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Determine Latitude by Noon-Sight

Assumptions-

You know how to use a sextant to take a Sun sight.
You know how to correct your sextant for Index Error.
You will be shooting the Sun's *Lower Limb*
You are located in a Northern Latitude
You are on land or on the ocean.

Conventions

I write Longitude and Latitude figures listing hemisphere first and then degrees.

Definitions

AH- *Artificial Horizon*
Any liquid in a bowl, dish or puddle that can be used to sight a celestial object's reflection in. Click here- an Artificial Horizon

Dip- The height of your eye above water. An angular figure which is subtracted from the Hs.

Ha- *Apparent Altitude*
The figure obtained when a sextant is corrected for Index Error and Dip.

Ho- *Height observed*
The angular figure obtained after making corrections to the Hs (Height of sextant) for "D-R-I-P-S"- *Dip, Refraction, Index Error, Parallax, Semi-diameter.*

Hs- *Height of sextant*
This is the initial measurement of the celestial body's angle (in our case the Sun) before any corrections are made to the figure.

LAN- *Local Apparent Noon.*
The time at which the Sun is directly on your meridian of Longitude- the time at which the Sun is at its zenith where you are. The highest point in the sky the Sun will reach on a particular day at your location.

GMT- *Greenwich Mean Time*

The time based on Greenwich, England. It's a *zone time*. As far as we're concerned it's the same as *UTC. GMT is the time designation used herein and not UTC.*

UTC- *Universal Coordinated Time*

UTC is also known as Greenwich Mean Time (GMT) and is the standard time of the Greenwich meridian (0° of longitude). *(credit- from the USNO Astronomical Phenomena for the year 2016)*

° The symbol for *degrees* of arc

' The symbol for *minutes* of arc

What you'll need

- a sextant
- an Artificial Horizon (AH) which can simply be a dish or bowl filled with water-
  Click here- an Artificial Horizon
- a pen or pencil (and an erasure)
- paper

- a watch set to GMT, *Universal Coordinated Time,* or you know what time zone you're in and how many hours you time zone is ahead or behind GMT. Example- W 075° is 5 hours behind GMT. When it's midnight in Greenwich England it's 7 PM Eastern Standard Time.

- Find your approximate *Longitude* and *Time Zone* using page 22 from Astronomical Phenomena for the year 2016

- Get the GMT/UTC time here- http://tycho.usno.navy.mil/what.html
- Get the GMT/UTC time here- http://time.is/UTC

- The Nautical Almanac or the "Sun only" pages for the current year.
  Get them here- TheNauticalAlmanac.com

- ALTITUDE CORRECTION TABLES 10° – 90° SUN, STARS, PLANETS
  Get it here- Altitude Correction Table.pdf

- a calculator (Casio fx-300ES Plus is good and inexpensive)
- an approximate idea of your Longitude
- Sunny skies

Procedure using an Artificial Horizon (AH)

The following method assumes you have no clear sight to the ocean's horizon and must use an *AH.*

There are several ways to determine Latitude by Noon-Sight. The simplest method doesn't require an accurate watch, or a watch at all, if you know your approximate Longitude within several degrees and have access to The Nautical Almanac daily pages or a list of Sun declinations for the date and time of the Sun sight.

At a minimum for accurate determination of Latitude you'll need to know the Sun's declination for the hour in which you are making the "noon-sight".

1- Find your approximate Longitude in the Sun's GHA column for the date you'll be determining Latitude. Your Longitude will be located between two hours in the Sun's GHA column.

Example-

Date- August 24, 2015 Your Longitude- W 075°

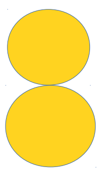
24	GHA	Dec
0	179°21.3	11°16.9
1	194°21.5	11°16.0
2	209°21.7	11°15.1
3	224°21.8	11°14.3
4	239°22.0	11°13.4
5	254°22.2	11°12.6
6	269°22.3	11°11.7
7	284°22.5	11°10.9
8	299°22.7	11°10.0
9	314°22.8	11°09.2
10	329°23.0	11°08.3
11	344°23.2	11°07.5
12	359°23.3	11°06.6
13	14°23.5	11°05.8
14	29°23.7	11°04.9
15	44°23.8	11°04.1
16	59°24.0	11°03.2
17	74°24.2	11°02.3
18	89°24.4	11°01.5
19	104°24.5	11°00.6
20	119°24.7	10°59.8
21	134°24.9	10°58.9
22	149°25.0	10°58.1
23	164°25.2	10°57.2
	SD.=15.8	d=-0.9

2- Notice that the Longitude of W 075° is between 17 & 18 hours GMT so that *LAN* (Local Apparent Noon) will occur between 17 & 18 hours GMT. On August 24, 2015 17 hours GMT is 1 PM DST at W 075° .

