Phys 10293 Lab #1:
The Sun and the Constellations

Introduction

Astronomers use a coordinate system that is fixed to Earth's latitude and longitude. This way, the coordinates of a star or planet are the same everywhere on Earth. This coordinate system is called the "Celestial Sphere".

The celestial sphere can be represented by a small model (we assume the little Earth is represented at the center). On each model, you can see a grid-like coordinate system on the surface. The Celestial Sphere coordinate system assumes all the stars and planets in the sky are at an equally large distance, "painted" somewhere on the surface of the sphere.

The major circle on each model is the Celestial Equator (see if you can locate this line on your sphere). The Celestial Equator is just a projection of Earth's equator onto the night sky. You can easily see in the clear models that the Celestial Equator lies directly over Earth's equator. The grid circles that run around the globe parallel to the Celestial Equator are a measure of Celestial Latitude (also called **Declination**). The lines perpendicular to Declination lines are Celestial Longitude lines (also called **Right Ascension**).

Since the latitude of the Earth's equator is 0 degrees, we can also say that the Declination of the Celestial Equator is 0 degrees. Likewise, the North Celestial Pole (NCP) is just the projection of the North Pole onto the sky (the NCP has a Declination of 90 degrees North). The ring that surrounds the Celestial Sphere and is parallel to the tabletop is meant to represent the observer's horizon (we'll call it the **Horizon Ring**), but it will only make sense if the Celestial Sphere is set up properly. So that will be our first step...

From lecture, you should recall that the altitude of the North Celestial Pole above the Northern horizon is equal to your latitude. We can use this information to set up the Celestial Sphere model as shown on the next page. Go ahead and set up your Celestial Sphere as shown for a latitude of +33° (our latitude in Fort Worth). The vertically oriented ring is the Meridian Ring, and since the NCP is at 90 degrees on this ring, you will want to line up your <u>northern</u> horizon with the 57 degree mark to ensure there are 33 degrees between the horizon and the NCP.

Celestial Sphere

NCP

33°

Horizon Ring
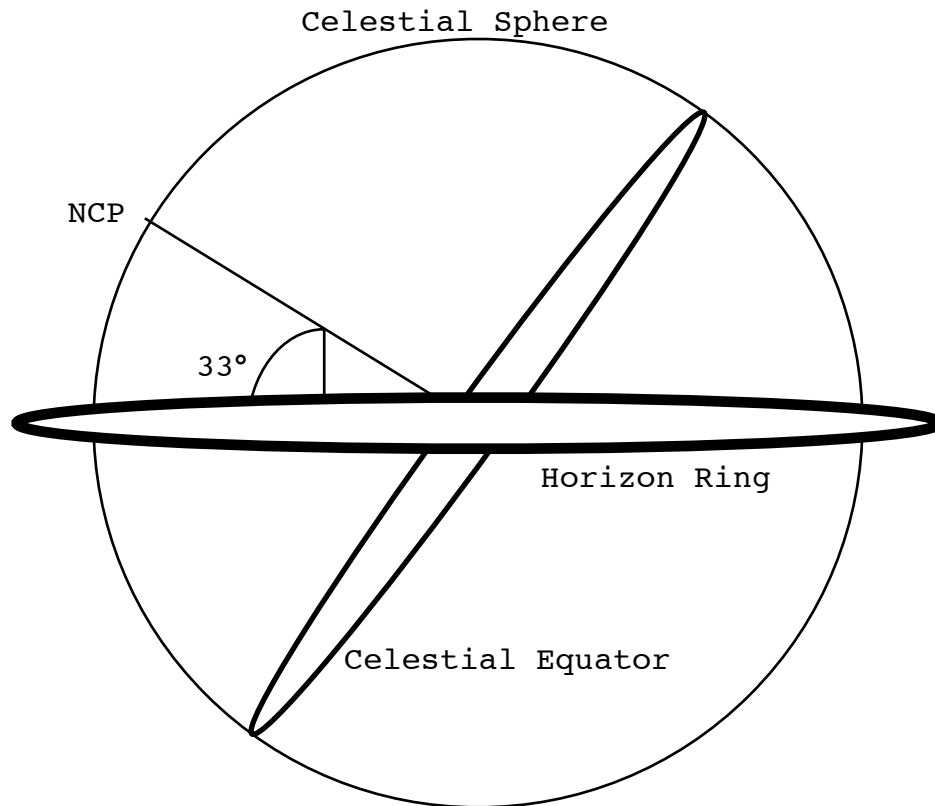
Celestial Equator

Also marked on your sphere is another circle, tilted 23.5° from the Celestial Equator. This is the Ecliptic, the apparent annual path of the Sun in the sky. Along the **Ecliptic**, you will see a series of month labels (e.g. "January, February, ..."). This is so you know where exactly the Sun is located on different days during the year. The stars do not move around on the celestial sphere, but the Sun does!

Look along the Ecliptic to find the current location of the Sun (based on today's date). In the space below, write down the Right Ascension of the Sun (to the nearest hour) and the Declination of the Sun (to the nearest degree). Use a tiny sticker on your sphere to denote the current location of the Sun or use the little yellow sphere in your model. Or you can just keep your finger on it while you proceed through the next steps.

