NAME ____________________

CLASS ____________ DATE ____________

CHAPTER 25

LAB INVESTIGATION

Time and the Sun

The altitude of any object in the sky is its vertical angle above the horizon. The altitude of Polaris, the North Star, can be used to determine the latitude of an observer on Earth. In Part A, you will find your latitude by measuring the altitude of Polaris in the night sky.

The altitude of the sun varies with the time of day, reaching its highest altitude at solar noon. However, the sun is seldom at its highest altitude at exactly noon on the clock. The altitude of the sun shows apparent solar time, while clock time is set to show average solar time. Solar time is either ahead of or behind clock time, depending on the season of the year. When the sun reaches its highest altitude before noon on the clock, apparent solar time is ahead of clock time. When the sun reaches its highest altitude after noon on the clock, apparent solar time is behind clock time.

The **analemma** is a graph that shows both the altitude of the sun and the difference between solar time and clock time for any day of the year. The table in Figure 25.4 shows the latitude at which the sun is directly overhead at solar noon on each of the dates given. These latitudes vary between 23.5° N and 23.5° S of the equator. The clock time at which the sun is directly overhead is also listed. In Part B, you will use these data and your own latitude to determine the noon altitudes of the sun at your location throughout the year. You will then use the altitudes of the sun and the time of solar noon to graph an analemma for your latitude.

Lab Skills and Objectives

- To **measure** latitude by measuring the altitude of Polaris
- To **graph** an analemma
- To **compare** the altitude of the sun on different dates using the analemma
- To **identify** the seasons during which solar time is ahead of and behind clock time

Materials

- protractor
- thread—about 15 cm
- paper clip
- Seasonal Star Maps, Appendix B, pages 660–661 of your text
- graph paper

Procedure

Part A

1. First you will make a device to measure the altitude of Polaris. Tie the paper clip to one end of the piece of thread. Tie the other end of the thread through the small hole in the protractor. (If there is no small hole in the protractor, tie the string around the center mark on the straight side.)

2. On a clear night with visible stars, locate Polaris in the sky. Refer to Seasonal Star Maps as needed.

3. Hold the protractor with the straight side pointing up (Figure 25.1). Sight along the straight edge of the protractor at Polaris. Read the angle on the protractor at the point where the string crosses. Record this value in Figure 25.2.

4. The angle you measured in procedure step 3 is the altitude of Polaris plus 90°. Subtract 90° to determine the altitude of Polaris. Record this value in Figure 25.2. The altitude of Polaris is equal to the latitude of your location. Record your latitude in Figure 25.2.

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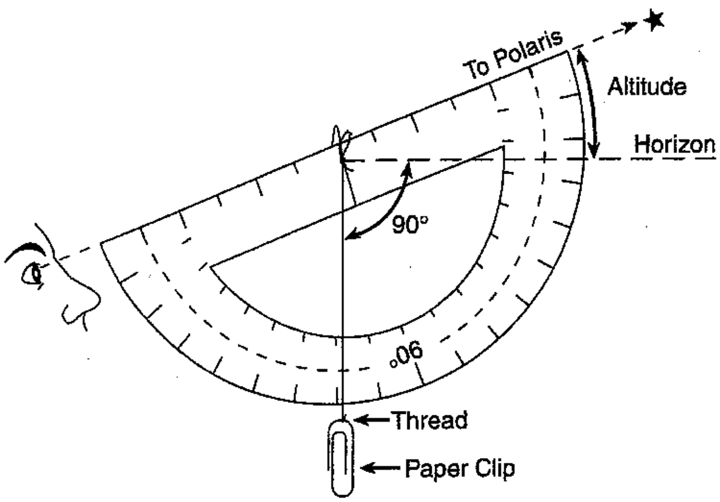

Figure 25.1
Using a protractor to find the altitude of Polaris

Finding Latitude Using Polaris	
Angle on Protractor	
Altitude of Polaris: 90°–angle on protractor	
Your Latitude	

Figure 25.2

Part B

5. Your latitude, which you measured in Part A, will be used to complete the table in Figure 25.4. The second column of Figure 25.4 shows the latitude on Earth where the sun is directly overhead (altitude 90°) at solar noon on each date. To complete the third column of the table, you need to determine how far away you are, in degrees of latitude, from each location. For locations south of the equator, this means adding that latitude to your latitude. For locations north of the equator, this means subtracting that latitude from your latitude. (Figure 25.3 illustrates why.) Look at January 10 as an example. If you are at 40° N latitude, you are 40° + 22.1°, or 62.1°, from the location where the sun is overhead. Using your latitude, complete the third column in Figure 25.4.