3- Fill a bowl of water for your AH.

4- Go outside before 17 hours GMT and set up your AH.

5- Find the reflected Sun in the AH and move the Sextant's Index Arm until the Sun in the sky is "brought down" to sit on top of the reflected AH Sun. The image should look similar to what you see here-



6- Keep taking sights until the Sun in the AH appears to "hang in the sky" neither ascending or descending. For our purposes this is *Local Apparent Noon* (LAN), which after doing a simple Sight Reduction will provide you with a fairly accurate Latitude.

7- You have just taken a sight of the Sun's *Lower Limb*.

8- Write down the Sextant reading found on the vernier scale. It's easy to make a mistake in reading the scale so verify the reading several times. The figure you now have is called the *Height of sextant* (Hs).

9- In this example let's say the Hs was 124° 22.2'

10- Since you were using an AH the Hs reading must be divided by 2.

11- The result is Hs 62° 11.1'

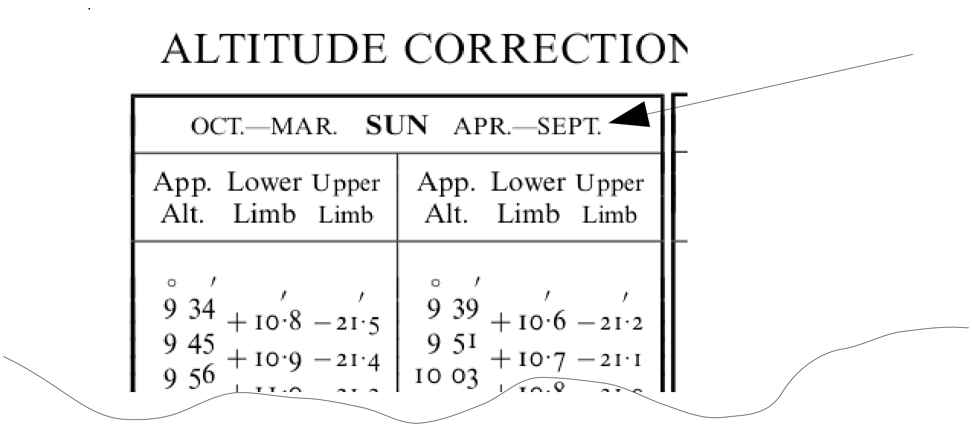
12- Correct your sextant for Index Error. The resulting figure is called *Apparent Altitude* (Ha). For this example we'll assume there is no Index Error.

13- The Casio calculator can make working with sexagesimal numbers easy. The Hs figure is a number based on 60 parts similar to time on a clock. For example- 25° divided by 2 equals 12° 30'

14- Get the ALTITUDE CORRECTION TABLES 10° – 90° SUN, STARS, PLANETS.

15- From here on I'll refer to the ALTITUDE CORRECTION TABLES as *ACT.*

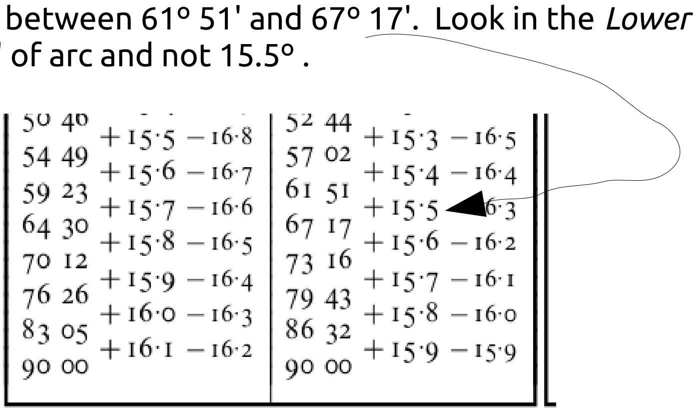
16- Find the Sun part of the ACT and locate the months column "APR – SEPT" as the example month is August.



ALTITUDE CORRECTION

OCT.—MAR.	SUN		APR.—SEPT.		
App. Alt.	Lower Limb	Upper Limb	App. Alt.	Lower Limb	Upper Limb
° ′	′	′	° ′	′	′
9 34	+10·8	−21·5	9 39	+10·6	−21·2
9 45	+10·9	−21·4	9 51	+10·7	−21·1
9 56			10 03		

17- The Ha of 62° 11.1' is between 61° 51' and 67° 17'. Look in the *Lower Limb* column and find + 15.5. That's 15.5' of arc and not 15.5° .



