The Noon Sight

The noon sight is an historic sight. By knowing declination, without knowing time, sailors were able to ascertain approximate latitude by observing the meridian passage: that point when the sun crossed the observer's meridian. This event was determined by noting when the sun reached its highest altitude in the sky, at which point it was seen either directly north or south of the observer.

With the invention of accurate timepieces, and with approximate longitude known, the noon sight became even more useful. An accurate daily fix could be determined, as this sight yielded a good approximate of both latitude (via declination) and longitude (via GHA).

Before we get into the specifics, here are a couple of important points to note regarding practical celestial navigation:

Although we have posed a problem that plopped us down on an unknown deserted island with the idea that "we haven't a bloody clue as to where we are", in fact, in practical celestial navigation the navigator always uses a **dead reckoning** position (known as a **DR** position) in conjunction with a celestial sight.

Position plotting and **sight reduction** (the process of determining a line of position through celestial navigation techniques) always includes a DR starting point. Thus, in the early days of sailing, an approximate time of local apparent noon could be found by using a DR longitude. From this, a good estimate of declination could be determined from tables, and in turn, latitude could be found using the noon sight.

Secondly, although we have posed a problem where the sight taker makes perfect sights all the time, in reality, sight taking is fraught with difficulties. All sorts of errors can occur. Therefore, in practice, the sight taker normally takes several sights in close proximity in time, and then averages these observations. I will refer to this concept later. Now back to the "noon sight".

MERIDIAN BECOMES VERTICAL CIRCLE

Understanding the mechanics of latitude and longitude determination using the noon sight is simplified when we picture that our normal **navigational triangle** formed by the hour circle of the body, the vertical circle, and the meridian of the observation **collapses into a line at the meridian passage**. This is a unique situation, and it applies to all celestial bodies. Once a day, every celestial body (due to the earth's rotation) will cross the observer's meridian. At meridian passage the body will appear either directly north of, or directly south of the observer, depending on the latitude of the observer and the declination of the body.

Let's focus on the sun. Meridian passage, by definition, is local apparent noon (LAN), or 12-00-00 apparent time. At this time:

- The sun is at its highest daily observed altitude.
- The navigational triangle becomes **a line on the observer's meridian**.
- The vertical circle becomes the observer's meridian.
- Zenith distance is measured on the observer's meridian.
- Declination of the body is measured on the observer's meridian.
- Latitude is measured on the observer's meridian.

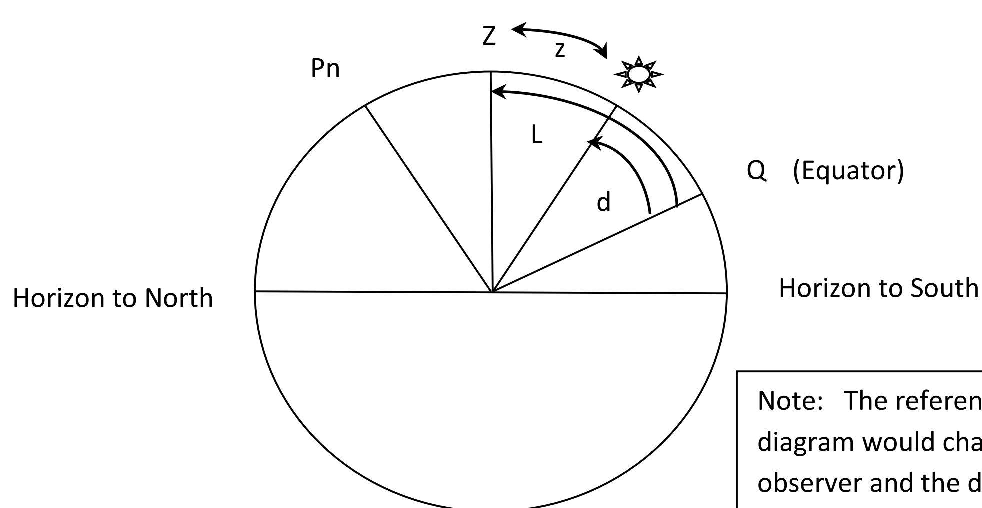
DETERMINING LATITUDE BY THE NOON SIGHT

Given a sextant altitude and declination at LAN, latitude can be directly and easily determined. There are three general cases to review:

(1) Latitude and declination are the same name (either both north, or both south), and latitude is greater than declination.
(2) Latitude and declination are the same name, and latitude is less than declination.
(3) Latitude and declination are contrary in name (one north, one south).

