Mate Gilmartin's Celestial Navigation Notes

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Great Circle Equations

$\cos L_v = (\cos L_1)(\sin C)$
$\sin DLo = (\cos C)(\csc L_v)$
$\csc DLo_v = (\sec C) / (\csc L_v)$
$\sin D_v = (\cos L_1)(\sin DLo_v)$
$\tan L_x = (\cos DLo_{vx})(\tan L_v)$
$\csc L_x = (\csc L_v)(\sec D_{vx})$

$\cos D = (\sin L_1 \sin L_2) + (\cos L_1 \cos L_2 \cos DLo)$
$\tan C = (\sin DLo) / (\cos L_1 \tan L_2 - \sin L_1 \cos DLo)$

L_1:Latitude at position 1
L_2: Latitude at position 2
L_v: Latitude of vertex
L_x: Latitude at position on great circle
C: course
DLo: Difference of Longitude between position 1 and position 2
DLo_v: Difference of Longitude between position 1 and vertex
DLo_{vx}: Difference of Longitude between vertex and position on great circle
D: Distance between position 1 and position 2
D_v: Distance between position 1 and vertex
D_{vx}: Distance between vertex and position on great circle

<u>All values entered in Degrees</u>

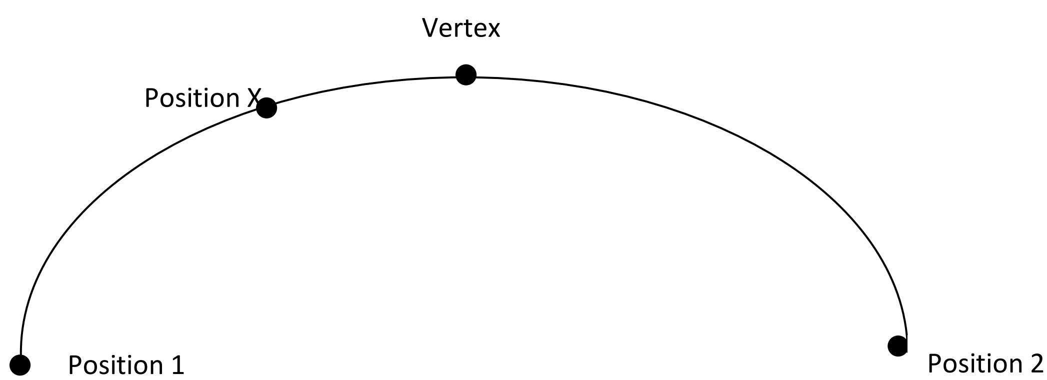
When crossing the Equator, L_2 becomes negative

sec = 1/cos   csc=1/sin   cot=1/tan

When moving a cos/sin/tan to the other side of an equation, make it a $\cos^{-1}/\sin^{-1}/\tan^{-1}$

Ex. $\sin D_v = (\cos L_1)(\sin DLo_v)$
$D_v = \sin^{-1}(\cos L_1)(\sin DLo_v)$

Working out $\csc DLo_v = (\sec C) / (\csc L_v)$ does become $Dlo_v = \sin^{-1}(\cos C / \sin L_v)$
(This is the hardest one and I have no idea why Bowditch writes it this way)



Mercator Sailing

Equations from Bowditch

$\tan C = DLo / m$

$D = \ell / \cos C$

Dlo: Difference of Longitude (in minutes)

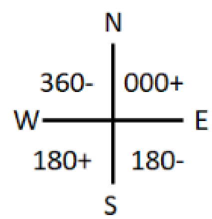
ℓ: Difference of Latitude (in minutes)

C: Course Angle (in degrees, needs to be corrected)

Cn: True Course (in degrees, the actual course)

M: Meridional Parts (From Book, based on Latitude)

m: Meridional Difference (difference between Meridional Parts)



Steps

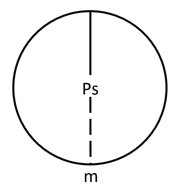
- Find Difference of Latitude (ℓ)
- Find Difference of Longitude (Dlo)
- Find M1 based on L1
- Find M2 based on L2
- Find m by finding the difference between M1 and M2
- Solve the Equations
- Correct C into Cn using the quadrant table

If you have Cn and D, adjust the equation to solve for ℓ and DLo and work backwards

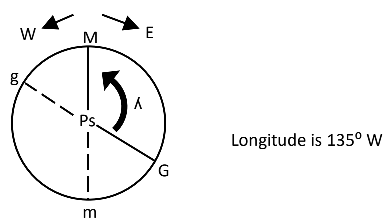
Time Diagrams

Time Diagrams are useful when attempting to understand the relationship between the different Hour Angle Circles (GHA, SHA, LHA)

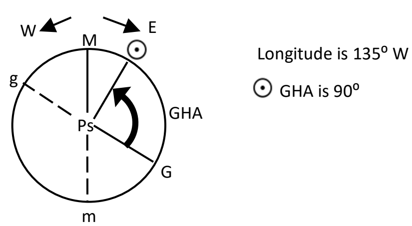
They are drawn facing the South Pole (Ps)
First draw the Observer's Meridian at the top.
Upper Branch is labeled M. Lower branch is labeled m.
West is drawn clockwise from M. East is drawn counterclockwise from M.



