

In the celestial sphere model, Earth is stationary and the stars are carried on a sphere that rotates about an axis which points at the North Star. In Figure 1 below, two stars, A and B, are each shown at four different positions (1, 2, 3, and 4) through which each star will pass during the course of one revolution of the celestial sphere. In addition, your location on Earth in the Northern Hemisphere and the portion of the celestial sphere that is above your horizon are shown.

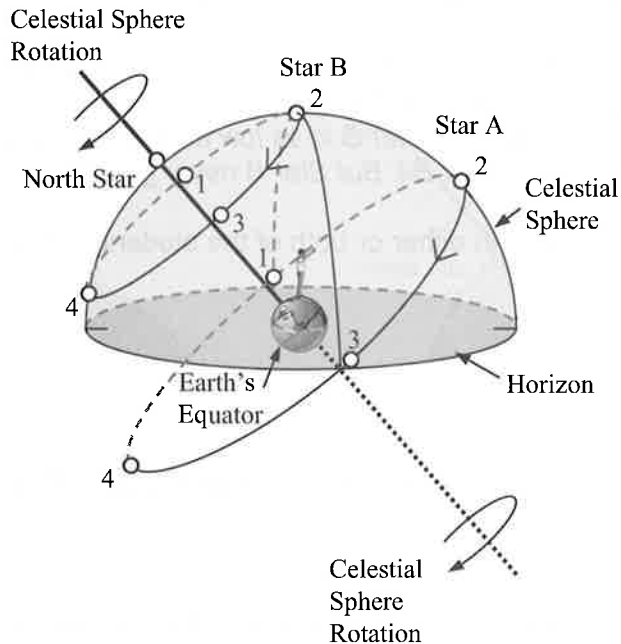


Figure 1

- 1) Is the horizon shown a real physical horizon or an imaginary plane that extends from your observing location and Earth out to the stars?
- 2) Can the observer shown see a star when it is located below the horizon? Why or why not?
- 3) Is either Star A or B ever in an unobservable position? If so, which position(s)?
- 4) When a star travels from a position below the observer's horizon to a position above the horizon, is that star rising or setting?
- 5) When a star travels from a position above the observer's horizon to a position below the horizon, is that star rising or setting?

- 6) Star A is just visible above your eastern horizon at Position 1. At which of the numbered positions is it just visible above your western horizon?
- 7) At which position(s), if any, does Star B rise and set?
- 8) Two students are discussing their answers to Question 7.

Student 1: *Locations B1 and B3 are on my horizon because they are rising and setting just like A1 and A3.*

Student 2: *Figure 1 shows that Star B is as low as it will get when it is just above the northern horizon at B4. But Star B never goes below the horizon.*

Do you agree or disagree with either or both of the students? Explain your reasoning.

- 9) Label the directions north, south, east, and west on Figure 1. Check your answer with another group.
- 10) For each indicated position, describe where in the sky you must look to see the star at that time. Each description requires two pieces of information: the direction you must face (north, northeast, east, etc.) and how far above the horizon you must look (low, high, or directly overhead). If you cannot see the star, state that explicitly. The descriptions for four positions are given as examples.
- a) A1: *east, low*
 - b) A2:
 - c) A3:
 - d) A4:
 - e) North Star: *north, high*
 - f) B1:
 - g) B2: *directly overhead*
 - h) B3: *northwest, high*
 - i) B4:

Check your answers with a nearby group and resolve any inconsistencies.

- 11) Does Star B ever set?

Part I: Looking North

For this activity, imagine you are the observer shown on Earth in the Northern Hemisphere and that the time is 6 P.M. Looking north, the sky will appear as shown in Figure 1. The positions and motions of the star in Figure 1 can be understood by imagining yourself as the observer at the center of the celestial sphere as shown in Figure 2. In the celestial sphere model, Earth is stationary and the stars are carried on a sphere that rotates about an axis which points at the North Star. Note that only the portion of the celestial sphere that is above your horizon is shown.



