

AST101: Our Place in the Universe
Lab 1: Stellarium and the Celestial Sphere
Version for Groups Meeting in Person

(Your group should import this document as a shared document into either Microsoft Office365 or Google Docs. Then your whole group should edit it together. If one member of your group is not present, list their name and write "absent" beside it.)

Group Number and Name:			
Member Name #1:		Email #1:	
Member Name #2:		Email #2:	
Member Name #3:		Email #3:	
Member Name #4:		Email #4:	
Lab Time and Date:			
Collaboration Method (in-person, online on Collaborate, etc.)			

Here we'll use Stellarium to take a good look at the basic motions of the sky, and see how the celestial sphere model developed. We'll also take an early look at the motion of perhaps the most important object in the entire sky: the Sun!

Materials

This lab makes extensive use of Stellarium. If you haven't downloaded it already, you can use the web version at <https://stellarium-web.org>, but someone in your group will need access to the standalone version. Remember, you're supposed to be working in groups; as a last resort, you can share screens.

Part 1: A First Look at the Celestial Sphere

Today, we take it for granted that the Earth moves around the Sun, and that the Earth spins on its axis, creating the apparent motion of the night sky. In short, the Earth does most of the moving. But that wasn't obvious to ancient astronomers. The early Greeks thought that all objects in the sky were attached to a physical celestial sphere that spun around the Earth.

The apparent motion of the celestial objects was due mostly to the sphere spinning, as well as the ability for some objects like the Sun to move along the sphere.

However, we know that the apparent motion of the night sky is really because the observer's perspective is rotating – attached to the spinning Earth. To model this, we're going to use the ability of smartphones to show everyone how the world looks from a changing perspective.

From your spot outside, first determine which directions are north, south, east, and west.

Your group should connect to Blackboard Collaborate using your smartphones even though you are meeting in person. Join the "Course Room", and join a separate breakout group. Turn your microphones off (you won't need them for this). One of your members should share their webcam with the others, so everyone else is looking through the lens of one person's phone.

First, that person should point their camera at some stationary object they can see – this is similar to Polaris. They should slowly rotate their camera clockwise.

The rest of the group should discuss what they see "through" Blackboard Collaborate on their own phones.

Explain how a *clockwise* rotation of the observer's camera produced this motion:

Then, another person should share their camera. Instead of pointing the camera directly at "Polaris", they should instead hold their camera horizontally in front of their chest. The Earth rotates west to east. So that person should slowly spin in place, moving west to east.

The rest of the group should again discuss what they see. Record that here.

Does the world around you appear to be moving west to east, or east to west? Explain how the west-to-east motion of the observer produced the motion that you see on your screen.

Part 2: Getting Acquainted with Stellarium

Ideally, you will have the “standalone” version of Stellarium on your computer. It has features that the web version doesn’t, and that will be helpful to you.

This set of exercises will get you familiar with Stellarium and with the connection between what you see on the screen and the motions of things in the real sky.

Fire up Stellarium. Set the time and location to your current time in Syracuse. (It may automatically be set for you.) Then turn off the atmosphere so you can see the stars even during the daytime. (There is an icon at the bottom to do this. If you are on the standalone version, you can use the hotkey A). Next, turn *on* the “azimuthal grid”. This will make it easier to relate what you see on your screen to the real sky. (The hotkey for this in the standalone version of Stellarium is Z.)

Practice moving around the sky in Stellarium using the mouse, and zooming in and out. If either the Sun or the Moon is visible above the horizon in Stellarium, find it. If neither object is visible (this will happen if you are doing an early evening lab, perhaps), see if you can find Jupiter in the southeastern sky.

If you can’t see any of these objects, point your view to the East and advance time until one of them rises above the horizon. To advance time in the web version of Stellarium, click on the timer in the bottom right and use the arrows to advance time one hour at a time. To advance time in the standalone version, press F5 to bring up the “date and time” panel. You may also use the hotkeys:

- L makes time go faster
- J makes time go slower
- K makes time pass at real time

Describe in words which object you found and where it is (e.g. “high in the northern sky”):

Then, let’s practice relating the motions of things in the simulated sky to the real one. Everyone should move so that they can see the screen of one laptop that has the *standalone* version of Stellarium. Speed time up so that you can see the motion of the stars, and point your camera to the north. You should see the celestial sphere rotating around Polaris. Your group should choose a bright star near Polaris – for instance, Kochab. (You can find any object in Stellarium by typing Ctrl-F and typing its name.)

