The Celestial Sphere
ASTR 1010

Name Taaruni Ananya ________________________________

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:
- Comprehend why a celestial sphere model is useful.
- Understand the Sun's altitude and duration of time in the sky.
- Use an astronomical database and coordinates to locate and name bright stars.
- See what changes in the night sky over a few years, and what appears unchanging.

Definitions –
- **Celestial Sphere**: the imaginary sphere which surrounds the Earth, onto which all celestial bodies – stars, planets, the Moon, and even the Sun can be projected.
- **Celestial Equator**: imaginary projection of Earth's equator onto the celestial sphere.
- **Ecliptic**: the apparent path that the sun traces across the sky over the course of a year as observed from Earth.
- **Right Ascension (RA)**: the East-to-West celestial coordinate. Analogous to longitude on Earth. It is measured in hours, minutes, and seconds.
- **Declination (Dec)**: the North-to-South celestial coordinate. Analogous to latitude on Earth. It is measured in units of degrees, arcminutes, and arcseconds.
- **Ecliptic**: the Sun's apparent path through the sky.
- **Constellation**: a group of stars that forms a recognizable pattern or shape in the night sky.
- **Circumpolar Star**: a star that, from a particular latitude on Earth, never set below the horizon.
- **North Celestial Pole**: the point in the sky directly above Earth's North Pole.
- **South Celestial Pole**: the point in the sky directly above Earth's South Pole.

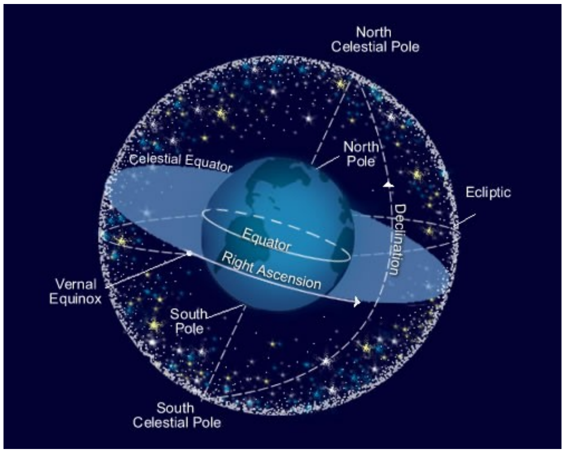
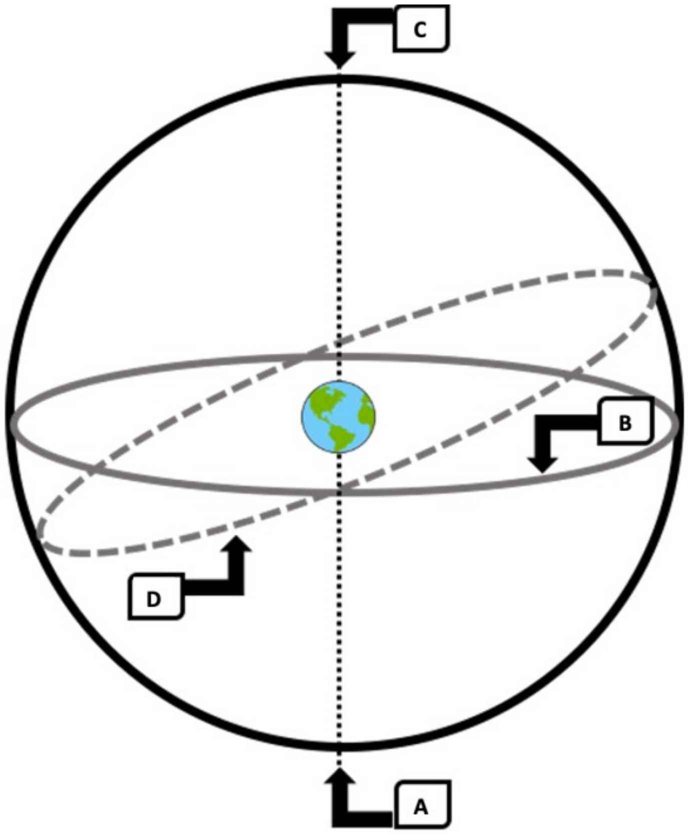


Image Credit: https://www.lpi.usra.edu/education/skytellers/constellations/

Part 1. Celestial Sphere

1) Match each letter with the corresponding definition from the list provided.



