

Spherical astronomy problems, with solutions

- Q:** What is the distance between Ljubljana ($\phi=46^\circ$ N, $\lambda=15^\circ 32'$ E) and Rio de Janeiro ($\phi=23^\circ$ S, $\lambda=43^\circ$ W)? What bearing (angle from North, in degrees) would you need to take to travel along the shortest path? The radius of Earth is 6400 km.

A: 9654 km, 128.9° .
- Q:** If we fly from Johannesburg ($\phi=26^\circ 08'$ S, $\lambda=27^\circ 54'$ E) in a westward direction, bearing 9.67° , and land after 8171 km, what are the geographic latitude and longitude of the landing site?

A: $\phi=46^\circ 03'$ S, $\lambda=14^\circ 32'$ E.
- Q:** A star crosses the south principal meridian at $h=85^\circ$ and the north principal meridian at $h=45^\circ$. What are the geographic latitude of the observatory and the declination of the star?

A: Either $\phi=65^\circ$, $\delta=70^\circ$, or $\phi=70^\circ$, $\delta=65^\circ$.
- Q:** At what geographic latitude is Castor ($\delta=31^\circ 53'$) circumpolar? At what geographic latitude does Betelgeuse ($\delta=7^\circ 24'$) culminate in zenith?

A: $\phi > 58^\circ 07'$, $\phi = 7^\circ 24'$.
- Q:** We observe two stars precisely due east, one is rising and the other is 30° above the horizon. The two stars do not culminate at the same time. Which one will culminate first and what will be the difference in the time of culminations of those two stars? We are observing from Villanova ($\phi=40^\circ 02' 14''$ N, $\lambda=75^\circ 20' 57''$ W). You may neglect the effects of atmospheric refraction.

A: The one 30° above the horizon will culminate first, 1h35m08s before the other star.
- Q:** A 1m long rod stands vertically on a level surface. When will its shadow be shortest? By how many centimeters does the shadow lengthen two hours later if we observe it from $\phi=46^\circ$ during (a) summer solstice, (b) winter solstice? You may neglect atmospheric refraction.

A: Its shadow will be the shortest when the Sun culminates. (a) $\Delta x=23\text{cm}$, (b) $\Delta x=93\text{cm}$.
- Q:** On June 3, 2016 we are observing η Ursae Majoris ($\alpha=13\text{h}47\text{m}29\text{s}$, $\delta=49^\circ 19' 32''$) from Villanova ($\phi=40^\circ 02' 14''$ N, $\lambda=75^\circ 20' 57''$ W). What are the altitude and azimuth of η Ursae Majoris at 11pm local time? We are observing from Villanova ($\phi=40^\circ 02' 14''$ N, $\lambda=75^\circ 20' 57''$ W).

A: $h=75^\circ 29' 30''$, $A=44^\circ 59' 03''$.
- Q:** On February 26, 2016 we see a star rise at 2h13m and set at 16h27m. When did the star culminate? What are its equatorial coordinates? We are observing from Villanova ($\phi=40^\circ 02' 14''$ N, $\lambda=75^\circ 20' 57''$ W).

A: $t_c=9\text{h}20\text{m}$, $\alpha=19\text{h}42\text{m}06\text{s}$, $\delta=19^\circ 13' 46''$.
- Q:** Astronomical dusk begins at sunset (at the time the Sun's edge is below the horizon) and ends when the center of the Sun is 18° below the horizon. Compute the length of astronomical dusk at the equinox and the solstices. We are observing from Villanova ($\phi=40^\circ 02' 14''$ N, $\lambda=75^\circ 20' 57''$ W). You may neglect the effects of atmospheric refraction. The angular diameter of the Sun is $32'$.

A: $1\text{h}32\text{m}11\text{s}$, $2\text{h}04\text{m}31\text{s}$, $1\text{h}41\text{m}41\text{s}$.
- Q:** A star is above the horizon for 9h40m. What is its azimuth as it sets, if we observe from Villanova ($\phi=40^\circ 02' 14''$ N, $\lambda=75^\circ 20' 57''$ W)?

A: $A=115^\circ 50' 07''$