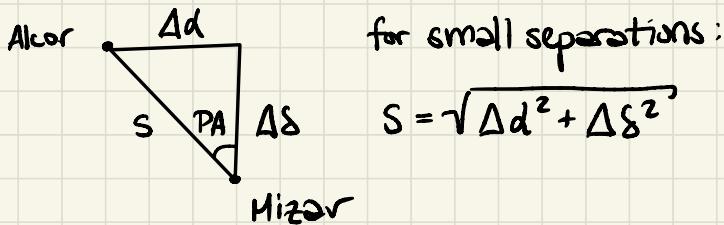


Homework 1 Solution:

1.

Δd	d	δ
Alcor	$13^{\circ}25'13.5''$	$+54^{\circ}59'16.6''$
Mizar	$13^{\circ}23'55.4''$	$+54^{\circ}55'31.3''$

(from Simbad)



$$\Delta d = (d_{\text{Alcor}} - d_{\text{Mizar}}) \cdot \cos \delta_{\text{avg}} = 1m 18.1s \cdot \cos(54.95^\circ)$$

$$\Delta d = 78.1s \cdot \sqrt{1} \cdot \cos(54.95^\circ) = 673''$$

$$\Delta \delta = (\delta_{\text{Alcor}} - \delta_{\text{Mizar}}) = 216''$$

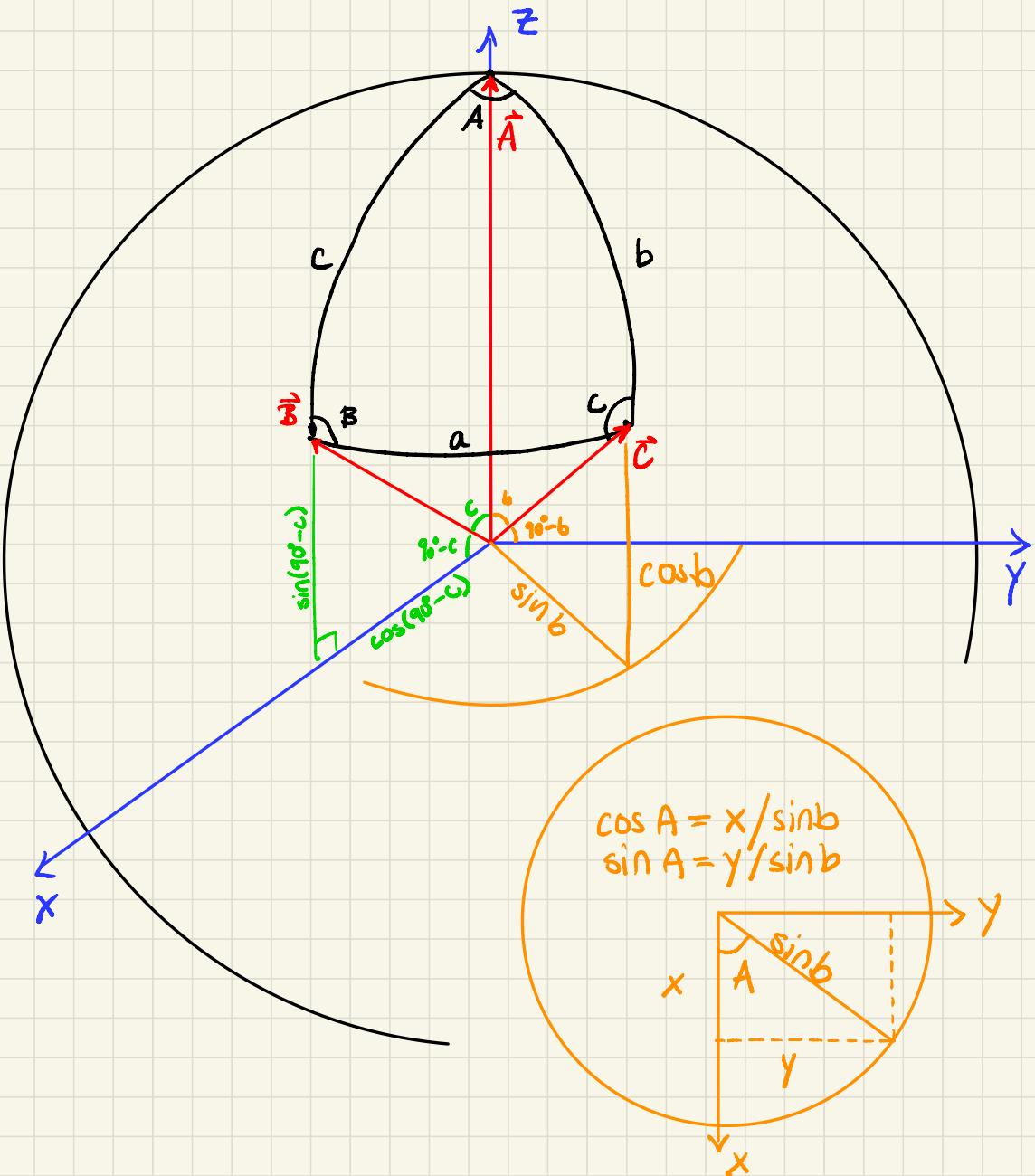
$$S = \sqrt{(673'')^2 + (216'')^2} = 707''$$

$$PA = \tan^{-1}(\Delta d / \Delta \delta) = \tan^{-1}(673''/216'') = 72.2^\circ$$

2. Generally, the Law of Cosines relates the angles and sides of a triangle on the surface of a sphere.

Start by drawing a triangle on the surface of a unit sphere. Since the angles and sides are not impacted by where you put it, orient it so one corner is at the pole and another is in the XZ plane.

