Name: ______________________________

Motions of the Sun – Student Guide

Seasonal Motion

Work through the explanatory material on *Sidereal vs. Synodic* and *Seasons and the Zodiac*. All of the concepts that are covered in these pages are used in the Paths of the Sun Simulator.

Question 1: For each of the following statements respond shorter, the same, or longer.

(A) If the Earth revolved more rapidly, its sidereal day would be _______________.

(B) If the Earth revolved more rapidly, it solar day would be ________________.

(C) If the Earth rotated more rapidly, its sidereal day would be _______________.

(D) If the Earth rotated more rapidly, it solar day would be ________________.

Question 2: Use the Zodiac Explorer to answer the following questions.

(A) On May 25th, the sun is in the constellation of ___________________.

(B) What would be a good time of year to observer the constellation Aries?

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(C) On July 4th at midnight, the constellation __________________ is on the observer's meridian.

(D) At sunrise on Christmas Day, the constellation on the observer's meridian is

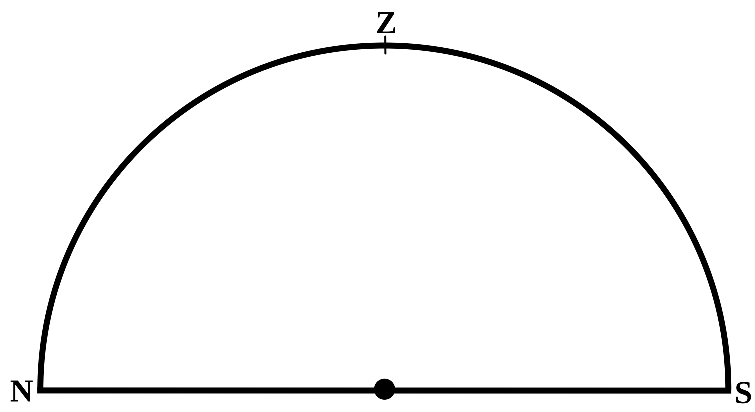
______________________.

Daily Motion with Seasonal Effects

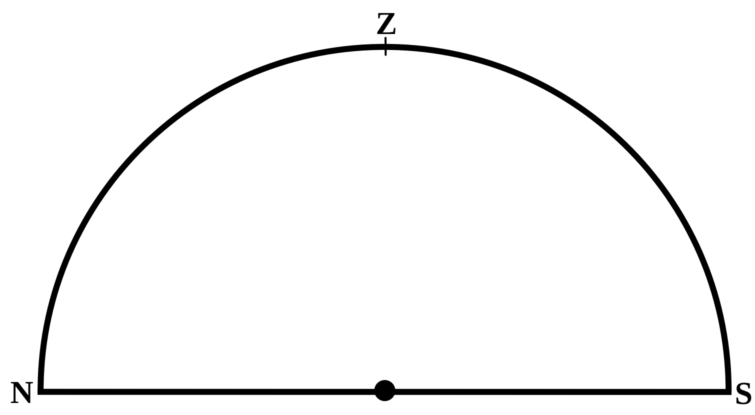
Work through the explanatory material on *Meridional Altitude* and *Sun Paths.*

Question 3: Complete the following table on meridional altitudes. You are encouraged to check your answers with the meridional altitude explorer, but you should make every effort to solve these problems yourself first. Note that part D is completed for you.

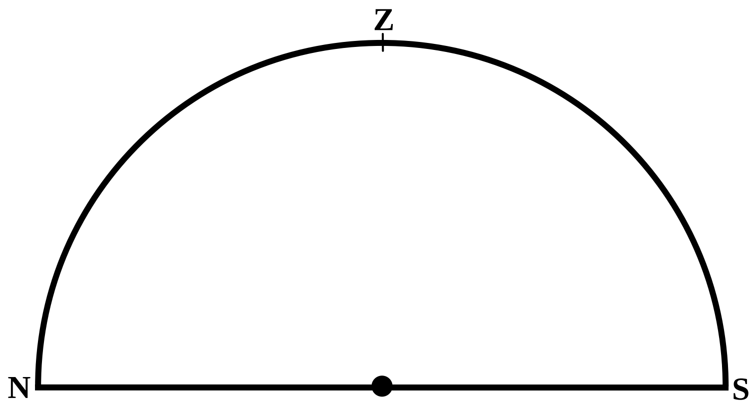
Location	Object	Meridional Altitude
North Pole (lat = 90°N)	Betelguese (dec. = +7)	



