Name_____ **Section**_____

Partner(s)_____ **Date**_____

CHARTING THE HEAVENS USING A VIRTUAL PLANETARIUM

You have had the opportunity to look at two different tools to display the night sky, the celestial sphere and the star chart. You are now acquainted with constellations and their boundaries, right ascension and declination, and non-planetary celestial object motion over time. Wouldn't it be great if you could chart the night sky on a given date and time for a particular location and watch the changes in an animated time sequence? Or wouldn't it be interesting to see how the sky appeared to our ancestors or how it will look to our descendants? This is possible with a planetarium where a projector can be set to display celestial objects for a given date and time on a domed surface and show motion of stars and planets.

Although we do not have a planetarium, we can generate a "virtual sky" by simulating celestial displays and motion using a computer program such as Stellarium, Celestia, Starry Night, TheSky, or Redshift.

These programs will allow you to select a location, date, and time for sky viewing. They also permit you to select the objects to be seen along with constellation and sky coordinate lines. You can set the sky in motion to see how the celestial display will change with time as the Earth rotates.

Starting a planetarium program

Each program runs differently so it would be impossible to describe all of them and some reading of the manual will have to be accomplished to fully understand what to do. Run your program in the manner that is relevant to your operating system (for instance in PCs you should go to **Start**, then **Programs** and locate your particular program; for Macs go to **Applications** and locate your particular program and double click on it; for Ubuntu you could go to the *Applications* in the upper left corner, or from the terminal/x-term you could type in the program name (example *prompt> stellarium*)).

Using the planetarium program

All planetarium programs have controls that change the screen display. Some are on the top of the program, some appear on the side and bottom of the program when the cursor is placed in that location (for example, Stellarium at http://www.stellarium.org). All program should have the ability to change location, date and time, displaying or not displaying objects or labels, changing coordinate system, turning grids on and off, etc. The user will need to read the manual. For an example Stellarium will be used here, but any software planetarium should work for this exercise (though you will need to find the appropriate command on your own).

Figure 1: The control for Stellarium on both left side and bottom. Position cursor over the icon while running to find out what each icon is in the control panel. Some are labeled here, but not all. Read the manual for more information.

Activity 1: The Nightly Motion of Stars

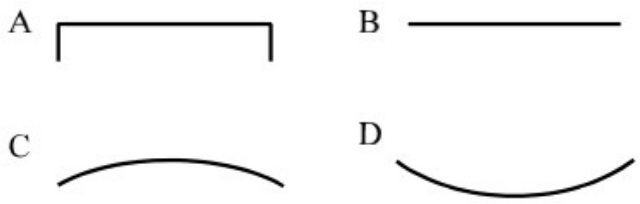
To look at the motion of the stars over a period of time we can set a site and time and put the sky in motion

- Set the location (**Location window [F6]**) for Washington D.C., United States
- Set the date **(Date/time window [F5])** for today (if not done automatically).
- Use curser (click and move) to view in the south direction **[S]** (be sure the **Cardinal points [Q]** are "on").
- Set to **Azimuthal Grid [Z]**.
- Set **Atmosphere [A]** off.
- Turn off ALL objects except the stars. Turn on the constellation patterns.
- Go to the time controls (the play, fast forward, reverse buttons like on a typical TV remote) icons and start moving to the future by pressing fast forward (double right arrows). Click on the double arrow pointing right to start the sky motion to the future. You can stop the motion by pressing play then pressing play (right arrow) again (you should see a pause button) or reverse the motion by pressing fast reverse button (double left arrows).

1. Observe the night sky in motion looking south [S].

Describe the motion.

What is the path taken by the stars when viewing to the south? _____



Now change your view to north [N], and start the motion after resetting the time to your initial conditions.

2. Observe the night sky in motion looking north.

Describe the motion.

Illustrate the path taken by the stars when viewing to the north.

Is there any star that is not following the path above? If so, identify it.

Does the Big Dipper go below the horizon? Explain.

Now go back to the **Date/Time window [F5]** and change the year to 5000.

3. Observe the night sky again looking north as you did just above.

Describe the motion.

What is different in the year 5000? Describe it.

Either using the celestial grid (you need to set to **Equatorial Grid [E]** for this) or cursor (you can search for Polaris using the **Search window [F3]**), determine the right ascension and declination of Polaris in 5000 (use *of date* not J2000).

