	45	S
DR Longitude		
173	20	E
True Course	Speed	Twilight
333	19.5	morning

B. Results obtained:

STAR CHART

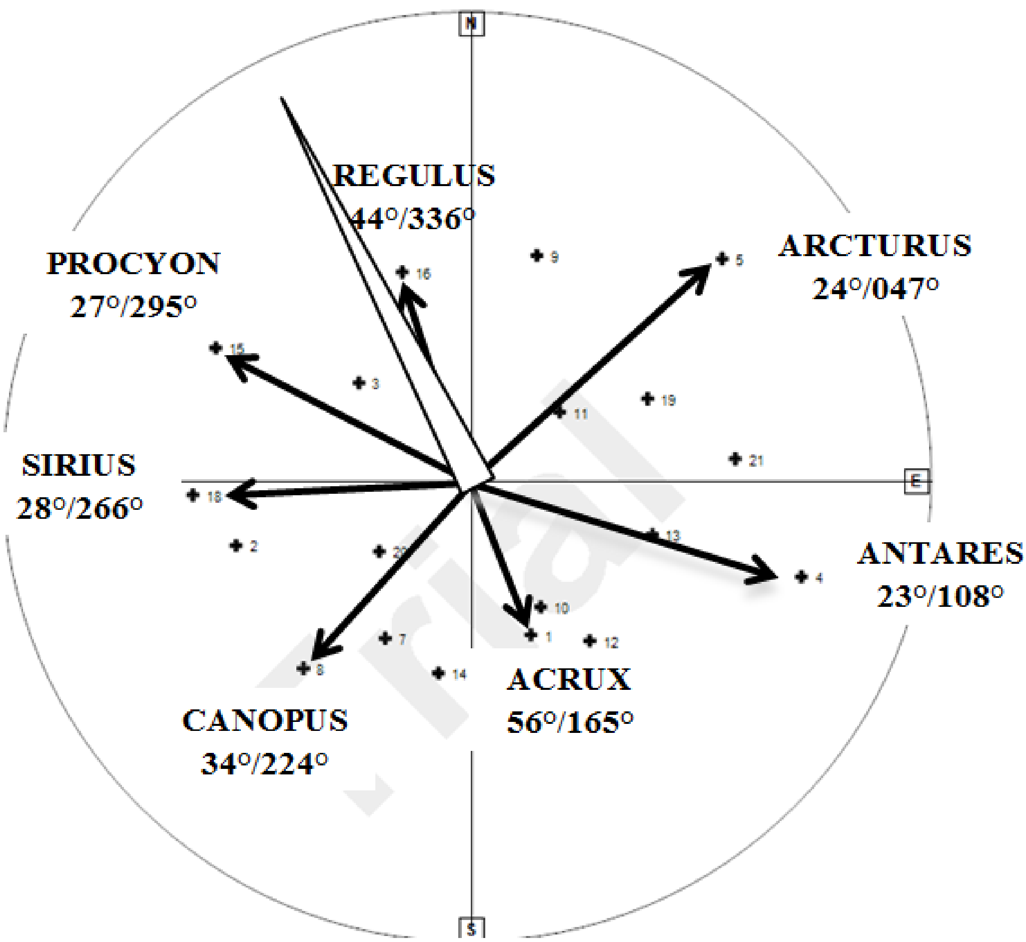


TABLE OF ALTITUDES AND BEARINGS

No	Star Name	Altitude	True Bearing
1	Acrux	55° 59.8'	165° 28.3'
2	Adhara	35° 20'	254° 29.6'
3	Alphard	56° 36.4'	305° 26.5'
4	Antares	21° 53.2'	108° 2.7'
5	Arcturus	23° 55'	47° 0.1'
6	Atria	31° 13'	155° 25.4'
7	Avior	49° 50.9'	213° 0.4'
8	Canopus	34° 12.3'	224° 5.8'
9	Denebola	43° 11.6'	11° 57.7'
10	Gacrux	60° 51.1'	158° 39.1'
11	Gienah	70° 27.2'	47° 42.6'
12	Hadar	49° 51.9'	148° 43.9'
13	Menkent	54° 5.2'	109° 50.5'
14	Miaplacidus	47° 33'	194° 40.6'
15	Procyon	27° 11.7'	295° 1.7'
16	Regulus	44° 0.3'	336° 34.3'
17	Rigil Kentaurus	45° 23.8'	147° 33'
18	Sirius	28° 5.4'	266° 13.2'
19	Spica	53° 30.5'	64° 1.6'
20	Suhail	61° 59.6'	235° 37.3'
21	zubenelgenubi	38° 46.6'	85° 58.4'

TRAINING APPLICATIONS

Application (1)

At Z.T. 0140 December 15th; 1990.
Ship was in DR Position (38° 25`.0 S; 159° 38`.0 E)

Steaming Speed 18.4 knots
Steering True course 059°.0

Calculate:

- Choose and name (7) suitable stars for observation at the morning twilight; referring to the *Air Navigation Tables* as a guide, giving their predicted altitudes & bearings (to the nearest degree).
- Draw a figure showing the horizon, true course of the ship and the chosen stars as a guide for observation.

Application (2)

At Z.T. 1340 December 15th; 1990.
Ship was in DR Position (38° 25`.0 S; 159° 38`.0 W)

Steaming Speed	18.4 knots
Steering True course	077°.0

Calculate:

- Choose and name (7) suitable stars for observation at the evening twilight; referring to the *Air Navigation Tables* as a guide, giving their predicted altitudes & bearings (to the nearest degree).
- Draw a figure showing the horizon, true course of the ship and the chosen stars as a guide for observation.

Application (3)

At Z.T. 1330 December 17th; 1990.
Ship was in DR Position (37° 40`.0 S; 160° 50`.0 E)

Steaming Speed	19.0 knots
Steering True course	099°.0

Calculate:

- Choose and name (7) suitable stars for observation at the evening twilight; referring to the *Air Navigation Tables* as a guide, giving their predicted altitudes & bearings (to the nearest degree).
- Draw a figure showing the horizon, true course of the ship and the chosen stars as a guide for observation.

Application (4)

At Z.T. 0130 December 16th; 1990.
Ship was in DR Position (37° 40`.0 S; 160° 50`.0 E)

Steaming Speed	19.0 knots
Steering True course	249°.0

Calculate:

- Choose and name (7) suitable stars for observation at the morning twilight; referring to the *Air Navigation Tables* as a guide, giving their predicted altitudes & bearings (to the nearest degree).
- Draw a figure showing the horizon, true course of the ship and the chosen stars as a guide for observation.

Application (5)

At Z.T. 1450 December 17th; 1990.
Ship was in DR Position (38° 32`.0 N; 154° 48`.0 E)

Steaming Speed	18.5 knots
Steering True course	209°.0

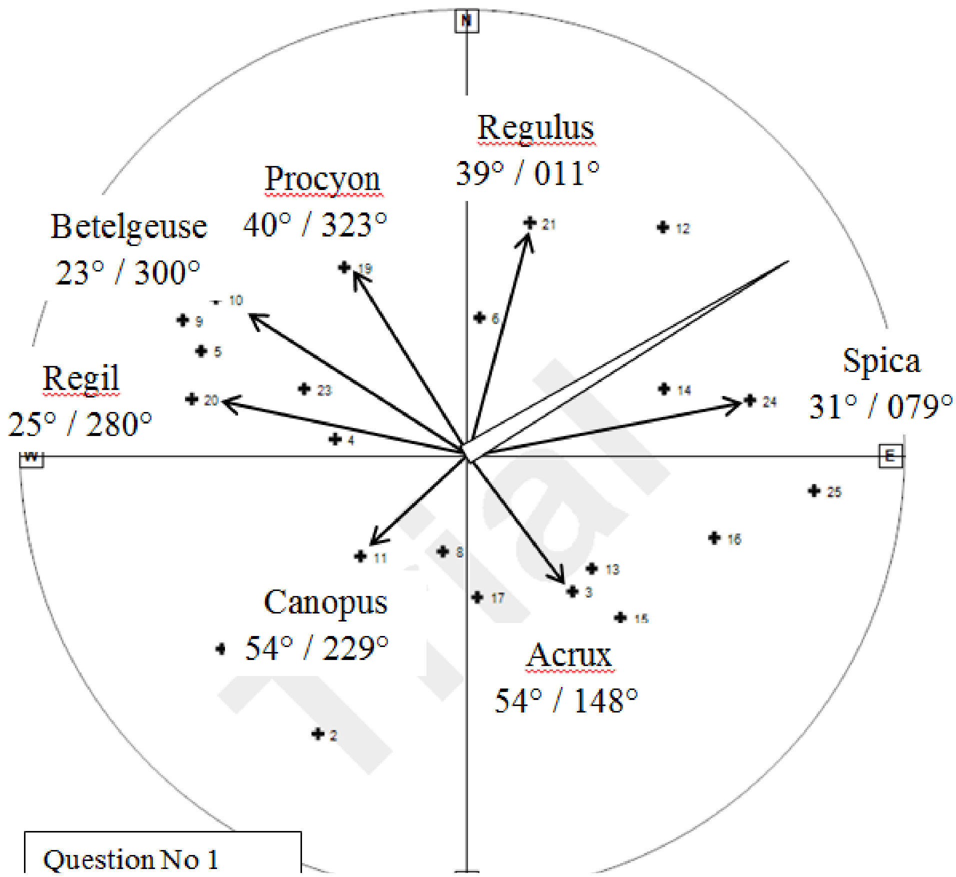
Calculate:

- Choose and name (7) suitable stars for observation at the evening twilight; referring to the *Air Navigation Tables* as a guide, giving their predicted altitudes & bearings (to the nearest degree).
- Draw a figure showing the horizon, true course of the ship and the chosen stars as a guide for observation.

ANSWERS:

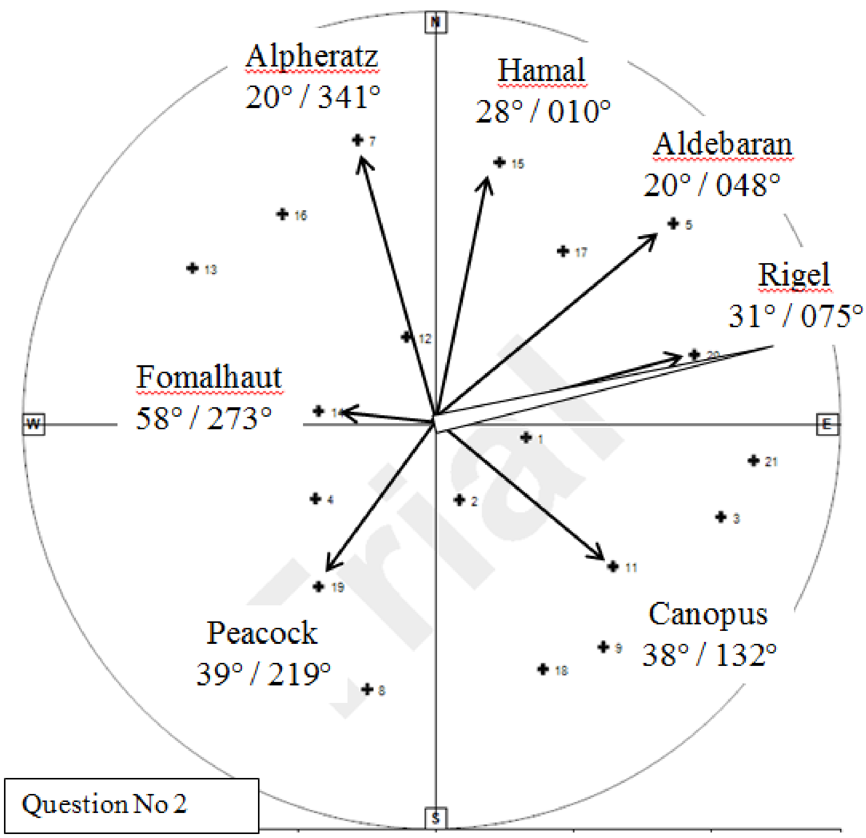
Answer of Application (1)

Answer of Application (1)			
#	Star Name	Altitude	True Bg.
1	♦Regulus	39°	011°
2	Spica	31°	079°
3	♦Acrux	54°	148°
4	Canopus	55°	229°
5	♦Regil	25°	280°
6	Betelgeuse	23°	300°
7	Procyon	40°	323°



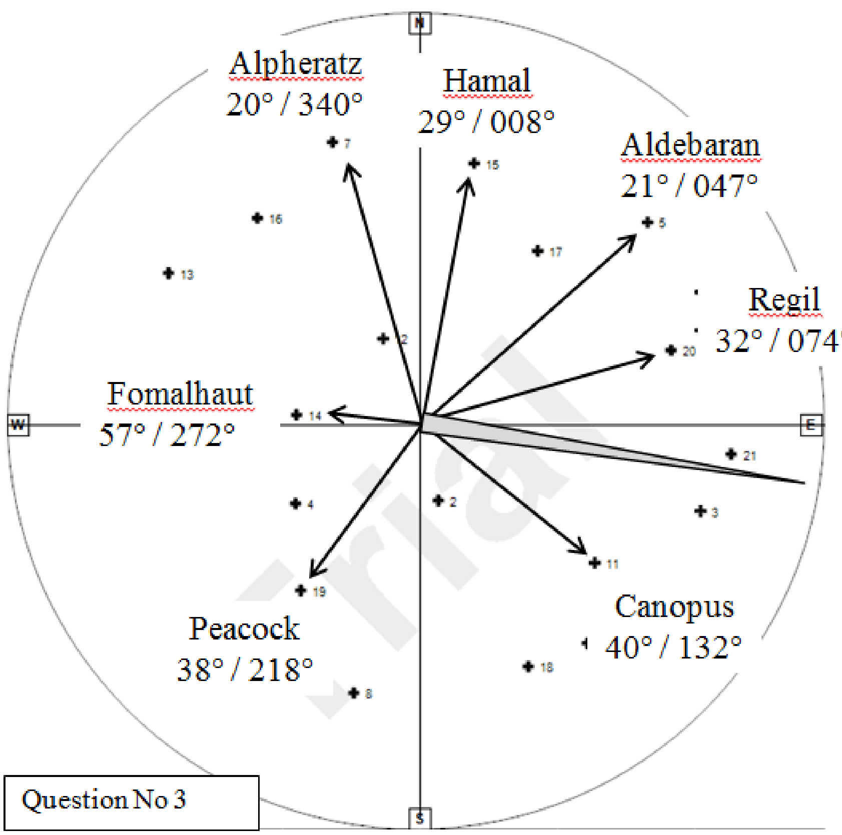
Answer of Application (2)

Answer of Application (2)			
#	Star Name	Altitude	True Bg.
1	♦Hamal	28°	010°
2	Aldebaran	20°	048°
3	Rigel	31°	075°
4	♦Canopus	38°	132°
5	Peacock	39°	219°
6	♦Fomalhaut	58°	273°
7	Alpheratz	20°	341°



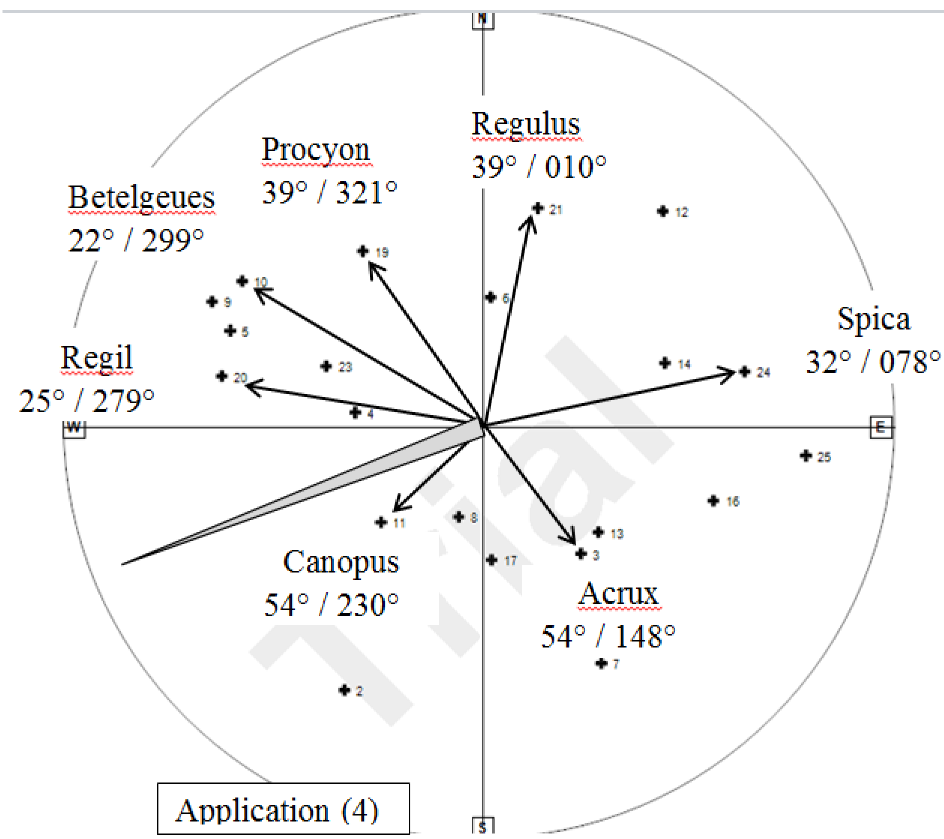
Answer of Application (3)

Answer of Application (3)			
#	Star Name	Altitude	True Bg.
1	Aldebaran	21°	047°
2	Alpheratz	20°	340°
3	Canopus	40°	132°
4	Fomalhaut	57°	272°
5	Hamal	29°	008°
6	Peacock	38°	218°
7	Regil	32°	074°



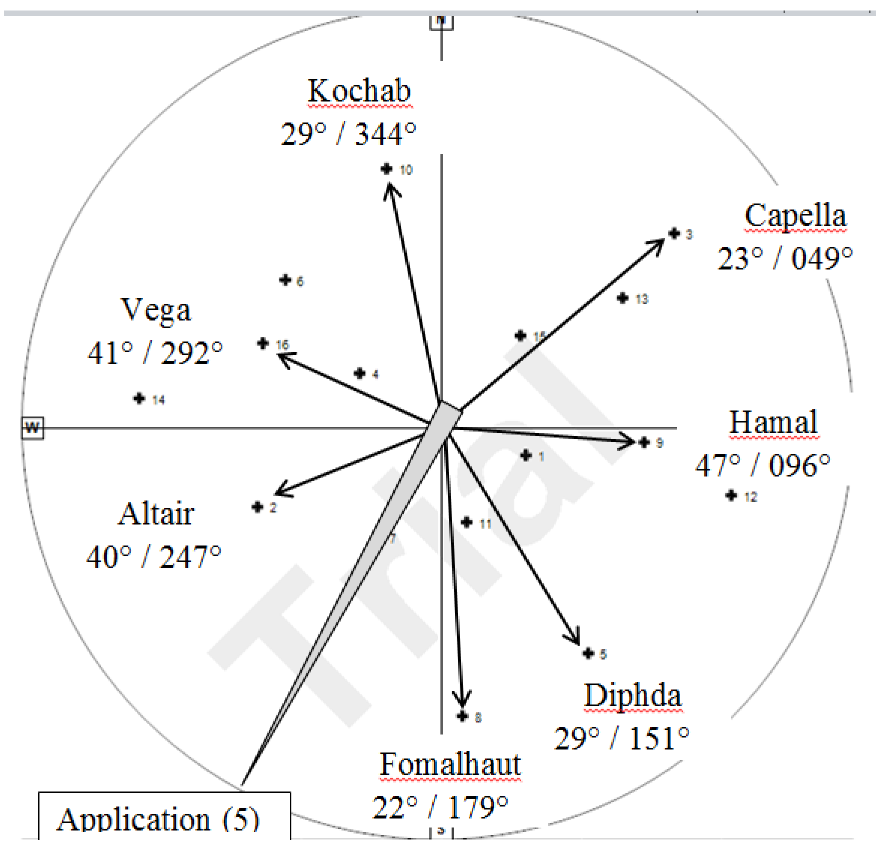
Answer of Application (4)

Answer of Application (4)			
#	Star Name	Altitude	True Bg.
1	♦Acrux	54°	148°
2	Betelgeuse	22°	299°
3	Canopus	54°	230°
4	Procyon	39°	321°
5	♦Regil	25°	279°
6	♦Regulus	39°	010°
7	Spica	32°	078°



Answer of Application (5)

Answer of Application (5)			
#	Star Name	Altitude	True Bg.
1	Altair	40°	247°
2	♦Capella	23°	049°
3	Diphda	29°	151°
4	♦Fomalhaut	22°	179°
5	Hamal	47°	096°
6	Kochab	29°	344°
7	♦Vega	41°	292°



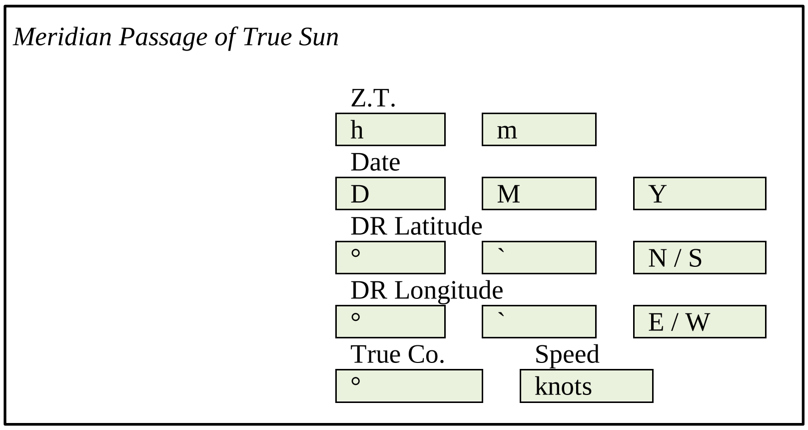
7) Meridian Passage

To apply this software programs you can proceed without any previous calculations.

The software program is designed to obtain:

- GMT of meridian passage of true sun to the nearest second.
- DR position corresponding to GMT of meridian passage of true sun.

The screen of the software program is given below



Solved Application

At Z.T. 0830; August 24th ; 1990
Ship was in D.R. position (40º 45`.0 S; 159º 42`.0 E)

True Co. to Steer	113º
Speed	19.5 knots

Calculate the following:

1) G.M.T. of meridian passage of the <u>True Sun</u> to the nearest second.
2) DR at G.M.T. of meridian passage

Manual Calculations:

To find G.M.T. of Noon:

Z.T.	0830 Aug. 24th
Z.N. (-)	11
G.D.	2130 Aug. 23rd

1st Approximation

L.M.T.	1203 Aug. 24th
± $Long_1$. w/ E	1039
G.M.T.$_1$	0124 Aug. 24th
G.D.	2130 Aug. 23rd
Interval	0354

Distance Run = (03h 54m) x 19.5 k = 76.1 **M**
True Course to steer **113.0**

d. Lat.	**dep.**	M. latitude	**d. Long.**
29`.7 S	70`.1 E	41°.0	92`.8 E

DR_1	Lat.	40° 45`.0 S	Long.	159° 42`.0 E
	d. Lat.	29`.7 S	d. Long.	1° 32`.8 E
DR_2	Lat.	41° 14`.7 S	Long.	161° 14`.8 E

2nd Approximation

L.M.T.	1203 Aug. 24th
± Long. w/ E (-)	1045
G.M.T.$_2$	0118 Aug. 24th
G.M.T.$_1$	0124 Aug. 24th
Interval	0006 (-)

Distance Run = (00h 06m) x 19.5 k = 2.0 **M**
True Course to steer (113.0 **+ 180) = 293.0**

d. Lat.	**dep.**	M. latitude	**d. Long.**
00`.8 N	1`.8 W	41°.2	2`.4 W

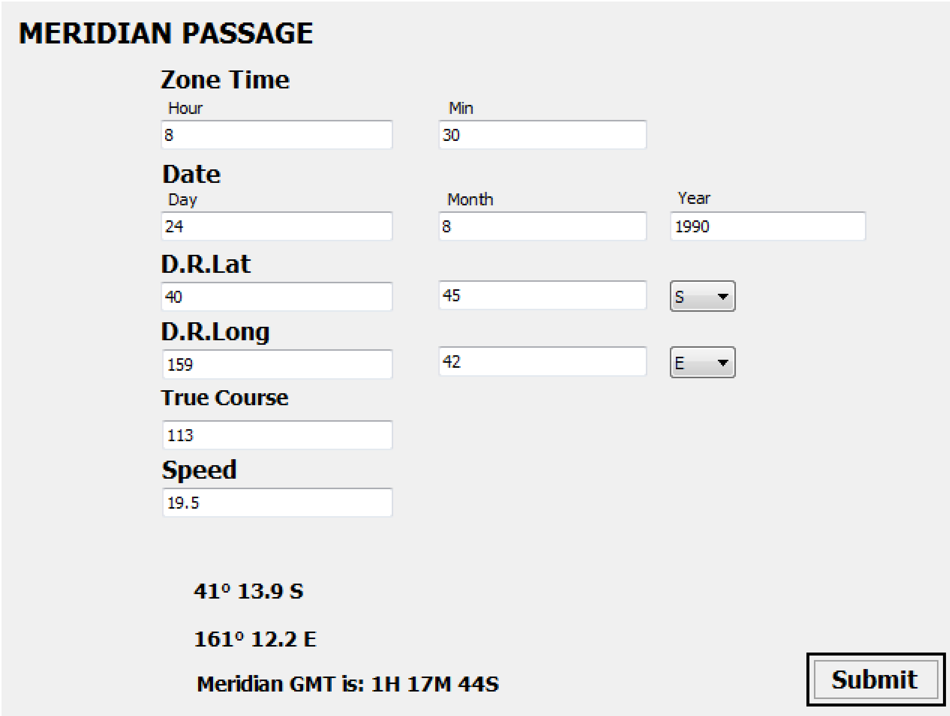
DR_2	Lat.	41° 14`.7 S	Long.	161° 14`.8 E
	d. Lat.	0`.8 N	d. Long.	2`.4 W
DR_3	Lat.	41° 13`.9 S	Long.	161° 12`.4 E

Accurate GMT of Noon sight

LHA	360° 00`.0	
± Long. w/ E (-)	161° 12`.4	
GHA	198° 47`.6	
Tab. GHA	194° 22`.0 →	01h
Incr.	4° 25`.6 →	17m 42s
GMT	01h 17m 42s Aug. 24th	

Procedure of application

A. Application of the soft-ware program;



B. Results obtained:

DR Lat.	41° 13`.9 S
DR Long.	161° 12`.2 E
GMT	01h 17m 44s

TRAINING APPLICATIONS

Application (1)

At Z.T. 0845; April 2nd; 1990

Ship was in D.R. position (38º 40`.0 N; 61º 49`.0 E)

True Co. to Steer	033º.0
Speed	17.0knots

Calculate the following:

1) G.M.T. of meridian passage of the **True Sun** to the nearest second.
2) DR at G.M.T. of meridian passage

Application (2)

At Z.T. 0915; October 15th; 1990

Ship was in D.R. position (43º 25`.0 S; 169º 40`.0 E)

True Co. to Steer	144º.0
Speed	15.0 knots

Calculate the following:

1) G.M.T. of meridian passage of the **True Sun** to the nearest second.
2) DR at G.M.T. of meridian passage

Application (3)

At Z.T. 0840; December 16th; 1990

Ship was in D.R. position (30º 38`.0 S; 109º 22`.0 W)

True Co. to Steer	131º
Speed	18.5 knots

Calculate the following:

1) G.M.T. of meridian passage of the **True Sun** to the nearest second.
2) DR at G.M.T. of meridian passage.

Application (4)

At Z.T. 0910; Jun. 17th; 1990

Ship was in D.R. position (00º 05`.0 S; 48º 43`.0 W)

True Co. to Steer	208º.0
Speed	14.0 knots

Calculate the following:

1) G.M.T. of meridian passage of the **True Sun** to the nearest second.
2) DR at G.M.T. of meridian passage

Application (5)

At Z.T. 0935; February 17th; 1990

Ship was in D.R. position (25º 45`.0 S; 158º 40`.0 E)

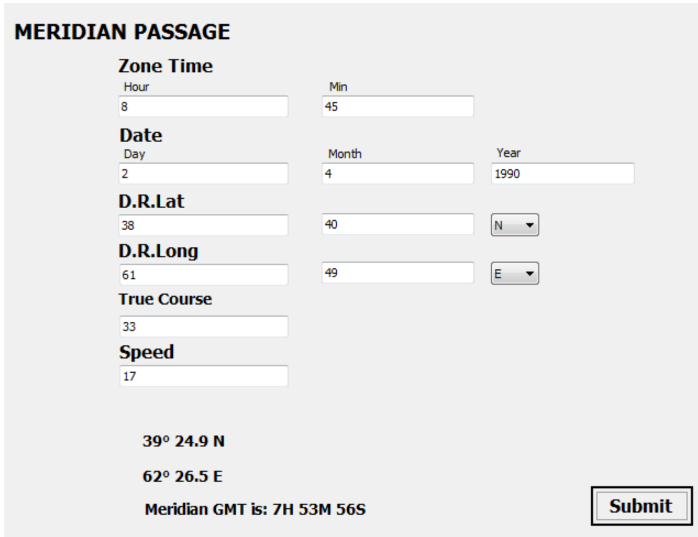
True Co. to Steer	105º.0
Speed	19.0 knots

Calculate the following:

1) G.M.T. of meridian passage of the **True Sun** to the nearest second.
2) DR at G.M.T. of meridian passage

ANSWERS

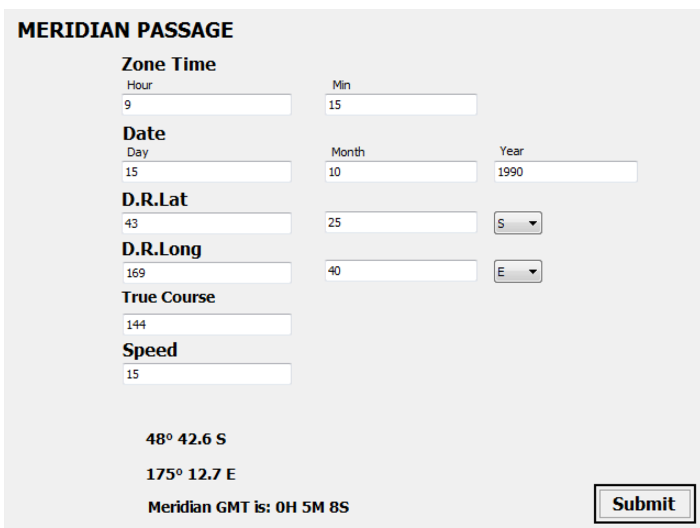
Application No (1)



Results obtained:

DR Lat.	39° 24`.9 N
DR Long.	62° 26`.5 E
GMT	07h 53m 56s

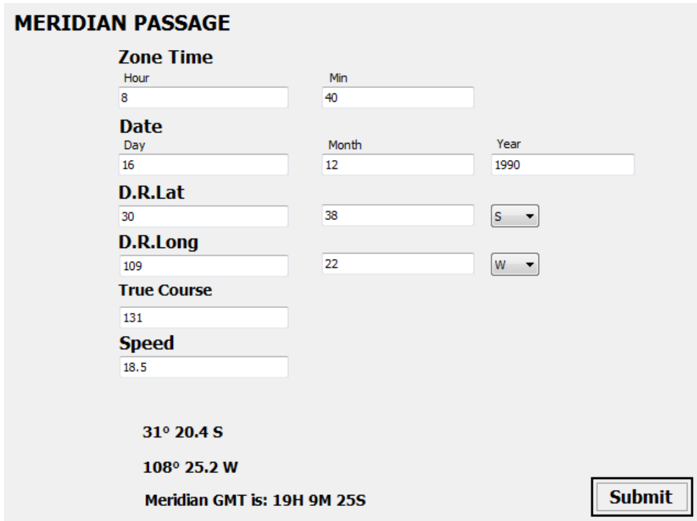
Application No (2)



Results obtained:

DR Lat.	48° 42`.6 S
DR Long.	175° 12`.7 E
GMT	0h 05m 08s

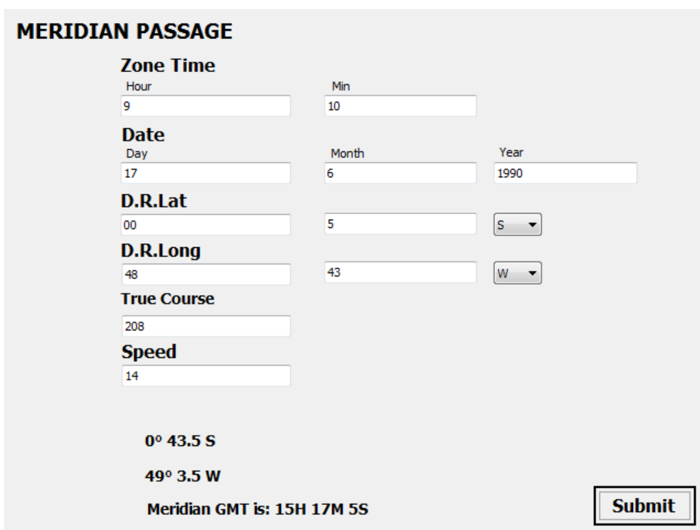
Application No (3)



Results obtained:

DR Lat.	31° 20`.4 S
DR Long.	108° 25`.2 W
GMT	19h 09m 25s

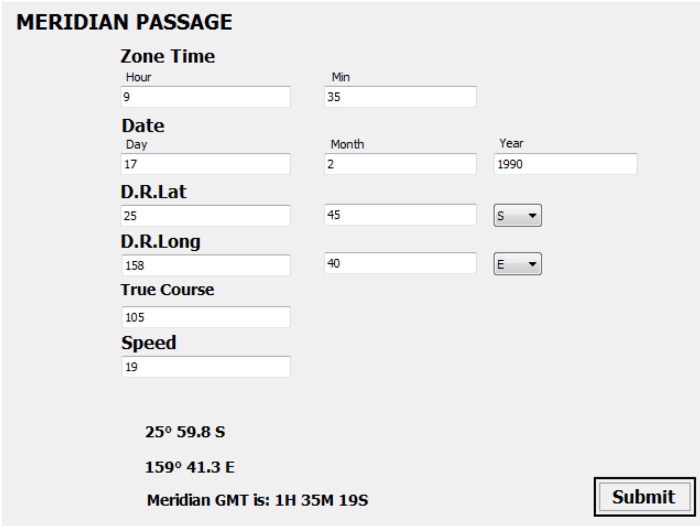
Application No (4)



Results obtained:

DR Lat.	00° 43`.5 S
DR Long.	49° 03`.5 W
GMT	15h 17m 05s

Application No (5)


MERIDIAN PASSAGE

Zone Time

Hour: 9 | Min: 35

Date

Day: 17 | Month: 2 | Year: 1990

D.R.Lat

25 | 45 | S

D.R.Long

158 | 40 | E

True Course

105

Speed

19

25º 59.8 S

159º 41.3 E

Meridian GMT is: 1H 35M 19S

Submit

Results obtained:

DR Lat.	25° 59`.8 S
DR Long.	159° 41`.3 E
GMT	1h 35m 19s

GROUP (3)

BASIC CELESTIAL NAVIGATION ACTIVITIES

- *Individual Sun Sight*
- *Calculated observed Position (Sun Run Sun)*
- *Individual Star Sight*
- *Most Probable Observed Position (Universal Method)*
- *Most Probable Observed Position (Egyptian Method)*

C. GROUP (3)

8) Sun Sight

To apply this software program you must:

- Calculate [*GHA* $_{Sun}$] and [*Dec.* $_{sun}$] at GMT.
- Extract semi-diameter of the sun [SD] from daily page of nautical almanac tables.

The software program is designed to obtain Intercept & True Bearing of the sun.

The screen of the software program is given below

Sun Sight

GMT
[h] [m] [s]
Sextant Altitude — Limb
[°] [`] [L / U]
GHA of Sun at GMT
[°] [`]
Dec. of Sun at GMT
[°] [`] [N / S]
I.E.
[`]
Ht of Eye
[meter]
S.D.
[`]
DR Latitude
[°] [`] [N / S]
DR Longitude
[°] [`] [E / W]

SOLVED APPLICATION

At Z.T. 1455 on October 14th ; 1990.
Ship was in D.R. position (40º 15`.0 S; 161º 00`.0 W).

- I.E. 1`.2 off the arc
- Ht. of eye 12.7 m
- Ch. error 3m 11s fast

Lower Limb of the Sun was observed as follows:

- Ch.Time 01h 51m 50s
- Sext.alt. 35º 35`.0

Find the elements of the position line by Intercept method.

Manual Calculations:

1st Step: To adjust time of G.M.T.

Z.T.	1455 Oct. 14th
Z.N.	11 (+)
G.D.	0155 Oct. 15th

Ch. Time	01h 51m 50s
Ch. Error (-)	03m 11s
G.M.T.	01h 48m 39s Oct. 15th

2nd Step: To Extract L.H.A. & Dec.

G.H.A.	198° 30\`.9	Dec.*	8° 21\`.2 S
Incr.	12° 09\`.8	d^c	0\`.7 (+)
G.H.A.	210° 40\`.7	C.Dec.*	8° 21\`.9 S
± long (E/W)	161° 00\`.0 (-)		
L.H.A.	49° 40\`.7		

3rd Step: To Calculate C.Z.D

Cos (CZD) = Cos (LHA) Cos (Lat.) Cos (Dec.) +Sin (Lat.) Sin (Dec.)

Cos (CZD) = Cos (49º 40\`.7) Cos (40º 15\`.0) Cos (8º 21\`.9) +Sin (40º 15\`.0) Sin (8º 21\`.9)

Cos (CZD) = 0.48862+ 0.09340 = 0.58261 → CZD = 54° 21\`.9

4th Step: To obtain Intercept

Sext alt	35° 35\`.0
I.E.	1\`.2 (+)
Obs. Alt	35° 36\`.2
Dip	6\`.3 (-)
App alt	35° 29\`.9
Corr.	14\`.9 (+)
T. alt	35° 44\`.8
90°	
T.Z.D.	54° 15\`.2
C.Z.D.	54° 21\`.9
Intercept	**6\`.7 T**

5th Step: To find True Bearing

L.H.A.	49° 40\`.7	A	0.718 N
Lat.	40° 15\`.0 S	B	0.193 S
Dec.	8° 21\`.9 S	C	0.525 N
		Az.	N 68°.1 W
		T. Bg.	**291°.8**

To apply the software program you must:

- Calculate [GHA $_{\text{Sun}}$] $_{\text{and}}$ [Dec. $_{\text{sun}}$] at GMT.
- Extract semi-diameter of the sun [SD] from daily page of nautical almanac tables.

The software program is designed to obtain <u>Intercept</u> & <u>True Bearing</u> of the sun.