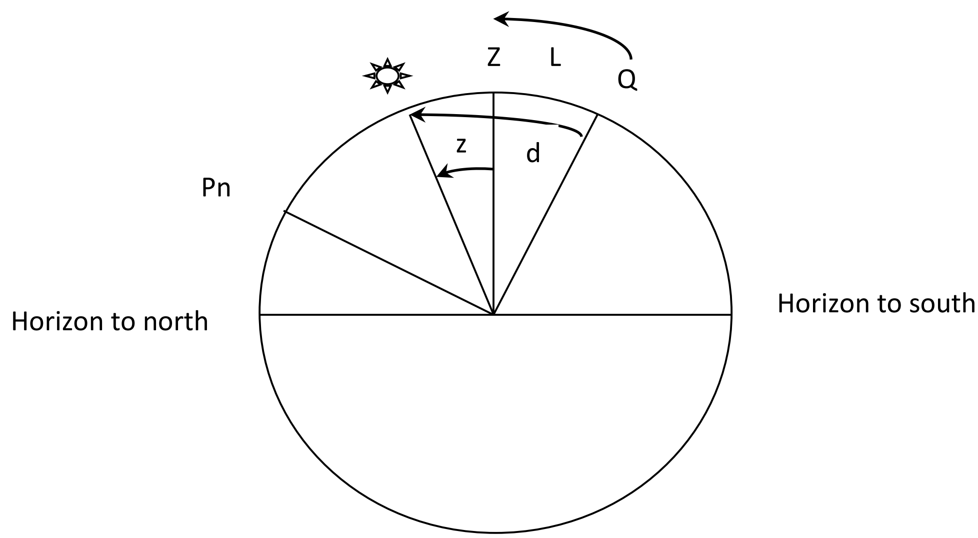
Below are diagrams and the formulas for latitude for each of the above cases.

CASE 1: Same name, L > Dec .... **Formula:** Latitude = zenith distance + declination (L = z + d)



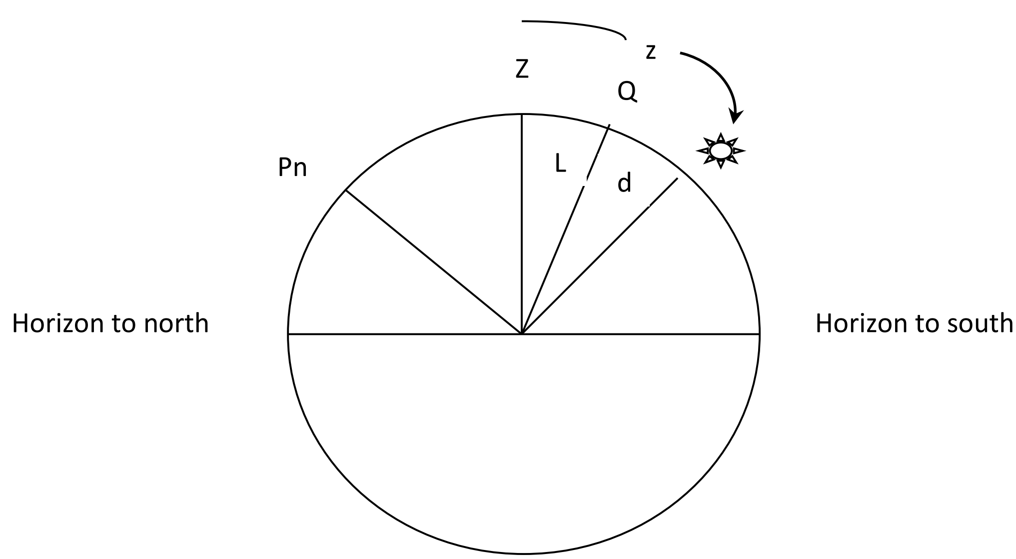
Note: The references on this diagram would change if both the observer and the declination were "South". The pole would be Ps, and the Latitude would be S, but the formula would be the same.

CASE 2: Same name, L < Dec .... **Formula:** Latitude = declination – zenith distance (L = d – z)



CASE 3: Latitude and declination contrary .... **Formula:** Latitude = zenith distance – declination

(L = z – d)



Note: In each of the above diagrams we have pictured the observer being in the northern hemisphere. The formulas remain the same if the sailor is in the southern hemisphere, but the diagrams change some of the reference points. The referenced pole (called the "**elevated pole**" in celestial navigation speak) would be Ps, the south celestial pole. Unless you like things looking "up-side down", the diagram would be flipped, and the horizon references changed.

HOW DO I FIND DECLINATION?