50 40			52 44		
	+15·5	−16·8		+15·3	−16·5
54 49			57 02		
	+15·6	−16·7		+15·4	−16·4
59 23			61 51		
	+15·7	−16·6		+15·5	6·3
64 30			67 17		
	+15·8	−16·5		+15·6	−16·2
70 12			73 16		
	+15·9	−16·4		+15·7	−16·1
76 26			79 43		
	+16·0	−16·3		+15·8	−16·0
83 05			86 32		
	+16·1	−16·2		+15·9	−15·9
90 00			90 00		

18- Take the Ha figure of 62° 11.1' and add 0° 15.5' to it. The result is called the *Height observed* or Ho.

62° 11.1'
<u>0° 15.5'</u>
Ho= 62° 26.6'

19- Using The Nautical Almanac daily pages or "Sun only" pages find the Sun's declination for the hour of 17 GMT on August 24, 2015 which is 11° 02.3'. This declination is *North* as there is no minus sign beside it. In this example you're in a Northern latitude and it's Summer so the declination is considered to be the *Same Name*. This simply means the Sun is in your hemisphere. If it had been of a *Contrary Name*, as it would be in the Fall and Winter, there would be a minus sign next to the declination figure.

20- Obtain your Latitude

90° (which is always the zenith angle)
<u>62° 26.6'</u> (Ho figure)
27° 33.4'

NOTE! There are 3 specific rules to properly determine Latitude and they are found on page 10 of 10. In this example Rule 1 is used.

21- Add the answer of 27° 33.4' to the declination of the Sun for the hour the sight was made.

27° 33.4' (Zenith distance minus Ho)
<u>11° 02.3'</u> (Sun's declination for the hour of observation)
38° 35.7'

22- Your Latitude is N 38° 35.7'

Procedure- using the Horizon

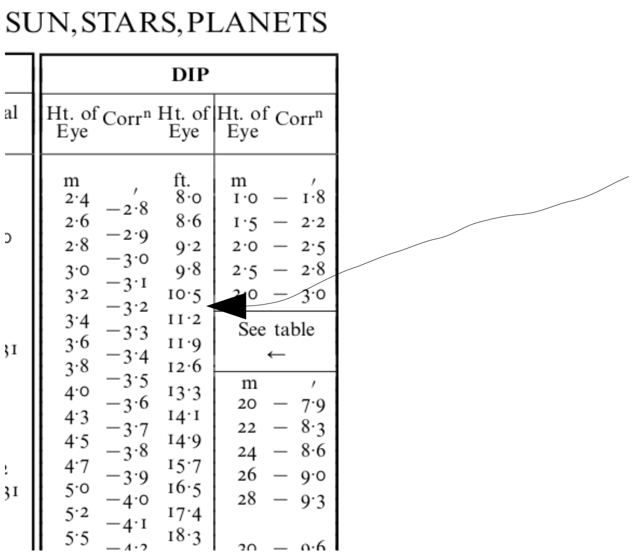
Assumption- you have a view to the unobstructed horizon that faces 180° South.

The procedure for taking a Noon-Sight is the same as using an AH except the following;

- you don't need an AH
- the Hs figure isn't divided by 2
- your sextant reading must be corrected for Dip

1- Use the same procedure when using an AH except begin at step 12 above correcting for Index Error and now....*Dip*.

2- Let's say the height of your eyes above water was 11 feet. Look in the ACT in the DIP column Ht. of Eye Corr and see that 11 feet would be located between 10.5 and 11.2. The dip figure is - 3.2 (minutes of arc).



SUN, STARS, PLANETS

DIP				
Ht. of Eye	Corrⁿ	Ht. of Eye	Ht. of Eye	Corrⁿ
m	′	ft.	m	′
2·4	−2·8	8·0	1·0	− 1·8
2·6	−2·9	8·6	1·5	− 2·2
2·8	−3·0	9·2	2·0	− 2·5
3·0	−3·1	9·8	2·5	− 2·8
3·2	−3·2	10·5	3·0	− 3·0
3·4	−3·3	11·2	See table ←	
3·6	−3·4	11·9		
3·8	−3·5	12·6	m	′
4·0	−3·6	13·3	20	− 7·9
4·3	−3·7	14·1	22	− 8·3
4·5	−3·8	14·9	24	− 8·6
4·7	−3·9	15·7	26	− 9·0
5·0	−4·0	16·5	28	− 9·3
5·2	−4·1	17·4		
5·5	[illegible]	18·3	30	− 9·6

3- Subtract the Dip figure of 3.2' from the Hs of 62° 14.3'. Why are we now using an Hs of 62° 14.3'? Because for consistency of methods, examples, reduce paper amount and to get the same Latitude figure in all of these examples. The Dip figure must be subtracted as, in this example, your eyes really are 11 feet above the water so there must be a correction to the sight.

62° 14.3'
0° 03.2
62° 11.1'

4- Return to step 14 in the AH procedure to continue finding Latitude.

