CE 103: Surveying

Lecture 15: Astronomical surveying (Contd.)

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Outline

- ❑Longitude, latitude
- ❑Spherical angle, spherical side
- ❑Relationship between altitude and latitude
- ❑Math problem on Azimuth and altitude

The Terrestrial Latitude and Longitude

Terrestrial Meridian:

- Great circle whose plane passes through the axis of earth (through north and south poles).

Terrestrial Equator:

- The great circle whose plane is perpendicular to the earth's axis.

Longitude (φ):

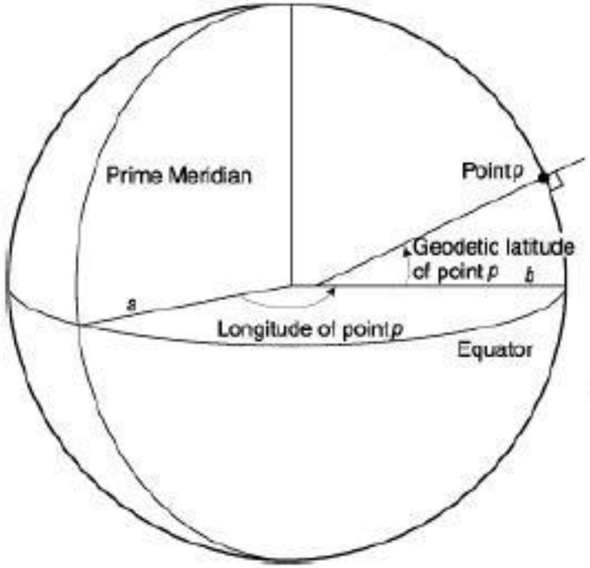
- Angle measured in equatorial plane .
- Range: 0° to 180° east or west of Greenwich Meridian

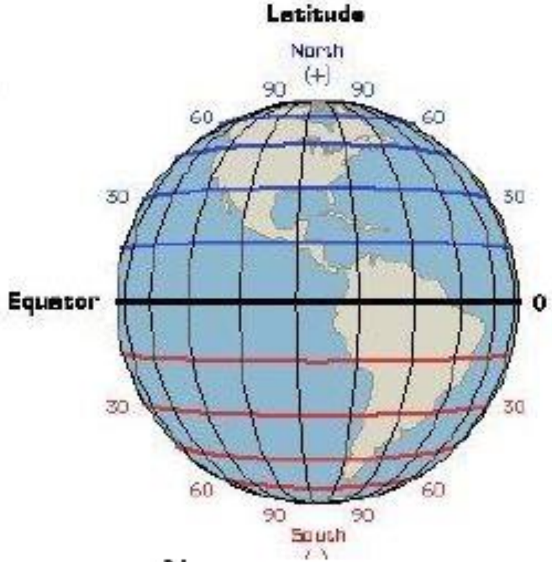
Latitude(θ):

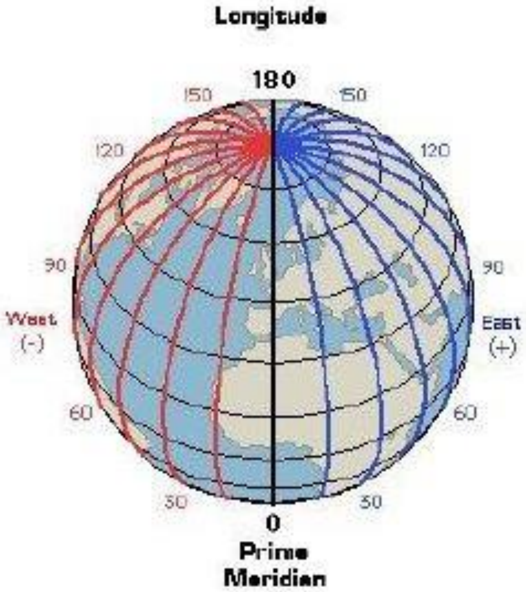
- Angle measured in plane normal to equatorial plane.
- Range: 0° to 90° north or south of equator.

