Astronomy 100, Fall 2008 Name(s):

Exercise 2: The UW planetarium

The University of Washington Physics and Astronomy Building houses a wonderful planetarium, in addition to some other interesting displays. Use those resources to answer the following questions.

Outside the planetarium

1. a. Find the **Foucault pendulum**. What is the significance of this pendulum? In other words, what does it do?

b. How does it do that? I mean: there's nothing twisting the cable to the ceiling, yet it **precesses**...how come?

2. Check out the **analemmic** sundial on the side of the building facing Pacific Avenue. In addition to the time, what else can you read from it? Hint: How do the metal "braces" help?

The planetarium

3. Once inside the planetarium, I'll demonstrate the cardinal directions, altitude and azimuth, and the ecliptic. As the stars come out, notice that Polaris, the end star on the handle of the Little Dipper, stays in place through the whole night, while all the other stars revolve around it. What other measurement is equal to the **altitude** of Polaris at any given location in the northern hemisphere?

4. As the Earth orbits the Sun, it also rotates in a CCW direction about its axis. Define 24 hours as the time from when the Sun is highest in the sky one day to when it is highest in the sky the next day. How many degrees does Earth rotate about its axis in exactly 24 hours?

a. exactly 360° b. less than 360° c. more than 360°

This means that the Earth rotates exactly 360° in:

a. exactly 24 hours b. less than 24 hours c. more than 24 hours

A **solar day** is defined as the time it takes the Sun to go from when its highest point in the sky on one day to its highest point in the sky the next day. This day is divided into 24 hours.

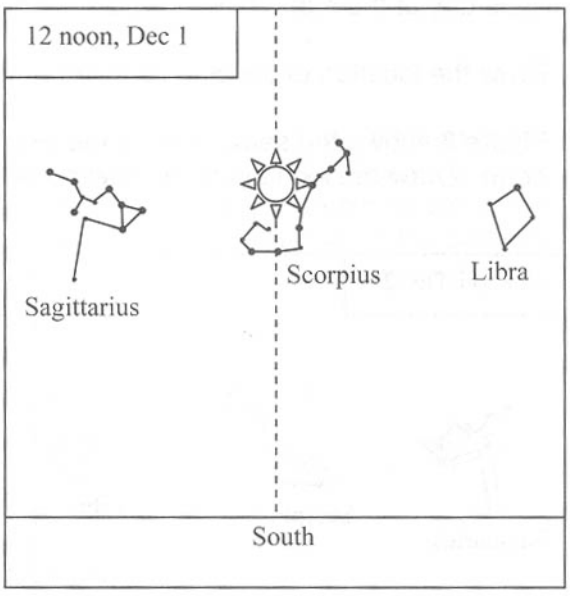
A **sidereal day** is defined as the time it takes for the Earth to rotate exactly 360° about its axis with respect to the distant stars.

When does the Earth rotate a greater amount, during a solar day or during a sidereal day?

Thus the _____ day is longer than the _____ day.

For the next figures, pretend that the stars are so bright and the Sun so dim that the stars can be seen during the day and do not "wash out" the Sun, which we can totally do in the planetarium.

On December 1 at noon, you are looking toward the south and see the Sun among the stars of the constellation Scorpius as shown in the figure below.



5. Two students are discussing their answers to the question "At 3 p.m. that afternoon, which constellation will the Sun appear?"

Student 1 (Goofus): The Sun moves from the east through the southern part of the sky and then to the west. By 3 p.m., it will have moved from being high in the southern sky to the west into the constellation Libra."

Student 2 (Gallant): You're forgetting that stars and constellations will rise in the east, move through the southern sky and then set in the west just like the Sun. So the Sun will still be in Scorpius at 3 p.m."

a. With whom do you agree? What argument convinced you?

b. So is it reasonable to pretend that the Sun is at a fixed position on the celestial sphere from one day to the very next day, and is carried along its path in the sky by the sphere's rotation?

