

## The Rotating Sky – Student Guide

Pretest Score: \_\_\_\_\_

### Horizon Coordinates

Work through the explanatory material on *the Observer*, *Two Systems – Celestial, Horizon, Bands in the Sky*, and *the Paths of Stars*. All of the concepts that are covered in these pages are used in the Rotating Sky Explorer and will be explored more fully there.

- Open the **Rotating Sky Explorer**

The Rotating Sky Explorer consists of a flat map of the Earth, Celestial Sphere, and a Horizon Diagram that are linked together. The directions below will help you fully explore the capabilities of the simulator.

- You may click and drag either the celestial sphere or the horizon diagram to change your perspective.
- A flat map of the earth is found in the lower left which allows one to control the location of the observer on the Earth. You may either drag the map cursor to specify a location, type in values for the latitude and longitude directly, or use the arrow keys to make adjustments in  $5^\circ$  increments. You should practice dragging the observer to a few locations (North Pole, intersection of the Prime Meridian and the Tropic of Capricorn, etc.).
- Note how the Earth Map, Celestial Sphere, and Horizon Diagram are linked together. Grab the map cursor and slowly drag it back and forth vertically changing the observer's latitude. Note how the observer's location is reflected on the Earth at the center of the Celestial Sphere (this may occur on the back side of the earth out of view).
- Continue changing the observer's latitude and note how this is reflected on the horizon diagram. When the observer is in the northern hemisphere the NCP is seen above the north point on the horizon at an altitude equal to the observer's latitude. When the observer is in the southern hemisphere the SCP is seen above the south point at an altitude equal to the observer's latitude.
- The Celestial Sphere and Horizon Diagram are also linked in that any stars are added to the simulation are shown on both. There are many features related to stars.
  - A star will be randomly created by clicking the **add star randomly** button.
  - A star may be created at a specific location on either sphere by shift-clicking at that location. (Hold down the shift key on the keyboard while clicking at that spot.)
  - You may move a star to any location by clicking on it and dragging it. Note that it moves on both spheres as you do this.

- Note that the celestial equatorial and horizon coordinates are provided for the “active” star. Only one star (or none) may be active at a given time. Simply click on a star to make it the active star. Click on any other location to make no star active.
- If you wish to delete a star, you should delete-click on it. (Hold down the delete key on the keyboard while clicking on the star.)
- You may remove all stars by clicking the **remove all stars** button.
- Note that stars are the vehicle by which you make coordinate measurements. If you want to make a measurement in either diagram – you place the active star at that location.
- There are several modes of animation as well as a slider to control speed.
  - You may turn on animate continuously or for preset time intervals: 1 hour, 3 hours, 6 hours, and 12 hours.
  - If you click-drag a sphere to change its perspective while the simulator is animating, the animation will cease. Once you release the mouse button the present animation mode will continue.
- This simulator has the power to create star trails on the horizon diagram.
  - A series of check boxes set the star trails option. **No star trails** is self-explanatory. **Short star trails** creates a trail behind a star illustrating its position for the past 3 hours. **Long trails** will trace out a parallel of declination in 1 sidereal day.
  - Stars are created without trails regardless of the trail option checked. If either short or long trails is checked, the trail will be drawn once the simulator is animated.
  - Existing star trails will be redrawn in response to changes – the star being dragged on either sphere or changing the observer’s location.
- What’s not in this simulation? – the revolution of the Earth around the sun. This simulator animates in sidereal time. One sidereal day (one 360° rotation of the earth) is 23 hours and 56 minutes long. You should think of this simulator as showing the Earth isolated in space as opposed to revolving around the sun.

Question 1: Complete the following table involving the horizon coordinate system. You should predict the answers and then use the simulator to check them. Remember that you can measure coordinates by dragging the active star to that location.

Description	Latitude	Azimuth	Altitude
West point of the horizon	Any		
Zenith	Any	Any	
NCP	30°N		
SCP	52°S		
SCP	Tropic of Capricorn		
Intersection of CE and Meridian	41°N		
Intersection of CE and Meridian		0°	35°

Question 2: Polaris is a very important landmark in the sky since it is located very near the NCP. The two end stars of the Big Dipper are known as the “pointer stars” since a line drawn through them points toward Polaris.

(A) Create an animation of the pointer stars revolving around Polaris. You will need to add the 7 stars of the Big Dipper and Polaris to the simulator.

Star Name		RA	DEC
Alpha UMi	Polaris	2.5h	+89.3°
Alpha UMa	Dubhe	11.1h	+61.8°
Beta UMa	Merak	11.0h	+56.4°
Gamma UMa	Phecda	11.9h	+53.7°
Delta UMa	Megrez	12.3h	+57.1°
Epsilon UMa	Alioth	12.9h	+56.0°
Zeta UMa	Mizar	13.4h	+54.9°
Eta UMa	Alkaid	13.8h	+49.3°

(B) Is this “cosmic landmark” useful to everyone? On what parts of the earth is it always available, sometimes available, or never available? \_\_\_\_\_

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Question 3: Setup the simulator for a latitude of  $40^\circ$  N and then create stars at the following coordinates and assume the simulator reflects time  $t = 0$ . You will be asked to make predications about the locations and motions of the stars as time advances. After recording your predictions (in the column labeled predictions) you should use the simulator to check your answer. If your original prediction was in error, record the correction in the next column.