The screen of the software program is given below

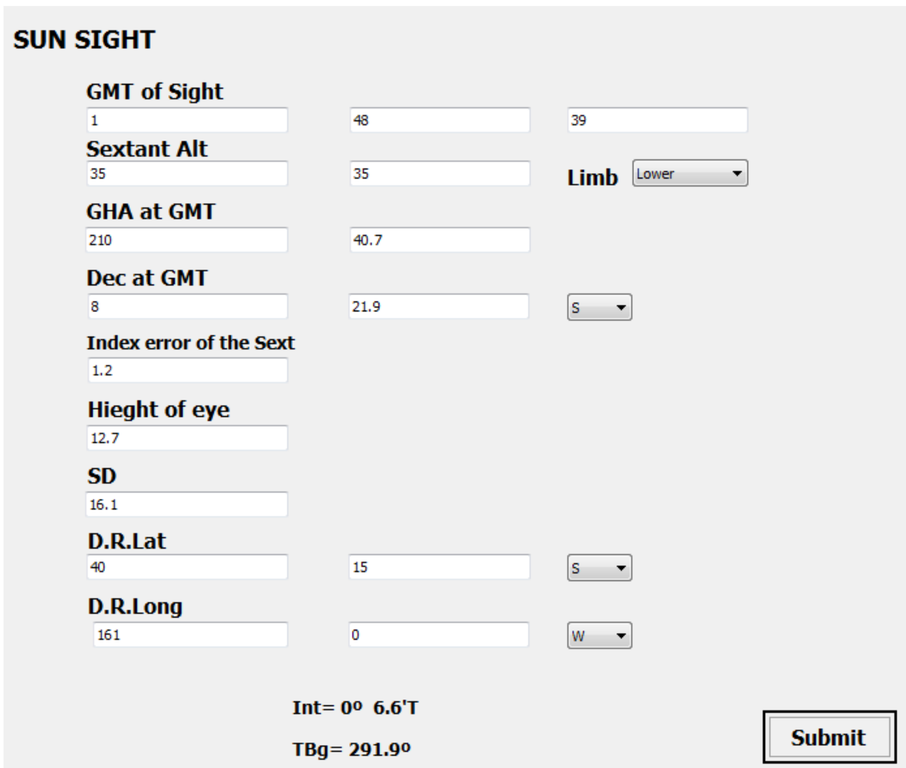
GMT		
00h	00m	00s
Sextant Alt.		
00°	00`.0	Limb
GHA at GMT		
00°	00`.0	
Dec.		
00°	00`.0	N / S
Index Error		
Height of Eye		
SD		
DR Latitude		
00°	00`.0	N / S
DR Longitude		
00°	00`.0	E / W

Procedure of application

A. Data extracted from NA tables

G.H.A.	198° 30\`.9	Dec.	8° 21\`.2 S	
Incr.	12° 09\`.8	d^c (+)	0\`.7	
G.H.A.	210° 40\`.7	C. Dec.	8° 21\`.9 S	S.D. 16\`.1

B. Application of the soft-ware program;



C. Results obtained:

Intercept	6\`.6 T
T. Bg.	291°.9

TRAINING APPLICATIONS

Question (1)

At Z.T. 1520 on April 2nd; 1990;

Ship was in D.R. position (51º 15`.0 N; 174º 30`.0 W).

- I.E. 1`.5 on the arc
- Ht. of eye 15.5 m
- Ch. Error 3m 13s slow

Lower Limb of the Sun was observed as follows:

- Ch.Time 03h 18m 27s
- Sext.alt. 25º 18`.5

Find the elements of the position line by Intercept method.

Question (2)

At Z.T. 1250 on February 16th; 1990;

Ship was in D.R. position (51º 10`.0 N; 174º 40`.0 W).

- I.E. 1`.5 off the arc
- Ht. of eye 16.0 m
- Ch. Error 2m 41s slow

Lower Limb of the Sun was observed as follows:

- Ch.Time 0h 56m 03s
- Sext.alt. 25º 05`.2

Find the elements of the position line by Intercept method.

Question (3)

At Z.T. 1550 on June 16th ; 1990;

Ship was in D.R. position (51º 05`.0 N; 174º 35`.0 E).

- I.E. 1`.7 on the arc
- Ht. of eye 17.3 m
- Ch. Error 3m 55s fast

Lower Limb of the Sun was observed as follows:

- Ch.Time 03h 45m 50s
- Sext.alt. 42º 40`.0

Find the elements of the position line by Intercept method.

Question (4)

At Z.T. 1440 on August 24th; 1990;

Ship was in D.R. position (31º 15`.0 S; 179º 10`.0 W).

- I.E. 1`.8 on the arc
- Ht. of eye 17.0 m
- Ch. Error 4m 13s fast

Lower Limb of the Sun was observed as follows:

- Ch.Time 02h 46m 53s
- Sext.alt. 32º 25`.0

Find the elements of the position line by Intercept method.

Question (5)

At Z.T. 1350 on December 16th ; 1990;

Ship was in D.R. position (41^{o} 07`.0 N; $034^{o}$ 50`.0 W).

- I.E. 1`.6 off the arc
- Ht. of eye 15.0 m
- Ch. Error 5m 18s fast

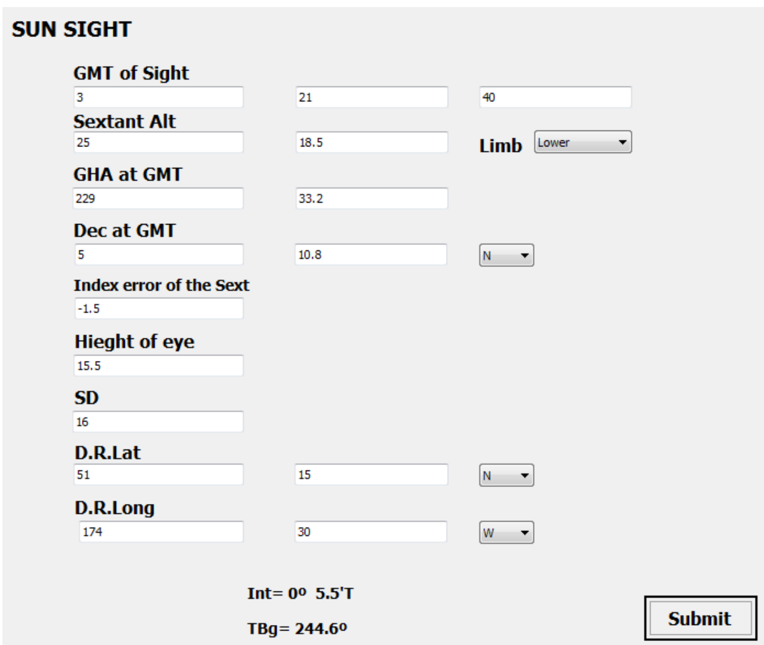
Lower Limb of the Sun was observed as follows:

- Ch.Time 03h 51m 28s
- Sext.alt. 22^{o} 10`.0

Find the elements of the position line by Intercept method.

ANSWERS:

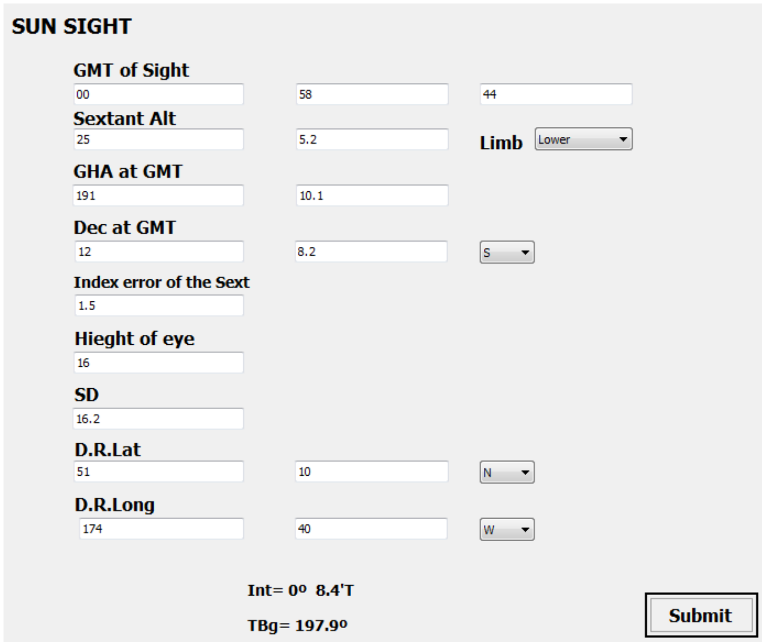
Application (1)



Answer:

Intercept	5`.5 T
T. Bg.	244^{o}.6

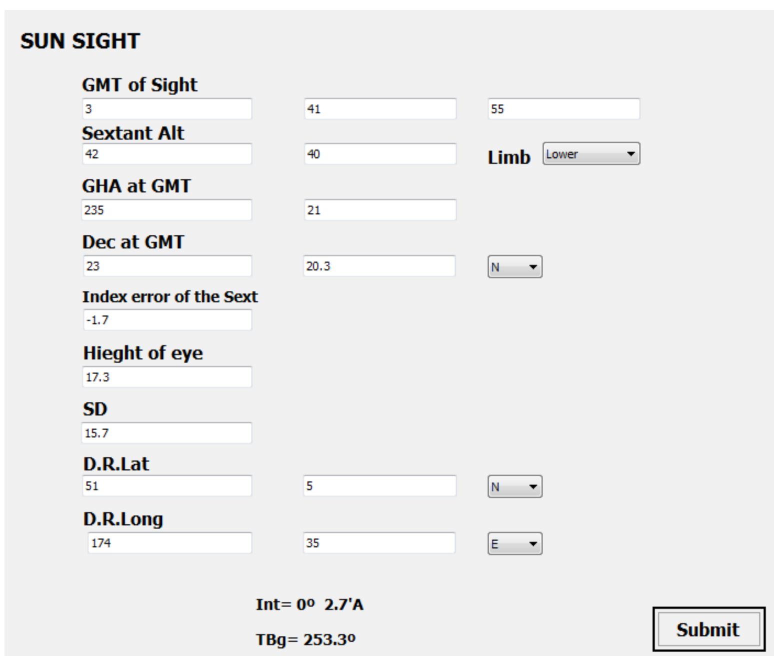
Application (2)



Answer:

Intercept	8`.4 T
T. Bg.	197º.9

Application (3)

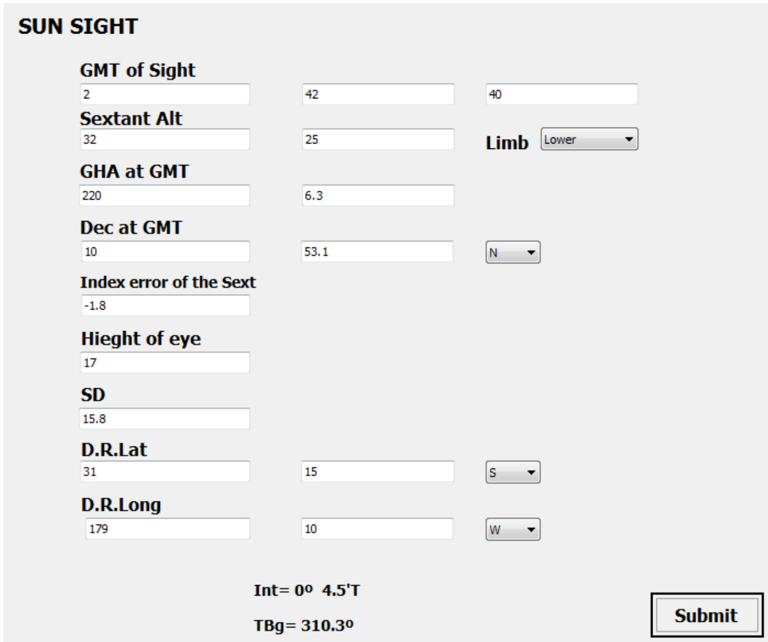


Answer:

Intercept	2`.7 A

T. Bg.	253º.3

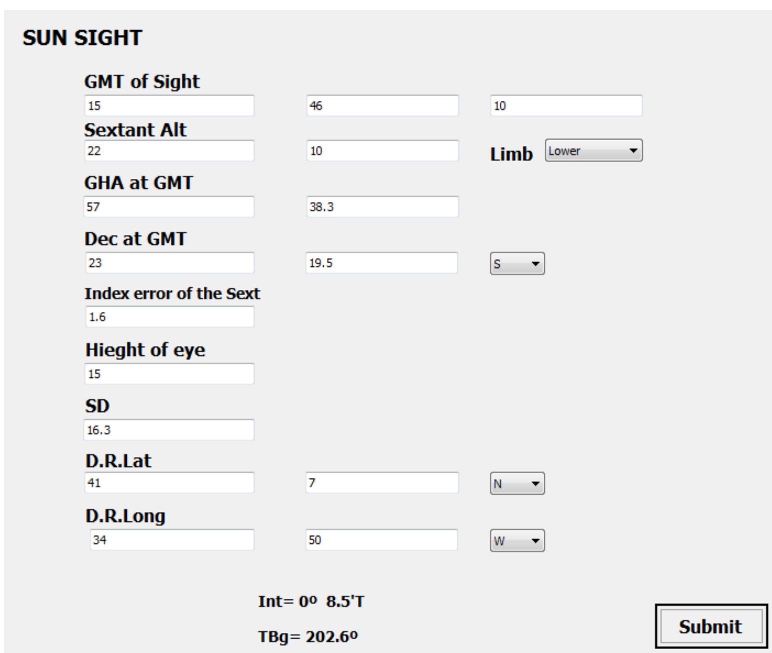
Application (4)



Answer:

Intercept	4`.5 T
T. Bg.	310º.3

Application (5)



Answer:

Intercept	8`.5 T

T. Bg.	202º.6

9) Sun Run Sun

To apply this software program you can proceed without any previous calculations. This is clear from the screen of the program below, because [*GHA $_{Sun}$*] and [*Dec. $_{sun}$*] at GMT_1 of the first sun sight and at GMT_2 of the second sun sight were calculated before when each sight was solved separately.

The software program is designed to obtain; the fixed position at GMT of the 2^{nd} sun sight as follows;

- *Application (1):*

Make run from before noon sun sight to meridian sun sight to obtain fixed position at noon.

- *Application (2):*

Make run from Meridian sun sight to afternoon sun sight to obtain fixed position at the afternoon sight.

The screen of the software program is given below

Sun Run Sun

First Sun Sight			*Second Sun Sight*		
GMT_1			GMT_2		
h	m	s	h	m	s
Sextant Altitude			Sextant Altitude		
°	`	L / U	°	`	L / U
GHA of Sun at GMT_1			GHA of Sun at GMT_2		
°	`		°	`	
Dec. of Sun at GMT_1			Dec. of Sun at GMT_2		
°	`	N / S	°	`	N / S

Sailing Information			*Setup Sextant*
DR_1 Latitude			I.E.
°	`	N / S	`
DR_1 Longitude			Ht of Eye
°	`	E / W	meter
True Co.	Speed		S.D.
°	knots		`

Solved Application

Z. T. 1312 of October 14th; 1990,
Ship was in DR position (34º 53`.0 S; 32º 25`.0 W).

T. Co. 341º.0
Speed 18 knots
I. E. 2.1 Off the arc
Ht. of eye 10.5 m
Ch. Error 1m 19s slow

The 1st Sight of Sun`s lower limb was observed as follows:

Ch. Time 3h 12m 05s
Sext. Alt. 57º 50`.0

The 2nd sight of Sun `s lower limb was observed as follows:

Ch. Time 5h 20m 31s
Sext. Alt. 36º 10`.0

Find the observed position at the time of the 2nd observation.

==

Manual Calculations:

A. Solution of the 1st Sun sight:

1st Step: To Adjust GMT:

Z.T.₁	1312 Oct. 14th
Z.N. (+)	2
G.D.₁	1512 Oct. 14th

Ch. Time 1	03 12 05
Ch. Error (+)	01 19
G.M.T. 1	15h 13m 24s Oct. 14th

2nd Step: To Extract LHA and Dec.

GHA	48° 29`.5
Incr.	3° 21`.0
GHA	51° 50`.5
Long (-)	32° 25`.0
LHA	**19° 25`.5**

Dec	8° 12`.0 S
d.corrn (+)	0`.2
C. Dec.	8° 12`.2 S

3rd Step: To Calculate C.Z.D:

Cos (CZD) = Cos (LHA) Cos (Lat.) Cos (Dec.) +Sin (Lat.) Sin (Dec.)
Cos (CZD) = Cos (**19° 25`.5**) Cos (34º 53`.0) Cos (8° 12`.2) +Sin (34º 53`.0) Sin (8° 12`.2)
Cos (CZD) = 0.76571 + 0.08160 = 0.84731 → CZD = 32° 04`.8

4th Step: To Correct Sextant Altitude and find Intercept:

Sext. alt.	57° 50`.0
IE (+)	2`.1
Obs. alt.	57° 52`.1
Dip (-)	5`.7
App. alt.	57° 46`.4
Corr^n (+)	15`.6
True alt.	58° 02`.0
90 (~)	
TZD	31° 58`.0
CZD	32° 04`.8
Inter.	**6`.8 T**

5th Step: To Find True Bearing

LHA 19° 25`.5	A	1.977 N
Lat. 34° 53`.0 S	B	0.433 S
Dec 8° 12`.2 S	C	1.544 N
	Az.	N 38°.3 W
	T. Bg.	**321°.7**

B. *Calculation of the 2nd DR Position:*

Ch. Time $_2$	05h 20m 31s
Ch. Error +	01m 19s
G.M.T. $_2$	17h 21m 50s Oct. 14th

The GMT of the 2nd *Sun* sight must be ahead of the 1st *Sun* sight; for this we add 12h to G.M.T.$_2$

G.M.T. $_2$	17h 21m 50s Oct. 14th
G.M.T. $_1$	15h 13m 24s Oct. 14th
Interval	02h 08m 26s

Distance Run = (02h 08m 26s) x 18.0 k = 38.5 M

Distance	True Co.	d. Lat.		dep.	
		N	S	E	W
6.6 T	321°.7	5.2			4.1
38.5	341°.0	36.4			12.5
		41`.6 N		16`.6 W	

d. Long. = dep. / cos (m. Lat.) =16`.6 /cos (34°.5) → where m. Lat. = [(34° 53`.0 +34° 11`.4)/2]
d. Long. = 20`.1 W

DR$_1$ Position	Lat.	34° 53`.0 S	Long.	32° 25`.0 W
	d. Lat.	41`.6 N	d. Long.	20`.1 W
DR$_2$ Position	**Lat.**	**34° 11`.4 S**	**Long.**	**32° 45`.1 W**

C. *Solution of the 2nd Sun sight:*

GMT: 17h 21m 50s Oct. 14th
DR$_2$: (34° 11`.4 S; 32° 45`.1 W)

2nd Step: To Extract LHA and Dec.

GHA	78° 29`.8	Dec	8° 13`.8 S
Incr.	5° 27`.5	d.corrn (+)	0`.3
GHA	83° 57`.3	**C.Dec.**	8° 14`.1 S
Long (-)	32° 45`.1		
LHA	**51° 12`.1**		

3rd Step: To Calculate C.Z.D:

Cos (CZD) = Cos (LHA) Cos (Lat.) Cos (Dec.) +Sin (Lat.) Sin (Dec.)
Cos (CZD) = Cos (51° 12`.1) Cos (34° 11`.4) Cos (8° 14`.1) +Sin (34° 11`.4) Sin (8° 14`.1)
Cos (CZD) = 0.51295+ 0.08049 = 0.59344 → CZD = 53° 35`.9

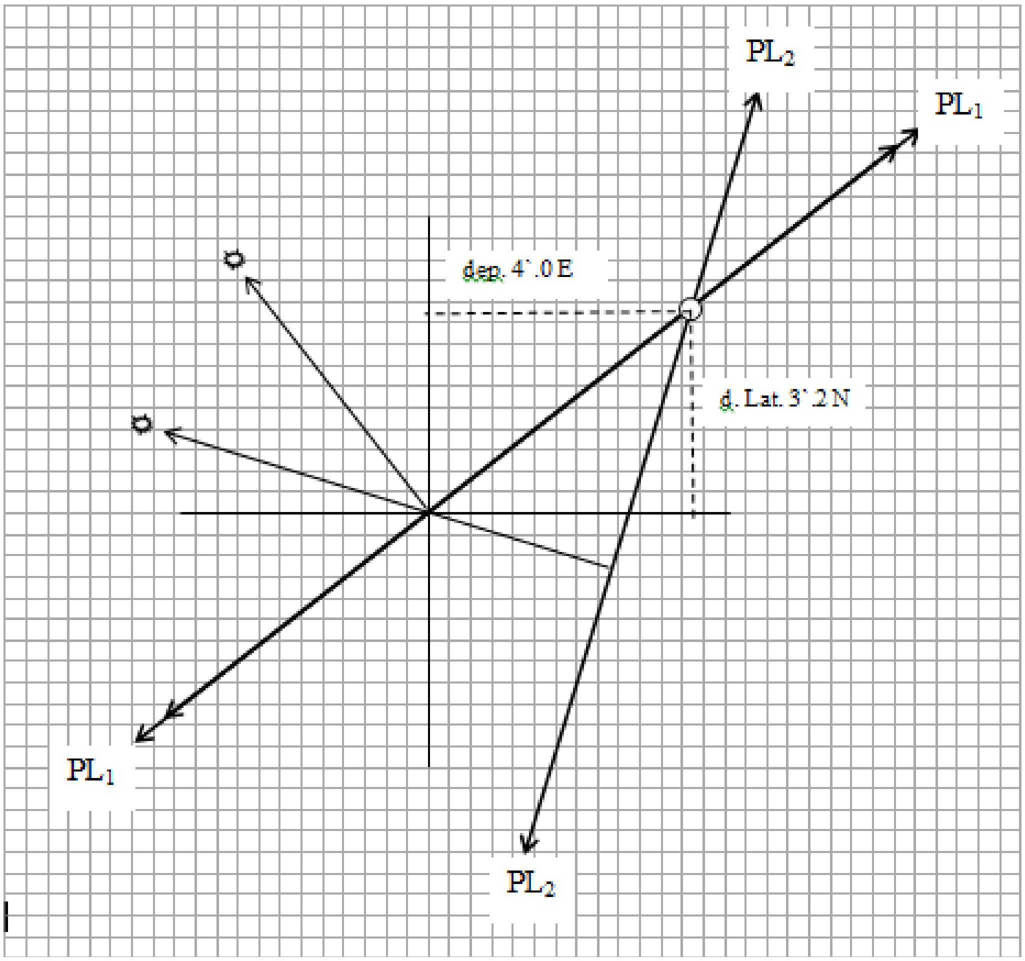
4th Step: To Correct Sextant Altitude and find Intercept:

Sext. alt.	36° 10`.0
IE (+)	2`.1
Obs. alt.	36° 12`.1
Dip (-)	5`.7
App. alt.	36° 06`.4
Corr^n (+)	14`.9
True alt.	36° 21`.3
90 (~)	
TZD	53° 38`.7
CZD	53° 35`.9
Inter.	**2`.8 A**

5th Step: To Find True Bearing:

LHA 51° 12`.1	A	0.546 N
Lat. 34° 11`.4 S	B	0.186 S
Dec 8° 14`.1 S	C	0.360 N
	Az.	N 73°.4 W
	T. Bg.	**286°.6**

D. Plotting and Obtaining the Observed Position:



From Plotting Sheet:

DR_2 Position	Lat. d. Lat.	34° 11`.4 S 03`.2 N	Long. d. Long.	32° 45`.1 W 04`.8 E
Fix. Position	**Lat.**	34° 08`.2 S	**Long.**	32° 40`.3 W

Procedure of application

Data extracted from NA tables

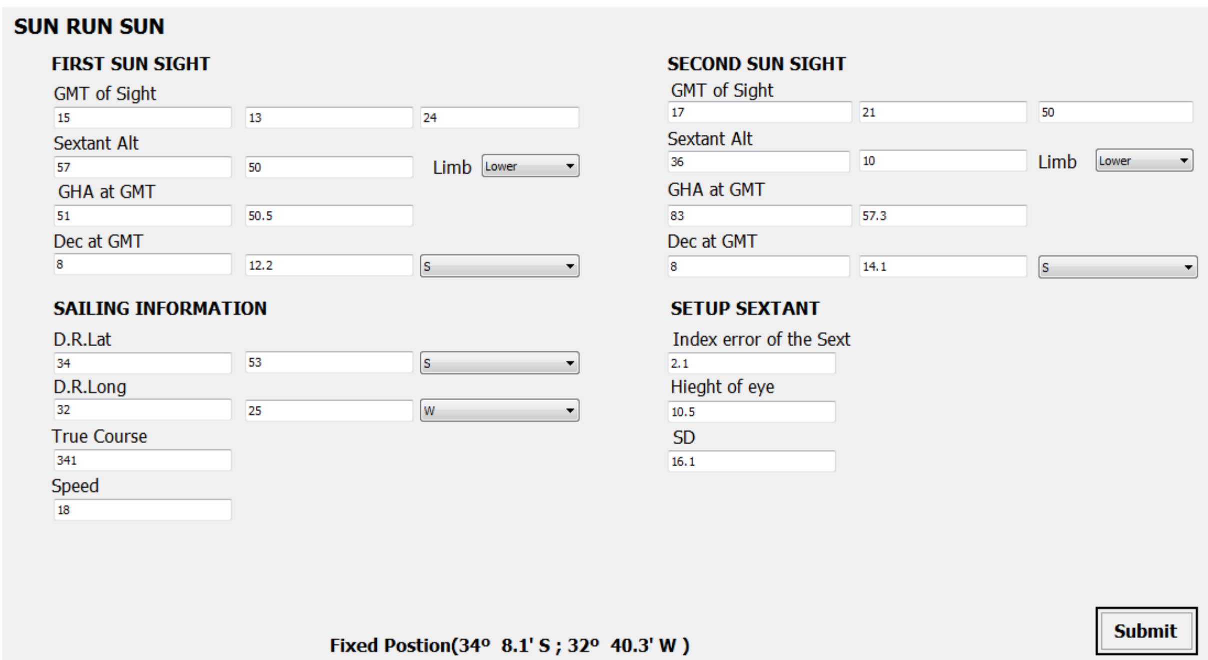
GMT₁: 15h 13m 24s Oct. 14th

G.H.A.	48° 29`.5	Dec.	8° 12`.0 S	
Incr.	3° 21`.0	dc	(+) 0`.2	
G.H.A.	51° 50`.5	C. Dec.	8° 12`.2 S	S.D. 16`.1

GMT₂: 17h 21m 50s Oct. 14th

G.H.A.	78° 29.8	Dec.	8° 13`.8 S
Incr.	5° 27`.5	dc	(+) 0`.3
G.H.A.	84° 23`.0	C. Dec.	8° 14`.1 S

Application of Software;



ANSWER;

Calculated Observed Position (34° 08`.1 S; 32° 40`.3 W)

TRAINING APPLICATIONS

Application (1)

Z. T. 1312 of June 16th; 1990,

Ship was in DR position (34º 53`.7 N; 32º 25`.3 E).

T. Co.	200º.0
Speed	18 knots
I. E.	Nil
Ht. of eye	10.1 m
Ch. Error	0m 14s slow

The 1st Sight of Sun`s lower limb was observed as follows:

Ch. Time	11h 12m 05s
Sext. Alt.	68º 52`.0

The 2nd sight of Sun `s lower limb was observed as follows:

Ch. Time	2h 00m 50s
Sext. Alt.	35º 22`.3

Find the observed position at the time of the 2nd observation.

Application (2)

Z. T. 1112 of October 14th; 1990,

Ship was in DR position (34º 53`.0 S; 179º 39`.0 W).

T. Co.	326º.0
Speed	18.3 knots
I. E.	2`.6 off the arc
Ht. of eye	14.5 m
Ch. Error	3m 39s slow

The 1st Sight of Sun`s lower limb was observed as follows:

Ch. Time	11h 02m 45s
Sext. Alt.	61º 45`.0

The 2nd sight of Sun `s lower limb was observed as follows:

Ch. Time	1h 50m 10s
Sext. Alt.	50º 50`.0

Find the observed position at the time of the 2nd observation.

Application (3)

Z. T. 1115 of April 2nd; 1990,

Ship was in DR position (32º 24`.0 S; 179º 44`.0 E).

T. Co.	059º.0
Speed	17.7 knots
I. E.	2`.6 on the arc
Ht. of eye	17.4 m
Ch. Error	2m 39s fast

The 1st Sight of Sun`s lower limb was observed as follows:

Ch. Time	11h 20m 35s
Sext. Alt.	51º 13`.9

The 2nd sight of Sun `s lower limb was observed as follows:

Ch. Time	2h 18m 45s
Sext. Alt.	41º 17`.2

Find the observed position at the time of the 2nd observation.

Application (4)

Z.T. 1055 June 16th; 1990

Ship was in DR position (39˚ 20`.0 N ; 179˚ 38`.0 W);

Ship was steaming as follows:

True course to steer	282˚.0
Speed	19.5 k
Chronometer error	01m 19s fast
Index error	2`.6 off the arc
Height of eye	15.4 m

1st sun sight at Ch. Time **10h** 58m 40s when observed gave :

Sextant alt. 69˚05`.0 (L.L.)

2nd sun sight at Ch. Time 01h 22m 40s when observed gave:

Sextant alt. 66˚45`.0 (L.L.)

Find the observed position at the time of the 2nd sight.

Application (5)

Z.T. 1055 January 2nd; 1990

Ship was in DR position (43˚ 40`.0 S ; 179˚ 54`.0 E);

Ship was steaming as follows:

True course to steer	077˚.0
Speed	20.7 k
Chronometer error	01m 49s slow
Index error	2`.0 off the arc
Height of eye	18.4 m

1st sun sight at Ch. Time 10h 58m 40s when observed gave:

Sextant alt. 65˚ 15`.0 (L.L.)

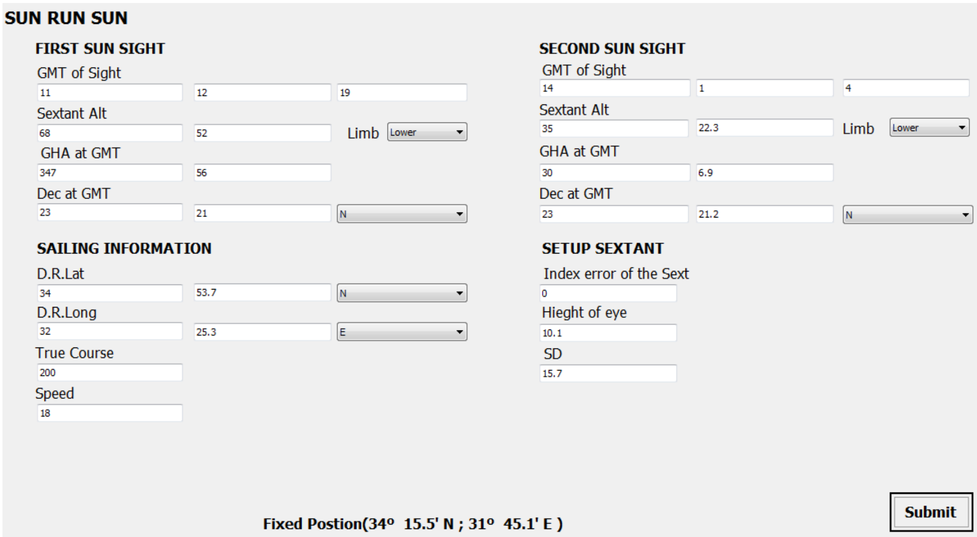
2nd sun sight at Ch. Time 01h 22m 40s when observed gave:

Sextant alt. 63˚ 02`.9 (L.L.)

Find the observed position at the time of the 2nd sight.

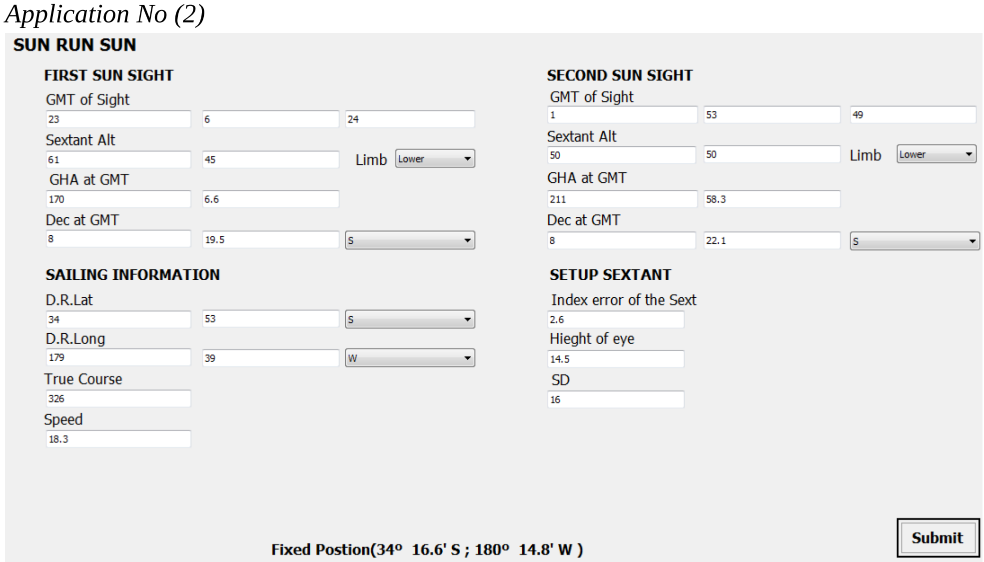
ANSWERS:

Application No (1)



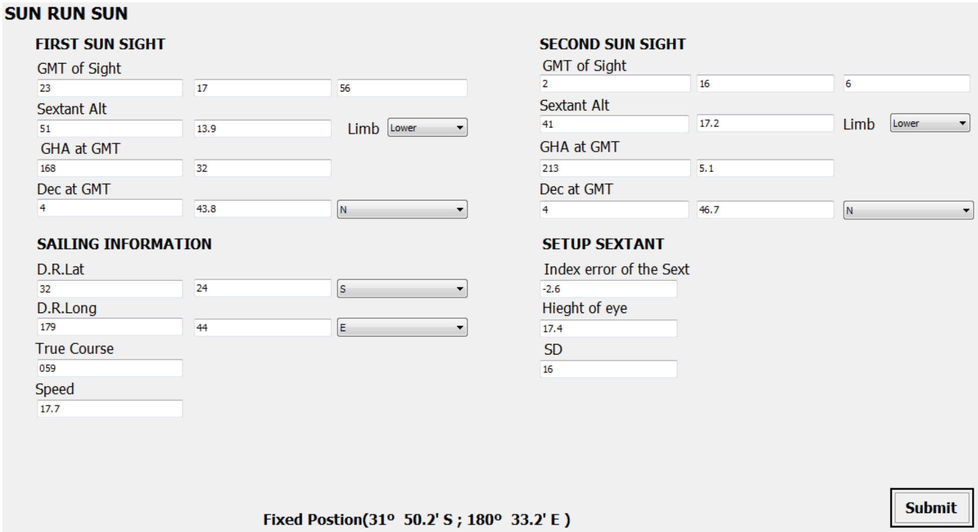
ANSWER: Fixed Position (34° 15`.5 N; 31° 45`.1E)

Application No (2)



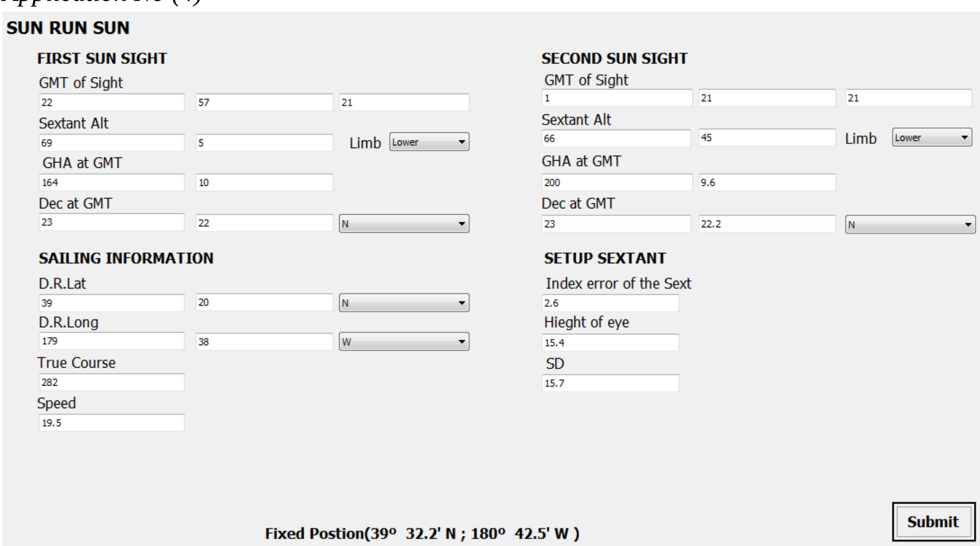
ANSWER: Fixed Position (34° 16`.6 S; 179° 45`.2 E)

Application No (3)



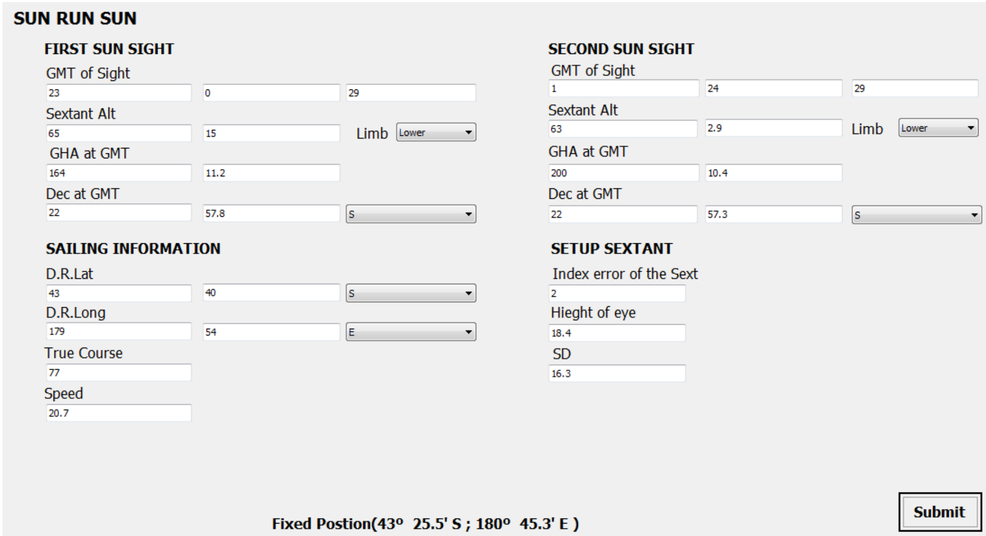
ANSWER: Fixed Position (31° 50`.2 S; 179° 26`.8 W)

Application No (4)



ANSWER: Fixed Position (39° 32`.2 N; 179° 17`.5 E)

Application No (5)



ANSWER: Fixed Position (43° 25`.5 S; 179° 14`.7 W)

10) Star Sight

To apply this software program you must:

- Calculate [$\underline{GHA_{star}}$] $_{at}$ GMT in-advance.
- Extract [$\underline{Dec._{star}}$].

The software program is designed to obtain Intercept & True Bearing of a star.

The screen of the software program is given below

Star Sight		
GMT		
h	m	s
Sextant Altitude		
°	`	
GHA of Star at GMT		
°	`	
Dec. of Star		
°	`	N / S
I.E.		
`		
Ht of Eye		
meter		
DR Latitude		
°	`	N /S
DR Longitude		
°	`	E / W

Solved Application

At Z.T.0602 on January 3rd; 1990 Ship was in D.R. position (41º 10`.0 N; 171º 05`.0 E).

- I.E. 2`.2 on the arc
- Ht. of eye 15 m
- Ch. error nil

Star **Regulus** was observed as follows:

- Ch.Time 6h 57m 45s
- Sext.alt. 40º 47`.1

Find the elements of the position line by Intercept method.

Manual Calculations:

1st Step: To Adjust Time Of G.M.T.

Z.T.	06 02 Jan. 3rd
Z.N.	-11
G.D.	19 02 Jan. 2nd

Ch. Time	6h 57m 45s
Ch. Error	0 00
G.M.T.	18h 57m 45s Jan. 2nd

2nd Step: To Extract L.H.A. & Dec.