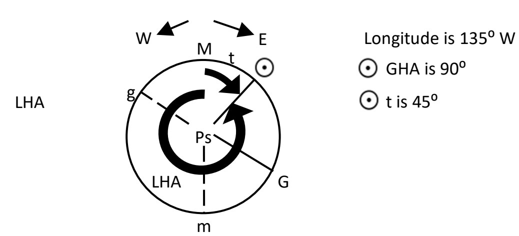
Next draw the Greenwich Meridian based upon the Observer's Longitude.
Since Longitude is measured FROM Greenwich TO the position, this is measured backwards from M.
So, if we are in a West Longitude we would draw the arc clockwise. (we are to the west of Greenwich)
Upper branch is labeled G. Lower branch is labeled g.



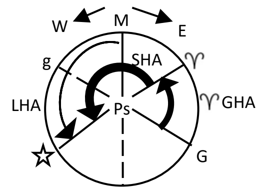
Then draw the Hour Angle for the Celestial Object
GHA is measured Counterclockwise (Westerly) from the Greenwich Meridian.



LHA is measured Counterclockwise (westerly)
from the Observer's Meridian.



SHA is measured Counterclockwise (westerly) from the GHA of Aries



Longitude is 135° W
☆ SHA is 110°
♈ GHA is 45°
☆ LHA is 20°

LHA = GHA +/- Longitude
Add East Longitude, Subtract Westerly Longitude
Must be measured Westerly for LHA, subtract from 360 if in the Easterly Direction

☆ LHA = ♈ GHA + SHA (+/-) Longitude
Add Westerly Longitude, Subtract Easterly Longitude

	GhA ♈	45°
+	ShA ☆	110°
	GhA ☆	155°
-	ʎ	110°
	LhA ☆	20°

Calc of Time for Celestial Phenomenon Notes

Step One:

Find time for Latitude. If in between two standard Latitudes, you must interpolate

Step Two:

Find difference of Longitude from your Longitude to the Central Meridian.

Step Three:

Convert Difference of Longitude into time using Arc to Time Table

Step Four:

Apply difference of Longitude to the time of the phenomenon for your Latitude.

- This is your First Estimate

Step Five:

If you are moving, find distance you will travel from your current position to this calculated time for the event. Find your position at this time. Repeat Steps One through Three.

- You can either plot and DR your position out or use one of the sailing methods you learned in T-Nav. Plane Sailing is the easiest
    - Difference of Latitude = Distance cos Course Angle
    - Difference of Longitude = Distance sine Course Angle
- This is necessary because you will be moving away from your current position which the time had been calculated for. You must find the time of the event for the position you will be in when it occurs. Sometimes the difference is small, sometimes it is quite significant.
- This is your Second Estimate

These steps are the same for all Celestial Phenomenon including Sunrise, Sunset and LAN. Only difference for LAN is that Latitude does not matter so you do not have to make a Latitude correction.

Azimuth of Polaris

Step One: Find LhA of Aries

- Find the GhA of Aries (hours)
- Fiind the GhA of Aries (m+s)
- Apply Longitude (Add east subtract west)

Step Two: Use Polaris Tables

- Across the top, find the column which has the correct LhA of Aries
- Trace this column down the page to the appropriate Latitude in the Azimuth Table at the bottom
- This is your True Bearing of Polaris

Step Three: Solve Compass Correction

- GET = Gyro, Gyro Error, True Angle (Add East from Left to Right)
- CDMVT =Can Dead Men Vote Twice (Add East from Left to Right)

Biggest Mistakes:

- Not knowing this one is easy or how to use the table

Calculating an Azimuth

Step one: Find GhA

- Look up the day for the observation
- Go to the hour for your observation, write this value for GhA (h)
- Go to the min/sec pages (back yellow section) and look up the value for the min and sec for the observation, write this value for GhA (m+s)
- Add the GhA hours to the Gha min and sec for Total GhA

Step two: Find LhA

- Apply your Longitude to the Total Gha
- Add East, Subtract West

Step Three: Find Declination

- While you were pulling info for GhA (h), also write down the Declination for the hour for Dec
- Note if the values get higher or lower as you go down the page. Higher you will add the correction, lower you subtract the correction
- Write the d Correction which is found at the bottom of the page
- When you turn to the min/sec pages (back yellow section) for finding GhA, also write down the corresponding d Correction (look at the right hand columns which say v or d corr, then find the value for the d Correction you found earlier, write down the number next to it)
- Apply this new d Corr to the initial Dec (add if values went higher, subtract if values went lower)

Step Four: Ho 229

- Check your Latitude, are you going to be in the front half or the back half of the publication
- Turn to your appropriate LhA. Remember, this is sometimes found in the bottom right hand page as well
- Make sure you are looking at the correct page. Check to see if your Latitude and Declination are the SAME or CONTRARY.
- Follow your Latitude Column down to the correct Declination Row. Write down the Z. This is your base Azimuth Angle. We need to correct for the LhA increments, the Latitude increments, and the Declination increments
- Pull Z from one degree Latitude up
- Pull Z from one degree Declination up
- Pull Z from one degree LhA up, you will have to turn the page for this one
- Find the difference between the Base Z and each the other three Z values
- Multiply the differences found for each of the three Z values by the corresponding increment value (increment value is found by taking the minutes left over for the LhA, the Latitude, or the Declination and dividing by 60. You are basically just converting the left over minutes we have not accounted for yet into a decimal degree.)

