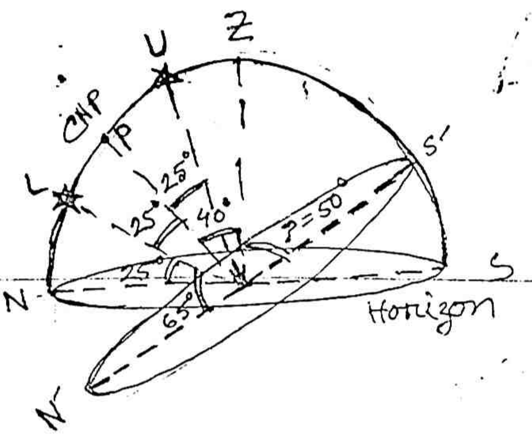
1. Astronomical Surveying

Declination of a circumpolar star, $\delta = 65^\circ$

Let, latitude of the place of observation $= \theta$



For a circumpolar star,

$$\delta > 90^\circ - \theta$$

$\therefore$ Latitude, $\theta = \angle S'$

$$= 90^\circ - 40^\circ$$

$$= \boxed{50^\circ N}$$

We know, star is always equidistant from pole.

$\therefore$ ~~Upper transit of star,~~ $PU = PL$

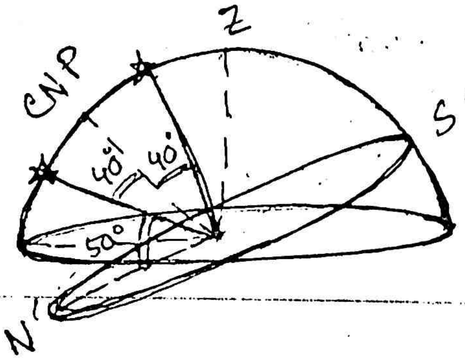
or, $PU = 25^\circ$

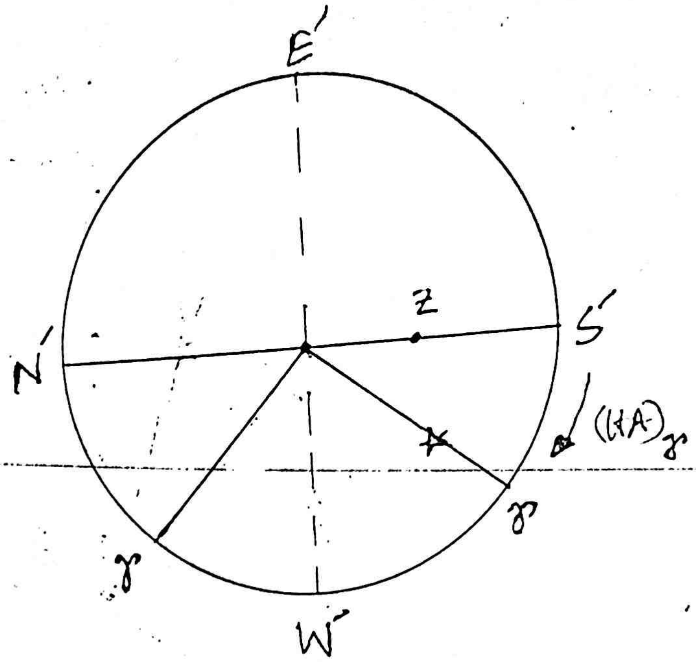
$\therefore$ Upper transit of star, $NU = NL + LP + PU$

$$= (25 + 25 + 25)^\circ$$

$$= \boxed{75^\circ N}$$

2.