Label the angles at each vertex A, B, C and the sides across from them a, b, c. Also draw vectors from the origin to each vertex and label them \vec{A} , \vec{B} , and \vec{C} .



Recall the general form of the dot product of two vectors:

$$\vec{x} \cdot \vec{y} = |\vec{x}| |\vec{y}| \cos \theta,$$

where θ is the angle between them.

Since $|\vec{B}| = |\vec{C}| = 1$

$$\cos \alpha = \vec{B} \cdot \vec{C}$$

Write \vec{B} and \vec{C} in cartesian coordinates to compute the dot product.

\vec{B} in cartesian coordinates:

$$(x, y, z) = (\sin c, 0, \cos c)$$

\vec{C} in cartesian coordinates:

From the vertex at the pole, rotate down by C , then rotate around by A . This point has height $\cos b$ and is on a circle with radius $\sin b$.

$$(x, y, z) = (\cos A \sin b, \sin A \sin b, \cos b)$$

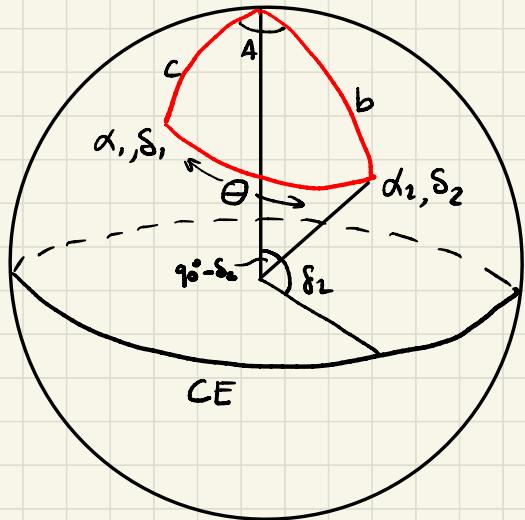
Then,

$$\cos \alpha = \vec{B} \cdot \vec{C}$$

$$= (\sin c \hat{i} + 0 \hat{j} + \cos c \hat{k}) \cdot (\cos A \sin b \hat{i} + \sin A \sin b \hat{j} + \sin b \hat{k})$$

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

In terms of RA and declination:

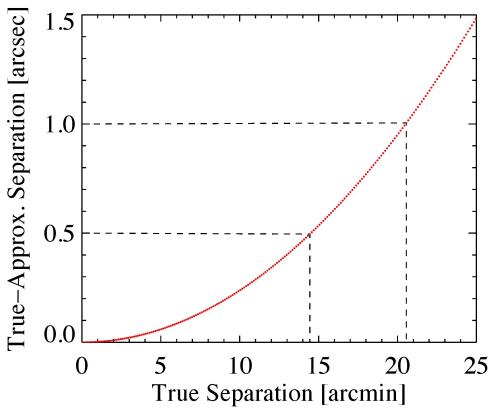


$\cos A$

$$\cos \theta = \cos(90^\circ - \delta_2) \cos(90^\circ - \delta_1) + \sin(90^\circ - \delta_1) \sin(90^\circ - \delta_2) \cos(\alpha_2 - \alpha_1)$$

$$\cos \theta = \sin \delta_2 \sin \delta_1 + \cos \delta_1 \cos \delta_2 \cos \Delta \alpha$$

Pythagorean approximation is good for arcsecond scale separations. By separations of 15' it is off by 0.5" and by 20' it is off by 1".



3.	Location	Constellation	λ	b	RA	dec
	Galactic center	Sagittarius	0	0	17:45	-28°
	Galactic anti-center	Auriga	180	0	05:45	+28°
	Galactic north pole	Coma	-	90	12:51	+27°
	Galactic south pole	Sculptor	-	-90	00:51	-27°
	Location(s) where ecliptic crosses GP	Ophiuchus / Taurus	6	0	17:51	-23°
			186	0	05:56	+23°

4. Jan 1 is about 9 months after the vernal equinox so
 $RA_0 = 0h + 9 \times \frac{24h}{12m} = 18h$.

At midnight, 6h RA is on the meridian $\rightarrow LST = 6h$.
 Over the course of the night, objects move E \rightarrow W.

HA is negative before crossing the meridian, so it goes from -6h to 6h over the course of the night.

