Celestial Coordinate system

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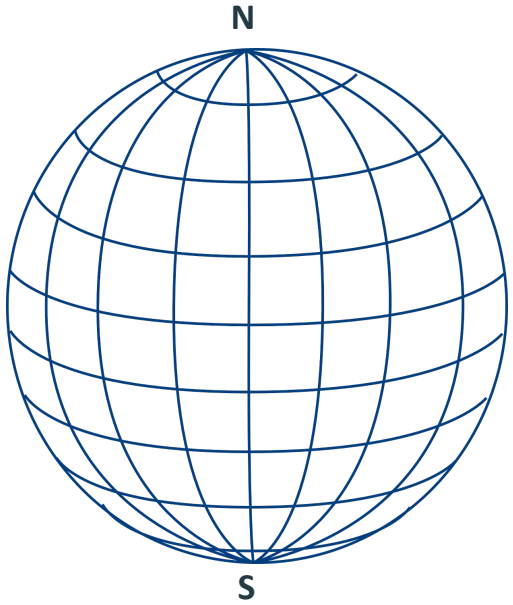
Outline

- Introduction to latitude and longitude.
- Celestial sphere.
- Celestial equator, meridian, and ecliptic.
- Introduction to celestial coordinate systems:
- Equatorial coordinate system
- Altazimuth coordinate system

What have we learnt earlier ?

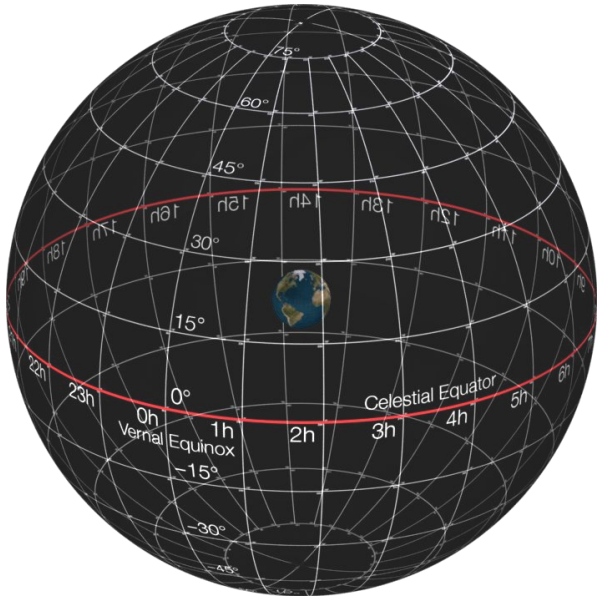
- Earth's equator divides the Earth into two equal halves: Northern hemisphere and Southern hemisphere.
- The parallel lines/ concentric circles above and below the equator are **latitudes**.
- The vertical lines joining the N pole and S poles are **longitudes**.
- Using latitude and Longitude one can determine the location of a place on the Earth.
- For example, location of Nagaon, Assam is: 26.348^0N, 92.68^0E



- The latitude of the Equator is 0 degree.
- The longitude passing through Greenwich is the 0 degree longitude and it’s the prime meridian.
- Depending upon the longitudes there are different time zones.
- The time difference between two longitudes 1 degree apart is 4 min.
- Coordinated Universal Time or Universal Time Coordinated (UTC) is the basis of the civil time and the time zones over the World.
- Indian Standard Time (IST) is based on the longitude passing through Mirzapur, Allahabad.

Celestial sphere

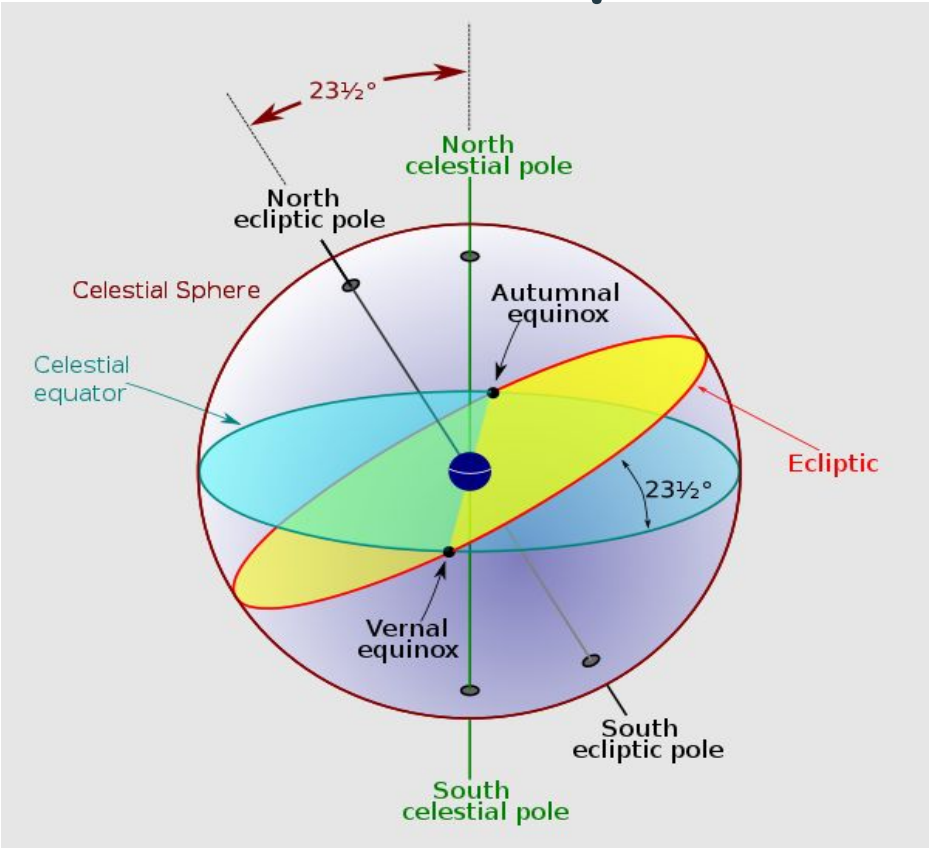
- The imaginary sphere having the observer at the centre and on which all the celestial objects are supposed to lie is the **Celestial sphere (CS)**.
- The **Celestial Equator (CE)** is the projection of the Earth's Equator out to the sky. It divides the CS into two halves: The Northern Celestial hemisphere (NCH), and Southern Celestial Hemisphere (SCH).
- The point on the CS that is directly over the head of the observer is known as **Zenith**.
- The point on the CS that is directly below the observer is called **Nadir**.



Celestial Meridian, Horizon, and Ecliptic

- The imaginary line joining the geographical North and South of the observer through the Zenith is Celestial Meridian.
- The apparent boundary between the Earth and the Sky, is the Horizon.
- The Sun, the planets along with the stars appear to rise in the East of our sky and set in the West of the Sky. Every celestial bodies follow an imaginary path across the sky.
- The imaginary path of the Sun across the sky is Ecliptic. ⏩ see the path of the Sun (Analemma).
- The CE and the Ecliptic crosses each other at two points: the Vernal Equinox (VE) and Autumnal Equinox(AE).
- The axis of Earth is tilted by 23.5 degrees with respect to the plane of its orbital motion. Therefore, the Ecliptic and the CE are tilted by an angle 23.5 degrees.

Celestial Meridian, Horizon, and Ecliptic cont...

