Complete Sun Sight Reduction Procedure

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Sun Sight

Reduction Form

Caution

If you find any errors in the following procedure please contact TheNauticalAlmanac.com at;
info@TheNauticalAlmanac.com

Usage

The Sun sight reduction form found at the end of this file simplifies the process of a Sun sight reduction while using the horizon. The steps are sequential starting from the top of the form and working downwards. In each step of the process explained herein please write in the figures obtained in each of the appropriate boxes so that you can see how the results are obtained.

In the following description and examples the writing may appear to be repetitive, dull and simple in style but the intention is to avoid ambiguity in explanation of the sight reduction process. The directions are written for the beginner who knows how to use a sextant but may not know how to complete a Sun sight reduction. All of this may be of some assistance to the solo sailor who, during a voyage, might be completely exhausted, confused and forgetful of the entire reduction process.

Conventions

In this procedure Latitude and Longitude figures are written listing hemisphere first and then degrees.

Assumptions

You know how to use a sextant and will be taking Sun sights from an unobstructed horizon- the ocean.

Explanation

Refer to the Sun sight reduction form at the end of this file. Each of the following topics are sequentially part of the form.

Sight

This is the number of the sight you took. It's not necessary but is helpful if you misplace the form or get several forms out of sequence.

DR Latitude/DR Longitude

This is the *Dead Reckoning Position Latitude* (DR. Lat.) and *Dead Reckoning* Position *Longitude* (DR. λ) that you'll use for the sight reduction. Simply, it's the whole degree figure of where you think you are and is typically based on your DR sailing log. Example- N 25° **/** W 025° would be written in the Sun sight form boxes **DR Latitude** and **DR Longitude.** **Note**- This IS NOT the same total, complete, figure used later as AP λ (Assumed Position longitude).

For the purposes of this Sun sight reduction a DR. Lat. of N 27° and an DR. λ of W 025° will be used.

Date

The date is based on UT/Greenwich time. Write the date in the *Date* box. For example, if you're sailing 20 nm off the East coast of the US at 9 PM DST on August 23 the time in UT is 01:00 and the date is August 24th. So be careful in writing in the date according to UT/Greenwich time and not Local time. In this process we'll use an example date of August 24, 2015.

GMT/UT

Universal Time or simply *UT,* is interchangeable with *Greenwich Mean Time* (GMT) for celestial work. Write the UT in the *GMT/UT box.* In this process we'll use an example time of UT 14:18:15 and date of August 24, 2015.

Hs

Height of Sextant. This is the initial uncorrected altitude observation you make with your sextant. It's the sight you took when you stepped on deck and *took the shot* of the Sun.

D. R. I. P. S.

D.R.I.P.S. has nothing directly to do with the Sun sight form attached herein. But, as you proceed along in the sight reduction process all of these corrections will be made to arrive at Ho (*Height Observed*). "D" stands for *Dip.* "R" stands for *Refraction.* "I" stands for *Index Error.* "P" stands for *Parallax* error. "S" stands for *semi-diameter.* In this tutorial semi-diameter applies to the Sun. Semi-diameter is found in The Nautical Almanac *daily pages* and is a specific figure for each day. You can get a one page list for Dip, Semi-diameter, Refraction and Parallax here- DRIPS.pdf

Index Error

Index Error is plus or minus. Write the amount of Index Error in the Index Error portion of the Sun sight reduction form.

What is Index Error?

The sextant has an index error if the index mirror and horizon mirror aren't parallel when the index arm and the drum with the minute scale are at zero while sighting a celestial body or the horizon. The image of the body or horizon will appear to be separated.

Most sextants have Index Errors which typically don't change unless the sextant is dropped or treated roughly. Index Error can be eliminated but has the habit of creeping back in. It's easier to determine Index Error and correct for it during the sight reduction than to keep adjusting the instrument to get rid of it.

To find index error use your sextant to look at a distance object. Adjust the drum to make the image equal with no overlapping. That is- adjust the distant image so that it doesn't appear to be split. Now, read the sextant- that's your index error.

Index Error Rules

If it's *on the arc- take it off.* That means if your sextant Index error is plus a certain amount of minutes then that figure is to be subtracted from the Hs.

If it's *off the arc- put it on.* That means if your sextant Index error is minus a certain amount of minutes then that figure is to be added to the Hs.

Dip

Dip is always subtracted. Dip is determined by *the height of eye* above the surface of the water. So, if your eyes are about 10-1/2 feet above the water then the Dip correction would be -3.1**'**. That's *minus* 3.1 minutes of arc to be subtracted from Hs.

Subtract dip from the Hs to obtain Ha (Apparent Altitude). Find the correction for dip using Altitude Correction Table. Get it here- Altitude Correction Table. Dip is on page 1 on the right hand side.

See the Picture- Dip Correction here. This is just a portion of page 1 of the Altitude Correction Table.

Write the amount of Dip in the Dip portion of the Sun sight reduction form.

Ha

Subtract or add the Index Error from the *Hs* according to the Index Errors Rules mentioned above. Subtract *Dip* from the *Hs*. The Ha (Apparent Altitude) is obtained after both Index Error and Dip are subtracted (or added) from the Hs.

+/- ACT

ACT is short for *Altitude Correction Tables*. Get it here- Altitude Correction . The nice part of the ACT is that it combines several corrections into one figure. When using the Sun the figure includes the following corrections; *Refraction, Parallax, Semi-diameter*. Do you recall *D.R.I.P.S.* mentioned in the "Dip" section above? You've already entered the corrections for *Dip* and *Index Error* and now the single figure found in the Altitude Correction Tables for the Sun will complete the necessary sextant corrections.

Use page 1 of the Altitude Corrcection Table and select the correct month range- **OCT. - MAR.** or **APR. - SEPT.** Choose the Sun's limb you made the observation of- *Upper Limb* or *Lower Limb.* In the App. Alt. column find the degree figures that the Ha falls between. Look to the right of that figure and find the minutes of arc for Altitude Correction. ACT is subtracted or added depending upon which Limb is observed. The ACT figure is to be written in the Sun sight reduction form +/- ACT box.

+/-ACT Example

In this example refer to Altitude Correction Tables picture here. This is just a portion of page 1 of the Altitude Correction Table.

You took a Lower Limb Sun sight on August 24, 2015. After correcting for Dip and Index Error you got an Ha of 72° 02**'.** Look down the APR. - SEPT. App. Alt. column and notice that the Hs of 72° 02**'** falls between 67° 15**'** and 73° 14**'**. In the Lower Limb column find the Altitude Correction of +15.6**'** *minutes of arc.*

Ho

Subtract or add the Altitude Correction figure from/to Ha to arrive at Ho- *Height Observed*.

ACT correction figure *Lower Limb* observations are always added to Ha.
ACT correction figure *Upper Limb* observations are always subtracted from Ha.

For the purpose of this procedure of Sun sight reduction an **Ho** of 72**°** 18**'** will be used.

GHA

Greenwich Hour Angle- just the whole hour figure is found in The Nautical Almanac. The *GHA increments* for the minutes and seconds of the Sun sight will be found later.

Get The Nautical Almanac or "Sun Only" Almanac here- TheNauticalAlmanac.com The GHA of the Sun is the angular measurement of the Sun West from Greenwich, England, and is specific to time. It is never more than 360**°**.

GHA is comparable to Longitude on the earth. *Declination* is equivalent to Latitude on earth. It'll be clearer, later, that if you were at the GP, *Geographical Position*, of the Sun at a particular moment in time that the Sun would be directly over your head- at *your* Zenith. For example- if you were at N 11**°** 04.9**'**, W 029**°** 23.7**'** (about 400 nm Southwest of Cape Verde) on August 24, 2015 at UT 14:00 the Sun would be directly over head. At that exact time the Sun's declination was N 11**°** 04.9**'** and its GHA was W 029**°** 23.7**'**.

