

### 3.1 Path of the Sun tutorial

Courtesy of Adams, Prather, Slater, and CAPER Team

Before doing this assignment, you must carefully read section 3.4 of Astronomy Notes! Figure 1 below shows more than half the sky as seen from the continental United States (U.S.). It shows the longest daily path of the Sun on the summer solstice (June 21st) and the shortest daily path on the winter solstice (December 21st). On the summer solstice the Sun reaches the maximum altitude in the southern sky above the horizon at about noon. Notice that the Sun never reaches the zenith (point directly overhead) for any observer in the continental U.S. Over the six months following the summer solstice, the altitude of the Sun at noontime moves progressively lower and lower until the winter solstice. After the winter solstice the noontime Sun altitude moves progressively higher and higher. **Therefore, the winter and summer solstice paths shown below are the lower and upper bounds of the Sun’s motion.** For all of the other 363 days of the year, the Sun’s daily arc is between the two arc paths shown.

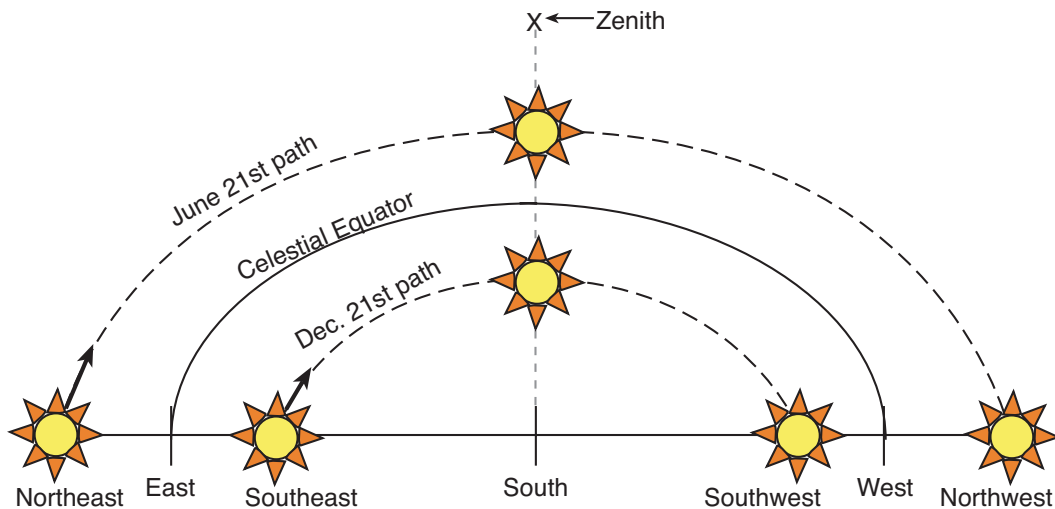


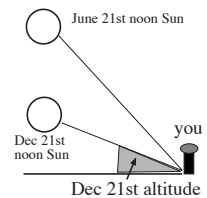
Figure 1

1. According to Figure 1, in which direction would you look to see the Sun when it reaches the highest position in the sky today?

Circle one: East          Southeast          South          Southwest          West

2. If it is wintertime right now (just after the winter solstice), how does the altitude of the Sun at noon change as summer approaches?

Circle one: increases          stays the same          decreases  
 \_\_\_\_\_ (arc gets higher)          \_\_\_\_\_ (arc gets lower)



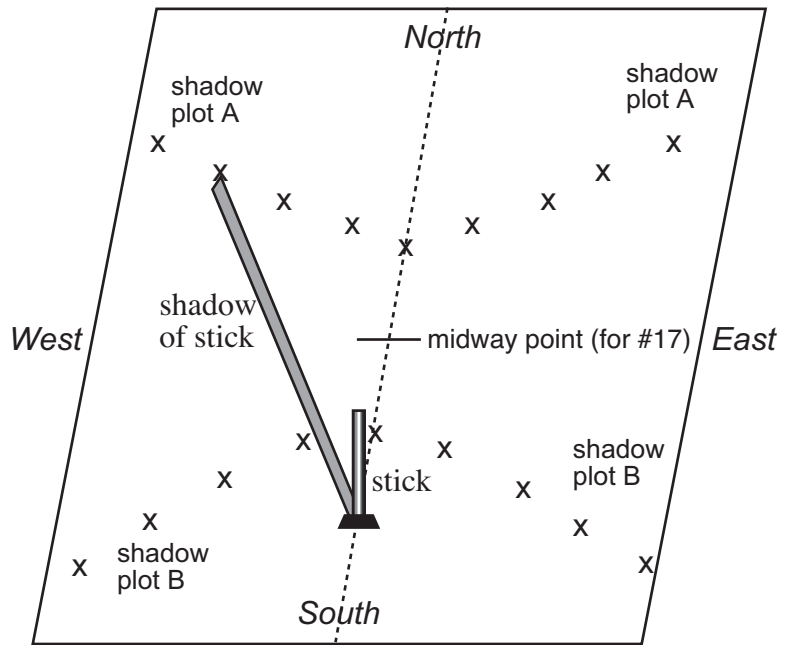
3. If Figure 1 is a reasonable representation for any observer in the continental U.S., is there ever a time of year when the Sun is directly overhead at the zenith (looking straight up) at noontime? If yes, on what date does this occur? (Read that first paragraph again! Do any of the arcs go through the zenith point in the drawing?)

