Celestial Coordinate Systems

Introduction

How does one go about describing the position of an object in the sky? Astronomers cannot rely on the imprecise method of merely pointing at an object. There must be some system of coordinates to express that position. Actually there are more than a few astronomical coordinate systems in general use today. In this lab exercise, we will work only with the Horizon system of coordinates. In any coordinate system used on a two dimensional surface, two different coordinates, or numbers, are needed to describe the position of any object on that surface. For example, we plot points on a piece of graph paper using an X and Y coordinate. Also, we can locate a position on the surface of Earth using longitude and latitude.

There is always a point on any coordinate system where both coordinates are equal to zero. In any coordinate system, this zero point is called the origin. Remember, there must always be exactly two coordinates in any system describing a two dimensional surface. The surface of a perfectly smooth sphere is an example of a two dimensional surface.

Ancient observers conceived of the idea of the celestial sphere. The stars, in their minds, were firmly attached to this sphere. For them, the planets, including the Sun and the Moon, wandered about on that sphere. Today, it is still convenient for us to think in terms of the Earth being in the exact center of the celestial sphere which carries the stars around once each sidereal day.

The two coordinates in the horizon system are **ALTITUDE** and **AZIMUTH**. Altitude is a measure of an object's angular distance above the celestial horizon. Now, imagine a line drawn through the object and perpendicular to the horizon. This line is part of a vertical circle. The point where the vertical circle intersects the horizon is called the foot of the circle. We measure the azimuth of an object as the angular distance around the horizon starting at the north point and ending at the foot of the vertical circle drawn through the object.

Figure 1

The Denoyer-Geppert celestial globe which you will use in this exercise is a model of the sky we see around us. For the purposes of this lab exercise, imagine the Earth to be in the center of this globe. The important thing to remember is that, as Earthly observers, we are at the very center of this model. On these globes, the horizontal wooden ring represents the **horizon** of an observer on Earth. This is where we see the ground meet the sky. Most of the time we do not see the real horizon very well since there are a lot of trees and buildings in the way. The vertical, metal ring represents the **meridian** for our observer.

Measuring the Stars of Autumn

Look at Figure 2 to see the various symbols used on these globes. The brightest stars such as Sirius are shown as red, five pointed stars. The next brightest group of stars as shown as black star symbols. Constellation names such as Canis Major are given in all capital letters surrounded by a box and constellation boundaries are shown by dotted lines. Individual star names such as Sirius are given in all capital letters.

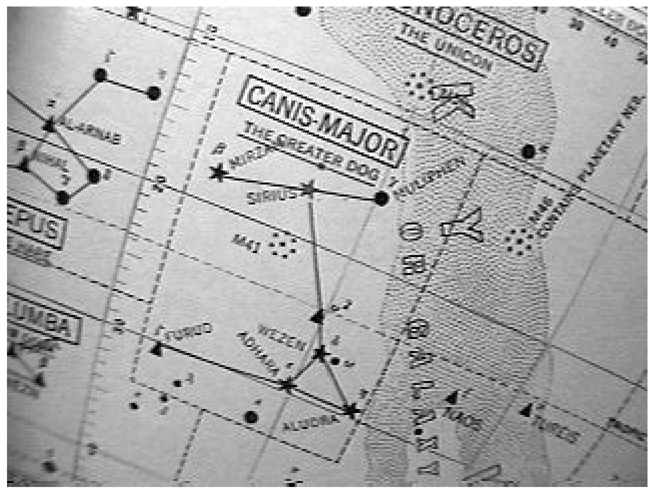

Figure 2

You are first asked to position the globe so that it is correctly oriented to the actual sky above Cranbrook Kingswood.. Do this by first aligning the north point on the globe's horizon with the actual direction north in the science lab. Now rotate the vertical metal ring so that the altitude of the north celestial pole is the same value as the latitude of this school on Earth. Our latitude here is equal to 42 degrees. So make the index mark at the bottom of the globe read 42. Refer to figure 3 to set the latitude. Make sure you are using the scale marked latitude and not the one marked co-latitude. Your globe should now appear as figure 1. Make certain that the north celestial pole, which has Polaris near it, is above the point labeled NORTH on your globe.

