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.
- 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. Some information is provided in the SKYGUIDE > GLOSSARY. Or you can use Google search.

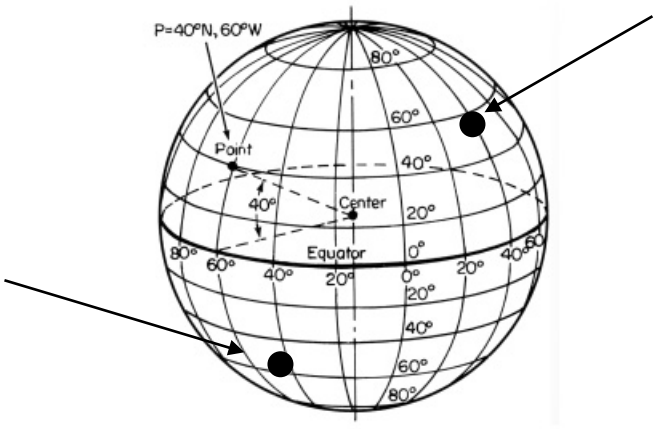
a) Define the Poles of the Earth.

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?
(Click Location ◊ > Latitude / Longitude or peek the Q.1(e) picture on next page.)

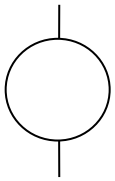
e) Give the longitude and latitude of each black dot:



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 sphere 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 [north celestial pole (NCP) and south celestial pole (SCP)].



Go to out SKYGUIDE > UNIT A: Earth, Moon and Sun > A5: The Celestial Sphere > 1: The Celestial Equator. 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 the plastic 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? (Press the "Home" button ⌂. You can view its daily motion by selecting Equatorial Coordinates with Grids [under SETTINGS > GUIDE AND LINES] and 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. (Select Equatorial Coordinates and 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:
(In Starry Night College, under SETTINGS > GUIDE AND LINES)

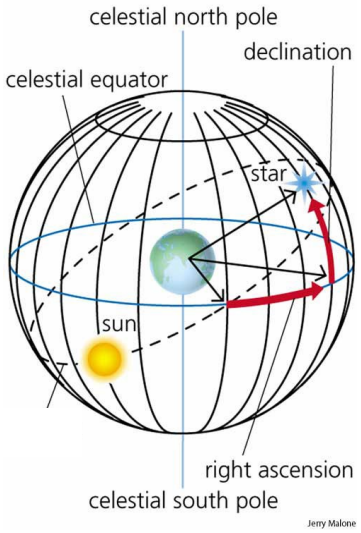
- **Lo**cal coordinates system or horizon system (select Horizon Coordinates),
- **Eq**uatorial coordinate system or **celestial coordinate** system (select Equatorial Coordinates)
- **Ec**liptic coordinate system (select Ecliptic Coordinates)
- **Ga**lactic coordinate system (select Galactic Coordinates)

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 respectively analogous to latitude and longitude on the surface of the Earth. (More information at SKYGUIDE > UNIT A: Earth, Moon and Sun > A6: The Celestial Coordinate System .)

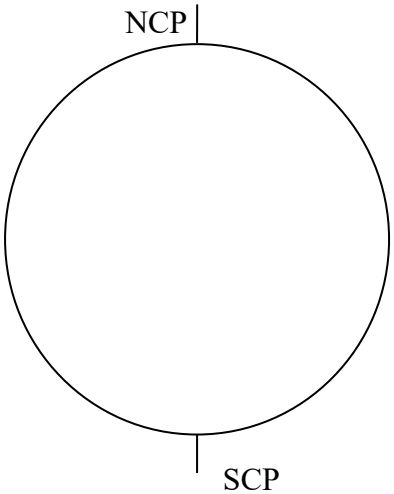
The **declination** (**DEC**) of an object is measured on the celestial sphere from the celestial equator (CE). The celestial equator is a projection of the terrestrial equator onto the celestial sphere.

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



Right ascension (**RA**) 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 all.



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

- Press the "Home" button ⌂ to be back on the Earth surface and remove all coordinate systems.
- Travel to a location on the Prime terrestrial meridian (longitude 0°), at a latitude of 80ºN.
- Display the Prime terrestrial meridian (SETTINGS > GUIDE AND LINES > Show Meridian). At that longitude, the local meridian is the same as the Prime terrestrial meridian.

Question 5: The celestial meridian is the line of zero right ascension (RA = 00h) in the equatorial coordinate system. Go to SETTINGS > GUIDE AND LINES > Select Equatorial Coordinates and Show Grid.

a) Is the celestial meridian (RA = 00h) always identical to the Prime terrestrial meridian?