Figure 1

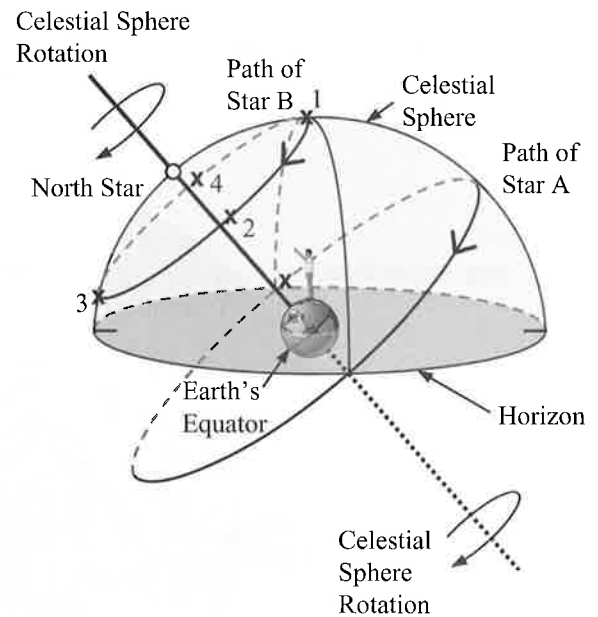


Figure 2

The x's in both figures represent four of the positions through which Star B will pass during the course of one revolution of the celestial sphere. Ignore Star A until Question 6.

- 1) Note in Figure 1 that the position of Star B at 6 P.M. has been identified for you. Circle the numbered position (1, 2, 3, or 4) in Figure 2 that corresponds to the identified location of Star B at 6 P.M. provided in Figure 1.
- 2) The rotation of the celestial sphere carries Star B around so that it returns to the same position at about 6 P.M. the next evening. Label each of the x's in both figures with the approximate time at which Star B will arrive (e.g., the location you circled in Question 1 will be labeled "6 P.M.").
- 3) Using Figure 2, describe the direction you have to look to see Star B at 6 A.M.
- 4) The position directly overhead is called the **zenith**. Label the direction of the zenith on Figure 2. How does the direction of the zenith compare to the direction that you identified in Question 3?

- 5) In Figure 1, the path that Star B follows is shown with a dashed line. Draw a small arrowhead on the path to represent the direction Star B would be moving at the instant it is at each of the four locations marked with an x. Check your answers with a nearby group.
- 6) Using Figure 2, describe in words where you would look to see Star A when it is halfway between rising and setting.

Part II: Looking East

Figure 3 shows an extended view along the eastern horizon showing the positions of Stars A and B at 6 P.M. The arrow shown is provided to indicate the direction that Star B will be moving at 6 P.M.

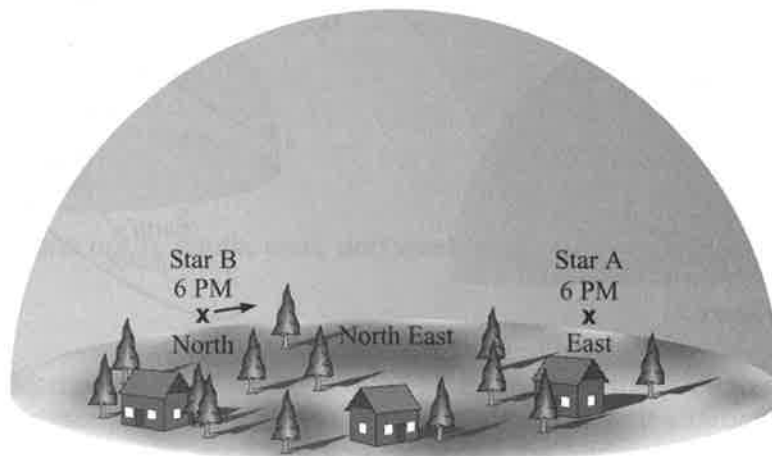


Figure 3

- 7) Recall that in Question 6, you found that Star A ends up high in the southern sky when it is halfway between rising and setting (and therefore never passes through your zenith). Draw a straight arrow at the x in the east in Figure 3 (the position of Star A at 6 P.M.) to indicate the direction Star A moves as it rises. Studying Figure 2 can also help clarify your answer.
- 8) Two students are discussing the direction of motion of a star rising directly in the east.

Student 1: Stars move east to west so any star rising directly in the east must be moving straight up so that it can end up in the west. If the arrow were angled, the star would not set in the west.