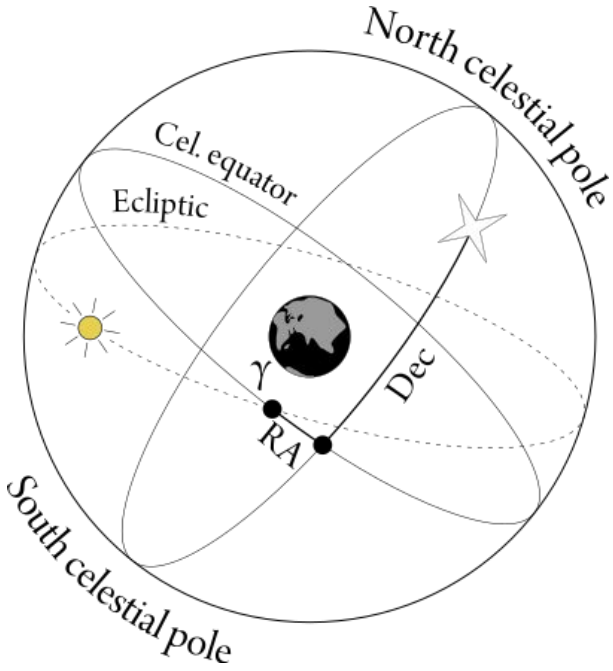


Celestial coordinate systems

- An observer can locate any celestial object with the help of Celestial Coordinates.
- There are different Celestial coordinate systems.
- Two important Celestial Coordinate Systems used in Astronomy are: Equatorial coordinate system, Altitude-Azimuth (Altazimuth) coordinate system,

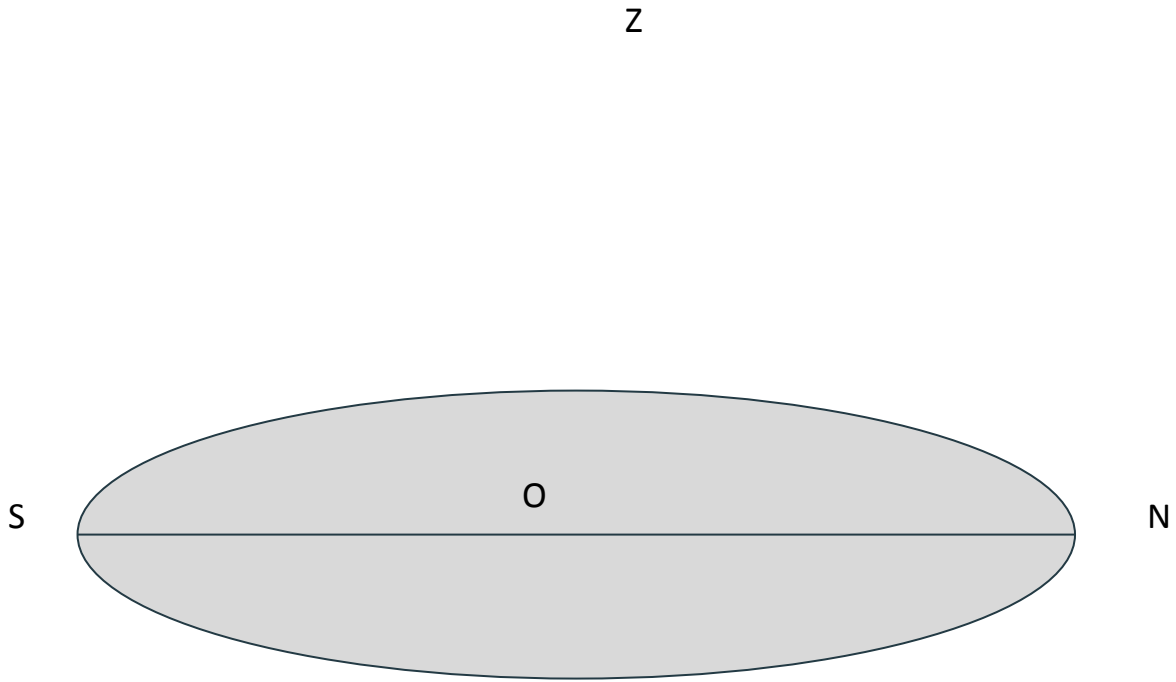
Equatorial Coordinate System: Introduction

The equatorial coordinate system is based on the Celestial Pole and Celestial Equator. The coordinates of this system are: Right ascension, and declination.



Step - by - step guide to draw Celestial Meridian, Horizon, Celestial equator, celestial axis, ecliptic and identify the celestial coordinates, Declination and Right Ascension.

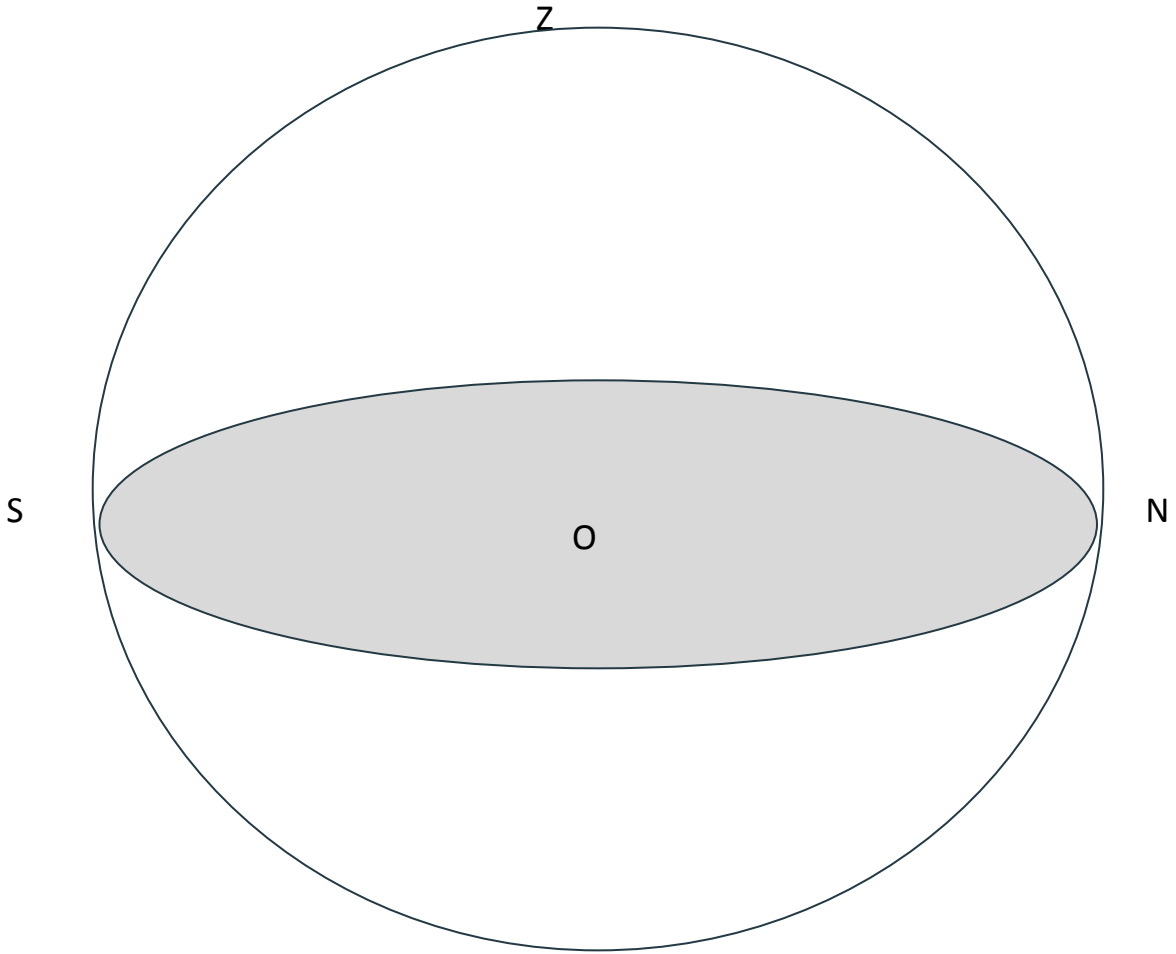
Step 1



Imagine the observer. Draw the **horizon**. Mark the geographical **North**, **South** and **zenith** of the observer.