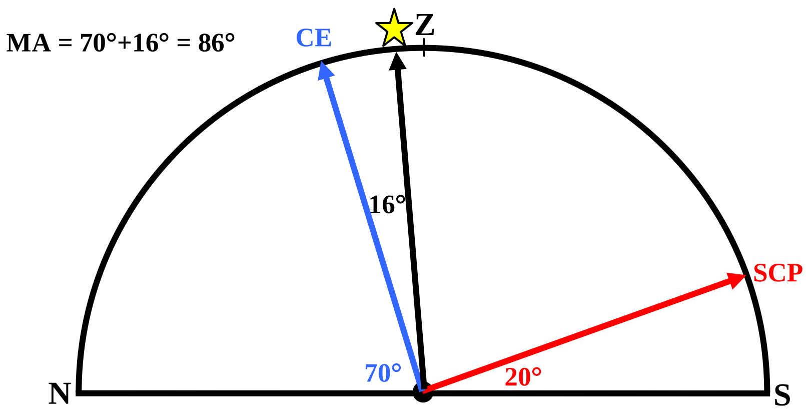
Location	Object	Meridional Altitude
Equator (lat = 0°)	Sirius(dec = -16°)	



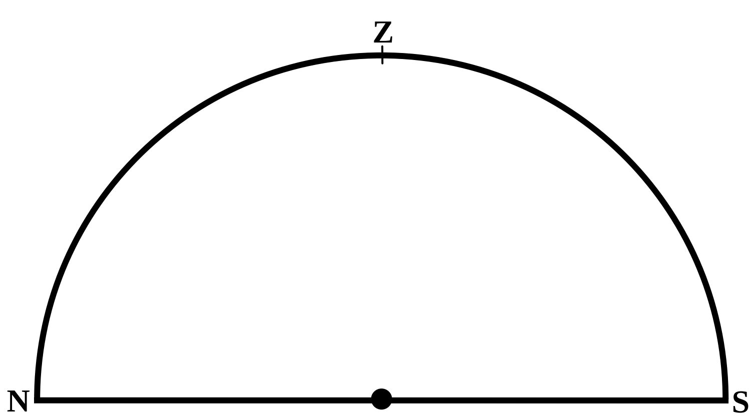
Location	Object	Meridional Altitude
Lincoln NE (lat = 41°N)	Summer Solstice Sun	



Location	Object	Meridional Altitude
Iquique, Chili (lat = 20°S)	Sirius(dec = -16°)	86°



Location	Object	Meridional Altitude
Ann Arbor, MI (lat = 42ºN)	Capella (dec = +46º)	



Paths of the Sun Simulator

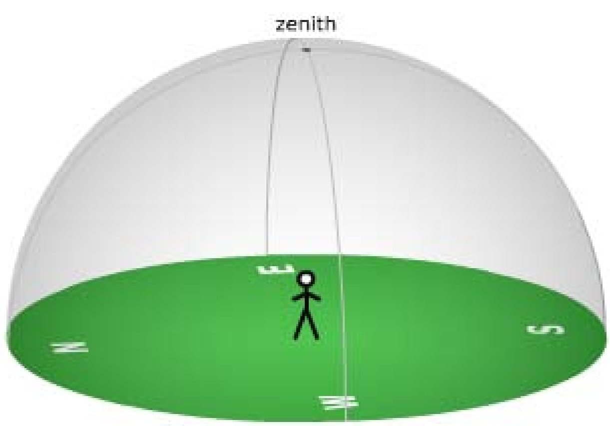
This simulator allows you to simulate the path of the sun for any date during the year for any latitude on the Earth. Spend some time familiarizing yourself with the simulator – most of the controls are fairly intuitive and similar to those in the preceding modules.

