Name: _____
Partner(s): _____
1101 or 3310: _____
Desk # _____
Date: _____

The Celestial Sphere

Purpose

- Describe the coordinate system used on the surface of the Earth
- Explain what the celestial sphere is and describe the coordinate system used in the sky
- Explain what the Zodiac is and describe how the constellations change with observing location
- Describe the difficulty in choosing a starting point for right ascension

Equipment

- Starry Night College
- Plastic celestial sphere
- Earth globe

Coordinates on the Earth: To specify a position on a flat map, two coordinates are necessary: one in the horizontal direction and one in the vertical direction. The surface of the Earth is also two-dimensional so, two coordinates are also necessary.

Question 1: Be as descriptive as possible with the following definitions.

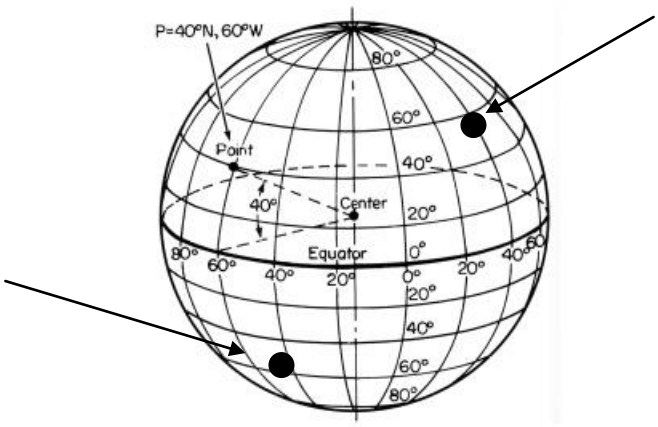
a) Define the poles of the Earth.

b) Define the terrestrial equator.

c) What is the Prime meridian, also called the Greenwich meridian?

d) What are the units for latitude and the units for longitude?

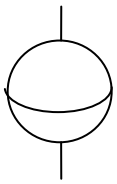
e) Give the longitude and latitude of each black dot:



The Celestial Sphere: To specify the position of a star in the sky, it is useful to imagine that stars are attached to a sphere surrounding the Earth. This fictitious construction is called the **celestial sphere**.

Question 2: Have a look at a plastic celestial spheres at the front of the room and notice the equatorial coordinate system.

a) Draw a sphere surrounding the Earth on the right. Include the celestial equator and the two celestial poles (NCP and SCP).



In Starry Night College, go to Favorites > Guides > Atlas. Observe the celestial sphere from the inside and compare it to a plastic celestial sphere. These are the two possible representations of the celestial sphere.

b) Look at one of the cheap inflatable celestial spheres. Does it show the view from inside or the outside of the celestial sphere?

Question 3: Think about the two ways the Earth is moving in the Solar system.

a) What is the reason for the apparent daily motion of the celestial sphere? (Help: You can view its daily motion by displaying the celestial coordinate system then play time (▶) with a step of one minute.)

b) What is the reason for the apparent yearly motion of the Sun? Describe what happens in space. (Help: Play time with a step of one sidereal day.)

Coordinates in the sky: To study the motion of objects in the sky we shall introduce a coordinate system that allows us to specify succinctly the location of particular objects in the heavens.

Astronomers use different coordinate systems depending on their needs:

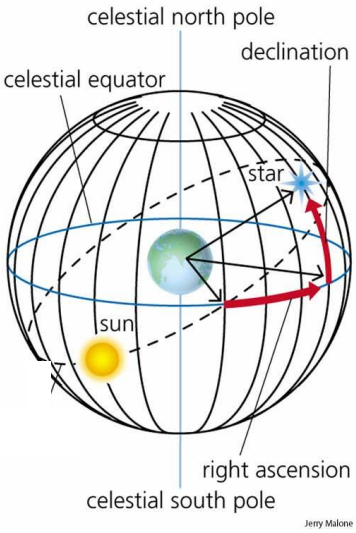
- **Lo**cal coordinates system or horizon system (click on View > Alt/Az Guides)
- **Eq**uatorial coordinate system or **celestial coordinate** system (View > Celestial Guides)
- **Ec**liptic coordinate system (View > Ecliptic Guides)
- **Ga**lactic coordinate system (View > Galactic Guides)

In this series of labs, we will only use the first two.

Question 4: In the **Eq**uatorial system, the two coordinates are called declination (DEC) and right ascension (RA). They are analogous to latitude and longitude on the surface of the Earth.