G.H.A.	012º 06`.7		
Incr.	14º 28`.6		
SHA	208º 02`.0	Dec.*	N 12º 00`.9
G.H.A.	234º 37`.3		
long (+)	171º 5`.0		
L.H.A.	045º 42`.3		

3rd Step: To Calculate C.Z.D

Cos (CZD) = Cos (LHA) Cos (Lat.) Cos (Dec.) +Sin (Lat.) Sin (Dec.)

Cos (CZD) = Cos (45º 42`.3) Cos (41º 10`.0) Cos (12º 00`.9) +Sin (41º 10`.0) Sin (12º 00`.9)

Cos (CZD) = 0.51420 + 0.09398 = 0.65123 → CZD = 49° 21`.9

4th Step: To Correct Sextant Altitude

Sext alt	40º 47`.1
I.E.	- 2`.2
Obs. Alt	40º 44`.9
Dip	- 6`.8
App alt	40º 38`.1
Corr.	- 1`.1
T. alt	40º 37`.0
90°	90°
T.Z.D.	49º 23`.0
C.Z.D.	49º 21`.9
Intercept	**1`.1 A**

5th Step: To Find True Bearing

L.H.A.	045º 42`.3	A	0.853 S
Lat.	N 41º 10`.0	B	0.297 N
Dec.	N 12º 00`.9	C	0.556 S
		Az.	S 67º.3 W
		T. Bg.	**247º.3**

Procedure of application

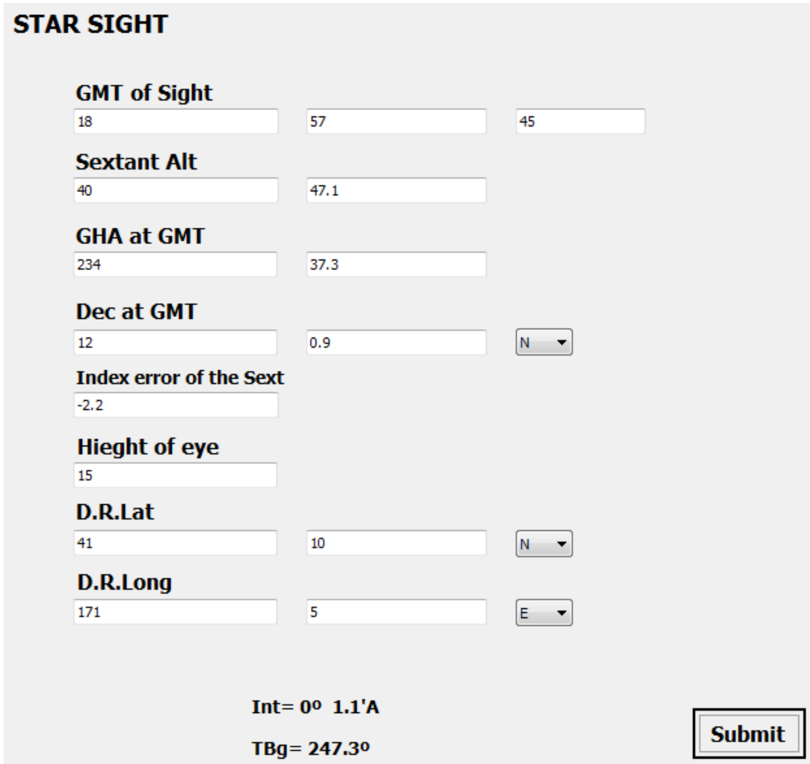
A. Obtain GMT

GMT: 18h 57m 45s July 31st

B. Data extracted from NA tables

G.H.A.	012º 06`.7		
Incr.	14º 28`.6		
SHA	208º 02`.0	Dec.	N 12º 00`.9
G.H.A.	234º 37`.3		

C. Apply soft-ware program as follows;



Answer:

Intercept 1`.1 Away

True Bearing 247°.3

TRAINING APPLICATIONS

Application (1)

At ZT 0500 Oct.15th; 1990.

Ship was in D.R. position (36º 15`.0 S; 175º 19`.0 E).

I. E.	1`.7	off the arc
Ht. of eye	15.4	m
Ch. Error	7m 41s slow	

The star **Aldebaran** was observed as follows:

Ch.Time	05h 05m 06s
Sext.alt.	31º 13`.4

Find the elements of the position line by Intercept method.

Application (2)

At ZT 0510 Oct.15th; 1990

Ship was in D.R. position (36º 20`.0 S; 175º 20`.0 E).

I. E.	1`.7	on the arc
Ht. of eye	16.0	m
Ch. Error	8m 44s fast	

The star **Acamar was** observed as follows:

Ch.Time	05h 21m 31s
Sext.alt.	49º 43`.4

Find the elements of the position line by Intercept method.

Application (3)

At ZT 0505 Oct.15th; 1990

Ship was in D.R. position (36º 19`.0 S; 175º 21`.0 E).

I. E.	2`.4	on the arc
Ht. of eye	16.1	m
Ch. Error	9m 33s slow	

The star **Ankaa was** observed as follows:

Ch.Time	05h 03m 14s
Sext.alt.	23º 37`.9

Find the elements of the position line by Intercept method.

Application (4)

At ZT 0512 Oct.15th; 1990

Ship was in D.R. position (36º 14`.0 S; 175º 17`.0 E).

I. E.	2`.8	on the arc
Ht. of eye	16.8	m
Ch. Error	9m 45s fast	

The star **Elnath was** observed as follows:

Ch.Time	05h 22m 32s
Sext.alt.	23º 48`.4

Find the elements of the position line by Intercept method.

Application (5)

At ZT 0515 Oct.15th; 1990

Ship was in D.R. position (36º 16`.0 S; 175º 16`.0 E).

I. E.	2`.5	off the arc
Ht. of eye	16.6	m
Ch. Error	3m 39s fast	

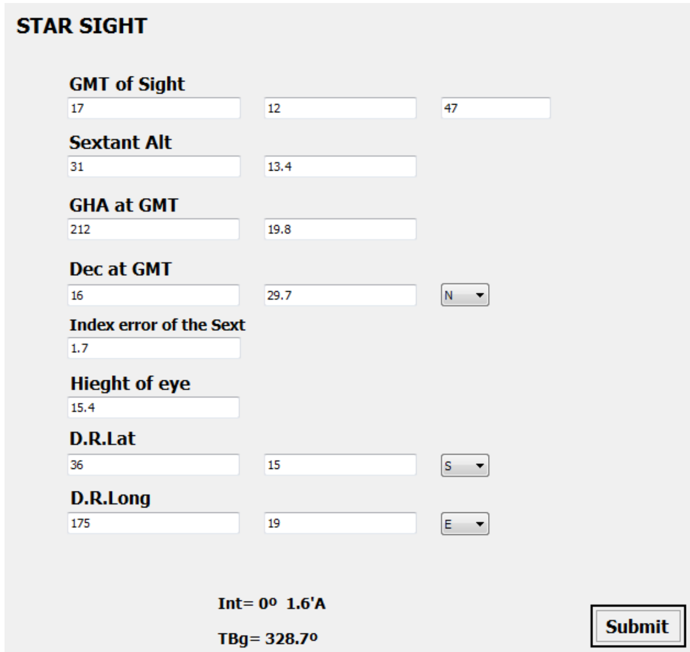
The star **Miaplacidus was** observed as follows:

Ch.Time	05h 16m 26s
Sext.alt.	49º 50`.8

Find the elements of the position line by Intercept method.

ANSWERS:

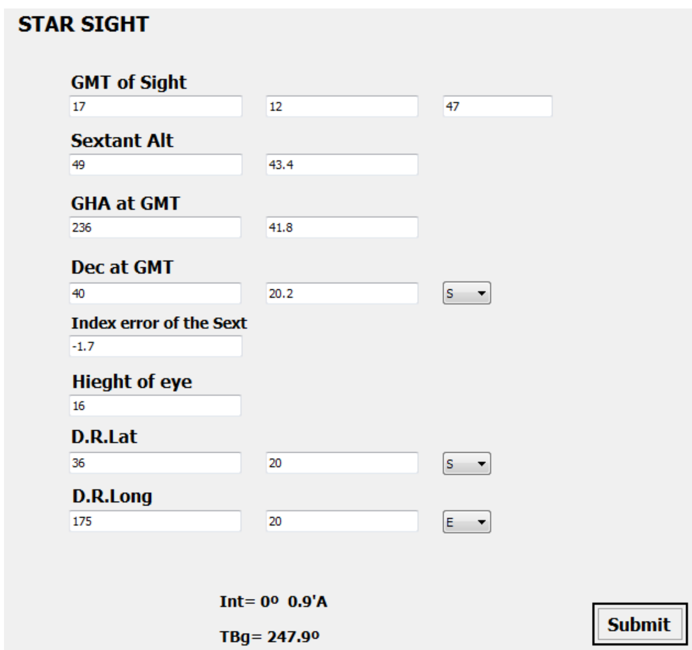
Application (1)



Answer: Intercept 1`.6 A

True Bearing 328°.7

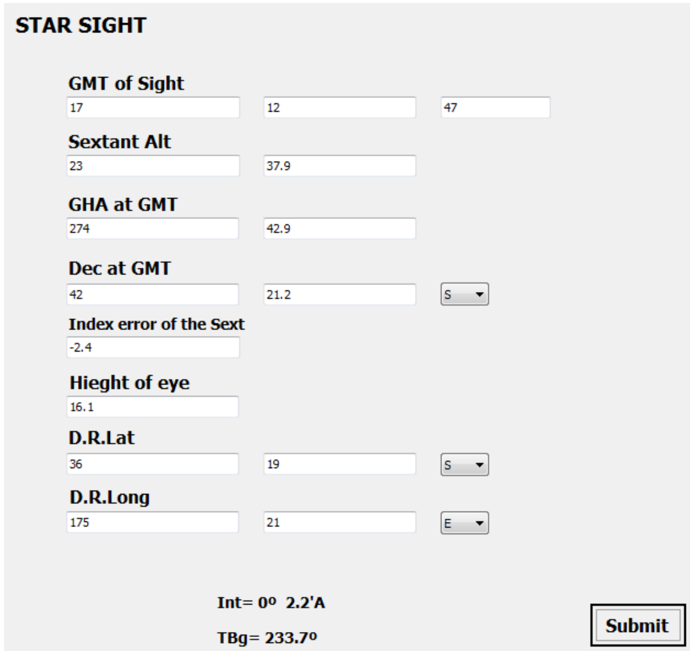
Application (2)



Answer: Intercept 0`.9 A

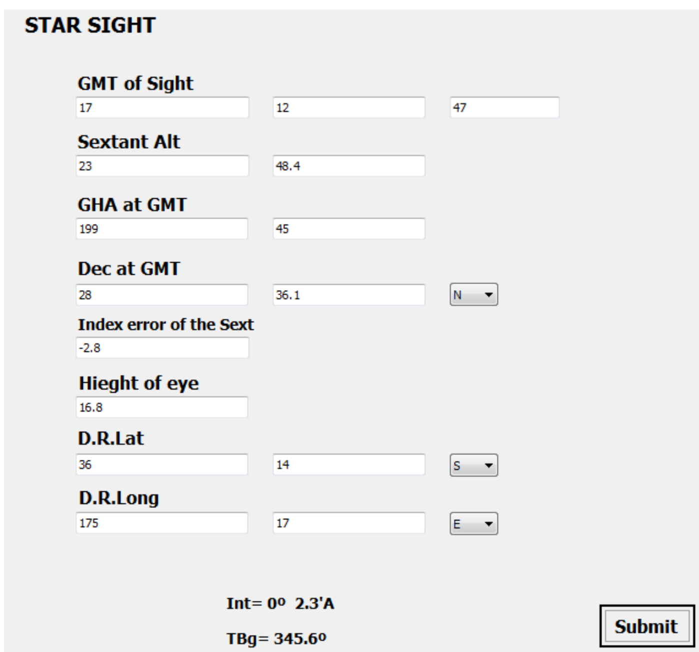
True Bearing 247°.9

Application (3)



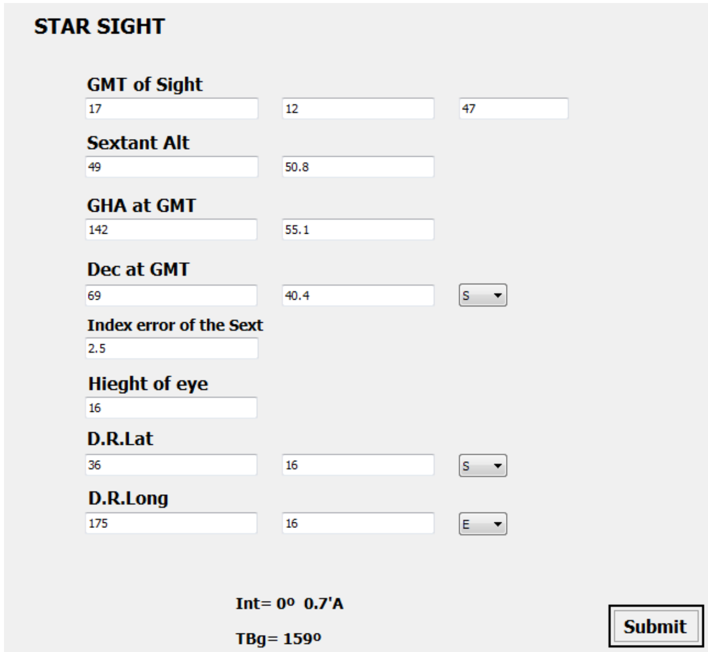
Answer: Intercept 2`.2 A
True Bearing 233°.7

Application (4)



Answer: Intercept 2`.3 A
True Bearing 345°.6

Application (5)



Answer: Intercept 0`.7 A
True Bearing 159°.0

11) UNIVERSAL METHOD

To apply this software program you must:

- Extract ***SHA*** & ***Dec.*** for each star concerned.
- Calculate ***GHA****= [GHA γ + SHA] for each star concerned at its GMT.

	Star (1)	Star (2)	Star (3)	Star (4)	Star (5)
GMT					
GHA γ					
(+)Incr. γ					
(+)S.H.A.					
GHA *					

- Arrange the data as given below to avoid mistakes of entry.

Co.	True Course
Sp.	Speed
I.E.	Index Error
H.E.	Height of eye
DRL	DR Latitude
DRG	DR Longitude
RT	Required time

Star	1	2	3	4	5
GMT					
Sext. Alt.					
GHA *					
Dec.					

The Input data are introduced in two steps;
Main data then press star number to introduce parameters of each one.

The following is the screen of the Universal Method software program:

Main Data

Number of Stars

i

True Co. | Speed

° | knots

I.E. | Ht. of Eye

` | meter

DR Latitude

° | ` | N / S

DR Longitude

° | ` | E / W

Required Time for Fix

h | m | s

Information of Star № (i)

GMT

h | m | s

Sextant Altitude

° | `

GHA

° | `

Dec.

° | ` | N / S

The software program is designed to obtain the most probable observed position MPOP; at the required time of fixing.

SOLVED APPLICATION

Z.T. 0407 January 2nd; 1990 Ship was in DR position (31° 19`.0 S; 172° 25`.0 E).

- True Course to steer 333°
- Steaming Speed 16.5 k
- I.E. 1`.3 on the arc
- Ht. of eye 19.0 m

The following are **7-Star** sights; were observed at morning twilight as follows:

Star Name	G.M.T. Jan. 1st	Sext. Alt.
Arcturus	16h 51m 38s	22° 08`.5
Antares	16h 54m 10s	21° 24`.3
Acrux	16h 57m 43s	56°19`.5
Canopus	17h 00m 00s	34° 49`.1
Sirius	17h 02m 50s	27° 15`.1
Procyon	17h 05m 11s	26° 12`.3
Regulus	17h 07m 49s	43° 20`.2

Find the most probable observed position at G.M.T. 17h 00m 00s January 1st; 1990;
Time at which the *Assumed G.P.S. Position is (31° 20`.5 S; 172° 25`.3 E).*

SOLUTION:

Step (1): *Extract GHA & Dec. of stars*;

Star *Arcturus*	GMT	16h 51m 38s Jan.1st	
GHA γ	341° 02`.6		
Incr.	12° 56`.6		
SHA*	146° 11`.9	Dec.*	N 19° 13`.8
GHA*	140° 11`.1		

Star *Antares*	GMT	16h 54m 10s Jan.1st	
GHA γ	341° 02`.6		
Incr.	13° 34`.7		
SHA*	112° 48`.2	Dec.*	S 26° 24`.7
GHA*	107° 25`.5		

Star *Acrux*	GMT	16h 57m 43s Jan.1st	
GHA γ	341° 02`.6		
Incr.	14° 28`.1		
SHA*	173° 29`.3	Dec.*	S 63° 02`.4
GHA*	169° 00`.0		

Star *Canopus*	GMT	17h 00m 00s Jan.1st	
GHA γ	356° 05`.1		
Incr.	00° 00`.0		
SHA*	264° 03`.4	Dec.*	S 52° 41`.3
GHA*	260° 08`.5		

Star *Sirius*	GMT	17h 02m 50s Jan.1st	
GHA γ	356° 05`.1		
Incr.	00° 42`.6		
SHA*	258° 48`.9	Dec.*	S 16° 42`.1
GHA*	255° 36`.6		

Star *Procyon*	GMT	17h 05m 11s Jan.1st	
GHA γ	356° 05`.1		
Incr.	01° 18`.0		
SHA*	245° 17`.8	Dec.*	N 5° 15`.1
GHA*	242° 40`.9		

Star *Regulus*	GMT	17h 07m 49s Jan.1st	
GHA γ	356° 05`.1		
Incr.	01° 57`.6		
SHA*	208° 02`.0	Dec.*	N 12° 00`.9
GHA*	206° 04`.7		

Step (2): *Arrange data in two tables as follows*;

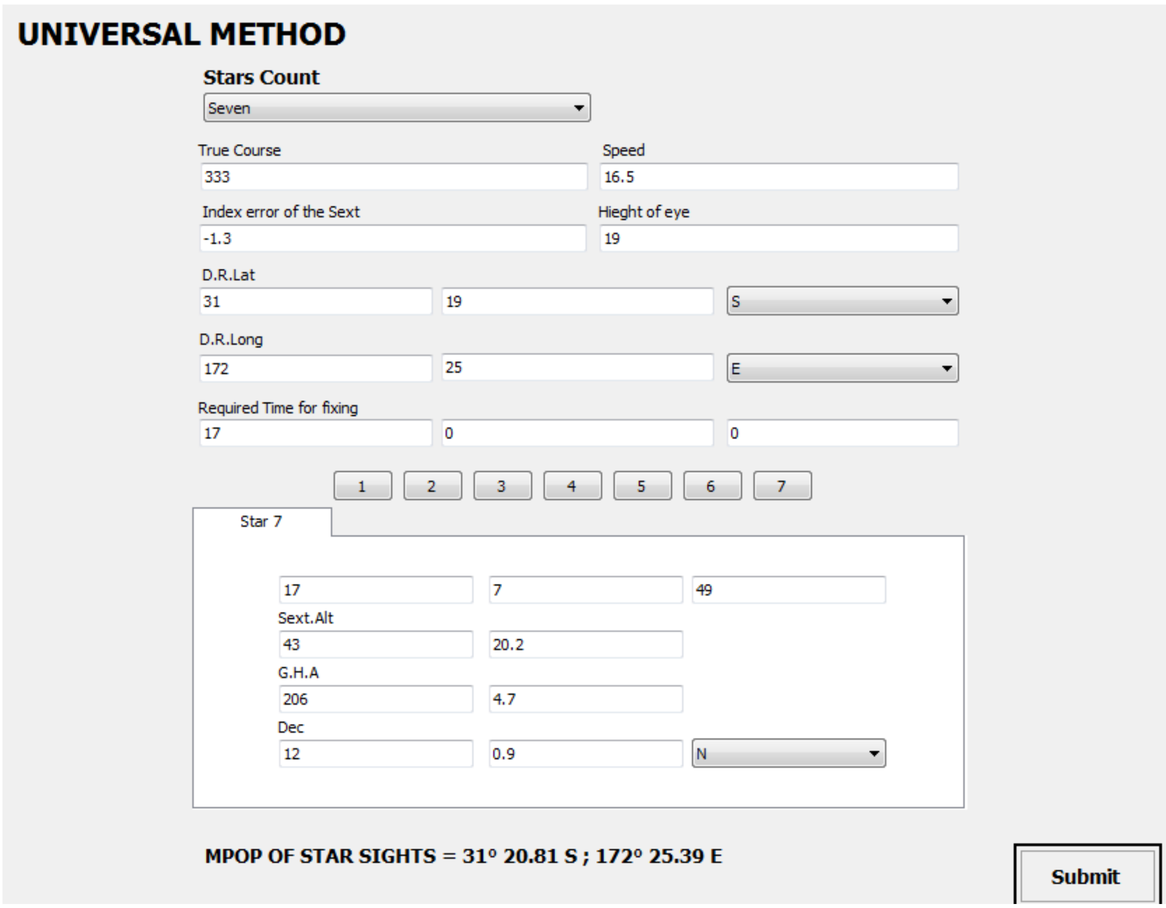
Main Data

Star number	7
DR Latitude	31° 19`.0 S
DR Longitude	172° 25`.0 E
True Course	333°
Speed	16.5
Index Error	- 1`.3
Height of Eye	19.0
Required Time for MPOP	17h 00m 00s

Data of Stars

(1) Arcturus	
GMT	16h 51m 38s
Sextant altitude	22° 08`.5
GHA of star	140° 11`.1
Declination of star	19° 13`.8 N
(2) Antares	
GMT	16h 54m 10s
Sextant altitude	21° 24`.3
GHA of star	107° 25`.5
Declination of star	26° 24`.7 S
(3) Acrux	
GMT	16h 57m 43s
Sextant altitude	56° 19`.5
GHA of star	169° 00`.0
Declination of star	63° 02`.4 S
(4) Canopus	
GMT	17h 00m 00s
Sextant altitude	34° 49`.1
GHA of star	260° 08`.5
Declination of star	52° 41`.3 S
(5) Sirius	
GMT	17h 02m 50s
Sextant altitude	27° 15`.1
GHA of star	255° 36`.6
Declination of star	16° 42`.1 S
(6) Procyon	
GMT	17h 05m 11s
Sextant altitude	26° 12`.3
GHA of star	242° 40`.9
Declination of star	5° 15`.1 N
(7) Regulus	
GMT	17h 07m 49s
Sextant altitude	43° 20`.2
GHA of star	206° 04`.7
Declination of star	12° 00`.9 N

Step (3): *Apply the software program;*



MPOP (31° 20`.8 S; 172° 25`.4 E)

TRAINING APPLICATIONS

Application (1)

Z.T. 0455 Jun. 17th ; 1990 Ship was in DR position (20° 45`.0 N; 54° 35`.0 W).

- True Course to steer 300°
- Steaming Speed 19.5 k
- I.E. 1`.2 on the arc
- Ht. of eye 16.0 m

The following are **3-Star** sights; were observed at morning twilight as follows:

Star Name	G.M.T.	Sext. Alt.
Hamal	08h 44m 47s	44° 20`.9
Ankaa	08h 47m 15s	23° 15`.2
Eltanin	08h 53m 10s	25° 31`.5

Find the most probable observed position at G.M.T. 08h 50m 00s Jun.17th; 1990; the time at which the *ASSUMED G.P.S Position is (20° 50`.0 N; 54° 30`.0 W).*

Application (2)

Z.T. 1755; Aug.23rd ; 1990. Ship was in DR position (39° 31`.0 S; 155° 23`.0 E).

- True Course to steer 133°
- Steaming Speed 18.3 k
- I.E. 1`.7 off the arc
- Ht. of eye 16.0 m

The following are **4-Star** sights; were observed at evening twilight as follows:

Star Name	G.M.T.	Sext. Alt.
Rasalhague	07h 30m 45s	33° 20`.4
Nunki	07h 33m 10s	51° 29`.9
Miaplacidus	07h 37m 32s	32° 34`.3
Spica	07h 42m 35s	43° 55`.4

Find the most probable observed position at G.M.T. 07h 40m 00s Aug. 23rd; 1990; the time at which the *ASSUMED G.P.S Position is (39° 30`.0 S; 155° 20`.0 E).*

Application (3)

Z.T. 1945 February 17th; 1990 Ship was in DR position (40° 35`.0 S; 35° 45`.0 W).

- True Course to steer 200°
- Steaming Speed 19.0 k
- I.E. 1`.6 off the arc
- Ht. of eye 18.6 m

The following are **5-Star** sights; were observed at evening twilight as follows:

Star Name	G.M.T.	Sext. Alt.
Betelguese	21h 38m 38s	40° 57`.1
Adhara	21h 40m 47s	64° 55`.9
Acrux	21h 43m 15s	27° 59`.8
Achernar	21h 48m 10s	51° 45`.8
Menkar	21h 51m 20s	35° 34`.0

Find the most probable observed position at G.M.T.21h 45m 00s. Feb. 17th; 1990;
Time at which the *ASSUMED G.P.S Position is (40° 30`.0 S; 35° 40`.0W)*

Application (4)

Z.T. 1837 April 2nd; 1990 Ship was in DR position (31° 00`.0 S; 100° 30`.0 E).

- True Course to steer 060°
- Steaming Speed 21.0 kts
- I.E. 1`.4 on the arc
- Ht. of eye 14.0 m

The following are **6-Star** sights; were observed at evening twilight as follows:

Star Name	G.M.T.	Sext. Alt.
Pollux	11h 18m 50s	29° 18`.9
Regulus	11h 20m 55s	25° 14`.4
Acrux	11h 23m 10s	29° 47`.0
Canopus	11h 25m 57s	67° 50`.7
Acamar	11h 28m 12s	42° 24`.2
Menkar	11h 30m 40s	24° 31`.1

Find the most probable observed position at G.M.T. 11h 30m 00s. April 2nd 1990;
Time at which the *Assumed G.P.S Position is (30° 55`.5 S; 100° 33`.3 E).*

Application (5)

Z.T. 1850, October 15th; 1990 Ship was in DR position (33° 30`.0 S; 140° 28`.0 W).

- True Course to steer 065°
- Steaming Speed 17 k
- I.E. 2`.3 off the arc
- Ht. of eye 14.3 m

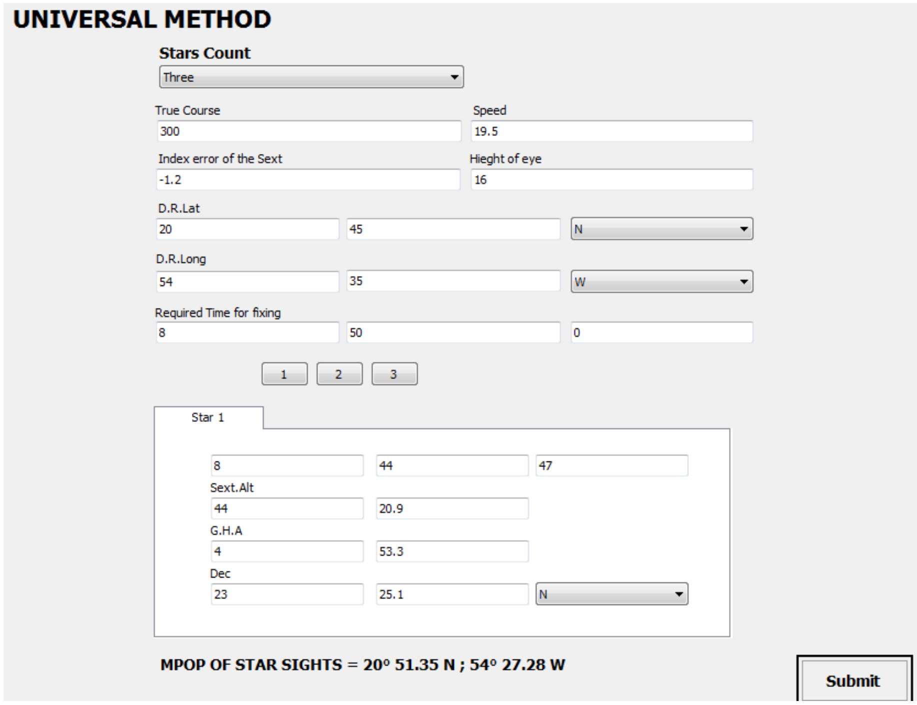
The following are **7-Star** sights; were observed at morning twilight as follows:

Star Name	G.M.T.	Sext. Alt.
Markab	3h 51m 00s	24° 56`.1
Diphda	3h 54m 00s	26° 50`.5
Achernar	3h 57m 00s	31° 48`.2
Rigil Kent.	4h 00m 00s	32° 03`.5
Antares	4h 03m 00s	41° 10`.9
Rasalhague	4h 06m 00s	29° 46`.4
Altair	4h 09m 00s	47° 07`.2

Find the most probable observed position at G.M.T. 04h 00m 00s October 15th ; 1990;
Time at which the *Assumed G.P.S. Position is (33° 28`.0 S; 140° 30`.0 W).*

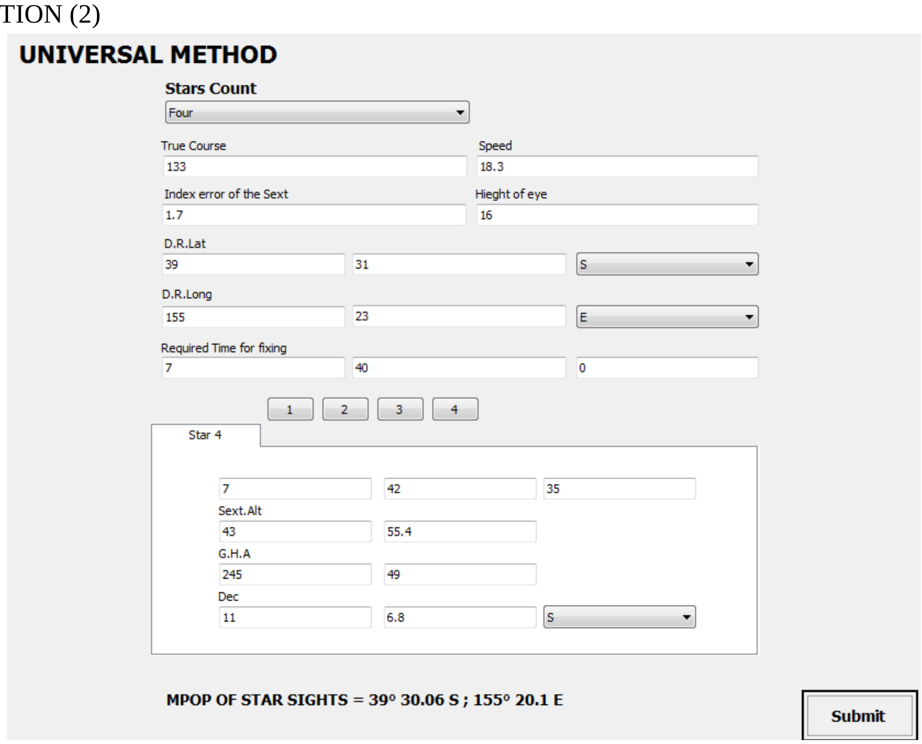
ANSWERS OF APPLICATIONS

APPLICATION (1)



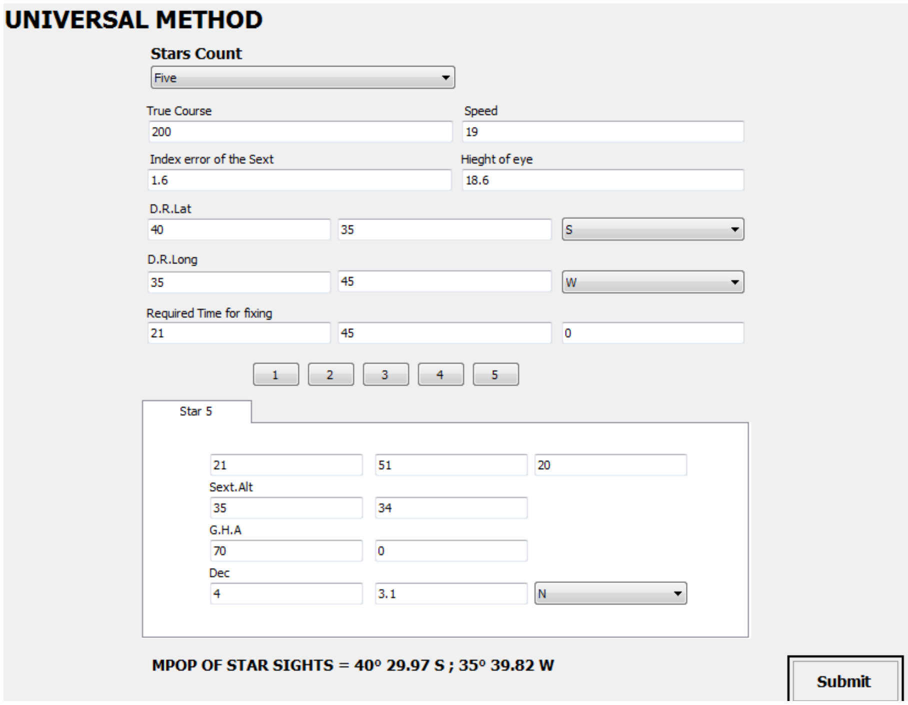
ANSWER (*20° 51`.4 N; 54° 27`.3 W)*

APPLICATION (2)



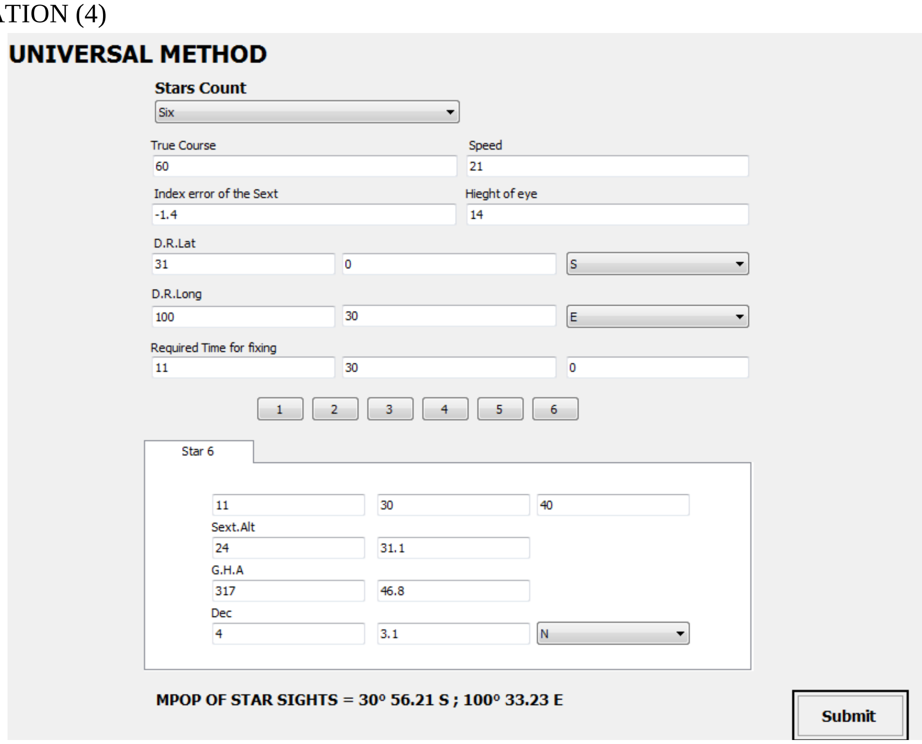
ANSWER (*39° 30`.1 S; 155° 20`.1 E)*

APPLICATION (3)



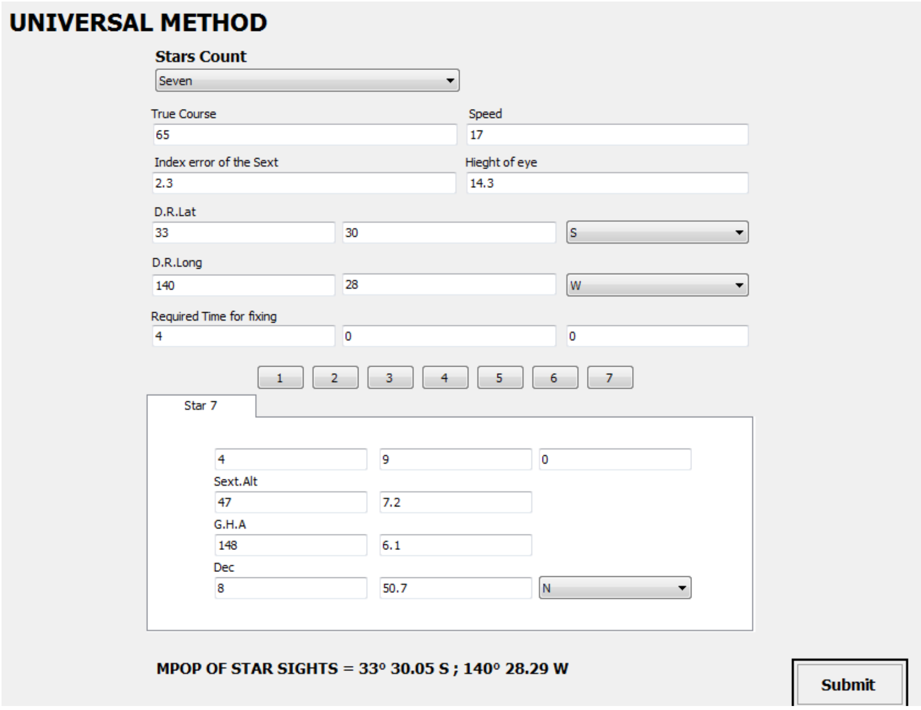
ANSWER (*40° 30`.0 S; 35° 39`.8 W)*

APPLICATION (4)



ANSWER (*30° 56`.2 S; 100° 33`.2 E)*

APPLICATION (5)



ANSWER (*33° 30`.1 S; 140° 28`.3 w)*

12) Egyptian Method

To apply this software program you must:

- **Practically,** decide the required time (GMT) of fixing. You choose a time of round figure of minuets (15m) say. As an example assume that the GMT`s for 5-star sights are given as:

	Star(1)	Star(2)	Star(3)	Star(4)	Star(5)
GMT	3h 22m 41s	3h 24m 13s	3h 26m 56s	3h 29m 09s	3h 32m 17s

So the required time (GMT) of fixing [**3h 30m 00s**] is suitable.

- **In the exercises**, required time (GMT) of fixing is given.

In both cases;

- Calculate [*GHA γ*] at the required time of fixing.
- Extract *SHA* & *Dec*. for each star concerned.
- Record Azimuth (Az.) for each star concerned obtained from the process of preparation for star sights.

In both cases; arrange the data as given below to avoid mistakes of entry.

GHRγ at RT	
Co.	True Course
Sp.	Speed
I.E.	Index Error
H.E.	Height of eye
DRL	DR Latitude
DRG	DR Longitude
RT	Required time

Star	1	2	3	4	5
GMT					
Sext. Alt.					
S.H.A.					
Dec.					
Az.					

The Input data are introduced in two steps;
Fill the main data then press star number to introduce parameters of each one.

The following is the screen of the Egyptian Method software program:

Main Data

Number of Stars | Twilight
[i] [Morning / Evening]

GHA γ at the Required Time
[°] [`]

True Co. | Speed
[°] [knots]

I.E. | Ht. of Eye
[`] [meter]

DR Latitude
[°] [`] [N / S]

DR Longitude
[°] [`] [E / W]

Required Time for Fix
[h] [m] [s]

Information of Star № (i)

GMT
[h] [m] [s]

Sextant Altitude
[°] [`]

SHA
[°] [`]

Dec.
[°] [`] [N / S]

Azimuth
[°]

The software program is designed to obtain the most probable observed position MPOP; at the required time of fixing.

