Name:
Group Members:

Lab 5

I. Starry Night

We will be using the Starry Night planetarium software tonight, which you have not yet used this semester. Thus the first portion of the lab is just a tutorial to get you familiar with the basic operations and ways to use the software.

(A) Open Starry Night and click on the "Sky Guide" tab on the left hand side of the screen. Then click on "Student Exercises", followed by "Tutorial". Work your way through the tutorial, answer the questions in the spaces below.

1. _____ 2. _____ 3. _____ 4. _____ 5. _____ 6. _____ 7. _____

II. Comparing Views

We are now going to make several observations of the Moon, Mars, and the star Antares, first from the Northern Hemisphere and then from the Southern Hemisphere. Only the latitude will be changing, the longitude and everything else will stay constant. In these observations:

(A) Do you expect the measured Azimuth to vary from North to South? (Yes or No)

(A) ____________

(B) Do you expect the measured Altitude to vary from North to South? (Yes or No)

(B) ____________

(C) Do you expect the measured Right Azimuth to vary from North to South? (Yes or No)

(C) ____________

(D) Do you expect the measured Declination to vary from North to South? (Yes or No)

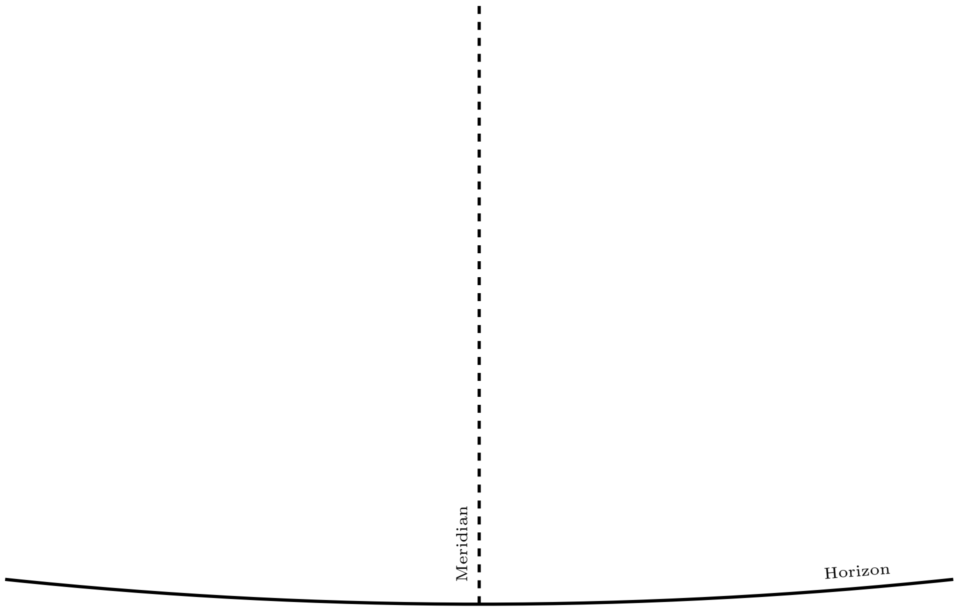
(D) ____________

III. A View from the North

Set up your observation following the below procedure:

- Set your location to **Salem** and the date/time to 1:00am on May 22, 2016
- Click on the **S** button near the upper right of the screen so that you are facing due South. You should be able to see the Moon!
- In the **Find** panel (left side of the screen), check on the box to the left of Mars, which should label Mars on your screen.
- Also in the **Find** panel, use the search box to look for the star Antares. Pressing enter will likely already check the box to make it visible, but if not check the box.
- In the **Options** panel (just below the Find panel), expand the **Alt-Az Guides** section and then check on **Meridian** to draw the meridian onto your screen.

(A) In the diagram below, which shows the horizon and the meridian, sketch in the relative locations of the Moon, Mars, and Antares at 1:00am. Label the compass directions as you see them on your screen and include a rough scale of the altitude along the meridian (e.g. Where is 10°? Where is 20°?)



(B) Step time forward (in minute increments) until Mars crosses the meridian. Record the time, the approximate altitude and azimuth, and the exact RA(JNow) and Dec(JNow) of Mars in the "Northern Hemisphere Observations" table. **Be sure that you do not round your RA and Dec numbers!**

(C) Step time forward more until the Moon crosses the meridian. Again, record the time, altitude, RA, and Dec of the Moon in the table.

(D) Step time forward one more time until Antares crosses the meridian. Again, record the time, altitude, RA, and Dec of Antares in Table 1.