GHA Example

In this example refer to the Picture- GHA & Dec of Sun- The Nautical Almanac. This is just a portion of the page from The Nautical Almanac.

You took a Sun sight on Monday, August 24, 2015 at UT 14:18:15. Locate the "h" column and find "Mon". The "h" stands for *hours* UT and *Mon* stands for Monday. Locate 14 in the "h" column then look to the right in the Sun's GHA column to find 29**°** 23.7**'**. That's the whole hour Sun's GHA figure. Write that figure in the Sun sight form box next to the first mention of GHA from the top of the sheet.

GHA incr.

Greenwich Hour Angle increment for the minutes of time of the Sun sight. On the Sun sight form *GHA increments* are written as **GHA incr.** just to abbreviate the words.

Get GHA increments on 2 pages for Sun only here- GHA increments Sun only. If you only do Sun sights it's easier to carry 1 sheet of paper (printed on both sides) than the entire "yellow pages".

See the Picture- Sun GHA increments "on 2 pages" This is just a portion of the page.

Get GHA increments- the "yellow pages" for Sun, planets, Moon and Aries here- GHA increments for Sun, planets, Moon and Aries - the "yellow pages"

GHA incr. Example

In this example refer to the Picture- Sun, Planet, Aries Moon increments ("yellow pages") This is just a portion of the page.

You took a Sun sight on Monday, August 24, 2015 at UT 14:18:15 and have already found the GHA whole hour figure of 29**°** 23.7**'**. Next you need to find the GHA minutes and seconds increment. Look in the "**m"** column (which stands for "minutes" of time) and see 18 below it. Descending in the 18 minute column find 15 (15 seconds of time). Look to the right in the **Sun Plan.** column and find 4**°** 33.8**'** which is the GHA increment for 18 minutes and 15 seconds of time for the Sun.

GHA

Add GHA integral hour and GHA increments to obtain the GHA.

Using the GHA figures above-	29**°** 23.7**'**	(GHA whole hour figure for 14 hours on August 24, 2015)
	4**°** 33.8**'**	(GHA increments for 18 minutes 15 seconds)
	33**°** 57.5'	(GHA for August 24, 2015 at UT 14:18:15)

Write the GHA of 33° 57.5**'** in the lowest GHA box of the Sun sight reduction form.

LHA

LHA is the *Local Hour Angle* and is never more than 360°. LHA is determined either by adding or subtracting the DR. Longitude from/to the GHA according to which Hemisphere you're in- Eastern or Western using the following rules.

LHA Rules in *West* Longitudes

In ***West Longitudes***- subtract DR. Longitude from GHA to obtain LHA. Only subtract the whole DR. Longitude degree figure from the whole GHA degree figure- do nothing with the minutes or arc. If GHA is *less than* DR. Longitude then add 360**°** to GHA and then subtract DR. Longitude from it to arrive at LHA.

LHA Example- *West* Longitudes

The GHA found previously is....	33**°** 57.5'	(August 24, 2015 UT 14:18:15)
Let's use an DR. Longitude of...	W 025**°** 21**'**	(subtract in West Longitudes).
LHA=	8**°**	

Remember- to obtain the LHA only subtract the whole degree DR. Longitude figure from the whole degree GHA figure and ignore the minutes of arc.

If GHA is less than the DR. Longitude add 360**°** to the GHA and subtract the DR. Longitude from it.

Let's use the GHA of.... 23° 57.6' (August 24, 2015 UT 13:38:16)
Let's use an DR. Longitude of... W 025°

360°
+ <u>23° 57.6'</u>
Add 360° to GHA 23° 57.6' = 383° 57.6'

360° added to GHA 383° 57.6'
Subtract the DR. Longitude from GHA W <u>025° 21'</u>
LHA= 358°

<u>LHA Rules in *East Longitudes*</u>

In ***East Longitudes***- round up the GHA figure to the next highest whole degree figure then add the DR. Longitude to GHA to obtain LHA. Only add the whole degree DR. Longitude figure to the rounded up whole degree GHA figure. If the resulting LHA figure is greater than 360° then subtract 360° from the figure to obtain the LHA.

Remember- to obtain the LHA in Eastern longitudes- *round up* the GHA figure to the next higher degree figure and add the whole degree DR. Longitude to it.

<u>LHA Example- *East* Longitudes</u>

In *East Longitudes*- add DR. Longitude to GHA to obtain LHA. If the resulting LHA figure is greater than 360° then subtract 360° from it to obtain the LHA.

Let's use the GHA of.... 33° 57.5' (August 24, 2015 UT 14:18:15)

GHA rounded up 34°
Let's use an DR. Longitude of... E <u>012° 00'</u>
LHA= 46°

Remember- to obtain the LHA in Eastern longitudes- *round up* the GHA figure to the next higher degree figure and add the whole degree DR. Longitude to it.

If the sum of the GHA and DR. Longitude is greater than 360° then subtract 360° from the sum of the GHA and DR. Longitude to arrive at LHA.

Let's say the GHA is.... 288° 56.5' (August 24, 2015 UT 07:18:15)

GHA rounded up 289°
Let's say your DR. Longitude is... <u>E 130°</u>
LHA= 419° (But, LHA must be 360° or less)

Subtract 360° from LHA of 419° 419°
<u>360°</u>
LHA= 059° That's the correct LHA.

Declination

Declination is comparable to Latitude on earth. The Sun's *declination* is found for the date and hour of the sight. Find the declination in The Nautical Almanac or “Sun Only” Almanac here- The Nautical Almanac. Make certain to indicate the correct hemisphere the Sun is in- *Same* or *Contrary name*. The Nautical Almanacs provided on our site use the letters “N” or “S” to indicate which Hemisphere the Sun is in during the year.

You can indicate which hemisphere the Sun is in using an “N” or “S”. Or, you can use a “+” or “-” but be certain you understand what that means relative to the hemisphere where you are making the observations and what the date is.

Declination Example

In this example refer to the Picture- GHA & Dec of Sun- The Nautical Almanac. This is just a portion of the page from The Nautical Almanac.

Using the previous example, you took a Sun sight on Monday, August 24, 2015 at UT 14:18:15. Locate the "h" column and find "Mon". The "h" stands for *hours* UT and *Mon* stands for Monday. Locate 14 in the "h" column then look to the right in the Sun's *Dec* column to find N 11**°** 04.9**'**. Write that figure in the Sun sight form box next to the **Dec** box.

Same name Declination

The Sun's declination with the *Same name* means the Sun's position will be somewhere in the hemisphere where you are making observations.

Declination in the Northern hemisphere would be of *Same name* if you were making Sun sights in the Northern hemisphere after the Vernal Equinox in March but before the Autumnal Equinox in September.

Declination in the Southern hemisphere would be of *Same name* if you were making Sun sights in the Southern hemisphere after the Vernal Equinox in September but before the Autumnal Equinox March.

Contrary name Declination

Declination in the Northern hemisphere would be of *Contrary name* if you were making Sun sights in the Northern hemisphere after the Autumnal Equinox in September but before the Vernal Equinox in March.

Declination in the Southern hemisphere would be of *Contrary name* if you were making Sun sights in the Southern hemisphere after the Autumnal Equinox in March but before the Vernal Equinox in September.

Read this before proceeding

The next 3 steps, obtaining *Hc, d* and *Z* are *usually* carried out by opening Pub. No. 249 one time and finding the Hc, d and Z figures on the same page and then closing the book. Once those figures are obtained the “d” correction is then obtained. In this writing once “d” is obtained the “d correction” is found to avoid ambiguity and to maintain the continuity of the process. Z is lastly found.

Hc

Use Pub. No. 249 to obtain Hc, *Height Computed.* The LHA, declination (correct *Name)* and DR. Latitude of the sight must be used to find Hc. Get the complete Pub. No. 249 at- TheNauticalAlmanac.com (It's located in "**Essential Celestial Navigation Downloads**" which is midway down the main page. Pub. No. 249 *was* also known as HO- 249.

