The Horizon System

Your own frame on the sky: how high, and which way

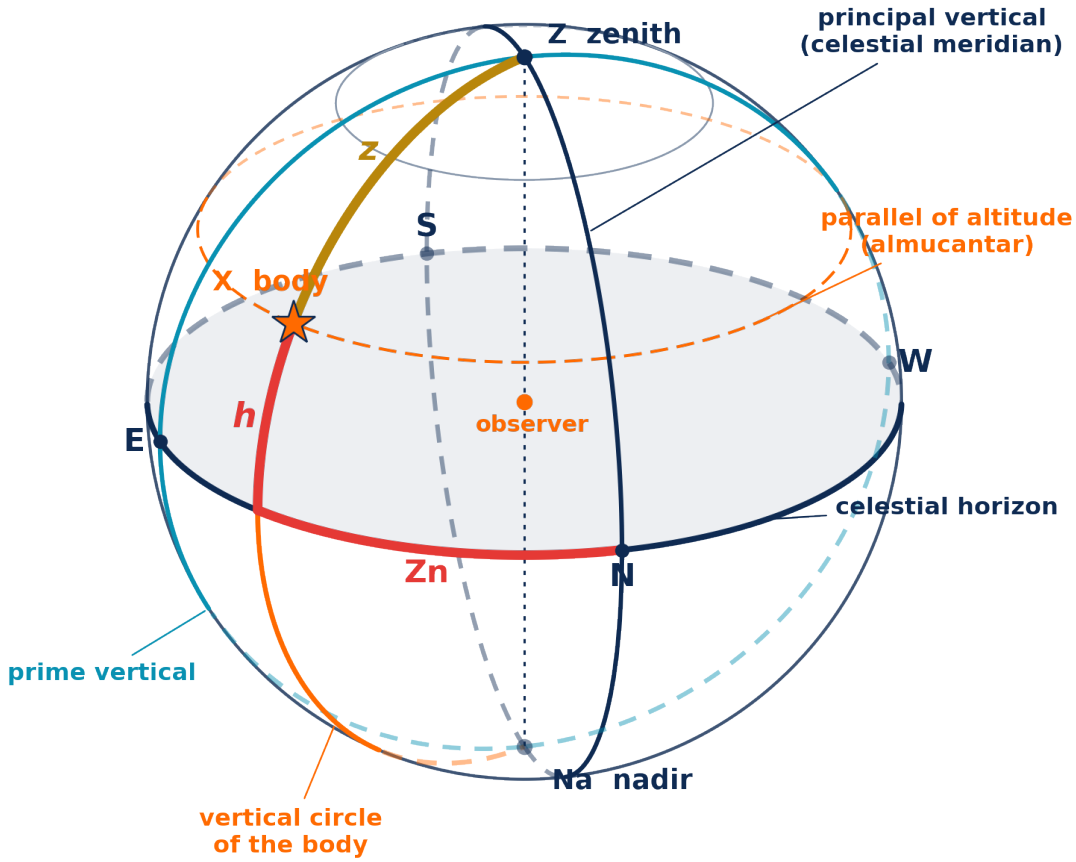
The equatorial system gives every body an address that is the same for every navigator on Earth. It cannot tell you where to look. This is the companion to Episode 5 — every circle and point of the horizon system in one figure, the two numbers it gives every body, and a short sheet of terms to keep at the chart table.

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1. The whole system in one figure

Everything is built on one line: the plumb line through the observer. Straight up it meets the sky at the **zenith** Z, straight down at the **nadir** Na. The great circle 90° from both is the **celestial horizon**.