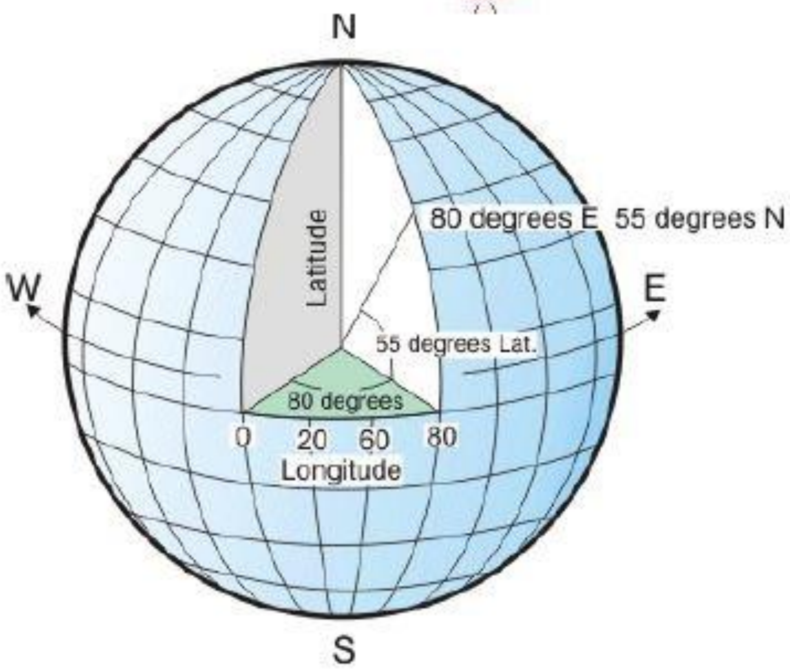
Parallel of Latitude:

- Small circle parallel to plane of equator whose latitude is constant.


Prime Meridian
Point p
Geodetic latitude of point p
b
a
Longitude of point p
Equator