First locate the declination degree figure in the horizontal row at the top of your DR. Latitude page. Drop down the declination column to where the LHA intersects it. Find Hc at the intersection of declination and LHA.

Hc example

In this example refer to **Pub. No. 249 Vol 2- page 162** which is for Latitude 27**°** *Same name* Declination. If you can't clearly see the picture click here to get the PDF- Pub. No. 249- Vol 2 27.pdf

The following figures will be used to find Hc, d and Z;

LHA= 8**°**

Declination= N 11**°** 04.9**'**

DR. Latitude= N 27**°**

First locate the correct Latitude- 27**°**

Next, locate the 11**°** declination column

Next, locate the 8**°** LHA row

Where the LHA row of 8**°** and Declination column of 11**°** intersect you will find the correct Hc, d and Z.

Find **Hc** which is 72 19 (meaning 72**°** 19**'**).
Write the Hc figure in Hc space on the Sun sight reduction form.

d/d corr

This step is in two parts.

Step 1- obtain "d"

In this example refer to **Pub. No. 249 Vol 2- page 162** which is for Latitude 27**°** *Same name* Declination. If you can't clearly see the picture click here to get the PDF- Pub. No. 249- Vol 2 27.pdf

Get "d" figure from Pub. No. 249 Vol 2 page 162. The figure is to the right of Hc and located in the "d" column.

First locate the correct Latitude- 27°

Next, locate the 11° declination column

Next, locate the 8° LHA row

Where the LHA row of 8° and Declination column of 11° intersect you will find the correct d figure. The d figure is to the right of Hc and located in the "d" column.

Find **d** which is 54. Write the **d** figure in the **d/d corr** blank space on the Sun sight reduction form. But, put the figure to the left of the **/** (forward slash). The **d** figure will be used to correct Hc for the minutes of the Sun's declination.

Note! If there is a minus sign next to the "**d**" figure it means that the "d correction" figure must be subtracted from Hc once the "d correction" is obtained (which is step-2...next). In this case the **54** is positive as it has no minus sign beside it so the "d correction" figure will not have to be subtracted.

Step 2- obtain "d correction"

In this example refer to Table 5. - Correction to Tabulated Altitude for Minutes of Declination.
If you can't clearly see the picture click here to get the PDF- TABLE 5- Correction to Tabulated Altitude for Minutes of Declination.pdf

Before proceeding- recall in the example being used the Sun's declination is N 11° 04.9'

Obtain the "d correction" from; *Table 5- Correction to Tabulated Altitude for Minutes of Declination.* Locate the Sun's minutes of declination of "**5**" (04.9**'** rounded up) in the column with the **'** (minute symbol)- it's the vertical column on the far left and far right of the Table.

Locate the "d" figure of **54** (found previously in Pub. No. 249) in the horizontal row at the top of Table 5.

Where the "d" figure of **54** and **5** minutes of declination intersect is found the minutes to be added (or subtracted) from Hc found in Pub. No. 249. The figure is 4. In the Sun sight reduction form write the correction figure of **4** beside the **/** (forward slash symbol). The space should look like this **54 / 4**

Z

In this example refer to **Pub. No. 249 Vol 2- page 162** which is for Latitude 27° *Same name* Declination.
(If you can't clearly see the picture click here to get the PDF- Pub. No. 249- Vol 2 27.pdf

Find **Z** which is **153** (meaning 153°). The **Z** stands for Azimuth or angle of the Sun along the horizon. The Z figure is to the right of Hc and "d" (found previously) and is found in the "Z" column.

Write the **Z** figure of 153 in the **Z** space on the Sun sight reduction form.

Later, Z will be compared to LHA to determine if 360° must be subtracted from it to arrive at the correct Zn.

Hc

Refer to the Sun sight reduction form

Obtain the final Hc figure by adding the "d corr" figure of **4** to the Hc of 72**°** 19**'**

Hc	72**°** 19**'**
d/d corr	54 / 4 **'**
Hc	72**°** 23**'**

Do nothing with the "d" figure. That was only used to find the "**d corr**" figure above.

Ap λ

Ap λ stands for *Assumed Position Longitude* and is a combination of the DR. Longitude integral degree and GHA *minutes of arc* determined by the following rules;

Ap λ in Western Longitudes

Ap λ stands for *Assumed Position Longitude* and is a combination of the DR. Longitude integral degree of W 025° and the total GHA *minutes* figure (57.5'). The GHA for this example was 33° 57.5**'.** Put Ap λ of W 025° 57.5' in the **Ap λ** space of the Sun sight reduction form. You will use this figure when plotting the LOP.

Ap λ in Eastern Longitudes

In Eastern longitudes the Ap λ is determined as follows;

DR longitude + (0°60' *minus* GHA minutes of arc)

Example- E 025° + (0°60' – 0° 57.5')= 25° 02.5' Ap λ

Zn

In the **Zn** space of the Sun sight reduction form the correct Z (azimuth) of the Sun is determined. The azimuth of the Sun is based on True North using the North Pole. It has nothing to do with magnetic North. The azimuth established in this step is the horizontal angle in which the Sun was observed using the North Pole as the starting reference point and you the observer. For example; if the Sun was observed by you due East (True, not magnetic) the azimuth would be E 90**°**, True.

This picture may help explain the relationship between True North, the observer and Azimuth- Azimuth.

In Pub. No. 249 Vol. 2 (and Vol. 3) in the top left and bottom left of each page are the rules for determining the correct Azimuth of the celestial body (in this case, the Sun).

<u>Zn Rules</u>

<u>To put Z into the right quadrant, apply the following rules-</u>

<u>For North Latitudes</u>:

LHA greater than 180°,	then	Zn=Z
LHA less than 180°,	then	Zn=360-Z

<u>For South Latitudes</u>:

LHA greater than 180°,	then	Zn=180°-Z
LHA less than 180°	then	Zn=180°+Z

Recall that the **Z** figure obtained from Pub. No. 249 Vol. 2 page 162 was **153**.

The Sun sight was made in the Northern Latitudes.

The LHA in this example is 8°.

Using the rules above the LHA is less than 180° so Zn= 360 – 153 which is 207°.

Write **207** in the Sun sight reduction form **Zn** space. This is the horizontal angle of the Sun between True North (the North Pole) and you the observer along the horizon. This picture may help explain the relationship between True North, the observer and Azimuth- Azimuth

<u>Intercept</u>

This is the *Intercept* and is found by subtracting the smaller figure from the larger- either Ho or Hc. Recall that in the **Ho** section of the form an Ho of 72° 18**'** was being used for this Sun sight reduction procedure. In the **Hc** section of the form an Hc of 72° 23**'** was calculated.

<u>Intercept Rules</u>

If Hc is greater than Ho then subtract Ho from it.
If Hc is greater than Ho then put an "A" next to it indicating the LOP (Line Of Position) will be plotted *Away* from the Ap. λ (Assumed position Longitude) in the opposite direction of the Sun's azimuth.

An easy way to remember is ***C****oast* ***G****uard* ***A****cademy.* If *H**c*** is ***G****reater* ***A****way-* the LOP will be plotted away from the Ap. λ (Assumed position Longitude) in the opposite direction of the Sun's azimuth.

If Ho is greater than Hc then subtract Hc from it.
If Ho is greater than Hc then put a "T" next to it indicating the LOP (Line Of Position) will be plotted *Toward* the direction of the Sun's azimuth.

An easy way to remember is if Ho is greater then plot the LOP ***tO**wards* the Ap λ (Assumed position Longitude) in the direction of the Sun's azimuth.

Recall that in the **Ho** section of the form an Ho of 72**°** 18**'** was being used for this Sun sight reduction procedure. In the **Hc** section of the form an Hc of 72**°** 23**'** was calculated.

