Celestial Motion I Lab Guide Experiment A02

Part A: Celestial Motion

1.) (5 points) We know that there is not some huge "sphere" encasing the Earth, so it is not this imaginary object that is rotating. The apparent motion of objects in the sky solely results from the rotation of the Earth (with exceptions like the moon and other planets that are close enough to Earth that their motions in their own orbits around the sun are perceivable; we are not worried about these right now). So, what is this question asking? Well, discuss the DIRECTION the Earth rotates. Let us agree that IF we said the Earth rotated CLOCKWISE (note that it may or may not; you will have to figure that out), that would mean that if you were looking at the earth from directly above the north pole then a point on the surface would be rotating around the north pole in the CLOCKWISE direction. Okay, so now let's actually figure out what direction the Earth is rotating by doing an experiment. By looking up in the sky, it looks like objects are moving east to west (from the Atlantic Ocean to the Pacific Ocean, for example). Now stand up and look at something in your room. Imagine your head is the Earth and the top of it is the north pole. Spin yourself (slowly) to your right (clockwise) and to your left (counter-clockwise). It APPEARS this object you are looking at is moving – JUST like the stars in the night sky. So, if "moving from the east to the west" means the object you are looking at is appearing to move to your RIGHT, are you spinning CW or CCW for it to move that way?

2.) (3 points; 1 each) There are two ways to get a solution to these problems. First is to spam the "add star randomly" button in the bottom-right "star-controls" box. Add a lot of these and then click "start animation." Now look at the top-right box – are any of these stars always staying BELOW the horizon? Are there are any stars that always stay ABOVE the horizon? Second, you can check the box "show never rise region" – if this region exists it is obvious what the answer is.

The answer for part c is NOT the sun – the sun is a star that definitely sets, hence nighttime. It is also NOT Polaris; Polaris is this type of star though…

3.) (4 points) "Up" is NOT a direction. If you were looking at Norfolk on a globe and imagining you were a little ant at this spot, would you have to look N, E, S, or W so see these stars?

4.) (4 points) Remember LAtitude lines are parallel to the equator (i.e. rungs on a LAdder). Also remember that the equator is 0 degrees latitude, and as you go towards the north pole (90 degrees latitude) you increase your latitude. You can also increase or decrease your latitude in the simulation by clicking and dragging your white dot around the world map on the bottom-left. This will change how many stars you always see in the top boxes (pro-tip; check the "show circumpolar region" box. From Norfolk, in what direction do you have to drag the white dot for this region to get LARGER?)

5.) (5 points) Imagine taking a long-exposure picture of the night sky over the entire night – sitting at the north pole, what would the resulting images look like? You can also move your white dot to the north pole and check the "long star trails" button in the "star controls" box to visually see what this would look like. You have to imagine being the little stick figure, though!

6.) (4 points) Same thing as question 5, however now move the white dot to the equator.

Part B: Constellations

1) (3 points) Lets first figure out what the image in this part is telling us. See that the Sun is in the center and around it orbits the Earth (the blue arrows). We know that one full revolution around the sun here represents one full year. We also know the Earth rotates about its axis as it revolves around the sun. A specific day of the year is associated with every point along this (blue) orbit. Let's look at one example along this path: August 21 (around the 1 o'clock position). As the Earth rotates about its axis on this day, we know that if we are on the part of the Earth that faces the sun it is *daytime*, and if we are facing away from the sun, it is *nighttime.* Ideally, if the sun is DIRECTLY overhead of us on Earth, it should be around NOON (mid-day; 12:00 pm), and this is represented by the blue dashed arrow pointing from Earth on Aug.21 to the sun. What does the other blue dashed arrow represent? Notice that this other arrow is directly on the other side of the Earth - essentially *12 hours* away from the one pointing to the sun if you think about how long it takes the Earth to rotate *one-half of a full rotation.* This would mean that this second

