Lab 2 – The Celestial Sphere

ASTR 1010

Name: _____

Overview

In this activity you will implement what you know about the celestial sphere and celestial coordinates to locate the Sun, stars, and planets in the sky. You will also explore how the positions of these bodies change throughout the year.

Objectives

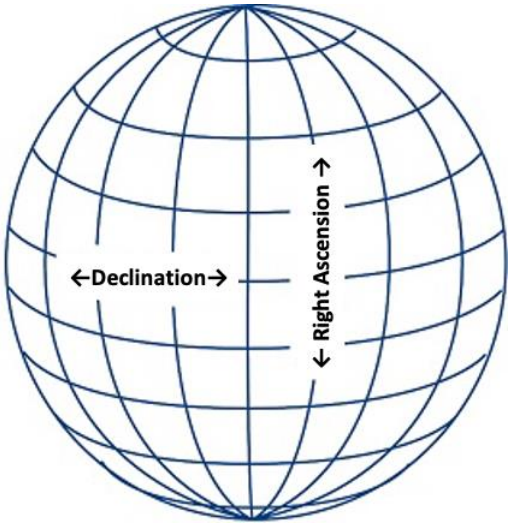
After completing this activity students will be able to:

- Identify the locations of the celestial poles, equator, and ecliptic.
- Use a celestial sphere simulator to find the Sun's position along the ecliptic for any day of the year
- Use a celestial sphere simulator to observe the changes in the sun's altitude and duration of time in the sky at different times of the year
- Use a celestial sphere simulator to identify stars and constellations in tonight's sky
- Use a celestial sphere simulator to estimate the rising and setting times for bright stars and planets

Definitions

Here are some terms from lecture that we will be using today in lab:

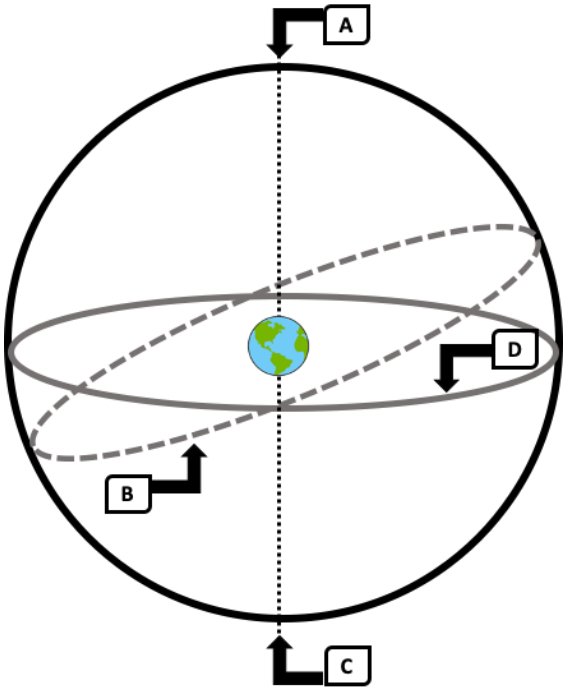
- **Celestial sphere** – an imaginary sphere of infinite radius on which we imagine all the stars to be attached. As this sphere appears to rotate from east to west, it carries all the stars and constellations with it. The vernal (spring) equinox is at the origin of this system (RA= 00h 00m 00s, Dec = 00 00' 00").



- **Right Ascension (RA)** – the east-west celestial coordinate (equivalent to longitude). RA is measured in units of time: hour (h), minutes (m), and seconds (s).
- **Declination (Dec)** – the north-south celestial coordinate (equivalent to latitude). Dec is measured in angular units of degrees, arcminutes (‘), and arcseconds (“). The celestial equator has a declination of 0°, the north celestial pole has a declination of +90°, and the south celestial pole has a declination of -90°.
- **Ecliptic** – the Sun's apparent path through the sky. Intersects the celestial equator twice per year at RA= 0h0m0s and RA=12h0m0s.

- **Constellation** – a region of the sky, bordered by arcs of right ascension and declination. Together, 88 constellations cover the entire celestial sphere, with their boundaries adopted officially by the International Astronomical Union in 1928.
- **Circumpolar star/constellation** – a star/constellation that never sets below the horizon due to its apparent proximity to one of the celestial poles.

Part 1. Location, location, location!