- Find the average of these three values (some may be labeled as a negative number if the Z values were going down)
- Apply this averaged value to the Base Z. This is your Az or Final Azimuth Angle.
- Lable the AZ N/S based upon Latitude. Label the E/W based upon your Meridian Angle. (If LhA is greater than 180 it is E, if LhA is less than 180 it is W)
- Convert the Az into a True Bearing or Azimuth labeled Zn.

NW 360 - Zn = T^{o}	NE Zn = T^{o}
SW 180 + Zn = T^{o}	SE 180 - Zn = T^{o}

Step Five: Solve Compass Correction

- GET = Gyro, Gyro Error, True Angle (Add East from Left to Right)
- CDMVT =Can Dead Men Vote Twice (Add East from Left to Right)

Biggest Mistakes:

- Applying Longitude incorrectly to GhA to find LhA. Add East Subtract West
- Correct page in Ho 229. Make sure you check if Latitude and Declination are Same or Contrary
- Pulling the correct values for Z from Ho 229. When you flip a page it is easy to pull the incorrect info
- Applying the increments correction wrong. You take the average of all corrections. Make sure you recognize if one should be a negative number.
- Correcting the Az to the Zn.

Calculating an Amplitude

Step One: Find Declination

- While you were pulling info for GhA (h), also write down the Declination for the hour for Dec
- Note if the values get higher or lower as you go down the page. Higher you will add the correction, lower you subtract the correction
- Write the d Correction which is found at the bottom of the page
- When you turn to the min/sec pages (back yellow section) for finding GhA, also write down the corresponding d Correction (look at the right hand columns which say v or d corr, then find the value for the d Correction you found earlier, write down the number next to it)
- Apply this new d Corr to the initial Dec (add if values went higher, subtract if values went lower)

Step Two: Amplitude Equation

- Use the Equation: $\text{Sin (Amplitude)} = \text{Sin (Declination)} \times \text{Sec (LAT)}$

- Which is converted into: $\text{Amplitude} = \text{Sin}^{-1}\left[\frac{\text{Sin (Declination)}}{\text{Cos (LAT)}}\right]$

- Or you can also use Table 22 instead of the Equation

- Was your Amplitude taken on the Celestial Horizon (Sun 2/3 above visible horizon)?
    - Yes, No Correction
    - No, you must apply a correction to place the Amplitude on the Celestial Horizon
        - Use Table 23, Apply correction away from the elevated pole (If Lat is North, apply in a Southerly direction). Sometimes you will add sometimes you will subtract
        - This is applied to your Observed Bearing

- Convert your Amplitude Angle into a True Bearing. This is different than Azimuth Angle and Course Angle. The Amplitude Angle is measured from East and West so use the table below
    - Also, note that the Amplitude is labeled based upon if it is Rising or Setting
        - Sun Rises in the East, Sets in the West (If Rising, East; If Setting, West)
    - The Amplitude is also labeled based upon if it is in the Declination (North or South)

NW 270 +	NE 90 -
SW 270 -	SE 90 +

Step Three: Solve Compass Correction

- GET = Gyro, Gyro Error, True Angle (Add East from Left to Right)
- CDMVT =Can Dead Men Vote Twice (Add East from Left to Right)

Biggest Mistakes:

- Labeling the Amplitude Angle
- Using the wrong correction table, the Amplitude Angle is measured from 90 or 270.
- Forgetting the Horizon Correction if you are on the Visible Horizon or applying it in the wrong direction

Corrections for other Celestial Bodies

The procedure for calculating any problem for any celestial body, such as the Azimuth for Duhbe, is exactly the same as solving the calculation for the Sun, plus a few small corrections. Below are the additional steps which are required for other bodies.

Stars

- You find GHA for Aries and then add the SHA of the star
- Declination is always the same for a star

Planets

- Apply the “v” correction to your GHA
    - Solving for the “v” correction is done the same as solving for the “d” correction in Declination

Moon

- Apply the “v” correction to your GHA
    - Solving for the “v” correction is done the same as solving for the “d” correction in Declination
- Apply the “HP” and “Main” correction to “Ha”
    - Pull “HP” value from daily pages
    - Solve for “Ha”
    - Use Moon Altitude Pages in the back of the Nautical almanac to find your “Main” correction
    - Continue down the same column in the Moon Altitude Pages to the “HP” Value
        - L is for Lower Limb, U is for Upper Limb
    - Add both the “Main” correction and the tabulated “HP” correction to “Ha”
        - Also subtract 30’ from “Ha” if the Upper Limb is used

Hs to Ho

Step 1: Hs to Ha (Height/Altitude Sighted to Height/Altitude Apparent)

- Hs is obtained from the Sextant
- Apply Index Correction (IC)
  - If IC is ON the arc, take it off (subtract)
  - If IC is OFF the arc, put it back on (add)
- Apply the Dip Correction
  - Based on your Height of Eye (your height plus the height of the deck you are standing on)

Step 2: Apply the Main Correction to Ha to get Ho

- Altitude Correction Tables based upon Time of year and Apparent Altitude
- Don't forget if you used the Upper Limb or the Lower Limb of the sun

Additional Corrections

- For extreme temperatures or Pressures, use table A4
- For the Moon, apply the HP correction using Altitude Correction Tables for the Moon found in back of Yellow Pages

Sight Reduction (Sun)

Step 1: Solve Hs to Ho

Step 2: Find Assumed Position LHA

This is very similar to finding LHA with an Azimuth. Big difference is that you must use an assumed position. Since we don't really know our true position yet, we can manipulate the numbers for this assumed position so that we don't have to interpolate as much, basically we will adjust our position so that we have a whole degree value for our Latitude and our LHA so that Ho 229 is much easier.