At its upper transit,

$(HA)_{\star} = 0$

∴ At upper transit,

$LST = (HA)_{\gamma} = (RA)_{\star} = 37°30'$

At lower transit,

$LST = (HA)_{\gamma} = (RA)_{\star} + (HA)_{\star}$

3. For place A, $\phi_A = 37°30'E$

$\theta_A = 40°30'N$

" " B, $\phi_B = 37°30'E$

$\theta_B = 35°S$

$37°30' = 2$ hr 30 min

$= 2.5\,h$

Let, GMH = 0 hr

$\therefore \; (LMT)_A = 0 + 37°30'$

$= 0 + 2.5\,h$

$= \boxed{2.5\,h \text{ AM}}$

and $(LMT)_B = 0 + 37°30'$

$= (0 + 2.5)\,h$

$= \boxed{2.5\,h \text{ AM}}$

4. Given,

Altitude of the sun's lower limb, $\alpha' = 30°45'30'' = 30.76°$

Declination of sun, $\delta = 8°30'N$

Semidiameter of sun, $\frac{d}{2} = 16'00''$

Horizontal parallax of sun, $P_n = 8.8''$

For parallax :- $\alpha = \alpha' + P_a$

where $P_a = P_n \cos\alpha' = 8.8'' \cos(30°45'30'')$

$= 7.56''$

$\therefore \alpha = 30°45'30'' + 7.56''$

$= 30°45'37.56''$

$= 30.76°$

Correction for refraction :-

$\alpha = \alpha' - P_r = 30.76° - P_r$

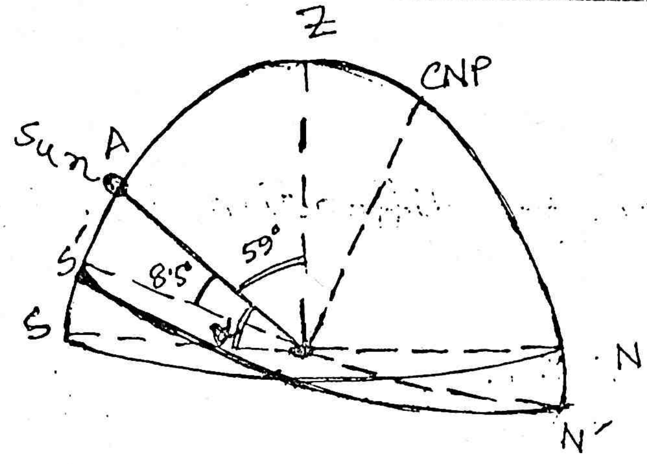
where, $P_r = 58'' \cot\alpha' = 1'37.46''$

$\therefore \alpha = 30°43'58.54'' = 30.73°$

Now, for semidiameter correction :-

$\alpha = \alpha' + \frac{d}{2}$ [as it is lower limb]

$= 30.73° = 30°59'58.54'' \approx 31°$.



Here, $SA = 31^\circ$

$S'A = 8.5^\circ$

$ZA = ZS - SA = 90^\circ - 31^\circ = 59^\circ$

$\therefore ZS' = 59^\circ + 8.5^\circ = 67.5^\circ$ N

or, $\theta = \boxed{67^\circ 30' \text{ N}}$

where, θ = latitude of the place of observation.

5. Given,

$\alpha' = 30^\circ 15'$

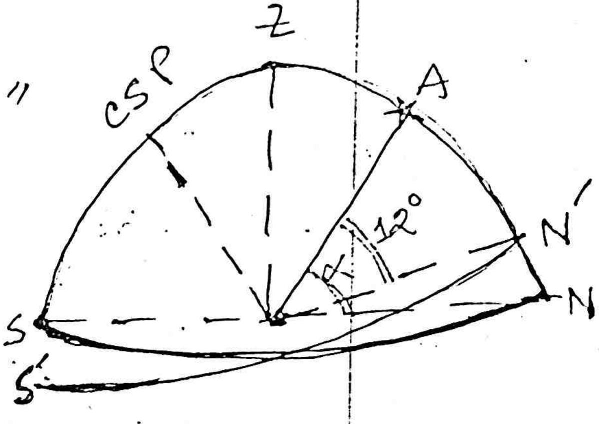
& $\delta = 12^\circ S$

For a star, only correction for diffraction is needed for this case.