Using the intercept rules above Hc is greater than Ho so Ho is subtracted from Hc as follows;

Hc 72**°** 23**'**
Ho 72**°** 18**'**
Intercept= 0**°** 05**'** (*Away*)

The sight reduction process is now done. We will be using the figures derived previously to plot the LOP, *Line of Position.*

Plotting the Line of Position

In this step of Plotting the Line of Position refer to this UPS- UPS Plot of the Line of Position.
If you can't clearly see the picture click here to get the PDF- UPS LOP plot.pdf.

Plotting tools needed

Universal Plotting Sheet. Get one here- Universal Plotting Sheet
Dividers
Parallel rules
Pencil

Figures we're working with to plot an LOP

Ap λ= W 025° 57.5' (**57.5'** are the minutes of Longitude derived from the GHA step above)

NOTE! In Eastern longitudes the Ap λ *Assumed position longitude* is determined as follows;

DR longitude + (0°60' *minus* GHA minutes of arc)

Example- DR longitude= E025° GHA= 14° 57.5'

E 025° + (0°60' – 0° 57.5')= 25° 02.5' Ap longitude

Intercept= 0**°** 05**'** (*Away*)

Zn= 207**°**

DR. Latitude= N 27**°**

Label lines of Latitude

Label the lines of Latitude with a mid Latitude of N 27**°** as seen on UPS Plot of the Line of Position.

Layout Longitude Lines on the UPS

The following steps refer to the UPS Plot of the Line of Position and notice the descriptive words designating the areas of the UPS being referred to. When in this explanation you read about, for example, “the compass rose” look on the UPS and find where the words “the compass rose” are located which will be close to the area of the UPS being discussed. Sometimes words and an arrow are used to point to the item be referred to.

The correct Longitude line must be draw on the UPS to establish the proper spacing of Latitude lines in relation to the lines of Longitude.

The spacing between lines of Latitude do not change on the UPS. The distance in nautical miles between whole degree parallels of Latitude is always 60 nm no matter where you are on earth.

The lines of Longitude exactly on the equator at 0**°** 00**'** are 60 nm apart. As you proceed any distance North or South of the Equator the lines of Longitude begin to converge until finally at the North, or South, Pole there is no distance between them.

In order to establish the correct relationship between lines of Latitude and Longitude on the UPS the lines of Longitude will have to be drawn in based on the DR. Latitude.

The UPS circle with the numerical degree marks is called “the compass rose”- for plotting purposes the compass rose uses True North and not magnetic North as 0°.

Using the middle graduated line of longitude as a vertical reference, place the parallel rules on the middle line of longitude and “walk” the parallel rules to the right so that the edge of parallel rules touch the outside of the compass rose at the 27 ° mark on the UPS (20 mark plus seven individual marks).

Draw a vertical line of Longitude through the outside of the compass rose 27° as seen on the UPS sheet. The line is drawn vertically between, and touches, the Latitude lines of N 27° and N 28°.

Using the middle graduated line of longitude as a vertical reference, place the parallel rules on the middle line of longitude and “walk” the parallel rules to the right so that the edge of parallel rules touch the outside of the compass rose at the 26° mark on the UPS (20 mark plus six individual marks).

Draw a vertical line of Longitude through the outside of the compass rose 26° as seen in the UPS. The line is drawn between, and touches, the Latitudes of N 26° and N 27°.

Notice that there is a small offset difference between the Longitude lines. This is a graphic illustration of the lines of Longitude getting closer the further North you proceed as you would see on a globe of the earth. The same graphic illustration of Longitude line convergence is true for the Southern hemisphere except that the Latitude figures would be reversed- S 26° would be at the top Latitude line of the UPS then S 27° and finally S 28° would be at the bottom of the UPS.

Setting the UPS Longitude scale

To set the proper spacing of Longitude minutes when using the UPS the scale in the lower right corner of the UPS is used. The Longitude minutes spacing scale is determined by Latitude which for this example is N 27°. Draw a horizontal line on the UPS Longitude scale between the 20 and 30 so that it approximates where 27° would be. Notice on the right side of UPS Longitude scale there are a series of five vertical lines. The distance between each of the lines represent 2 minutes of Longitude based on the Latitude being plotted, in this example it's N 27°. Notice that these lines converge the closer they are to 70° which shows how lines of Longitude get closer together the further North (or South) on a chart an area is shown.

There are 5 other curved vertical lines on the UPS Longitude scale. The space between each of these lines represents 10**'** (10 minutes) of Longitude. So, when you add up the horizontal distance from the far left side of the UPS longitude scale to the far right side of UPS longitude scale the result is 60' (60 minutes of arc) or 1° of Longitude.

Plot the Ap λ minutes of longitude

Using the UPS longitude scale and dividers measure **58'** minutes (57.5' rounded up) and set the dividers to that distance. The minutes figure was rounded up to make plotting easier as your pencil width will almost be as wide as 00.5' (minutes of Longitude on the scale being used). Remember that the minutes of Longitude are derived from the GHA minutes portion of the final GHA figure found in the GHA step above.

Using the dividers place one point of the dividers where N 27° intersects with W 025°. Place the other point of the dividers horizontally across the N 27° line of Latitude and make a tiny mark. This second point is the location of the Ap λ W 025° **58'** (remember- for ease of plotting the 57.5' was rounded up to 58').

Take your pencil and make a small mark at the 58' point.

Draw the Azimuth line

The azimuth line (Zn) to be drawn is 207**°** as calculated above in the Zn section**.**

Take the parallel rules and put one edge of the rules on the very center of the compass rose. Align the same edge so that it intersects 207° as seen on the UPS marked as “azimuth line”.

Without changing their angle, “walk” the parallel rules over so that one edge of the rules intersects the pencil point placed at the W 025° 58**'** Ap. λ and draw the azimuth line towards the direction of the 207° mark. Remember- don't change the angle of the parallel rules. You're just drawing a 207° line through the Ap. λ point placed at W 025° 58**'.** Draw the line a little longer in the opposite direction as in the next step you will be drawing the Intercept line *Away* from direction of the Sun.

If you want you can draw a circle at the end of the line near 207° to remind you of the direction of the Sun from your Assumed Position.

Mark the Intercept line location

The Intercept as calculated in the **Intercept** section above was 0**°** 05**'** (*Away*). “Away” means that the LOP (Line of Position) will be drawn away from the direction of the observed celestial body- the Sun.

Using the dividers and the vertical graduated latitude scale in the middle of the UPS, measure off and set the dividers to 5**'** (minutes). Put one point of the dividers on the 26° Latitude line and the other point on the 5**'** mark on the vertical Latitude scale in the middle of the UPS.

Using the dividers set to 5**'** put one point of the dividers on the 58**'** mark that's located at W 025° 58**'**. Put the other point of the dividers along the azimuth line in the opposite direction of 207° (away from the Sun) and mark a small point. Re-mark the new point using a pencil.

Draw the Intercept line- the LOP

The Intercept line is drawn 90**°** to the azimuth line**.**

Subtract 90° from 207° and get 117°.

Take the parallel rules and put one edge of the rules on the very center of the compass rose. Align the same edge so that it intersects 117° on the UPS. That's at the 110° mark plus 7° on the UPS.

Without changing their angle, "walk" the parallel rules up so that one edge of the rules intersect the pencil point placed at the 05**'** *Away* mark and draw the intercept line so that it's about 3 inches long (1-1/2" on either side of azimuth line).

Remember- don't change the angle of the parallel rules when you "walk" them.

Conclusion

You're now finished performing a Sun sight reduction and plotting an LOP (Line of Position). If this had been an actual Sun sight reduction while you're sailing you would be located *somewhere* along the LOP that was just drawn.

If you then wanted to obtain a position "fix" then you must wait about 1 hour and take another observation of the Sun and perform another Sun sight reduction and plot the resulting LOP. If you're at sea, the first LOP would have to be advanced in the True direction (not magnetic) you have been traveling and the DR distance. Where the two LOPs intersect is the position "fix"- where you were at the time of the second Sun sight.

