Stellarium and Sky Visualization

Objectives—

- Install the *Stellarium* sky visualization software.
- Use *Stellarium* to find different astronomical objects.
- Use *Stellarium* to explore precession and how our view of the stars changes depending on our longitude and latitude.

Introduction— *Stellarium* is a planetarium for your computer. It can show you a view of the sky from any location on the Earth right now or a few thousand years in the past or future. With it, you can identify objects in the sky, from planets to stars to galaxies to constellations. You can also choose a telescope and eyepiece or binoculars to look at distant objects as if you were outside.

Installation— *Stellarium* is free, open-source software. You can go to `http://www.stellarium.org` and download the program for the Mac, Windows, or Linux operating systems. Simply follow the instructions after clicking the appropriate operating system icon at the top of the page.

Procedure—

1. Start up *Stellarium*.
2. Notice that there are **two main menu bars** that appear when you scroll your mouse over them. One is on the bottom of the screen the other is on the left. Everything in the menu bar is also accessible via hotkeys which we often refer to parenthetically below. Throughout the procedure, in addition to using hotkeys, you may also wish to identify where options are on the menu bar.
3. Access the location menu (F6) in the left menu bar and change your current location to New York City.
4. Look around the sky by clicking and dragging your mouse or using the arrow keys. To customize your viewing experience,
   - press G to toggle the ground on and off;
   - press A to toggle the atmosphere (including the Sun!);
   - press Q to toggle labeling of the cardinal points;
   - press D to toggle identification of deep sky objects;
   - press P to toggle identification of planets.

   (Each of the above options can also be accessed in the bottom menu bar.) Later, you can explore the many options, as well as read about sky-lore, in the sky-viewing menu (F4).
5. Use the bottom menu bar to toggle between equatorial and azimuthal telescope mounts (Cmd+M on Mac). What is the difference?
6. At the right of the bottom menu bar adjust the rate at which time passes (j, k, and l reverse, stop/start, and advance the rate of time flow). When advancing time flow, what direction do stars appear to move across the sky?
7. Now find Polaris. You may do this by using the search window (F3) in the left menu bar, typing in Polaris and hitting enter on the keyboard. Polaris will always be up in New York. Why?
8. Turn off the atmosphere (Sun) and advance the rate of time. Notice that the rest of the stars seem to rotate around Polaris. At what location would Polaris be directly overhead? Move to that location. To test whether Polaris is directly overhead, turn on the azimuthal grid in the bottom menu bar (Z). Where is Polaris on this grid? Where is overhead? Also try turning on the Equatorial grid. Where is Polaris on this grid?
9. Polaris has not always been the North Star. Due to precession (wobble) of the Earth about its spin axis, the Celestial North Pole has moved in the past several thousand years. To see this, use the Date/Time window in the left menu bar (F5) to change the year to 1000 AD and to 1000 BC (-1000 in Stellarium). Where is Polaris? Does the rest of the sky still seem to rotate around it?

10. Go to the date October 4, 1582 using the 'Date/time window' (F5). Fast forward the time using the bottom menu or the key 'l' and keep your eye on the date you see. Did you find anything interesting? Try entering any date between October 5th and October 14th of 1582. Stellarium doesn't allow you to enter these dates, because they don't exist!! This is because of the calendar reforms by Pope Gregory in 1582. Do you think 1400 AD was a leap year? What about 1700 AD, 1800 AD? Can you go to February 29th of the respective years? Julian calendar did not take the precession motion of earth into account. Pope Gregory tried to nullify this error in Julian calendar by skipping 10 days and modifying the formula for leap years. Can you identify the criterion for a leap year in the Gregorian calendar?

11. Go to the 'Sky and viewing options' (F4) and the section Markings in it. Select Equator and Ecliptic there. Ecliptic is the apparent path of the sun in the sky. The intersections of these lines are called equinoxes. The sun is on the vernal equinox on 21st of March. Change the date to March 21st. You will see the sun near the vernal equinox i.e. intersection of the equator and ecliptic. Now change the year in steps of 200 in the past. Do you still see the sun on the vernal equinox on March 21st? Can you find the date on which the sun is on the vernal equinox in those years? Do you see any pattern in it?

12. You can use the ability to change the date by thousands of years to see when the Sun's position matches the Zodiac signs. Find the Sun and turn on the constellation names (V) and connecting lines (C) (or bottom menu bar). Change the date to your birthday and note which constellation the Sun is in. Now change the year to when you estimate the Zodiac was defined. Where was the Sun then?

13. Now that we are comfortable moving around, let's explore. First go back to the current time by clicking the hourglass shape on the right of the bottom menu bar (8). Now try locating a deep sky object, say the Andromeda Galaxy (M31) or the Perseus Double Cluster. Select the object in *Stellarium* by using the the search window (F3) or by manually locating and clicking on the object. You can zoom in by scrolling with the trackpad or mouse wheel. Alternatively you may use the forward slash and backwards slash keys to quickly zoom in or zoom away from a selected object.

14. Now locate a planet, say Jupiter, and zoom in. In the Sky View menu (F4), go to the "Sky" tab and check the box titled "show planet orbits." Now turn off the ground and atmosphere again and speed up time to see the four largest moons of Jupiter orbit the gas giant. What do you notice? How could you find the other planets from Jupiter's orbital path?

15. As one last exploration try changing your location to somewhere in the southern hemisphere. Notice the changes in the sky. Look at the South Celestial Pole by moving to the South Pole and look at the zenith. Change the rate of time passage and watch the sky rotate around that point.

16. Finally, at the upper right portion of the screen is the "Oculars" menu bar. This menu bar allows you to simulate looking at the night sky through a telescope or binoculars. You can customize the type of telescope and eyepiece that you use. Experiment!