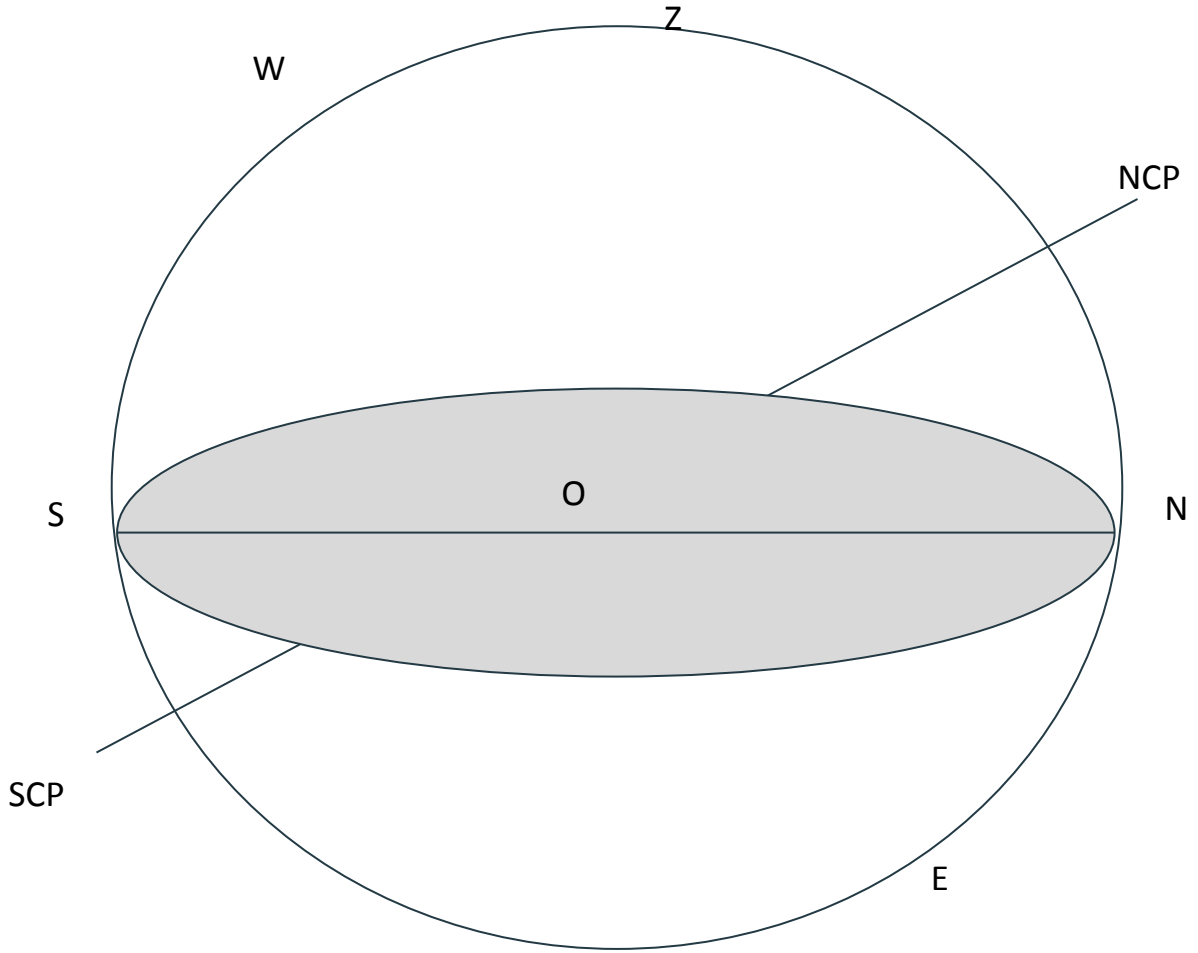
Step 2

Draw a sphere touching the Zenith, Geo-North, and South. This is the **Celestial Sphere**



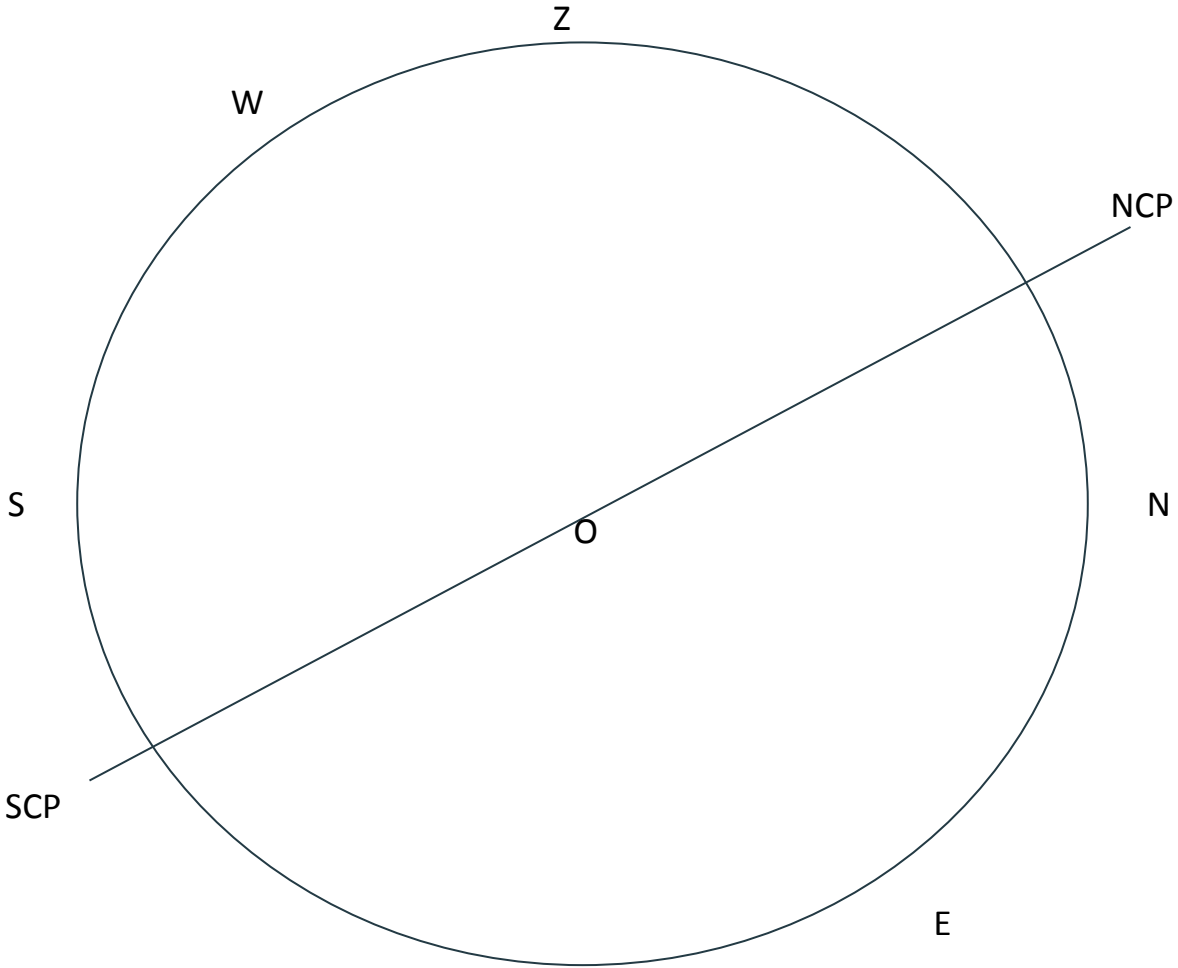
Step 3

Identify your **NCP** (The angle between the NCP and the equator is equal to your latitude). Draw the Celestial Axis from NCP to Observer. Extend the Axis below the horizon. The other end of this axis points towards the SCP (South Celestial Pole).



