The Celestial Sphere

PROBLEM SET

1 Derive the relationship between a planet's synodic period and its sidereal period (Eq. 1). Consider both inferior and superior planets.

$$1/S = \begin{cases} 1/P - 1/P_{\oplus} & \text{(inferior)} \\ 1/P_{\oplus} - 1/P & \text{(superior)} \end{cases} \tag{1}$$

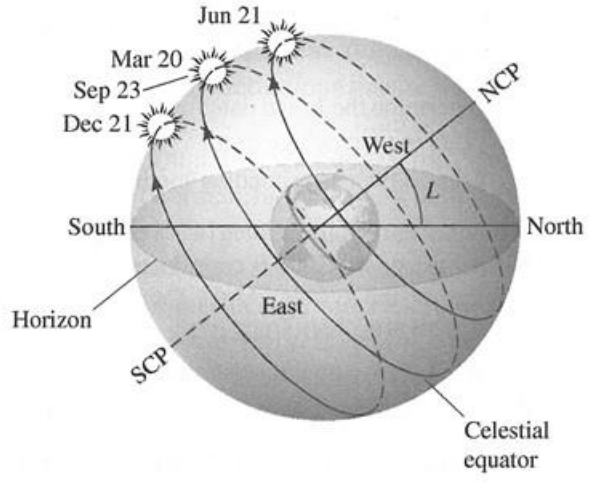
2 Devise methods to determine the *relative* distances of each of the planets from the Sun given the information available to Copernicus (observable angles between the planets and the Sun, orbital configurations, and synodic periods).

3 **(a)** The observed orbital synodic periods of Venus and Mars are 583.9 days and 779.9 days, respectively. Calculate their sidereal periods.

(b) Which one of the superior planets has the shortest synodic period? Why?

4 List the right ascension and declination of the Sun when it is located at the vernal equinox, the summer solstice, the autumnal equinox, and the winter solstice.

5 **(a)** Referring to Fig. 12(a), calculate the altitude of the Sun along the meridian on the first day of summer for an observer at a latitude of 42° north.

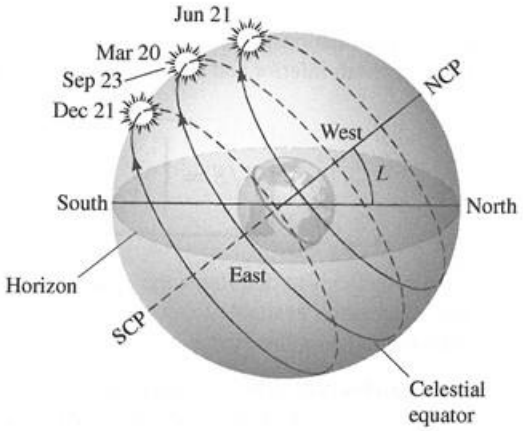


(a)

FIGURE 12 (a) The diurnal path of the Sun across the celestial sphere for an observer at latitude L when the Sun is located at the vernal equinox (March), the summer solstice (June), the autumnal equinox (September), and the winter solstice (December). NCP and SCP designate the north and south celestial poles, respectively. The dots represent the location of the Sun at local noon on the approximate dates indicated.

(b) What is the maximum altitude of the Sun on the first day of winter at the same latitude?

6 (a) Circumpolar stars are stars that never set below the horizon of the local observer or stars that are never visible above the horizon. After sketching a diagram similar to Fig.12(a), calculate the range of declinations for these two groups of stars for an observer at the latitude L.



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(b) At what latitude(s) on Earth will the Sun never set when it is at the summer solstice?

(c) Is there any latitude on Earth where the Sun will never set when it is at the vernal equinox? If so, where?

7 (a) Determine the Julian date for 16:15 UT on July 14, 2006. (*Hint:* Be sure to include any leap years in your calculation.)

(b) What is the corresponding modified Julian date?

8 Proxima Centauri (α Centauri C) is the closest star to the Sun and is a part of a triple star system. It has the epoch J2000.0 coordinates $(\alpha, \delta) = (14^h29^m42.95^s, -62°40'46.1'')$. The brightest member of the system, Alpha Centauri (α Centauri A) has J2000.0 coordinates of $(\alpha, \delta) = (14^h39^m36.50^s, -60°50'02.3'')$.

(a) What is the angular separation of Proxima Centauri and Alpha Centauri?

(b) If the distance to Proxima Centauri is 4.0×10^{16} m, how far is the star from Alpha Centauri?

9 (a) Using the information in Problem 8, precess the coordinates of Proxima Centauri to epoch J2010.0.

(b) The proper motion of Proxima Centauri is $3.84'' \text{ yr}^{-1}$ with the position angle 282°. Calculate the change in α and δ due to proper motion between 2000.0 and 2010.0.

(c) Which effect makes the largest contribution to changes in the coordinates of Proxima Centauri: precession or proper motion?

10 Which values of right ascension would be best for viewing by an observer at a latitude of 40° in January?

11 Verify that Eq. (7) follows directly from the expression immediately preceding it.

$$\Delta\delta = \Delta\theta \cos\phi. \tag{7}$$