SOLVED APPLICATION

Z.T. 1945 February 17th; 1990 Ship was in DR position (40° 35`.0 S; 35° 45`.0 W).

- True Course to steer 200°
- Steaming Speed 19.0 kts
- I.E. 1`.6 off the arc
- Ht. of eye 18.6 m

The following are **7-Star** sights; were observed at evening twilight as follows:

Star Name	G.M.T.	Sext. Alt.	Az.
Procyon	21h 38m 38s	32° 34`.0	046°.7
Suhail	21h 40m 47s	46° 30`.3	114°.4
Acrux	21h 43m 15s	27° 59`.8	150°.9
Al Na`ir	21h 45m 55s	19° 13`.8	223°.8
Diphda	21h 48m 10s	28° 06`.6	269°.6
Menkar	21h 51m 20s	35° 34`.0	316°.3
Elnath	21h 54m 47s	20° 56`.7	000°.8

Find the most probable observed position at G.M.T. 21h 45m 00s Feb.17th; 1990; the time at which the *ASSUMED G.P.S Position is (40° 30`.0 S; 35° 40`.0 W).*

SOLUTION:

Step (1): Calculate GHRγ at G.M.T. 21h 45m 00s Feb.17th; 1990

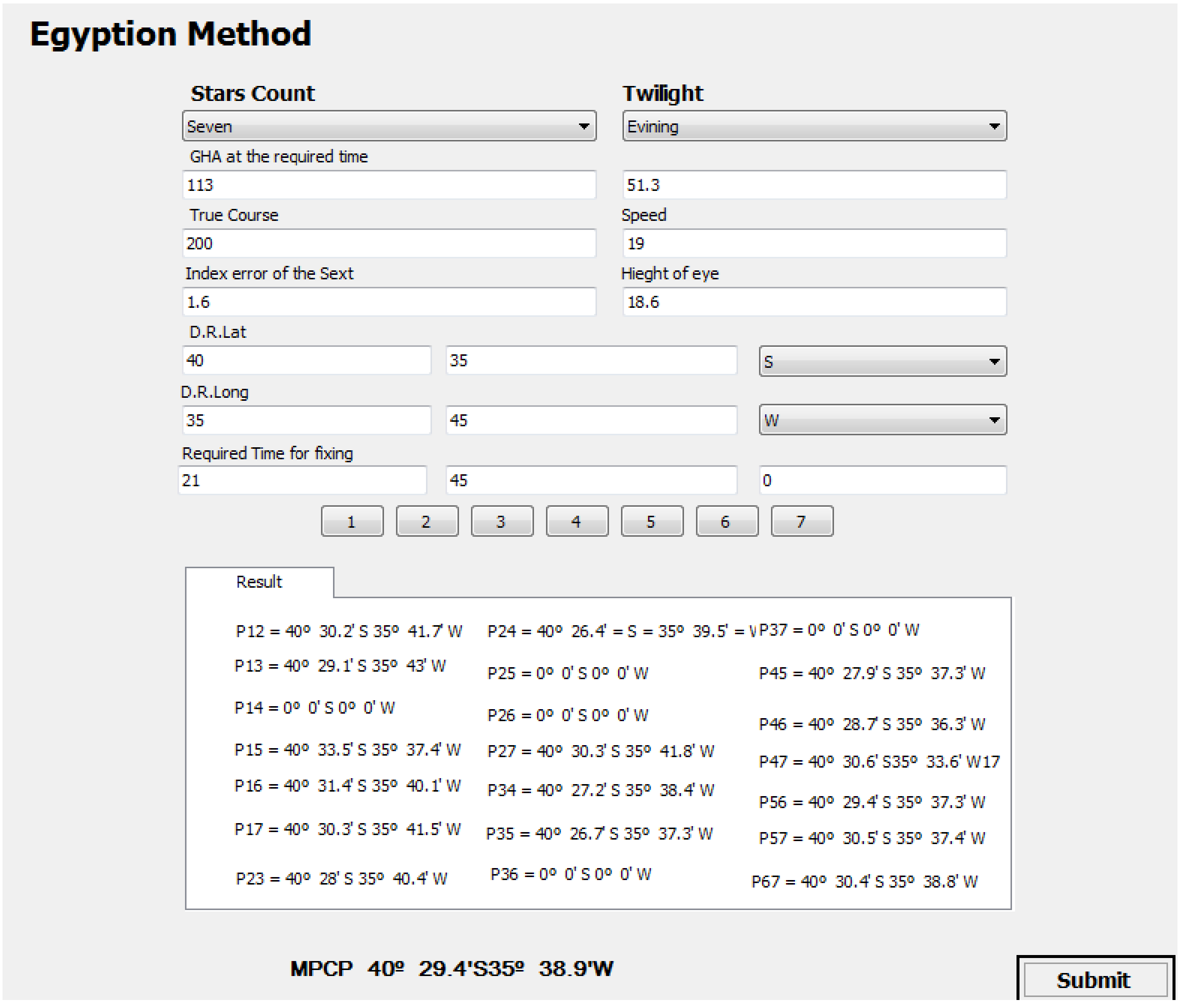
GHA γ	102° 34`.5
Incr.	11° 16`.8
GHA γ	113° 51`.3

Step (2): Extract SHA & *Dec*. for each star concerned

Step (3): Arrange data as follows;

GHRγ at RT	113° 51`.3
Co.	200°.0
Sp.	19.0
I.E.	1`.6
H.E.	18.6 m
DRL	40° 35`.0 S
DRG	35° 45`.0 W
RT	21h 45m 00s Feb. 17th

star	*Procyon*	*Suhail*	*Acrux*	*Al Na`ir*	*Diphda*	*Menkar*	*Elnath*
GMT	21 38 38	21 40 47	21 43 15	21 45 55	21 48 10	21 51 20	21 54 47
Sext. Alt.	32 34.0	46 30.3	27 59.8	19 13.8	28 06.6	35 34.0	20 56.7
S.H.A.	245 17.7	223 05.0	173 28.8	28 05.9	349 13.6	314 33.4	278 34.6
Dec.	5 15.0 N	43 23.6 S	63 02.6 S	47 00.6 S	18 02.5 S	4 03.1 N	28 36.2 N
Az.	**046.7**	**114.4**	**150.9**	**223.8**	**269.6**	**316.3**	**000.8**



MPOP is (40° 29`.4 S; 35° 38`.9 W)

Note:

The above figure is the final seen of application; where some couples of stars failed to solve.
This is due to the condition of the difference of azimuths in theory; [ΔAz. ≤ 30°] or [150° ≤ ΔAz. ≤ 210°].
As an example P_{14} is not solved because Az. of $star_1$ *(Procyon)* = 046°.7 and $star_4$ *Al Na`ir*= 223°.8 so the difference =177°.1.

TRAINING APPLICATIONS

Application (1)

Z.T. 0455 Jun. 17th ; 1990 Ship was in DR position (20° 45`.0 N; 54° 35`.0 W).

- True Course to steer 300°
- Steaming Speed 19.5 k
- I.E. 1`.2 on the arc
- Ht. of eye 16.0 m

The following are **3-Star** sights; were observed at morning twilight as follows:

Star Name	G.M.T.	Sext. Alt.	Az.
Hamal	08h 44m 47s	44° 20`.9	077°.1
Ankaa	08h 47m 15s	23° 15`.2	161°.1
Eltanin	08h 53m 10s	25° 31`.5	318.3

Find the most probable observed position at G.M.T. 08h 50m 00s Jun.17th; 1990; the time at which the *ASSUMED G.P.S Position is (20° 50`.0 N; 54° 30`.0 W).*

Application (2)

Z.T. 1755; Aug.23rd ; 1990. Ship was in DR position (39° 31`.0 S; 155° 23`.0 E).

- True Course to steer 133°
- Steaming Speed 18.3 k
- I.E. 1`.7 off the arc
- Ht. of eye 16.0 m

The following are **4-Star** sights; were observed at evening twilight as follows:

Star Name	G.M.T.	Sext. Alt.	Az.
Rasalhague	07h 30m 45s	33° 20`.4	028°.7
Nunki	07h 33m 10s	51° 29`.9	083°.6
Miaplacidus	07h 37m 32s	32° 34`.3	203°.7
Spica	07h 42m 35s	43° 55`.4	296°.4

Find the most probable observed position at G.M.T. 07h 40m 00s Aug. 23rd; 1990; the time at which the *ASSUMED G.P.S Position is (39° 30`.0 S; 155° 20`.0 E).*

Application (3)

Z.T. 1945 February 17th; 1990 Ship was in DR position (40° 35`.0 S; 35° 45`.0 W).

- True Course to steer 200°
- Steaming Speed 19.0 k
- I.E. 1`.6 off the arc
- Ht. of eye 18.6 m

The following are **5-Star** sights; were observed at evening twilight as follows:

Star Name	G.M.T.	Sext. Alt.	Az.
Betelguese	21h 38m 38s	40° 57`.1	015°.9
Adhara	21h 40m 47s	64° 55`.9	071°.4
Acrux	21h 43m 15s	27° 59`.8	150°.9
Achernar	21h 48m 10s	51° 45`.8	225°.3
Menkar	21h 51m 20s	35° 34`.0	316°.3

Find the most probable observed position at G.M.T.21h 45m 00s. Feb. 17th; 1990; Time at which the *ASSUMED G.P.S Position is (40° 30`.0 S; 35° 40`.0W)*

Application (4)

Z.T. 0407 January 2nd; 1990 Ship was in DR position (31° 19`.0 S; 172° 25`.0 E).

- True Course to steer 333°
- Steaming Speed 16.5 k
- I.E. 1`.3 on the arc
- Ht. of eye 19.0 m

The following are **6-Star** sights; were observed at morning twilight as follows:

Star Name	G.M.T.	Sext. Alt.	Az.
Arcturus	16h 51m 38s	22° 08.5	048°.5
Antares	16h 54n 10s	21° 24.3	108°.8
Acrux	16h 57m 43s	56° 19.5	165°.0
Sirius	17h 02m 50s	27° 15.1	266°.2
Procyon	17h 05m 11s	26° 12.3	294°.6
Regulus	17h 07m 49s	43° 20.2	334°.8

Find the most probable observed position at G.M.T. 17h 00m 00s January 1st; 1990;
Time at which the *Assumed G.P.S. Position is (31° 20`.5 S; 172° 25`.3 E).*

Application (5)

Z.T. 1850, October 15th; 1990 Ship was in DR position (33° 30`.0 S; 140° 28`.0 W).

- True Course to steer 065°
- Steaming Speed 17 k
- I.E. 2`.3 off the arc
- Ht. of eye 14.3 m

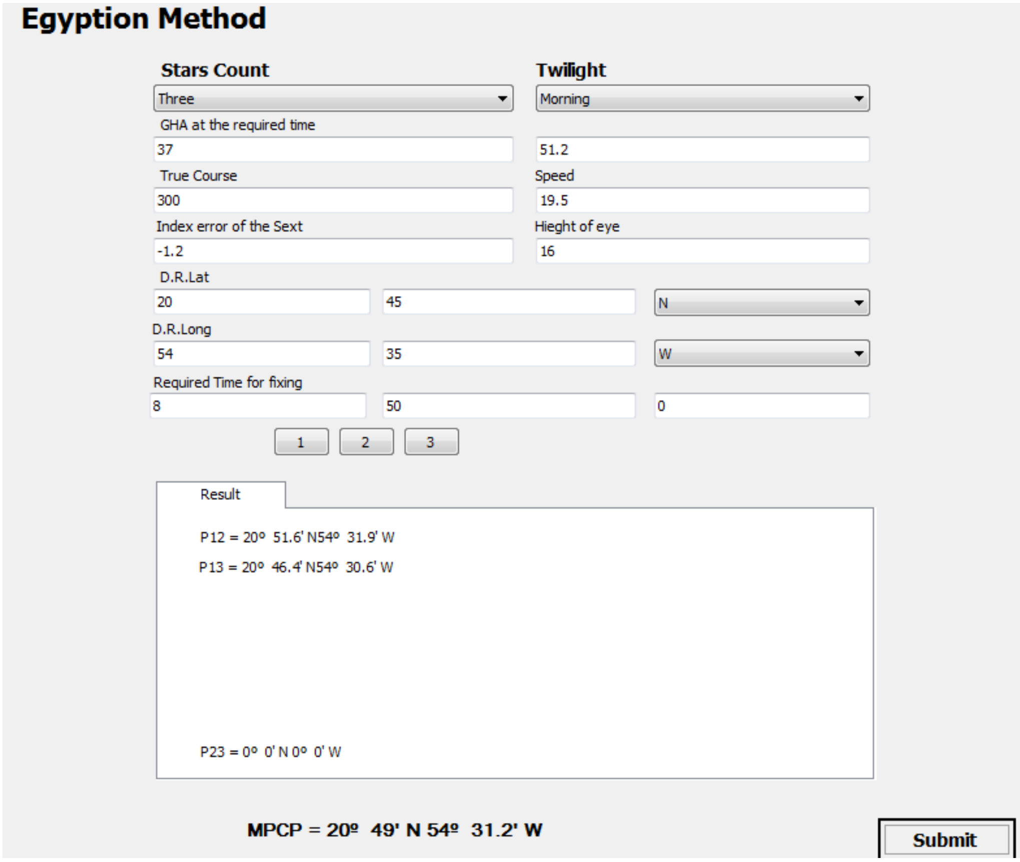
The following are **7-Star** sights; were observed at morning twilight as follows:

Star Name	G.M.T.	Sext. Alt.	Az.
Markab	3h 51m 00s	24° 56`.1	049°.3
Diphda	3h 54m 00s	26° 50`.5	094°.7
Achernar	3h 57m 00s	31° 48`.2	141°.0
Rigil Kent.	4h 00m 00s	32° 03`.5	214°.8
Antares	4h 03m 00s	41° 10`.9	262°.5
Rasalhague	4h 06m 00s	29° 46`.4	312°.7
Altair	4h 09m 00s	47° 07`.2	348°.8

Find the most probable observed position at G.M.T. 04h 00m 00s October 15th ; 1990;
Time at which the *Assumed G.P.S. Position is (33° 28`.0 S; 140° 30`.0 W).*

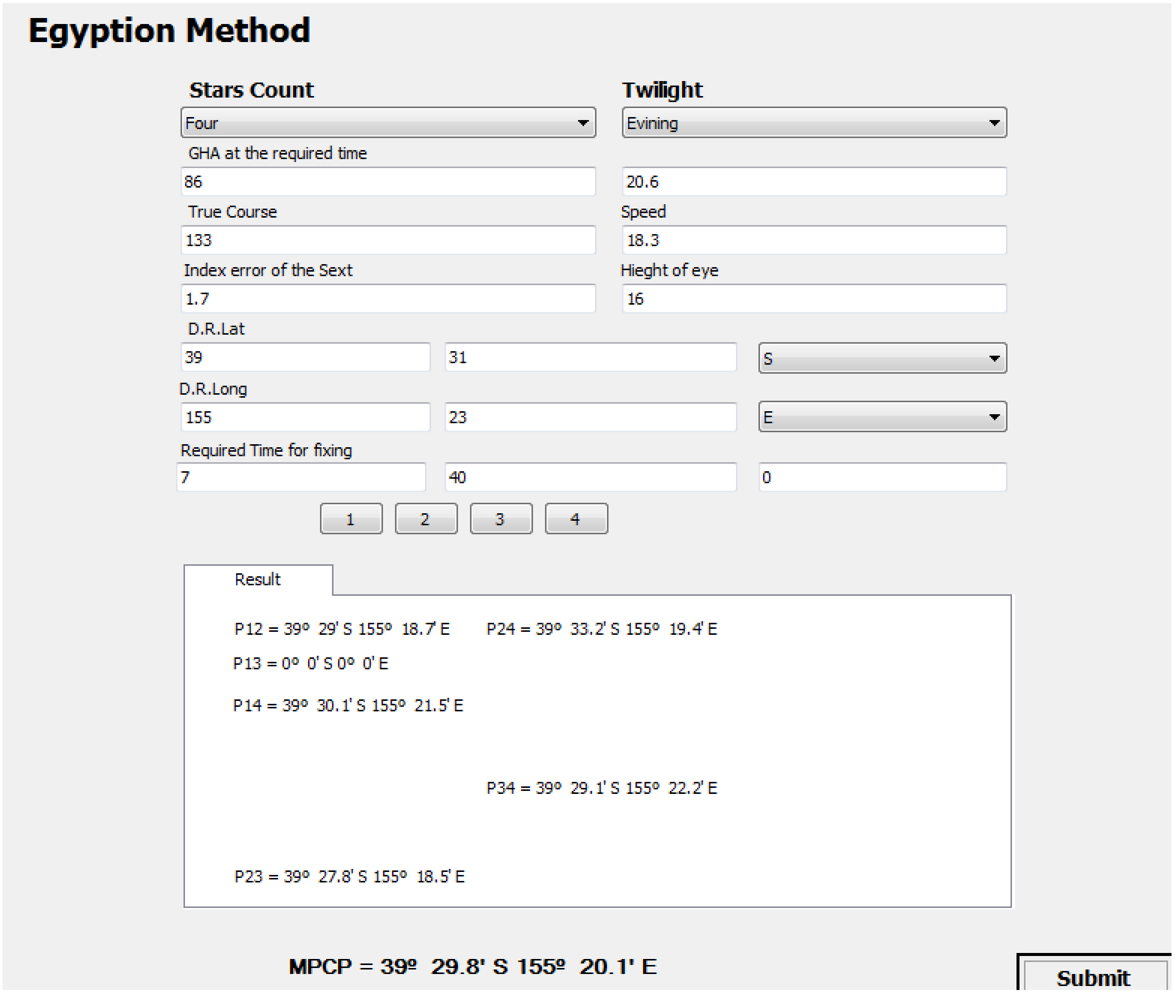
ANSWERS OF APPLICATIONS

APPLICATION (1)



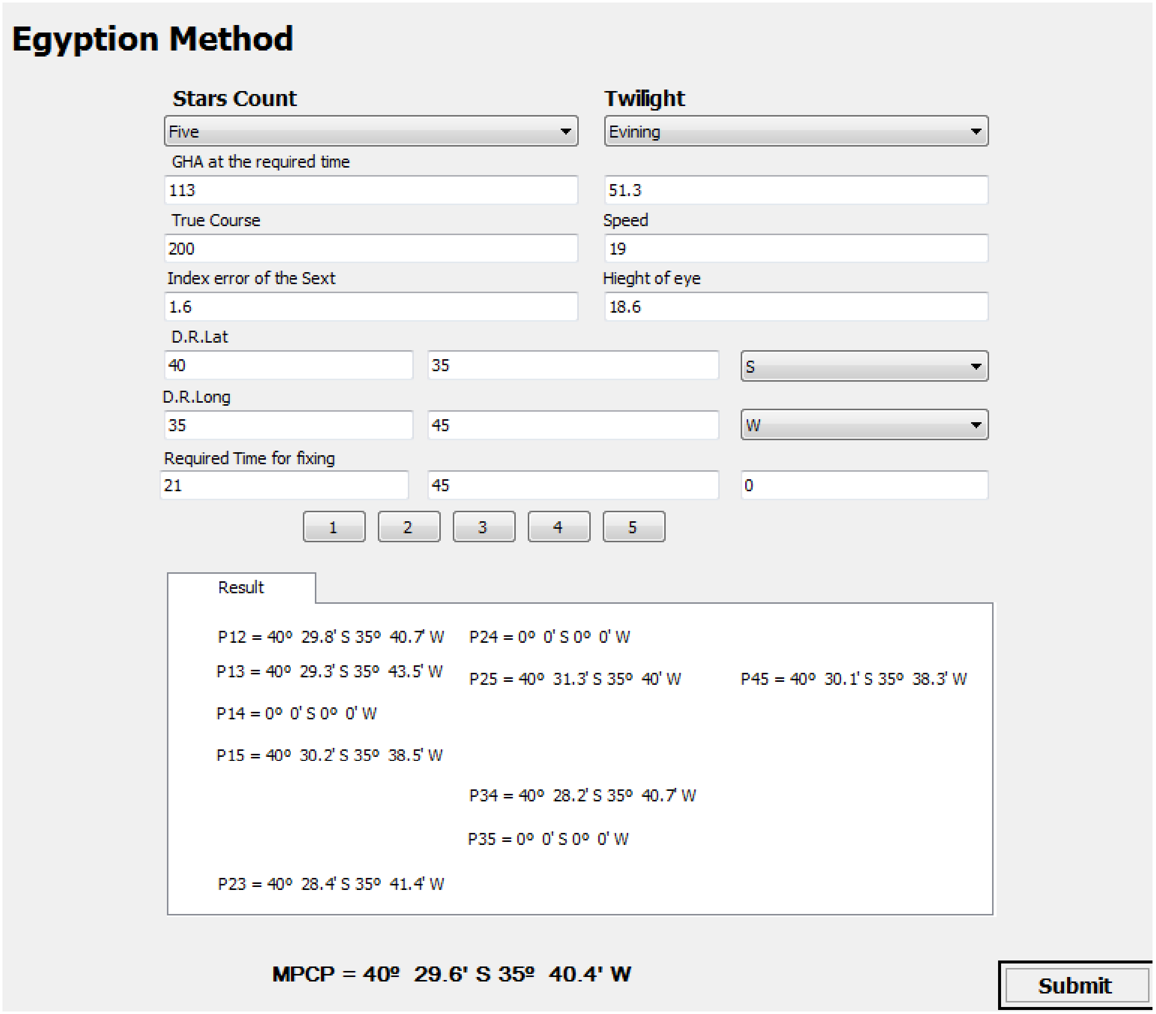
MPOP is (20° 49`.0 N; 54° 31`.2 W)

APPLICATION (2)



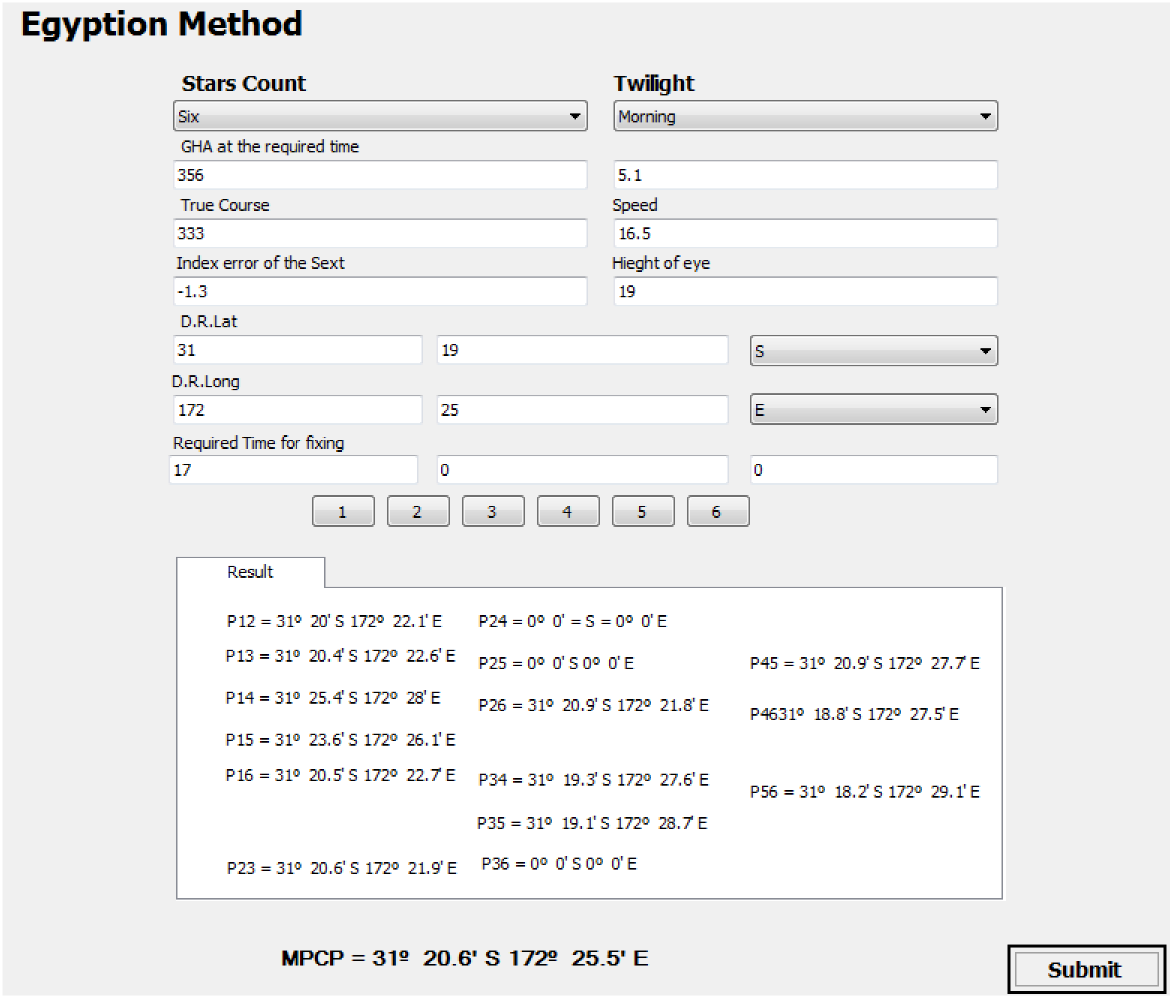
MPOP is (39° 29`.8 S; 155° 20`.1 E)

APPLICATION (3)



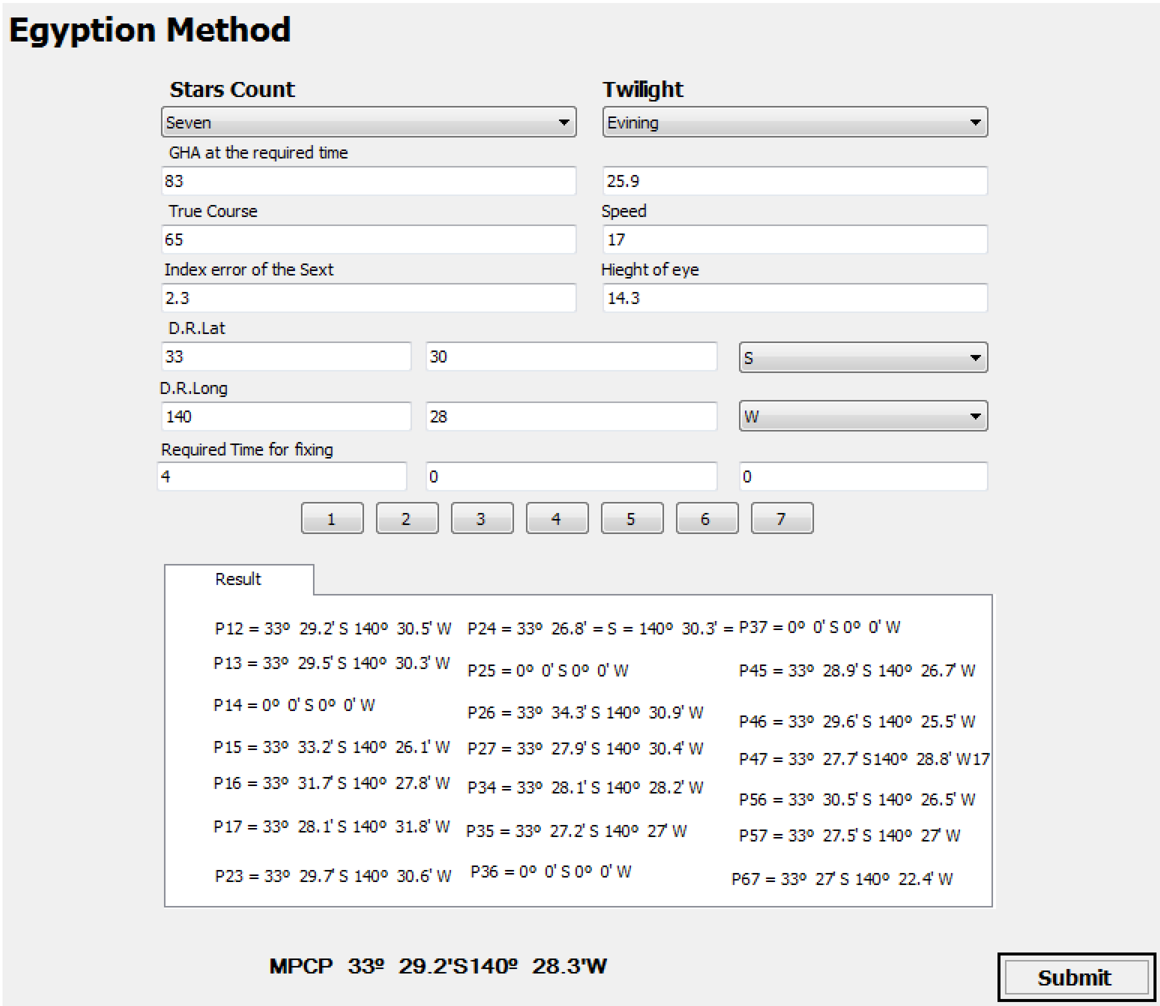
MPOP is (40° 29`.6 S; 35° 40`.4 W)

APPLICATION (4)



MPOP is (31° 20`.6 S; 172° 25`.5 E)

APPLICATION (5)



MPOP is (33° 29`.2 S; 140° 28`.3W)

GROUP (4)

PROBLEMS RELATED TO CELESTIAL NAVIGATION

- *Identification of Unknown Bright Star*
- *Coordinates of Sun, Aries and Equation of Time*

D. GROUP (4)

13) Unknown Star Identification

To apply this software program you must:

- Calculate [GHA_{γ}] at GMT [time of taking *Bearing* and *Altitude*]
- Extract DR position at GMT.

The software program is designed to give the name of the unknown star.

The screen of the software program is given below

Unknown Star Identification

DR Latitude
° ` N / S
DR Longitude
° ` E / W
Altitude
°
True Bg.
°
GHA γ at Time of Observation
° `
Hemisphere
East / West

Solved Application

Z.T. 0055 Aug. 13th, 1990; DR (44° 02`.6 S; 29° 50`.1 E)
Sky was cloudy, and a bright star was seen in a clearance of clouds. Altitude and Bearing was taken as follows;

Altitude ≈19°.0

True Bearing ≈146°.5

Identify the name of that star.

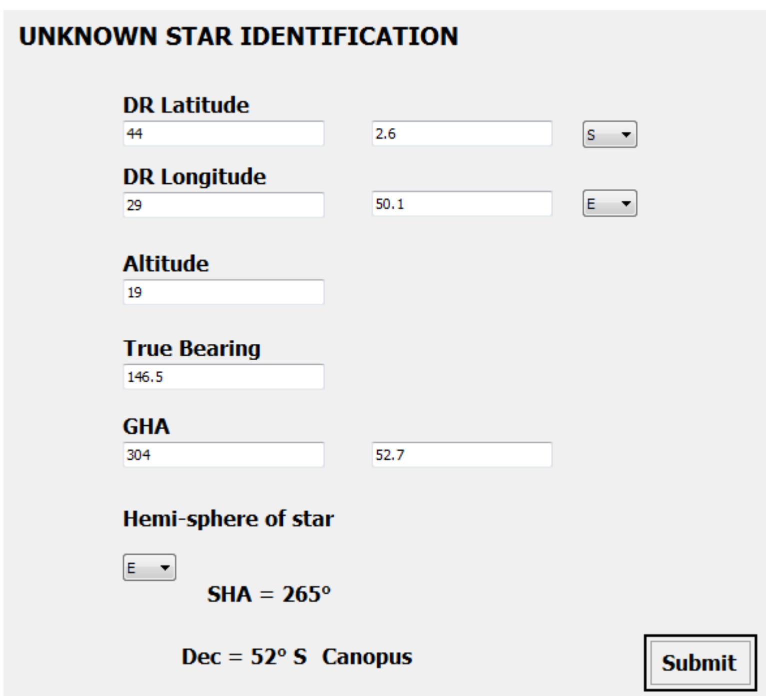
Solution

Step (1); Extract GHA γ

Z.T.	0055 Aug. 13th
Z.N	-2
G D	2255 Aug. 12th

GHA γ	291° 05`.4
Incr.	13° 47`.3
GHA γ	304° 52`.7

Step (2); Apply Software as follows;



Answer: The unknown star is *Canopus*

TRAINING APPLICATIONS

Application (1)

GMT 08h 06m 00s Jan. 2nd 1990; DR (31° 00`.0 S; 172° 29`.7 E)

Sky was cloudy, and a bright star was seen in a clearance of clouds. Altitude and Bearing was taken as follows;

Altitude ≈31°.0

True Bearing ≈107°

Identify the name of that star.

Application (2)

GMT 08h 06m 00s Jan. 2nd 1990; DR (31° 00`.0 S; 172° 29`.7 E)

Sky was cloudy, and a bright star was seen in a clearance of clouds. Altitude and Bearing was taken as follows;

Altitude ≈63°.0

True Bearing ≈194°

Identify the name of that star.

Application (3)

GMT 17h 06m 00s Jan. 1st 1990; DR (31° 19`.0 S; 172° 28`.3 E)

Sky was cloudy, and a bright star was seen in a clearance of clouds. Altitude and Bearing was taken as follows;

Altitude ≈ 44°.0

True Bearing ≈ 337°

Identify the name of that star.

Application (4)

GMT 17h 48m 00s June 27th 1990; DR (38° 10`.0 N; 154° 38`.0 E)

Sky was cloudy, and a bright star was seen in a clearance of clouds. Altitude and Bearing was taken as follows;

Altitude ≈ 45°.0

True Bearing ≈ 290°

Identify the name of that star.

Application (5)

GMT 06h 51m 00s December 7th 1990; DR (38° 00`.4 N; 154° 24`.9 E)

Sky was cloudy, and a bright star was seen in a clearance of clouds. Altitude and Bearing was taken as follows;

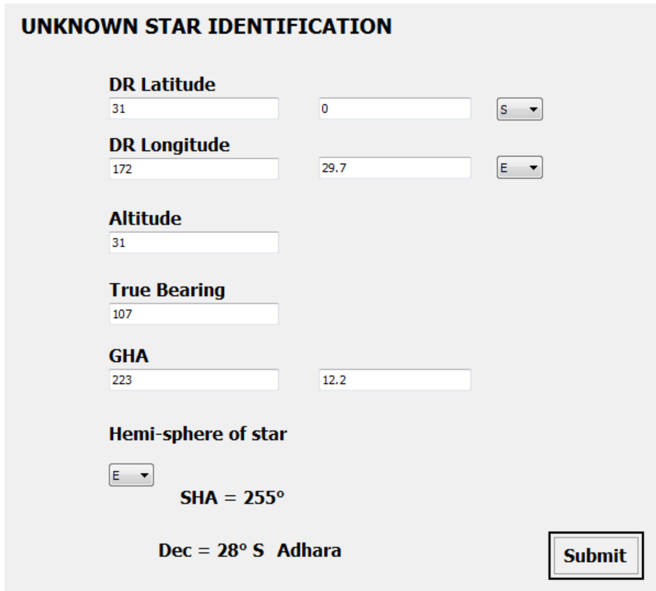
Altitude ≈ 17°.0

True Bearing ≈ 044°

Identify the name of that star.

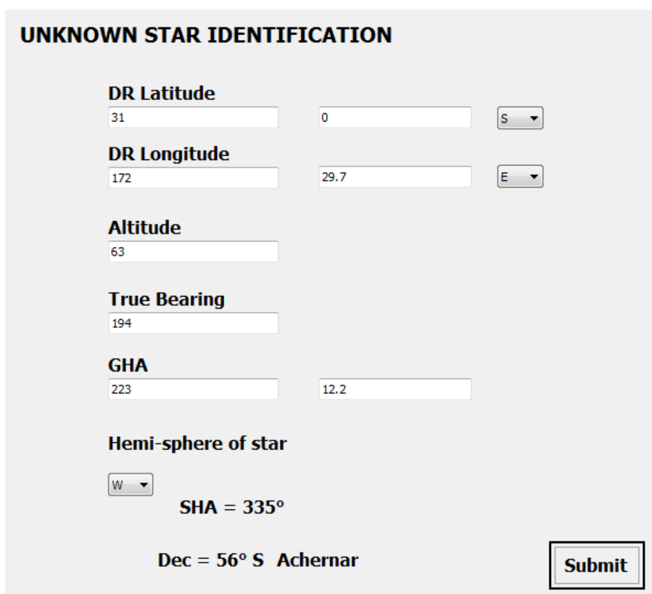
ANSWERS;

Application (1)



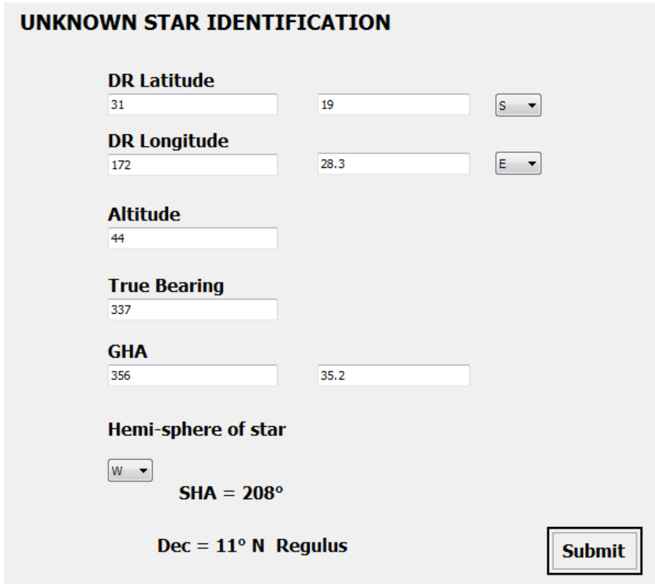
The unknown star is *Adhara*

Application (2)



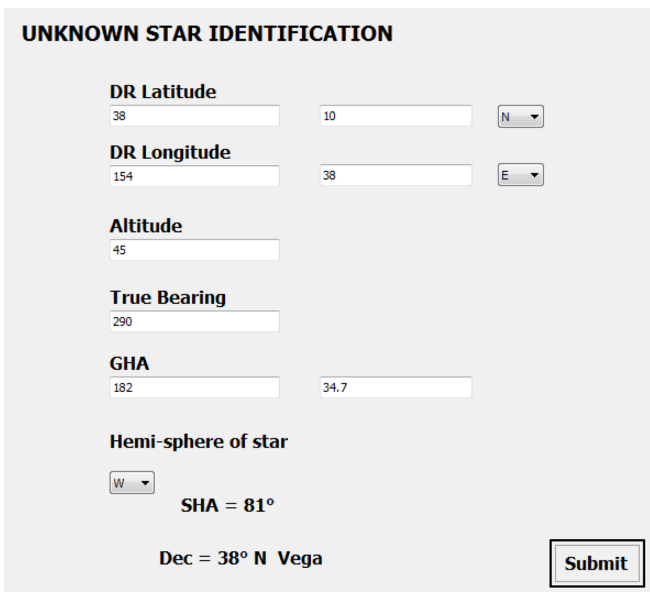
The unknown star is *Achernar*

Application (3)



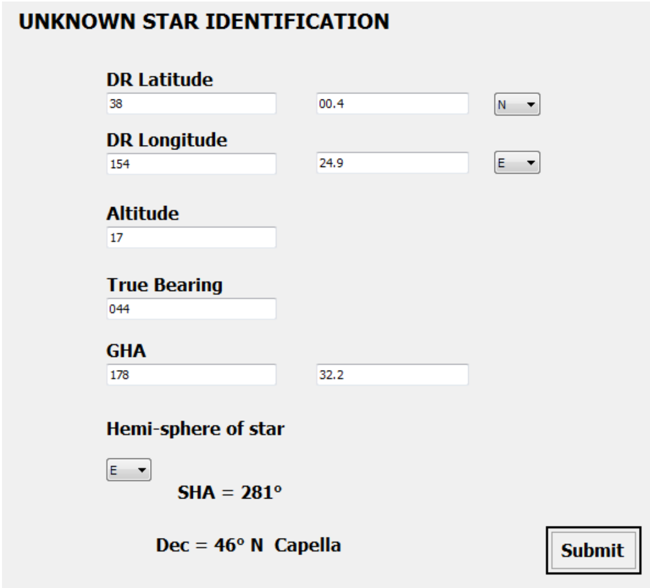
The unknown star is *Regulus*

Application (4)



The unknown star is *Vega*

Application (5)



The unknown star is *Capella*

14) Equation of Time and the Coordinates of Sun and Aries:

To apply this software programs you can proceed without any previous calculations.
The software program is designed to obtain the following parameters at a given set of time:

- Dec. of true sun.
- G.H.A. of true sun, (error < 1`.0).
- S.H.A. of true sun.
- R.A. of true sun.
- G.H.A. of Aries, (error < 1`.0).
- Equation of time.