Latitude
North (+)
90
60
30
Equator
0
South

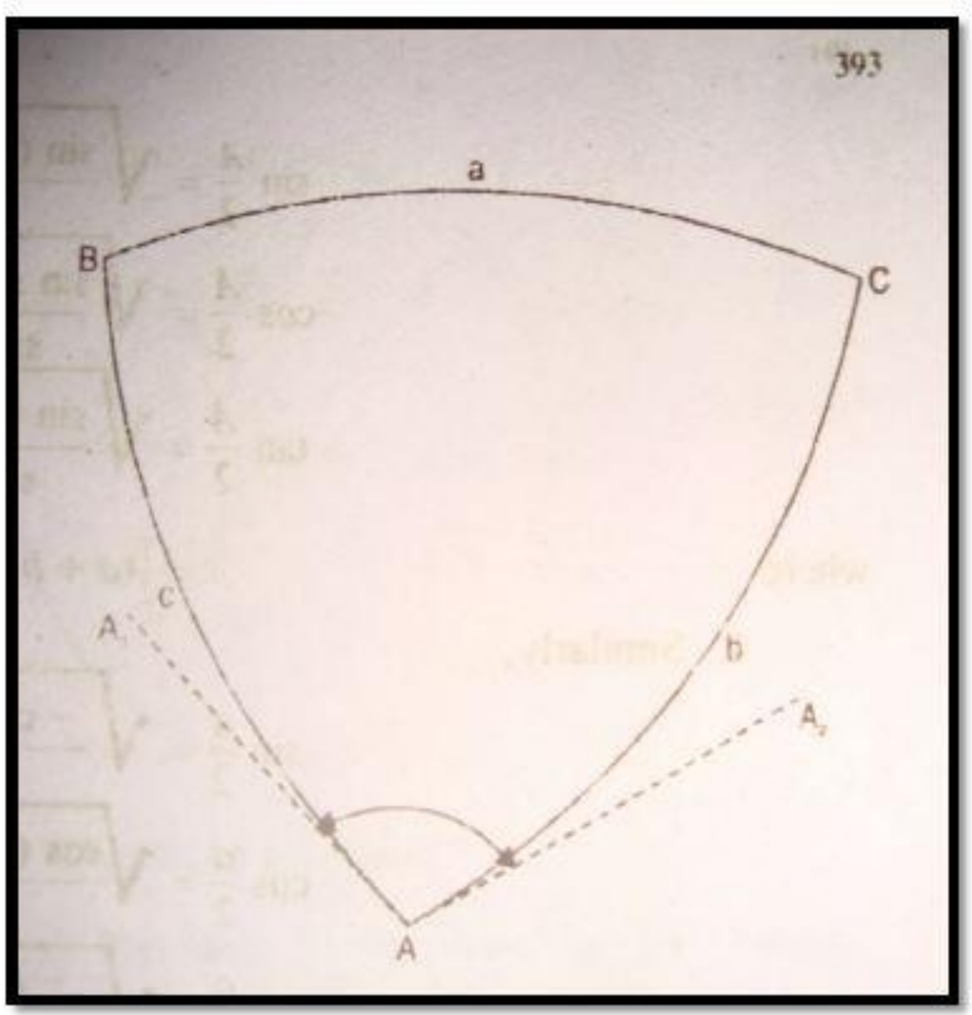

Longitude
180
150
120
90
60
30
West (-)
East (+)
0
Prime Meridian


N
W
E
S
Latitude
80 degrees E 55 degrees N
55 degrees Lat.
80 degrees
0 20 60 80
Longitude

Spherical Triangle. Triangle formed on the surface of sphere by parts of three great circles. The spherical triangle ABC has three sides (a,b,c) and three angles (A,B,C) all of them represented by angles.

Spherical side: The three arcs forming the spherical triangle. Each arc is represented by the angle formed by it at the centre.

Spherical angle: The angle between the tangents at each corner point of the spherical triangle



$$\frac{\sin a}{\sin A} = \frac{\sin b}{\sin B} = \frac{\sin c}{\sin A}$$

$$\cos a = \cos b \cos c + \sin b \sin c \cos A$$

Relation between Altitude of the pole and latitude of the observer

1. The Relation between Altitude of the Pole and Latitude of the Observer.

In Fig. 13.20. *H-H* is the horizon plane and *E-E* is the equatorial plane. *O* is the centre of the earth. *ZO* is perpendicular to *HH* while *OP* is perpendicular to *EE*.

Now latitude of place = $\theta = \angle FOZ$

And altitude of pole = $\alpha = \angle HOP$

$$\angle EOP = 90° = \angle EOZ + \angle ZOP$$

$$= \theta + \angle ZOP \qquad \ldots(i)$$

$$\angle HOZ = 90° = \angle HOP + \angle POZ$$

$$= \alpha + \angle POZ \qquad \ldots(ii)$$

Equating the two, we get

$$\theta + \angle ZOP = \alpha + \angle POZ \quad \text{or} \quad \theta = \alpha$$

