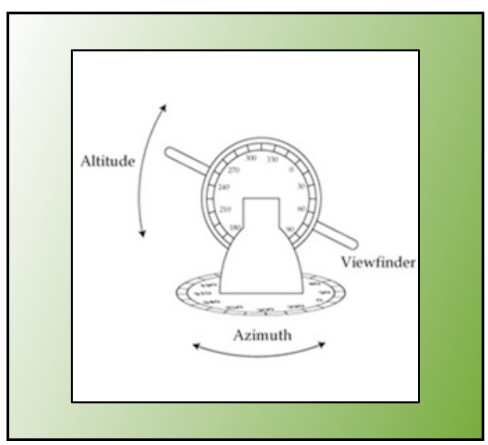
Name		
Partner(s)		
Date		
Grade		
Category	**Max Points**	**Points Received**
On Time	5	
Printed Copy	5	
Lab Work	55	
Solar Position	35	
Total	100	

Measuring the Sky

1. Introduction

The point of this lab is to get you outside, looking at and thinking about the sky. You will also become acquainted with angular measure and the **HORIZON SYSTEM** for specifying the coordinates of an astronomical object.

This Week's Lab will have Three Parts



1. We will go on the roof of Van Allen Hall and become acquainted with the Horizon System for describing the positions of astronomical objects, and use instruments called **THEODOLITES**. We will measure the **AZIMUTH** and **ALTITUDE** angles of landmarks around Iowa City. We will also measure the altitude and azimuth angles of the Sun, and see how they change during the lab period.

2. We will make a simple scientific device with which you can measure the angular distance between two astronomical objects, such as a bright star and the Moon or a planet.
3. In coming weeks you will use these Theodolites to determine distances via **PARALLAX** measurement, observe the changing position of sunset, and make other basic astronomical measurement

2. Measurements with the Theodolites

The Theodolites are mounted on the south railing of the roof of Van Allen Hall. A schematic illustration of one is shown in Figure 1.
To use the Theodolite, sight through the tube at the object you are measuring. The viewfinder tube will move in both azimuth angle (horizontal scale) and altitude angle (vertical scale). Start out by familiarizing yourself with the instrument. When pointing the tube at the horizon, due south, you should measure an azimuth angle of 180 degrees, and an altitude angle of 0 degrees. Move the sighting tube to the east. You should see the azimuth angle change to an angle less than 180 degrees. Point the sighting tube higher up in the sky. You should measure an altitude angle greater than 0 degrees. ***Note that the scale is graded to ½ degree. Try and estimate your angles to half this amount, realizing that this is also the uncertainty in your measurement.***

Measuring the Landscape

The teaching assistant will point out to you two objects on the distant horizon (City High School and a tree beyond the airport) and one closer object (the northwest corner of the Jefferson Building). ***Measure the azimuth and altitude angle of all three objects, and record them here.***

Object	Azimuth	Altitude
City High School		
"The Tree"		
Jefferson Building		

Now use the Theodolites to measure the azimuth and altitude of the Sun. **DO NOT, UNDER ANY CIRCUMSTANCES, LOOK DIRECTLY THROUGH THE TUBE AT THE SUN. INSTEAD, FOLLOW THE DIRECTIONS GIVEN HERE.** Point the sighting tube in the general direction of the Sun, and observe its shadow projected on your notebook, or any other flat, white surface. When you are pointing directly at the Sun, the shadow of the sighting tube will be perfectly round and have the smallest possible area.

If you have pointed particularly accurately, you will see a small bright spot (the image of the Sun) in the middle of the shadow. You will need to try this a few time before you get an accurate pointing. When you have the tube pointed accurately at the Sun, read the azimuth and altitude scales, and note your data in the table below. Make one measurement now, and then return to the lab room for part 2. After you have made your string, come back to the roof and make another measurement of the azimuth and altitude of the Sun.

Time (CDT)	Azimuth	Altitude

String for Angular Distance Measurements

Ask your instructor for a length of string. While in the lab room, there is a mark on the outer wall which indicates 8 degrees. If you stand on the far side of the room (inner wall), this mark subtends 8 degrees. Hold your string at arm's length and hold your fingers at the points corresponding to the tips of the mark. Either make knots here or use a pen to mark the string at these two points. Put another knot or mark halfway between. You now have knots or pen marks at intervals of 4 degrees. Divide these to provide 2 degree intervals. Finally, copy this whole sequence over, so you have a string capable of measuring a total angle of 24 - 30 degrees. ***Note the resolution and total angular span below***.

Resolution	
Angular Span	

You can now test this string out on the sky, and make sure it is giving you the right answer. Use it to measure the angular distance between "The Tree" and the Jefferson Building, and compare your result with that from the measurements with the Theodolites above. For the case of the Theodolites, the ANGULAR DISTANCE (θ) is given by

$$\theta = \sqrt{\Delta AZ^2 + \Delta AL^2}$$

Where Δ**AZ** is the difference between the azimuth angles of the tree and the Jefferson building, and Δ**AL** is the difference in the altitude angles. Do your calculation in the space provided and record your results in Table 4 located below.

One of the most problematic complications is that different calculators, computers, books have different ways of displaying scientific notation. Your calculator may use a button labeled “EE” or “EXP”. Try entering a number such as 3.2 x 10^5; may have to type 3.2 <EE> 5 or 3.2 <EXP> 5. Be sure and show your work in the ***Calculation Space*** provided.