- Practice using the yearly slider to move to different dates during the year.
- Practice using the map to move to different latitudes during the year.
- Note that the simulation lists the right ascension, declination, azimuth, and altitude for the sun at all times.
- Note that some advanced features such as the sidereal time, hour angle, equation of time, and the analemma are available in a box in the lower left in this simulation, but will not be covered in this guide.
- Note that there are three different animation modes.
  - If you select **continuous**, time will move forward in a natural fashion. You may adjust the rate at which time passes using the animation speed slider. You may modify this mode with the **loop day** check box which will cause the sun's motion for the current day to continually repeat.
  - If you select **step by day**, time will leap forward in 24 hour increments and the time of day will not change.
- Special care should be taken to make sure that you understand what is being simulated at all times. This is especially true in regard to discriminating between the yearly and daily motion of the sun.
  - Move to a middle United States Latitude like 35°N. Click **show ecliptic** and **show month labels**. This is the sun's yearly path on the celestial sphere and is denoted by a white circle in the simulator. Note that it crosses the blue celestial equator on the equinoxes.
  - Change your time to noon (12 pm) and animate the simulator in the step by day mode. You can watch the changing meridinal altitude of the sun throughout the year.
  - Stop the simulation near the summer solstice. The simulator readout should state "The horizon diagram is shown for an observer at latitude 35° on 21 June at 12:00 (12:00 pm)". Think about what the sun's path should look like in the sky on that day.
  - Now check **show the sun's declination circle** which is a yellow circle in the simulator. This is what the sun's path in the sky would be on the summer solstice. Note that this circle has the proper meridinal altitude (78.8°) and is a coaxial circle with the celestial equator (picture the slinky).

Question 4: Set up the simulator for Lincoln, NE which has a latitude of 41° N. Complete the following chart for the meridional altitude and the rising and setting azimuths for the 3 major paths of the sun. Note that the rising azimuth can be determined by dragging the sun (dragging in time of day mode) and reading off the azimuth when the altitude is zero.

Date	**Meridional Altitude**	**Rising Azimuth**	**Setting Azimuth**
Summer Solstice			
Autumnal Equinox			
Winter Solstice			

Now use the results from the table above to help you draw the 3 paths in the horizon diagram below. Label each path.



Question 5: Suppose that you are visiting Lincoln, NE and on July 10 you wake up early and note the rising azimuth of the sun. In which direction would the value change if you measured it two weeks later?

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Question 6: Note that the sun can never be at the zenith for Lincoln (lat = 41ºN)? How far would you need to move on the Earth to find a latitude where the sun can be at the zenith?

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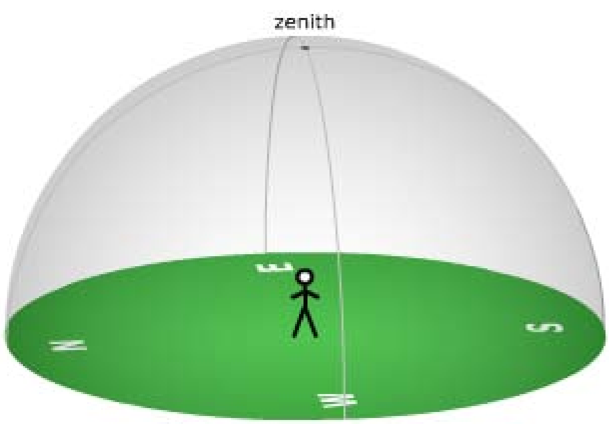
Question 7: Set up the simulator for Nordkapp, Norway which has a latitude of 71° N. Complete the following chart for the meridional altitude and the rising and setting azimuths for the 3 major paths of the sun.

Date	**Meridional Altitude**	**Rising Azimuth**	**Setting Azimuth**
Summer Solstice			
Autumnal Equinox			
Winter Solstice			

Now use the results from the table above to help you draw the 3 paths in the horizon diagram below. Label each path.



Question 8: Note that the sun doesn't rise every day from Nordkaap. How far would you need to move on the Earth to find a latitude where the sun does rise every day?

Question 9: The Paths of the Sun Simulator is also very useful for determining how long the sun is above the horizon each day. Simply make sure that the option for dragging the sun's disk is set to **time of day** and drag the sun to the eastern/western horizon read the clock to determine the time at which the sun rises/sets.

Latitude	**Date**	**Rising Time**	**Setting Time**	**Total Time**
0º	June 21			
	Sept 21			
	Dec 21			
41º	June 21	4:35	19:35	15:00
	Sept 21			
	Dec 21			
66.5º	June 21			
	Sept 21			
	Dec 21			
90º	June 21			
	Sept 21			
	Dec 21	Doesn't rise	Doesn't set	0

Question 10: Based on your answers to the previous questions, is it best to refer to sunlight as a seasonal or daily phenomena? Does this depend on latitude?