Where the Set of time is consists of; (Year; Month; Day; Hours; Minutes; Seconds)

The screen of the software program is given below

Coordinates of the True Sun and Equation of Time

Date		
Y	M	D
GMT		
h	m	s

Solved Application

Extract GHA, Dec for the Sun, Equation of time and GHA γ at GMT 12h 00m 00s July 15^{th} 1990.

Manual Solution

A. For Sun

GHA	358° 31`.3
Incr.	00
GHA	358° 31`.3

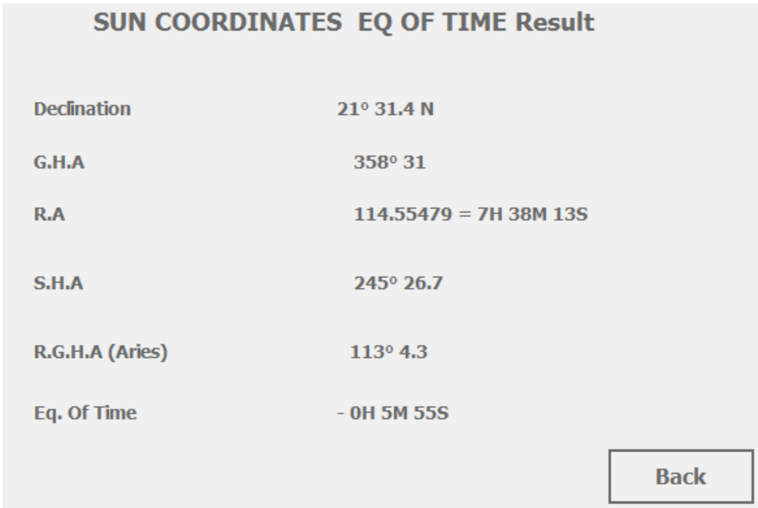
Dec	21° 31`.4 N
d^{corr}	00
C. Dec	21° 31`.4 N

B. Equation of time [- 5m 55s]

C. For Aries γ

GHA	113° 04`.9
Incr.	00
GHA	113° 04`.9

Software Application



ANSWERS;

Dec. $_{sun}$	21° 31`.4 N
GHA $_{sun}$	358° 31`.0
Eq. of time	- 5m 55s
GHA γ	113° 04`.3

Training Applications

Application (1)

Find GHA, Dec for the Sun, Equation of time and GHA γ at GMT 18h 00m 00s August 20th 1990.

Application (2)

Find GHA, Dec for the Sun, Equation of time and GHA γ at GMT 00h 30m 00s January 2nd 1990.

Application (3)

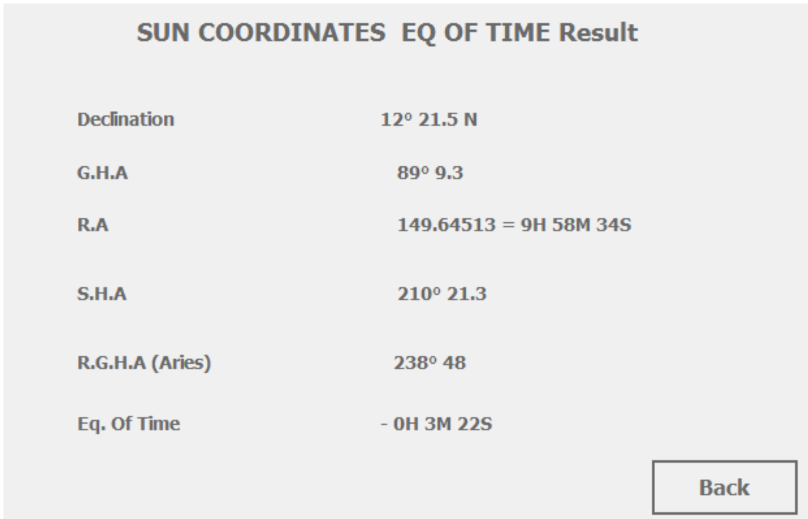
Find GHA, Dec for the Sun, Equation of time and GHA γ at GMT 06h 00m 00s June 18th 1990.

Application (4)

Find GHA, Dec for the Sun, Equation of time and GHA γ at GMT 18h 00m 00s December 1st 1990.

ANSWERS

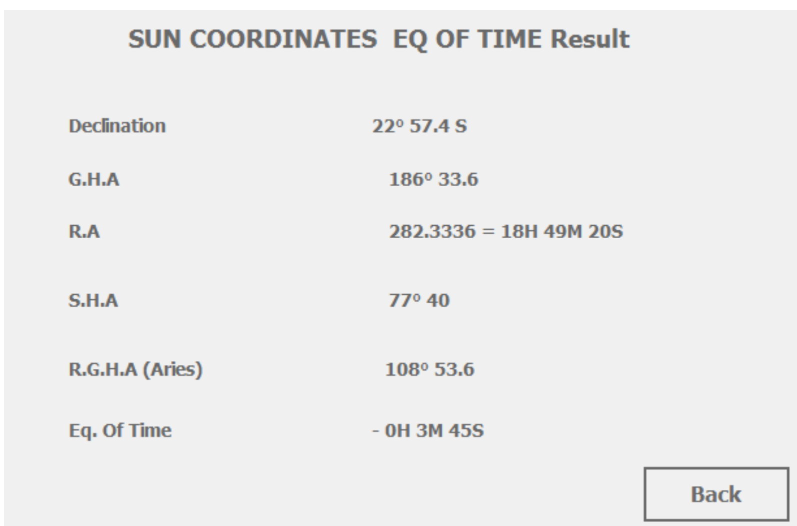
Application (1)



ANSWERS;

Dec. $_{sun}$	12° 21\`.5 N
GHA $_{sun}$	89° 09\`.3
Eq. of time	- 3m 22s
GHA γ	238° 48\`.0

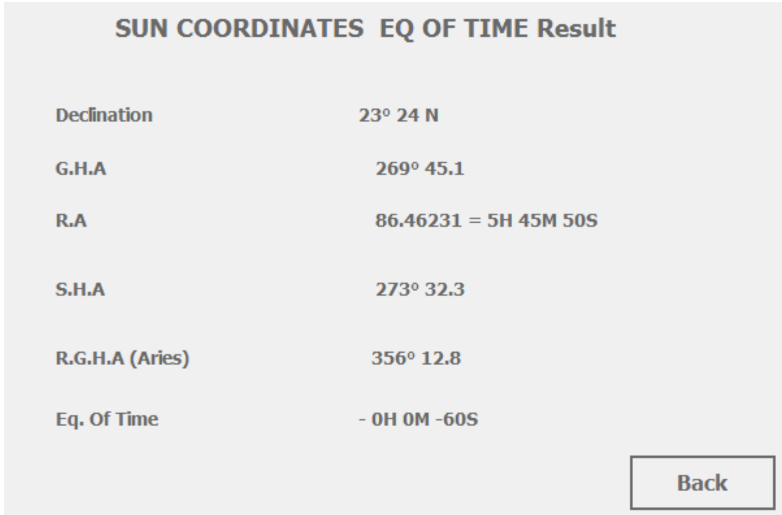
Application (2)



ANSWERS;

Dec. $_{sun}$	22° 57\`.4 S
GHA $_{sun}$	186° 33\`.6
Eq. of time	- 3m 45s
GHA γ	108° 53\`.6

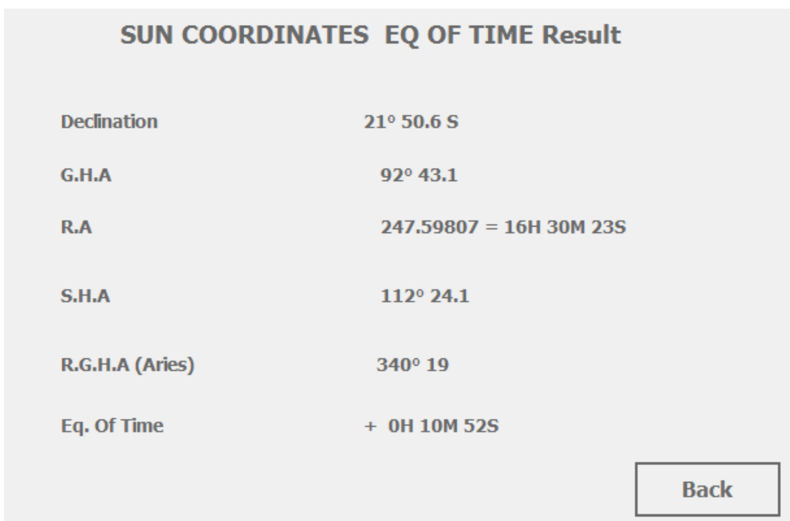
Application (3)



ANSWERS;

Dec. $_{sun}$	23° 24`.0 N
GHA $_{sun}$	269° 45`.1
Eq. of time	- 0m 60s
GHA γ	356° 12`.8

Application (4)



ANSWERS;

Dec. $_{sun}$	21° 50`.6 S
GHA $_{sun}$	92° 43`.1
Eq. of time	+ 10m 52s
GHA γ	340° 19`.0

xC

UT (GMT) d h	ARIES G.H.A. ° ′	VENUS −4.5 G.H.A. ° ′	VENUS Dec. ° ′	MARS +1.5 G.H.A. ° ′	MARS Dec. ° ′	JUPITER −2.7 G.H.A. ° ′	JUPITER Dec. ° ′	SATURN +0.5 G.H.A. ° ′	SATURN Dec. ° ′
1 00	100 23.2	152 11.4	S16 59.0	212 24.3	S21 55.6	4 42.6	N23 13.3	173 29.9	S22 14.3
01	115 25.7	167 14.3	58.4	227 24.9	55.9	19 45.4	13.3	188 32.1	14.3
02	130 28.1	182 17.2	57.9	242 25.5	56.2	34 48.2	13.3	203 34.2	14.2
03	145 30.6	197 20.1	· · 57.4	257 26.1	· · 56.5	49 51.0	· · 13.3	218 36.4	· · 14.2
04	160 33.0	212 23.0	56.9	272 26.7	56.8	64 53.9	13.4	233 38.5	14.2
05	175 35.5	227 26.0	56.4	287 27.3	57.1	79 56.7	13.4	248 40.7	14.2
06	190 38.0	242 28.9	S16 55.8	302 27.9	S21 57.4	94 59.5	N23 13.4	263 42.8	S22 14.1
07	205 40.4	257 31.8	55.3	317 28.5	57.7	110 02.4	13.4	278 45.0	14.1
08	220 42.9	272 34.7	54.8	332 29.0	57.9	125 05.2	13.4	293 47.1	14.1
M 09	235 45.4	287 37.7	· · 54.3	347 29.6	· · 58.2	140 08.0	· · 13.5	308 49.3	· · 14.0
O 10	250 47.8	302 40.6	53.8	2 30.2	58.5	155 10.8	13.5	323 51.4	14.0
N 11	265 50.3	317 43.6	53.3	17 30.8	58.8	170 13.7	13.5	338 53.6	14.0
D 12	280 52.8	332 46.5	S16 52.7	32 31.4	S21 59.1	185 16.5	N23 13.5	353 55.7	S22 13.9
A 13	295 55.2	347 49.5	52.2	47 32.0	59.4	200 19.3	13.5	8 57.8	13.9
Y 14	310 57.7	2 52.4	51.7	62 32.6	59.7	215 22.2	13.5	24 00.0	13.9
15	326 00.2	17 55.4	· · 51.2	77 33.2	21 59.9	230 25.0	· · 13.6	39 02.1	· · 13.8
16	341 02.6	32 58.4	50.7	92 33.8	22 00.2	245 27.8	13.6	54 04.3	13.8
17	356 05.1	48 01.3	50.2	107 34.4	00.5	260 30.7	13.6	69 06.4	13.8
18	11 07.5	63 04.3	S16 49.7	122 35.0	S22 00.8	275 33.5	N23 13.6	84 08.6	S22 13.7
19	26 10.0	78 07.3	49.1	137 35.6	01.1	290 36.3	13.6	99 10.7	13.7
20	41 12.5	93 10.3	48.6	152 36.1	01.4	305 39.1	13.7	114 12.9	13.7
21	56 14.9	108 13.3	· · 48.1	167 36.7	· · 01.6	320 42.0	· · 13.7	129 15.0	· · 13.7
22	71 17.4	123 16.3	47.6	182 37.3	01.9	335 44.8	13.7	144 17.2	13.6
23	86 19.9	138 19.3	47.1	197 37.9	02.2	350 47.6	13.7	159 19.3	13.6
2 00	101 22.3	153 22.3	S16 46.6	212 38.5	S22 02.5	5 50.5	N23 13.7	174 21.5	S22 13.6
01	116 24.8	168 25.3	46.1	227 39.1	02.8	20 53.3	13.8	189 23.6	13.5
02	131 27.3	183 28.3	45.6	242 39.7	03.0	35 56.1	13.8	204 25.7	13.5
03	146 29.7	198 31.3	· · 45.1	257 40.3	· · 03.3	50 58.9	· · 13.8	219 27.9	· · 13.5
04	161 32.2	213 34.3	44.6	272 40.9	03.6	66 01.8	13.8	234 30.0	13.4
05	176 34.7	228 37.3	44.1	287 41.4	03.9	81 04.6	13.8	249 32.2	13.4
06	191 37.1	243 40.4	S16 43.6	302 42.0	S22 04.2	96 07.4	N23 13.9	264 34.3	S22 13.4
07	206 39.6	258 43.4	43.1	317 42.6	04.4	111 10.2	13.9	279 36.5	13.3
T 08	221 42.0	273 46.5	42.6	332 43.2	04.7	126 13.1	13.9	294 38.6	13.3
U 09	236 44.5	288 49.5	· · 42.1	347 43.8	· · 05.0	141 15.9	· · 13.9	309 40.8	· · 13.3
E 10	251 47.0	303 52.5	41.5	2 44.4	05.3	156 18.7	13.9	324 42.9	13.2
S 11	266 49.4	318 55.6	41.0	17 45.0	05.6	171 21.6	13.9	339 45.1	13.2
D 12	281 51.9	333 58.7	S16 40.5	32 45.6	S22 05.8	186 24.4	N23 14.0	354 47.2	S22 13.2
A 13	296 54.4	349 01.7	40.0	47 46.1	06.1	201 27.2	14.0	9 49.4	13.1
Y 14	311 56.8	4 04.8	39.5	62 46.7	06.4	216 30.0	14.0	24 51.5	13.1
15	326 59.3	19 07.9	· · 39.1	77 47.3	· · 06.7	231 32.9	· · 14.0	39 53.6	· · 13.1
16	342 01.8	34 10.9	38.6	92 47.9	06.9	246 35.7	14.0	54 55.8	13.1
17	357 04.2	49 14.0	38.1	107 48.5	07.2	261 38.5	14.1	69 57.9	13.0
18	12 06.7	64 17.1	S16 37.6	122 49.1	S22 07.5	276 41.4	N23 14.1	85 00.1	S22 13.0
19	27 09.1	79 20.2	37.1	137 49.7	07.8	291 44.2	14.1	100 02.2	13.0
20	42 11.6	94 23.3	36.6	152 50.3	08.0	306 47.0	14.1	115 04.4	12.9
21	57 14.1	109 26.4	· · 36.1	167 50.8	· · 08.3	321 49.8	· · 14.1	130 06.5	· · 12.9
22	72 16.5	124 29.5	35.6	182 51.4	08.6	336 52.7	14.2	145 08.7	12.9
23	87 19.0	139 32.6	35.1	197 52.0	08.9	351 55.5	14.2	160 10.8	12.8
3 00	102 21.5	154 35.7	S16 34.6	212 52.6	S22 09.1	6 58.3	N23 14.2	175 13.0	S22 12.8
01	117 23.9	169 38.8	34.1	227 53.2	09.4	22 01.1	14.2	190 15.1	12.8
02	132 26.4	184 41.9	33.6	242 53.8	09.7	37 04.0	14.2	205 17.3	12.7
03	147 28.9	199 45.1	· · 33.1	257 54.4	· · 10.0	52 06.8	· · 14.2	220 19.4	· · 12.7
04	162 31.3	214 48.2	32.6	272 54.9	10.2	67 09.6	14.3	235 21.6	12.7
05	177 33.8	229 51.3	32.1	287 55.5	10.5	82 12.4	14.3	250 23.7	12.6
06	192 36.3	244 54.5	S16 31.7	302 56.1	S22 10.8	97 15.3	N23 14.3	265 25.8	S22 12.6
W 07	207 38.7	259 57.6	31.2	317 56.7	11.0	112 18.1	14.3	280 28.0	12.6
E 08	222 41.2	275 00.7	30.7	332 57.3	11.3	127 20.9	14.3	295 30.1	12.5
D 09	237 43.6	290 03.9	· · 30.2	347 57.9	· · 11.6	142 23.8	· · 14.4	310 32.3	· · 12.5
N 10	252 46.1	305 07.0	29.7	2 58.4	11.9	157 26.6	14.4	325 34.4	12.5
E 11	267 48.6	320 10.2	29.2	17 59.0	12.1	172 29.4	14.4	340 36.6	12.5
S 12	282 51.0	335 13.4	S16 28.7	32 59.6	S22 12.4	187 32.2	N23 14.4	355 38.7	S22 12.4
D 13	297 53.5	350 16.5	28.3	48 00.2	12.7	202 35.1	14.4	10 40.9	12.4
A 14	312 56.0	5 19.7	27.8	63 00.8	12.9	217 37.9	14.4	25 43.0	12.4
Y 15	327 58.4	20 22.9	· · 27.3	78 01.4	· · 13.2	232 40.7	· · 14.5	40 45.2	· · 12.3
16	343 00.9	35 26.1	26.8	93 01.9	13.5	247 43.5	14.5	55 47.3	12.3
17	358 03.4	50 29.3	26.3	108 02.5	13.7	262 46.4	14.5	70 49.5	12.3
18	13 05.8	65 32.4	S16 25.9	123 03.1	S22 14.0	277 49.2	N23 14.5	85 51.6	S22 12.2
19	28 08.3	80 35.6	25.4	138 03.7	14.3	292 52.0	14.5	100 53.7	12.2
20	43 10.8	95 38.8	24.9	153 04.3	14.5	307 54.8	14.6	115 55.9	12.2
21	58 13.2	110 42.0	· · 24.4	168 04.8	· · 14.8	322 57.7	· · 14.6	130 58.0	· · 12.1
22	73 15.7	125 45.3	23.9	183 05.4	15.1	338 00.5	14.6	146 00.2	12.1
23	88 18.1	140 48.5	23.5	198 06.0	15.3	353 03.3	14.6	161 02.3	12.1
Mer. Pass.	h m 17 11.7	v 3.1	d 0.5	v 0.6	d 0.3	v 2.8	d 0.0	v 2.1	d 0.0

STARS

Name	S.H.A. ° ′	Dec. ° ′
Acamar	315 31.3	S40 20.7
Achernar	335 39.4	S57 17.4
Acrux	173 29.3	S63 02.4
Adhara	255 26.0	S28 57.4
Aldebaran	291 09.3	N16 29.5
Alioth	166 35.8	N56 00.4
Alkaid	153 12.7	N49 21.4
Al Na'ir	28 05.9	S47 00.8
Alnilam	276 03.9	S 1 12.4
Alphard	218 13.1	S 8 36.9
Alphecca	126 26.1	N26 44.6
Alpheratz	358 01.9	N29 02.3
Altair	62 25.7	N 8 50.4
Ankaa	353 32.9	S42 21.8
Antares	112 48.2	S26 24.7
Arcturus	146 11.9	N19 13.8
Atria	108 06.5	S69 00.6
Avior	234 24.8	S59 28.5
Bellatrix	278 50.6	N 6 20.6
Betelgeuse	271 20.0	N 7 24.4
Canopus	264 03.4	S52 41.3
Capella	281 00.1	N45 59.5
Deneb	49 44.0	N45 14.7
Denebola	182 51.4	N14 37.5
Diphda	349 13.5	S18 02.5
Dubhe	194 12.5	N61 48.0
Elnath	278 34.5	N28 36.1
Eltanin	90 54.9	N51 29.2
Enif	34 04.7	N 9 49.8
Fomalhaut	15 43.4	S29 40.7
Gacrux	172 20.8	S57 03.3
Gienah	176 10.4	S17 29.2
Hadar	149 13.5	S60 19.4
Hamal	328 20.6	N23 25.2
Kaus Aust.	84 07.5	S34 23.5
Kochab	137 19.5	N74 11.4
Markab	13 56.1	N15 09.2
Menkar	314 33.3	N 4 03.2
Menkent	148 28.6	S36 19.2
Miaplacidus	221 42.9	S69 40.4
Mirfak	309 05.4	N49 49.9
Nunki	76 20.5	S26 18.7
Peacock	53 47.3	S56 46.2
Pollux	243 48.8	N28 03.1
Procyon	245 17.8	N 5 15.1
Rasalhague	96 23.1	N12 33.8
Regulus	208 02.0	N12 00.9
Rigel	281 28.7	S 8 12.7
Rigil Kent.	140 16.3	S60 47.5
Sabik	102 33.1	S15 42.9
Schedar	350 00.9	N56 29.3
Shaula	96 46.2	S37 05.9
Sirius	258 48.9	S16 42.1
Spica	158 49.9	S11 06.6
Suhail	223 05.1	S43 23.4
Vega	80 51.3	N38 46.3
Zuben'ubi	137 25.2	S16 00.1

	S.H.A. ° ′	Mer. Pass. h m
Venus	51 59.9	13 44
Mars	111 16.2	9 49
Jupiter	264 28.1	23 32
Saturn	72 59.1	12 21

Day	UT (GMT) d h	SUN G.H.A. ° ′	SUN Dec. ° ′	MOON G.H.A. ° ′	MOON v ′	MOON Dec. ° ′	MOON d ′	MOON H.P. ′
MONDAY	1 00	179 10.5	S23 02.5	131 54.3	12.4	S11 50.4	14.2	57.6
	01	194 10.2	02.3	146 25.7	12.4	11 36.2	14.3	57.6
	02	209 09.9	02.1	160 57.1	12.4	11 21.9	14.3	57.6
	03	224 09.6	.. 01.9	175 28.5	12.5	11 07.6	14.3	57.7
	04	239 09.3	01.7	190 00.0	12.6	10 53.3	14.5	57.7
	05	254 09.0	01.5	204 31.6	12.5	10 38.8	14.5	57.7
	06	269 08.7	S23 01.3	219 03.1	12.6	S10 24.3	14.5	57.7
	07	284 08.4	01.1	233 34.7	12.6	10 09.8	14.6	57.7
	08	299 08.1	00.9	248 06.3	12.7	9 55.2	14.7	57.7
	09	314 07.8	.. 00.7	262 38.0	12.6	9 40.5	14.7	57.8
	10	329 07.5	00.5	277 09.6	12.7	9 25.8	14.8	57.8
	11	344 07.2	00.3	291 41.3	12.8	9 11.0	14.8	57.8
	12	359 06.9	S23 00.1	306 13.1	12.7	S 8 56.2	14.9	57.8
	13	14 06.7	22 59.9	320 44.8	12.8	8 41.3	14.9	57.8
	14	29 06.4	59.7	335 16.6	12.8	8 26.4	15.0	57.9
	15	44 06.1	.. 59.5	349 48.4	12.8	8 11.4	15.0	57.9
	16	59 05.8	59.3	4 20.2	12.8	7 56.4	15.0	57.9
	17	74 05.5	59.1	18 52.0	12.9	7 41.4	15.2	57.9
	18	89 05.2	S22 58.9	33 23.9	12.9	S 7 26.2	15.1	57.9
	19	104 04.9	58.6	47 55.8	12.8	7 11.1	15.2	58.0
	20	119 04.6	58.4	62 27.6	12.9	6 55.9	15.2	58.0
	21	134 04.3	.. 58.2	76 59.5	13.0	6 40.7	15.3	58.0
	22	149 04.0	58.0	91 31.5	12.9	6 25.4	15.3	58.0
	23	164 03.7	57.8	106 03.4	12.9	6 10.1	15.4	58.0
TUESDAY	2 00	179 03.4	S22 57.6	120 35.3	13.0	S 5 54.7	15.4	58.0
	01	194 03.1	57.4	135 07.3	13.0	5 39.3	15.4	58.1
	02	209 02.8	57.1	149 39.3	12.9	5 23.9	15.5	58.1
	03	224 02.5	.. 56.9	164 11.2	13.0	5 08.4	15.5	58.1
	04	239 02.2	56.7	178 43.2	13.0	4 52.9	15.5	58.1
	05	254 01.9	56.5	193 15.2	13.0	4 37.4	15.5	58.1
	06	269 01.7	S22 56.3	207 47.2	13.0	S 4 21.9	15.6	58.2
	07	284 01.4	56.0	222 19.2	13.0	4 06.3	15.6	58.2
	08	299 01.1	55.8	236 51.2	13.0	3 50.7	15.7	58.2
	09	314 00.8	.. 55.6	251 23.2	13.0	3 35.0	15.6	58.2
	10	329 00.5	55.4	265 55.2	13.0	3 19.4	15.7	58.2
	11	344 00.2	55.1	280 27.2	13.0	3 03.7	15.7	58.2
	12	358 59.9	S22 54.9	294 59.2	13.0	S 2 48.0	15.8	58.3
	13	13 59.6	54.7	309 31.2	13.0	2 32.2	15.7	58.3
	14	28 59.3	54.5	324 03.2	13.0	2 16.5	15.8	58.3
	15	43 59.0	.. 54.2	338 35.2	13.0	2 00.7	15.8	58.3
	16	58 58.7	54.0	353 07.2	12.9	1 44.9	15.8	58.3
	17	73 58.4	53.8	7 39.1	13.0	1 29.1	15.8	58.4
	18	88 58.2	S22 53.6	22 11.1	12.9	S 1 13.3	15.9	58.4
	19	103 57.9	53.3	36 43.0	13.0	0 57.4	15.8	58.4
	20	118 57.6	53.1	51 15.0	12.9	0 41.6	15.9	58.4
	21	133 57.3	.. 52.9	65 46.9	12.9	0 25.7	15.9	58.4
	22	148 57.0	52.6	80 18.8	12.9	S 0 09.8	15.8	58.4
	23	163 56.7	52.4	94 50.7	12.9	N 0 06.0	15.9	58.5
WEDNESDAY	3 00	178 56.4	S22 52.2	109 22.6	12.9	N 0 21.9	15.9	58.5
	01	193 56.1	51.9	123 54.5	12.8	0 37.8	15.9	58.5
	02	208 55.8	51.7	138 26.3	12.8	0 53.7	16.0	58.5
	03	223 55.5	.. 51.4	152 58.1	12.8	1 09.7	15.9	58.5
	04	238 55.3	51.2	167 29.9	12.8	1 25.6	15.9	58.5
	05	253 55.0	51.0	182 01.7	12.7	1 41.5	15.9	58.6
	06	268 54.7	S22 50.7	196 33.4	12.8	N 1 57.4	15.9	58.6
	07	283 54.4	50.5	211 05.2	12.6	2 13.3	15.9	58.6
	08	298 54.1	50.2	225 36.8	12.7	2 29.2	15.9	58.6
	09	313 53.8	.. 50.0	240 08.5	12.6	2 45.1	16.0	58.6
	10	328 53.5	49.8	254 40.1	12.7	3 01.1	15.9	58.6
	11	343 53.2	49.5	269 11.8	12.5	3 17.0	15.8	58.7
	12	358 52.9	S22 49.3	283 43.3	12.6	N 3 32.8	15.9	58.7
	13	13 52.7	49.0	298 14.9	12.5	3 48.7	15.9	58.7
	14	28 52.4	48.8	312 46.4	12.4	4 04.6	15.9	58.7
	15	43 52.1	.. 48.5	327 17.8	12.4	4 20.5	15.8	58.7
	16	58 51.8	48.3	341 49.2	12.4	4 36.3	15.9	58.7
	17	73 51.5	48.0	356 20.6	12.4	4 52.2	15.8	58.8
	18	88 51.2	S22 47.8	10 52.0	12.3	N 5 08.0	15.8	58.8
	19	103 50.9	47.5	25 23.3	12.2	5 23.8	15.8	58.8
	20	118 50.7	47.3	39 54.5	12.2	5 39.6	15.7	58.8
	21	133 50.4	.. 47.0	54 25.7	12.2	5 55.3	15.8	58.8
	22	148 50.1	46.8	68 56.9	12.1	6 11.1	15.7	58.8
	23	163 49.8	46.5	83 28.0	12.1	6 26.8	15.7	58.9
		S.D. 16.3	d 0.2	S.D. 15.8		15.9		16.0

Lat. °	Twilight Naut. h m	Twilight Civil h m	Sunrise h m	Moonrise 1 h m	Moonrise 2 h m	Moonrise 3 h m	Moonrise 4 h m
N 72	08 23	10 40	▬	11 34	10 58	10 25	09 49
N 70	08 05	09 48	▬	11 20	10 54	10 29	10 03
68	07 49	09 16	▬	11 09	10 50	10 32	10 13
66	07 37	08 53	10 26	11 00	10 47	10 35	10 23
64	07 26	08 34	09 49	10 52	10 45	10 38	10 30
62	07 17	08 18	09 22	10 45	10 43	10 40	10 37
60	07 09	08 05	09 02	10 39	10 41	10 42	10 43
N 58	07 02	07 54	08 45	10 34	10 39	10 43	10 48
56	06 56	07 44	08 31	10 30	10 37	10 45	10 53
54	06 50	07 36	08 19	10 25	10 36	10 46	10 57
52	06 44	07 28	08 08	10 22	10 35	10 47	11 01
50	06 39	07 20	07 59	10 18	10 33	10 48	11 04
45	06 28	07 05	07 38	10 11	10 31	10 51	11 12
N 40	06 18	06 52	07 22	10 04	10 29	10 53	11 18
35	06 09	06 40	07 08	09 59	10 27	10 55	11 24
30	06 00	06 30	06 56	09 54	10 25	10 56	11 29
20	05 44	06 12	06 35	09 45	10 22	10 59	11 37
N 10	05 28	05 55	06 17	09 38	10 20	11 02	11 45
0	05 12	05 38	06 00	09 31	10 17	11 04	11 52
S 10	04 53	05 20	05 43	09 24	10 15	11 06	11 59
20	04 31	05 00	05 25	09 16	10 13	11 09	12 07
30	04 02	04 36	05 03	09 08	10 10	11 12	12 16
35	03 44	04 21	04 50	09 03	10 08	11 14	12 21
40	03 22	04 03	04 36	08 57	10 06	11 16	12 27
45	02 52	03 41	04 18	08 51	10 04	11 18	12 34
S 50	02 08	03 12	03 56	08 43	10 01	11 21	12 42
52	01 42	02 58	03 46	08 39	10 00	11 22	12 46
54	01 03	02 40	03 34	08 35	09 59	11 24	12 51
56	////	02 19	03 20	08 30	09 57	11 25	12 55
58	////	01 51	03 04	08 25	09 56	11 27	13 01
S 60	////	01 08	02 44	08 19	09 54	11 29	13 07

Lat. °	Sunset h m	Twilight Civil h m	Twilight Naut. h m	Moonset 1 h m	Moonset 2 h m	Moonset 3 h m	Moonset 4 h m
N 72	▬	13 28	15 45	20 22	22 38	24 56	00 56
N 70	▬	14 20	16 04	20 33	22 38	24 45	00 45
68	▬	14 52	16 19	20 42	22 38	24 37	00 37
66	13 42	15 16	16 31	20 49	22 39	24 30	00 30
64	14 20	15 34	16 42	20 55	22 39	24 24	00 24
62	14 46	15 50	16 51	21 00	22 39	24 19	00 19
60	15 06	16 03	16 59	21 04	22 39	24 15	00 15
N 58	15 23	16 14	17 06	21 08	22 39	24 11	00 11
56	15 37	16 24	17 13	21 12	22 39	24 08	00 08
54	15 49	16 33	17 19	21 15	22 39	24 05	00 05
52	16 00	16 41	17 24	21 18	22 39	24 02	00 02
50	16 10	16 48	17 29	21 20	22 39	23 59	25 22
45	16 30	17 03	17 40	21 26	22 39	23 54	25 11
N 40	16 46	17 16	17 50	21 30	22 39	23 49	25 02
35	17 00	17 28	17 59	21 34	22 39	23 46	24 54
30	17 12	17 38	18 08	21 37	22 39	23 42	24 47
20	17 33	17 57	18 24	21 43	22 39	23 36	24 35
N 10	17 51	18 13	18 40	21 48	22 39	23 31	24 25
0	18 08	18 30	18 56	21 53	22 39	23 26	24 15
S 10	18 25	18 48	19 15	21 58	22 39	23 22	24 06
20	18 43	19 08	19 37	22 03	22 39	23 16	23 56
30	19 05	19 32	20 05	22 08	22 39	23 11	23 44
35	19 18	19 47	20 23	22 12	22 39	23 07	23 38
40	19 32	20 05	20 46	22 15	22 39	23 04	23 30
45	19 50	20 27	21 15	22 19	22 39	22 59	23 21
S 50	20 12	20 55	21 59	22 24	22 39	22 54	23 11
52	20 22	21 10	22 24	22 26	22 39	22 52	23 06
54	20 34	21 27	23 03	22 29	22 39	22 49	23 01
56	20 48	21 48	////	22 31	22 39	22 46	22 55
58	21 04	22 15	////	22 34	22 39	22 43	22 49
S 60	21 23	22 57	////	22 38	22 39	22 40	22 41

Day	SUN Eqn. of Time 00 h (m s)	SUN Eqn. of Time 12 h (m s)	SUN Mer. Pass. (h m)	MOON Mer. Pass. Upper (h m)	MOON Mer. Pass. Lower (h m)	MOON Age (d)	MOON Phase
1	03 17	03 32	12 04	15 42	03 19	04	
2	03 46	04 00	12 04	16 28	04 05	05	
3	04 14	04 28	12 04	17 15	04 52	06	

UT (GMT) d h	ARIES G.H.A.	VENUS −4.6 G.H.A.	Dec.	MARS +1.3 G.H.A.	Dec.	JUPITER −2.5 G.H.A.	Dec.	SATURN +0.6 G.H.A.	Dec.
15 00	144 44.5	212 18.5	S15 04.6	221 45.9	S23 28.8	53 41.1	N23 25.7	212 21.1	S21 36.0
01	159 46.9	227 20.3	04.7	236 46.4	28.7	68 43.7	25.7	227 23.2	36.0
02	174 49.4	242 22.1	04.9	251 46.8	28.5	83 46.2	25.7	242 25.4	35.9
03	189 51.8	257 23.9	05.0	266 47.3	28.4	98 48.8	25.7	257 27.6	35.9
04	204 54.3	272 25.6	05.2	281 47.8	28.3	113 51.3	25.7	272 29.8	35.8
05	219 56.8	287 27.4	05.3	296 48.3	28.1	128 53.9	25.7	287 32.0	35.8
06	234 59.2	302 29.2	S15 05.5	311 48.8	S23 28.0	143 56.4	N23 25.7	302 34.2	S21 35.8
07	250 01.7	317 30.9	05.6	326 49.3	27.9	158 59.0	25.7	317 36.4	35.7
T 08	265 04.2	332 32.7	05.8	341 49.7	27.7	174 01.5	25.8	332 38.6	35.7
H 09	280 06.6	347 34.4	05.9	356 50.2	27.6	189 04.1	25.8	347 40.8	35.7
U 10	295 09.1	2 36.2	06.0	11 50.7	27.5	204 06.6	25.8	2 42.9	35.6
R 11	310 11.6	17 37.9	06.2	26 51.2	27.3	219 09.2	25.8	17 45.1	35.6
S 12	325 14.0	32 39.7	S15 06.3	41 51.7	S23 27.2	234 11.7	N23 25.8	32 47.3	S21 35.6
D 13	340 16.5	47 41.4	06.5	56 52.2	27.1	249 14.3	25.8	47 49.5	35.5
A 14	355 18.9	62 43.2	06.6	71 52.6	26.9	264 16.8	25.8	62 51.7	35.5
Y 15	10 21.4	77 44.9	06.8	86 53.1	26.8	279 19.4	25.8	77 53.9	35.4
16	25 23.9	92 46.6	06.9	101 53.6	26.7	294 21.9	25.8	92 56.1	35.4
17	40 26.3	107 48.4	07.0	116 54.1	26.5	309 24.5	25.8	107 58.3	35.4
18	55 28.8	122 50.1	S15 07.2	131 54.6	S23 26.4	324 27.0	N23 25.8	123 00.4	S21 35.3
19	70 31.3	137 51.8	07.3	146 55.1	26.3	339 29.6	25.8	138 02.6	35.3
20	85 33.7	152 53.5	07.5	161 55.5	26.1	354 32.1	25.8	153 04.8	35.3
21	100 36.2	167 55.2	07.6	176 56.0	26.0	9 34.7	25.8	168 07.0	35.2
22	115 38.7	182 56.9	07.8	191 56.5	25.8	24 37.2	25.8	183 09.2	35.2
23	130 41.1	197 58.6	07.9	206 57.0	25.7	39 39.7	25.8	198 11.4	35.1
16 00	145 43.6	213 00.3	S15 08.0	221 57.5	S23 25.6	54 42.3	N23 25.8	213 13.6	S21 35.1
01	160 46.1	228 02.0	08.2	236 57.9	25.4	69 44.8	25.9	228 15.8	35.1
02	175 48.5	243 03.7	08.3	251 58.4	25.3	84 47.4	25.9	243 18.0	35.0
03	190 51.0	258 05.4	08.5	266 58.9	25.1	99 49.9	25.9	258 20.2	35.0
04	205 53.4	273 07.1	08.6	281 59.4	25.0	114 52.5	25.9	273 22.3	35.0
05	220 55.9	288 08.8	08.7	296 59.9	24.9	129 55.0	25.9	288 24.5	34.9
06	235 58.4	303 10.5	S15 08.9	312 00.4	S23 24.7	144 57.5	N23 25.9	303 26.7	S21 34.9
07	251 00.8	318 12.1	09.0	327 00.8	24.6	160 00.1	25.9	318 28.9	34.9
08	266 03.3	333 13.8	09.2	342 01.3	24.4	175 02.6	25.9	333 31.1	34.8
F 09	281 05.8	348 15.5	09.3	357 01.8	24.3	190 05.2	25.9	348 33.3	34.8
R 10	296 08.2	3 17.2	09.4	12 02.3	24.1	205 07.7	25.9	3 35.5	34.7
I 11	311 10.7	18 18.8	09.6	27 02.8	24.0	220 10.2	25.9	18 37.7	34.7
D 12	326 13.2	33 20.5	S15 09.7	42 03.3	S23 23.8	235 12.8	N23 25.9	33 39.9	S21 34.7
A 13	341 15.6	48 22.1	09.8	57 03.7	23.7	250 15.3	25.9	48 42.1	34.6
Y 14	356 18.1	63 23.8	10.0	72 04.2	23.6	265 17.9	25.9	63 44.2	34.6
15	11 20.6	78 25.4	10.1	87 04.7	23.4	280 20.4	25.9	78 46.4	34.6
16	26 23.0	93 27.1	10.3	102 05.2	23.3	295 22.9	25.9	93 48.6	34.5
17	41 25.5	108 28.7	10.4	117 05.7	23.1	310 25.5	25.9	108 50.8	34.5
18	56 27.9	123 30.3	S15 10.5	132 06.2	S23 23.0	325 28.0	N23 26.0	123 53.0	S21 34.4
19	71 30.4	138 32.0	10.7	147 06.6	22.8	340 30.6	26.0	138 55.2	34.4
20	86 32.9	153 33.6	10.8	162 07.1	22.7	355 33.1	26.0	153 57.4	34.4
21	101 35.3	168 35.2	10.9	177 07.6	22.5	10 35.6	26.0	168 59.6	34.3
22	116 37.8	183 36.8	11.1	192 08.1	22.4	25 38.2	26.0	184 01.8	34.3
23	131 40.3	198 38.5	11.2	207 08.6	22.2	40 40.7	26.0	199 04.0	34.3
17 00	146 42.7	213 40.1	S15 11.3	222 09.1	S23 22.1	55 43.2	N23 26.0	214 06.2	S21 34.2
01	161 45.2	228 41.7	11.5	237 09.5	21.9	70 45.8	26.0	229 08.3	34.2
02	176 47.7	243 43.3	11.6	252 10.0	21.8	85 48.3	26.0	244 10.5	34.2
03	191 50.1	258 44.9	11.8	267 10.5	21.6	100 50.8	26.0	259 12.7	34.1
04	206 52.6	273 46.5	11.9	282 11.0	21.5	115 53.4	26.0	274 14.9	34.1
05	221 55.0	288 48.1	12.0	297 11.5	21.3	130 55.9	26.0	289 17.1	34.0
06	236 57.5	303 49.7	S15 12.2	312 12.0	S23 21.2	145 58.4	N23 26.0	304 19.3	S21 34.0
07	252 00.0	318 51.3	12.3	327 12.4	21.0	161 01.0	26.0	319 21.5	34.0
S 08	267 02.4	333 52.9	12.4	342 12.9	20.9	176 03.5	26.0	334 23.7	33.9
A 09	282 04.9	348 54.4	12.6	357 13.4	20.7	191 06.0	26.0	349 25.9	33.9
T 10	297 07.4	3 56.0	12.7	12 13.9	20.6	206 08.6	26.0	4 28.1	33.9
U 11	312 09.8	18 57.6	12.8	27 14.4	20.4	221 11.1	26.1	19 30.3	33.8
R 12	327 12.3	33 59.2	S15 13.0	42 14.9	S23 20.3	236 13.6	N23 26.1	34 32.5	S21 33.8
D 13	342 14.8	49 00.7	13.1	57 15.3	20.1	251 16.2	26.1	49 34.7	33.8
A 14	357 17.2	64 02.3	13.2	72 15.8	19.9	266 18.7	26.1	64 36.8	33.7
Y 15	12 19.7	79 03.9	13.3	87 16.3	19.8	281 21.2	26.1	79 39.0	33.7
16	27 22.2	94 05.4	13.5	102 16.8	19.6	296 23.7	26.1	94 41.2	33.6
17	42 24.6	109 07.0	13.6	117 17.3	19.5	311 26.3	26.1	109 43.4	33.6
18	57 27.1	124 08.5	S15 13.7	132 17.8	S23 19.3	326 28.8	N23 26.1	124 45.6	S21 33.6
19	72 29.5	139 10.1	13.9	147 18.2	19.2	341 31.3	26.1	139 47.8	33.5
20	87 32.0	154 11.6	14.0	162 18.7	19.0	356 33.9	26.1	154 50.0	33.5
21	102 34.5	169 13.2	14.1	177 19.2	18.8	11 36.4	26.1	169 52.2	33.5
22	117 36.9	184 14.7	14.3	192 19.7	18.7	26 38.9	26.1	184 54.4	33.4
23	132 39.4	199 16.2	14.4	207 20.2	18.5	41 41.4	26.1	199 56.6	33.4
Mer. Pass.	24 h 14.8 m	v 1.7	d 0.1	v 0.5	d 0.1	v 2.5	d 0.0	v 2.2	d 0.0