Then, putting this laptop where everyone can see it, everyone should stand up and trace the motion of your star in the *real* sky with your fingers. The idea here is to relate three things together: the motion you see on the screen in *Stellarium*, a description in *words* of the motion of the star, and then the actual motion in the *real* sky.

Describe in words how Kochab moves over the course of one day.

Now, look to the east and wait for the Sun to rise. Watch several simulated days. How does the Sun move in the sky?

Again, everyone in your group should trace the motion of the *real* Sun in the sky with your fingers.

Describe in words how the Sun moves in the sky from sunrise to sunset. After it rises, where does it go? Does it move straight overhead to the zenith, or does it go somewhere else?

When you've finished this, call your TA or coach over and show them how the Sun moves in the real sky over a day. Tell them your group number; they'll "sign" your work by giving you a code to write down here. Enter that code here.

Now, set your location to the equator (You can either find a location at the equator, or just set the latitude to 0). At the equator, where do the stars rise? Where do they set?

At the equator, is the North Celestial Pole (NCP) visible? What about the SCP (South Celestial Pole)? Where can they be found?

Now, set your location to the North Pole (latitude of 90°). Where do the stars rise and set here? Can you see the NCP or SCP?

Part 3: Motion Of The Sun at Different Times of Year

Each person should do the following on their own laptop, if possible – talk to each other while you’re doing it, though, and discuss what you are seeing!

Make sure your location is set to Syracuse New York, and set the time to be 6am on September 21, 2020. Advance time (remember you can speed up time!) until the Sun is at its highest point in the sky; that is, it’s at its the highest it ever gets above the ground.

When the Sun is at its highest point, where is it (North, Southeast, etc.)? This should happen near noon.

How high is it at this highest point? You can give your answer in “degrees above the horizon”. Stellarium will tell you this: if you still have the azimuthal grid turned on (press Z), the lines running across the sky are labeled.

Stop time (press K) when the Sun is at its highest point in the sky. advance time forward by 1 solar day (Hotkey =) many times.

Question 20. Continue adding solar days until the Sun is at its lowest point at noon during the year. Around what date does this occur? What is the date for when the Sun is at its highest point at noon? Are these days special in some other way?

Date Sun is lowest at noon	Height of Sun (deg)	Date Sun is highest at noon	Height of Sun (deg)
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Your group should now use your fingers again to trace the motion of the Sun across the sky. Do this twice: one for the time of the year that it is *lowest* in the sky, and once when it is *highest*.

Something similar to this next section is on Project 2. If you have time, you should do the following in lab, while you have someone around to help you. It’ll be useful for your project!

Part 4: The Sun And The Zodiac

Keeping yourself in Syracuse New York, set the date to August 20, 2020, and advance time to the day so that you can see the Sun. Turn off the atmosphere, and turn on Constellation Lines, Constellation Art, and Constellation Labels. What constellation is the Sun in?

Let's investigate how the Sun moves relative to the stars in *one* day. Speed up the rate of time so that you can see the stars and the Sun move. Follow the Sun as it moves (you can click on the Sun to select it, then hit the spacebar to follow it); over the course of a single day, does the Sun ever leave the constellation it was in in your previous answer?

Now, stop time by hitting "K", and advance one solar day at a time by hitting "=" or using the date panel.

Keep allowing time to advance until the Sun is very clearly in a new constellation. About how long did it take the Sun to change constellations?

Continue adding solar days, and watch the stars behind the Sun. Does the background stay fixed, or appear to move?

Remember that in the celestial sphere model, the objects in the sky all exist on one single celestial sphere. Based on your answer to the previous question, do you think some of the objects on the sphere can move along it, or are they all fixed in place?

If they can move, what other objects might be able to move along the sphere?

Your birth sign is the zodiac constellation that was behind the Sun at the time of your birth. Set the date to your birthday, and find what constellation was behind the Sun at that time. (If the Sun is below the horizon, advance time until it rises.) Does it match the birth sign your horoscope claims is yours? If you want to know why your birth sign is wrong, look up "precession of the equinoxes" on Wikipedia, or wait to talk about this in class!

When you are done with your lab, make sure your document is still set to the sharing option “Anyone with the link can view”. Then email a link to your shared document to suast101labs@gmail.com. The subject line in your email should be “Lab 1 – Group ##### – <your names>”.