arrow pointing away from the sun represents what you would see directly overhead at MIDNIGHT (12:00 am; 12 hours after 12:00pm noon).
Represented around the outer perimeter of this picture is the *celestial sphere*, but notice it's only a certain part of it. In this section we will only be interested in the constellations that we can observe by looking *directly overhead* at either noon or midnight, and thus only those constellations are shown. So for our Aug.21 example, directly overhead at midnight (represented by the arrow directly across from the one that points straight towards the sun) we can see *Aquarius*.
Now we have enough info to answer problem 1 here: "what constellations would be directly overhead at midnight in late January." Well, first we can find "late January" on this picture – we see the Earth is around the 8 o'clock position on January 21. Similar to our example we can draw a straight line from Earth on this date to the sun – this is representative what we'd see looking directly overhead at noon. Now think about extending that STRAIGHT line in the other direction until it intersects with the celestial sphere. This is representative of the other arrow from our example: what we'd see directly overhead at midnight. What is the *closest* constellation this straight line intersects on the celestial sphere?

2) (3 points) Now what do the orange circles on this celestial sphere represent? Let's think about being on the Earth in this picture on Aug.21. If the sun were not bright then we would be able to see stars during both the day and night (since we know the only reason we see stars only at night is because the sun is just too bright during the day). The not-so-bright sun in this case would then look to be at a certain location on the celestial sphere – just like how the moon takes its own place among the stars on a clear night. We can find this location on the picture by extending the first blue dashed arrow all the way to the other side of the celestial sphere. Where this line intersects with the celestial sphere is where the sun would appear to be in relation to the other constellations. If this line intersects with a certain constellation, then the sun would *appear* to be located in this constellation. In our example, at noon on Aug.21 the sun appears to be in *Leo!* This is why at this point (where the line through the sun from Aug.21 intersects with the celestial sphere) is labeled with that same date – Aug.21 – because on this date the sun would *appear* to be at this location along the celestial sphere if you looked directly overhead at noon!
Now you can easily figure out question 2, you now are just using YOUR OWN birth month!
3) (3 points) The trick here is realizing that this question is fundamentally *the same* as question 2.
4) (3 points) Now we are going back to the same logic we used to solve question 1 but using your birth month!
5) (3 points) 6 months is half a year, right? So, travel along Earth's orbit for *half a year* (i.e., half an orbit) and then analyze the position of Earth in the same celestial sphere at THIS location.
6) (5 points) Yes, the Earth orbits the sun, but why DOES the night sky seem to change as the year progresses? Think about how the "nighttime" blue dashed arrow changes as you move month-to-month.

Part C: Reasons for the Seasons

1) (1 point) It looks like the Earth revolves around the sun in the same direction the Earth rotates about its axis… The best way to label this image for this section is to "Draw" on the word document. You can do it whatever way you think is best, as long as it is legible to me.
2) (2 points) The whole point of this part is to understand that it is the tilt of the Earth on its axis (relative to the plane on which it orbits around the sun) that causes our seasons – NOT how far away we are from the sun. How is this the case? Well, since this tilt exists, there are times in which the northern hemisphere (i.e. where we live) is tilted towards the sun. This results in the northern hemisphere getting more direct sunlight and thus being warmer than the southern hemisphere (which obviously must be tilted away from the sun, getting less direct sunlight). So, when we are tilted toward the sun we (the northern hemisphere) experience summer, while the southern hemisphere experiences winter. It is not difficult to assume what the inverse means, right? What about when the Earth's axis ISNT tilted towards the sun, as is the case in the top and bottom image (i.e. the 12 o'clock and 6 o'clock positions)? Well, we have pretty much just answered the two extremes (the right and left images), so we can deduce the answer just by knowing the season right after and just before it! Just remember that the northern and southern hemispheres never experience the same season at the same time! Don't forget that for each image on your lab manual you have to label what season the northern AND southern hemispheres are in at that point in the Earths orbit (so you need to label 8 things here).
3) (2 points) This is part of the 8 things you have to label mentioned above.