- Find GHA (hours) of the Sun
- Find GHA (min + sec) of the Sun
- Find total GHA (h, m,& s)
- Apply Longitude so that we get whole degrees of LHA (you may have to change minutes of Longitude so that it equals 0, this is ok because it is only an Assumed Position)
    - Add East, Subtract West
    - Make sure that this Assumed Longitude is within 30' of original DR position
        - You may have to change your degrees assumed longitude up or down a degree to make this work

Step 3: Find Declination (Same as before)

Step 4: Find Hc

- Look up your LHA, your Lat (rounded to a whole degree), and your declination and pull out the value Ht (labeled Hc in Ho 229)
- Look up your Ht correction (labeled d in Ho 229)
- Take the minutes of Declination / 60 and multiply this value by the Ht correction (this is to interpolate for exact Declination)
- Apply the interpolated Ht Correction to get your Hc

Step 5: Find Zenith Angle

- Look up your LHA, your Lat (rounded to a whole degree), and your declination and pull out the Z_1 value (Value for Z in the whole Declination)
- Pull the Z_2 value which is directly below your Z_1 value
- Find the difference between Z_1 and Z_2 which will give you your Z correction
- Multiply the Z correction by minutes of Declination / 60 (this is to interpolate for exact Declination)
- Apply the interpolated Z correction so that the final Az value is in between Z_1 and Z_2
- Label the Az (Azimuth Angle) based upon your Latitude and your t angle
- Solve for your true Zn (Zenith Angle)

Step 6: Compare Ho to Hc to find "a" (true position difference from assumed position)

- Find the difference between Ho and Hc
- Label Toward or Away
    - Ho Mo To
    - If Ho is More labeled Toward

Step 7: Plot Sunline

Common Mistakes:

The process for calculating information for a LOP is very similar to an Azimuth calculation so the things that are different are what most people mess up

- Assumed Longitude
    - This must be manipulated so that it is within 30' of original position but when combined with GHA, creates a whole degree of LHA
- Interpolating for Declination
    - This seems different than Azimuths but it is exactly the same, we are just interpolating for only Declination and not for Latitude and for LHA
- Interpolating for Ht
    - This is the same as Interpolating for Declination

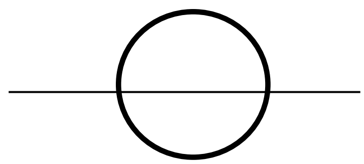
Latitude by LAN

Step 1: Solve Hs to Hs

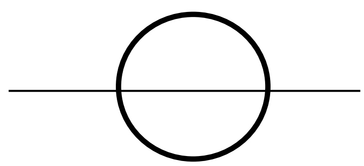
Step 2: Find total Declination
- Don't forget to apply the d correction

Step 3: Find Zenith Distance
- 90 – Ho = Zenith Distance

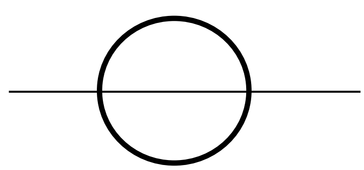
Step 4: Apply Declination to Zenith Distance to get Latitude
- Draw Diagram to determine relationship
    - Ship and Sun in Opposite Hemispheres
        - Latitude = Zenith Distance – Declination



    - Ship and Sun in Same Hemisphere (Declination less than Latitude)
        - Latitude = Zenith Distance + Declination



    - Ship and Sun in Same Hemisphere (Declination more than Latitude)
        - Latitude = Declination – Zenith Distance



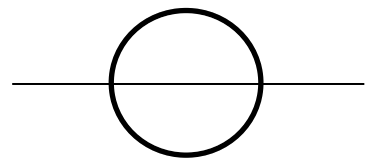
Example:

Date: March 24, 1981

Latitude 22°-34.1'N
Longitude 32°-58.0W

Zt 1214
Zd +2
GMT 1414

Hs 68°-47.5
IC 0.0
Dip(60ft) -7.5
Ha 68°-40.0
Main +15.8
Ho 68°-55.8



Dec N 1°-31.6
D(+1.0) +.2
Dec N 1°-31.8

90 - 00.0 89 - 60.0'
Ho 68° - 55.8'
Zenith Dist 21° - 04.2'
-Dec N 1° – 31.8'
LAT 22° – 36.0' N

Latitude by Polaris

Step 1: Solve Hs to Ho

Step 2: Find LHA of Aries

- Find GHA(h) of Aries in Nautical Almanac
- Add GHA (m+s) for stars
- Apply Longitude
    - Add East, Subtract West

Step 3: Go to Polaris Tables (in back of Nautical Almanac, in front of yellow pages)

- Find column for LHA of Aries
- Pull the values for a_0, a_1, a_2
    - a_0 is based on LHA Aries
    - a_1 is based on Latitude (round to the nearest)
    - a_2 is based on Month

Step 4: Solve the equation

- Latitude = Ho - 1° + a_0 + a_1 + a_2

Assumed Position

Latitude 44°N — October 25 1981

Longitude 40°-30'W — 0505 GMT

Hs	44° - 03.0'	
IC	-2.0'	
Dip(10.0)	-3.1'	
Ha	44° - 24.9'	a_0 = 18.5'
Main	-1.0'	a_1 = 0.6'
Ho	44° - 23.9'	a_2 = 0.4'

GHA ♈ (h)	108° - 29.9'
GHA ♈ (m+s)	1° - 15.0'
GHA ♈	109° - 44.9'

Latitude = 44°-23.9' - 1° +18.5' +0.6' + 0.4'

Latitude = 43°-43.4'N

Star Finders

The Star Finder is made up of a plastic star base, clear plastic latitude templates and a clear plotting template. One side of the star base is for northern latitudes and the other is for southern latitudes. Each clear plastic template also has a corresponding north and south side. The star base has the celestial equator printed halfway between the pole (center of the star base) and the outer rim which indicates degrees of SHA. Major navigable stars have been printed on the star base however lesser stars or planets must be plotted on the star base in order to be used on the star finder which is accomplished through the use of the clear plastic plotting template.