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

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

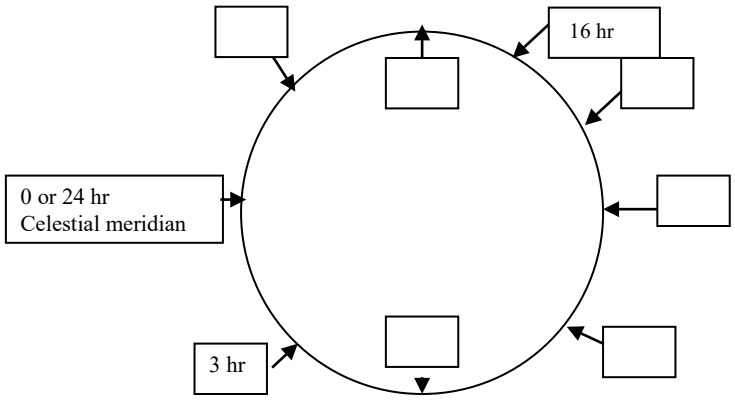
c) Explain why we observe the motion described in (b) from the surface of the Earth.

d) Why can we not choose the Prime terrestrial meridian as an origin to measure the right ascension of a star? (Help: Select Equatorial Coordinates or use the plastic celestial sphere.)

Question 6:

a) What is the unit for right ascension? (Hint: Right click on a star > Show info, check the RA of that star.)

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



Question 7: Press the Home button and find Alpheratz (Use Search).

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

RA = DEC =

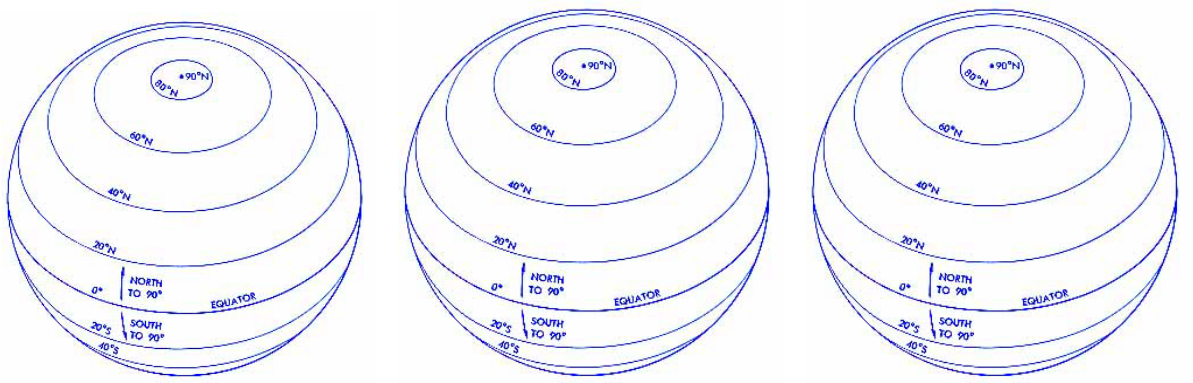
b) Find the celestial coordinates of Capella:

RA = DEC =

c) Find the celestial coordinates of Eltanin.

RA = DEC =

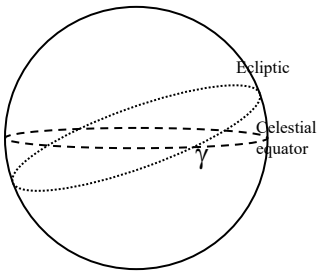
d) Draw the position of each of these three stars on the celestial sphere. Make an arbitrary choice for the position of the celestial meridian. (Once you pick one, and then it should be the same for all three spheres below.) Right ascension RA is measured anticlockwise.



The Vernal equinox: For this part, go to SKYGUIDE > UNIT A: Earth, Moon and Sun > A5: The Celestial Sphere > 7: The Equinox, or use 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.

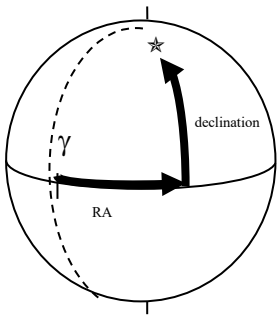
The **ecliptic** is defined as the yearly path of the Sun on the celestial sphere. Follow the yearly motion of the Sun on the celestial sphere of your choice.

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.

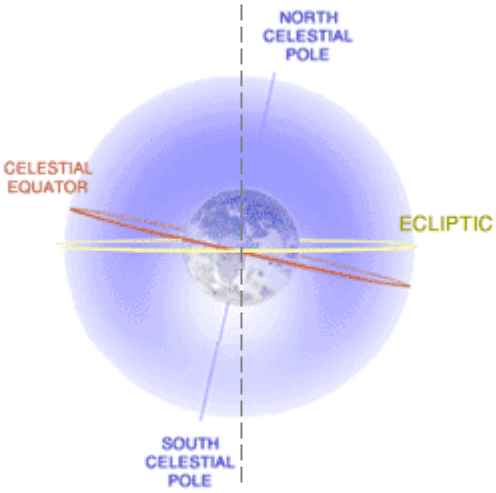
Find the origin of the equatorial coordinate system on the celestial sphere of your choice.



You may want to check out "SKYGUIDE > UNIT A: Earth, Moon and Sun > A5: The Celestial Sphere > 6: The inclination of the ecliptic" for Questions 8 and 9.

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.)