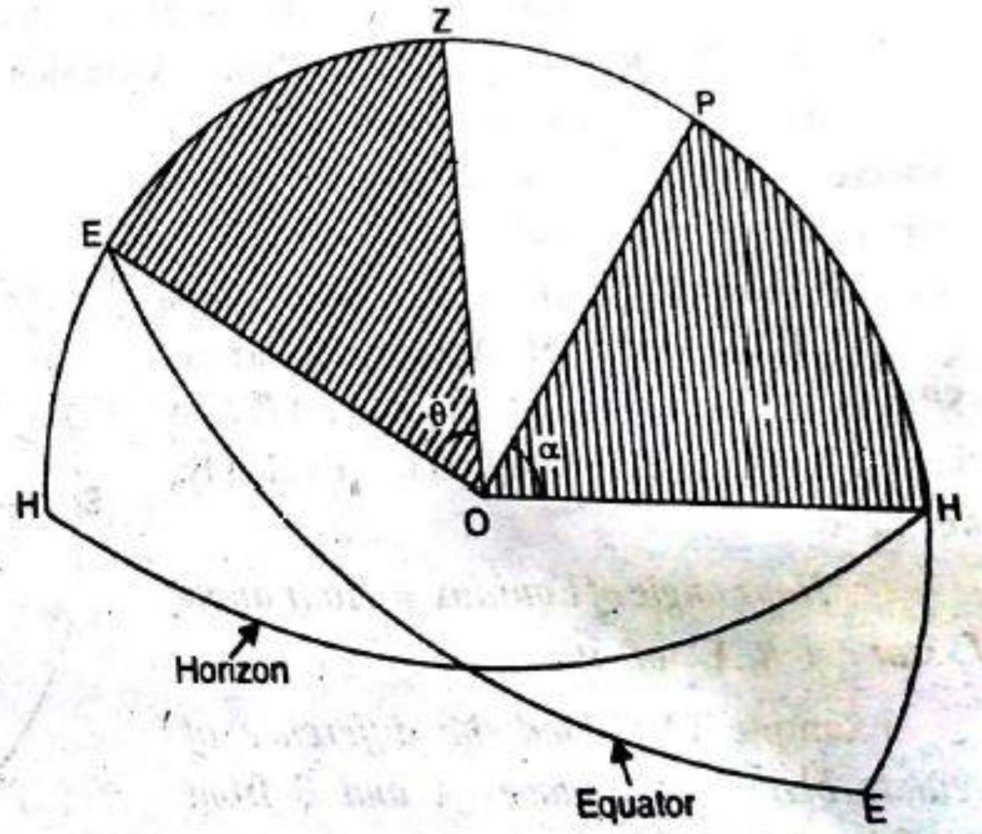


FIG. 13.20.

Hence *the altitude of the pole is always equal to the latitude of the observer.*

- Determine the azimuth and altitude of a star from following data:

I. Declination of star = $20°30' N$