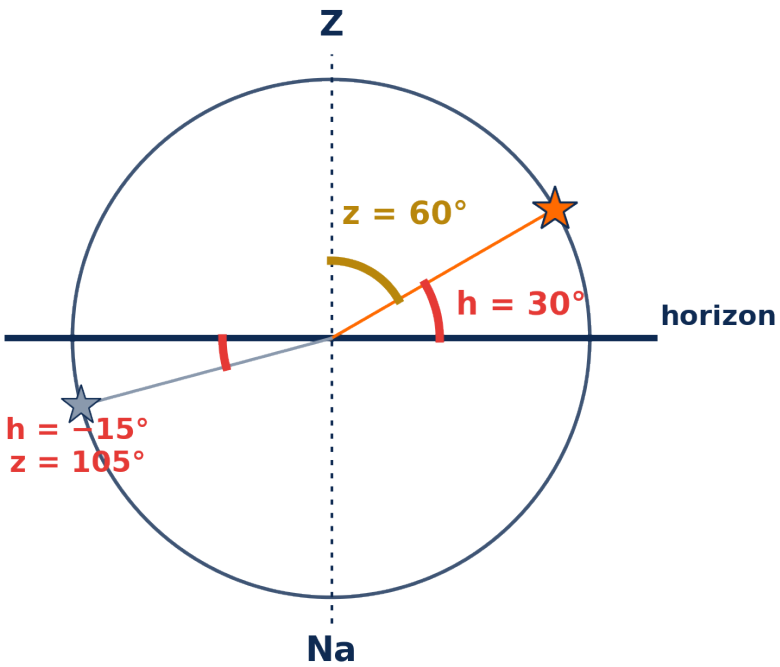
The body X is drawn at altitude 30°, azimuth 060°. Solid lines are on the near side of the sphere, dashed lines on the far side.

2. The circles and points

zenith Z, nadir Na	The points straight above and straight below the observer. They move with you: sail north and your zenith moves north across the stars.
celestial horizon	The great circle 90° from Z and Na. All altitudes are measured from it.
vertical circle	Any great circle through Z and Na. It stands at right angles to the horizon. Every body has its own.
principal vertical	The vertical circle through the celestial poles. It is your celestial meridian, and it cuts the horizon at the north and south points.
prime vertical	The vertical circle at right angles to the principal vertical. It cuts the horizon at the east and west points.
N, E, S, W	The four cardinal points, where the two principal circles meet the horizon.
parallel of altitude	A small circle parallel to the horizon: every point on it has the same altitude. Also called an *almucantar*.

East and west are where the equator meets the horizon. The celestial equator and the horizon are two great circles, so they cross at two points 180° apart. Both are at right angles to the meridian, so the crossings are 90° from it: due east and due west. At the equinoxes the Sun is on the celestial equator, and it rises close to due east and sets close to due west, wherever you are.

3. Two numbers for every body



Altitude *h*. The arc of the body's vertical circle from the horizon up to the body. 0° on the horizon, 90° at the zenith, negative below the horizon.

Zenith distance z. The same arc counted down from the zenith:

$$\boxed{z = 90^\circ - h}$$

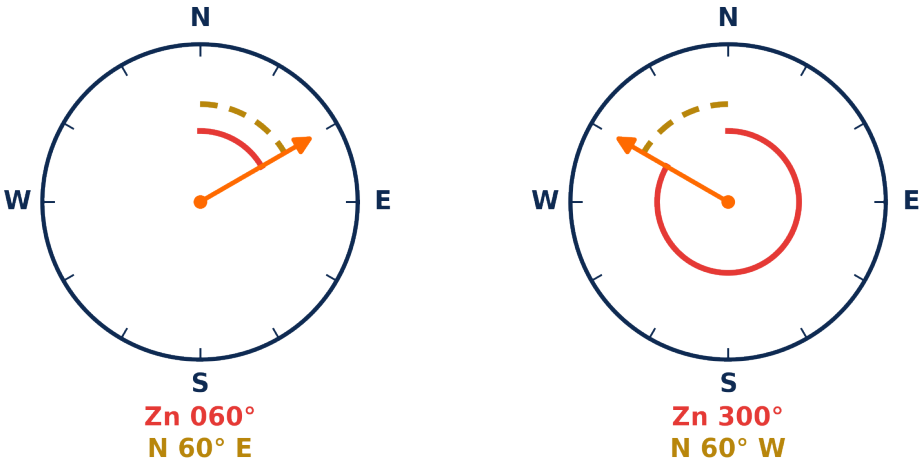
A body at $h = 30^\circ$ is $z = 60^\circ$ from your zenith; a body 15° below the horizon is 105° from it.