Object	Mars	Moon	Antares
Time of Transit			
Compass Dir			
Altitude			
RA(JNow)			
Dec(JNow)			

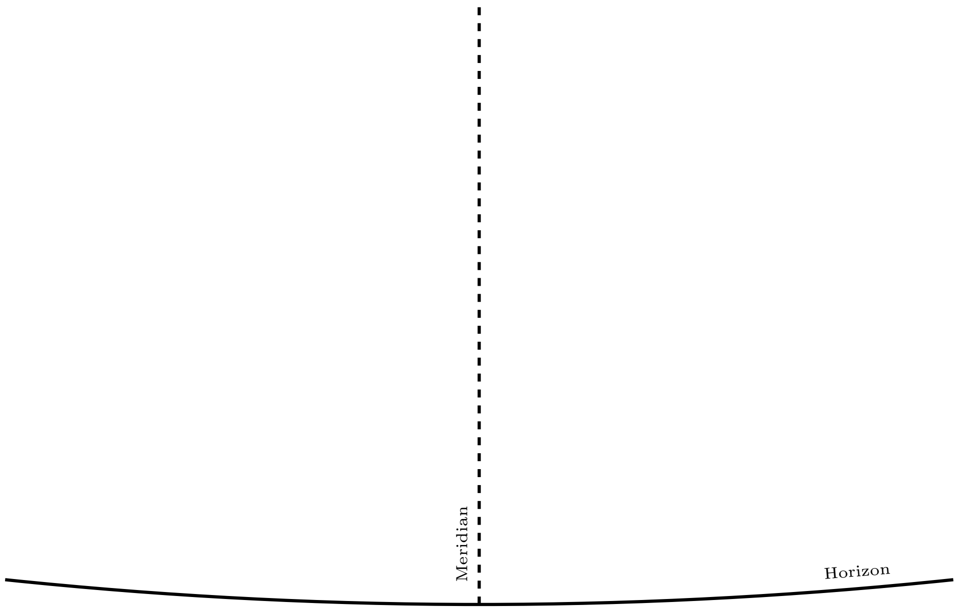
Table 1: Northern Hemisphere Observations

IV. **A View from Down Under**

Now we want to view the same situation, but from the Southern Hemisphere:

- Change the **Viewing Location** by clicking on "Salem, United States," and then on "Other." Click on the "Latitude/Longitude" tab, and change the *N* in the latitude box to *S*. Then click on **Go to Location**. This should take you to a location in the Southern Hemisphere with the same longitude as Salem, but 45° S of the Equator instead of 45° N.
- Reset the date/time to 1:00am on May 22, 2016.
- Click on the **N** button near the upper right of the screen so that you are facing due North. (Recall that objects cross the meridian opposite in the Southern Hemisphere.)
- Drag upwards on the screen to find the Moon, Mars, and Antares. They are higher in altitude than previously.

(A) In the diagram below, sketch the relative locations of the Moon, Mars, and Antares at 1:00am. Label the compass directions as you see them on your screen.



(B) Repeat the observations you made for the Northern Hemisphere, recording your values in the "Southern Hemisphere Observations" section in Table 2.

Object	Mars	Moon	Antares
Time of Transit			
Compass Dir			
Altitude			
RA(JNow)			
Dec(JNow)			

Table 2: Southern Hemisphere Observations

V. **The Distance to the Sun!**

Now you'll want to compare your Northern and Southern observations. For each of the three objects, calculate how much the RA(JNow) and Dec(JNow) change when you move from the Northern Hemisphere to the Southern Hemisphere. Write your answers in Table 3.

	N. Hemisphere RA - S. Hemisphere RA (in minutes)	N. Hemisphere Dec - S. Hemisphere Dec (in degrees and arcminutes)
Mars		
Moon		
Antares		

Table 3: Parallax Shifts of various objects.

(A) The changes in the coordinates that you see are the result of geocentric parallax; objects appear to be in slightly different locations on the celestial sphere when viewed from different locations on Earth. The observing locations have been chosen so that this shift is entirely in declination rather than right ascension.

1. Which object shows the largest parallax shift?

   1. ____________

2. Which object shows the smallest parallax shift?

   2. ____________

3. Is this consistent with what you know about the relationship between parallax shift and an object's distance from the Earth? Explain.