Fair winds....clear skies & following seas

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Freely ye have received, freely give

Pictures

Picture- Dip Correction

Find the Dip correction on the right hand side of page 1 of the Altitude Correction Tables

Picture- Altitude Correction Table

Altitude Correction Table (SUN) left hand side of page 1.

ALTITUDE CORRECTION TABLES 10°-90°—SUN, STARS, PLANETS

SUN

OCT.—MAR. App. Alt.	Lower Limb	Upper Limb	APR.—SEPT. App. Alt.	Lower Limb	Upper Limb
° ′	′	′	° ′	′	′
9 34			9 39		
	+10·8	−21·5		+10·6	−21·2
9 45			9 51		
	+10·9	−21·4		+10·7	−21·1
9 56			10 03		
	+11·0	−21·3		+10·8	−21·0
10 08			10 15		
	+11·1	−21·2		+10·9	−20·9
10 21			10 27		
	+11·2	−21·1		+11·0	−20·8
10 34			10 40		
	+11·3	−21·0		+11·1	−20·7
10 47			10 54		
	+11·4	−20·9		+11·2	−20·6
11 01			11 08		
	+11·5	−20·8		+11·3	−20·5
11 15			11 23		
	+11·6	−20·7		+11·4	−20·4
11 30			11 38		
	+11·7	−20·6		+11·5	−20·3
11 46			11 54		
	+11·8	−20·5		+11·6	−20·2
12 02			12 10		
	+11·9	−20·4		+11·7	−20·1
12 19			12 28		
	+12·0	−20·3		+11·8	−20·0

STARS AND PLANETS

App Alt.	Corr^n
° ′	′
9 56	
	−5·3
10 08	
	−5·2
10 20	
	−5·1
10 33	
	−5·0
10 46	
	−4·9
11 00	
	−4·8
11 14	
	−4·7
11 29	
	−4·6
11 45	
	−4·5
12 01	
	−4·4
12 18	
	−4·3
12 35	
	−4·2
12 54	
	−4·1

App. Alt.	Additional Corr^n
2003	
VENUS	
Jan. 1–Feb. 20	
°	′
0	
	+0·2
41	
	+0·1
76	
Feb. 21–Dec. 31	
°	′
0	
	+0·1
60	
MARS	
Jan. 1–May 2	
Dec. 17–Dec. 31	

DIP

Ht. of Eye	Corr^n	Ht. of Eye
m	′	ft.
2·4		8·0
	−2·8	
2·6		8·6
	−2·9	
2·8		9·2
	−3·0	
3·0		9·8
	−3·1	
3·2		10·5
	−3·2	
3·4		11·2
	−3·3	
3·6		11·9
	−3·4	
3·8		12·6
	−3·5	
4·0		13·3
	−3·6	
4·3		14·1
	−3·7	
4·5		14·9
	−3·8	
4·7		15·7
	−3·9	
5·0		16·5
	−4·0	

Ht. of Eye	Corr^n
m	′
1·0	− 1·8
1·5	− 2·2
2·0	− 2·5
2·5	− 2·8
3·0	− 3·0
See table ←	
m	′
20	− 7·9
22	− 8·3
24	− 8·6
26	− 9·0

Picture- GHA & Dec of Sun- The Nautical Almanac

Find the Sun's whole hour GHA and Declination in the The Nautical Almanac. (This is from August, 2015).

2015 August 23 to Aug. 25

h	Sun		Moon				
Sun	**GHA**	**Dec**	**GHA**	**v**	**Dec**	**d**	**HP**
0	179°17.4	N11°37.2	90°23.9	11.3'	S16°02.7	-4.7'	55.7'
1	194°17.6	36.3	104°54.2	11.3'	16°07.4	-4.7'	55.8'
2	209°17.8	35.5	119°24.4	11.2'	16°12.0	-4.6'	55.8'
3	224°17.9	·· 34.6	133°54.6	11.1'	16°16.6	-4.5'	55.8'
4	239°18.1	33.8	148°24.7	11.1'	16°21.1	-4.4'	55.9'
5	254°18.2	33.0	162°54.7	11.0'	16°25.4	-4.4'	55.9'
6	269°18.4	N11°32.1	177°24.7	11.0'	S16°29.8	-4.3'	55.9'
7	284°18.6	31.3	191°54.6	10.9'	16°34.0	-4.2'	56.0'
8	299°18.7	30.4	206°24.5	10.8'	16°38.2	-4.1'	56.0'
9	314°18.9	·· 29.6	220°54.3	10.8'	16°42.2	-4.0'	56.0'
10	329°19.0	28.7	235°24.0	10.7'	16°46.2	-4.0'	56.1'
11	344°19.2	27.9	249°53.7	10.6'	16°50.1	-3.9'	56.1'
12	359°19.4	N11°27.0	264°23.3	10.6'	S16°54.0	-3.8'	56.1'
13	14°19.5	26.2	278°52.9	10.5'	16°57.7	-3.7'	56.2'
14	29°19.7	25.3	293°22.4	10.5'	17°01.4	-3.6'	56.2'
15	44°19.9	·· 24.5	307°51.8	10.4'	17°05.0	-3.5'	56.2'
16	59°20.0	23.6	322°21.2	10.3'	17°08.5	-3.5'	56.3'
17	74°20.2	22.8	336°50.5	10.3'	17°11.9	-3.4'	56.3'
18	89°20.4	N11°22.0	351°19.8	10.2'	S17°15.2	-3.3'	56.3'
19	104°20.5	21.1	5°49.0	10.2'	17°18.4	-3.2'	56.4'
20	119°20.7	20.3	20°18.1	10.1'	17°21.6	-3.1'	56.4'
21	134°20.9	·· 19.4	34°47.1	10.0'	17°24.6	-3.0'	56.4'
22	149°21.0	18.6	49°16.2	10.0'	17°27.6	-2.9'	56.5'
23	164°21.2	17.7	63°45.1	9.9'	17°30.5	-2.8'	56.5'
	S.D.=15.8	d=-0.8			S.D.=15.2		
Mon	**GHA**	**Dec**	**GHA**	**v**	**Dec**	**d**	**HP**
0	179°21.3	N11°16.9	78°14.0	9.9'	S17°33.3	-2.7'	56.5'
1	194°21.5	16.0	92°42.8	9.8'	17°36.0	-2.7'	56.6'
2	209°21.7	15.1	107°11.6	9.7'	17°38.6	-2.6'	56.6'
3	224°21.8	·· 14.3	121°40.3	9.7'	17°41.1	-2.5'	56.6'
4	239°22.0	13.4	136°08.9	9.6'	17°43.5	-2.4'	56.7'
5	254°22.2	12.6	150°37.5	9.6'	17°45.9	-2.3'	56.7'
6	269°22.3	N11°11.7	165°06.0	9.5'	S17°48.1	-2.2'	56.8'
7	284°22.5	10.9	179°34.5	9.4'	17°50.2	-2.1'	56.8'
8	299°22.7	10.0	194°02.9	9.4'	17°52.3	-2.0'	56.8'
9	314°22.8	·· 09.2	208°31.2	9.3'	17°54.2	-1.9'	56.9'
10	329°23.0	08.3	222°59.5	9.3'	17°56.1	-1.8'	56.9'
11	344°23.2	07.5	237°27.8	9.2'	17°57.8	-1.7'	56.9'
12	359°23.3	N11°06.6	251°55.9	9.1'	S17°59.5	-1.6'	57.0'
13	14°23.5	05.8	266°24.1	9.1'	18°01.1	-1.5'	57.0'
14	29°23.7	04.9	280°52.1	9.0'	18°02.5	-1.4'	57.1'
15	44°23.8	·· 04.1	295°20.1	9.0'	18°03.9	-1.3'	57.1'
16	59°24.0	03.2	309°48.1	8.9'	18°05.2	-1.2'	57.1'
17	74°24.2	02.3	324°16.0	8.9'	18°06.3	-1.1'	57.2'
18	89°24.4	N11°01.5	338°43.8	8.8'	S18°07.4	-1.0'	57.2'
19	104°24.5	11°00.6	353°11.6	8.8'	18°08.3	-0.9'	57.2'
20	119°24.7	10°59.8	7°39.3	8.7'	18°09.2	-0.8'	57.3'
21	134°24.9	·· 58.9	22°07.0	8.6'	18°09.9	-0.7'	57.3'
22	149°25.0	58.1	36°34.6	8.6'	18°10.6	-0.6'	57.4'
23	164°25.2	57.2	51°02.2	8.5'	18°11.1	-0.5'	57.4'
	S.D.=15.8	d=-0.9			S.D.=15.4		
Tue	**GHA**	**Dec**	**GHA**	**v**	**Dec**	**d**	**HP**
0	179°25.4	N10°56.3	65°29.7	8.5'	S18°11.6	-0.4'	57.4'
1	194°25.5	55.5	79°57.2	8.4'	18°11.9	-0.3'	57.5'
2	209°25.7	54.6	94°24.6	8.4'	18°12.2	-0.2'	57.5'
3	224°25.9	·· 53.8	108°51.9	8.3'	18°12.3	-0.1'	57.6'
4	239°26.1	52.9	123°19.2	8.3'	18°12.3	0.0'	57.6'
5	254°26.2	52.1	137°46.5	8.2'	18°12.2	0.1'	57.6'
6	269°26.4	N10°51.2	152°13.7	8.2'	S18°12.0	0.2'	57.7'
7	284°26.6	50.3	166°40.9	8.1'	18°11.7	0.4'	57.7'
8	299°26.7	49.5	181°08.0	8.1'	18°11.3	0.5'	57.8'
9	314°26.9	·· 48.6	195°35.0	8.0'	18°10.8	0.6'	57.8'
10	329°27.1	47.8	210°02.1	8.0'	18°10.2	0.7'	57.8'
11	344°27.3	46.9	224°29.0	7.9'	18°09.4	0.8'	57.9'
12	359°27.4	N10°46.0	238°56.0	7.9'	S18°08.6	0.9'	57.9'
13	14°27.6	45.2	253°22.8	7.9'	18°07.6	1.0'	57.9'
14	29°27.8	44.3	267°49.7	7.8'	18°06.5	1.1'	58.0'
15	44°27.9	·· 43.4	282°16.5	7.8'	18°05.4	1.2'	58.0'
16	59°28.1	42.6	296°43.2	7.7'	18°04.1	1.3'	58.1'
17	74°28.3	41.7	311°09.9	7.7'	18°02.7	1.5'	58.1'
18	89°28.5	N10°40.9	325°36.6	7.6'	S18°01.2	1.6'	58.1'
19	104°28.6	40.0	340°03.2	7.6'	17°59.5	1.7'	58.2'
20	119°28.8	39.1	354°29.8	7.6'	17°57.8	1.8'	58.2'
21	134°29.0	·· 38.3	8°56.3	7.5'	17°56.0	1.9'	58.3'
22	149°29.2	37.4	23°22.8	7.5'	17°54.0	2.0'	58.3'
23	164°29.3	36.5	37°49.3	7.4'	17°51.9	2.1'	58.3'
	S.D.=15.8	d=-0.9			S.D.=15.7		