We know, corrected altitude,

$\alpha = \alpha' - P_r$

where, $P_r = 58'' \cot\alpha' = 1' 39.45''$



$\therefore \alpha = 30^\circ 13' 20.55''$

Here,

$ZA = ZN - AN$

$= 90^\circ - 30^\circ 13' 20.55''$

$= 59^\circ 46' 39.45''$

$\therefore ZN' = ZA + AN'$

or, $\boxed{\theta = 71^\circ 46' 39.45'' S}$

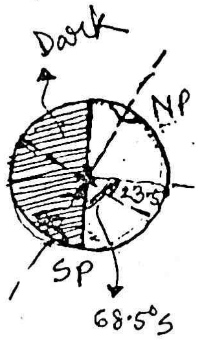
For a circumpolar star, $\delta > (90^\circ - \theta)$

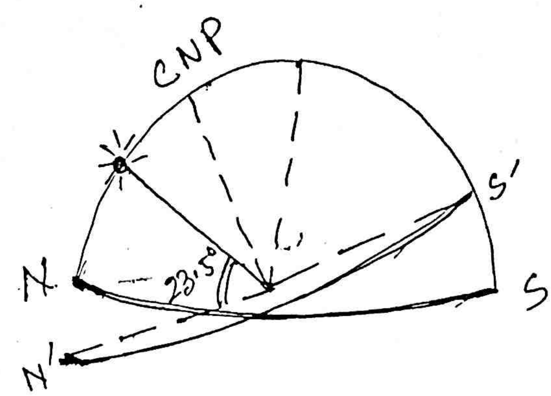
Here, $90^\circ - \theta = 18^\circ 13' 20.55''$

$\therefore \delta < (90^\circ - \theta)$

So, this is not a circumpolar star.

6.





For 89° S

ii) 0 hrs < Daytime < 12 hrs

For 40°S

iv) 12 hrs < Daytime < 24 hrs.

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7. Given; GMT = ?

LMT = 2 a.m

Longitude = 67.5° E

= 67° 30′ E

Now, 67° 30′ = 4 hrs 30 min

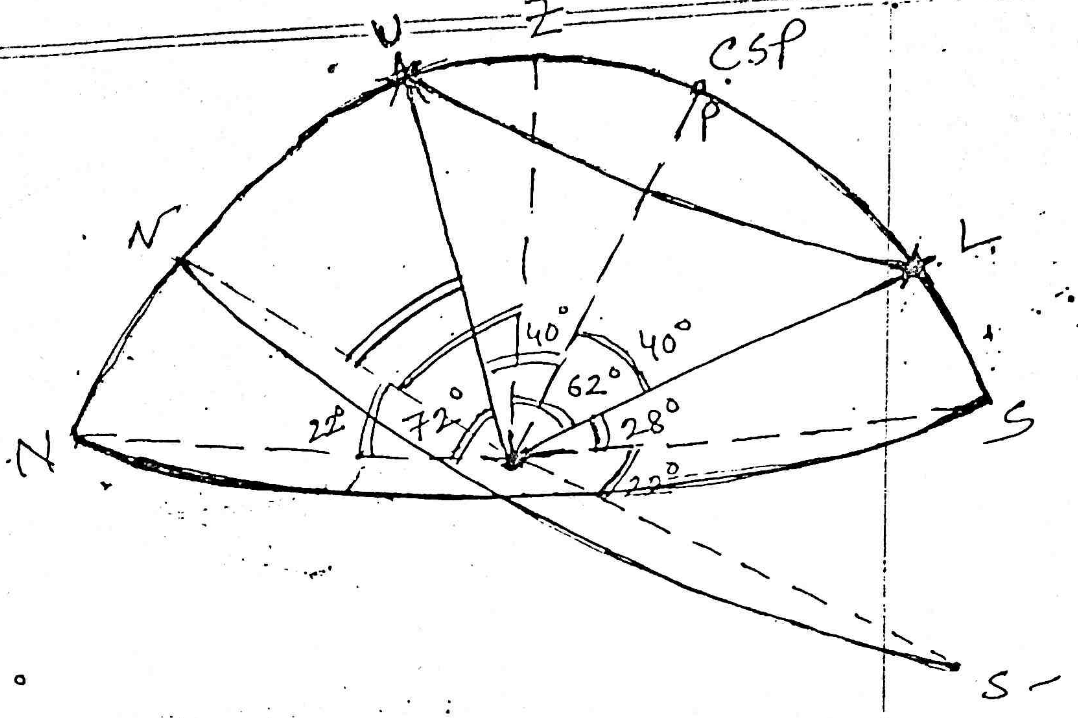
We know, L.M.T = GMT + East Longitude

or, GMT = LMT − East "

or, GMT = 2 am − 4 h 30 m = 21.5 h − 12

∴ $\boxed{\text{GMT} = 9\text{ h } 30\text{ m p.m.}}$

9.