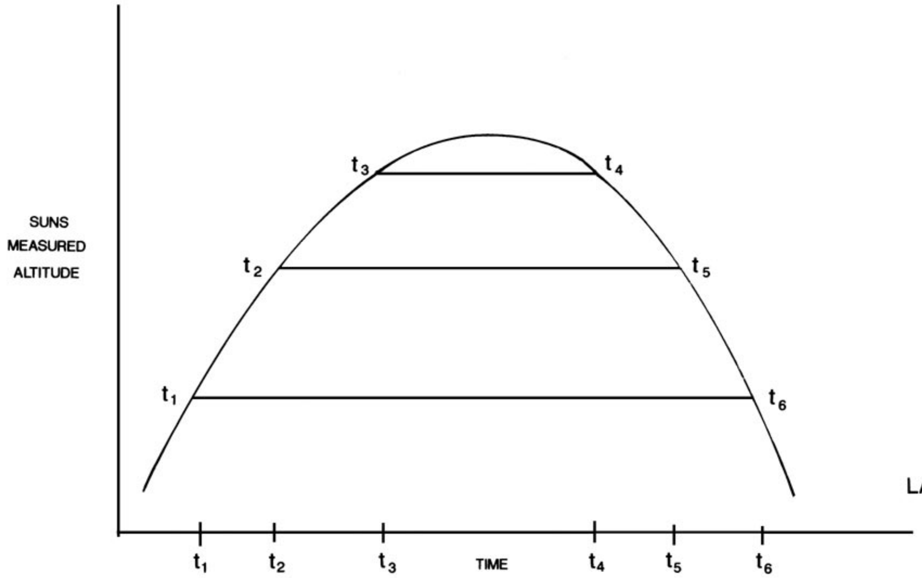
So, it is now becoming apparent that finding latitude from a noon sight observation is not so difficult. All you need is knowledge of zenith distance and declination. Zenith distance is determined directly from the observed altitude, **Ho**, of the sun as it reaches its highest daily peak. The formula is:

$$z = 90° - Ho$$

But what about declination? How is this found? Declination is found from the Nautical Almanac, but the entering argument is the day and time at Greenwich. The GMT of LAN (Local Apparent Noon) needs to be known.

If the celestial navigator is keeping a chronometer synchronized to GMT, as should be the case, then the GMT of local apparent noon can be ascertained with reasonable accuracy. If you could mark the time when the sun reached its apex, bingo, you've got it! However, if you give this a try, it is easier said than done. This is because the change in altitude of the sun slows dramatically just about noon. As there is always some error in sextant observations, there will be a period of a couple of minutes where the sun seems to hover, and some of your observations will be higher or lower than the actual altitude. You likely would have several "apexes", so which one would you select for LAN?

The proper approach is to begin taking sights about 30 minutes prior to estimated LAN, and continue for 30 minutes after. The precise time of every sight is marked. By noting the times of equal altitude on either side of the meridian passage, and averaging these times, you can arrive at a very close estimate of the actual GMT of LAN. Here is how this is depicted in Bowditch:



$$T_A = \frac{t_1 + t_6}{2}$$

$$T_B = \frac{t_2 + t_5}{2}$$

$$T_C = \frac{t_3 + t_4}{2}$$

$$LAN = \frac{T_A + T_B + T_C}{3}$$

AVERAGING SIGHTS AND TIMES: Here is another point of practical celestial navigation. You see above that in estimating the time of LAN, this navigator picked three times for which the observed altitude of the sun was the same on either side of meridian passage. He averaged these times to estimate LAN, but then he averaged the three estimates. Given that any celestial sight is fraught with potential errors ("darn it all, why did that wave hit just when I was marking the time?"), best practice is to always take several sights in close proximity of time, then average the altitudes and the times and use the averages for sight reduction. By averaging, it is hoped that individual sight errors will tend to offset each other, and the average will be better than the individual sights. While on this topic also note that if one of a series of sights is clearly wonky, it is excluded from the others before averaging.

Back to our subject: With the time of LAN now known in terms of GMT and day at Greenwich, declination is determined from the Nautical Almanac in the normal fashion, and latitude can be easily calculated by one of the three formulas described above depending on which of the three cases apply.

WHAT ABOUT LONGITUDE?

If time is known at Greenwich by keeping a watch synchronized to GMT, then using the procedures described earlier, the mean time of LAN can be calculated with great accuracy. With UT (Universal Time, a.k.a. GMT) of LAN known, GHA and Dec can be found from the Nautical Almanac in normal fashion. Latitude can be determined from zenith distance and declination, and longitude from GHA: Bingo, a really good fix!

As the navigational triangle collapses to a line, LHA goes to zero, and GHA becomes longitude.

- If GHA is less than 180°, then Longitude is west and equal to GHA.
- If GHA is greater than 180°, then Longitude is east and equal to 360° minus GHA.

Thank you Mr. John Harrison!

Thus endth the epistle of the noon sight.