Coordinates of the Sun today:

RA = _____ hours, Dec = _____°

Step 2
Let's start this lab by looking at how the night sky changes over the course of a year. Today, when the Sun sets, you can tell what constellations will be up in the sky by simply looking around at the part of the celestial sphere above the horizon. We define the zenith to be the highest point above the horizon (so it would be the point on your sphere that is furthest from the table-top, or furthest from the horizon ring).

Spin your celestial sphere to a position for which the Sun is just setting below the Western horizon, then look to find out which constellations are close to the zenith point (and will therefore be high overhead tonight at sunset) as well as which bright stars are close to the zenith point. Write down the names of these objects in the space below.

Name two zodiacal constellations close to zenith at sunset tonight:

_____, _____

At sunset tonight, what direction along the horizon should you look to see the constellation Orion?

_____

At sunset tonight, what direction along the horizon should you look to see the constellation Lyra?

_____

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Step 3

    The galaxy Andromeda (also called the M31 nebula) is located within the constellation Andromeda. See if you can locate this on the North Celestial Hemisphere. At what time of day (sunrise, noon, sunset, midnight) does this galaxy pass close to our zenith point from Fort Worth? Answer this and other related questions below.

When does M31 (Andromeda galaxy) pass close to our zenith, as viewed from Fort Worth (sunrise, noon, sunset, midnight)?

_____

When is the constellation Gemini closest to zenith (sunrise, noon, sunset, midnight)?

_____

When is the bright star Arcturus (within the constellation Bootes) closes to zenith?

_____

Step 4

    Now let's see how the constellations change over the course of a year. On your sphere, first locate the Sun on September 21, the date of the autumnal equinox. In the space below, write down the Right Ascension (to the nearest hour) and the Declination (to the nearest degree) of the Sun on September 21.

Sep. 21 solar coordinates:

RA = _____ hrs, Dec = _____°

Name two constellations close to zenith at sunset on Sep. 21:

_____, _____

When is Andromeda (M31) closest to zenith (sunrise, noon, sunset, midnight)?

_____

When is Gemini closest to zenith (sunrise, noon, sunset, midnight)?

_____

Step 5

    You may notice as the Sun moves along the ecliptic during the year, it moves through a series of 13 constellations. These constellations therefore have special significance to some people. Your astrological sign is supposed to be the constellation the Sun is in on the day of your birth (time of day doesn't matter ... as you can see, the sun doesn't move much during one day relative to the background stars and constellations).

    Find out what sign the Sun is in on your birthday. The position of the ecliptic relative to the constellations does wobble over thousands of years, which can cause the dates associated with certain constellations to change. We will explore this phenomenon in a later lab.

What is the month and day of your birthday? _____

In what constellation is the Sun on this day? _____

Step 6

    Now let's focus on the daily motion of the Sun on a few different days during the year. First, return your Sun marker to today's date and let's analyze the Sun's motion through the sky. We want to find out the Sun's setting azimuth as well as its noontime altitude above the horizon.

    The Sun's azimuth at sunset can be found by measuring along the horizon ring. With the Sun located on the ecliptic on today's date, rotate your sphere so that the Sun is on the Western horizon.

    When the entire Sun dips completely below the horizon ring, that is the time of sunset. Due West on your ring is at an azimuth of 90 degrees, but your setting sun is likely somewhat north or south of this point, depending on the time of year. If your setting Sun is south of West, then you might see a degree measure along the horizon of, say, 110 degrees. That is equivalent to 20 degrees South of West. By contrast, if the Sun is at an azimuth of 75 degrees, that would be the same as saying 15 degrees North of West.

    You can find the Sun's noontime altitude above the horizon in the same way you set up the North Celestial Pole. Look at what

degree mark is on the Southern horizon and count off degrees
along the vertical Meridian Ring until you reach the Sun's
location. For example, if the meridian ring says 55 degrees on
the Southern horizon and 23 degrees where the Sun crosses it
today, then the Sun's altitude is (55 – 23 =) 32 degrees.

Now let's estimate the day length. You can do this by
starting with the Sun on the Eastern horizon. Now, keep your
eye on the Western horizon and slowly turn the sphere so that
the sky passes down through the Western horizon (objects set in
the West). As each hour on the Celestial Equator passes below
the horizon, one hour of time passes. Count off the hours until
you see the Sun drop below the Western horizon...that's how long
the Sun is above the horizon during the day: the day length.

Finally, repeat these measurements for a different latitude
on Earth: Fairbanks, Alaska, which has a latitude of 60° North.

Today as seen from Fort Worth....

 the Sun rises _____ degrees South of East.

 the Sun sets _____ degrees South of West.

 the Sun's altitude above the Southern horizon at noon is

 _____ degrees.

 the length of the day (to the nearest hour) is about

 _____ hours.

Today as seen from Alaska (latitude 60° North)...

 the Sun rises _____ degrees South of East.

 the Sun sets _____ degrees South of West.

 the Sun's altitude above the Southern horizon at noon is

 _____ degrees.

 the length of the day (to the nearest hour) is about

 _____ hours.

Essay

In your essay, use the results of your lab to explain why the constellations overhead at midnight change over the course of a year. A simple diagram may help. In the next paragraph, explain why winters in Alaska are colder than winters in Fort Worth (if you are doing this lab in January). Use the results from step 6 to support your answer.

(space for diagram)

_____

_____

_____

_____

_____

_____

_____