STARS

Name	S.H.A.	Dec.
Acamar	315 31.6	S40 20.8
Achernar	335 39.8	S57 17.4
Acrux	173 28.7	S63 02.6
Adhara	255 26.0	S28 57.6
Aldebaran	291 09.4	N16 29.5
Alioth	166 35.3	N56 00.4
Alkaid	153 12.2	N49 21.3
Al Na'ir	28 05.9	S47 00.6
Alnilam	276 04.0	S 1 12.5
Alphard	218 13.0	S 8 37.0
Alphecca	126 25.7	N26 44.5
Alpheratz	358 02.0	N29 02.2
Altair	62 25.6	N 8 50.3
Ankaa	353 33.1	S42 21.7
Antares	112 47.9	S26 24.7
Arcturus	146 11.5	N19 13.7
Atria	108 05.7	S69 00.5
Avior	234 24.7	S59 28.8
Bellatrix	278 50.6	N 6 20.5
Betelgeuse	271 20.1	N 7 24.4
Canopus	264 03.6	S52 41.6
Capella	281 00.2	N45 59.6
Deneb	49 44.0	N45 14.5
Denebola	182 51.1	N14 37.4
Diphda	349 13.6	S18 02.5
Dubhe	194 12.0	N61 48.1
Elnath	278 34.6	N28 36.1
Eltanin	90 54.6	N51 29.0
Enif	34 04.6	N 9 49.7
Fomalhaut	15 43.5	S29 40.6
Gacrux	172 20.3	S57 03.5
Gienah	176 10.1	S17 29.4
Hadar	149 12.8	S60 19.5
Hamal	328 20.7	N23 25.1
Kaus Aust.	84 07.2	S34 23.5
Kochab	137 18.6	N74 11.3
Markab	13 56.1	N15 09.1
Menkar	314 33.4	N 4 03.1
Menkent	148 28.2	S36 19.4
Miaplacidus	221 42.8	S69 40.7
Mirfak	309 05.6	N49 49.9
Nunki	76 20.2	S26 18.7
Peacock	53 47.1	S56 46.1
Pollux	243 48.7	N28 03.1
Procyon	245 17.7	N 5 15.0
Rasalhague	96 22.8	N12 33.7
Regulus	208 01.7	N12 00.8
Rigel	281 28.7	S 8 12.8
Rigil Kent.	140 15.7	S60 47.6
Sabik	102 32.7	S15 43.0
Schedar	350 01.2	N56 29.2
Shaula	96 45.9	S37 05.9
Sirius	258 48.9	S16 42.2
Spica	158 49.6	S11 06.8
Suhail	223 05.0	S43 23.6
Vega	80 51.1	N38 46.1
Zuben'ubi	137 24.8	S16 00.2

	S.H.A.	Mer. Pass.
Venus	67 16.8	9 47
Mars	76 13.9	9 12
Jupiter	268 58.7	20 18
Saturn	67 30.0	9 46

UT (GMT) d h	SUN G.H.A. ° ′	SUN Dec. ° ′	MOON G.H.A. ° ′	v ′	Dec. ° ′	d ′	H.P. ′
15 00	176 27.3	S12 50.5	302 44.5	15.2	S14 32.1	11.9	54.4
01	191 27.4	49.6	317 18.7	15.1	14 44.0	11.9	54.4
02	206 27.4	48.7	331 52.8	15.1	14 55.9	11.8	54.4
03	221 27.4	.. 47.9	346 26.9	15.1	15 07.7	11.7	54.4
04	236 27.5	47.0	1 01.0	15.0	15 19.4	11.7	54.4
05	251 27.5	46.2	15 35.0	15.0	15 31.1	11.6	54.4
06	266 27.5	S12 45.3	30 09.0	15.0	S15 42.7	11.5	54.3
07	281 27.5	44.5	44 43.0	14.9	15 54.2	11.4	54.3
T 08	296 27.6	43.6	59 16.9	14.8	16 05.6	11.4	54.3
H 09	311 27.6	.. 42.8	73 50.7	14.9	16 17.0	11.3	54.3
U 10	326 27.6	41.9	88 24.6	14.7	16 28.3	11.3	54.3
R 11	341 27.7	41.0	102 58.3	14.8	16 39.6	11.2	54.3
S 12	356 27.7	S12 40.2	117 32.1	14.6	S16 50.8	11.1	54.3
D 13	11 27.7	39.3	132 05.7	14.7	17 01.9	11.0	54.3
A 14	26 27.8	38.5	146 39.4	14.6	17 12.9	11.0	54.3
Y 15	41 27.8	.. 37.6	161 13.0	14.5	17 23.9	10.9	54.3
16	56 27.8	36.7	175 46.5	14.5	17 34.8	10.8	54.3
17	71 27.9	35.9	190 20.0	14.4	17 45.6	10.8	54.3
18	86 27.9	S12 35.0	204 53.4	14.4	S17 56.4	10.7	54.3
19	101 27.9	34.2	219 26.8	14.3	18 07.1	10.6	54.3
20	116 28.0	33.3	234 00.1	14.3	18 17.7	10.5	54.3
21	131 28.0	.. 32.4	248 33.4	14.2	18 28.2	10.4	54.2
22	146 28.0	31.6	263 06.6	14.2	18 38.6	10.4	54.2
23	161 28.1	30.7	277 39.8	14.1	18 49.0	10.3	54.2
16 00	176 28.1	S12 29.8	292 12.9	14.1	S18 59.3	10.2	54.2
01	191 28.1	29.0	306 46.0	14.0	19 09.5	10.1	54.2
02	206 28.2	28.1	321 19.0	14.0	19 19.6	10.1	54.2
03	221 28.2	.. 27.3	335 52.0	13.9	19 29.7	9.9	54.2
04	236 28.2	26.4	350 24.9	13.8	19 39.6	9.9	54.2
05	251 28.3	25.5	4 57.7	13.8	19 49.5	9.8	54.2
06	266 28.3	S12 24.7	19 30.5	13.7	S19 59.3	9.7	54.2
07	281 28.3	23.8	34 03.2	13.7	20 09.0	9.7	54.2
08	296 28.4	22.9	48 35.9	13.6	20 18.7	9.5	54.2
F 09	311 28.4	.. 22.1	63 08.5	13.6	20 28.2	9.5	54.2
R 10	326 28.5	21.2	77 41.1	13.4	20 37.7	9.4	54.2
I 11	341 28.5	20.3	92 13.5	13.5	20 47.1	9.2	54.2
D 12	356 28.5	S12 19.5	106 46.0	13.4	S20 56.3	9.2	54.2
A 13	11 28.6	18.6	121 18.4	13.3	21 05.5	9.2	54.2
Y 14	26 28.6	17.7	135 50.7	13.2	21 14.7	9.0	54.2
15	41 28.7	.. 16.9	150 22.9	13.2	21 23.7	8.9	54.2
16	56 28.7	16.0	164 55.1	13.1	21 32.6	8.8	54.2
17	71 28.7	15.1	179 27.2	13.1	21 41.4	8.8	54.2
18	86 28.8	S12 14.3	193 59.3	13.0	S21 50.2	8.6	54.2
19	101 28.8	13.4	208 31.3	13.0	21 58.8	8.6	54.2
20	116 28.9	12.5	223 03.3	12.8	22 07.4	8.5	54.2
21	131 28.9	.. 11.6	237 35.1	12.9	22 15.9	8.3	54.2
22	146 28.9	10.8	252 07.0	12.7	22 24.2	8.3	54.2
23	161 29.0	09.9	266 38.7	12.7	22 32.5	8.2	54.2
17 00	176 29.0	S12 09.0	281 10.4	12.6	S22 40.7	8.1	54.2
01	191 29.1	08.2	295 42.0	12.6	22 48.8	8.0	54.2
02	206 29.1	07.3	310 13.6	12.5	22 56.8	7.8	54.2
03	221 29.1	.. 06.4	324 45.1	12.4	23 04.6	7.8	54.2
04	236 29.2	05.5	339 16.5	12.4	23 12.4	7.7	54.2
05	251 29.2	04.7	353 47.9	12.3	23 20.1	7.6	54.2
06	266 29.3	S12 03.8	8 19.2	12.2	S23 27.7	7.5	54.3
07	281 29.3	02.9	22 50.4	12.2	23 35.2	7.4	54.3
S 08	296 29.4	02.1	37 21.6	12.1	23 42.6	7.2	54.3
A 09	311 29.4	.. 01.2	51 52.7	12.1	23 49.8	7.2	54.3
T 10	326 29.5	12 00.3	66 23.8	11.9	23 57.0	7.1	54.3
U 11	341 29.5	11 59.4	80 54.7	12.0	24 04.1	6.9	54.3
R 12	356 29.5	S11 58.6	95 25.7	11.8	S24 11.0	6.9	54.3
D 13	11 29.6	57.7	109 56.5	11.8	24 17.9	6.7	54.3
A 14	26 29.6	56.8	124 27.3	11.7	24 24.6	6.7	54.3
Y 15	41 29.7	.. 55.9	138 58.0	11.7	24 31.3	6.5	54.3
16	56 29.7	55.0	153 28.7	11.6	24 37.8	6.4	54.3
17	71 29.8	54.2	167 59.3	11.5	24 44.2	6.3	54.3
18	86 29.8	S11 53.3	182 29.8	11.5	S24 50.5	6.2	54.3
19	101 29.9	52.4	197 00.3	11.4	24 56.7	6.1	54.3
20	116 29.9	51.5	211 30.7	11.3	25 02.8	6.0	54.4
21	131 30.0	.. 50.7	226 01.0	11.3	25 08.8	5.8	54.4
22	146 30.0	49.8	240 31.3	11.2	25 14.6	5.8	54.4
23	161 30.1	48.9	255 01.5	11.1	25 20.4	5.6	54.4
	S.D. 16.2	d 0.9	S.D. 14.8		14.8		14.8

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

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

Day	SUN Eqn. of Time 00ʰ m s	SUN Eqn. of Time 12ʰ m s	SUN Mer. Pass. h m	MOON Mer. Pass. Upper h m	MOON Mer. Pass. Lower h m	Age d	Phase
15	14 11	14 09	12 14	03 56	16 17	20	
16	14 08	14 06	12 14	04 40	17 02	21	
17	14 04	14 02	12 14	05 26	17 50	22	

UT (GMT) d h	ARIES G.H.A.	VENUS −4.4 G.H.A.	Dec.	MARS +1.0 G.H.A.	Dec.	JUPITER −2.2 G.H.A.	Dec.	SATURN +0.6 G.H.A.	Dec.
1 00 Sunday	189 05.7	222 41.3	S12 06.7	231 09.2	S17 26.0	96 05.2	N23 29.4	252 48.9	S21 02.5
01	204 08.2	237 41.2	06.1	246 09.8	25.5	111 07.4	29.4	267 51.2	02.5
02	219 10.6	252 41.2	05.5	261 10.4	25.0	126 09.6	29.4	282 53.5	02.4
03	234 13.1	267 41.2	· · 04.9	276 11.0	· · 24.4	141 11.7	· · 29.4	297 55.9	· · 02.4
04	249 15.6	282 41.2	04.3	291 11.5	23.9	156 13.9	29.4	312 58.2	02.4
05	264 18.0	297 41.1	03.8	306 12.1	23.4	171 16.1	29.4	328 00.5	02.4
06	279 20.5	312 41.1	S12 03.2	321 12.7	S17 22.9	186 18.3	N23 29.4	343 02.8	S21 02.4
07	294 23.0	327 41.1	02.6	336 13.3	22.4	201 20.4	29.4	358 05.1	02.3
08	309 25.4	342 41.0	02.0	351 13.9	21.8	216 22.6	29.3	13 07.5	02.3
09	324 27.9	357 41.0	· · 01.5	6 14.5	· · 21.3	231 24.8	· · 29.3	28 09.8	· · 02.3
10	339 30.3	12 41.0	00.9	21 15.1	20.8	246 26.9	29.3	43 12.1	02.3
11	354 32.8	27 40.9	12 00.3	36 15.7	20.3	261 29.1	29.3	58 14.4	02.3
12	9 35.3	42 40.9	S11 59.7	51 16.3	S17 19.7	276 31.3	N23 29.3	73 16.8	S21 02.2
13	24 37.7	57 40.9	59.1	66 16.8	19.2	291 33.5	29.3	88 19.1	02.2
14	39 40.2	72 40.8	58.5	81 17.4	18.7	306 35.6	29.3	103 21.4	02.2
15	54 42.7	87 40.8	· · 57.9	96 18.0	· · 18.2	321 37.8	· · 29.3	118 23.7	· · 02.2
16	69 45.1	102 40.8	57.4	111 18.6	17.7	336 40.0	29.3	133 26.1	02.2
17	84 47.6	117 40.7	56.8	126 19.2	17.1	351 42.1	29.3	148 28.4	02.1
18	99 50.1	132 40.7	S11 56.2	141 19.8	S17 16.6	6 44.3	N23 29.3	163 30.7	S21 02.1
19	114 52.5	147 40.7	55.6	156 20.4	16.1	21 46.5	29.3	178 33.0	02.1
20	129 55.0	162 40.6	55.0	171 21.0	15.6	36 48.7	29.3	193 35.4	02.1
21	144 57.5	177 40.6	· · 54.4	186 21.6	· · 15.0	51 50.8	· · 29.3	208 37.7	· · 02.0
22	159 59.9	192 40.6	53.8	201 22.2	14.5	66 53.0	29.3	223 40.0	02.0
23	175 02.4	207 40.5	53.2	216 22.7	14.0	81 55.2	29.3	238 42.3	02.0
2 00 Monday	190 04.8	222 40.5	S11 52.6	231 23.3	S17 13.5	96 57.3	N23 29.3	253 44.7	S21 02.0
01	205 07.3	237 40.4	52.1	246 23.9	12.9	111 59.5	29.3	268 47.0	02.0
02	220 09.8	252 40.4	51.5	261 24.5	12.4	127 01.7	29.3	283 49.3	01.9
03	235 12.2	267 40.4	· · 50.9	276 25.1	· · 11.9	142 03.8	· · 29.3	298 51.6	· · 01.9
04	250 14.7	282 40.3	50.3	291 25.7	11.4	157 06.0	29.3	313 54.0	01.9
05	265 17.2	297 40.3	49.7	306 26.3	10.8	172 08.2	29.3	328 56.3	01.9
06	280 19.6	312 40.2	S11 49.1	321 26.9	S17 10.3	187 10.3	N23 29.3	343 58.6	S21 01.9
07	295 22.1	327 40.2	48.5	336 27.5	09.8	202 12.5	29.3	359 01.0	01.8
08	310 24.6	342 40.2	47.9	351 28.1	09.3	217 14.7	29.3	14 03.3	01.8
09	325 27.0	357 40.1	· · 47.3	6 28.7	· · 08.7	232 16.8	· · 29.3	29 05.6	· · 01.8
10	340 29.5	12 40.1	46.7	21 29.3	08.2	247 19.0	29.3	44 07.9	01.8
11	355 32.0	27 40.0	46.1	36 29.8	07.7	262 21.2	29.3	59 10.3	01.8
12	10 34.4	42 40.0	S11 45.5	51 30.4	S17 07.2	277 23.3	N23 29.3	74 12.6	S21 01.7
13	25 36.9	57 40.0	44.9	66 31.0	06.6	292 25.5	29.3	89 14.9	01.7
14	40 39.3	72 39.9	44.3	81 31.6	06.1	307 27.7	29.3	104 17.2	01.7
15	55 41.8	87 39.9	· · 43.7	96 32.2	· · 05.6	322 29.8	· · 29.3	119 19.6	· · 01.7
16	70 44.3	102 39.8	43.1	111 32.8	05.0	337 32.0	29.3	134 21.9	01.7
17	85 46.7	117 39.8	42.5	126 33.4	04.5	352 34.2	29.3	149 24.2	01.6
18	100 49.2	132 39.8	S11 41.9	141 34.0	S17 04.0	7 36.3	N23 29.3	164 26.6	S21 01.6
19	115 51.7	147 39.7	41.2	156 34.6	03.4	22 38.5	29.3	179 28.9	01.6
20	130 54.1	162 39.7	40.6	171 35.2	02.9	37 40.6	29.3	194 31.2	01.6
21	145 56.6	177 39.6	· · 40.0	186 35.8	· · 02.4	52 42.8	· · 29.3	209 33.5	· · 01.6
22	160 59.1	192 39.6	39.4	201 36.4	01.9	67 45.0	29.3	224 35.9	01.5
23	176 01.5	207 39.5	38.8	216 37.0	01.3	82 47.1	29.3	239 38.2	01.5
3 00 Tuesday	191 04.0	222 39.5	S11 38.2	231 37.6	S17 00.8	97 49.3	N23 29.3	254 40.5	S21 01.5
01	206 06.4	237 39.4	37.6	246 38.2	17 00.3	112 51.5	29.3	269 42.9	01.5
02	221 08.9	252 39.4	37.0	261 38.8	16 59.7	127 53.6	29.3	284 45.2	01.5
03	236 11.4	267 39.3	· · 36.4	276 39.3	· · 59.2	142 55.8	· · 29.3	299 47.5	· · 01.4
04	251 13.8	282 39.3	35.8	291 39.9	58.7	157 57.9	29.3	314 49.9	01.4
05	266 16.3	297 39.3	35.1	306 40.5	58.1	173 00.1	29.3	329 52.2	01.4
06	281 18.8	312 39.2	S11 34.5	321 41.1	S16 57.6	188 02.3	N23 29.3	344 54.5	S21 01.4
07	296 21.2	327 39.2	33.9	336 41.7	57.1	203 04.4	29.3	359 56.8	01.4
08	311 23.7	342 39.1	33.3	351 42.3	56.5	218 06.6	29.3	14 59.2	01.3
09	326 26.2	357 39.1	· · 32.7	6 42.9	· · 56.0	233 08.7	· · 29.3	30 01.5	· · 01.3
10	341 28.6	12 39.0	32.1	21 43.5	55.5	248 10.9	29.3	45 03.8	01.3
11	356 31.1	27 39.0	31.4	36 44.1	54.9	263 13.1	29.3	60 06.2	01.3
12	11 33.6	42 38.9	S11 30.8	51 44.7	S16 54.4	278 15.2	N23 29.3	75 08.5	S21 01.3
13	26 36.0	57 38.9	30.2	66 45.3	53.9	293 17.4	29.3	90 10.8	01.2
14	41 38.5	72 38.8	29.6	81 45.9	53.3	308 19.5	29.2	105 13.2	01.2
15	56 40.9	87 38.8	· · 29.0	96 46.5	· · 52.8	323 21.7	· · 29.2	120 15.5	· · 01.2
16	71 43.4	102 38.7	28.3	111 47.1	52.3	338 23.8	29.2	135 17.8	01.2
17	86 45.9	117 38.7	27.7	126 47.7	51.7	353 26.0	29.2	150 20.2	01.2
18	101 48.3	132 38.6	S11 27.1	141 48.3	S16 51.2	8 28.2	N23 29.2	165 22.5	S21 01.1
19	116 50.8	147 38.6	26.5	156 48.9	50.6	23 30.3	29.2	180 24.8	01.1
20	131 53.3	162 38.5	25.8	171 49.5	50.1	38 32.5	29.2	195 27.2	01.1
21	146 55.7	177 38.5	· · 25.2	186 50.1	· · 49.6	53 34.6	· · 29.2	210 29.5	· · 01.1
22	161 58.2	192 38.4	24.6	201 50.7	49.0	68 36.8	29.2	225 31.8	01.1
23	177 00.7	207 38.4	24.0	216 51.3	48.5	83 38.9	29.2	240 34.2	01.0
Mer. Pass.	11 17.8 (h m)	v 0.0	d 0.6	v 0.6	d 0.5	v 2.2	d 0.0	v 2.3	d 0.0

STARS

Name	S.H.A.	Dec.
Acamar	315 31.8	S40 20.7
Achernar	335 40.0	S57 17.2
Acrux	173 28.5	S63 02.9
Adhara	255 26.2	S28 57.7
Aldebaran	291 09.6	N16 29.5
Alioth	166 35.1	N56 00.6
Alkaid	153 11.9	N49 21.4
Al Na'ir	28 05.7	S47 00.4
Alnilam	276 04.1	S 1 12.5
Alphard	218 13.0	S 8 37.1
Alphecca	126 25.4	N26 44.5
Alpheratz	358 02.0	N29 02.1
Altair	62 25.3	N 8 50.3
Ankaa	353 33.1	S42 21.5
Antares	112 47.5	S26 24.8
Arcturus	146 11.2	N19 13.7
Atria	108 04.8	S69 00.6
Avior	234 25.1	S59 28.9
Bellatrix	278 50.8	N 6 20.5
Betelgeuse	271 20.2	N 7 24.4
Canopus	264 03.9	S52 41.6
Capella	281 00.4	N45 59.6
Deneb	49 43.7	N45 14.4
Denebola	182 51.0	N14 37.4
Diphda	349 13.6	S18 02.4
Dubhe	194 12.0	N61 48.2
Elnath	278 34.8	N28 36.1
Eltanin	90 54.1	N51 29.0
Enif	34 04.4	N 9 49.6
Fomalhaut	15 43.3	S29 40.4
Gacrux	172 20.1	S57 03.7
Gienah	176 10.0	S17 29.5
Hadar	149 12.4	S60 19.7
Hamal	328 20.8	N23 25.0
Kaus Aust.	84 06.8	S34 23.4
Kochab	137 17.8	N74 11.4
Markab	13 56.0	N15 09.0
Menkar	314 33.5	N 4 03.1
Menkent	148 27.9	S36 19.5
Miaplacidus	221 43.2	S69 40.9
Mirfak	309 05.9	N49 49.8
Nunki	76 19.8	S26 18.6
Peacock	53 46.6	S56 45.9
Pollux	243 48.9	N28 03.1
Procyon	245 17.9	N 5 15.0
Rasalhague	96 22.5	N12 33.7
Regulus	208 01.7	N12 00.8
Rigel	281 28.9	S 8 12.8
Rigil Kent.	140 15.2	S60 47.8
Sabik	102 32.4	S15 43.0
Schedar	350 01.3	N56 29.1
Shaula	96 45.4	S37 05.9
Sirius	258 49.1	S16 42.3
Spica	158 49.3	S11 06.9
Suhail	223 05.1	S43 23.8
Vega	80 50.7	N38 46.1
Zuben'ubi	137 24.5	S16 00.3

	S.H.A.	Mer. Pass. (h m)
Venus	32 35.6	9 09
Mars	41 18.5	8 34
Jupiter	266 52.5	17 30
Saturn	63 39.8	7 04

UT (GMT) d	h	SUN G.H.A. ° ′	SUN Dec. ° ′	MOON G.H.A. ° ′	v ′	MOON Dec. ° ′	d ′	H.P. ′
1	00	178 58.7	N 4 21.4	107 32.9	3.6	N27 15.8	0.1	59.3
	01	193 58.9	22.3	121 55.5	3.7	27 15.9	0.2	59.3
	02	208 59.1	23.3	136 18.2	3.7	27 15.7	0.3	59.2
	03	223 59.3	. . 24.3	150 40.9	3.7	27 15.4	0.5	59.2
	04	238 59.5	25.2	165 03.6	3.9	27 14.9	0.7	59.2
	05	253 59.7	26.2	179 26.5	3.8	27 14.2	0.8	59.2
	06	268 59.9	N 4 27.2	193 49.3	3.9	N27 13.4	1.1	59.1
	07	284 00.0	28.1	208 12.2	4.0	27 12.3	1.2	59.1
	08	299 00.2	29.1	222 35.2	4.0	27 11.1	1.5	59.1
SUNDAY	09	314 00.4	. . 30.1	236 58.2	4.1	27 09.6	1.6	59.0
	10	329 00.6	31.0	251 21.3	4.1	27 08.0	1.8	59.0
	11	344 00.8	32.0	265 44.4	4.2	27 06.2	1.9	59.0
	12	359 01.0	N 4 32.9	280 07.6	4.3	N27 04.3	2.2	58.9
	13	14 01.2	33.9	294 30.9	4.3	27 02.1	2.3	58.9
	14	29 01.4	34.9	308 54.2	4.4	26 59.8	2.5	58.9
	15	44 01.5	. . 35.8	323 17.6	4.5	26 57.3	2.7	58.9
	16	59 01.7	36.8	337 41.1	4.5	26 54.6	2.9	58.8
	17	74 01.9	37.8	352 04.6	4.7	26 51.7	3.0	58.8
	18	89 02.1	N 4 38.7	6 28.3	4.6	N26 48.7	3.2	58.8
	19	104 02.3	39.7	20 51.9	4.8	26 45.5	3.4	58.7
	20	119 02.5	40.7	35 15.7	4.9	26 42.1	3.5	58.7
	21	134 02.7	. . 41.6	49 39.6	4.9	26 38.6	3.7	58.7
	22	149 02.8	42.6	64 03.5	5.0	26 34.9	3.9	58.7
	23	164 03.0	43.6	78 27.5	5.1	26 31.0	4.1	58.6
2	00	179 03.2	N 4 44.5	92 51.6	5.2	N26 26.9	4.2	58.6
	01	194 03.4	45.5	107 15.8	5.3	26 22.7	4.4	58.6
	02	209 03.6	46.4	121 40.1	5.3	26 18.3	4.5	58.5
	03	224 03.8	. . 47.4	136 04.4	5.5	26 13.8	4.7	58.5
	04	239 04.0	48.4	150 28.9	5.5	26 09.1	4.9	58.5
	05	254 04.1	49.3	164 53.4	5.7	26 04.2	5.0	58.4
	06	269 04.3	N 4 50.3	179 18.1	5.7	N25 59.2	5.2	58.4
	07	284 04.5	51.3	193 42.8	5.8	25 54.0	5.4	58.4
	08	299 04.7	52.2	208 07.6	6.0	25 48.6	5.5	58.3
MONDAY	09	314 04.9	. . 53.2	222 32.6	6.0	25 43.1	5.6	58.3
	10	329 05.1	54.1	236 57.6	6.1	25 37.5	5.8	58.3
	11	344 05.2	55.1	251 22.7	6.2	25 31.7	6.0	58.3
	12	359 05.4	N 4 56.1	265 47.9	6.3	N25 25.7	6.1	58.2
	13	14 05.6	57.0	280 13.2	6.5	25 19.6	6.3	58.2
	14	29 05.8	58.0	294 38.7	6.5	25 13.3	6.4	58.2
	15	44 06.0	. . 58.9	309 04.2	6.6	25 06.9	6.5	58.1
	16	59 06.2	4 59.9	323 29.8	6.7	25 00.4	6.7	58.1
	17	74 06.4	5 00.9	337 55.5	6.9	24 53.7	6.8	58.1
	18	89 06.5	N 5 01.8	352 21.4	6.9	N24 46.9	7.0	58.0
	19	104 06.7	02.8	6 47.3	7.1	24 39.9	7.1	58.0
	20	119 06.9	03.7	21 13.4	7.1	24 32.8	7.3	58.0
	21	134 07.1	. . 04.7	35 39.5	7.3	24 25.5	7.4	58.0
	22	149 07.3	05.7	50 05.8	7.3	24 18.1	7.5	57.9
	23	164 07.5	06.6	64 32.1	7.5	24 10.6	7.7	57.9
3	00	179 07.6	N 5 07.6	78 58.6	7.6	N24 02.9	7.7	57.9
	01	194 07.8	08.5	93 25.2	7.7	23 55.2	8.0	57.8
	02	209 08.0	09.5	107 51.9	7.8	23 47.2	8.0	57.8
	03	224 08.2	. . 10.5	122 18.7	7.9	23 39.2	8.2	57.8
	04	239 08.4	11.4	136 45.6	8.0	23 31.0	8.3	57.8
	05	254 08.6	12.4	151 12.6	8.1	23 22.7	8.4	57.7
	06	269 08.8	N 5 13.3	165 39.7	8.3	N23 14.3	8.6	57.7
	07	284 08.9	14.3	180 07.0	8.3	23 05.7	8.7	57.7
	08	299 09.1	15.2	194 34.3	8.5	22 57.0	8.7	57.6
TUESDAY	09	314 09.3	. . 16.2	209 01.8	8.5	22 48.3	9.0	57.6
	10	329 09.5	17.2	223 29.3	8.7	22 39.3	9.0	57.6
	11	344 09.7	18.1	237 57.0	8.8	22 30.3	9.1	57.5
	12	359 09.9	N 5 19.1	252 24.8	8.9	N22 21.2	9.3	57.5
	13	14 10.0	20.0	266 52.7	9.0	22 11.9	9.4	57.5
	14	29 10.2	21.0	281 20.7	9.1	22 02.5	9.4	57.5
	15	44 10.4	. . 22.0	295 48.8	9.2	21 53.1	9.6	57.4
	16	59 10.6	22.9	310 17.0	9.4	21 43.5	9.7	57.4
	17	74 10.8	23.9	324 45.4	9.4	21 33.8	9.8	57.4
	18	89 11.0	N 5 24.8	339 13.8	9.5	N21 24.0	9.9	57.3
	19	104 11.1	25.8	353 42.3	9.7	21 14.1	10.0	57.3
	20	119 11.3	26.7	8 11.0	9.8	21 04.1	10.1	57.3
	21	134 11.5	. . 27.7	22 39.8	9.8	20 54.0	10.3	57.3
	22	149 11.7	28.6	37 08.6	10.0	20 43.7	10.3	57.2
	23	164 11.9	29.6	51 37.6	10.1	20 33.4	10.4	57.2
		S.D. 16.0	d 1.0	S.D. 16.1		15.9		15.7

Lat. °	Twilight Naut. h m	Twilight Civil h m	Sunrise h m	Moonrise 1 h m	Moonrise 2 h m	Moonrise 3 h m	Moonrise 4 h m
N 72	01 29	03 37	04 52	□	□	□	□
N 70	02 15	03 54	05 00	□	□	□	09 26
68	02 44	04 07	05 06	□	□	□	10 15
66	03 06	04 18	05 12	□	□	08 20	10 46
64	03 22	04 26	05 16	□	06 35	09 09	11 08
62	03 36	04 34	05 20	06 09	07 48	09 40	11 26
60	03 47	04 40	05 23	06 58	08 24	10 03	11 41
N 58	03 56	04 46	05 26	07 29	08 49	10 21	11 54
56	04 04	04 51	05 29	07 53	09 10	10 37	12 04
54	04 11	04 55	05 31	08 12	09 27	10 50	12 14
52	04 18	04 59	05 33	08 28	09 41	11 01	12 22
50	04 23	05 03	05 35	08 42	09 54	11 11	12 30
45	04 35	05 10	05 40	09 10	10 19	11 33	12 46
N 40	04 43	05 16	05 43	09 32	10 40	11 50	12 59
35	04 51	05 21	05 46	09 51	10 57	12 04	13 10
30	04 56	05 25	05 49	10 07	11 12	12 17	13 20
20	05 05	05 31	05 53	10 34	11 37	12 38	13 37
N 10	05 11	05 36	05 57	10 57	11 58	12 56	13 51
0	05 16	05 40	06 00	11 18	12 18	13 14	14 04
S 10	05 18	05 43	06 04	11 40	12 38	13 31	14 18
20	05 20	05 45	06 07	12 03	12 59	13 49	14 32
30	05 19	05 47	06 11	12 30	13 24	14 10	14 48
35	05 19	05 48	06 13	12 46	13 39	14 22	14 58
40	05 17	05 49	06 16	13 04	13 55	14 36	15 08
45	05 15	05 49	06 18	13 27	14 15	14 52	15 21
S 50	05 12	05 49	06 22	13 55	14 40	15 12	15 36
52	05 10	05 49	06 23	14 09	14 52	15 22	15 43
54	05 08	05 49	06 25	14 25	15 06	15 33	15 51
56	05 06	05 49	06 27	14 44	15 22	15 45	15 59
58	05 04	05 49	06 29	15 07	15 41	15 59	16 09
S 60	05 01	05 49	06 31	15 38	16 04	16 15	16 20

Lat. °	Sunset h m	Twilight Civil h m	Twilight Naut. h m	Moonset 1 h m	Moonset 2 h m	Moonset 3 h m	Moonset 4 h m
N 72	19 18	20 35	22 51	□	□	□	□
N 70	19 10	20 17	21 59	□	□	□	06 36
68	19 03	20 03	21 28	□	□	□	05 46
66	18 58	19 52	21 05	□	□	05 51	05 14
64	18 53	19 43	20 48	□	05 38	05 02	04 50
62	18 49	19 35	20 34	03 56	04 25	04 31	04 31
60	18 46	19 29	20 23	03 07	03 49	04 07	04 15
N 58	18 42	19 23	20 13	02 36	03 22	03 48	04 02
56	18 40	19 18	20 05	02 13	03 02	03 32	03 51
54	18 37	19 13	19 58	01 54	02 45	03 18	03 40
52	18 35	19 09	19 51	01 37	02 30	03 06	03 31
50	18 33	19 06	19 45	01 23	02 17	02 55	03 23
45	18 29	18 58	19 34	00 55	01 50	02 33	03 06
N 40	18 25	18 52	19 25	00 33	01 29	02 15	02 51
35	18 22	18 47	19 17	00 14	01 12	02 00	02 39
30	18 19	18 43	19 11	24 57	00 57	01 46	02 28
20	18 14	18 37	19 02	24 31	00 31	01 24	02 10
N 10	18 11	18 32	18 56	24 08	00 08	01 04	01 54
0	18 07	18 28	18 52	23 47	24 45	00 45	01 38
S 10	18 03	18 24	18 49	23 26	24 26	00 26	01 23
20	18 00	18 22	18 47	23 04	24 06	00 06	01 06
30	17 56	18 20	18 47	22 37	23 43	24 47	00 47
35	17 54	18 19	18 48	22 22	23 29	24 36	00 36
40	17 51	18 18	18 49	22 04	23 13	24 23	00 23
45	17 48	18 17	18 51	21 42	22 54	24 08	00 08
S 50	17 45	18 17	18 54	21 14	22 30	23 49	25 07
52	17 43	18 17	18 56	21 00	22 18	23 40	25 00
54	17 41	18 17	18 58	20 44	22 05	23 30	24 53
56	17 40	18 17	19 00	20 26	21 49	23 18	24 45
58	17 38	18 17	19 02	20 03	21 31	23 05	24 36
S 60	17 35	18 17	19 05	19 32	21 08	22 49	24 26

Day	SUN Eqn. of Time 00h m s	SUN Eqn. of Time 12h m s	SUN Mer. Pass. h m	MOON Mer. Pass. Upper h m	MOON Mer. Pass. Lower h m	MOON Age d	MOON Phase
1	04 05	03 56	12 04	17 33	05 02	06	◐
2	03 48	03 39	12 04	18 32	06 03	07	
3	03 30	03 21	12 03	19 26	07 00	08	

