

# Problem Set 3 Solution

Problems 1, 3, 6, 7, 9, and 10

Problem 1(a) See scan on next page.

Problem 1(b) Refer to drawing on next page.

We are looking for the angle labeled  $\epsilon$ .

$\epsilon = \delta + \varphi$  From part (a) we know  $\delta$ . It is  $2.16^\circ$ .

$\varphi$  we haven't calculated, but  $\tan \varphi = \frac{\overline{OB}}{\overline{OA}}$

$$\left. \begin{array}{l} \overline{OA} = \sin \delta = 0.017 \\ \overline{OB} = \sin \delta = 0.038 \end{array} \right\} \text{also from part (a).}$$

Putting it all together

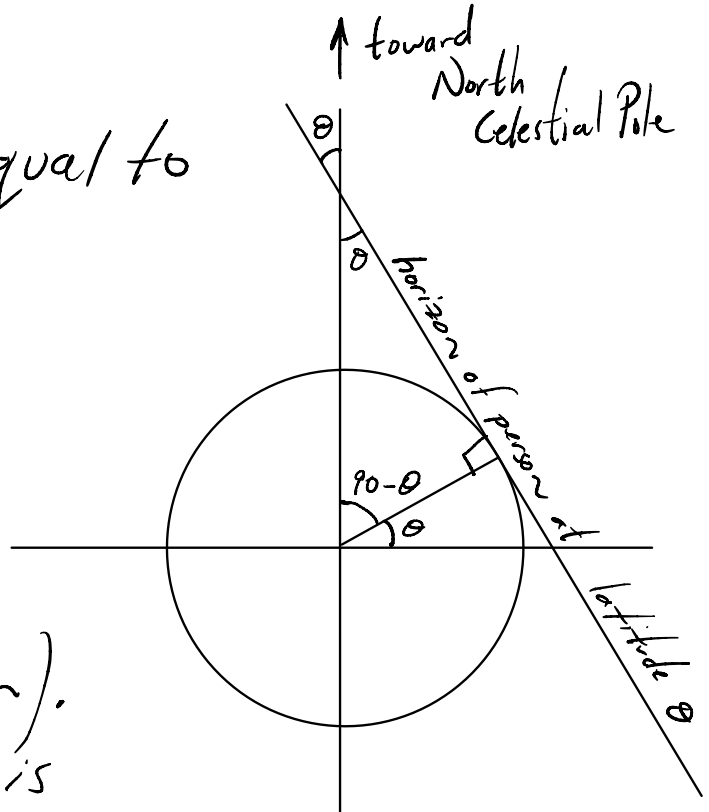
$$\epsilon = \delta + \varphi = 2.16^\circ + \underbrace{\tan^{-1} \frac{0.038}{0.017}}_{66^\circ} = 68^\circ$$

There may be a fair amount of rounding error due to division by a small # (0.017) before taking the arctangent. There is not much we can do about this. It traces back to  $\alpha$  and  $\beta$  being pretty close to each other.



# Problem 3

Several angles are equal to the latitude  $\theta$  in this diagram, including the one we are seeking (the altitude of the North Celestial Pole above the horizon).



Note the question is slightly sloppily posed. The North Star (Polaris) revolves around the North Celestial Pole, but at a circle of less than  $1^\circ$ .

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Problem 6 Using the diagram from problem 3, we see that if a star is within  $\theta$  of the North Celestial Pole, <sup>NCP</sup> it is always above the horizon. Similarly, if it is within  $\theta$  of the <sup>SCP</sup> South Celestial Pole, it is never above the horizon. Since DEC is measured from the equator and is  $+90^\circ$  at the NCP and  $-90^\circ$  at the SCP, we can say

always visible  $\Leftrightarrow$   $DEC > 90 - \theta$  never visible  $\Leftrightarrow$   $DEC < -90 + \theta$

Deep Springs is at latitude  $\theta = 37.37^\circ$   
(and longitude  $-117.98^\circ$ )

Always visible at Deep Springs  $\Leftrightarrow$   
 $DEC > 52.63^\circ$

Never visible at Deep Springs  $\Leftrightarrow$   
 $DEC < -52.63^\circ$

## Problem 9

The circumference of the Earth at latitude  $\theta$  is  $\cos\theta$  of the circumference at the equator.

Therefore  $1^\circ$  of longitude (which by definition is 60 nautical miles at the equator) is only  $\cos\theta$  of 60 nautical miles at latitude  $\theta$ . Let's check a few numbers in the table:

Latitude	Table Value	$\cos\theta \cdot 60'$
5	59.77	59.77168
25	54.38	54.37847
45	42.43	42.426

## Problem 10

One or more of Problems 10, 13, 14 we will do in class on Feb. 7.

Hopefully people will find 10 straightforward once we have done it together.