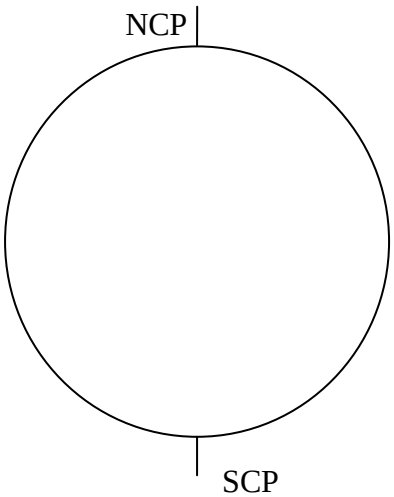
The declination of an object is measured on the celestial sphere from the celestial equator (CE). The celestial equator is a projection of the terrestrial equator onto the celestial sphere.

a) Draw a star at a declination of 30ºS on the diagram to the right.



Right ascension is measured from a zero celestial meridian, simply called celestial meridian in the software.

b) Draw the Earth inside the celestial sphere on the right and show the prime terrestrial meridian. On the celestial sphere, draw the celestial equator and a zero celestial meridian of your choice. Label both.



Zero celestial meridian: Choosing the zero celestial meridian is more difficult than choosing the prime terrestrial meridian.

- Click the "Home" button to return to Vancouver on the Earth surface.
- Remove all coordinate systems.
- Travel to a location on the Prime terrestrial meridian (e.g. London, UK).
- Display the Prime terrestrial meridian (View > Alt/Az Guides > Meridian). At that longitude, the local meridian is the same as the Prime terrestrial meridian.

Question 5: Display the zero celestial meridian (View > Celestial Guides > Meridian).

a) Is the zero celestial meridian always identical to the Prime terrestrial meridian?

Play the apparent daily motion of the sky using the play button ▶ with a step of 3 min.

b) Describe the apparent motion of the celestial meridian in the course of a day.

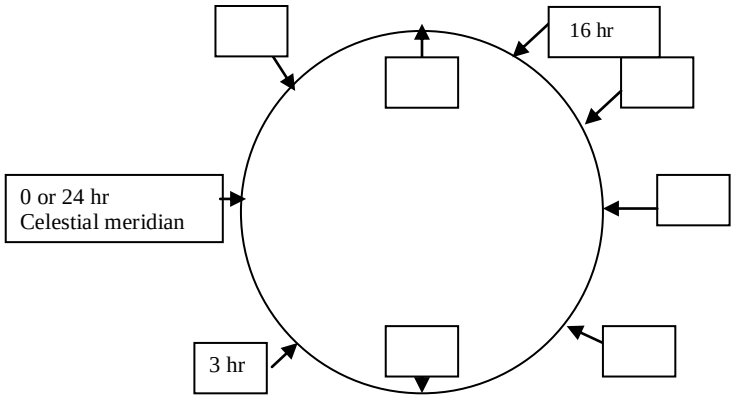
c) Explain why we observe the motion described in (b) from the surface of the Earth.

d) Why can we not choose the Prime terrestrial meridian as an origin to measure the right ascension of a star? (Help: View > Alt/Az coordinates or use the plastic celestial sphere).

Question 6:

a) What is the unit for right ascension? (Hint: Roll over a star).

b) Fill in this top view of the celestial equator with values of right ascension. (Hint: use a plastic celestial sphere.)



Question 7: Find Alpheratz.

a) What are the celestial coordinates of this star? Be as precise as possible.

RA (JNow) = DEC (JNow) =

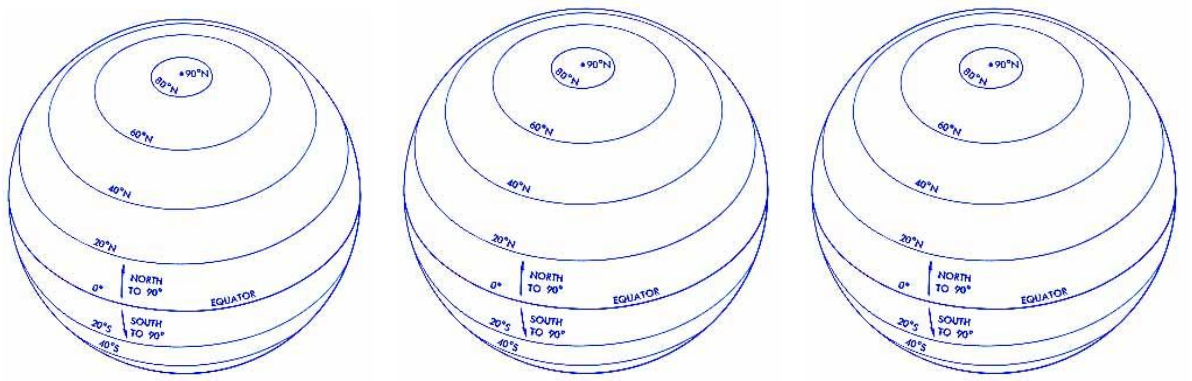
b) Find the celestial coordinates of Capella:

RA (JNow) = DEC (JNow) =

c) Find the celestial coordinates of Eltanin.