4. During what time(s) of year would the Sun rise:
  - (a) north of east?
  - (b) south of east?
  - (c) directly in the east? (Hint: It is on only which TWO dates of the year?)
  
5. Does the Sun always set in precisely the same location throughout the year? If not, tell where the sun will set throughout the year.
  
6. If the Sun rises south of east on a given day, where will it set on that day?

Shadows are long when the Sun is low in the sky and short when the Sun is high in the sky. All shadows everywhere in the universe always point directly away from the light source.

Figure 2 shows a small, vertical stick which casts a shadow while it rests on a large piece of paper or poster-board.

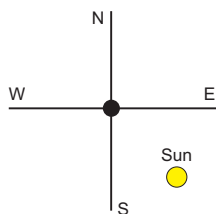
For two different days of the year, the very top of the shadow has been marked with an "x" every hour throughout the day. Although this sketch is somewhat exaggerated, these *shadow plots* indicate how the position of the Sun changes in the sky through the course of these two days. The following questions are designed to show the relationship between Figure 1 above and Figure 2 at right.



**Figure 2**

7. Using Figures 1 and 2, in what direction would the shadow of the stick be cast on the poster-board if the Sun rises in the southeast? Remember that any shadow points directly away (or opposite) the light source, so if the Sun is southeast, the shadow points...

Circle one: West      Northwest      North      Northeast      East      Southeast



8. Clearly circle *and label* the  $\times$  for the shadow that corresponds to the time of noon for plot A and for plot B.
  - b Are shadows long when the Sun is high in the sky or when the Sun is low in the sky nearer the horizon?
  - c As the Sun gets higher in the sky, the shadow lengths \_\_\_\_\_. (Hint: recall the length of your own body's shadow near sunrise or sunset vs. near noon.)  
*Circle one:* get shorter      stay the same      get longer
9. Compare the position of the  $\times$  that corresponds to noon for shadow plots A and B. Which shadow plot (A or B) goes with a *noon* Sun at its highest position? Explain your reasoning.
10. What do the  $\times$ 's in the shadow plots mean? Are they the position of the Sun or the top of the shadow? (Circle which one—look at the figure caption again before answering this.)
11. Which shadow plot has the longer shadows around noon time? Which shadow plot has the shorter shadows around noon time?
12. Which shadow plot (A or B) is most closely *associated with* the Sun's path through the sky during the summer and which is *associated with* the winter? Explain your reasoning. (Does winter have long shadows or short shadows? Does the Sun get high in the sky during the summer or does it stay low?) Make sure your reasoning is logically consistent with #8bc, #9, & #11.
13. On Figure 2, sketch the Sun's position at sunrise in the summer AND label the  $\times$  that the stick's shadow would make at this time.
14. Based on the shadow plots in Figure 2, during which time of the year (summer or winter) does the Sun rise south of east? Explain your reasoning *using shadow lengths and **directions***. Make sure your reasoning is logically consistent with #7 & #12.
15. If shadow plot A corresponds to the stick's shadow on the day of the winter solstice (double-check answer to #12, #14!), is it possible that there would ever be a time when the stick would cast a shadow longer than the one shown along the north-to-south line that indicates the Sun's position **at noon**? So compare the winter solstice noon shadow with noon shadows at other times of the year. Explain your reasoning. (Hint: Read the bold-face sentence at the top of the first page.)

16. If shadow plot B corresponds to the stick's shadow on the day of the summer solstice (double-check answer to #12, #14!), is it possible that there would ever be a time when the stick would cast a shadow shorter than the one shown along the north-to-south line that indicates the Sun's position **at noon**? So compare the summer solstice noon shadow with noon shadows at other times of the year. Explain your reasoning. (Hint: Read the bold-face sentence at the top of the first page.)
17. Mark the top of the stick's shadow with an  $\times$  where it should be placed along the north-to-south line to indicate the Sun's position at noon *today*. Clearly explain why you placed the  $\times$  where you did. (Hint: The equinox noon is exactly midway between plot A's noon and plot B's noon. So is today between the equinox and summer solstice date or is it between the equinox and winter solstice date? THEN answer: is today closer to the equinox or to the solstice date?)
18. Will the stick ever cast a shadow along the north-to-south line that extends to the south of the stick in the continental U.S.? Explain your reasoning. (Hint: Read the bold-face sentence at the top of the first page—is the *noon* Sun ever in the north direction in the continental U.S.?)
19. Is there ever a clear (no clouds and no total solar eclipse) day of the year in the continental U.S. when the stick casts no shadow? If so, when does this occur and where exactly in the sky does the Sun have to be? (Double-check your answer to #3!)

Every 2 / = 0.25; every 1 O = 0.25;

1 O (18 C)  $\Rightarrow$  4.75, 17 C  $\Rightarrow$  4.5, 16 C  $\Rightarrow$  4.25, 15 C  $\Rightarrow$  4, 14 C  $\Rightarrow$  3.75, 13 C  $\Rightarrow$  3.5, 12 C  $\Rightarrow$  3.25, 11 C  $\Rightarrow$  3, 10 C  $\Rightarrow$  2.75, 9 C  $\Rightarrow$  2.5, etc.