II. Hour angle of star = $42^0 6'$

III. Latitude of observer = $50^0 N$

(Example 13.10 , Page – 408

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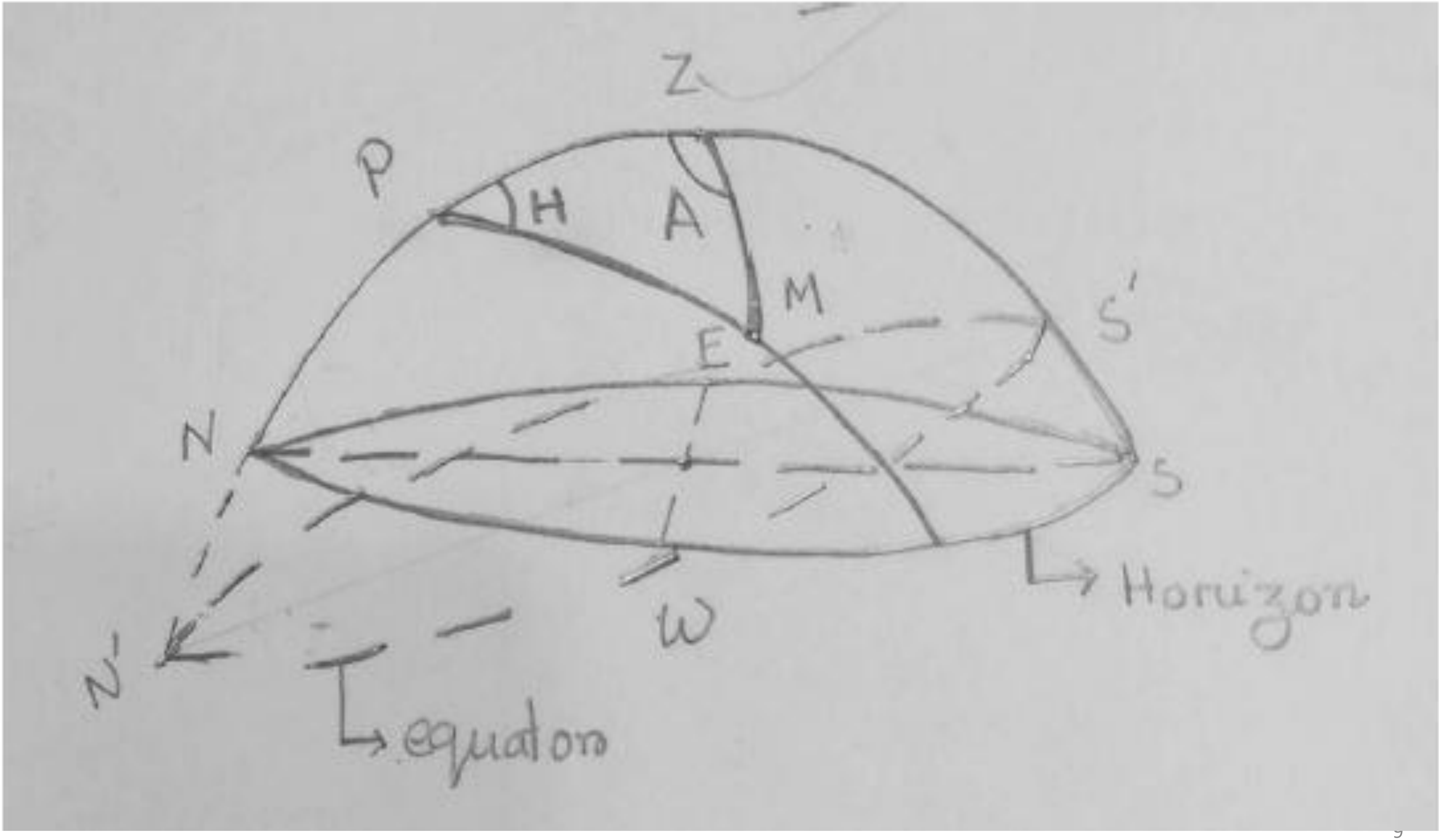
Z
P
H
A
M
S'
E
N
S
W
Horizon
N'
equator