4) (5 points) The idea here is to start with a prediction: any rational person would predict that it is the distance to the big hot thing in the sky that determines the seasons here on Earth. Thus, this person would PREDICT that this should mean that in the months where we experience the hottest temperatures, we should be the CLOSEST to the sun in our orbit. Now analyze the data table given in the lab manual. Is this actually the case? Discuss what you see here.
5) (5 points) Do a quick google search or look into your textbook to get some real detain on WHY the tilt causes the seasons. Give me a quick summary. Good noodles will incorporate the word 'flux.'
6) (5 points) Think about how much direct sunlight the northern hemisphere would get relative to the southern hemisphere in this new case. Would it be different? How different would each season be relative to each other?

Part D: The Lunar Cycle

1.) (2 points) Click "Start animation" and you should see the Earth begin rotating counterclockwise (hey this is familiar!). The little stick figure on the surface (standing on the equator) is the observer in question. For this question you must first determine what "sunset" is to this observer. This is simple; its basically when the observer is just about to rotate into the dark region, i.e., nighttime (in this case, when the figure is at the six o'clock position). You can click and drag the observer into this position, and also move the moon into position above it ("directly overhead"). The box in the upper-right of the simulation tells you what phase the moon is in according to an observer on Earth. In this position, what is this moon phase?
2.) (2 points) Now do the same as before but considering the moon over the observer's head at SUNRISE.
3.) (2 points) This can be a bit confusing. The best way to figure this out is to use the bottom-right box "horizon diagram" and by considering an example. Let's put the observer on the onset of sunset (i.e. the 6 o'clock position we talked about in question 1. Now put the moon in its "full moon" phase: the 3 o'clock position. Now click "start animation" with the "animation rate" turned down a bit. In the "horizon diagram," see that it turns dark – meaning the observer is experiencing nighttime. Also see that the moon "rises" and is up in the sky for the entire night (rather, the entire time the observer spends on the "dark side"). Keep watching and see that as the moon "sets" and the sun rises (and thus begins daytime and the picture brightens up again). The moon is not up at all during the entire day, and (when the moon is full) only "rises" again after the sun sets.

    For this problem, you are doing something similar, but now you want to know the phase of the moon that can be seen for (FIRST) half of the night and then (SECOND) half of the day. You basically want to play around with the simulator until you get your moon to rise in the middle of the night, guaranteeing it stays up for the rest of the night (half of the night) and then half of the next day (while the sun is out, too). ***pro-tip; note that if your answer is waning crescent then you are close (but wrong) and need to remember what phase you started with when you clicked "start."
4.) (2 points) Now you are doing the same thing as before but looking for what phase the moon is in when you can see it (FIRST) for half of the day and then (SECOND) half of the night.
5.) (5 points) Note here that the instructions state that the full moon is considered "0" in the order, so now you have to order the other 5 correctly (i.e., you should have numbers 0-5). Also note that it may look like two are the same phase (just pictures taken at different times during that phase). This is correct, the difference is important in the next question.
6.) (5 points) This is an exercise is visualization. The one thing you must realize here is what direction the suns rays are coming from! Note that in the lab manual vs. the simulator they are coming from different directions! You have to take this into consideration and imagine what you would see if you were on Earth (i.e., how much of the moon would be lit up).
7.) (2 points) Why do you think a "month" is called that? Sounds a lot like *moonth*…
8.) (2 points) Let's assume a moonth is always 4 weeks. Thus, a lunar cycle easily breaks up into quarters; one per week. If the moon is full, what phase would it be in one-quarter of a lunar cycle in the future?
9.) (3 points) We just discussed that one lunar cycle is one moonth, so this should be easy now.
10.) (10 points) We know that there IS a side we never see (since the moon is tidally locked to Earth). Does that mean that side is always "dark"? Elaborate a bit on your thoughts here.