A: Celestial South Pole

B: Celestial Equator

C: Celestial North Pole

D: Ecliptic

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

The celestial equator and ecliptic are offset from each other because of Earth ’ s tilted axis.

3) How does the celestial sphere relate to the Earth’s position in space?

The celestial sphere helps astronomers map out celestial object ’ s prositions relative to the Earth ’ s position in space.

Part 2. The Motion of the Sun

For this section we will be using the Motions of the Sun simulator which can be found here: https://ccnmtl.github.io/astro-simulations/sun-motion-simulator/ 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.

To begin, change the date in the simulator to find the Sun’s right ascension and declination at the equinoxes, solstices, and today. Complete the table below:

DATE	RA (hours, minutes)	Dec (degrees)
March 21	0h 8m	0.2
June 21	6h 6m	23.4
September 21	11h 59m	0.7
December 21	18h 5m	-23.4
Today’s Date:	21h 37m	-14.7

4) How does the declination of the Sun in June compare to the declination in December? Explain why.

The declination of the Sun in June is positive, while in December, it ’ s the exact same measurement of 23.4 but negative due to Earth's axial tilt and orbit around the sun.

5) Is your answer to the question above true for everyone on the Earth? Explain.

Yes, I ran the simulation twice for both months in Australia and got the same results. I also tested the simulation in Canada and got the same results.

Now, let us compare the amount of time the Sun spends in the sky. Set the simulator to your June date and drag the Sun so it is just peaking above the eastern horizon to imitate sunrise. Record the time in the table below. Now drag the Sun across the sky so it is just below the western horizon. This will imitate sunset, and again record the time. Change to your December date and repeat.

DATE	Sunrise Time	Sunset Time
June 21	4:29 AM	7:41 PM
December 21	7:14 AM	4:56 PM

6) In which month does the Sun spend the least time above the horizon? Explain why.

The Sun spends the least time above the horizon in December because of Earht ’ s lowest declination at -23.4 caused by the Earth ’ s axial tilt of 23.4, leading to lesser sunshine during this month

7) Is your answer to the question above true for everyone on the Earth? Explain.

No, the countries on the Sourhern hemisphere like Australia experience the least amount of daylight time in June because of the sun being at its lowest declination of -23.4.

8) Change the latitude to 90 degrees North. For the entire month of June, how many times does the Sun set?

In June, the Sun never sets because it remains above Earth ’ s horizon.

9) While at 90 degrees North, how many times does the Sun rise in December?

In December, the Sun never rises because it remains below Earth ’ s horizon.

10) Where on Earth are you at 90 degrees North?