Plotting objects on the star base (such as planets and lesser stars)

- Determine the objects SHA and Declination
  - Planets have SHA at the bottom of the Daily Pages
  - Lesser Stars are found in the back of the Nautical Almanac. If you are having a difficult time finding the star you are looking for remember that the right hand pages are the Common name and the left hand pages are the Astronomical name of the same star and that they are grouped by constellation
- Convert the SHA to RA (Right Ascension)
  - 360-SHA
- Put the clear plastic plotting template on the star base
  - Make sure that you are using the correct side of the star base (North/South)
- Shift the arrow on the clear plastic plotting template over to the object's RA
- Find the Declination (through the square hole in the plastic plotting template) and plot the position of the object at this location

Star Selection

- Determine the LHA of Aries
- Place the clear plastic latitude template on the star base
  - Make sure that you are using the right hemisphere for both the star base and the clear plastic latitude template
  - Use the correct clear plastic latitude template based on your latitude
- The grid on the clear plastic latitude template will indicate the bearing (ZN) and the altitude (Ho) of the celestial body.
  - "good cross" (bearing about 45° between each)
  - good altitude, not too high or too low (between 20°-70°)
  - Make sure they are bright
  -

Star Identification

- Same set up as Star Selection only identify the star based on the Ho and the Altitude of the body you had observed. Be sure to plot the planets beforehand because they could also be the object which you had observed

Time Tick and Chronometer Error

Chronometer: An extremely accurate clock used onboard vessels to keep time. All clocks gain or lose time however, Chronometers are extremely accurate because of the fact that they gain or lose time at a very precise rate. Chronometers are able maintain this very precise rate of time loss/gain because their design and the fact that they are wound every day at exactly the same time. They are also usually placed in a well-protected area with gimbled mountings and padding which help protect the clock for outside influences.

Chronometers are set to GMT every time they are cleaned and are not reset in-between cleanings. Usually, there is quite a bit of time that elapses between cleanings so substantial error can be accumulated over time. This error is determined by the Time Tick.

The Time Tick is a radio broadcast signal which is sent at the top of the hour to indicate exact GMT time. This is utilized by comparing exact GMT time to the Chronometer to determine Chronometer Error. The Time Tick is completed in a 24 hour clock format.

Finding Chronometer Error from the Time Tick

- Compare Chronometer to Time Tick
  - Ignore the dots and the dashes the question mentions, it just makes the problem confusing and is auxiliary information
  - Time Tick is exact GMT time, Chronometer is very close to GMT time
    - Time Tick utilizes 24 hour clock, Chronometer utilizes 12 hour clock
      - Replace the Time Tick with the Chronometer hours, they are the same thing. Now you have the exact Time Tick in GMT

- If a Comparing Watch is used, the Comparing Watch was used at the same time as the Time Tick, exact top of the hour GMT Time
  - Find the error between the Comparing Watch and the Time Tick
  - Then compare the Chronometer to the Comparing Watch
  - Combine the error from the Time Tick to Comparing Watch with the error of the Comparing Watch to the Chronometer to get total error.

- Sometimes it is difficult to obtain a Time Tick for several days, this is when knowing how the Chronometer Gains or Loses time can be helpful
  - Multiply the time that has elapsed by the Gain/Loss rate of the Chronometer
  - Apply to the previous amount of error found at the last Time Tick

Amplitude of the Sun

Date ___________

Lat _______________

Zt _____________

Long ______________

Zd ______________

GMT____________

Gyro Ø _____ Variation _______ Deviation _______ Gyro heading _______

Dec ______________

d(   ) ______________

Dec ______________

Was it on the Celestial Horizon (2/3 above Visible)?

If not, apply the correction:

Amp = __________

Corr = ___________

Amp = ___________

$$\text{Amp} = \sin^{-1}\left(\frac{\sin(\text{Dec})}{\cos(\text{LAT})}\right)$$

$$\text{Amp} = \sin^{-1}\left(\frac{\sin(\_\_\_\_\_\_)}{\cos(\_\_\_\_\_\_)}\right)$$

Conversion to True:

NW	NE
270 +	90 -
SW	SE
270 -	90 +

____

Amp = __________

True Amp = ________________

	G	E	T	
	______	______	______	
	G	E	T	
	______	______	______	
C	D	M	V	T
______	______	______	______	______

Azimuth of ______________ Date ___________

Lat _______________ Zt _____________

Long ______________ Zd _____________

GMT____________

Gyro Ø _____ Variation ______ Deviation ______ Gyro heading ______

ShA or v_____________

GhA (h) _____________ Dec ______________

GhA (m+s)___________ d( ) _____________

GhA ________________ Dec ______________

aλ __________________

LhA ________________

LhA	LAT	Dec
( ) _________	( ) _________	( ) _________
( ) _________	( ) _________	( ) _________
_________	_________	_________
_________	_________	_________
_________	_________	_________

base ______________

Corr______________

Az _______________

360--	000+
180+	180-

Az _________________ = ___________ Zn

G	E	T
_________	_________	_________

G	E	T
_________	_________	_________

C	D	M	V	T
_______	_______	_______	_______	_______

Sun Fix

Date ____________

LAT		
LONG		
Zt		
Zd		
GMT		
GhA♈ (h)		
GhA♈ (m+s)		
GhA♈		
aλ		
LhA		
Dec		
d (___)		
Dec		
Ht		
Corr		
Hc		
Z_1		
Z_2		
Zcorr		
Az		
Zn		
Hs		
IC		
Dip (_____)		
Ha		
Main		
Ho		
Ho		
Hc		
"a"		
aLAT		
aLONG		
"a"		
Zn		

Course ______________ Speed ___________

LAN

1200 Position

Lat ____________ Local Meridian _____________

Long ___________ Central Meridian___________

Diff of Long _______________

Arc to Time _______________

LAN at Central Meridian _____________

Arc to Time _______________________

Est of LAN _______________________

LAT	
LONG	
Zt	
Zd	
GMT	
Hs	
IC	
Dip (_____)	
Ha	
Main	
Ho	
Dec	
d (___)	
Dec	
90 – 00.0	
Ho	
Co-alt	
(+/-) Dec	
LAT	

Completed ___________________ Mate Signature ___________________

Star Fix

Date ___________

Course ___________ Speed __________

Body				
LAT				
LONG				
Zt				
Zd				
GMT				
ShA (or v)				
GhA (h)				
GhA (m+s)				
GhA				
aλ				
LhA				
Dec				
d (_____)				
Dec				
Ht				
Corr				
Hc				
Z_1				
Z_2				
Zcorr				
Az				
Zn				
Hs				
IC				
Dip (______)				
Ha				
Main				
HP or v corr				
Ho				
Ho				
Hc				
"a"				
aLAT				
aLONG				
"a"				
Zn				

Plotting on a Universal Plotting Sheet

An Universal Plotting Sheet is a unique chart which can be used for any position in the world due to the fact that you create your own Meridians. Other than the fact that you must draw the Meridians, it can be treated as a normal Mercator projection chart used for Open Ocean Sailing.

Step 1: Create the Lines of Longitude

- Draw a line across the Longitude Scale according to your Latitude
- Measure a full 60minutes (or 1 degree) of Longitude on the Longitude Scale
- Use this measurement by measuring away from the center Meridian on either side
- Draw the Lines of Longitude in at these measurements

Step 2: Label the Lines of Latitude and Longitude

- Double check that you are going in the correct direction (South and East are commonly written backwards)

Step 3: Plot your Track line

- Plot your last known position
- Plot your Track line
- Plot the DRs for the top of every hour (Run the DR at least 2 hours after the last observation)

Step 4: Plot your Assumed Position for your first LOP

Step 5: Measure Zn from your Assumed Position

Step 6: Measure the Intercept (“a”) Towards or Away from the direction of your Zn

Step 7: Draw your LOP perpendicular to your Zn at the measured Intercept

Step 8: Advance or Retard the LOP to the desired time

Note:

Measure all distances along the Latitude Scale.
Measure all Longitude measurements on the Longitude Scale

Plotting on a Universal Plotting Sheet

Latitude @ LAN

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Step 3: Plot your Track line

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- Plot your Track line
- Plot the DRs for the top of every hour (Run the DR at least 2 hours after the last observation)

Step 4: Draw in LAN at your calculated LAN

Note:

Measure all distances along the Latitude Scale.
Measure all Longitude measurements on the Longitude Scale

Plotting on a Universal Plotting Sheet

Sun Line or Star LOP

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- Use this measurement by measuring away from the center Meridian on either side
- Draw the Lines of Longitude in at these measurements

Step 2: Label the Lines of Latitude and Longitude

- Double check that you are going in the correct direction (South and East are commonly written backwards)

Step 3: Plot your Track line

- Plot your last known position
- Plot your Track line
- Plot the DRs for the top of every hour (Run the DR at least 2 hours after the last observation)

Step 4: Plot your Assumed Position for your first LOP

Step 5: Measure Zn from your Assumed Position

Step 6: Measure the Intercept (“a”) Towards or Away from the direction of your Zn