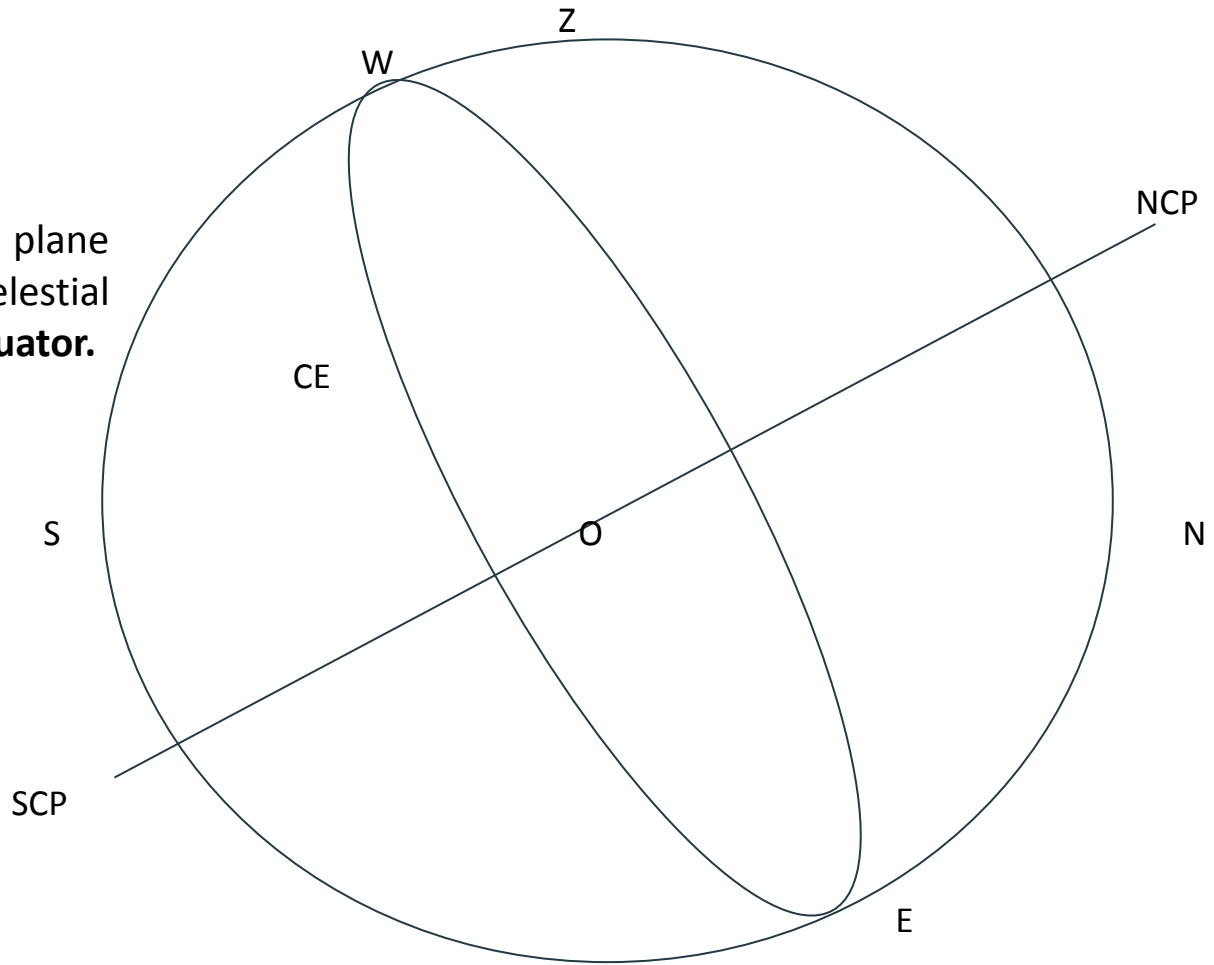
Step 4

Erase the **horizon**.



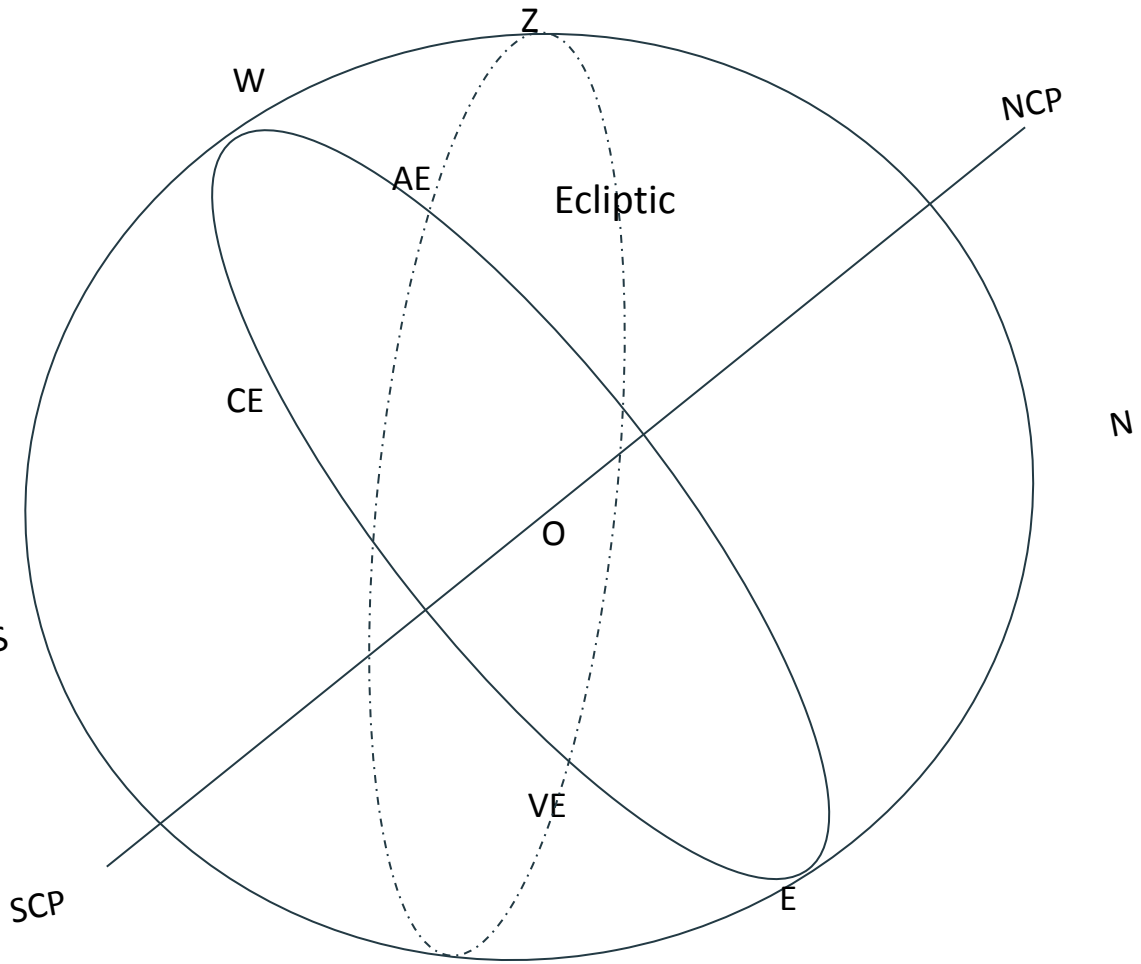
Step 5

Draw an elliptical plane perpendicular to the Celestial Axis. This is the **Celestial Equator.**