$PZ = 90^0 - 50^0 = 40^0$

$PM = 90^0 - 20^0 30' = 69^0 30'$

$\angle ZPM = H = 42^0 6'$

From spherical triangle properties,

$\cos ZM = \cos PZ \cos PM + \sin PZ \sin PM \cos H$

$\Rightarrow \cos ZM = \cos 40^0 \cos 69^0 30' + \sin 40^0 \sin 69^0 30' \cos 42^0 6' = 0.71501$

So, $ZM = 44^0\ 21'$

Altitude of the star $= 90^0 - ZM = 90^0 - 44^0\ 21' = 45^0 39'$

Again using cosine rule ,

$\cos PM = \cos PZ \cos ZM + \sin PZ \sin ZM \cos A$

$\Rightarrow \cos A = (\cos PM - \cos PZ \cos ZM)/(\sin PZ \sin ZM) = -0.43972$

$A = 116\ ^0 5'$

Azimuth $= 116\ ^0 5'$W

- Determine the azimuth and altitude of a star from following data:

I. Declination of star = $8°30' S$

II. Hour angle of star = $322°$

III. Latitude of observer = 50^0N

(Example 13.11 , Page – 409

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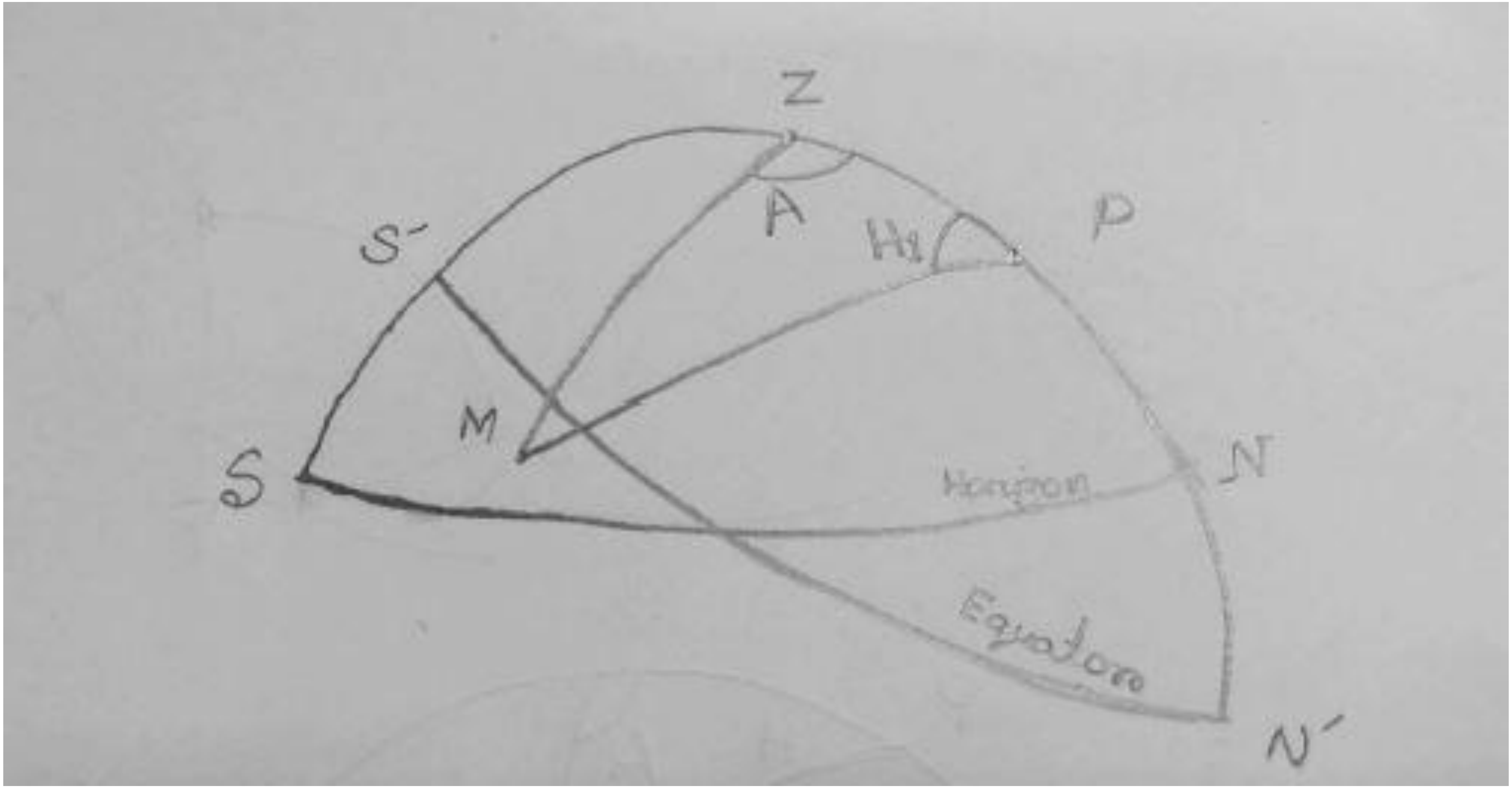
Z
A
P
Ht
S´
M
S
N
Horizon
Equator
N´

$PZ = 90^0 - 50^0 = 40^0$

$PM = 90^0 + 8^0 30' = 98^0 30'$

$<ZPM = 360^0 - H = H_1 = 360^0 - 322^0 = 38^0$

From spherical triangle properties,

$\cos ZM = \cos PZ \cos PM + \sin PZ \sin PM \cos H$

$\Rightarrow \cos ZM = \cos 40^0 \cos 69^0 30' + \sin 40^0 \sin 69^0 30' \cos 42^0 6' = 0.38771$

So, $ZM = 67^0\ 11'$

Altitude of the star $= 90^0 - ZM = 90^0 - 67^0\ 11' = 22^0 49'$

Again using cosine rule ,

$\cos PM = \cos PZ \cos ZM + \sin PZ \sin ZM \cos A$

$\Rightarrow \cos A = (\cos PM - \cos PZ \cos ZM)/(\sin PZ \sin ZM) = -0.75051$

$A = 138^0 38'$ E