Possible Errors

- Wrong sextant vernier reading.

- The sextant has a large Index Error that wasn't corrected in the calculations.

- Wrong Longitude and hour figure on which to base LAN. You could've been off by 7-1/2° or even 15° which would've placed you 1 hour ahead or behind the correct hour on which you took the sight. However, that wouldn't change the declination figure that much but it would've probably yielded an incorrect Hs.

- When making the observation you thought, incorrectly, you sighted the Sun at its highest point (zenith).

- You shot Sun's UL (Upper Limb) but used the figure from ACT for the LL (Lower Limb).

- Wrong date and declination figure. A declination figure from the correct date but wrong hour will not introduce large errors. In the example of August 24, 2015 the Sun's declination changes -0.9' per hour. The daily pages “d” figure at the bottom of the declination column reads d= -0.9'. That's about 1' of arc per hour which is equivalent to 1 nautical mile of Latitude. It isn't that much of an error. Getting a Latitude figure within 5 miles of your actual Latitude is pretty good. If you were on the ocean and 1,500 miles from land that figure would be acceptable.

- AH problems- the wind disturbed the water resulting in an inaccurate reading. Put a “tent” of glass over the bowl or dish of water like you see here- Click here- an Artificial Horizon

Summary of method to obtain Latitude by Noon-Sight using an AH

1- Determine, approximately, at what hour LAN occurs at your Longitude using The Nautical Almanac.

2- Obtain the Sun's declination for the hour you'll be making the observation.

3- Using an AH, take sights of the Sun's Lower Limb until the Sun is at its zenith.

4- Record the sextant Hs figure.

5- Divide the Hs figure by 2

6- Correct the sextant Hs figure for Index Error to obtain the Ha figure.

7- Using the “ALTITUDE CORRECTION TABLES 10° – 90° SUN, STARS, PLANETS” (ACT) find the Sun's Ha figure in the Sun's Lower Limb column which is between 2 of the Ha figures. The amount will be in minutes of arc.

8- Add the answer found in the ACT tables to the Ha figure to obtain the Ho figure.

9- Subtract the Ho figure from 90°.

10- Find the Sun's declination for the hour of observation and add or subtract it to the figure obtained in step 9 according to the following rules. The answer is your Latitude.

Rules to Calculate Latitude

1- Latitude and declination *Same names* but latitude is greater than declination:
Latitude= (90° – Ho) + declination

2- Latitude and declination *Same names* but declination greater than latitude:
Latitude= Declination – (90° – Ho)

3- Latitude and declination *Contrary names*:
Latitude= (90° – Ho) – Declination

An easier way to determine Latitude using an AH *no corrections*

In step 5 for determining Latitude using an AH you brought the Sun down so it just “sat” on top of the AH's reflected Sun. When using an AH you can also superimpose the Sun so the reflection in the AH appears to be one Sun.

With this method you aren't going to correct for *Parallax, Refraction* or *Semi-diameter.* All of these figures are conveniently combined into one figure using the ACT. The result won't be as accurate if you performed all of the necessary corrections but it'll be *close enough.*

No further corrections to the sextant are needed (unless you must or want to correct for Index Error).

Here's how to do it;

1- Follow step 6 in the AH method only this time superimpose the two Suns.

2- Record the sextant measurement and divide it by two to give you the Hs.

3- Subtract the Hs figure from the zenith distance of 90°.

4- Add or subtract the figure found in step 3 to the Sun's declination for the hour of the Noon-Sight according to the rules on page 10 of 10.

5- The result is your Latitude.

So let's see how different the answer is than the one found in step 22 above. For this example the Sun's diameter of about 0° 30' was added in because the Sun was superimposed in the AH. This *diameter* is the Sun's Semi-diameter multiplied by 2.

90° 00' (zenith distance)
– <u>62° 26.1'</u> Hs
27° 33.9'

27° 33.9'
+ <u>11° 02.3'</u> (Sun's declination for the hour of observation)
38° 36.2'

Your Latitude is N 38° 36.2'. The Latitude found in step 22 was N 38° 35.7'. The two figures are very close with a difference of less than 1 mile. For a more accurate figure correct the Hs figure for Refraction.

<u>Note</u>- I've tried this method many times and have found the result very close to actual Latitude. It's a very fast method requiring only the Sun's declination for the hour in which you took the Noon-Sight.

Rules to Calculate Latitude

1- Latitude and declination *Same names* but latitude is greater than declination:

Latitude= $(90^\circ - Ho) + declination$

2- Latitude and declination *Same names* but declination greater than latitude:

Latitude= $Declination - (90^\circ - Ho)$

3- Latitude and declination *Contrary names*:

Latitude= $(90^\circ - Ho) - Declination$