RA (JNow) = DEC (JNow) =

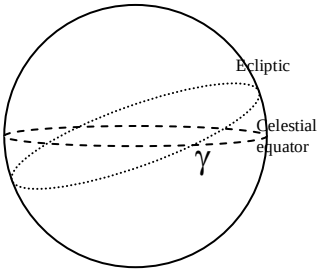
d) Draw the position of each of these three stars on the celestial sphere. Make an arbitrary choice for the position of the celestial meridian. RA is measured anticlockwise.



The Vernal equinox: For this part, use either Starry Night Favorites > Guides > Atlas or the plastic celestial sphere (or both!). Since the zero celestial meridian cannot be set as being the Prime terrestrial meridian, a specific celestial meridian must be chosen.

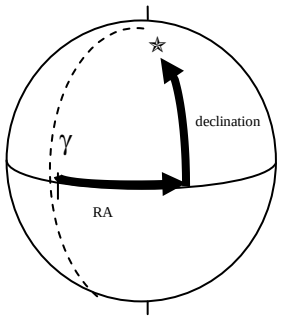
The **ecliptic** is defined as the yearly path of the Sun on the celestial sphere. Follow the yearly motion of the Sun on the celestial sphere of your choice.

One of the two intersections of the ecliptic and the celestial equator is called the Vernal equinox or Spring equinox (symbol: γ).



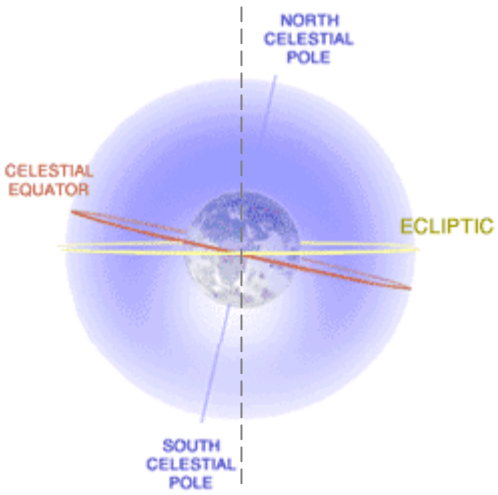
It was decided that the Vernal equinox would be the origin of the equatorial coordinate system.

Find the origin of the equatorial coordinate system on the celestial sphere of your choice.



Question 8:

a) What is the maximum angular distance between the ecliptic and the celestial equator? Show that angle on the diagram to the right. (Round off to the nearest degree).



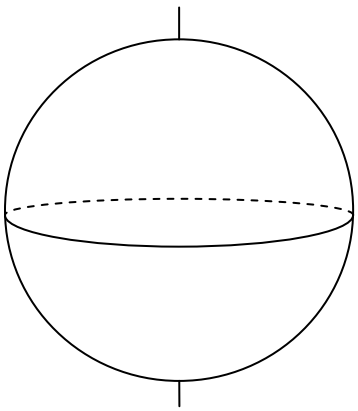
b) What is the tilt, also called **obliquity**, of the Earth?

Question 9:

a) Give the exact dates when the Sun is at the intersection of the celestial equator and the ecliptic this year, i.e. when its declination is equal to zero (2 answers).

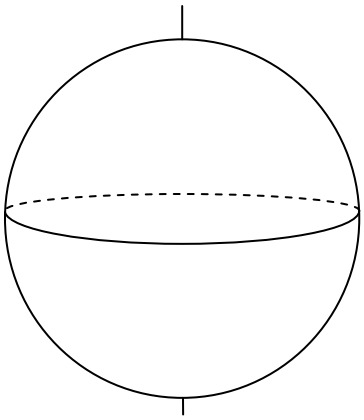
b) Which of these two positions is the Vernal equinox (i.e. when does the Sun reach position RA=0, DEC=0)?

c) On the celestial sphere to the right, draw the celestial poles, the celestial equator, the ecliptic, the celestial meridian, γ and a star at position RA=6hr, DEC=30º (RA is measured anticlockwise).