Zenith distance on the Earth. Your zenith is straight above you; the body is straight above its geographical position. So the angle z on the sky is also the angle between you and that position at the centre of the Earth, and one minute of arc there is one nautical mile:

$$z = 60^\circ = 3600' \quad \Rightarrow \quad \text{3600 NM to the body's geographical position.}$$

In the film: $30^\circ = 1800' = 1800$ NM. Where that position is, comes in the next episode.

4. Which way: azimuth



True azimuth Zn. Measured along the horizon from true north, clockwise through east, from 000° to 360° — like a true bearing. Always written with three figures.

Azimuth angle Z. Some sight-reduction tables give the same direction as an angle of 0° to 180°, counted from north or from south, east or west. Converting is a matter of naming it:

azimuth angle	true azimuth	example
N Z E	$Zn = Z$	N 60° E = 060°
N Z W	$Zn = 360^\circ - Z$	N 60° W = 300°
S Z E	$Zn = 180^\circ - Z$	S 60° E = 120°
S Z W	$Zn = 180^\circ + Z$	S 60° W = 240°

5. North from the sky

Polaris. At the end of 2026 Polaris is 0.63° (37.5′) from the north celestial pole. A line from Polaris straight down to the horizon therefore misses true north by at most:

latitude	30° N	40° N	50° N	60° N
greatest error	0.7°	0.8°	1.0°	1.3°

The error is zero when Polaris is directly above or below the pole and largest six hours later; it grows with latitude as $\sin p / \cos \varphi$, where p is the star's distance from the pole.

The Southern Cross. There is no bright south pole star. Extend the long axis of the Cross, from Gacrux through Acrux, about four and a half times its own length: the end of the line is within about 6° of the south celestial pole. Drop that point to the horizon and you have south to within a few degrees.

Try it. On the next clear night, find the pole, drop a line to the horizon beneath it, and compare with your compass. Tell us in the comments how close you got.

6. Terms to keep at the chart table

term	symbol	meaning
zenith	Z	point straight above the observer
nadir	Na	point straight below the observer
celestial horizon		great circle 90° from the zenith
vertical circle		great circle through Z and Na
principal vertical		vertical circle through the poles; the celestial meridian; gives N and S
prime vertical		vertical circle at right angles to it; gives E and W
parallel of altitude		small circle of equal altitude; almucantar
altitude	h	arc from the horizon up to the body; negative below
zenith distance	z	arc from the zenith to the body; $z = 90° - h$
true azimuth	Zn	from true north, clockwise, 000°–360°
azimuth angle	Z	from N or S towards E or W, 0°–180°
from the equatorial system (Episode 3)		
declination	Dec	arc from the celestial equator, N or S
Greenwich hour angle	GHA	from the Greenwich meridian, westward
local hour angle	LHA	from your meridian, westward

Two addresses, one body. Dec and GHA are the sky's address: the same for every navigator at the same moment, and published in advance. h and Zn are yours: measured from your own zenith, your own horizon and your own north, and no one can give them to you. Everything that follows in this series is about joining the two.

7. What this document does not cover

Deliberately left out, each being a subject of its own: **the visible horizon** — the sea line you actually measure from, and how it differs from the celestial horizon; **refraction** and the other corrections to a sextant altitude; **the astronomical triangle** — pole, zenith and star, which joins the two systems (next episode); and **the compass** — variation and deviation.

Every number in this document has been computed rather than copied. The figures are drawn from the same geometry as the film. Polaris' distance from the pole is its J2000 position carried forward to the end of 2026 by the standard precession formulae; the Southern Cross is drawn from catalogue positions of Gacrux and Acrux.

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