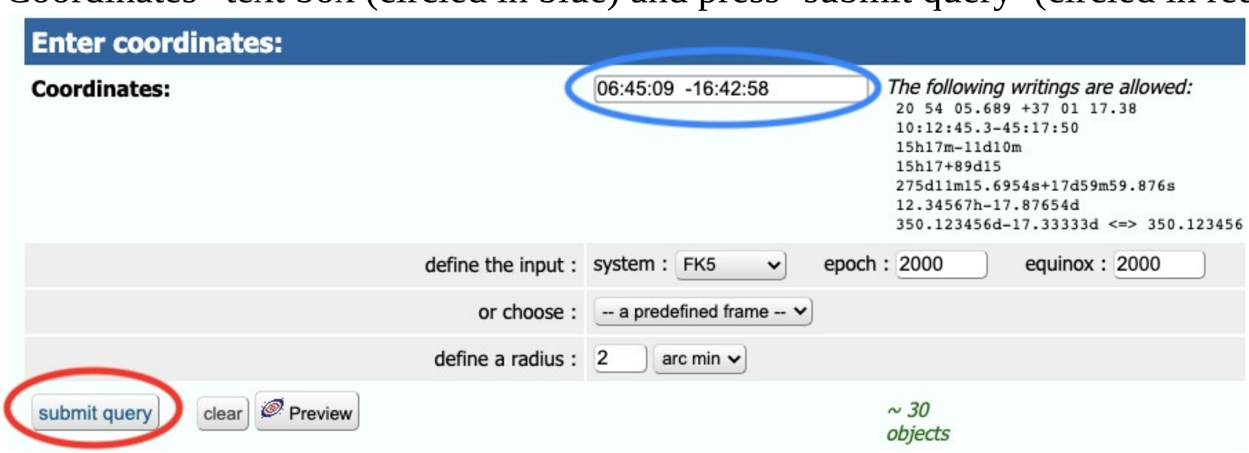
The North Pole

Part 3. Finding Stars

For this section we will be using the “Coordinate Query” task from the astronomical database *SIMBAD*, which can be found at the here:
https://simbad.cds.unistra.fr/simbad/sim-fcoo
Copy and paste the RA and Dec given in the table below to find 10 bright stars in the night sky – NB: Make sure you include the +/- on the declination values!

Star	RA (hrs,min,s)	Dec (deg,arcsec,arcmin)	Name of Star
1	06:45:09	-16:42:58	Dog Star, Sirius, Sirius A
2	07:39:18	+05:13:30	Procyon, Procyon A
3	20:41:26	+45:16:49	Deneb
4	19:50:47	+08:52:06	Altair
5	05:16:41	+45:59:53	Capella
6	05:14:32	-08:12:06	Rigel
7	14:15:40	+19:10:57	Arcturus
8	05:55:10	+07:24:25	Betelgeuse
9	16:29:24	-26:25:55	Antares B
10	18:36:56	+38:47:01	Vega

Let’s do the first one together! Click the link above to open the “Coordinate Query” task in *SIMBAD*. Copy the coordinates for Star 1 and paste them into the “Coordinates” text box (circled in blue) and press ‘submit query’ (circled in red):



Once you submit your query, you should see a table generated that is very similar if not exactly like this (note that the image below is truncated):

N	Identifier	dist(asec)	Otype	ICRS (J2000) RA	ICRS (J2000) DEC	Mag U	Mag B
1	* alf CMa	1.17	SB*	06 45 08.91728	-16 42 58.0171	-1.51	-1.46
2	* alf CMa B	5.15	WD*	06 45 09.3021501316	-16 43 00.716804119		8.41
3	[TSA98] J064510.77-164237.51	32.67	X	06 45 10.77	-16 42 37.5		
4	[TSA98] J064511.57-164240.56	40.83	X	06 45 11.57	-16 42 40.6		
5	[TSA98] J064511.97-164240.59	46.09	X	06 45 11.97	-16 42 40.6		
6	[BCL2000] 7	58.49	*	06 45 10.34	-16 43 53.2		
7	[TSA98] J064510.48-164203.49	58.49	X	06 45 10.48	-16 42 03.5		
8	[BCL2000] 3	59.60	*	06 45 12.97	-16 43 19.4		

For Star 1, the RA values for "alf CMa" and "alf CMa B" are both nearly exactly 6:46:09, but the DEC value (-16:42:58.0171) for the first object is a much closer match to the Dec value in the table, so 'alf CMa' (in the red square) is our star! Click on "alf CMa" and you will come to a screen that has basic data and an image of the star. Scroll down to "Identifiers" –

Identifiers (64) :

An access of full data is available using the icon Vizier near the identifier of the catalogue

* alf CMa
* 9 CMa
* alf CMa A
** AGC 1A
ADS 5423 A
AKARI-FIS-V1 J0645085-164258
BD-16 1591
BD-16 1591A
CCDM J06451-1643A
CEL 1368
Ci 20 396
CNS5 1676
CSI-16 1591 1
FK5 257
GAT 474
GC 8833
GCRV 4392
GEN# +1.00048915A
GJ 244 A
HD 48915
HD 48915A
HGAM 556
HIC 32349
HIP 32349
HR 2491
IDS 06408-1635 A
IRAS 06429-1639
IRAS S06429-1639
IRAS S06430-1639
IRC -20105
JP11 1425
LFT 486
LHS 219
LPM 243
LTT 2638
2MASS J06450887-1642566
N30 1470
NAME Dog Star
NAME Sirius
NAME Sirius A
NLTT 16953
NSV 17173
8pc 379.21A
PLX 1577
PMC 90-93 186
PM 06430-1639A
PPM 217626
RAFGL 1007