TABLE 4 - ANGULAR DISTANCE CALCULATION

Jefferson Building	AZ		AL	
“The Tree”	AZ		AL	
Calculation Space				
θ **Theodolite**				
θ **String**				

Later in the semester, we will use the string to measure angular distances between stars, and between stars and planets, so make sure you keep your string. ***Also, if you haven’t already, make your second measurement of the sun’s location and record you result in Table 2.***

3. Calculation and Concept Quaestions

Estimating the Length of Today's Day

With the data from Part 1.2, you can make a rough estimate of the length of today's day. First, use the measurements in Table 2 to calculate the angular distance θ the sun traveled between the two observations you made during lab. Next, divide this distance by the change in time between the measurements (in hours) to obtain the solar rate in deg/hour. Now consult Table 5 to estimate the total angular distance the sun will travel for today's date. Use the solar path length from the table and the solar rate you calculated to estimate the length of today's day. Do your calculations in the space provided below in Table 6.

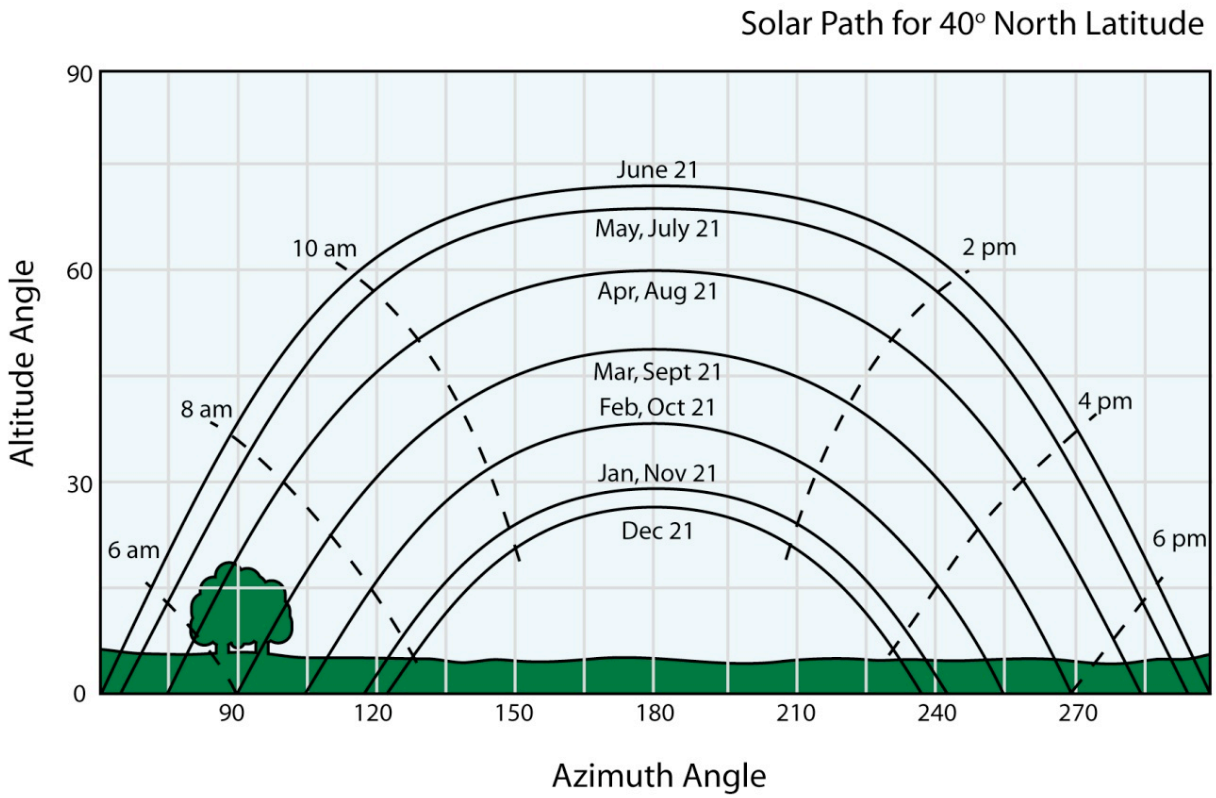


FIGURE 2 - SOLAR PATH FOR 40 DEGREES NORTH LATITUDE

TABLE 5 - SOLAR PATH LENTH IN DEGREES (40 DEGREES NORTH LATITUDE)

Jan 21	145.5	**Apr 21**	247.5	**July 21**	276.0	**Oct 21**	175.5
Feb 21	175.5	**May 21**	276.0	**Aug 21**	247.5	**Nov 21**	145.5
Mar 21	216.0	**June 21**	291.0	**Sept 21**	216.0	**Dec 21**	132.0

TABLE 6 – SUNRISE/SUNSET ESTIMATE

Calculation Space	
Solar Rate (deg/hr)	
Solar Path Length	
Est. Length of Day	

Now check the correct length today's day. There are many places where this information is available, one of which is the *Weather Channel* website at http://www.weather.com. Pick Iowa City as your location. Write down the true time of sunrise or sunset, and compare your day length estimate to the actual value.

TABLE 7 – SUNRISE/SUNSET TIMES

Source		
Sunrise	**Sunset**	**Length of Day**

4. Measuring the Position of the Sun Through the Semester

This part of the lab project is to be done during the next 2-3 months of the semester. During your lab section, you should go to the roof of Van Allen Hall on clear days and measure the altitude and azimuth of the sun. Try and do this 4 days throughout the semester to observe how the position of the sun changes from month to month when observed at similar times. Use the table below to record your results and turn it in after the final session.

TABLE 8 - OBSERVATION DATES

	Time	Date	Azimuth	Altitude
Session 1				
Session 2				
Session 3				
Session 4				