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

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

Day	Sun Eqn.of Time 00h mm:ss	Sun Eqn.of Time 12h mm:ss	Sun Mer. Pass hh:mm	Moon Mer.Pass. Upper hh:mm	Moon Mer.Pass. Lower hh:mm	Moon Age 9-11 57-77%
23	02:50	02:42	12:03	18:36	06:11	
24	02:35	02:27	12:02	19:28	07:02	
25	02:18	02:10	12:02	20:23	07:55	

Picture- Sun GHA increments "on 2 pages"

Found on GHA increments on 2 pages for Sun only. File location is listed above in **GHA incr**. Section. This is just a small portion of page 1. Locate the GHA increment figure for the minutes and seconds (UT time) of the sight.

	Minutes									
Seconds	0	1	2	3	4	5	6	7	8	9
0	0° 00.0'	0° 15.0'	0° 30.0'	0° 45.0'	1° 00.0'	1° 15.0'	1° 30.0'	1° 45.0'	2° 00.0'	2° 15.0'
1	0° 00.3'	0° 15.3'	0° 30.3'	0° 45.3'	1° 00.3'	1° 15.3'	1° 30.3'	1° 45.3'	2° 00.3'	2° 15.3'
2	0° 00.5'	0° 15.5'	0° 30.5'	0° 45.5'	1° 00.5'	1° 15.5'	1° 30.5'	1° 45.5'	2° 00.5'	2° 15.5'
3	0° 00.8'	0° 15.8'	0° 30.8'	0° 45.8'	1° 00.8'	1° 15.8'	1° 30.8'	1° 45.8'	2° 00.8'	2° 15.8'
4	0° 01.0'	0° 16.0'	0° 31.0'	0° 46.0'	1° 01.0'	1° 16.0'	1° 31.0'	1° 46.0'	2° 01.0'	2° 16.0'
5	0° 01.3'	0° 16.3'	0° 31.3'	0° 46.3'	1° 01.2'	1° 16.3'	1° 31.3'	1° 46.3'	2° 01.3'	2° 16.3'
6	0° 01.5'	0° 16.5'	0° 31.5'	0° 46.5'	1° 01.5'	1° 16.5'	1° 31.5'	1° 46.5'	2° 01.5'	2° 16.5'
7	0° 01.8'	0° 16.8'	0° 31.8'	0° 46.8'	1° 01.7	1° 16.8'	1° 31.8'	1° 46.8'	2° 01.8'	2° 16.8'
8	0° 02.0'	0° 17.0'	0° 32.0'	0° 47.0'	1° 02.0'	1° 17.0'	1° 32.0'	1° 47.0'	2° 02.0'	2° 17.0'
9	0° 02.3'	0° 17.3'	0° 32.3'	0° 47.3'	1° 02.3'	1° 17.3'	1° 32.3'	1° 47.3'	2° 02.3'	2° 17.3'
10	0° 02.5'	0° 17.5'	0° 32.5'	0° 47.5'	1° 02.5'	1° 17.5'	1° 32.5'	1° 47.5'	2° 02.5'	2° 17.5'
11	0° 02.8'	0° 17.8'	0° 32.8'	0° 47.8'	1° 02.8'	1° 17.8'	1° 32.8'	1° 47.8'	2° 02.8'	2° 17.8'
12	0° 03.0'	0° 18.0'	0° 33.0'	0° 48.0'	1° 03.0'	1° 18.0'	1° 33.0'	1° 48.0'	2° 03.0'	2° 18.0'
13	0° 03.3'	0° 18.3'	0° 33.3'	0° 48.3'	1° 03.3'	1° 18.3'	1° 33.3'	1° 48.3'	2° 03.3'	2° 18.3'
14	0° 03.5'	0° 18.5'	0° 33.5'	0° 48.5'	1° 03.5'	1° 18.5'	1° 33.5'	1° 48.5'	2° 03.5'	2° 18.5'
15	0° 03.8'	0° 18.8'	0° 33.8'	0° 48.8'	1° 03.8'	1° 18.8'	1° 33.8'	1° 48.8'	2° 03.8'	2° 18.8'
16	0° 04.0'	0° 19.0'	0° 34.0'	0° 49.0'	1° 04.0'	1° 19.0'	1° 34.0'	1° 49.0'	2° 04.0'	2° 19.0'
17	0° 04.3'	0° 19.3'	0° 34.3'	0° 49.3'	1° 04.3'	1° 19.3'	1° 34.3'	1° 49.3'	2° 04.3'	2° 19.3'
18	0° 04.5'	0° 19.5'	0° 34.5'	0° 49.5'	1° 04.5'	1° 19.5'	1° 34.5'	1° 49.5'	2° 04.5'	2° 19.5'
19	0° 04.8'	0° 19.8'	0° 34.8'	0° 49.8'	1° 04.8'	1° 19.8'	1° 34.8'	1° 49.8'	2° 04.8'	2° 19.8'
20	0° 05.0'	0° 20.0'	0° 35.0'	0° 50.0'	1° 05.0'	1° 20.0'	1° 35.0'	1° 50.0'	2° 05.0'	2° 20.0'