Here,

$NU = 72^\circ$

$\therefore ZU = ZN - NU = 90^\circ - 72^\circ = 18^\circ$

We know, star is always equidistant from pole.

$\therefore PL = PU$ - - - (i)

Now, $ZL = ZS - LS = 90^\circ - 28^\circ = 62^\circ$

& $NU + LU + SL = 180^\circ$

$\Rightarrow 72^\circ + LU + 28^\circ = 180^\circ$

$\therefore LU = 80^\circ$

From eq^n (i) $\rightarrow$ $PL = PU = \frac{80^\circ}{2} = 40^\circ$

$SP + SS' = 90^\circ$

$\Rightarrow SS' = 90^\circ - 68^\circ$

$\therefore SS' = 22^\circ$

$\therefore NN' = 22^\circ$

$\therefore$ Declination of star, $\delta = N'U = NU - NN'$

$= 72^\circ - 22^\circ$

$= \boxed{50^\circ S}$

Again, $ZP = ZL - PL = 62^\circ - 40^\circ = 22^\circ$

& $ZU = PU - ZP = 40^\circ - 22^\circ = 18^\circ$

$\therefore$ Latitude of the place of observation,

$$\theta = ZN' = ZU + N'U$$
$$= 18^\circ + 50^\circ$$

$$\therefore \boxed{\theta = 68^\circ S}$$

10. Shortest distance will be along - a great circle AB.

PAB is the spherical triangle.

Now, b = arc AP = $90^\circ - 15^\circ = 75^\circ$ &
a = arc BP = $90^\circ + 20^\circ = 110^\circ$ } spherical sides.

Spherical angle at P will be → $P = 360^\circ - (110^\circ + 30^\circ) = 220^\circ > 180^\circ$

$\therefore P = 110^\circ + 30^\circ$;
$= 140^\circ < 180^\circ$

Now for p →

$\cos p = \cos P \sin a \sin b + \cos a \cos b$

$= \cos 140^\circ \times \sin 110^\circ \times \sin 75^\circ + \cos 110^\circ \times \cos 75^\circ$

$\therefore p = 141.61^\circ$

So arc AB $= \frac{141.61}{360} \times 2\pi \times 6370$ km ; [Considering earth's radius, R = 6370 km]

$\therefore \boxed{AB = 15745.88 \text{ km}}$ (Ans)

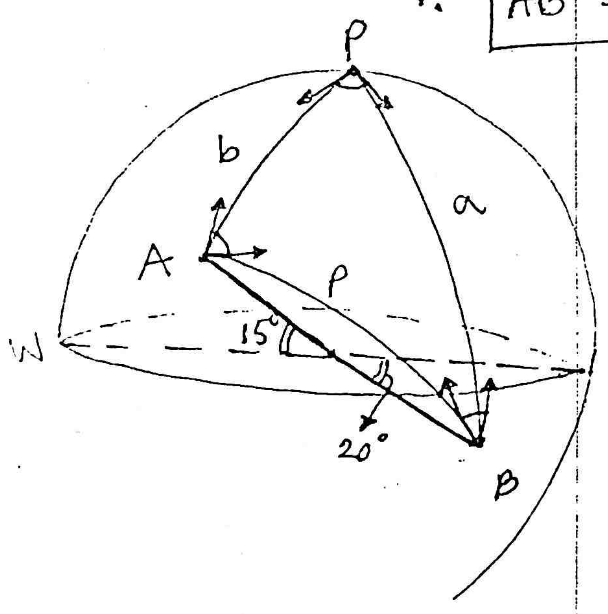


Fig-1

* Direction of AB from A :—

$$\tan\frac{A+B}{2} = \frac{\cos\frac{a-b}{2}}{\cos\frac{a+b}{2}}\cot\frac{P}{2} = \frac{\cos\frac{110-75}{2}}{\cos\frac{110+75}{2}}\cot\frac{140^\circ}{2}$$

$$\therefore \frac{A+B}{2} = 82.84^\circ$$

Again, $$\tan\frac{A-B}{2} = \frac{\sin\frac{a-b}{2}}{\sin\frac{a+b}{2}}\cot\frac{P}{2} = \frac{\sin\frac{110-75}{2}}{\sin\frac{110+75}{2}}\times\cot\frac{140^\circ}{2}$$