By carefully observing the sky night after night, we find that the celestial sphere rotates slightly more than 360° every 24 hours. The figures below show the same view of the sky as the previous one, except one day later and one month later, respectively (for comparison, the gray constellations show the positions of the constellations on December 1 at the same time).

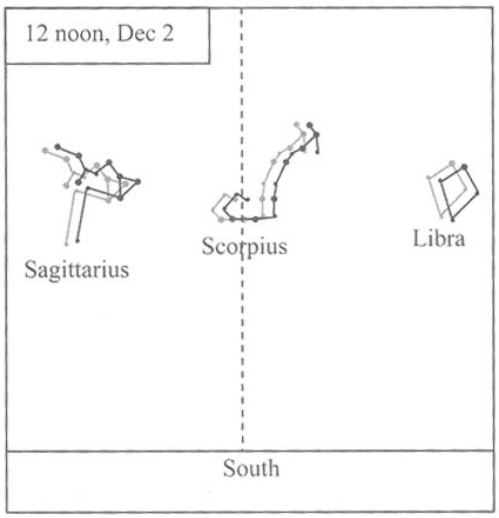


Figure 3

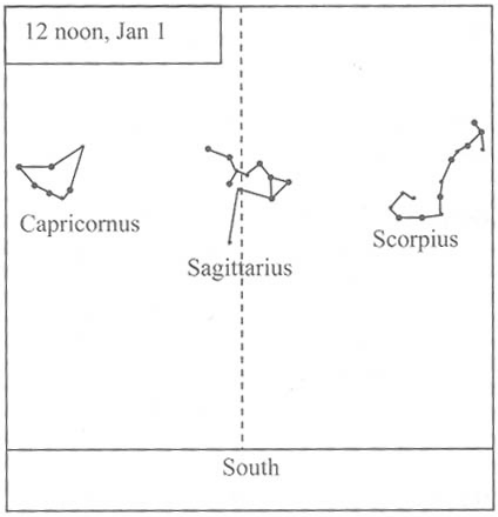


Figure 4

6. Draw the location of the Sun as accurately as possible on figure 3.

7. Two students are discussing their answers to the question "Figure 4 shows the same view of the sky one month later on January 1. Draw the location of the Sun as accurately as possible on figure 4."

Student 1 (Davey): The Sun will always lie along the dotted line in the figures when it's noon.

Student 2 (Goliath): I don't know, Davey; we saw in question 8 that the Sun's motion can be modelled by assuming it is stuck to the celestial sphere. The Sun must, therefore, stay in Scorpius.

Student 1 (Davey): If that were true, then by March the Sun would be setting at noon. The Sun must shift a little along the celestial sphere each day so that in 30 days it has moved to the east in the next constellation.

Whom do you believe? What convinced you? And sketch the Sun in its proper location in figure 4.

8. Why is it reasonable to think of the Sun as attached to the celestial sphere over the course of a single day as suggested in question 5 even though we know from question 7 that the Sun's position is not truly fixed on the celestial sphere?

Now consider the whole celestial sphere; the Sun's position on the celestial sphere on December 1 is shown in figure 5 (next page), among the stars of the constellation Scorpius.

9. a. Draw where the Sun will be located on the celestial sphere on January 1. Label this position "Jan. 1". Then locate and label the Sun's position for February 1, March 1, April 1, May 1, June 1, July 1, August 1, September 1, October 1 and finally, November 1.

b. Clearly, the line shown in figure 5 going through the Zodiac is the **ecliptic**, the "pathway" of the Sun. And the length of time it takes to complete one cycle is