UT (GMT) d h	ARIES G.H.A.	VENUS −4.0 G.H.A.	VENUS Dec.	MARS +0.4 G.H.A.	MARS Dec.	JUPITER −1.9 G.H.A.	JUPITER Dec.	SATURN +0.2 G.H.A.	SATURN Dec.
	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′
15 00 FRIDAY	263 01.1	216 43.6	N15 22.2	252 25.4	N 2 24.3	155 52.4	N22 41.6	327 05.4	S21 11.1
01	278 03.6	231 43.2	23.0	267 26.2	25.0	170 54.3	41.5	342 08.0	11.1
02	293 06.1	246 42.7	23.9	282 27.0	25.6	185 56.2	41.4	357 10.6	11.1
03	308 08.5	261 42.3	· · 24.7	297 27.8	· · 26.3	200 58.1	· · 41.4	12 13.2	· · 11.2
04	323 11.0	276 41.8	25.6	312 28.6	27.0	216 00.0	41.3	27 15.8	11.2
05	338 13.4	291 41.4	26.4	327 29.4	27.7	231 01.8	41.3	42 18.5	11.2
06	353 15.9	306 40.9	N15 27.3	342 30.2	N 2 28.4	246 03.7	N22 41.2	57 21.1	S21 11.3
07	8 18.4	321 40.5	28.1	357 31.0	29.1	261 05.6	41.1	72 23.7	11.3
08	23 20.8	336 40.0	29.0	12 31.8	29.8	276 07.5	41.1	87 26.3	11.3
09	38 23.3	351 39.6	· · 29.8	27 32.6	· · 30.5	291 09.4	· · 41.0	102 28.9	· · 11.3
10	53 25.8	6 39.1	30.7	42 33.4	31.2	306 11.3	41.0	117 31.6	11.4
11	68 28.2	21 38.6	31.5	57 34.2	31.8	321 13.1	40.9	132 34.2	11.4
12	83 30.7	36 38.2	N15 32.3	72 35.0	N 2 32.5	336 15.0	N22 40.8	147 36.8	S21 11.4
13	98 33.2	51 37.7	33.2	87 35.8	33.2	351 16.9	40.8	162 39.4	11.5
14	113 35.6	66 37.3	34.0	102 36.6	33.9	6 18.8	40.7	177 42.0	11.5
15	128 38.1	81 36.8	· · 34.9	117 37.4	· · 34.6	21 20.7	· · 40.7	192 44.6	· · 11.5
16	143 40.6	96 36.3	35.7	132 38.3	35.3	36 22.5	40.6	207 47.3	11.5
17	158 43.0	111 35.9	36.6	147 39.1	36.0	51 24.4	40.5	222 49.9	11.6
18	173 45.5	126 35.4	N15 37.4	162 39.9	N 2 36.7	66 26.3	N22 40.5	237 52.5	S21 11.6
19	188 47.9	141 35.0	38.2	177 40.7	37.4	81 28.2	40.4	252 55.1	11.6
20	203 50.4	156 34.5	39.1	192 41.5	38.0	96 30.1	40.4	267 57.7	11.7
21	218 52.9	171 34.0	· · 39.9	207 42.3	· · 38.7	111 31.9	· · 40.3	283 00.4	· · 11.7
22	233 55.3	186 33.6	40.7	222 43.1	39.4	126 33.8	40.2	298 03.0	11.7
23	248 57.8	201 33.1	41.6	237 43.9	40.1	141 35.7	40.2	313 05.6	11.7
16 00 SATURDAY	264 00.3	216 32.6	N15 42.4	252 44.7	N 2 40.8	156 37.6	N22 40.1	328 08.2	S21 11.8
01	279 02.7	231 32.2	43.3	267 45.5	41.5	171 39.5	40.0	343 10.8	11.8
02	294 05.2	246 31.7	44.1	282 46.3	42.2	186 41.3	40.0	358 13.5	11.8
03	309 07.7	261 31.3	· · 44.9	297 47.1	· · 42.9	201 43.2	· · 39.9	13 16.1	· · 11.9
04	324 10.1	276 30.8	45.8	312 47.9	43.5	216 45.1	39.9	28 18.7	11.9
05	339 12.6	291 30.3	46.6	327 48.7	44.2	231 47.0	39.8	43 21.3	11.9
06	354 15.0	306 29.9	N15 47.4	342 49.5	N 2 44.9	246 48.9	N22 39.7	58 23.9	S21 11.9
07	9 17.5	321 29.4	48.3	357 50.3	45.6	261 50.7	39.7	73 26.6	12.0
08	24 20.0	336 28.9	49.1	12 51.1	46.3	276 52.6	39.6	88 29.2	12.0
09	39 22.4	351 28.5	· · 49.9	27 51.9	· · 47.0	291 54.5	· · 39.6	103 31.8	· · 12.0
10	54 24.9	6 28.0	50.8	42 52.7	47.7	306 56.4	39.5	118 34.4	12.1
11	69 27.4	21 27.5	51.6	57 53.5	48.4	321 58.3	39.4	133 37.0	12.1
12	84 29.8	36 27.0	N15 52.4	72 54.3	N 2 49.0	337 00.1	N22 39.4	148 39.7	S21 12.1
13	99 32.3	51 26.6	53.2	87 55.1	49.7	352 02.0	39.3	163 42.3	12.2
14	114 34.8	66 26.1	54.1	102 55.9	50.4	7 03.9	39.3	178 44.9	12.2
15	129 37.2	81 25.6	· · 54.9	117 56.8	· · 51.1	22 05.8	· · 39.2	193 47.5	· · 12.2
16	144 39.7	96 25.2	55.7	132 57.6	51.8	37 07.7	39.1	208 50.2	12.2
17	159 42.2	111 24.7	56.6	147 58.4	52.5	52 09.5	39.1	223 52.8	12.3
18	174 44.6	126 24.2	N15 57.4	162 59.2	N 2 53.2	67 11.4	N22 39.0	238 55.4	S21 12.3
19	189 47.1	141 23.7	58.2	178 00.0	53.8	82 13.3	38.9	253 58.0	12.3
20	204 49.5	156 23.3	59.0	193 00.8	54.5	97 15.2	38.9	269 00.6	12.4
21	219 52.0	171 22.8	15 59.8	208 01.6	· · 55.2	112 17.0	· · 38.8	284 03.3	· · 12.4
22	234 54.5	186 22.3	16 00.7	223 02.4	55.9	127 18.9	38.8	299 05.9	12.4
23	249 56.9	201 21.8	01.5	238 03.2	56.6	142 20.8	38.7	314 08.5	12.4
17 00 SUNDAY	264 59.4	216 21.4	N16 02.3	253 04.0	N 2 57.3	157 22.7	N22 38.6	329 11.1	S21 12.5
01	280 01.9	231 20.9	03.1	268 04.8	58.0	172 24.6	38.6	344 13.7	12.5
02	295 04.3	246 20.4	04.0	283 05.6	58.6	187 26.4	38.5	359 16.4	12.5
03	310 06.8	261 19.9	· · 04.8	298 06.4	2 59.3	202 28.3	· · 38.4	14 19.0	· · 12.6
04	325 09.3	276 19.5	05.6	313 07.2	3 00.0	217 30.2	38.4	29 21.6	12.6
05	340 11.7	291 19.0	06.4	328 08.0	00.7	232 32.1	38.3	44 24.2	12.6
06	355 14.2	306 18.5	N16 07.2	343 08.8	N 3 01.4	247 34.0	N22 38.3	59 26.9	S21 12.6
07	10 16.7	321 18.0	08.1	358 09.6	02.1	262 35.8	38.2	74 29.5	12.7
08	25 19.1	336 17.6	08.9	13 10.5	02.8	277 37.7	38.1	89 32.1	12.7
09	40 21.6	351 17.1	· · 09.7	28 11.3	· · 03.4	292 39.6	· · 38.1	104 34.7	· · 12.7
10	55 24.0	6 16.6	10.5	43 12.1	04.1	307 41.5	38.0	119 37.4	12.8
11	70 26.5	21 16.1	11.3	58 12.9	04.8	322 43.3	38.0	134 40.0	12.8
12	85 29.0	36 15.6	N16 12.1	73 13.7	N 3 05.5	337 45.2	N22 37.9	149 42.6	S21 12.8
13	100 31.4	51 15.1	13.0	88 14.5	06.2	352 47.1	37.8	164 45.2	12.9
14	115 33.9	66 14.7	13.8	103 15.3	06.9	7 49.0	37.8	179 47.8	12.9
15	130 36.4	81 14.2	· · 14.6	118 16.1	· · 07.5	22 50.9	· · 37.7	194 50.5	· · 12.9
16	145 38.8	96 13.7	15.4	133 16.9	08.2	37 52.7	37.6	209 53.1	12.9
17	160 41.3	111 13.2	16.2	148 17.7	08.9	52 54.6	37.6	224 55.7	13.0
18	175 43.8	126 12.7	N16 17.0	163 18.5	N 3 09.6	67 56.5	N22 37.5	239 58.3	S21 13.0
19	190 46.2	141 12.2	17.8	178 19.3	10.3	82 58.4	37.5	255 01.0	13.0
20	205 48.7	156 11.8	18.6	193 20.1	11.0	98 00.3	37.4	270 03.6	13.1
21	220 51.1	171 11.3	· · 19.4	208 20.9	· · 11.6	113 02.1	· · 37.3	285 06.2	· · 13.1
22	235 53.6	186 10.8	20.3	223 21.8	12.3	128 04.0	37.3	300 08.8	13.1
23	250 56.1	201 10.3	21.1	238 22.6	13.0	143 05.9	37.2	315 11.5	13.2
Mer. Pass. (h m)	6 22.9	v −0.5	d 0.8	v 0.8	d 0.7	v 1.9	d 0.1	v 2.6	d 0.0

STARS

Name	S.H.A.	Dec.
	° ′	° ′
Acamar	315 31.6	S40 20.3
Achernar	335 39.6	S57 16.7
Acrux	173 28.8	S63 03.2
Adhara	255 26.5	S28 57.5
Aldebaran	291 09.5	N16 29.5
Alioth	166 35.3	N56 00.8
Alkaid	153 12.0	N49 21.7
Al Na'ir	28 04.9	S47 00.2
Alnilam	276 04.2	S 1 12.4
Alphard	218 13.2	S 8 37.1
Alphecca	126 25.2	N26 44.7
Alpheratz	358 01.5	N29 02.2
Altair	62 24.8	N 8 50.5
Ankaa	353 32.6	S42 21.2
Antares	112 47.1	S26 24.9
Arcturus	146 11.2	N19 13.9
Atria	108 04.0	S69 00.9
Avior	234 25.7	S59 28.9
Bellatrix	278 50.9	N 6 20.6
Betelgeuse	271 20.3	N 7 24.4
Canopus	264 04.4	S52 41.4
Capella	281 00.5	N45 59.4
Deneb	49 43.0	N45 14.6
Denebola	182 51.2	N14 37.5
Diphda	349 13.2	S18 02.1
Dubhe	194 12.5	N61 48.4
Elnath	278 34.8	N28 36.1
Eltanin	90 53.6	N51 29.3
Enif	34 03.9	N 9 49.8
Fomalhaut	15 42.8	S29 40.2
Gacrux	172 20.3	S57 04.0
Gienah	176 10.1	S17 29.5
Hadar	149 12.3	S60 20.0
Hamal	328 20.5	N23 25.1
Kaus Aust.	84 06.2	S34 23.5
Kochab	137 18.0	N74 11.8
Markab	13 55.5	N15 09.2
Menkar	314 33.4	N 4 03.3
Menkent	148 27.8	S36 19.7
Miaplacidus	221 44.2	S69 40.9
Mirfak	309 05.7	N49 49.6
Nunki	76 19.3	S26 18.6
Peacock	53 45.7	S56 45.8
Pollux	243 49.1	N28 03.1
Procyon	245 18.0	N 5 15.0
Rasalhague	96 22.1	N12 33.9
Regulus	208 01.9	N12 00.9
Rigel	281 29.0	S 8 12.6
Rigil Kent.	140 15.0	S60 48.1
Sabik	102 32.0	S15 43.0
Schedar	350 00.7	N56 28.9
Shaula	96 44.9	S37 06.0
Sirius	258 49.3	S16 42.1
Spica	158 49.3	S11 06.9
Suhail	223 05.5	S43 23.8
Vega	80 50.2	N38 46.3
Zuben'ubi	137 24.3	S16 00.4

	S.H.A.	Mer. Pass.
	° ′	h m
Venus	312 32.4	9 34
Mars	348 44.4	7 09
Jupiter	252 37.3	13 32
Saturn	64 08.0	2 07

	UT (GMT)	SUN G.H.A.	SUN Dec.	MOON G.H.A.	MOON v	MOON Dec.	MOON d	MOON H.P.
	d h	° ′	° ′	° ′	′	° ′	′	′
	15 00	179 55.9	N23 17.4	283 40.4	13.7	S 5 51.5	14.7	57.3
	01	194 55.8	17.5	298 13.1	13.7	5 36.8	14.7	57.3
	02	209 55.6	17.6	312 45.8	13.7	5 22.1	14.8	57.3
	03	224 55.5	. . 17.7	327 18.5	13.6	5 07.3	14.7	57.4
	04	239 55.4	17.8	341 51.1	13.7	4 52.6	14.9	57.4
	05	254 55.2	17.9	356 23.8	13.7	4 37.7	14.8	57.4
	06	269 55.1	N23 18.1	10 56.5	13.6	S 4 22.9	14.9	57.4
	07	284 55.0	18.2	25 29.1	13.7	4 08.0	14.9	57.5
	08	299 54.8	18.3	40 01.8	13.6	3 53.1	15.0	57.5
F	09	314 54.7	. . 18.4	54 34.4	13.6	3 38.1	15.0	57.5
R	10	329 54.6	18.5	69 07.0	13.6	3 23.1	15.0	57.6
I	11	344 54.4	18.6	83 39.6	13.6	3 08.1	15.1	57.6
D	12	359 54.3	N23 18.7	98 12.2	13.5	S 2 53.0	15.0	57.6
A	13	14 54.2	18.8	112 44.7	13.6	2 38.0	15.2	57.7
Y	14	29 54.0	18.9	127 17.3	13.5	2 22.8	15.1	57.7
	15	44 53.9	. . 19.0	141 49.8	13.5	2 07.7	15.1	57.7
	16	59 53.8	19.1	156 22.3	13.5	1 52.6	15.2	57.8
	17	74 53.6	19.2	170 54.8	13.4	1 37.4	15.2	57.8
	18	89 53.5	N23 19.3	185 27.2	13.5	S 1 22.2	15.3	57.8
	19	104 53.4	19.4	199 59.7	13.4	1 06.9	15.2	57.8
	20	119 53.2	19.5	214 32.1	13.3	0 51.7	15.3	57.9
	21	134 53.1	. . 19.6	229 04.4	13.4	0 36.4	15.3	57.9
	22	149 53.0	19.7	243 36.8	13.3	0 21.1	15.3	57.9
	23	164 52.8	19.8	258 09.1	13.3	S 0 05.8	15.3	58.0
	16 00	179 52.7	N23 19.9	272 41.4	13.2	N 0 09.5	15.4	58.0
	01	194 52.6	20.0	287 13.6	13.3	0 24.9	15.3	58.0
	02	209 52.4	20.1	301 45.9	13.1	0 40.2	15.4	58.1
	03	224 52.3	. . 20.2	316 18.0	13.2	0 55.6	15.4	58.1
	04	239 52.2	20.3	330 50.2	13.1	1 11.0	15.4	58.1
	05	254 52.0	20.4	345 22.3	13.0	1 26.4	15.4	58.2
	06	269 51.9	N23 20.5	359 54.3	13.1	N 1 41.8	15.4	58.2
	07	284 51.8	20.6	14 26.4	13.0	1 57.2	15.4	58.2
S	08	299 51.6	20.7	28 58.4	12.9	2 12.6	15.4	58.3
A	09	314 51.5	. . 20.8	43 30.3	12.9	2 28.0	15.4	58.3
T	10	329 51.4	20.9	58 02.2	12.8	2 43.4	15.5	58.3
U	11	344 51.2	20.9	72 34.0	12.8	2 58.9	15.4	58.3
R	12	359 51.1	N23 21.0	87 05.8	12.8	N 3 14.3	15.4	58.4
D	13	14 50.9	21.1	101 37.6	12.7	3 29.7	15.5	58.4
A	14	29 50.8	21.2	116 09.3	12.6	3 45.2	15.4	58.4
Y	15	44 50.7	. . 21.3	130 40.9	12.6	4 00.6	15.5	58.5
	16	59 50.5	21.4	145 12.5	12.6	4 16.1	15.4	58.5
	17	74 50.4	21.5	159 44.1	12.4	4 31.5	15.4	58.5
	18	89 50.3	N23 21.6	174 15.5	12.5	N 4 46.9	15.4	58.6
	19	104 50.1	21.6	188 47.0	12.3	5 02.3	15.4	58.6
	20	119 50.0	21.7	203 18.3	12.3	5 17.7	15.4	58.6
	21	134 49.9	. . 21.8	217 49.6	12.3	5 33.1	15.4	58.7
	22	149 49.7	21.9	232 20.9	12.2	5 48.5	15.4	58.7
	23	164 49.6	22.0	246 52.1	12.1	6 03.9	15.4	58.7
	17 00	179 49.5	N23 22.0	261 23.2	12.0	N 6 19.3	15.3	58.8
	01	194 49.3	22.1	275 54.2	12.0	6 34.6	15.4	58.8
	02	209 49.2	22.2	290 25.2	12.0	6 50.0	15.3	58.8
	03	224 49.1	. . 22.3	304 56.2	11.8	7 05.3	15.3	58.9
	04	239 48.9	22.4	319 27.0	11.8	7 20.6	15.3	58.9
	05	254 48.8	22.4	333 57.8	11.7	7 35.9	15.2	58.9
	06	269 48.6	N23 22.5	348 28.5	11.6	N 7 51.1	15.3	58.9
	07	284 48.5	22.6	2 59.1	11.6	8 06.4	15.2	59.0
	08	299 48.4	22.7	17 29.7	11.5	8 21.6	15.2	59.0
S	09	314 48.2	. . 22.7	32 00.2	11.4	8 36.8	15.1	59.0
U	10	329 48.1	22.8	46 30.6	11.3	8 51.9	15.2	59.1
N	11	344 48.0	22.9	61 00.9	11.2	9 07.1	15.0	59.1
D	12	359 47.8	N23 23.0	75 31.1	11.2	N 9 22.1	15.1	59.1
A	13	14 47.7	23.0	90 01.3	11.1	9 37.2	15.0	59.2
Y	14	29 47.6	23.1	104 31.4	11.0	9 52.2	15.0	59.2
	15	44 47.4	. . 23.2	119 01.4	10.9	10 07.2	15.0	59.2
	16	59 47.3	23.2	133 31.3	10.8	10 22.2	14.9	59.3
	17	74 47.2	23.3	148 01.1	10.8	10 37.1	14.9	59.3
	18	89 47.0	N23 23.4	162 30.9	10.6	N10 52.0	14.8	59.3
	19	104 46.9	23.4	177 00.5	10.6	11 06.8	14.8	59.3
	20	119 46.7	23.5	191 30.1	10.4	11 21.6	14.8	59.4
	21	134 46.6	. . 23.6	205 59.5	10.4	11 36.4	14.7	59.4
	22	149 46.5	23.6	220 28.9	10.3	11 51.1	14.6	59.4
	23	164 46.3	23.7	234 58.2	10.2	12 05.7	14.6	59.5
		S.D. 15.8	d 0.1	S.D.	15.7		15.9	16.1

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

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

Day	SUN Eqn. of Time 00h	SUN Eqn. of Time 12h	SUN Mer. Pass.	MOON Mer. Pass. Upper	MOON Mer. Pass. Lower	MOON Age	MOON Phase
	m s	m s	h m	h m	h m	d	
15	00 16	00 23	12 00	05 15	17 37	22	◑
16	00 29	00 35	12 01	06 00	18 24	23	
17	00 42	00 48	12 01	06 48	19 12	24	

UT (GMT)	ARIES	VENUS −3.9		MARS −0.3		JUPITER −1.9		SATURN +0.3		STARS		
d h	G.H.A. ° ′	G.H.A. ° ′	Dec. ° ′	G.H.A. ° ′	Dec. ° ′	G.H.A. ° ′	Dec. ° ′	G.H.A. ° ′	Dec. ° ′	Name	S.H.A. ° ′	Dec. ° ′
23 00	331 01.7	197 15.5	N18 07.8	277 19.3	N17 21.8	207 45.0	N20 13.7	39 57.3	S22 00.7	Acamar	315 31.1	S40 20.1
01	346 04.2	212 14.8	07.0	292 20.4	22.1	222 47.0	13.6	54 59.8	00.7	Achernar	335 38.8	S57 16.6
02	1 06.6	227 14.1	06.3	307 21.5	22.5	237 48.9	13.5	70 02.4	00.7	Acrux	173 29.3	S63 03.1
03	16 09.1	242 13.5	· · 05.5	322 22.6	· · 22.8	252 50.8	· · 13.4	85 05.0	· · 00.7	Adhara	255 26.2	S28 57.3
04	31 11.6	257 12.8	04.8	337 23.7	23.2	267 52.7	13.3	100 07.6	00.7	Aldebaran	291 09.1	N16 29.6
05	46 14.0	272 12.2	04.0	352 24.8	23.5	282 54.6	13.2	115 10.2	00.8			
06	61 16.5	287 11.5	N18 03.3	7 25.9	N17 23.8	297 56.6	N20 13.1	130 12.8	S22 00.8	Alioth	166 35.8	N56 00.8
07	76 19.0	302 10.8	02.5	22 27.0	24.2	312 58.5	12.9	145 15.4	00.8	Alkaid	153 12.4	N49 21.7
T 08	91 21.4	317 10.2	01.7	37 28.1	24.5	328 00.4	12.8	160 18.0	00.8	Al Na'ir	28 04.5	S47 00.3
H 09	106 23.9	332 09.5	· · 01.0	52 29.2	· · 24.9	343 02.3	· · 12.7	175 20.6	· · 00.9	Alnilam	276 03.8	S 1 12.2
U 10	121 26.3	347 08.9	18 00.2	67 30.3	25.2	358 04.2	12.6	190 23.1	00.9	Alphard	218 13.2	S 8 37.0
R 11	136 28.8	2 08.2	17 59.4	82 31.4	25.6	13 06.2	12.5	205 25.7	00.9			
S 12	151 31.3	17 07.5	N17 58.7	97 32.5	N17 25.9	28 08.1	N20 12.4	220 28.3	S22 00.9	Alphecca	126 25.4	N26 44.9
D 13	166 33.7	32 06.9	57.9	112 33.5	26.3	43 10.0	12.3	235 30.9	00.9	Alpheratz	358 01.0	N29 02.5
A 14	181 36.2	47 06.2	57.1	127 34.6	26.6	58 11.9	12.2	250 33.5	01.0	Altair	62 24.6	N 8 50.7
Y 15	196 38.7	62 05.6	· · 56.4	142 35.7	· · 26.9	73 13.8	· · 12.1	265 36.1	· · 01.0	Ankaa	353 32.0	S42 21.1
16	211 41.1	77 04.9	55.6	157 36.8	27.3	88 15.8	12.0	280 38.7	01.0	Antares	112 47.2	S26 24.9
17	226 43.6	92 04.2	54.8	172 37.9	27.6	103 17.7	11.9	295 41.3	01.0			
18	241 46.1	107 03.6	N17 54.1	187 39.0	N17 28.0	118 19.6	N20 11.7	310 43.8	S22 01.0	Arcturus	146 11.4	N19 13.9
19	256 48.5	122 02.9	53.3	202 40.1	28.3	133 21.5	11.6	325 46.4	01.1	Atria	108 04.4	S69 01.1
20	271 51.0	137 02.3	52.5	217 41.2	28.7	148 23.5	11.5	340 49.0	01.1	Avior	234 25.7	S59 28.6
21	286 53.5	152 01.6	· · 51.7	232 42.3	· · 29.0	163 25.4	· · 11.4	355 51.6	· · 01.1	Bellatrix	278 50.5	N 6 20.7
22	301 55.9	167 01.0	51.0	247 43.4	29.3	178 27.3	11.3	10 54.2	01.1	Betelgeuse	271 19.9	N 7 24.5
23	316 58.4	182 00.3	50.2	262 44.5	29.7	193 29.2	11.2	25 56.8	01.1			
24 00	332 00.8	196 59.7	N17 49.4	277 45.6	N17 30.0	208 31.1	N20 11.1	40 59.4	S22 01.2	Canopus	264 04.0	S52 41.1
01	347 03.3	211 59.0	48.6	292 46.7	30.4	223 33.1	11.0	56 02.0	01.2	Capella	280 59.9	N45 59.3
02	2 05.8	226 58.4	47.8	307 47.8	30.7	238 35.0	10.9	71 04.5	01.2	Deneb	49 42.8	N45 14.9
03	17 08.2	241 57.7	· · 47.1	322 48.9	· · 31.0	253 36.9	· · 10.8	86 07.1	· · 01.2	Denebola	182 51.3	N14 37.5
04	32 10.7	256 57.1	46.3	337 50.1	31.4	268 38.8	10.6	101 09.7	01.2	Diphda	349 12.7	S18 02.0
05	47 13.2	271 56.4	45.5	352 51.2	31.7	283 40.7	10.5	116 12.3	01.3			
06	62 15.6	286 55.7	N17 44.7	7 52.3	N17 32.1	298 42.7	N20 10.4	131 14.9	S22 01.3	Dubhe	194 12.9	N61 48.2
07	77 18.1	301 55.1	43.9	22 53.4	32.4	313 44.6	10.3	146 17.5	01.3	Elnath	278 34.4	N28 36.1
08	92 20.6	316 54.4	43.2	37 54.5	32.7	328 46.5	10.2	161 20.1	01.3	Eltanin	90 53.8	N51 29.6
F 09	107 23.0	331 53.8	· · 42.4	52 55.6	· · 33.1	343 48.4	· · 10.1	176 22.6	· · 01.3	Enif	34 03.6	N 9 50.1
R 10	122 25.5	346 53.1	41.6	67 56.7	33.4	358 50.4	10.0	191 25.2	01.4	Fomalhaut	15 42.3	S29 40.1
I 11	137 28.0	1 52.5	40.8	82 57.8	33.8	13 52.3	09.9	206 27.8	01.4			
D 12	152 30.4	16 51.8	N17 40.0	97 58.9	N17 34.1	28 54.2	N20 09.8	221 30.4	S22 01.4	Gacrux	172 20.7	S57 03.9
A 13	167 32.9	31 51.2	39.2	113 00.0	34.4	43 56.1	09.7	236 33.0	01.4	Gienah	176 10.2	S17 29.4
Y 14	182 35.3	46 50.5	38.4	128 01.1	34.8	58 58.1	09.6	251 35.6	01.4	Hadar	149 12.8	S60 20.0
15	197 37.8	61 49.9	· · 37.6	143 02.2	· · 35.1	74 00.0	· · 09.4	266 38.1	· · 01.5	Hamal	328 20.0	N23 25.2
16	212 40.3	76 49.3	36.9	158 03.3	35.4	89 01.9	09.3	281 40.7	01.5	Kaus Aust.	84 06.2	S34 23.5
17	227 42.7	91 48.6	36.1	173 04.4	35.8	104 03.8	09.2	296 43.3	01.5			
18	242 45.2	106 48.0	N17 35.3	188 05.5	N17 36.1	119 05.7	N20 09.1	311 45.9	S22 01.5	Kochab	137 19.2	N74 11.8
19	257 47.7	121 47.3	34.5	203 06.7	36.4	134 07.7	09.0	326 48.5	01.5	Markab	13 55.1	N15 09.4
20	272 50.1	136 46.7	33.7	218 07.8	36.8	149 09.6	08.9	341 51.1	01.6	Menkar	314 32.9	N 4 03.4
21	287 52.6	151 46.0	· · 32.9	233 08.9	· · 37.1	164 11.5	· · 08.8	356 53.6	· · 01.6	Menkent	148 28.0	S36 19.7
22	302 55.1	166 45.4	32.1	248 10.0	37.5	179 13.4	08.7	11 56.2	01.6	Miaplacidus	221 44.5	S69 40.6
23	317 57.5	181 44.7	31.3	263 11.1	37.8	194 15.4	08.6	26 58.8	01.6			
25 00	333 00.0	196 44.1	N17 30.5	278 12.2	N17 38.1	209 17.3	N20 08.5	42 01.4	S22 01.6	Mirfak	309 04.9	N49 49.7
01	348 02.5	211 43.4	29.7	293 13.3	38.5	224 19.2	08.3	57 04.0	01.6	Nunki	76 19.2	S26 18.6
02	3 04.9	226 42.8	28.9	308 14.4	38.8	239 21.1	08.2	72 06.6	01.7	Peacock	53 45.3	S56 46.0
03	18 07.4	241 42.2	· · 28.1	323 15.6	· · 39.1	254 23.1	· · 08.1	87 09.1	· · 01.7	Pollux	243 48.8	N28 03.0
04	33 09.8	256 41.5	27.3	338 16.7	39.5	269 25.0	08.0	102 11.7	01.7	Procyon	245 17.8	N 5 15.1
05	48 12.3	271 40.9	26.5	353 17.8	39.8	284 26.9	07.9	117 14.3	01.7			
06	63 14.8	286 40.2	N17 25.7	8 18.9	N17 40.1	299 28.8	N20 07.8	132 16.9	S22 01.7	Rasalhague	96 22.2	N12 34.1
07	78 17.2	301 39.6	24.9	23 20.0	40.5	314 30.8	07.7	147 19.5	01.8	Regulus	208 02.0	N12 00.9
S 08	93 19.7	316 38.9	24.1	38 21.1	40.8	329 32.7	07.6	162 22.1	01.8	Rigel	281 28.6	S 8 12.4
A 09	108 22.2	331 38.3	· · 23.3	53 22.2	· · 41.1	344 34.6	· · 07.5	177 24.6	· · 01.8	Rigil Kent.	140 15.5	S60 48.1
T 10	123 24.6	346 37.7	22.5	68 23.4	41.5	359 36.5	07.4	192 27.2	01.8	Sabik	102 32.0	S15 42.9
U 11	138 27.1	1 37.0	21.7	83 24.5	41.8	14 38.5	07.2	207 29.8	01.8			
R 12	153 29.6	16 36.4	N17 20.9	98 25.6	N17 42.1	29 40.4	N20 07.1	222 32.4	S22 01.9	Schedar	349 59.9	N56 29.2
D 13	168 32.0	31 35.7	20.0	113 26.7	42.5	44 42.3	07.0	237 35.0	01.9	Shaula	96 45.0	S37 06.0
A 14	183 34.5	46 35.1	19.2	128 27.8	42.8	59 44.2	06.9	252 37.5	01.9	Sirius	258 49.0	S16 41.9
Y 15	198 36.9	61 34.5	· · 18.4	143 28.9	· · 43.1	74 46.2	· · 06.8	267 40.1	· · 01.9	Spica	158 49.5	S11 06.8
16	213 39.4	76 33.8	17.6	158 30.1	43.4	89 48.1	06.7	282 42.7	01.9	Suhail	223 05.6	S43 23.5
17	228 41.9	91 33.2	16.8	173 31.2	43.8	104 50.0	06.6	297 45.3	02.0			
18	243 44.3	106 32.6	N17 16.0	188 32.3	N17 44.1	119 51.9	N20 06.5	312 47.9	S22 02.0	Vega	80 50.3	N38 46.6
19	258 46.8	121 31.9	15.2	203 33.4	44.4	134 53.9	06.4	327 50.4	02.0	Zuben'ubi	137 24.5	S16 00.3
20	273 49.3	136 31.3	14.4	218 34.6	44.8	149 55.8	06.3	342 53.0	02.0		S.H.A. ° ′	Mer. Pass. h m
21	288 51.7	151 30.6	· · 13.5	233 35.7	· · 45.1	164 57.7	· · 06.2	357 55.6	· · 02.0			
22	303 54.2	166 30.0	12.7	248 36.8	45.4	179 59.7	06.0	12 58.2	02.1	Venus	224 58.8	10 52
23	318 56.7	181 29.4	11.9	263 37.9	45.8	195 01.6	05.9	28 00.8	02.1	Mars	305 44.8	5 29
Mer. Pass.	h m 1 51.6	v −0.6	d 0.8	v 1.1	d 0.3	v 1.9	d 0.1	v 2.6	d 0.0	Jupiter	236 30.3	10 05
										Saturn	68 58.5	21 12

UT (GMT) d	h	SUN G.H.A.	SUN Dec.	MOON G.H.A.	v	Dec.	d	H.P.
		° ′	° ′	° ′	′	° ′	′	′
23 THURSDAY	00	179 17.9	N11 36.3	152 49.4	14.8	S 3 45.7	14.4	56.2
	01	194 18.1	35.5	167 23.2	14.8	4 00.1	14.3	56.2
	02	209 18.3	34.6	181 57.0	14.8	4 14.4	14.3	56.2
	03	224 18.4	. . 33.8	196 30.8	14.9	4 28.7	14.3	56.1
	04	239 18.6	32.9	211 04.7	14.8	4 43.0	14.2	56.1
	05	254 18.7	32.1	225 38.5	14.8	4 57.2	14.2	56.1
	06	269 18.9	N11 31.2	240 12.3	14.9	S 5 11.4	14.1	56.1
	07	284 19.1	30.4	254 46.2	14.9	5 25.5	14.1	56.0
	08	299 19.2	29.5	269 20.1	14.8	5 39.6	14.1	56.0
	09	314 19.4	. . 28.7	283 53.9	14.9	5 53.7	14.1	56.0
	10	329 19.5	27.9	298 27.8	14.9	6 07.8	14.0	55.9
	11	344 19.7	27.0	313 01.7	14.9	6 21.8	13.9	55.9
	12	359 19.9	N11 26.2	327 35.6	14.9	S 6 35.7	13.9	55.9
	13	14 20.0	25.3	342 09.5	14.8	6 49.6	13.9	55.9
	14	29 20.2	24.5	356 43.3	14.9	7 03.5	13.8	55.8
	15	44 20.4	. . 23.6	11 17.2	14.9	7 17.3	13.8	55.8
	16	59 20.5	22.8	25 51.1	14.9	7 31.1	13.8	55.8
	17	74 20.7	21.9	40 25.0	14.9	7 44.9	13.7	55.8
	18	89 20.8	N11 21.1	54 58.9	14.8	S 7 58.6	13.6	55.7
	19	104 21.0	20.2	69 32.7	14.9	8 12.2	13.6	55.7
	20	119 21.2	19.4	84 06.6	14.9	8 25.8	13.6	55.7
	21	134 21.3	. . 18.5	98 40.5	14.8	8 39.4	13.5	55.7
	22	149 21.5	17.7	113 14.3	14.9	8 52.9	13.4	55.6
	23	164 21.7	16.8	127 48.2	14.8	9 06.3	13.4	55.6
24 FRIDAY	00	179 21.8	N11 16.0	142 22.0	14.9	S 9 19.7	13.4	55.6
	01	194 22.0	15.1	156 55.9	14.8	9 33.1	13.3	55.6
	02	209 22.2	14.3	171 29.7	14.8	9 46.4	13.2	55.5
	03	224 22.3	. . 13.4	186 03.5	14.8	9 59.6	13.2	55.5
	04	239 22.5	12.5	200 37.3	14.8	10 12.8	13.2	55.5
	05	254 22.7	11.7	215 11.1	14.8	10 26.0	13.1	55.5
	06	269 22.8	N11 10.8	229 44.9	14.7	S10 39.1	13.0	55.4
	07	284 23.0	10.0	244 18.6	14.8	10 52.1	13.0	55.4
	08	299 23.2	09.1	258 52.4	14.7	11 05.1	12.9	55.4
	09	314 23.3	. . 08.3	273 26.1	14.7	11 18.0	12.8	55.4
	10	329 23.5	07.4	287 59.8	14.7	11 30.8	12.8	55.4
	11	344 23.7	06.6	302 33.5	14.7	11 43.6	12.8	55.3
	12	359 23.8	N11 05.7	317 07.2	14.7	S11 56.4	12.7	55.3
	13	14 24.0	04.9	331 40.9	14.6	12 09.1	12.6	55.3
	14	29 24.2	04.0	346 14.5	14.6	12 21.7	12.5	55.3
	15	44 24.3	. . 03.1	0 48.1	14.6	12 34.2	12.5	55.2
	16	59 24.5	02.3	15 21.7	14.6	12 46.7	12.5	55.2
	17	74 24.7	01.4	29 55.3	14.6	12 59.2	12.3	55.2
	18	89 24.8	N11 00.6	44 28.9	14.5	S13 11.5	12.3	55.2
	19	104 25.0	10 59.7	59 02.4	14.5	13 23.8	12.3	55.2
	20	119 25.2	58.9	73 35.9	14.5	13 36.1	12.1	55.1
	21	134 25.3	. . 58.0	88 09.4	14.4	13 48.2	12.1	55.1
	22	149 25.5	57.1	102 42.8	14.5	14 00.3	12.1	55.1
	23	164 25.7	56.3	117 16.3	14.4	14 12.4	12.0	55.1
25 SATURDAY	00	179 25.8	N10 55.4	131 49.7	14.3	S14 24.4	11.9	55.0
	01	194 26.0	54.6	146 23.0	14.4	14 36.3	11.8	55.0
	02	209 26.2	53.7	160 56.4	14.3	14 48.1	11.7	55.0
	03	224 26.3	. . 52.8	175 29.7	14.3	14 59.8	11.7	55.0
	04	239 26.5	52.0	190 03.0	14.2	15 11.5	11.6	55.0
	05	254 26.7	51.1	204 36.2	14.2	15 23.1	11.6	55.0
	06	269 26.9	N10 50.3	219 09.4	14.2	S15 34.7	11.5	54.9
	07	284 27.0	49.4	233 42.6	14.2	15 46.2	11.3	54.9
	08	299 27.2	48.5	248 15.8	14.1	15 57.5	11.4	54.9
	09	314 27.4	. . 47.7	262 48.9	14.1	16 08.9	11.2	54.9
	10	329 27.5	46.8	277 22.0	14.0	16 20.1	11.2	54.9
	11	344 27.7	46.0	291 55.0	14.1	16 31.3	11.1	54.8
	12	359 27.9	N10 45.1	306 28.1	13.9	S16 42.4	11.0	54.8
	13	14 28.1	44.2	321 01.0	14.0	16 53.4	10.9	54.8
	14	29 28.2	43.4	335 34.0	13.9	17 04.3	10.9	54.8
	15	44 28.4	. . 42.5	350 06.9	13.9	17 15.2	10.8	54.8
	16	59 28.6	41.6	4 39.8	13.8	17 26.0	10.7	54.8
	17	74 28.7	40.8	19 12.6	13.8	17 36.7	10.6	54.7
	18	89 28.9	N10 39.9	33 45.4	13.7	S17 47.3	10.5	54.7
	19	104 29.1	39.0	48 18.1	13.8	17 57.8	10.5	54.7
	20	119 29.3	38.2	62 50.9	13.6	18 08.3	10.3	54.7
	21	134 29.4	. . 37.3	77 23.5	13.7	18 18.6	10.3	54.7
	22	149 29.6	36.5	91 56.2	13.6	18 28.9	10.2	54.7
	23	164 29.8	35.6	106 28.8	13.5	18 39.1	10.1	54.6
		S.D. 15.8	d 0.9	S.D.	15.2	15.1		14.9

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

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

Day	SUN Eqn. of Time 00 h	12 h	Mer. Pass.	MOON Mer. Pass. Upper	Lower	Age	Phase
	m s	m s	h m	h m	h m	d	
23	02 49	02 41	12 03	14 14	01 52	03	
24	02 33	02 25	12 02	14 57	02 35	04	
25	02 17	02 09	12 02	15 41	03 19	05	