Look for "NAME". Looking at the screenshot above we see that the name of Star 1 is "Dog Star" or "Sirius" or "Sirius A". If your star has multiple names, record them all in the table! The different names can be for various reasons. In the case of Sirius, the name "Dog Star" is tied in to history and culture and can be traced back to the Ancient Egyptians. "Sirius" refers to the binary star system located in the constellation Canis Major, while "Sirius A" specifically denotes the primary star. Again, for our purposes, list all the names.

Part 4. The Sky
For this final section we will be using the *Stellarium Web* which can be found here: https://stellarium-web.org/
First, at the top left corner, click on "View Settings" then make sure that "Ecliptic Line" is checked. To get into full screen mode click on the three horizontal lines on the top left corner of the screen. At the bottom of the screen there are nine icons. Click on the third from the left, which is "Atmosphere". Next click on "Constellations". Click on the location box (bottom left) to make sure it is set to, or near, Atlanta. Also note that you can click on the map and drag it around,which you will need to do to answer the questions below.

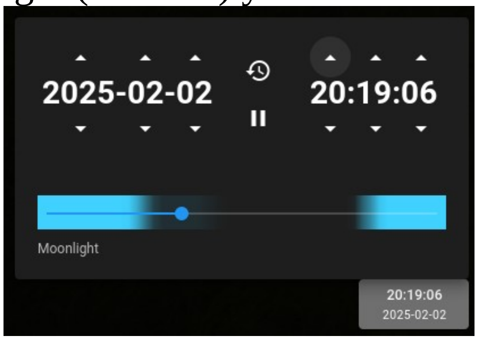
11) Record the current time, and list all planets (if any) that are visible in the sky.

Time: 9:26, planets: Jupiter, Mars, Uranus

12) Now move the screen so that you have a good view directly below (in other words, look at the ground and it will become transparent). What planets are currently (if any) below the horizon?

Venus, Saturn, Mercury

If you click on the bottom right (the time) you will see this interactive icon:



You can now see how the sky changes per hour, per minute, per second, per day, per month, or even per year! You can pause the sky, or if you need to reset the little clock image will take you back to the current time. Such power at your fingertips.

13) Go to Feb 03, 2025 at about 12:30. Looking up at the sky, you should see the Sun and a few planets – if you do not see anything make sure you click on "Atmosphere". What planets do you see? Is the Moon up in the sky?

Planets: Saturn, Neptune, Uranus, Mercury, Venus; Moon: yes

14) Now, jump a year forward! What planets do you see? Is the Moon up in the sky?

Planets: Saturn, Uranus, Neptune, Mars, Mercury, Venus; Moon: no

15) Keep clicking "up" each year until you get to the year 2100! What changes/moves from year-to-year, and what appears to hardly change if at all?

Jupiter, Saturn, and Neptune are not in the sky. Mars, Uranus, Mercury, and Venus are all in the sky.

16) Explain why is it that in 75 years some "things" look like they have not really changed/moved at all?

Some planets take longer to complete their orbit, the farther away they are from the sun, the longer thier orbit is. The reason why some planets and constellations stay the same and some move is all connected to how long they orbit the Sun compared to Earth.

17) Based on your answers to the previous questions, what does the movement of celestial bodies in our Solar System as well as the relatively fixed positions of other celestial objects reflect in our understanding of the Earth's orbit and the nature of planetary motion?

The movement of celestial bodies in our Solar System as well as the relatively fixed positions of other celestial objects reflects the Solar System's planets' orbital periods, Earth's position and orbit in relation to that of other planets, relatively fixed positions of stars and constellations, and the slow/long term changes.