LAB #4 - Solar Motion and Seasons

This lab is to be completed in pairs and you should both participate equally. You should answer all of the questions on a separate sheet of paper and hand in just one copy per pair with both your names on it. However, it is to your advantage if you both keep a record of your answers so you will have something to study from.

Purpose: Understand and explore the cause of the Earth's Seasons.

We experience seasons on Earth as a variation of the average daily temperature over the course of the year. We know that the Sun is the Earth's main source of energy and heat, so the cause of the seasons must somehow be related to the motion of the sun through the sky. Most people (even some Harvard professors) believe that seasonal variation is caused by variations in the Earth-Sun distance, because it seems obvious that the closer we are to the sun, the hotter it will be. But we found in class that variations in the Earth-Sun distance could not be the cause of the seasons. What else affects the amount of sunlight each location receives?

(A) Solar Motions - Length of the Day

Go to: http://astro.unl.edu/naap/motion3/animations/sunmotions.html

1. Familiarize yourself with the "Time and Location Controls" and with the "General Settings". What does the yellow line represent? Manipulate the simulator to verify your conclusion.

   The white line represents the location of the ecliptic. We won't need that for this lab, so turn it off in the controls.

2. Use the simulator to determine how long the day will be today, by:
   a. Setting the observer's latitude to Tucson's = 32.2˚N.
   b. Setting the date to today.
   c. Changing your view of the observer and his horizon by dragging it so that you're looking at him from the side (you can see the whole stick figure standing upright), looking East. Tilt this view just slightly so that you can see the N/S/E/W directions on his horizon.
   d. Pressing Animate and watching as the sun moves across the sky over the course of the day
   e. Record the time of sunrise and sunset and use this to determine the length of the day.

3. Repeat this for March 21, June 21, September 21 and December 21 and record your answers in a table, along with your answer from 2e for today's date. Leave room for six more columns in your table, which you will fill in later. The table should have a total of 6 rows (a row for column labels, then the five dates) and 8 columns.

4. According to what you've found and recorded in your table, is the length of a day in Tucson the same throughout the year? If not, describe how it varies. Be specific in your answer! How much does it change in minutes? As a percentage?

5. How do you think the length of the day will vary in the Southern hemisphere? In the first blank column of your table, and **without looking at the simulator**, record a **prediction** for the length of the day at the same latitude in the Southern hemisphere (32.2˚S) for each of

the five days (today, March 21, June 21, September 21 and December 21). Write a sentence describing why you've made these predictions.

6. Now use the simulator to test your predictions. Set the latitude in the simulator to 32.2˚S and record the actual day length for each of the five dates in the second blank column of the table. Describe whether your prediction matched reality. Why or why not?

7. What about for an observer on the Equator (0 degrees)? How would the length of their day vary throughout the year? Record your **predictions** (do NOT look at the simulator until after you've made them) for day length at the equator in the third blank column for each of the five dates and write a sentence describing why you've made these predictions.

8. Now use the simulator to test your predictions. Set the latitude in the simulator to 0˚ and record the actual day length for each of the five dates in the fourth blank column of the table. Describe whether your prediction matched reality. Why or why not?

9. What about for an observer at the North Pole (90 degrees)? How would the length of their day vary throughout the year? Record your **predictions** (do NOT look at the simulator until after you've made them) for day length at the polein the fifth blank column for each of the five dates and write a sentence describing why you've made these predictions.

10. Now use the simulator to test your predictions. Set the latitude in the simulator to 90˚ and record the actual day length for each of the five dates in the sixth blank column of the table. Describe whether your prediction matched reality. Why or why not?

11. Based on your findings, and using specifics from your table, do you think the varying length of the day could be the main reason for the seasons? Why or why not?

12. Under "Animation Controls" choose "step by day" instead of "continuous". What is the maximum altitude (given in the "information" box) that the sun reaches in the sky for an observer at the North Pole? Is this number familiar? What does it correspond to? What date does this occur?

13. Describe in 1-2 sentences how the maximum daily altitude of the sun varies with time of year at the North Pole.

14. Sunrise and sunset occur when the sun is at 0˚ altitude (on the horizon). At Tucson's latitude, sunrise and sunset occur every day. At the North Pole, how often does the sun rise and set? Check with your simulator by changing the animation back to continuous and looking for moments when the sun hits 0˚ altitude. Write down the exact date and time for sunrise(s) and sunset(s). Given this information, how long is a "day" on the north pole?

15. Examine the following chart, which shows mean monthly temperatures at the North Pole. What is the maximum mean monthly temperature at the North Pole, and in which month does it occur?

16. In July, the mean temperature in Quito (Lat=0˚) is 66˚ F. If the number of daylight hours were the main factor influencing the seasons, would you expect the North Pole to be colder than Quito in July? Why/why not?

17. If you've decided number of daylight hours are not the main factor, can you think of another explanation? Hint: Simulate the path of the sun on June 21 on the North Pole and again on the Equator - what else do you notice about the path of the sun that may influence temperature?

(B) Illumination Angle

Once you've completed part A), check in with your instructor for an important demo.

Flashlight Demo:
Using a pen, circle the beam of light made by the flashlight when it's held vertical (position A) and then again at an angle (position B) (your instructor will demonstrate).

1. Which of the two lighted areas appears brighter?

2. Which of the two lighted areas is smaller?

3. If you placed a thermometer in each of the lighted areas, which would be hotter?

Now go to: http://astro.unl.edu/naap/motion1/animations/seasons_ecliptic.html and answer the following questions:

4. Place the observer on the North Pole (by clicking and dragging the stick figure). Then run the simulator and observe how the angle of sunlight changes throughout the year.

5. Note that the angle and altitude depicted are for the sun at noon (when its highest in the sky) on any given day. Is the sun ever overhead at the North Pole? Record the maximum altitude the sun reaches and the date. Does this match your answer from question 12 in Part A? Why or why not?

6. Now place an observer on the Equator and do the same. Is the sun ever directly overhead at noon? If so, on what date? Is this the only date this happens?

7. Record the **minimum** altitude the sun reaches at noon on the equator and the date. Is this the only date this happens?

8. You can also click on "sunbeam spread" which will show you how a beam of sunlight would spread out on the surface of the earth for each latitude (in a similar way to the flashlight demo). Do this for Jun 21. How does the area of the sunbeam on the North Pole compare to the area of the sunbeam on the equator?

9. From Tucson, when is the sun directly overhead at Noon? Try to answer before running the simulator, and then confirm your reasoning. Are you surprised by what you've discovered?

10. Summarize what you learned in this lab in 1-2 paragraphs. Was anything surprising? Has it generated any questions or doubts? Having done this lab, what do you think is the main cause of the Seasons on Earth, and how did you arrive at that conclusion?