Question 10:

a) On the celestial sphere to the right, draw the celestial equator, the ecliptic, γ and the position of the Sun on June 21st, Sept 21st and Dec 21st. Label the seasons.



b) Which direction does the Earth actually orbit around the Sun?
□ Clockwise □ Anticlockwise

c) Which direction does the Sun seem to move against the background of the stars, as seen from the Earth?
□ Clockwise □ Anticlockwise

Question 11:

a) What is the exact time (rounded off to the nearest minute) of the winter solstice this year? (Hint: Roll over the Sun while time is playing to display the changes in RA.)

b) What is the exact time (rounded off to the nearest minute) of the winter solstice next year?

c) Comment on your answers from (a) and (b).

d) What is the date of each solstice and equinox this year?

Summer solstice	Fall equinox	Winter solstice	Spring equinox

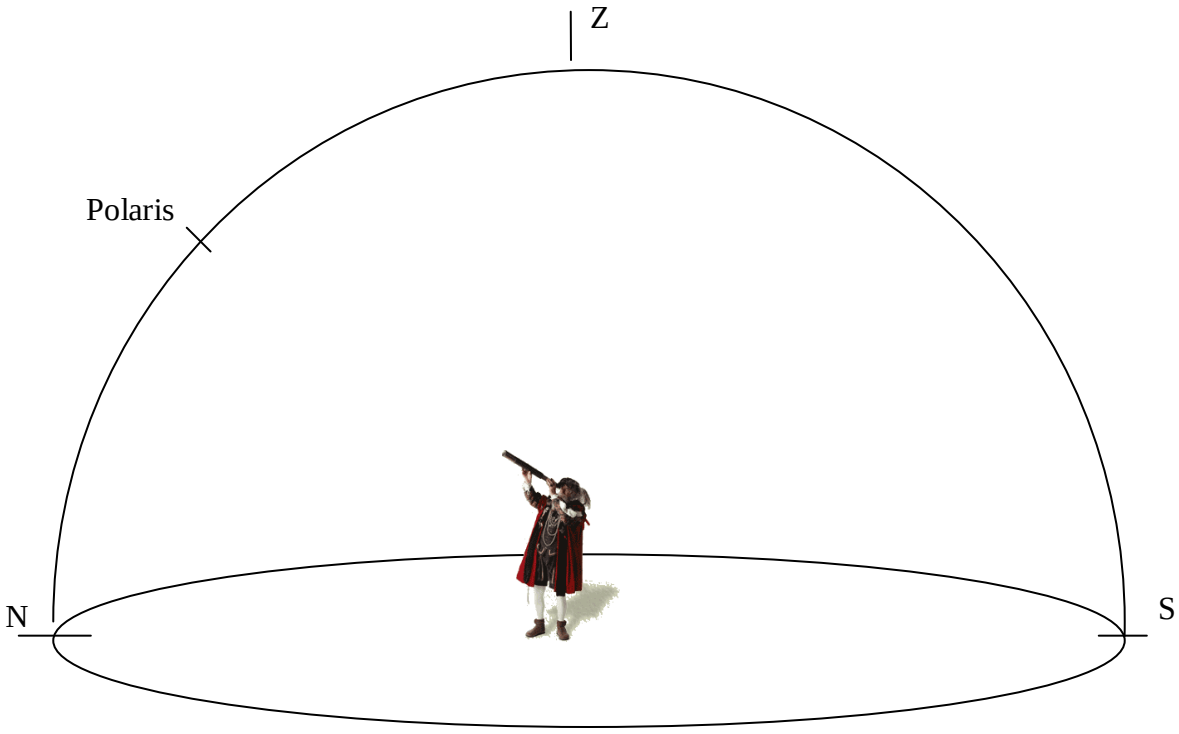
Question 12: Complete the following table with the celestial coordinates of the Sun:

Day	Summer solstice	Autumn equinox	Winter solstice	Vernal equinox
$RA_{\odot}$				
$DEC_{\odot}$				

The celestial sphere as seen from Vancouver: Travel to Vancouver. Display the celestial grid and the ecliptic at midnight on the winter solstice this year.

Question 13:

a) On the bowl diagram below, draw the celestial grid as seen from Vancouver. Include the celestial equator, ecliptic and the NCP.
b) ASTR 1101 only. Add the Vernal equinox and Betelgeuse to your diagram.



Conclusion: Write a 3 to 5 lines conclusion about this lab. What did you learn? What is the use of what you have learnt? How could you use that knowledge in your backyard?