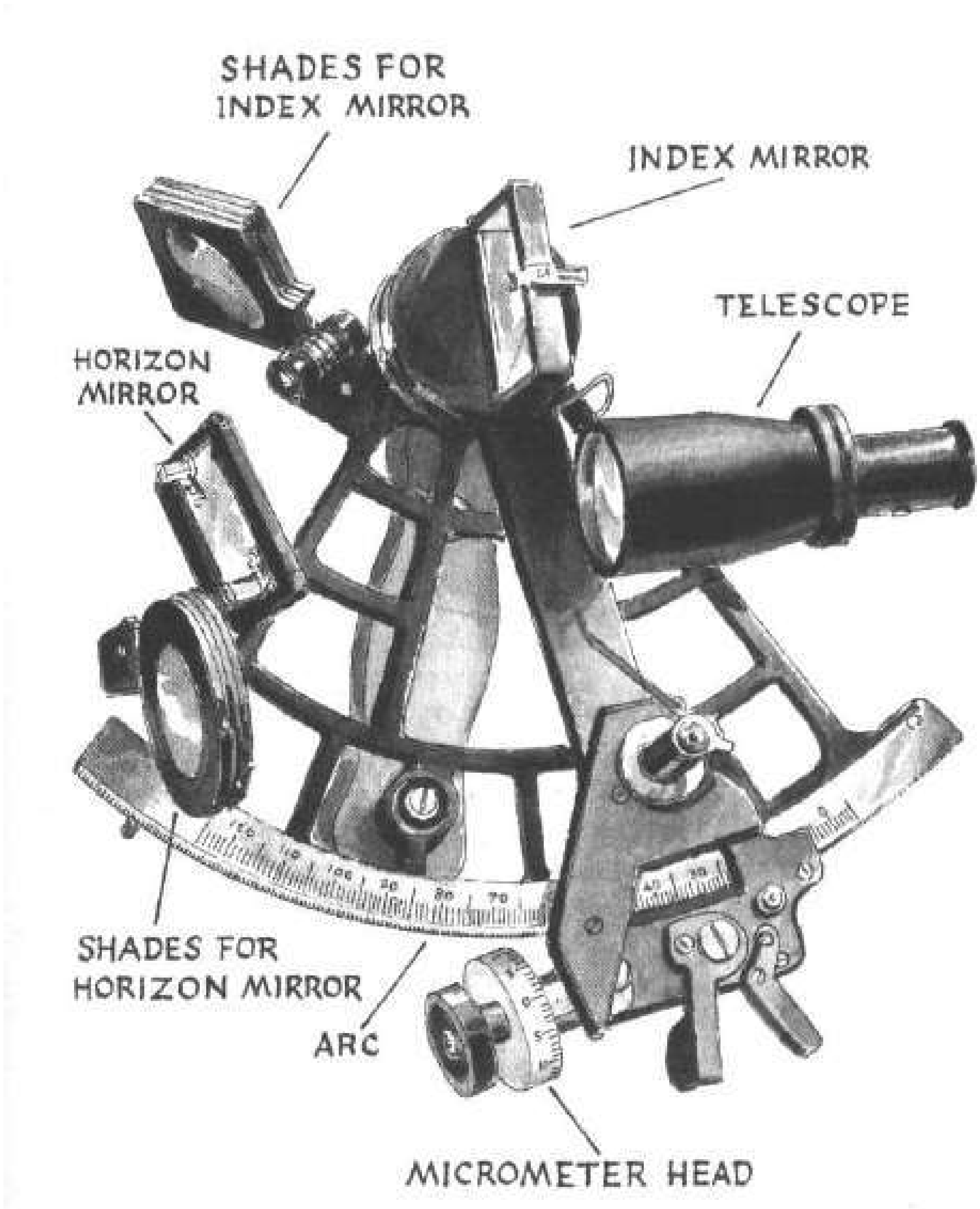
Step 7: Draw your LOP perpendicular to your Zn at the measured Intercept

Step 8: Advance or Retard the LOP to the desired time

Note:

Measure all distances along the Latitude Scale.
Measure all Longitude measurements on the Longitude Scale

Parts of a Sextant



The nautical sextant : errors and adjustments

altitude correction tables

- Instrument error (prismatic error, graduation errors, eccentricity of sextant)
- Adjustable sextant errors

Instrument error

A good sextant is accompanied by a calibration certificate which reports the " reading errors " along its full graduated scale; otherwise the factory declares that the instrument is free of errors (certifying that the error is less than +/- 9" which is negligible for practical use). Cassens & Plath and Freiberger attest that ! It is not an " adjustable sextant error ".

Adjustable errors

the sequence has to be respected in detecting and removing of errors :

1 - Perpendicularity Error

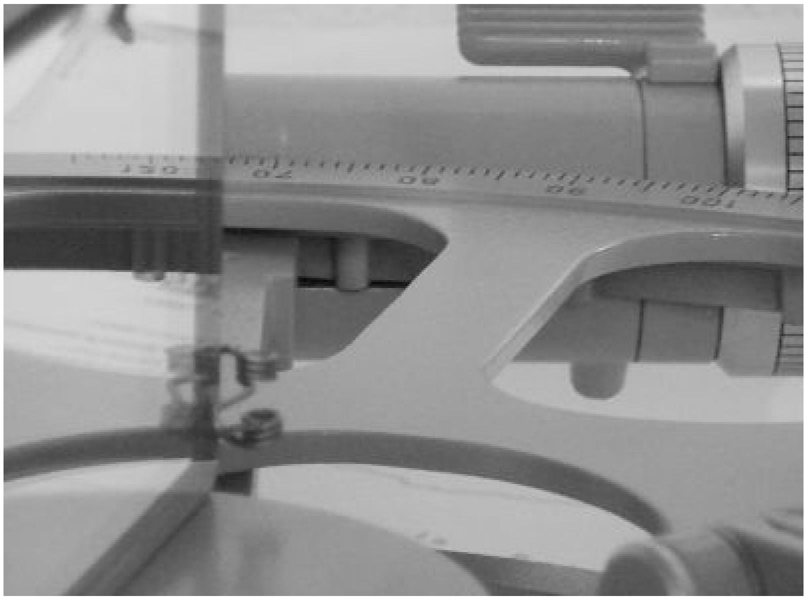
2 – Side Error

3 – Collimation Error

4 – Index Error

Perpendicularity Error

This error appears when the index mirror (rectangular mirror) is not perpendicular to the frame (and arc). It is easy to detect it. Put the sextant on an horizontal plane and move the alidade to a position 35°-45° degrees. Look at the index mirror in the direction of arc (graduated scale). We see two images of the scale: the reflected image on the left side, the direct image on the right side. We must see a straight line (the arc with the graduated scale) as in this photo:



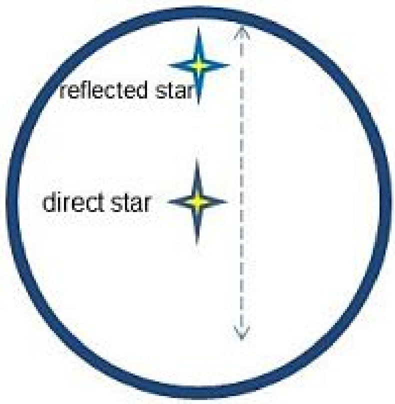
If we see a broken line we remove the error using the adjusting screw on the index mirror:

Side Error

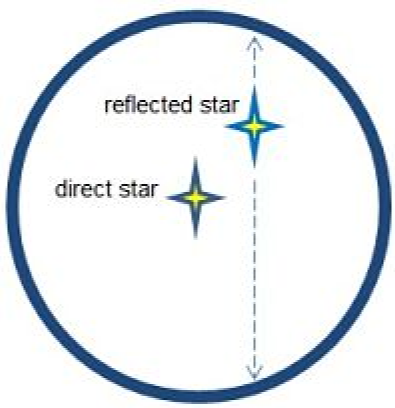
This error appears when the horizon mirror (rounded mirror) is not perpendicular to the frame.

We choose a very small star in the sky (less than magnitude 4.0 or 5.0) to identify the error . Set the alidade to zero degrees, observe the star with the sextant and move the drum (minute scale).

The reflected star has to pass alternately below and above the direct star (not reflected) :

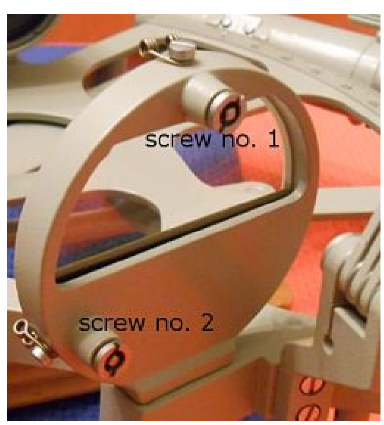


Here the reflected star does not pass on the direct star in the vertical movement:



the " side error " must be removed using the adjusting screw on the horizon mirror (screw no. 1):

adjustment screws on the horizon mirror



Collimation Error

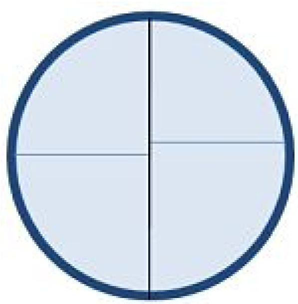
" a high quality sextant is not affected by this error "

Index error

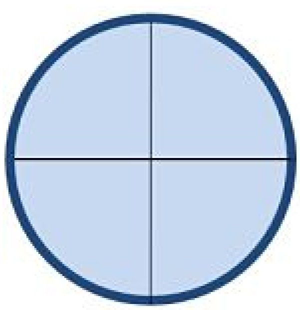
We can use the sea horizon, a small star, the Sun or an horizontal line at a distance of 3 nautical miles at least (to avoid the parallax error).

The sextant has an index error if the index mirror and horizon mirror are not parallel when the index arm (alidade) and the drum with minute scale are set exactly at zero. If the error is more than +/-3,0' we have to reduce it.

We look at the horizon with the telescope: direct horizon and the reflected horizon should be a straight line.



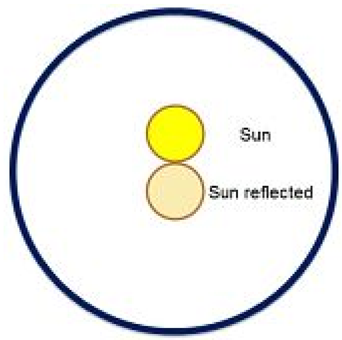
index error



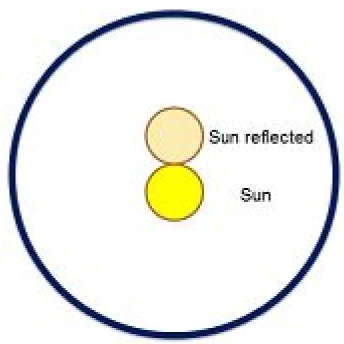
no index error

We move the drum until we see a straight line: the reading is the index error.

We can use the Sun to detect this error with two, four, six measurements:



measurement no. 1



measurement no. 2

example :

measurement no. 1 reading : +18,5’

measurement no. 2 reading : - 13,5’

index error = (algebraic sum of the measurements) / 2

index error + 2,5’.....correction for index error : -2,5’ (the opposite of +2,5’) the “index error” must be removed or reduced using the adjusting screw on the horizon mirror (adjustig screw no. 2).

If we turn the adjusting screw for the index error we will discover a new small side error: at the end of the operations we have to repeat the series : check up and adjusting of the side and index errors.

sextant altitude – instrument error – index error = observed altitude

Altitude measured with a sextant : corrections to apply