Student 2: I disagree. From Figure 2, the path of Star A starts in the east, then it moves high in the southern sky yet still sets in the west. To do this it has to move toward the south as it rises so I drew my arrow angled up and to the right.

Do you agree or disagree with either or both of the students? Explain your reasoning.

- 9) Imagine you could see Star B at noon. Fifteen minutes later, in what direction will Star B have moved? Explain your reasoning.
- 10) Consider the student comment below.

Student: *The amount of time that all stars are above the horizon is 12 hours because it takes 12 hours for a star to rise in the east and then set in the west.*

Do you agree or disagree with the student? Explain your reasoning.

Consider the situation shown below in which the Sun and a group of constellations are shown at sunrise, Figure 4, and then shown again 8 hours later, Figure 5.

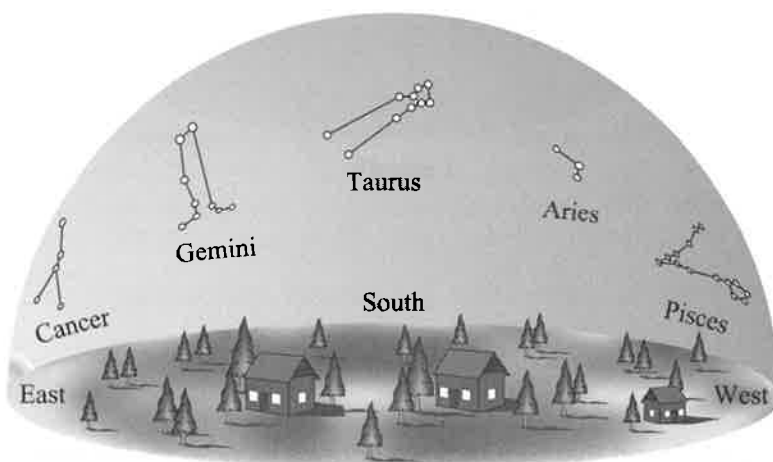


Figure 4

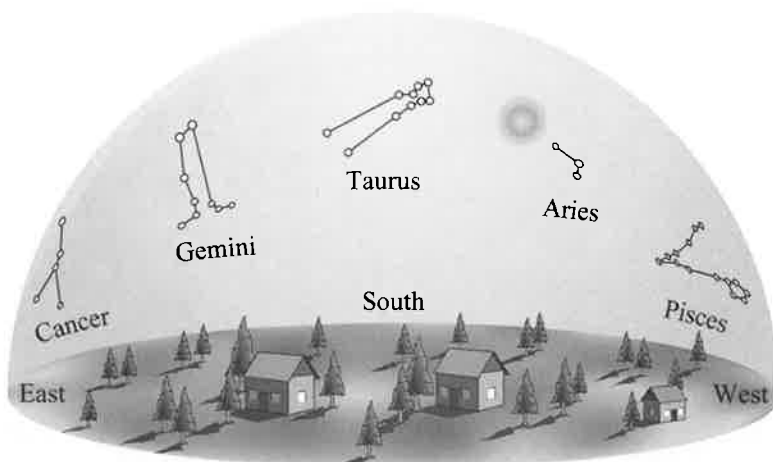


Figure 5

- 11) Consider the following debate between two students regarding the motion of the Sun and constellations shown in Figures 4 and 5.

Student 1: *We know the Sun rises in the east and moves through the southern part of the sky and then sets in the west. Eight hours after sunrise, it makes sense that the Sun will have moved from being on the eastern horizon near the constellation Cancer to being located high in the southwestern sky near the constellation Aries.*

Student 2: *You're forgetting that some stars and constellations also move from the east through the southern sky and to the west just like the Sun. So, the Sun will still be near Cancer eight hours later. So Figure 5 is drawn incorrectly. It should show that the constellations have all moved like the Sun, so Cancer would also be located high in the southwestern sky, with the Sun, eight hours later.*

Do you agree or disagree with either or both of the students? Explain your reasoning. Check your answers with another group.

- 12) In Question 11, we found that Figure 5 was drawn incorrectly. Redraw Figure 5 on the figure below by sketching the approximate location of any constellations from Figure 5 that would still be visible.