$$\therefore \frac{A-B}{2} = 6.25^\circ$$

$\therefore$ Solving we get $\rightarrow$ $B = 76.59^\circ$

& $A = 89.09^\circ$

$\therefore$ Direction of B from A = $\boxed{N\ 89.09^\circ\ E}$

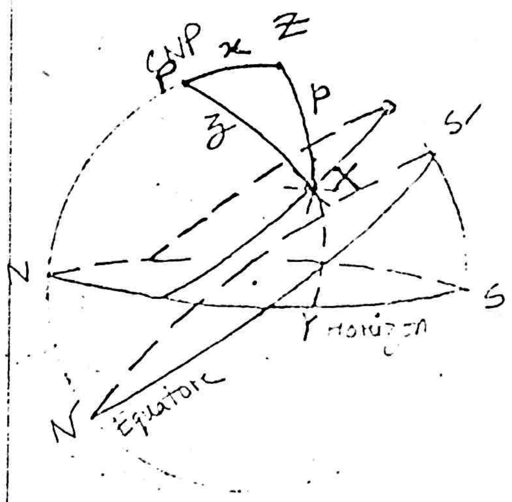
" " A " B = $\boxed{S\ 76.59^\circ\ W}$

(Ans)

8. Here, longitude $= 75^\circ W$

$= 300\,m$

$= 5\,h$



Given, GMN = 10:30 am

$= 10h\,30m$

$\therefore$ GMT at time of observation

$= 10h\,30m + 5h$

$= 15h\,30m$

which is $3h\,30m$ after GMN.

$\therefore \delta_{sun} = 3^\circ - 1' \times 3.5$

$= 2^\circ 56' 30''$

At observation, sun is at X.

Given, $ZS' = 45^\circ N$

& $XY = \alpha_{sun} = \dfrac{25^\circ 30' + 25^\circ 50'}{2} = 25^\circ 40' = 25.67^\circ$

Spherical triangle PZX, we get →

$x = \text{arc } PZ = 90^\circ - 45^\circ = 45^\circ$

& $p = \text{arc } ZX = 90^\circ - 25^\circ 40' = 64^\circ 20'$

& $z = \text{arc } PX = 90^\circ - 2^\circ 56' 30'' = 87^\circ 3' 30''$

We know, $\cos z = \cos Z \sin p \sin x + \cos p \cos x$

or, $\cos Z = \dfrac{\cos z - \cos p \cos x}{\sin p \sin x}$

or, $\cos Z = \dfrac{\cos(87.06) - \cos(64°20')\cos(45°)}{\sin(64°20')\sin(45°)}$

$\therefore Z = 113.58'$

or, $\boxed{Z = 113°34'48.13'' \text{ W}}$

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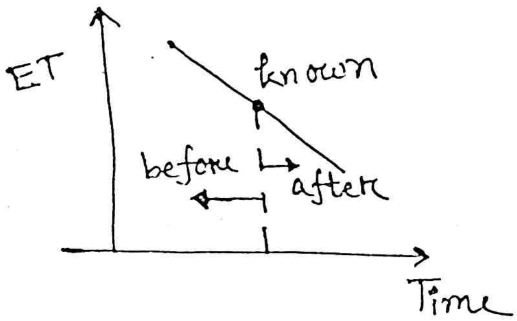
15. Given,

LMT = 10h 20m 30 s

Longitude = 45°18' E

Now, 45°18' = 3h 1 m 12 s



∴ GMT = LMT − East longitude

= 10 h 20m 30s − 3h 1m 12s

= 7 h 19m 18 s

= 7.322 h

∴ Time before GMN = 12 − 7h 19m 18s

= 4 h 40m 42s = 4.678 h

ET at GMN = −4m 4.35s

∴ ET at instant time of observation

$= -4m\,4.35s + 0.32 \times 4.678s$

$= -4'\,2.85''$

∴ $LAT = LMT + ET$

$= 10h\,20m\,30s - 4'\,2.85''$

or, $\boxed{LAT = 10h\,16'\,27.15''}$