RA _____ DEC _____

Activity 2: Observing Planetary Motion

- Set the date for today
- Turn off all grids (equatorial and azimuthal), boundaries, and labels.
- Make sure ground, atmosphere, fog, etc. is off (so you can see the movement better).
- Set the **switch between equatorial and azimuthal mount** on**.** This will keep the stars in the same position on the screen all the time.
- Go to the **sky and viewing options window [F4]** and in {Markings} turn on the ecliptic line. Though not necessary setting to perspective might help you view the planetary motion without the star motion. Zoom out to get a more encompassing sky view.
- View in the west direction (be sure you see the ecliptic line). Turn off the **cardinal points [Q]**.
- Turn off ALL objects except the stars and planets.
- To see the path of the planets, go to **sky and viewing options window [F4]** and in {sky} turn on planet orbits.
- Go to the time controls (the play, fast forward, reverse buttons like on a typical TV remote) icons and start moving to the future by pressing fast forward (double right arrows). Click on the double arrow pointing right to start the sky motion to the future. You can stop the motion by pressing play then pressing play (right arrow) again (you should see a pause button) or reverse the motion by pressing fast reverse button (double left arrows).

1. Observe the motion of the planets.

What is changing?

What is not changing?

2. Now turn the stars off and turn the planets orbit on. Start the motion again and let it run awhile. What do you notice about the planets' motion? Describe or illustrate it.

More Advanced Virtual Planetarium Activities

Activity 3: Looking East at Different Latitudes

- Use the curser (click and move) to view in the east direction.
- Set to **Azimuthal Grid [A]**.
- Go to the time controls (the play, fast forward, reverse buttons like on a typical TV remote) icons and start moving to the future by pressing fast forward (double right arrows). Click on the double arrow pointing right to start the sky motion to the future. You can stop the motion by pressing play then pressing play (right arrow) again (you should see a pause button) or reverse the motion by pressing fast reverse button (double left arrows).

1. View the eastern horizon for the following four locations which can be set in the **Location window [F6]**. Record the latitude for the locations given below. Put the sky in motion for each location, observe, and sketch the motion paths below in the boxes. Use a series of arrows to show direction.

North Pole - Latitude _____

Washington, DC - Latitude _____

Equator - Latitude _____

Southern Hemisphere - Latitude _____

2. Explain the pattern based on the varying positions on Earth.

3. Predict what the pattern would look like in Canada, say half way between the north pole and Washington, D.C.

4. Predict the path of motion looking west in Washington, D.C.

Activity 4: The Changing North Star

- Use the curser (click and move) to view in the north direction.
- Make sure ground, atmosphere, fog, etc. is off (so you can see the movement better).
- Set to **Azimuthal Grid [A]**. At the top of this grid (+90 degrees) is the zenith.
- Go to the time controls (the play, fast forward, reverse buttons like on a typical TV remote) icons and start moving to the future by pressing fast forward (double right arrows). Click on the double arrow pointing right to start the sky motion to the future. You can stop the motion by pressing play then pressing play (right arrow) again (you should see a pause button) or reverse the motion by pressing fast reverse button (double left arrows).

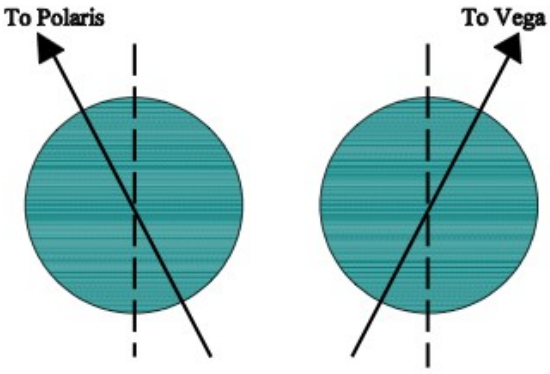
Reset conditions to Washington, D.C. on 16 August 1999 at 22 hours, 4 minutes. Zoom out so that both Polaris and the zenith can be viewed.

1. Identify the star at the zenith. _____ This star field is printed below for your convenience.

The star is Vega, which was our north star about 13,000 years ago and will be again in 13,000 years. This is due to the precession of the Earth's axis. Think of a toy top spinning and the axis changes with time, both rotating around and wobbling.

2. How many degrees apart are Polaris and Vega?

3. The Earth's rotation axis is tilted 23.5 degrees with a wobble of ± 1.5 degrees (variation). What is the maximum angle, considering the variation, for the axis making a complete swing?



Maximum Precession

4. How does the measured angle from the star field compare to your maximum angle calculated above?

5. Now on the printed star field (below) using a ruler, draw a line connecting Polaris and Vega. Find the mid-point of this line. Set a compass to this distance and place the pointed end at the mid-point. Draw a circle with the compass and you will have approximately identified the path of the precession of the Earth's axis over time. It takes about 26,000 years to complete one cycle. List three other possible stars on the path (circle) that could have been north stars. The axis, as it precesses, also wobbles, so you can go a little off the circle to get these stars.