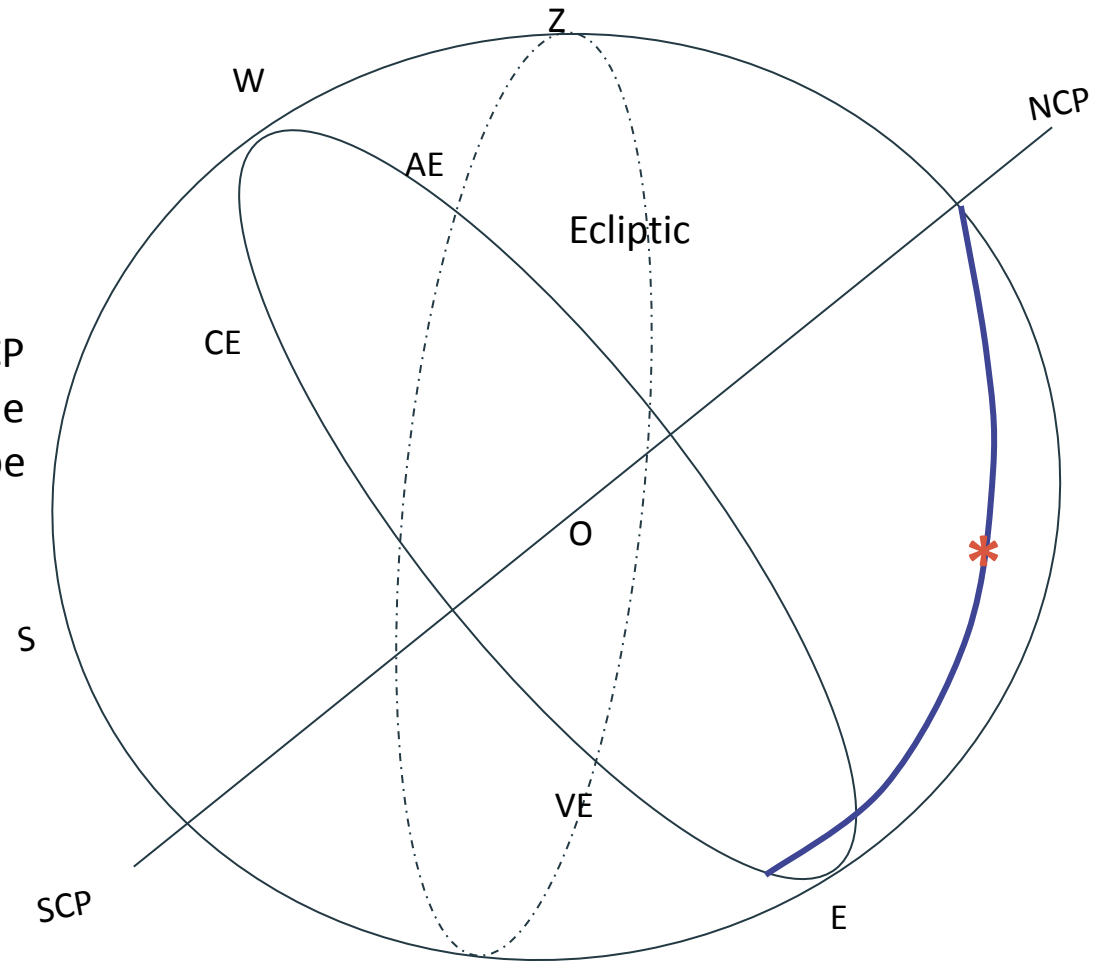
Step 6

- Draw an ellipse at an angle of 23.5^0 w.r.t. the CE. This is the **ecliptic.**
- The The ecliptic and the CE crosses at two points: the **Vernal Equinox** and the **Autumnal Equinox.**



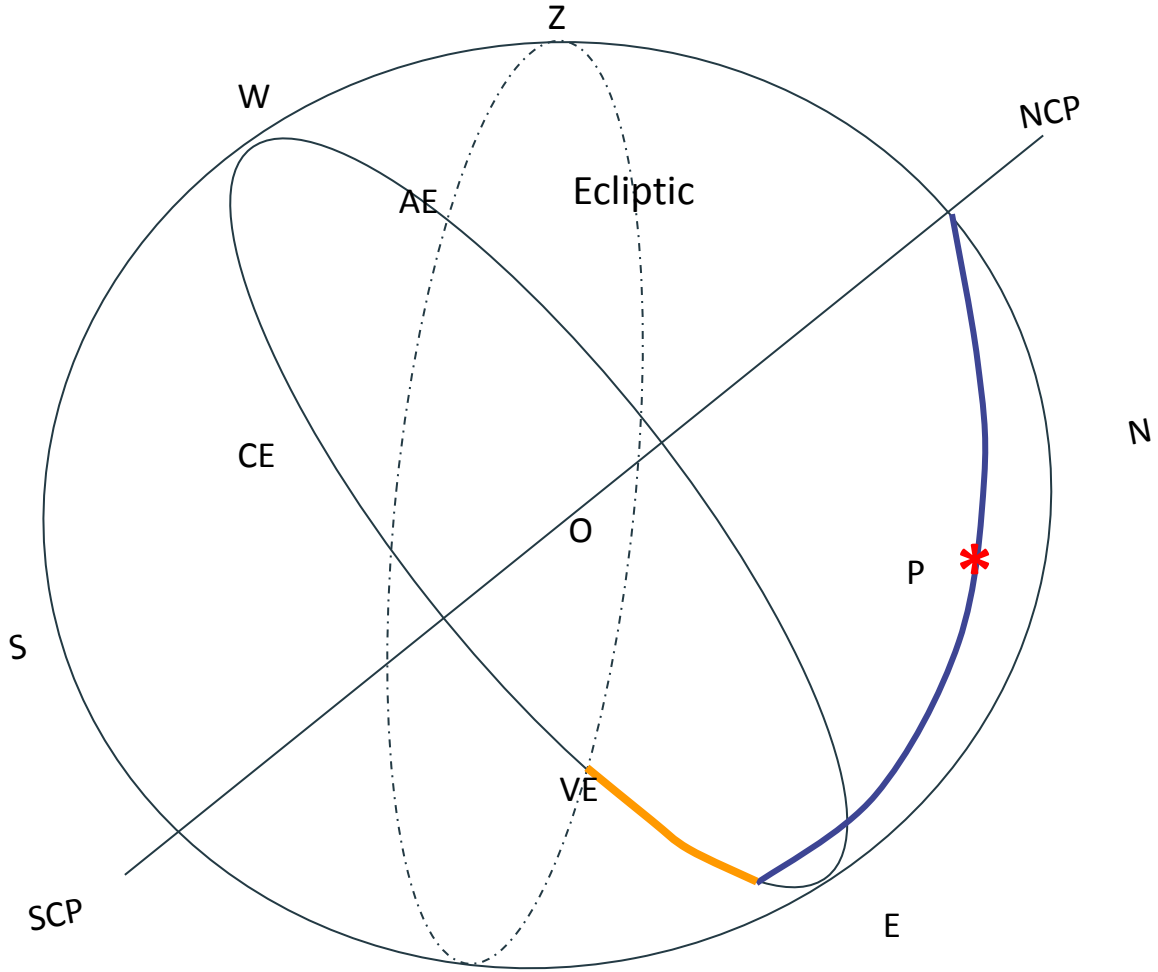
Step 7

Draw a perpendicular from NCP to the Celestial Axis through the Star whose position is to be calculated.