6. Now you will use your distance from the latitude where the sun is overhead at solar noon to find your local sun altitude at solar noon. Your distance from the latitude where the sun is overhead is the same as the local distance of the sun from an altitude of 90°. The altitude of the sun on each date at your latitude is 90° minus your distance from the latitude where the sun is overhead. Using January 10 again, if you are at 40° N and are thus 62.1° from that latitude, the altitude of the sun is 90°–62.1° or 27.9°. Using your latitude, complete the fourth column of Figure 25.4.

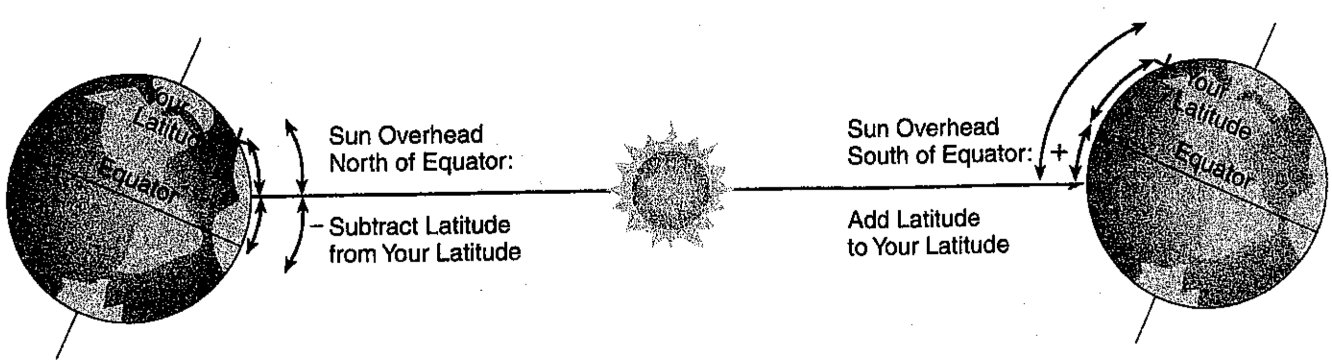

Figure 25.3
Finding your distance from the latitude where the sun is overhead at solar noon

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Date	Latitude where Sun Is Overhead at Solar Noon	Your Distance from Latitude in Column 2	Altitude of Sun at Solar Noon at Your Latitude	Clock Time at Solar Noon (h)
Jan 10	22.1°S			12:07
Jan 20	20.3°S			12:11
Jan 30	17.9°S			12:13
Feb 10	14.6°S			12:14
Feb 20	11.2°S			12:14
Mar 5	6.4°S			12:12
Mar 10	4.4°S			12:11
Mar 20	0.5°S			12:08
Mar 30	3.4°N			12:05
Apr 10	7.6°N			12:02
Apr 20	11.2°N			11:59
Apr 30	14.5°N			11:57
May 10	17.4°N			11:56
May 20	19.8°N			11:56
May 30	21.6°N			11:57
Jun 10	22.9°N			11:59
Jun 20	23.4°N			12:01
Jun 30	23.2°N			12:04
Jul 10	22.3°N			12:05
Jul 20	20.8°N			12:06
Jul 30	18.7°N			12:06
Aug 10	15.8°N			12:05
Aug 20	12.7°N			12:04
Aug 30	9.3°N			12:01
Sep 10	5.3°N			11:57
Sep 20	1.4°N			11:54
Sep 30	2.5°S			11:50
Oct 10	6.3°S			11:47
Oct 20	10.0°S			11:45
Oct 30	13.5°S			11:44
Nov 10	16.9°S			11:44
Nov 20	19.5°S			11:46
Nov 30	21.5°S			11:49
Dec 10	22.8°S			11:53
Dec 20	23.4°S			11:57
Dec 30	23.2°S			12:02