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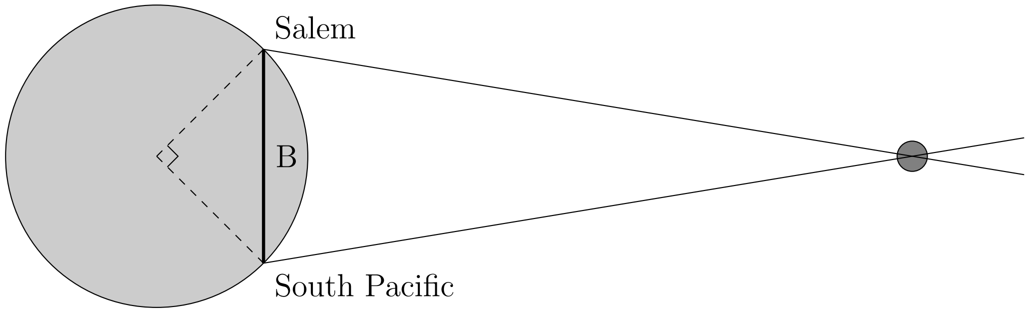
   ....

   ....

(B) Since you will need them later, convert the angular shifts from degrees and arcminutes to decimal degrees (eg. $1°30' = 1.5°$).

- Declination shift of Mars in degrees: ____________
- Declination shift of the Moon in degrees: ____________

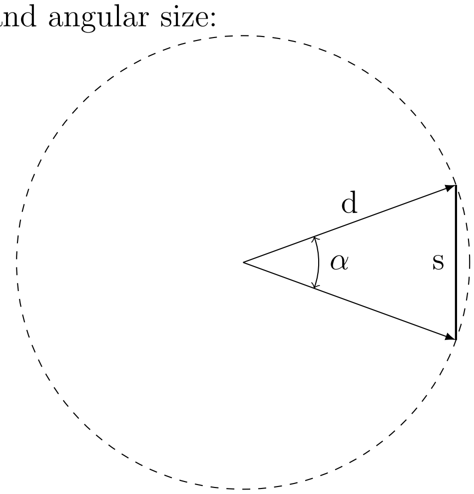
(C) The diagram below shows the basic geometry of parallax (though obviously not to scale!).



1. On the diagram, mark the angle you are measuring when you measure declination shift as viewed from your two locations.
2. Because the latitude of Salem is very close to 45°, the angle at the center of the Earth is very close to 90°. Use the Pythagorean theorem and the fact that the radius of the Earth is about 6360 km to find the length of the "baseline" between the observing locations (Labeled B in the diagram).

2. ____________

3. We previously used the below equation to determine the relationship between distance and angular size:



$$\frac{\alpha}{360} = \frac{s}{2\pi d}$$

We can flip it around a bit here to correspond to our particular situation. Check back at the previous figure if you need help working out what is what.

- The declination shift in degrees corresponds to the variable: ____________
- The "baseline" B corresponds to the variable: ____________
- The distance to the astronomical object corresponds to the variable: ____________

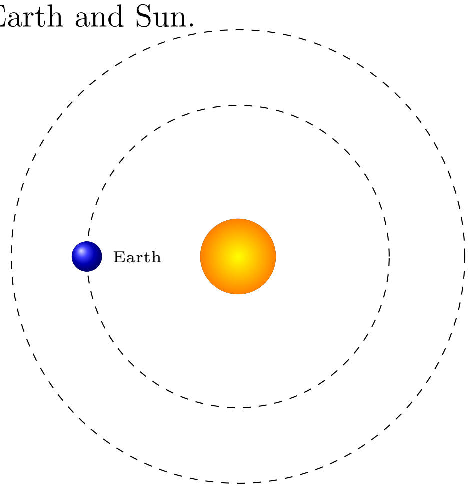
(D) Use the angular size / distance formula above along with your identified variables to find the distance to the Mars and to the Moon, in kilometers.

Distance to Mars: ____________

Distance to the Moon: ____________

(E) Since Kepler's Laws give you the relative sizes of the planets' orbits, the distance to Mars can be used to estimate the distance to the Sun! To get there though, we need to work out a few other things.

1. In the observations you made, Mars is transiting close to astronomical midnight (1am in daylight savings time!). On the diagram below, mark the position of Mars relative to the Earth and Sun.



2. Mars has an orbital period of 1.88 years. What is the semi-major axis of its orbit in AU?

2. ____________

3. With the assumption that both the Earth and Mars have circular orbits (as seen in the diagram), what is the distance in AU between the Earth and Mars at the time of the observations?

3. ____________

4. Use your answer above, along with the distance to Mars you found earlier to estimate the Earth-Sun distance in kilometers. If it is not clear how to do this, think about the ratio:

$$\frac{\text{Earth-Mars distance in AU}}{\text{Earth-Sun distance in AU}} = \frac{\text{Earth-Mars distance in km}}{\text{Earth-Sun distance in km}}$$

4. ____________

5. How does this compare with the modern value of the AU, which is approximately $1.50 \times 10^8\,\text{km}$?

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