Match letter to corresponding location:

Celestial Equator ☐

Ecliptic ☐

Celestial North Pole ☐

Celestial South Pole ☐

1. Define the ecliptic. What objects travel through the ecliptic?

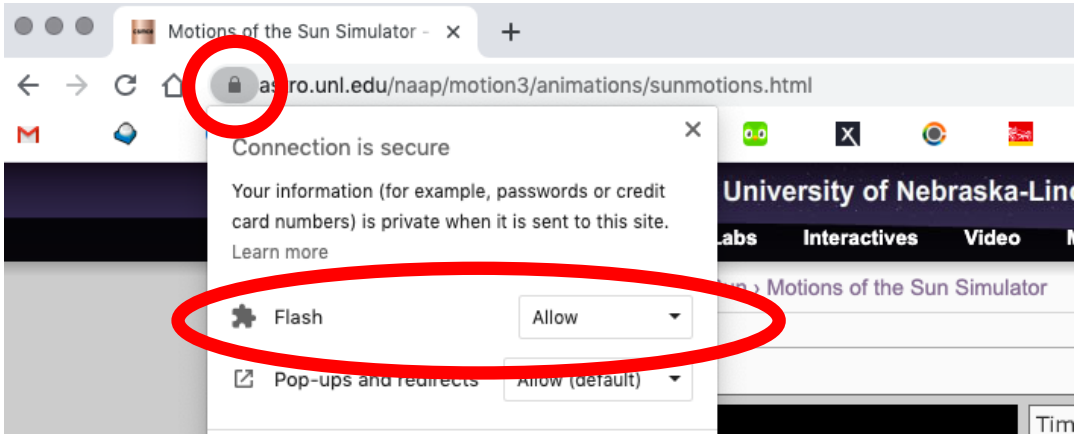
2. Why are the celestial equator and ecliptic offset from each other?

Part 2. The Sun's Journey

Instructions for Part 2 – For this section you will be using the Motions of the Sun simulator from the University of Nebraska – Lincoln. The simulator can be found here:

https://astro.unl.edu/naap/motion3/animations/sunmotions.html

If the applet is not loading, please check that your Flash settings are set to "Allow". In Chrome, you do this by clicking on the lock icon on your web browser's address bar.



Note. Allowing Flash will vary depending on your web browser. If you are using a browser that is not Chrome, ask Google how to allow flash for your browser.

Once the applet has loaded, **set your location to Atlanta by changing the observer's latitude to 33.8° N**. In the General Settings (bottom right), make sure the boxes for the sun's declination circle, the ecliptic, underside of celestial sphere, stick figure and shadow, and time of day are checked. You can change the location of the Sun by clicking and dragging the Sun on the celestial sphere diagram.

To begin, change the date in the simulator to find the Sun's RA and Dec at the equinoxes, solstices, and today. Complete the Table A:

Table A. Location of the Sun

Date	RA (hrs:mins)	Dec (degrees)
March 21		
June 21		
September 21		
December 21		

Part 2 Questions

Choose a date in July and a date in December (any date in those months). Record your choices and the declination of the Sun on those dates.

3. July date: _____ July declination: _____
4. December date: _____ December declination: _____
5. How does the declination of the Sun in July compare to the declination in December? Why do you think that is?

For the two dates in July and December you chose, compare the amount of time the Sun spends in the sky. Set the simulator to your July date and drag the Sun so it is just peaking above the eastern horizon to imitate sunrise. Record the time below. Now drag the Sun across the sky so it is just below the western horizon. This will imitate sunset. Record the time below. Change to your December date and repeat.

6. July sunrise time: _____ July sunset time: _____
7. December sunrise time: _____ December sunset time: _____

Note. You may need to rotate (click and drag) the celestial sphere to move Sun from one edge of the sphere to the other

8. In which month does the Sun spend the most time above the horizon? Explain why this happens using the Sun's declination.

Change the latitude to 90 degrees N (the latitude of the North Pole). For your July and December dates, record the declinations of the Sun at the North Pole on those dates:

9. July declination at North Pole: _____
10. December declination at North Pole: _____

11. What is different at this latitude than at the latitude of Atlanta?

Set the simulator to your chosen July date. **Set the time to midnight (00:00 – 24hr time).** Under the animation controls menu, click 'Start Animation'. Watch the Sun move through one day of animation.