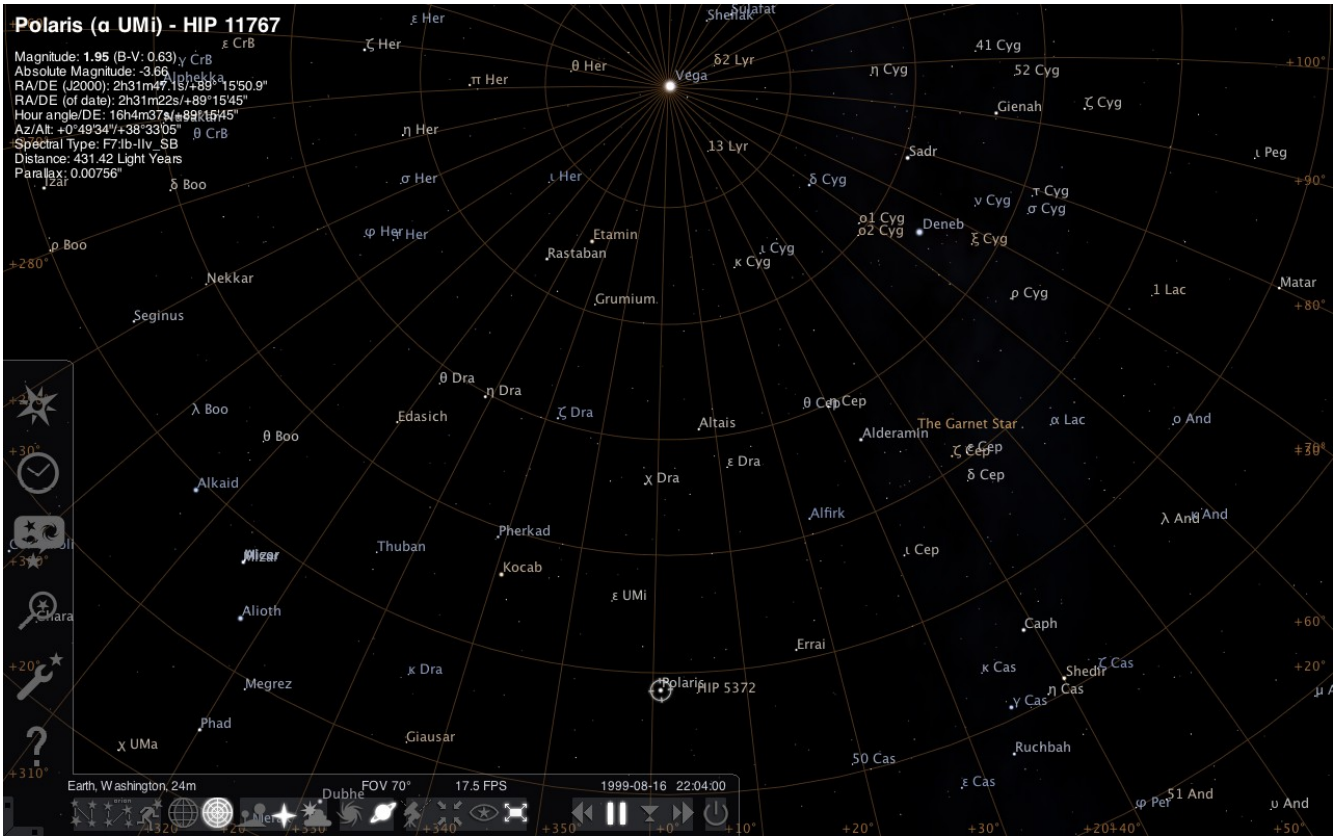
1. _____ 2. _____ 3. _____

6. About 2700 years ago, a small star was the north star. Set the time to -2700 years (2700 BC) and observe the motion to identify this star. You may want to turn the labels on.

North star at -2700 years _____ in the Constellation _____

What was occurring in history at this time (you may use a history book or the internet for this)?

7. Which direction is the north celestial pole going to migrate? Show with an arrow on the precession circle.


Polaris (α UMi) - HIP 11767
Magnitude: 1.95 (B-V: 0.63)
Absolute Magnitude: -3.66
RA/DE (J2000): 2h31m47.15s/+89°15'50.9"
RA/DE (of date): 2h31m22s/+89°15'45"
Hour angle/DE: 16h4m37s/+89°15'45"
Az/Alt: +0°49'34"/+38°33'05"
Spectral Type: F7:Ib-IIv_SB
Distance: 431.42 Light Years
Parallax: 0.00756"
Vega
Sheliak
Sulafat
Alkaid
Mizar
Alioth
Megrez
Phad
Dubhe
Merak
Phecda
Thuban
Kochab
Pherkad
Edasich
Nekkar
Seginus
Rastaban
Etamin
Grumium
Altais
Alderamin
The Garnet Star
Deneb
Sadr
Gienah
Errai
Caph
Shedir
Ruchbah
Matar
Polaris
HIP 5372
Earth, Washington, 24m
FOV 70°
17.5 FPS
1999-08-16 22:04:00