Star	Azimuth	Altitude
A	$0^\circ$	$20^\circ$
B	$90^\circ$	$0^\circ$
C	$180^\circ$	$-20^\circ$

Question	Predictions	Corrections
What will be the coordinates of star A at $t = 6$ hours?		
At $t = 12$ hours		
At $t = 24$ hours		
For what fraction of the day is star A visible?		
What will be the coordinates of star B at $t = 3$ hours?		
At $t = 6$ hours?		
At $t = 12$ hours?		
For what fraction of the day is star B visible?		
What will be the coordinates of star C at $t = 6$ hours?		
For what fraction of the day is star C visible?		

Question 4: In which of the 3 declination ranges (circumpolar, rise and set, or never rise) are stars A, star B, and star C found?

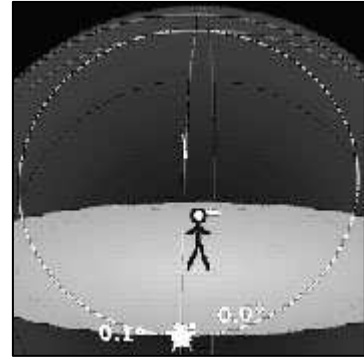
Star A: \_\_\_\_\_

Star B: \_\_\_\_\_

Star C: \_\_\_\_\_

Star	Azimuth	Altitude
A	0°	20°
B	90°	0°
C	180°	-20°

Let's explore the boundaries of these 3 regions. Make sure you are still at a latitude of 40° N, create a star, select the long trails option for star trails, and animate for 24 hours so that a complete parallel of declination is made for the star. Now drag this active star so that it is at the north point of the horizon. (Make sure the star is active so you can read off its coordinates.) Note that a star with a slightly smaller declination would dip below the north point while a star that is closer to the NCP would obviously be circumpolar. Thus, this star's declination is a limiting value for the circumpolar declination range. Complete columns 2 and 3 for each of the given latitudes.



Latitude	North Point Declination	Circumpolar Range	South Point Declination	Rise & Set Range
10° N				
25° N				
40° N	+50°	+50° to +90°		
55° N				
70° N				

Now drag the star to the south point on the horizon and read off the star's declination. This is a limiting value for the never rise declination range. You should now be able to complete columns four and five in the table above.

Question 5: Set the simulator up for an observer on the equator. Create some stars (~20) in the simulator and click animate continuously. Describe the circumpolar stars seen from the equator. \_\_\_\_\_

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Question 6: Set the simulator up for an observer at the south pole. Make sure that there are still stars (~20) in the simulator and click animate continuously. Describe the circumpolar stars seen from the south pole. \_\_\_\_\_

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Question 7: Use your experiences from questions 4, 5, and 6 to help you state a general rule for identifying the three declination ranges given the observer's latitude. \_\_\_\_\_

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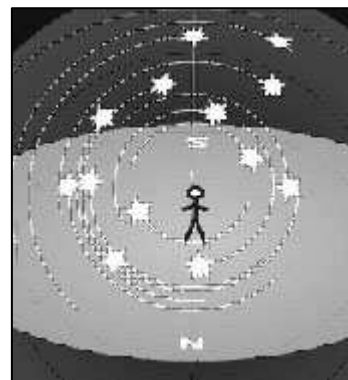
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Question 8: Visualizing star trails is an important skill that is very closely related to declination ranges. Again set up the simulator for a latitude of  $40^\circ$  N, create about 20 stars randomly in the sky, turn on long star trails, and click animate continuously. The view to the right illustrates the region around the north celestial pole. Realize that we need to imagine what these trails would look like from the stick figure's perspective.



Sketch the star trails from the observer's perspective for each of the following latitudes and directions.

Latitude	Direction	Star Trail Description
40° N	N	
40° N	S	
40° N	E	
40° N	W	
90° N	??	
0° N	E	
0° N	N (or S)	

Question 9: Note that the simulator has a display option that illustrates the angle that the celestial equator makes with the horizon. The angle will be nearly the same for other parallels of declination (i.e. star trails) near the east or west point. Use the table below to record the star trail angle for rise and set stars at various latitudes.

Latitude	Direction	Star Trail Angle
10° N	E	
25° N	E	
40° N	E	
55° N	E	
70° N	E	

Question 10: Describe a general rule for determining your latitude from looking at star trails. \_\_\_\_\_

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**Posttest Score:** \_\_\_\_\_