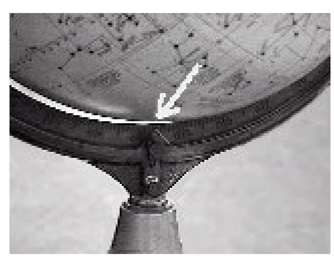

Figure 3

On the globe, you will find a dashed red line with numbers in circles along this line. The numbers go from zero to three hundred fifty. Refer to figure 4. Notice how this line is tilted by about 23 degrees from the celestial equator. This line is the **ecliptic**. The Sun is found somewhere along the ecliptic throughout the year. The numbers correspond with the ecliptic longitude of the Sun. You would have to know today's ecliptic longitude of the Sun in order to locate the Sun on this globe for today's date. I will give you the Sun's ecliptic longitude for today. With that number, mark the position of the Sun on the globe using *chalk* only!

Figure 4

Now spin the globe until you get to that point which represents the time of sunset today. Fill in the first of the four tables at the end of this lab with the altitudes and azimuths of the five stars in the list below.

Stars of Autumn

Altair
Deneb
Arcturus
Antares
Vega

Much of your time will be spent trying to find these stars. Once you have found a star, you may mark its position on the globe with chalk as shown in figure 5.

Figure 5

If you set the globe properly for sunset in mid September, all of these stars should be above the horizon. Azimuth is read on the inner scale of the horizontal ring. See figure 6. Altitude of any star may be measured using the paper scales provided. It is important that you place as strip as seen in figure 7 so that it is perpendicular to the horizon.

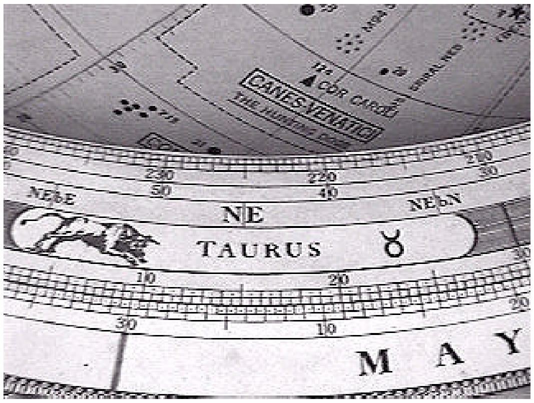

Figure 6

Figure 7

After completing the table for sunset today in Michigan, spin the globe ahead in time to represent local midnight when the Sun is crossing our lower meridian. Complete the second table with the same five stars. Not all of the stars will still be above the horizon. You will not be able to measure those stars which are not.

Now we will reset the latitude on the globe for different locations on the surface of Earth. Position the globe so that it shows what the sky will look like for an observer on the equator of Earth at sunset. remember, you will have to reset the latitude adjustment in order to do this. Complete the third table for sunset stars at the equator.

Finally, set the globe for an observer at the North Pole of Earth tonight . Notice that the term sunset does not have a clear meaning at the North Pole, today or on any other date. Look at what happens to the altitudes of celestial objects for an observer at the North Pole. Fill out the last of four data tables for this location as best you can.

Name ___________________________________

What is the range of possible values for the altitude of a given object? What is the range for the value of the azimuths? By range of values, we mean the minimum and maximum values.

Altitudes range from _______° to _______°
Azimuths range from _______° to _______°

When you moved the globe from sunset to midnight at Cranbrook, what happened to the altitudes and azimuths of the stars?

How are the altitudes and azimuths of the stars at the equator position different from the ones measured at our Cranbrook location at sunset?

How is "sunset" different at the North Pole of Earth? What happens to the altitudes and azimuths of stars at the North Pole as time goes by?

Sunset at Cranbrook

Star Name	Azimuth	Altitude

Midnight at Cranbrook

Star Name	Azimuth	Altitude

Sunset at Earth's Equator

Star Name	Azimuth	Altitude

"Sunset" at the North Pole

Star Name	Azimuth	Altitude