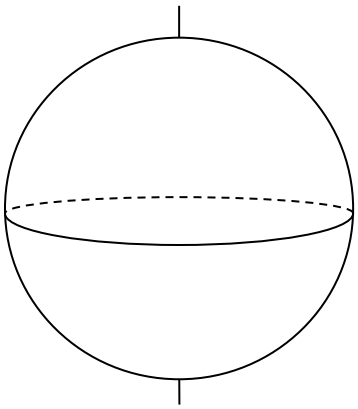
b) What is the tilt, also called **obliquity**, of the Earth?

Question 9:

a) Give the exact dates when the Sun is at the intersection of the celestial equator and the ecliptic in 2023, i.e. when its declination is equal to zero (2 answers).

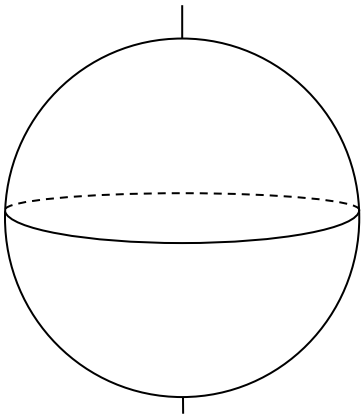
b) Which of these two positions (dates above) is the Vernal equinox (i.e. when does the Sun reach position RA = 0, DEC = 0)?

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

You may want to check out "SKYGUIDE > UNIT A: Earth, Moon and Sun > A5: The Celestial Sphere > 8: The Solstices" for Questions 11 and 12.

Question 11: ASTR1101 only

a) What is the exact time (rounded off to the nearest minute) of the winter solstice at Vancouver in 2023? (Hint: Check "Show Info" of 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 at Vancouver in 2024?

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

d) What is the date of each solstice and equinox in 2008?

Summer solstice	Fall equinox	Winter solstice	Spring equinox

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

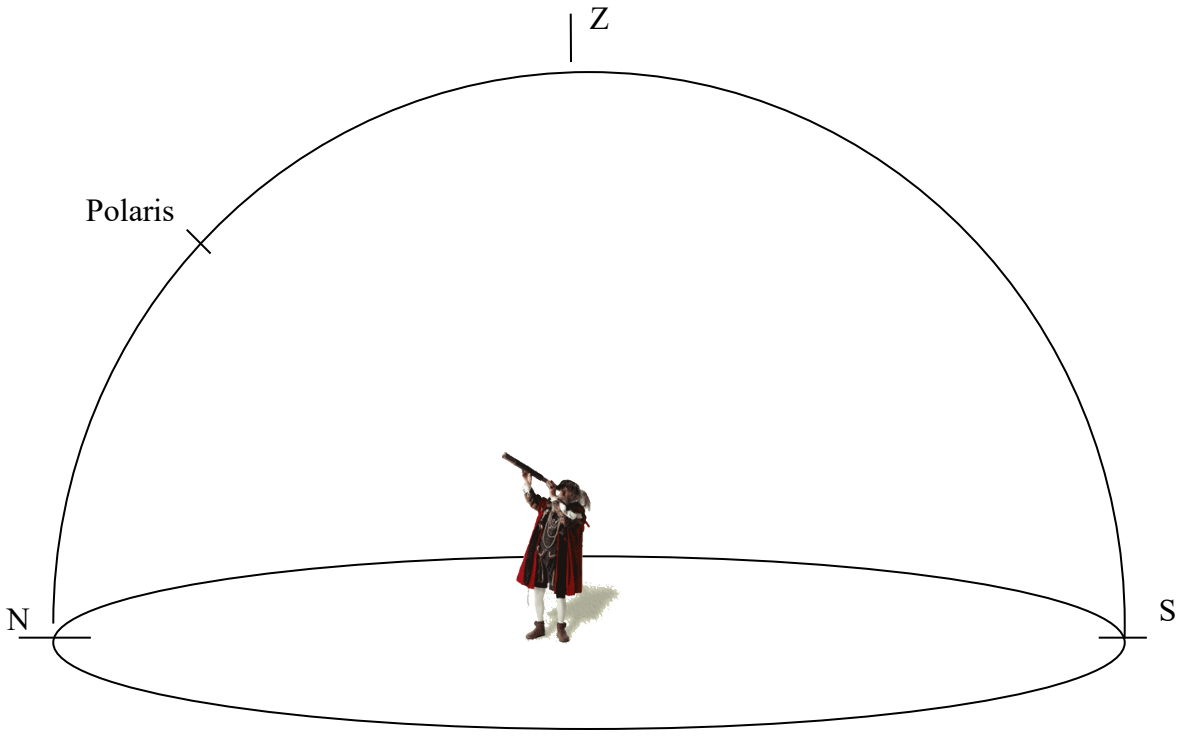
Day	Summer solstice	Autumn equinox	Winter solstice	Vernal equinox
$RA_{\odot}$				
$DEC_{\odot}$				

The celestial sphere as seen from Vancouver: Travel to Vancouver. Display the Equatorial coordinates with grid (celestial grid) and the ecliptic at midnight on the winter solstice in 2023. You may find it helpful to use the plastic celestial sphere for Question 13.

Question 13:

a) On the bowl diagram below, draw the celestial grid as seen from Vancouver. Include the celestial equator 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?