Step 8

- The angular separation between the Vernal Equinox and the base of the perpendicular (∠VEOE) is the Right ascension (RA or α) of the star.
- The elevation of the star from the observer (∠POE) is the declination (dec. or δ).



Important points in brief

Right Ascension	Declination
Similar to geographical longitude.	Similar to geographical latitude.
Measured from vernal equinox eastward.	Measured from the CE.
Unit: hour, minute, second	Unit: degree, minute, second
Runs from 0 hr to 24 hr.	Ranges from -90^0 to $+90^0$

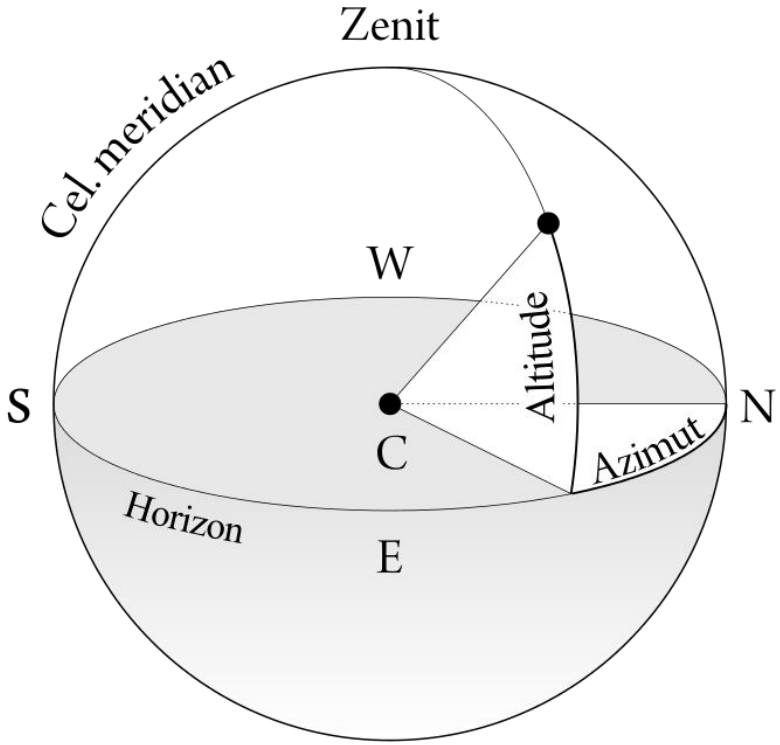
- If the object is at the North of the CE, dec. is +ve.
- If the object is at the South of the CE dec. is -ve.
- If the object is at the CE, dec. is 0^0.
- If the object is at NCP dec. is 90^0.
- RA is measured from vernal equinox towards the East. Thus, the RA of VE is 0^0, and the RA of AE is 180^0.

RA and Dec of a few bright stars

Star	RA	Dec
Pole star	$2^h\ 41^m$	$+89^0\ 15'$
Sirius	$06^h\ 45^m$	-16.43^0
Vega	$18^h\ 36^m$	$+38^0\ 47'$
Betelgeuse	$5^h\ 55^m$	$+7^0\ 24'$
Spica	$13^h\ 25^m$	$-11^0\ 10'$
Rigel	$5^h\ 14^m$	$-8^0\ 12'$

Altazimuth Coordinate System: Introduction

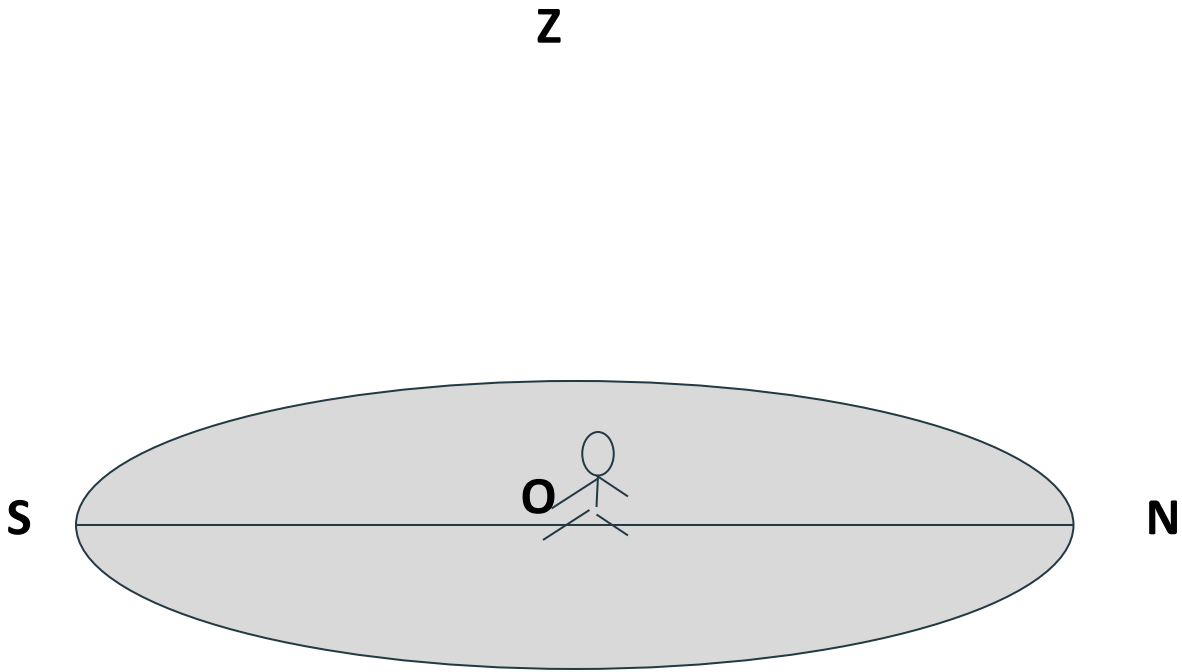
In Altazimuth or Horizontal coordinate system is based on observer's local horizon and zenith. The coordinates of this system are: **Altitude**, and **Azimuth**.



Step - by - step guide to draw Celestial Meridian, Horizon, Zenith, and identify the celestial coordinates, Altitude and Azimuth.