12. How much time does the Sun spend in the sky in July at the North Pole? Explain using the sun's declination.

13. Knowing what happens in July, what do you think you would observe if you repeated this for the December date? Why?

Part 3. Stars and Planets

Instructions for Part 3 - For this section you will be using the Stellarium Web Online Star Map. The simulator can be found here:

https://stellarium-web.org/

To get Stellarium ready to go:

- At the top left corner, click on 'View Settings,' then make sure that 'Ecliptic
- Line' is checked.
- Click the 3 horizontal lines on the top left corner of the screen to close the left-hand menu.
- On the bottom of the screen, click the 'Landscape' option to make the landscape disappear, giving you a full look at the celestial sphere.
- Click on the 'Atmosphere' option to stop the Sun from blocking out stars.
- Click on the 'Constellations' option to draw and label the constellations.
- Lastly, click on the 'Equatorial Grid' option to label the coordinates on the sky. RA and Dec coordinates will appear on the boundaries of the screen.

Using this setup, you use RA and Dec to locate 10 bright stars in the night sky! The coordinates for ten bright stars are given in Table B. Use these positions to identify each star and to find the constellation to which it belongs.

Hint. To find the first star, go along the equator to an RA of 06h43m and then go south to a Dec of -17. Click on the brightest star you see. You should find the star Sirius in the constellation of Canis Major. Write these results down in Table B for Star 1.

Now find the other nine stars!

Table B. Positions of Ten Bright Stars

Star	RA (hrs:mins)	Dec (degrees)	Star Name	Constellation
1	06:43	-17		
2	07:37	+05		
3	20:40	+45		
4	19:48	+9		
5	5:13	+46		
6	5:13	-08		
7	14:10	+19		
8	05:53	+07		
9	16:27	-26		
10	18:36	+39		

The word planet comes from the Greek word planḗtēs, which means wanderer. Due to their wandering nature, they are constantly moving to new coordinates. So, we can't give you coordinates to find the planets. Instead, use your eyes! The brightest planets (visible to the unaided eye) will appear on the celestial sphere. Click on each and record the constellation in which each planet is presently located in Table C.

Table C. Planet Locations

Planet	Constellation
Mercury	
Venus	
Mars	
Jupiter	
Saturn	

14. What celestial sphere feature do the planets follow along?

Part 4. Tonight's Sky

Instructions for Part 4 - To prepare for the final part of this activity:

- Refresh your browser window to reset your view.
- Follow previous Stellarium directions to add ecliptic, minimize left menu, remove the atmosphere, and add constellation labels and equatorial grid.
- Click on the location box (bottom left) to make sure it is set to in or near Atlanta.
- Click the clock (bottom right) to set it for tonight at 21:00 (9:00 pm in 24-hr time).

Above the horizon, the crosshair on the equatorial grid marks the north celestial pole (NCP). Click on the clock (bottom left) and drag the circle along the moonlight bar. You should have noticed the stars very near the NCP moving in a circle around the pole and as you move time, they do not set below the horizon. **These are circumpolar stars**, which are always visible from your location on the Earth.

15. List some of the circumpolar constellations visible from Atlanta:

Of course, the number of circumpolar stars is dependent on your latitude. If you are visiting the North Pole, then all the stars visible to you will be circumpolar.

Now rotate your view upwards until the horizon completely surrounds the outer edges of your screen. Click off the 'Equatorial grid' and click on 'Azimuthal grid'. Constellations and stars seen at the crosshairs of the Azimuthal grid in this orientation are at zenith, directly overhead.

16. Name a constellation which is:
    a. On the zenith:
    b. Rising on the eastern horizon:
    c. Setting on the western horizon:

17. Click on the clock (bottom left) and drag the circle along the moonlight bar from sunset to sunrise. Name a constellation that is visible almost the entire night (excluding previously listed circumpolar constellations):

Click on the clock (bottom left) and reset the time to 21:00 (9pm). Choose a bright star on the eastern horizon and click on it. Record the following details about your choice:

18. Star name: Star RA: Star Dec:

Clicking on the clock again, click the up arrow on the month portion of the date (Stellarium gives dates in YYYY-MM-DD format). Watch how the star's position changes as you keep the time of night the same but change the month.

19. How is the star moving as you move from month-to-month? What causes this motion?

To complete this assignment for grading:

- File → Save As… → Rename the file 'YourLastName – CelSphLab'
- Upload to the file to the 'Lab 1 – Celestial Sphere' assignment in iCollege (click Add Attachments → Upload → upload renamed saved file → Update).
- Complete the Reflection activity on iCollege
- Find a mirror, look and nod approvingly at yourself for a job well done!