1990 OCTOBER 13, 14, 15 (SAT., SUN., MON.)

UT (GMT) d	h	SUN G.H.A.	SUN Dec.	MOON G.H.A.	v	MOON Dec.	d	H.P.
		° ′	° ′	° ′	′	° ′	′	′
13	00	183 23.7	S 7 35.6	246 17.4	11.0	N16 16.4	12.2	57.6
	01	198 23.9	36.5	260 47.4	11.1	16 04.2	12.3	57.6
	02	213 24.0	37.4	275 17.5	11.1	15 51.9	12.4	57.6
	03	228 24.2	. . 38.4	289 47.6	11.3	15 39.5	12.4	57.6
	04	243 24.3	39.3	304 17.9	11.4	15 27.1	12.5	57.5
	05	258 24.5	40.2	318 48.3	11.4	15 14.6	12.6	57.5
	06	273 24.6	S 7 41.2	333 18.7	11.5	N15 02.0	12.6	57.5
	07	288 24.8	42.1	347 49.2	11.7	14 49.4	12.7	57.5
S	08	303 24.9	43.0	2 19.9	11.7	14 36.7	12.8	57.4
A	09	318 25.1	. . 44.0	16 50.6	11.8	14 23.9	12.8	57.4
T	10	333 25.2	44.9	31 21.4	11.8	14 11.1	12.9	57.4
U	11	348 25.4	45.9	45 52.2	12.0	13 58.2	12.9	57.4
R	12	3 25.5	S 7 46.8	60 23.2	12.0	N13 45.3	13.0	57.4
D	13	18 25.7	47.7	74 54.2	12.2	13 32.3	13.1	57.3
A	14	33 25.8	48.7	89 25.4	12.2	13 19.2	13.1	57.3
Y	15	48 26.0	. . 49.6	103 56.6	12.3	13 06.1	13.1	57.3
	16	63 26.1	50.5	118 27.9	12.3	12 53.0	13.3	57.3
	17	78 26.3	51.5	132 59.2	12.5	12 39.7	13.2	57.2
	18	93 26.4	S 7 52.4	147 30.7	12.5	N12 26.5	13.3	57.2
	19	108 26.6	53.3	162 02.2	12.5	12 13.2	13.4	57.2
	20	123 26.7	54.3	176 33.7	12.7	11 59.8	13.4	57.2
	21	138 26.9	. . 55.2	191 05.4	12.7	11 46.4	13.4	57.1
	22	153 27.0	56.1	205 37.1	12.8	11 33.0	13.5	57.1
	23	168 27.2	57.1	220 08.9	12.9	11 19.5	13.5	57.1
14	00	183 27.3	S 7 58.0	234 40.8	13.0	N11 06.0	13.6	57.1
	01	198 27.5	58.9	249 12.8	13.0	10 52.4	13.6	57.0
	02	213 27.6	7 59.9	263 44.8	13.1	10 38.8	13.7	57.0
	03	228 27.8	8 00.8	278 16.9	13.1	10 25.1	13.6	57.0
	04	243 27.9	01.7	292 49.0	13.2	10 11.5	13.8	57.0
	05	258 28.1	02.6	307 21.2	13.3	9 57.7	13.7	57.0
	06	273 28.2	S 8 03.6	321 53.5	13.3	N 9 44.0	13.8	56.9
	07	288 28.4	04.5	336 25.8	13.4	9 30.2	13.8	56.9
	08	303 28.5	05.4	350 58.2	13.5	9 16.4	13.9	56.9
S	09	318 28.7	. . 06.4	5 30.7	13.5	9 02.5	13.9	56.9
U	10	333 28.8	07.3	20 03.2	13.6	8 48.6	13.9	56.8
N	11	348 28.9	08.2	34 35.8	13.7	8 34.7	13.9	56.8
D	12	3 29.1	S 8 09.2	49 08.5	13.7	N 8 20.8	14.0	56.8
A	13	18 29.2	10.1	63 41.2	13.7	8 06.8	14.0	56.8
Y	14	33 29.4	11.0	78 13.9	13.8	7 52.8	14.0	56.8
	15	48 29.5	. . 12.0	92 46.7	13.9	7 38.8	14.1	56.7
	16	63 29.7	12.9	107 19.6	13.9	7 24.7	14.0	56.7
	17	78 29.8	13.8	121 52.5	13.9	7 10.7	14.1	56.7
	18	93 29.9	S 8 14.7	136 25.4	14.1	N 6 56.6	14.1	56.7
	19	108 30.1	15.7	150 58.5	14.0	6 42.5	14.2	56.6
	20	123 30.2	16.6	165 31.5	14.1	6 28.3	14.1	56.6
	21	138 30.4	. . 17.5	180 04.6	14.2	6 14.2	14.2	56.6
	22	153 30.5	18.5	194 37.8	14.2	6 00.0	14.1	56.6
	23	168 30.7	19.4	209 11.0	14.2	5 45.9	14.2	56.6
15	00	183 30.8	S 8 20.3	223 44.2	14.3	N 5 31.7	14.2	56.5
	01	198 30.9	21.2	238 17.5	14.3	5 17.5	14.3	56.5
	02	213 31.1	22.2	252 50.8	14.4	5 03.2	14.2	56.5
	03	228 31.2	. . 23.1	267 24.2	14.4	4 49.0	14.2	56.5
	04	243 31.4	24.0	281 57.6	14.5	4 34.8	14.3	56.4
	05	258 31.5	24.9	296 31.1	14.5	4 20.5	14.2	56.4
	06	273 31.6	S 8 25.9	311 04.6	14.5	N 4 06.3	14.3	56.4
	07	288 31.8	26.8	325 38.1	14.6	3 52.0	14.3	56.4
	08	303 31.9	27.7	340 11.7	14.6	3 37.7	14.3	56.4
M	09	318 32.1	. . 28.7	354 45.3	14.6	3 23.4	14.2	56.3
O	10	333 32.2	29.6	9 18.9	14.6	3 09.2	14.3	56.3
N	11	348 32.3	30.5	23 52.5	14.7	2 54.9	14.3	56.3
D	12	3 32.5	S 8 31.4	38 26.2	14.8	N 2 40.6	14.3	56.3
A	13	18 32.6	32.4	53 00.0	14.7	2 26.3	14.3	56.3
Y	14	33 32.8	33.3	67 33.7	14.8	2 12.0	14.3	56.2
	15	48 32.9	. . 34.2	82 07.5	14.8	1 57.7	14.3	56.2
	16	63 33.0	35.1	96 41.3	14.8	1 43.4	14.2	56.2
	17	78 33.2	36.1	111 15.1	14.9	1 29.2	14.3	56.2
	18	93 33.3	S 8 37.0	125 49.0	14.9	N 1 14.9	14.3	56.1
	19	108 33.4	37.9	140 22.9	14.9	1 00.6	14.3	56.1
	20	123 33.6	38.8	154 56.8	14.9	0 46.3	14.2	56.1
	21	138 33.7	. . 39.8	169 30.7	15.0	0 32.1	14.3	56.1
	22	153 33.9	40.7	184 04.7	14.9	0 17.8	14.2	56.1
	23	168 34.0	41.6	198 38.6	15.0	0 03.6	14.3	56.0
		S.D. 16.1	d 0.9	S.D. 15.6		15.5		15.3

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

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

Day	SUN Eqn. of Time 00h	SUN Eqn. of Time 12h	SUN Mer. Pass.	MOON Mer. Pass. Upper	MOON Mer. Pass. Lower	Age	Phase
	m s	m s	h m	h m	h m	d	
13	13 35	13 42	11 46	07 50	20 14	24	
14	13 49	13 56	11 46	08 37	21 00	25	
15	14 03	14 10	11 46	09 22	21 43	26	

UT (GMT)	ARIES G.H.A.	VENUS −3.9 G.H.A.	VENUS Dec.	MARS −1.3 G.H.A.	MARS Dec.	JUPITER −2.1 G.H.A.	JUPITER Dec.	SATURN +0.5 G.H.A.	SATURN Dec.	STARS Name	S.H.A.	Dec.
d h	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′		° ′	° ′
16 00	24 15.2	187 04.0	S 5 54.4	311 06.6	N21 56.2	251 12.1	N18 01.2	93 32.0	S22 07.9	Acamar	315 30.7	S40 20.2
01	39 17.7	202 03.6	55.6	326 08.9	56.3	266 14.3	01.1	108 34.4	07.9	Achernar	335 38.5	S57 16.8
02	54 20.1	217 03.1	56.9	341 11.2	56.4	281 16.4	01.0	123 36.7	07.8	Acrux	173 29.3	S63 02.8
03	69 22.6	232 02.7	· · 58.1	356 13.5	· · 56.5	296 18.5	· · 00.9	138 39.1	· · 07.8	Adhara	255 25.8	S28 57.2
04	84 25.1	247 02.3	5 59.3	11 15.8	56.6	311 20.7	00.9	153 41.4	07.8	Aldebaran	291 08.7	N16 29.7
05	99 27.5	262 01.9	6 00.6	26 18.1	56.7	326 22.8	00.8	168 43.8	07.8			
06	114 30.0	277 01.4	S 6 01.8	41 20.4	N21 56.8	341 24.9	N18 00.7	183 46.2	S22 07.8	Alioth	166 35.9	N56 00.5
07	129 32.5	292 01.0	03.0	56 22.7	57.0	356 27.1	00.6	198 48.5	07.8	Alkaid	153 12.6	N49 21.5
T 08	144 34.9	307 00.6	04.3	71 25.0	57.1	11 29.2	00.5	213 50.9	07.8	Al Na'ir	28 04.6	S47 00.4
U 09	159 37.4	322 00.1	· · 05.5	86 27.3	· · 57.2	26 31.3	· · 00.5	228 53.3	· · 07.8	Alnilam	276 03.4	S 1 12.2
E 10	174 39.9	336 59.7	06.7	101 29.6	57.3	41 33.5	00.4	243 55.6	07.8	Alphard	218 12.9	S 8 37.0
S 11	189 42.3	351 59.3	07.9	116 31.9	57.4	56 35.6	00.3	258 58.0	07.8			
D 12	204 44.8	6 58.9	S 6 09.2	131 34.2	N21 57.5	71 37.8	N18 00.2	274 00.3	S22 07.7	Alphecca	126 25.7	N26 44.8
A 13	219 47.2	21 58.4	10.4	146 36.5	57.6	86 39.9	00.1	289 02.7	07.7	Alpheratz	358 00.9	N29 02.6
Y 14	234 49.7	36 58.0	11.6	161 38.8	57.8	101 42.0	00.0	304 05.1	07.7	Altair	62 24.8	N 8 50.7
15	249 52.2	51 57.6	· · 12.8	176 41.1	· · 57.9	116 44.2	18 00.0	319 07.4	· · 07.7	Ankaa	353 31.9	S42 21.2
16	264 54.6	66 57.1	14.1	191 43.5	58.0	131 46.3	17 59.9	334 09.8	07.7	Antares	112 47.4	S26 24.8
17	279 57.1	81 56.7	15.3	206 45.8	58.1	146 48.4	59.8	349 12.2	07.7			
18	294 59.6	96 56.3	S 6 16.5	221 48.1	N21 58.2	161 50.6	N17 59.7	4 14.5	S22 07.7	Arcturus	146 11.5	N19 13.8
19	310 02.0	111 55.8	17.7	236 50.4	58.3	176 52.7	59.6	19 16.9	07.7	Atria	108 05.0	S69 01.0
20	325 04.5	126 55.4	19.0	251 52.7	58.4	191 54.9	59.6	34 19.2	07.7	Avior	234 25.2	S59 28.4
21	340 07.0	141 55.0	· · 20.2	266 55.1	· · 58.6	206 57.0	· · 59.5	49 21.6	· · 07.6	Bellatrix	278 50.1	N 6 20.7
22	355 09.4	156 54.5	21.4	281 57.4	58.7	221 59.1	59.4	64 24.0	07.6	Betelgeuse	271 19.5	N 7 24.5
23	10 11.9	171 54.1	22.6	296 59.7	58.8	237 01.3	59.3	79 26.3	07.6			
17 00	25 14.4	186 53.7	S 6 23.9	312 02.0	N21 58.9	252 03.4	N17 59.2	94 28.7	S22 07.6	Canopus	264 03.5	S52 41.0
01	40 16.8	201 53.2	25.1	327 04.4	59.0	267 05.6	59.2	109 31.0	07.6	Capella	280 59.3	N45 59.4
02	55 19.3	216 52.8	26.3	342 06.7	59.1	282 07.7	59.1	124 33.4	07.6	Deneb	49 43.0	N45 15.1
03	70 21.7	231 52.4	· · 27.5	357 09.0	· · 59.2	297 09.8	· · 59.0	139 35.8	· · 07.6	Denebola	182 51.2	N14 37.4
04	85 24.2	246 51.9	28.8	12 11.4	59.4	312 12.0	58.9	154 38.1	07.6	Diphda	349 12.5	S18 02.0
05	100 26.7	261 51.5	30.0	27 13.7	59.5	327 14.1	58.9	169 40.5	07.6			
06	115 29.1	276 51.1	S 6 31.2	42 16.0	N21 59.6	342 16.3	N17 58.8	184 42.8	S22 07.6	Dubhe	194 12.6	N61 47.9
W 07	130 31.6	291 50.6	32.4	57 18.4	59.7	357 18.4	58.7	199 45.2	07.5	Elnath	278 33.9	N28 36.1
E 08	145 34.1	306 50.2	33.7	72 20.7	59.8	12 20.6	58.6	214 47.6	07.5	Eltanin	90 54.3	N51 29.6
D 09	160 36.5	321 49.8	· · 34.9	87 23.1	21 59.9	27 22.7	· · 58.5	229 49.9	· · 07.5	Enif	34 03.7	N 9 50.1
N 10	175 39.0	336 49.3	36.1	102 25.4	22 00.0	42 24.8	58.5	244 52.3	07.5	Fomalhaut	15 42.3	S29 40.2
E 11	190 41.5	351 48.9	37.3	117 27.7	00.1	57 27.0	58.4	259 54.6	07.5			
S 12	205 43.9	6 48.5	S 6 38.6	132 30.1	N22 00.3	72 29.1	N17 58.3	274 57.0	S22 07.5	Gacrux	172 20.7	S57 03.6
D 13	220 46.4	21 48.0	39.8	147 32.4	00.4	87 31.3	58.2	289 59.3	07.5	Gienah	176 10.2	S17 29.4
A 14	235 48.8	36 47.6	41.0	162 34.8	00.5	102 33.4	58.1	305 01.7	07.5	Hadar	149 13.0	S60 19.8
Y 15	250 51.3	51 47.2	· · 42.2	177 37.1	· · 00.6	117 35.6	· · 58.1	320 04.1	· · 07.5	Hamal	328 19.7	N23 25.4
16	265 53.8	66 46.7	43.4	192 39.5	00.7	132 37.7	58.0	335 06.4	07.4	Kaus Aust.	84 06.4	S34 23.5
17	280 56.2	81 46.3	44.7	207 41.9	00.8	147 39.8	57.9	350 08.8	07.4			
18	295 58.7	96 45.8	S 6 45.9	222 44.2	N22 00.9	162 42.0	N17 57.8	5 11.1	S22 07.4	Kochab	137 20.0	N74 11.6
19	311 01.2	111 45.4	47.1	237 46.6	01.0	177 44.1	57.7	20 13.5	07.4	Markab	13 55.1	N15 09.6
20	326 03.6	126 45.0	48.3	252 48.9	01.1	192 46.3	57.7	35 15.8	07.4	Menkar	314 32.5	N 4 03.5
21	341 06.1	141 44.5	· · 49.5	267 51.3	· · 01.3	207 48.4	· · 57.6	50 18.2	· · 07.4	Menkent	148 28.1	S36 19.5
22	356 08.6	156 44.1	50.8	282 53.7	01.4	222 50.6	57.5	65 20.6	07.4	Miaplacidus	221 43.9	S69 40.4
23	11 11.0	171 43.7	52.0	297 56.0	01.5	237 52.7	57.4	80 22.9	07.4			
18 00	26 13.5	186 43.2	S 6 53.2	312 58.4	N22 01.6	252 54.9	N17 57.4	95 25.3	S22 07.4	Mirfak	309 04.4	N49 49.8
01	41 16.0	201 42.8	54.4	328 00.8	01.7	267 57.0	57.3	110 27.6	07.3	Nunki	76 19.4	S26 18.6
02	56 18.4	216 42.3	55.6	343 03.1	01.8	282 59.2	57.2	125 30.0	07.3	Peacock	53 45.6	S56 46.1
03	71 20.9	231 41.9	· · 56.9	358 05.5	· · 01.9	298 01.3	· · 57.1	140 32.3	· · 07.3	Pollux	243 48.4	N28 02.9
04	86 23.3	246 41.5	58.1	13 07.9	02.0	313 03.4	57.0	155 34.7	07.3	Procyon	245 17.5	N 5 15.1
05	101 25.8	261 41.0	6 59.3	28 10.2	02.1	328 05.6	57.0	170 37.0	07.3			
06	116 28.3	276 40.6	S 7 00.5	43 12.6	N22 02.3	343 07.7	N17 56.9	185 39.4	S22 07.3	Rasalhague	96 22.4	N12 34.1
07	131 30.7	291 40.1	01.7	58 15.0	02.4	358 09.9	56.8	200 41.8	07.3	Regulus	208 01.7	N12 00.8
T 08	146 33.2	306 39.7	02.9	73 17.4	02.5	13 12.0	56.7	215 44.1	07.3	Rigel	281 28.2	S 8 12.4
H 09	161 35.7	321 39.3	· · 04.2	88 19.8	· · 02.6	28 14.2	· · 56.6	230 46.5	· · 07.3	Rigil Kent.	140 15.8	S60 47.9
U 10	176 38.1	336 38.8	05.4	103 22.1	02.7	43 16.3	56.6	245 48.8	07.2	Sabik	102 32.3	S15 42.9
R 11	191 40.6	351 38.4	06.6	118 24.5	02.8	58 18.5	56.5	260 51.2	07.2			
S 12	206 43.1	6 37.9	S 7 07.8	133 26.9	N22 02.9	73 20.6	N17 56.4	275 53.5	S22 07.2	Schedar	349 59.6	N56 29.5
D 13	221 45.5	21 37.5	09.0	148 29.3	03.0	88 22.8	56.3	290 55.9	07.2	Shaula	96 45.2	S37 06.0
A 14	236 48.0	36 37.0	10.2	163 31.7	03.1	103 24.9	56.3	305 58.2	07.2	Sirius	258 48.6	S16 41.9
Y 15	251 50.5	51 36.6	· · 11.4	178 34.1	· · 03.2	118 27.1	· · 56.2	321 00.6	· · 07.2	Spica	158 49.5	S11 06.8
16	266 52.9	66 36.2	12.7	193 36.5	03.3	133 29.2	56.1	336 02.9	07.2	Suhail	223 05.2	S43 23.4
17	281 55.4	81 35.7	13.9	208 38.9	03.5	148 31.4	56.0	351 05.3	07.2			
18	296 57.8	96 35.3	S 7 15.1	223 41.3	N22 03.6	163 33.5	N17 56.0	6 07.6	S22 07.1	Vega	80 50.6	N38 46.7
19	312 00.3	111 34.8	16.3	238 43.6	03.7	178 35.7	55.9	21 10.0	07.1	Zuben'ubi	137 24.6	S16 00.3
20	327 02.8	126 34.4	17.5	253 46.0	03.8	193 37.8	55.8	36 12.3	07.1		S.H.A.	Mer. Pass.
21	342 05.2	141 33.9	· · 18.7	268 48.4	· · 03.9	208 40.0	· · 55.7	51 14.7	· · 07.1		° ′	h m
22	357 07.7	156 33.5	19.9	283 50.8	04.0	223 42.1	55.6	66 17.1	07.1	Venus	161 39.3	11 33
23	12 10.2	171 33.1	21.2	298 53.3	04.1	238 44.3	55.6	81 19.4	07.1	Mars	286 47.7	3 11
	h m									Jupiter	226 49.1	7 11
Mer. Pass.	22 15.4	v −0.4	d 1.2	v 2.3	d 0.1	v 2.1	d 0.1	v 2.4	d 0.0	Saturn	69 14.3	17 39

	UT (GMT) d h	ARIES G.H.A.	VENUS −3.9 G.H.A.	VENUS Dec.	MARS −1.5 G.H.A.	MARS Dec.	JUPITER −2.4 G.H.A.	JUPITER Dec.	SATURN +0.6 G.H.A.	SATURN Dec.
		° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′
	15 00	83 23.6	169 40.9	S24 09.9	26 13.1	N22 08.1	307 30.2	N17 26.6	147 44.6	S21 28.5
	01	98 26.0	184 40.0	09.9	41 16.2	08.0	322 32.8	26.7	162 46.8	28.4
	02	113 28.5	199 39.0	09.9	56 19.3	07.9	337 35.4	26.7	177 48.9	28.4
	03	128 31.0	214 38.0	· · 09.9	71 22.4	· · 07.9	352 38.0	· · 26.8	192 51.1	· · 28.4
	04	143 33.4	229 37.0	09.9	86 25.5	07.8	7 40.5	26.8	207 53.3	28.3
	05	158 35.9	244 36.0	09.9	101 28.6	07.8	22 43.1	26.9	222 55.5	28.3
	06	173 38.3	259 35.1	S24 09.9	116 31.7	N22 07.7	37 45.7	N17 26.9	237 57.7	S21 28.2
	07	188 40.8	274 34.1	09.9	131 34.8	07.6	52 48.3	26.9	252 59.8	28.2
S	08	203 43.3	289 33.1	09.9	146 37.9	07.6	67 50.9	27.0	268 02.0	28.1
A	09	218 45.7	304 32.1	· · 09.9	161 41.0	· · 07.5	82 53.5	· · 27.0	283 04.2	· · 28.1
T	10	233 48.2	319 31.1	09.9	176 44.1	07.4	97 56.1	27.1	298 06.4	28.1
U	11	248 50.7	334 30.2	09.9	191 47.2	07.4	112 58.6	27.1	313 08.5	28.0
R	12	263 53.1	349 29.2	S24 09.9	206 50.2	N22 07.3	128 01.2	N17 27.2	328 10.7	S21 28.0
D	13	278 55.6	4 28.2	09.9	221 53.3	07.2	143 03.8	27.2	343 12.9	27.9
A	14	293 58.1	19 27.2	09.9	236 56.4	07.2	158 06.4	27.3	358 15.1	27.9
Y	15	309 00.5	34 26.3	· · 09.9	251 59.5	· · 07.1	173 09.0	· · 27.3	13 17.3	· · 27.8
	16	324 03.0	49 25.3	09.9	267 02.6	07.0	188 11.6	27.3	28 19.4	27.8
	17	339 05.4	64 24.3	09.9	282 05.7	07.0	203 14.2	27.4	43 21.6	27.7
	18	354 07.9	79 23.3	S24 09.9	297 08.7	N22 06.9	218 16.8	N17 27.4	58 23.8	S21 27.7
	19	9 10.4	94 22.3	09.8	312 11.8	06.8	233 19.3	27.5	73 26.0	27.7
	20	24 12.8	109 21.4	09.8	327 14.9	06.8	248 21.9	27.5	88 28.1	27.6
	21	39 15.3	124 20.4	· · 09.8	342 18.0	· · 06.7	263 24.5	· · 27.6	103 30.3	· · 27.6
	22	54 17.8	139 19.4	09.8	357 21.0	06.6	278 27.1	27.6	118 32.5	27.5
	23	69 20.2	154 18.4	09.8	12 24.1	06.6	293 29.7	27.7	133 34.7	27.5
	16 00	84 22.7	169 17.5	S24 09.8	27 27.2	N22 06.5	308 32.3	N17 27.7	148 36.9	S21 27.4
	01	99 25.2	184 16.5	09.7	42 30.2	06.5	323 34.9	27.7	163 39.0	27.4
	02	114 27.6	199 15.5	09.7	57 33.3	06.4	338 37.5	27.8	178 41.2	27.4
	03	129 30.1	214 14.5	· · 09.7	72 36.4	· · 06.3	353 40.1	· · 27.8	193 43.4	· · 27.3
	04	144 32.6	229 13.5	09.7	87 39.4	06.3	8 42.7	27.9	208 45.6	27.3
	05	159 35.0	244 12.6	09.6	102 42.5	06.2	23 45.3	27.9	223 47.7	27.2
	06	174 37.5	259 11.6	S24 09.6	117 45.6	N22 06.1	38 47.8	N17 28.0	238 49.9	S21 27.2
	07	189 39.9	274 10.6	09.6	132 48.6	06.1	53 50.4	28.0	253 52.1	27.1
	08	204 42.4	289 09.6	09.5	147 51.7	06.0	68 53.0	28.1	268 54.3	27.1
S	09	219 44.9	304 08.7	· · 09.5	162 54.7	· · 06.0	83 55.6	· · 28.1	283 56.4	· · 27.0
U	10	234 47.3	319 07.7	09.5	177 57.8	05.9	98 58.2	28.2	298 58.6	27.0
N	11	249 49.8	334 06.7	09.4	193 00.8	05.8	114 00.8	28.2	314 00.8	27.0
D	12	264 52.3	349 05.7	S24 09.4	208 03.9	N22 05.8	129 03.4	N17 28.3	329 03.0	S21 26.9
A	13	279 54.7	4 04.8	09.3	223 06.9	05.7	144 06.0	28.3	344 05.2	26.9
Y	14	294 57.2	19 03.8	09.3	238 10.0	05.6	159 08.6	28.3	359 07.3	26.8
	15	309 59.7	34 02.8	· · 09.3	253 13.0	· · 05.6	174 11.2	· · 28.4	14 09.5	· · 26.8
	16	325 02.1	49 01.8	09.2	268 16.1	05.5	189 13.8	28.4	29 11.7	26.7
	17	340 04.6	64 00.8	09.2	283 19.1	05.5	204 16.4	28.5	44 13.9	26.7
	18	355 07.1	78 59.9	S24 09.1	298 22.2	N22 05.4	219 19.0	N17 28.5	59 16.0	S21 26.6
	19	10 09.5	93 58.9	09.1	313 25.2	05.3	234 21.6	28.6	74 18.2	26.6
	20	25 12.0	108 57.9	09.0	328 28.3	05.3	249 24.2	28.6	89 20.4	26.6
	21	40 14.4	123 56.9	· · 09.0	343 31.3	· · 05.2	264 26.8	· · 28.7	104 22.6	· · 26.5
	22	55 16.9	138 56.0	08.9	358 34.3	05.2	279 29.4	28.7	119 24.7	26.5
	23	70 19.4	153 55.0	08.9	13 37.4	05.1	294 32.0	28.8	134 26.9	26.4
	17 00	85 21.8	168 54.0	S24 08.8	28 40.4	N22 05.0	309 34.6	N17 28.8	149 29.1	S21 26.4
	01	100 24.3	183 53.0	08.8	43 43.4	05.0	324 37.2	28.9	164 31.3	26.3
	02	115 26.8	198 52.1	08.7	58 46.5	04.9	339 39.8	28.9	179 33.4	26.3
	03	130 29.2	213 51.1	· · 08.7	73 49.5	· · 04.9	354 42.4	· · 29.0	194 35.6	· · 26.2
	04	145 31.7	228 50.1	08.6	88 52.5	04.8	9 45.0	29.0	209 37.8	26.2
	05	160 34.2	243 49.1	08.5	103 55.6	04.7	24 47.6	29.1	224 40.0	26.2
	06	175 36.6	258 48.1	S24 08.5	118 58.6	N22 04.7	39 50.2	N17 29.1	239 42.1	S21 26.1
	07	190 39.1	273 47.2	08.4	134 01.6	04.6	54 52.8	29.2	254 44.3	26.1
	08	205 41.5	288 46.2	08.4	149 04.6	04.6	69 55.4	29.2	269 46.5	26.0
M	09	220 44.0	303 45.2	· · 08.3	164 07.6	· · 04.5	84 58.0	· · 29.2	284 48.7	· · 26.0
O	10	235 46.5	318 44.2	08.2	179 10.7	04.4	100 00.6	29.3	299 50.8	25.9
N	11	250 48.9	333 43.3	08.2	194 13.7	04.4	115 03.2	29.3	314 53.0	25.9
D	12	265 51.4	348 42.3	S24 08.1	209 16.7	N22 04.3	130 05.8	N17 29.4	329 55.2	S21 25.8
A	13	280 53.9	3 41.3	08.0	224 19.7	04.3	145 08.4	29.4	344 57.4	25.8
Y	14	295 56.3	18 40.3	08.0	239 22.7	04.2	160 11.0	29.5	359 59.5	25.8
	15	310 58.8	33 39.4	· · 07.9	254 25.7	· · 04.2	175 13.6	· · 29.5	15 01.7	· · 25.7
	16	326 01.3	48 38.4	07.8	269 28.8	04.1	190 16.2	29.6	30 03.9	25.7
	17	341 03.7	63 37.4	07.7	284 31.8	04.0	205 18.8	29.6	45 06.1	25.6
	18	356 06.2	78 36.4	S24 07.7	299 34.8	N22 04.0	220 21.4	N17 29.7	60 08.2	S21 25.6
	19	11 08.7	93 35.5	07.6	314 37.8	03.9	235 24.0	29.7	75 10.4	25.5
	20	26 11.1	108 34.5	07.5	329 40.8	03.9	250 26.6	29.8	90 12.6	25.5
	21	41 13.6	123 33.5	· · 07.4	344 43.8	· · 03.8	265 29.2	· · 29.8	105 14.8	· · 25.4
	22	56 16.0	138 32.5	07.3	359 46.8	03.8	280 31.8	29.9	120 16.9	25.4
	23	71 18.5	153 31.6	07.3	14 49.8	03.7	295 34.4	29.9	135 19.1	25.3
	Mer. Pass.	h m 18 19.5	v −1.0	d 0.0	v 3.1	d 0.1	v 2.6	d 0.0	v 2.2	d 0.0

STARS

Name	S.H.A.	Dec.
	° ′	° ′
Acamar	315 30.7	S40 20.5
Achernar	335 38.7	S57 17.1
Acrux	173 28.6	S63 02.7
Adhara	255 25.4	S28 57.5
Aldebaran	291 08.4	N16 29.6
Alioth	166 35.4	N56 00.2
Alkaid	153 12.3	N49 21.2
Al Na'ir	28 04.9	S47 00.5
Alnilam	276 03.1	S 1 12.3
Alphard	218 12.5	S 8 37.1
Alphecca	126 25.6	N26 44.5
Alpheratz	358 01.0	N29 02.7
Altair	62 25.0	N 8 50.7
Ankaa	353 32.1	S42 21.4
Antares	112 47.3	S26 24.8
Arcturus	146 11.3	N19 13.6
Atria	108 05.0	S69 00.7
Avior	234 24.5	S59 28.6
Bellatrix	278 49.7	N 6 20.6
Betelgeuse	271 19.2	N 7 24.4
Canopus	264 03.1	S52 41.3
Capella	280 58.9	N45 59.5
Deneb	49 43.4	N45 15.1
Denebola	182 50.8	N14 37.2
Diphda	349 12.6	S18 02.2
Dubhe	194 11.9	N61 47.6
Elnath	278 33.5	N28 36.1
Eltanin	90 54.5	N51 29.3
Enif	34 03.8	N 9 50.1
Fomalhaut	15 42.5	S29 40.3
Gacrux	172 20.1	S57 03.6
Gienah	176 09.8	S17 29.5
Hadar	149 12.5	S60 19.6
Hamal	328 19.6	N23 25.4
Kaus Aust.	84 06.5	S34 23.5
Kochab	137 19.9	N74 11.2
Markab	13 55.2	N15 09.6
Menkar	314 32.4	N 4 03.4
Menkent	148 27.8	S36 19.5
Miaplacidus	221 42.9	S69 40.6
Mirfak	309 04.2	N49 50.0
Nunki	76 19.5	S26 18.6
Peacock	53 46.0	S56 46.1
Pollux	243 47.9	N28 02.9
Procyon	245 17.0	N 5 14.9
Rasalhague	96 22.4	N12 33.9
Regulus	208 01.3	N12 00.6
Rigel	281 27.9	S 8 12.6
Rigil Kent.	140 15.4	S60 47.7
Sabik	102 32.2	S15 42.9
Schedar	349 59.8	N56 29.7
Shaula	96 45.2	S37 05.9
Sirius	258 48.2	S16 42.1
Spica	158 49.2	S11 06.9
Suhail	223 04.6	S43 23.6
Vega	80 50.8	N38 46.5
Zuben'ubi	137 24.4	S16 00.3

	S.H.A.	Mer. Pass.
	° ′	h m
Venus	84 54.8	12 44
Mars	303 04.5	22 06
Jupiter	224 09.6	3 25
Saturn	64 14.2	14 04

UT (GMT)	SUN G.H.A.	SUN Dec.	MOON G.H.A.	v	MOON Dec.	d	H.P.
d h	° ′	° ′	° ′	′	° ′	′	′
15 00	181 17.7	S23 14.6	207 31.4	11.5	S24 18.9	5.3	54.0
01	196 17.4	14.7	222 01.9	11.5	24 24.2	5.1	54.0
02	211 17.1	14.8	236 32.4	11.4	24 29.3	5.0	54.0
03	226 16.8	. . 15.0	251 02.8	11.4	24 34.3	4.9	54.0
04	241 16.5	15.1	265 33.2	11.3	24 39.2	4.8	54.0
05	256 16.2	15.2	280 03.5	11.3	24 44.0	4.7	54.0
06	271 15.9	S23 15.4	294 33.8	11.3	S24 48.7	4.5	54.0
07	286 15.6	15.5	309 04.1	11.2	24 53.2	4.4	54.0
S 08	301 15.3	15.6	323 34.3	11.2	24 57.6	4.4	54.0
A 09	316 15.0	. . 15.8	338 04.5	11.2	25 02.0	4.2	54.0
T 10	331 14.7	15.9	352 34.7	11.1	25 06.2	4.0	54.0
U 11	346 14.4	16.0	7 04.8	11.1	25 10.2	4.0	54.0
R 12	1 14.1	S23 16.2	21 34.9	11.0	S25 14.2	3.9	53.9
D 13	16 13.8	16.3	36 04.9	11.0	25 18.1	3.7	53.9
A 14	31 13.5	16.4	50 34.9	11.0	25 21.8	3.6	53.9
Y 15	46 13.2	. . 16.6	65 04.9	11.0	25 25.4	3.5	53.9
16	61 12.9	16.7	79 34.9	10.9	25 28.9	3.4	53.9
17	76 12.6	16.8	94 04.8	10.9	25 32.3	3.2	53.9
18	91 12.3	S23 16.9	108 34.7	10.9	S25 35.5	3.2	53.9
19	106 12.0	17.1	123 04.6	10.8	25 38.7	3.0	53.9
20	121 11.7	17.2	137 34.4	10.8	25 41.7	2.8	53.9
21	136 11.4	. . 17.3	152 04.2	10.8	25 44.5	2.8	53.9
22	151 11.1	17.4	166 34.0	10.8	25 47.3	2.7	53.9
23	166 10.8	17.5	181 03.8	10.7	25 50.0	2.5	53.9
16 00	181 10.5	S23 17.7	195 33.5	10.7	S25 52.5	2.4	53.9
01	196 10.2	17.8	210 03.2	10.7	25 54.9	2.3	53.9
02	211 09.9	17.9	224 32.9	10.7	25 57.2	2.1	53.9
03	226 09.6	. . 18.0	239 02.6	10.6	25 59.3	2.0	53.9
04	241 09.3	18.1	253 32.2	10.7	26 01.3	2.0	53.9
05	256 08.9	18.3	268 01.9	10.6	26 03.3	1.7	53.9
06	271 08.6	S23 18.4	282 31.5	10.6	S26 05.0	1.7	53.9
07	286 08.3	18.5	297 01.1	10.5	26 06.7	1.5	53.9
08	301 08.0	18.6	311 30.6	10.6	26 08.2	1.4	53.9
S 09	316 07.7	. . 18.7	326 00.2	10.5	26 09.6	1.3	53.9
U 10	331 07.4	18.8	340 29.7	10.6	26 10.9	1.2	53.9
N 11	346 07.1	18.9	354 59.3	10.5	26 12.1	1.0	53.9
D 12	1 06.8	S23 19.0	9 28.8	10.5	S26 13.1	0.9	53.9
A 13	16 06.5	19.2	23 58.3	10.5	26 14.0	0.8	53.9
Y 14	31 06.2	19.3	38 27.8	10.5	26 14.8	0.7	53.9
15	46 05.9	. . 19.4	52 57.3	10.5	26 15.5	0.5	53.9
16	61 05.6	19.5	67 26.8	10.4	26 16.0	0.4	53.9
17	76 05.3	19.6	81 56.2	10.5	26 16.4	0.3	53.9
18	91 05.0	S23 19.7	96 25.7	10.5	S26 16.7	0.1	53.9
19	106 04.7	19.8	110 55.2	10.4	26 16.8	0.1	53.9
20	121 04.4	19.9	125 24.6	10.5	26 16.9	0.1	54.0
21	136 04.1	. . 20.0	139 54.1	10.4	26 16.8	0.3	54.0
22	151 03.8	20.1	154 23.5	10.5	26 16.5	0.3	54.0
23	166 03.5	20.2	168 53.0	10.4	26 16.2	0.5	54.0
17 00	181 03.2	S23 20.3	183 22.4	10.5	S26 15.7	0.6	54.0
01	196 02.9	20.4	197 51.9	10.4	26 15.1	0.7	54.0
02	211 02.6	20.5	212 21.3	10.5	26 14.4	0.9	54.0
03	226 02.2	. . 20.6	226 50.8	10.5	26 13.5	1.0	54.0
04	241 01.9	20.7	241 20.3	10.4	26 12.5	1.1	54.0
05	256 01.6	20.8	255 49.7	10.5	26 11.4	1.2	54.0
06	271 01.3	S23 20.9	270 19.2	10.5	S26 10.2	1.4	54.0
07	286 01.0	21.0	284 48.7	10.5	26 08.8	1.4	54.0
08	301 00.7	21.1	299 18.2	10.5	26 07.4	1.6	54.0
M 09	316 00.4	. . 21.2	313 47.7	10.5	26 05.8	1.8	53.9
O 10	331 00.1	21.3	328 17.2	10.5	26 04.0	1.8	54.0
N 11	345 59.8	21.4	342 46.7	10.5	26 02.2	2.0	54.0
D 12	0 59.5	S23 21.5	357 16.2	10.6	S26 00.2	2.1	54.0
A 13	15 59.2	21.5	11 45.8	10.5	25 58.1	2.3	54.0
Y 14	30 58.9	21.6	26 15.3	10.6	25 55.8	2.3	54.0
15	45 58.6	. . 21.7	40 44.9	10.6	25 53.5	2.5	54.0
16	60 58.3	21.8	55 14.5	10.6	25 51.0	2.6	54.0
17	75 58.0	21.9	69 44.1	10.7	25 48.4	2.8	54.0
18	90 57.7	S23 22.0	84 13.8	10.6	S25 45.6	2.8	54.0
19	105 57.3	22.1	98 43.4	10.7	25 42.8	3.0	54.0
20	120 57.0	22.1	113 13.1	10.7	25 39.8	3.1	54.1
21	135 56.7	. . 22.2	127 42.8	10.7	25 36.7	3.2	54.1
22	150 56.4	22.3	142 12.5	10.7	25 33.5	3.4	54.1
23	165 56.1	22.4	156 42.2	10.8	25 30.1	3.4	54.1
	S.D. 16.3	d 0.1	S.D. 14.7		14.7		14.7

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

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

Day	SUN Eqn. of Time 00 h	12 h	Mer. Pass.	MOON Mer. Pass. Upper	Lower	Age	Phase
	m s	m s	h m	h m	h m	d	
15	05 11	04 57	11 55	10 31	22 56	28	
16	04 42	04 28	11 56	11 21	23 46	29	●
17	04 13	03 59	11 56	12 11	24 36	00	