Figure 25.4

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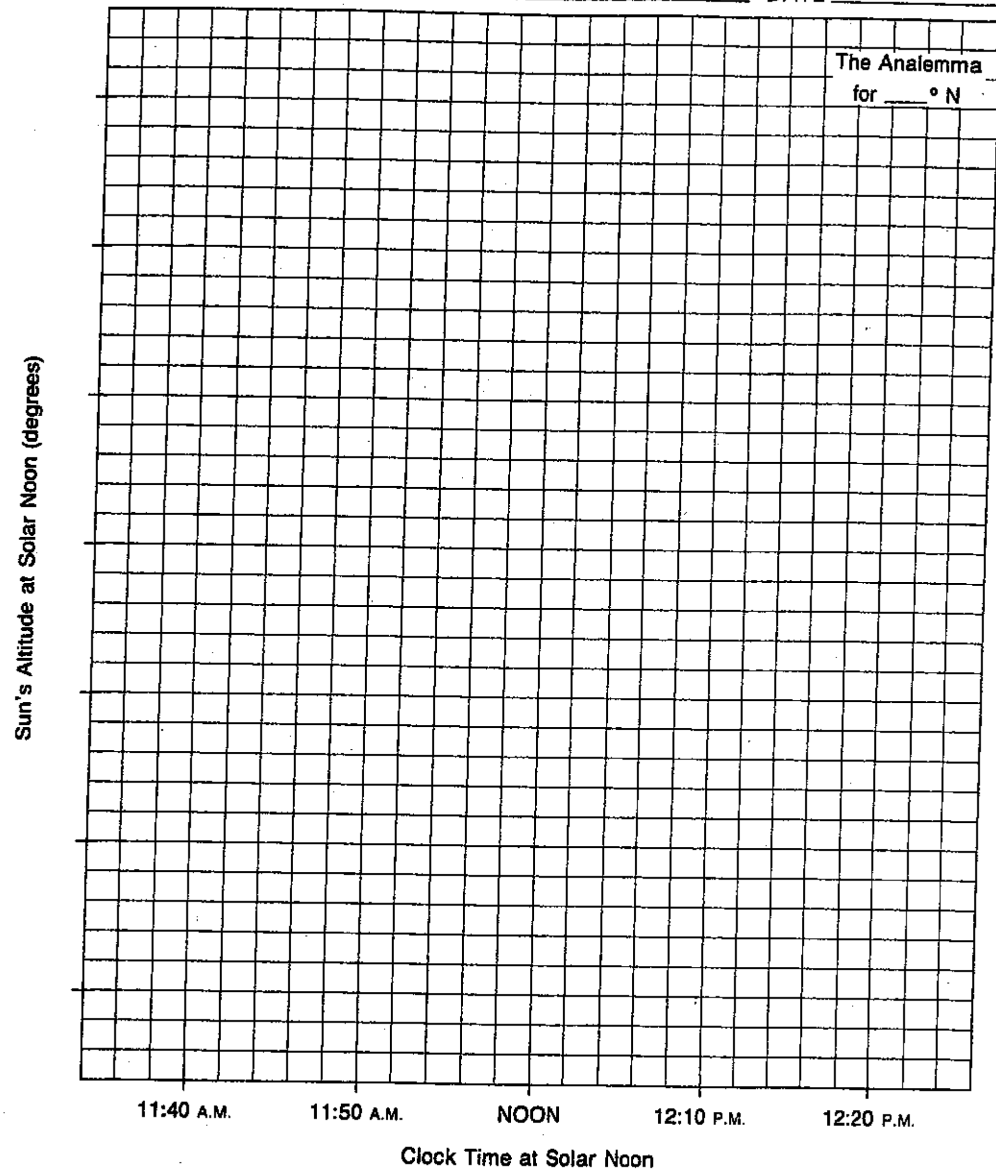

Figure 25.5

7. You now have complete data to graph an analemma for your latitude. Set up the horizontal and vertical axes of your graph as shown in Figure 25.5. Notice that the vertical axis does not have any values written along it. The values you use depend on your data. To figure out the values you should use, find the highest and lowest values for the sun's altitude in your table (Figure 25.4). Make the lowest value on your graph the closest even multiple of 10 that is below your lowest altitude value. Make the highest value the closest even multiple of 10 that is above your highest altitude value. Label every tenth value in between. Your finished vertical axis will read 10, 20, 30, and so on, or 20, 30, 40, and so on, or 30, 40, 50, and so on, depending on your latitude.

8. For each date, graph the clock time of solar noon (fifth column) against the altitude of the sun at solar noon (fourth column). On the points that represent the 20th of each month, write the date. When you are finished, connect the points in the order of the months of the year.

9. Answer Analysis and Conclusions questions 1–12.

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Analysis and Conclusions

1. On your graph, what is the maximum altitude of the sun? On what date does this maximum altitude occur?

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____

2. On the date you gave in question 1, at what latitude was the sun directly overhead at solar noon?

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3. What is the name of the imaginary circle around Earth very near the latitude you gave in your answer to question 2? (Refer to Chapter 25 if needed.)

____

4. What season begins in the Northern Hemisphere on the approximate date in your answer for question 1?

____

5. On your graph, what is the minimum altitude of the sun? On what date does the minimum altitude occur?

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6. On the date you gave for question 6, at what latitude was the sun directly overhead at solar noon?

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7. What is the name of the imaginary circle around Earth close to the latitude you gave in your answer to question 6?

____

8. What season begins in the Northern Hemisphere on the approximate date of your answer for question 5?

____

9. Using the table in Figure 25.4, find the two dates when the sun is overhead closest to the equator at solar noon. Name the seasons that begin close to each of these dates.

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10. On your graph, find the dates you listed in your answer to question 9. Where are these dates on the graph?

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11. During which two seasons is apparent solar time ahead of clock time? (Review the introduction to this investigation for help.)

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12. During which two seasons is apparent solar time behind clock time?

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