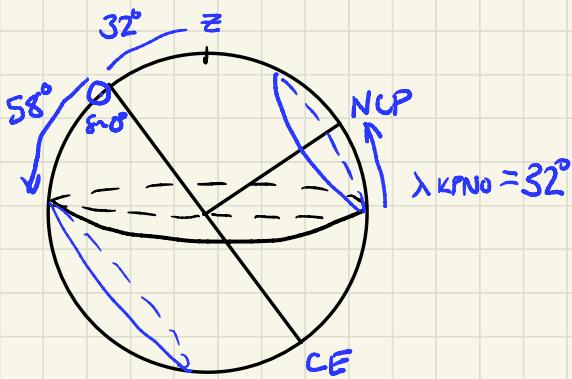
$$LST = RA_{obj} + HA_{obj} \text{ and } LST = RA_0 + HA_0$$

$$\text{local time (LT)} = LST + 12h$$

$$\Rightarrow LT = RA_{obj} + HA_{obj} - RA_0 + 12h$$

Also, KPNO is at latitude $\lambda = 32^\circ$, needed to get Z_{min} .

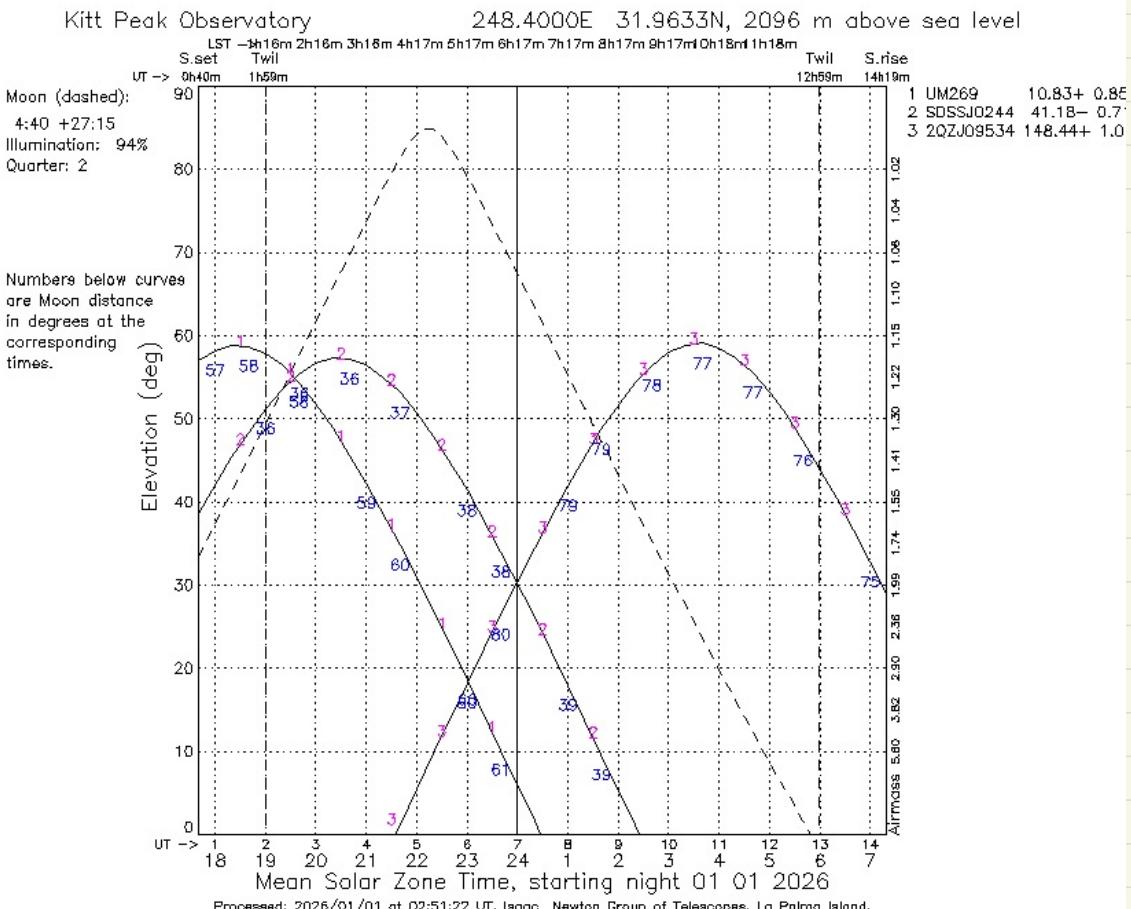
Name	RA	dec	transit	rise	set	Z_{min}	X_{min}
UM269	00:43	00:51	18:43	12:43	00:43	31°	1.16
J0244	02:44	-00:42	20:44	14:44	02:44	33°	1.19
J0953	09:53	01:03	03:53	21:53	09:53	31°	1.16



From KPNO, can see declinations of -58° to $+90^\circ$, so all objects will rise.

Circumpolar objects will have $\delta > 90^\circ - \lambda_{\text{obs}} \approx 90^\circ - 32^\circ = 58^\circ$. None of these in the list.

5.



6. varies

7. varies