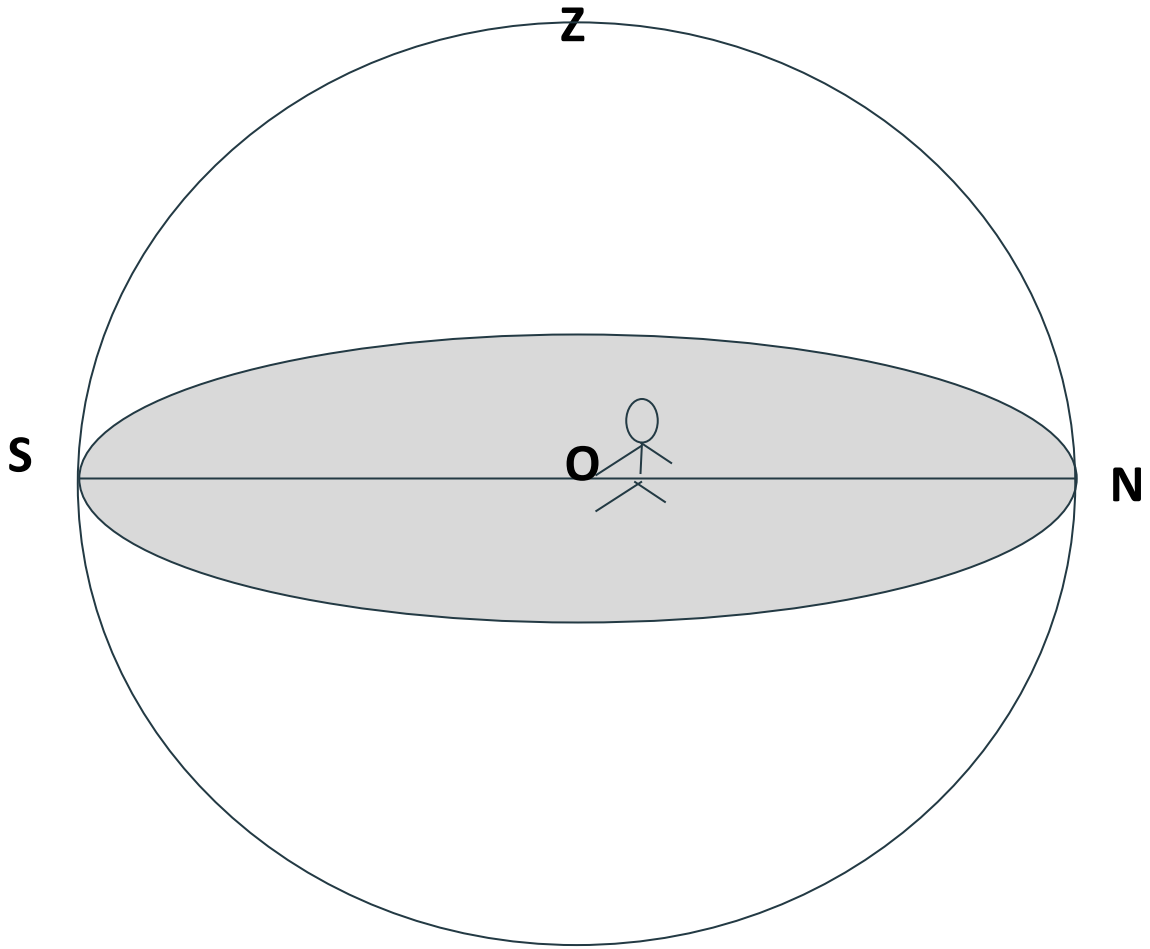
Step 1

Imagine the observer. Draw the **horizon**. Mark the geographical **North**, **South** and **zenith** of the observer.



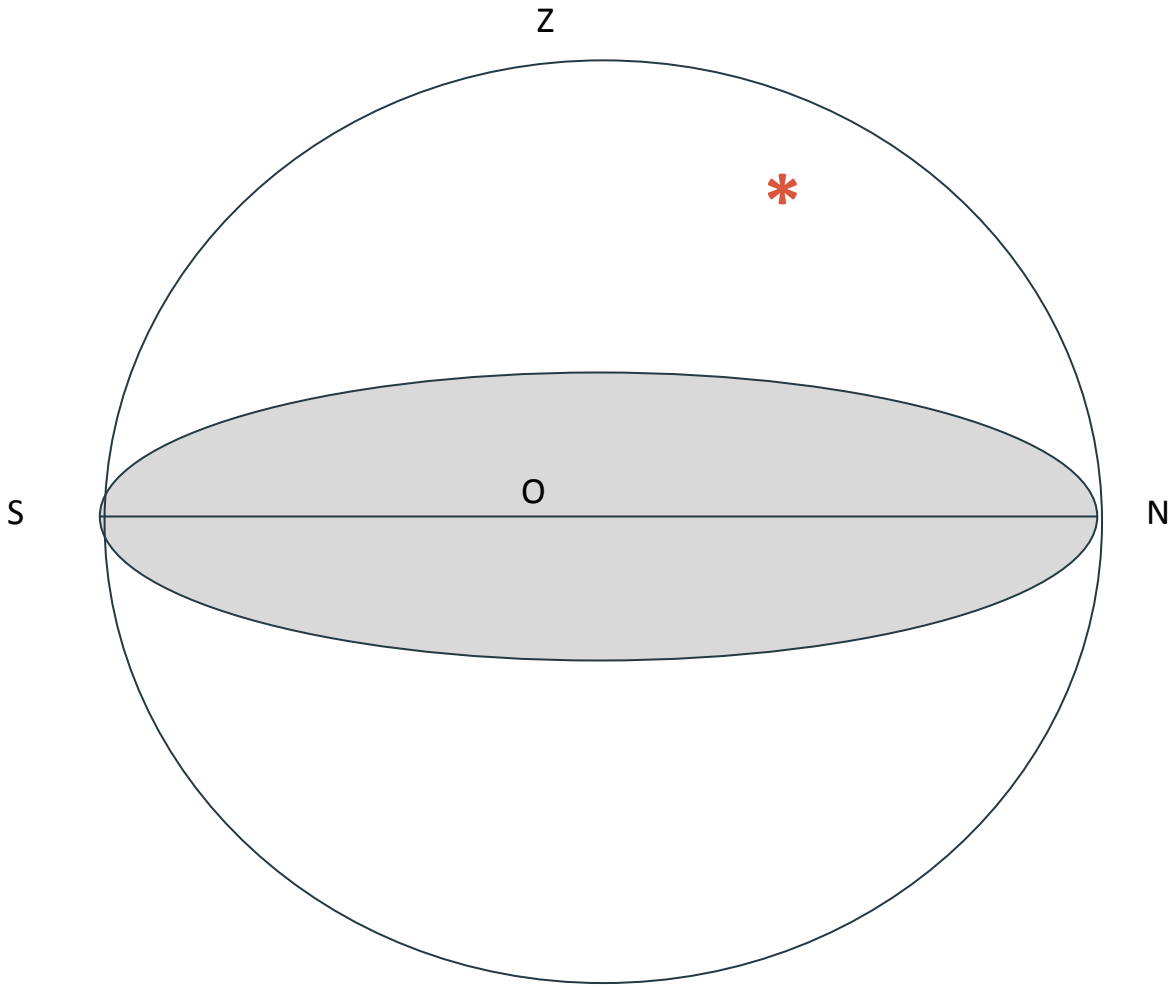
Step 2

Draw a sphere touching the Zenith, Geo-North, and South.