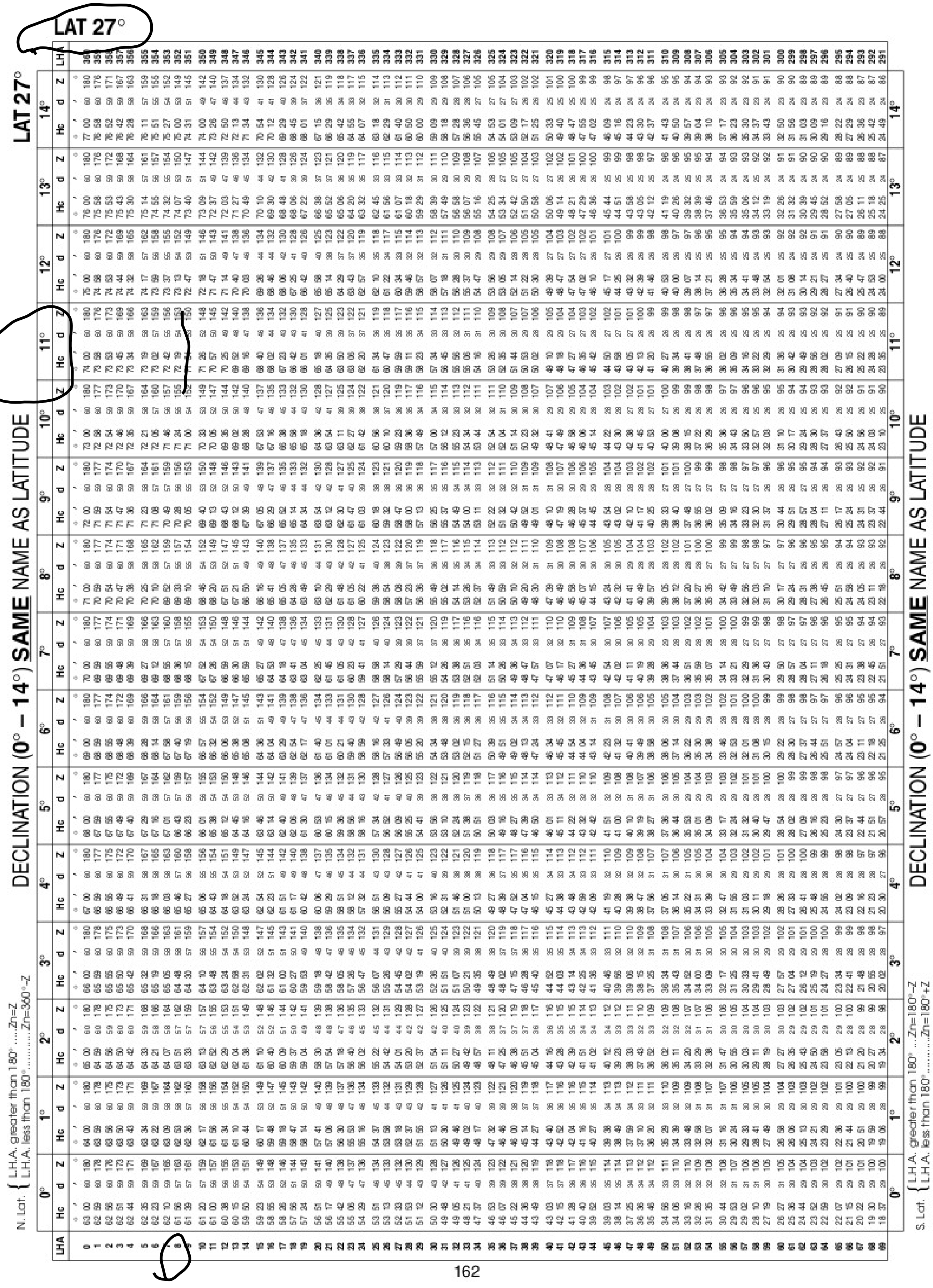
Picture- Sun, Planet, Aries Moon increments ("yellow pages")

Get the Sun GHA minutes increment from "the yellow pages" too. Locate the GHA increment figure for the minutes and seconds (UT time) of the sight. This picture shows 18 minutes portion.

Seconds here

m 18	Sun Plan.	Aries	Moon	v and d corr		
0	4°30.0	4°30.7	4°17.7	0.0 - 0.0	6.0 - 1.9	12.0 - 3.7
1	4°30.2	4°31.0	4°17.9	0.1 - 0.0	6.1 - 1.9	12.1 - 3.7
2	4°30.5	4°31.2	4°18.2	0.2 - 0.1	6.2 - 1.9	12.2 - 3.8
3	4°30.8	4°31.5	4°18.4	0.3 - 0.1	6.3 - 1.9	12.3 - 3.8
4	4°31.0	4°31.7	4°18.7	0.4 - 0.1	6.4 - 2.0	12.4 - 3.8
5	4°31.2	4°32.0	4°18.9	0.5 - 0.2	6.5 - 2.0	12.5 - 3.9
6	4°31.5	4°32.2	4°19.1	0.6 - 0.2	6.6 - 2.0	12.6 - 3.9
7	4°31.8	4°32.5	4°19.4	0.7 - 0.2	6.7 - 2.1	12.7 - 3.9
8	4°32.0	4°32.7	4°19.6	0.8 - 0.2	6.8 - 2.1	12.8 - 3.9
9	4°32.2	4°33.0	4°19.8	0.9 - 0.3	6.9 - 2.1	12.9 - 4.0
10	4°32.5	4°33.2	4°20.1	1.0 - 0.3	7.0 - 2.2	13.0 - 4.0
11	4°32.8	4°33.5	4°20.3	1.1 - 0.3	7.1 - 2.2	13.1 - 4.0
12	4°33.0	4°33.7	4°20.6	1.2 - 0.4	7.2 - 2.2	13.2 - 4.1
13	4°33.2	4°34.0	4°20.8	1.3 - 0.4	7.3 - 2.3	13.3 - 4.1
14	4°33.5	4°34.2	4°21.0	1.4 - 0.4	7.4 - 2.3	13.4 - 4.1
15	4°33.8	4°34.5	4°21.3	1.5 - 0.5	7.5 - 2.3	13.5 - 4.2
16	4°34.0	4°34.7	4°21.5	1.6 - 0.5	7.6 - 2.3	13.6 - 4.2
17	4°34.3	4°35.0	4°21.8	1.7 - 0.5	7.7 - 2.4	13.7 - 4.2
18	4°34.5	4°35.3	4°22.0	1.8 - 0.6	7.8 - 2.4	13.8 - 4.3
19	4°34.8	4°35.5	4°22.2	1.9 - 0.6	7.9 - 2.4	13.9 - 4.3