_____ .

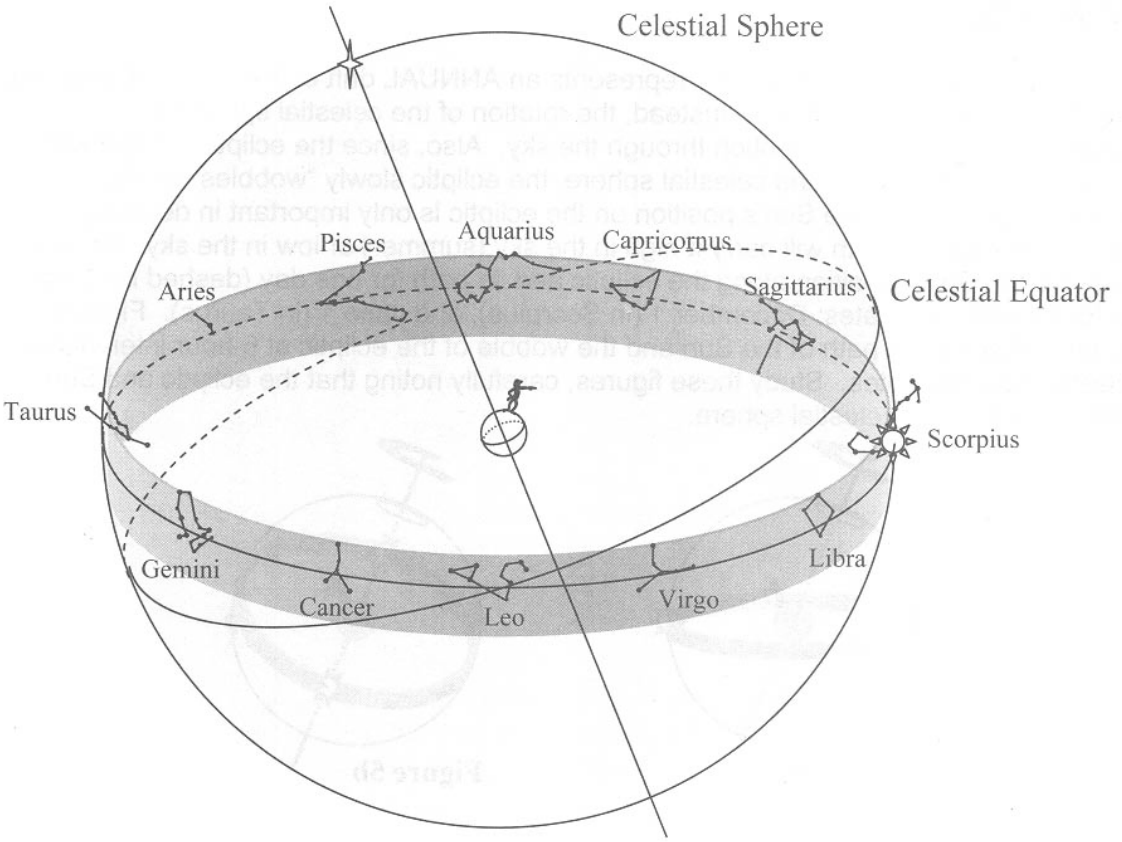


Figure 5: The celestial sphere

The annual cycle

From the viewpoint of the Earth, it appears that the Sun revolves around the Earth once per year. The Sun follows a nearly circular "orbit" around the Earth (from the perspective of the Earth), which the ancients named the **ecliptic**. The constellations along the ecliptic, called the **Zodiac**, allowed the ancients to predict what part of the sky the Sun inhabited during various portions of the year.

The apparent motion of the Sun, from noon to noon compared to the background stars, is west to east across the sky.

10. a. When viewed from high above the North Pole of the Earth, does the Earth move around the Sun CW or CCW? How does this compare to the direction of the Earth's rotation?

b. This is no mere coincidence. What is the deeper reason why the two motions (**rotation** and **revolution**) are similar? (Hint: consider the current origin theory of the solar system)

11. Given the diagram on the previous page, then, how come news reports always mention that the **autumn equinox** (or for that matter the vernal equinox or either of the **solstices**) occurs at a particular time and day? This year, the autumn equinox was at 8:44 a.m. on Monday. What definition of "equinox" allows this kind of precision?

The figure below shows a top-down view of the heliocentric Earth-Sun system. Arrows indicate the directions of the rotational and orbital motions of Earth. For the observer shown, the Sun is highest in the sky at 12 noon.