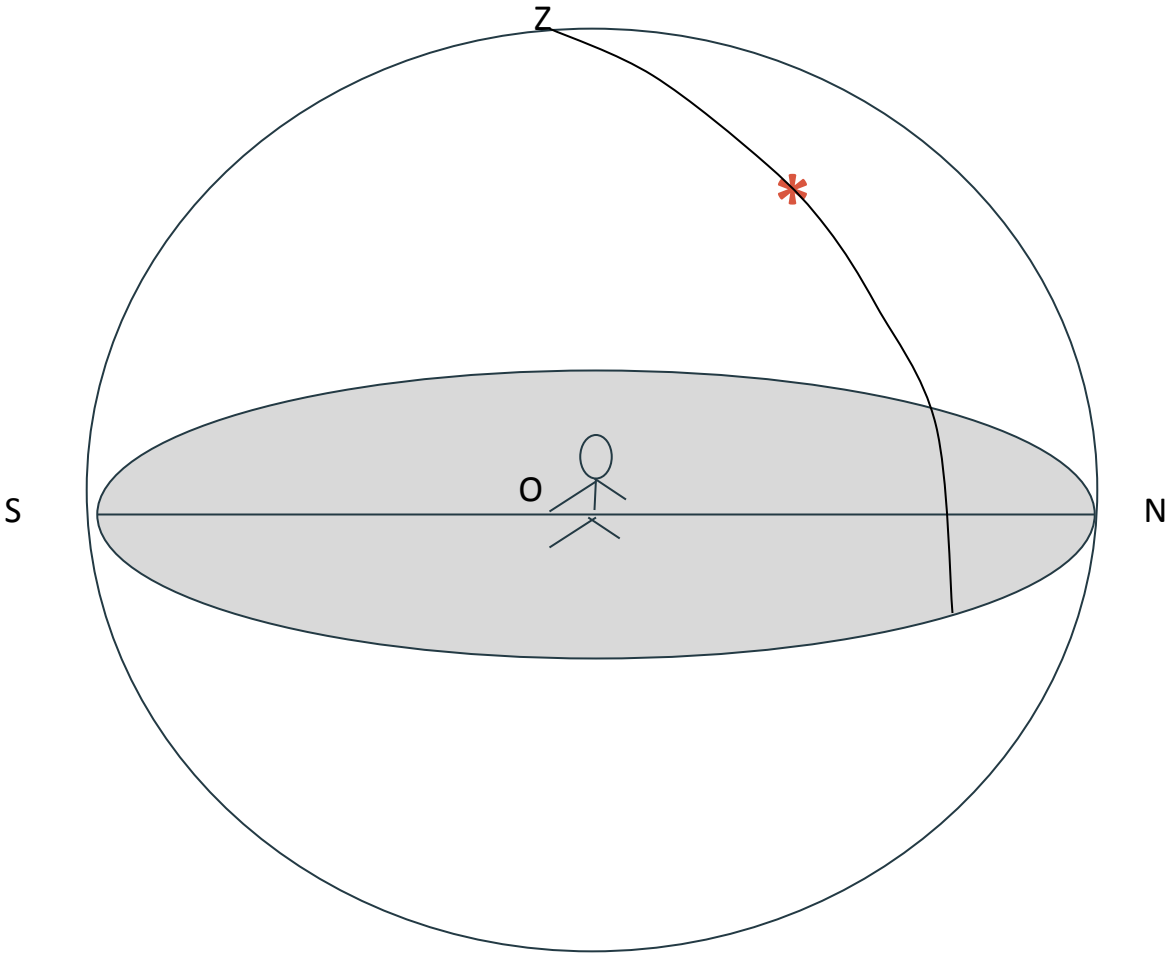
Step 3

Locate the star whose position has to be determine



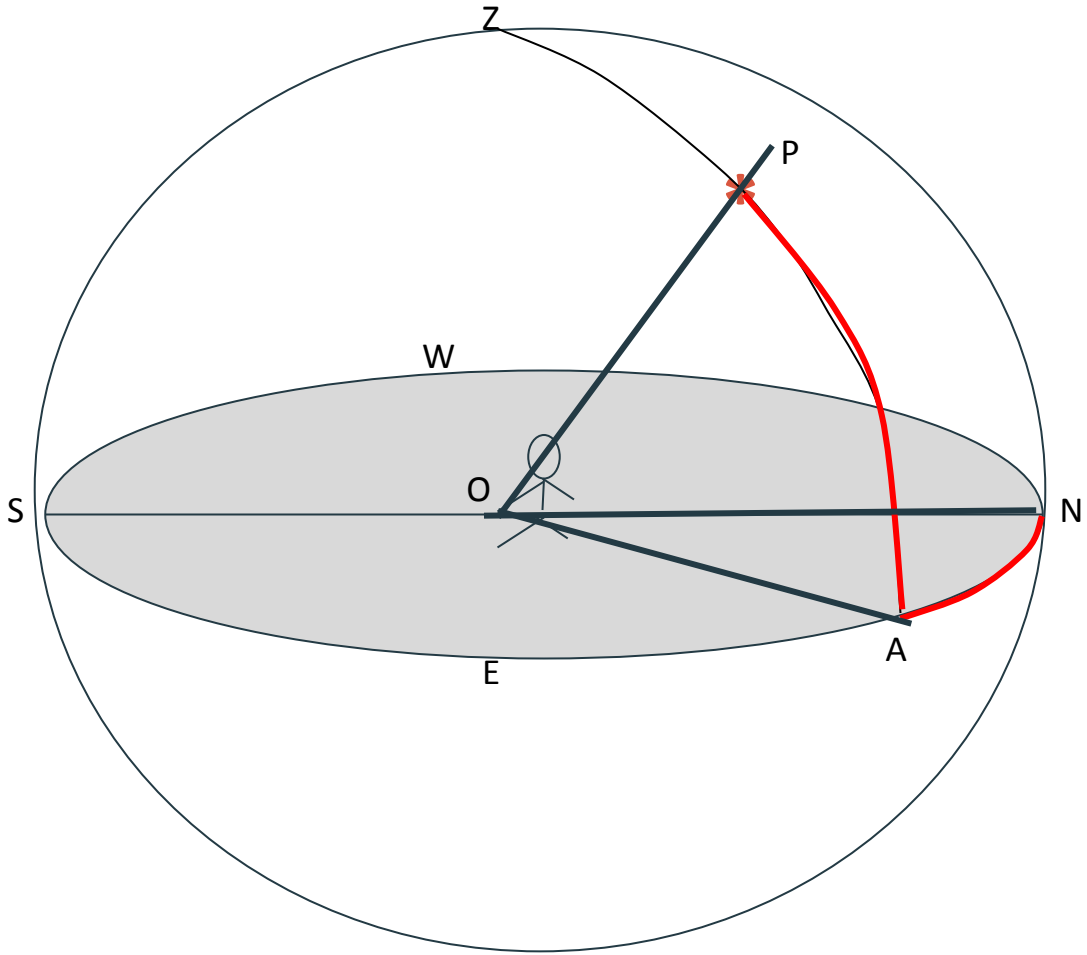
Step 4

Draw a perpendicular from the Zenith to the horizon through the star.



Step 5

- The angular separation between the star and the horizon (∠AOP) is the **Altitude** of the star.
- The angular separation between the base of the perpendicular and geographical North (∠AON) is the **Azimuth** of the star.



Important points in brief

Altitude	Azimuth
Similar to geographical latitude.	Similar to geographical longitude.
Ranges from 0^0 to 90^0.	Ranges from 0^0 to 360^0.
Measure from horizon.	Measure from North.

Azimuth values for the cardinal directions	
Cardinal Point	**Azimuth**
North	0^0
East	90^0
South	180^0
West	270^0

Advantages and disadvantages

Advantages:

- This coordinate system is useful to trace the path of the stars. One can determine how high a star is above the horizon and in what direction it can be found. The rising/setting time of the stars can also be calculated.

Disadvantages:

- This coordinate system is based on observer's local horizon. So, the altitude and azimuth of the same object, at the same time will be different for observers of different locations. So, this is not an universal coordinate system.
- This coordinate system is fixed to the Earth, not the stars. Therefore due to earth's rotation, the Azimuth and Altitude of the same celestial object changes very rapidly.

Home Work

Explain the terms ecliptic, North and South celestial pole, horizon, celestial equator, latitude, longitude, declination, right ascension, altitude, azimuth, and hour angle. Draw a celestial sphere and show the positions of above mentioned terms in the celestial sphere.

Thank You for your attention!