Picture- Pub. No. 249 Vol. 2 page 162



Picture Table 5. - Correction to Tabulated Altitude for Minutes of Declination

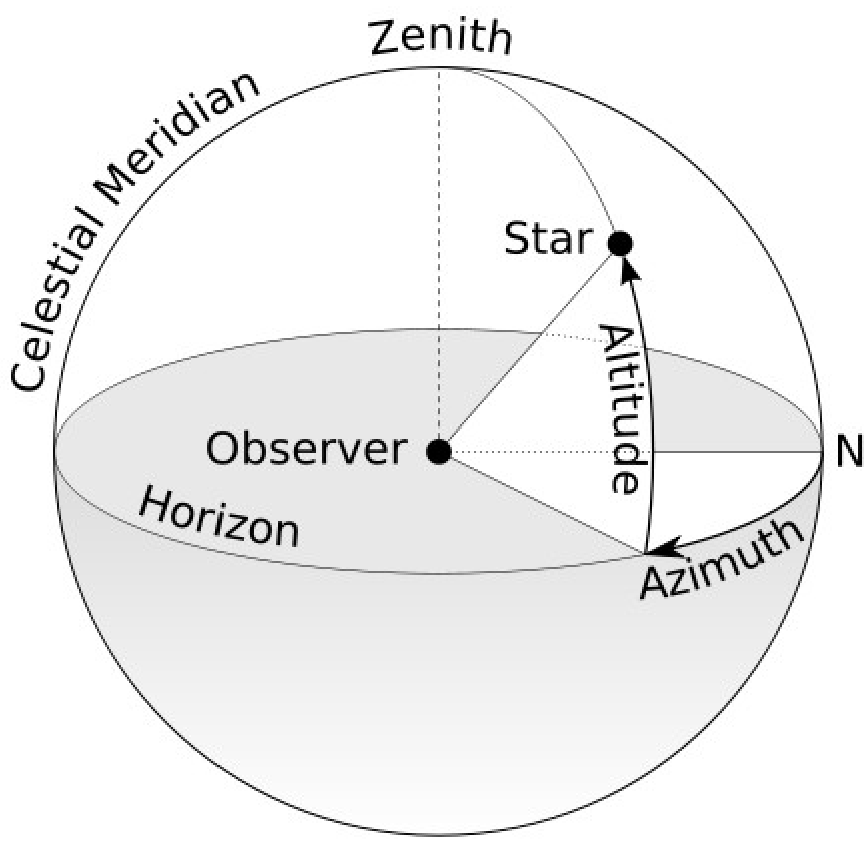
Step 2- obtain “d correction”

TABLE 5. — Correction to Tabulated Altitude for Minutes of Declination

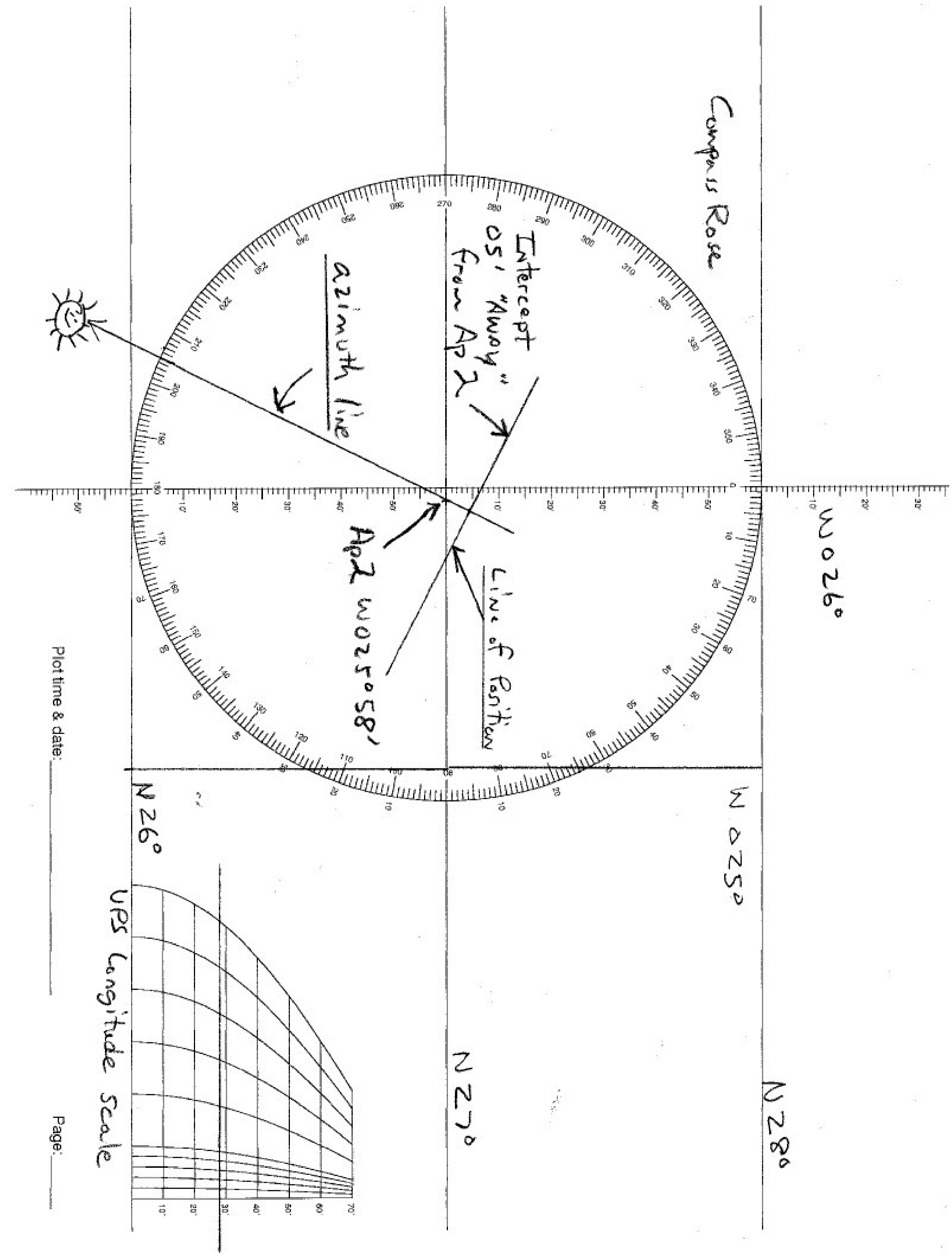
d ′	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1
2	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2
4	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2
5	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	3	3	3	3	3	3
6	1	1	2	2	2	2	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	4	4
7	2	2	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	4	4	4	4	4	4	4
8	2	2	2	2	2	2	3	3	3	3	3	3	3	3	4	4	4	4	4	4	4	5	5	5
9	2	2	2	2	3	3	3	3	3	3	3	4	4	4	4	4	4	4	5	5	5	5	5	5

d ′	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
2	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3
4	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	4	4	4	4	4	4	4	4
5	3	3	3	3	3	4	4	4	4	4	4	4	4	4	4	4	4	4	5	5	5	5	5	5
6	4	4	4	4	4	4	4	4	4	5	5	5	5	5	5	5	5	5	6	6	6	6	6	6
7	4	4	5	5	5	5	5	5	5	5	5	6	6	6	6	6	6	6	6	7	7	7	7	7
8	5	5	5	5	5	6	6	6	6	6	6	6	7	7	7	7	7	7	7	7	8	8	8	8
9	6	6	6	6	6	6	6	7	7	7	7	7	7	8	8	8	8	8	8	8	9	9	9	9

Picture- Azimuth illustration



Picture- UPS Plot of LOP



Sun sight reduction form using Ocean Horizon

Sight #					
DR Latitude					
DR Longitude					
Date	/ /	/ /	/ /	/ /	/ /
GMT/UT	: :	: :	: :	: :	: :
Hs	° '	° '	° '	° '	° '
Index Error +/-	° '	° '	° '	° '	° '
-- Dip	° '	° '	° '	° '	° '
Ha	° '	° '	° '	° '	° '
+/- ACT	'	'	'	'	'
Ho	° '	° '	° '	° '	° '
GHA	° '	° '	° '	° '	° '
GHA inc.	° '	° '	° '	° '	° '
GHA	° '	° '	° '	° '	° '
LHA	°	°	°	°	°
Dec	° '	° '	° '	° '	° '
Hc	° '	° '	° '	° '	° '
d/d corr	/ '	/ '	/ '	/ '	/ '
Z	°	°	°	°	°
Hc	° '	° '	° '	° '	° '
Ap λ	° '	° '	° '	° '	° '
Zn	°	°	°	°	°
Intercept					

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