5th Grade Curriculum
Space Systems: Stars and the Solar System

An electronic copy of this lesson in color that can be edited is available at the website below, if you click on Soonertarium Curriculum Materials and login in as a guest. The password is "soonertarium". http://moodle.norman.k12.ok.us/course/index.php?categoryid=16

PART 1 – MOVEMENT AND PATTERNS OF THE SKY

ACTIVITY – PATH OF SHADOWS

This activity involves having a student trace another student's shadow outside with chalk at different times of the day to observe the length and direction of the shadows during the day relative to the position of the sun.

The McDonald Observatory in Texas has developed classroom activities & resources available at (http://mcdonaldobservatory.org/teachers/classroom), and this activity was taken from (http://stardate.org/sites/default/files/pdfs/teachers/ShadowPlay.pdf).

ACTIVITY – EXPERIMENTING WITH SHADOWS

This activity involves having students explore how to make shadows with a flashlight. The students are then asked to take measurements of the length of the shadow as the flashlight is moved to different positions around a plastic hemisphere so that they can use the measurements to create a bar graph of the data.

The McDonald Observatory in Texas has developed classroom activities & resources available at (http://mcdonaldobservatory.org/teachers/classroom), and this activity was taken from (http://stardate.org/sites/default/files/pdfs/teachers/ShadowPlay.pdf).

ACTIVITY – WHAT MAKES DAY AND NIGHT?

This activity introduces students to the idea that it is actually the earth that orbits the sun instead of the sun orbiting the earth as it appears from our perspective. Students then practice rotating counterclockwise on their own axis in a circle around a lamp to review that the sun rises in the east and sets in the west.

The McDonald Observatory in Texas has developed classroom activities & resources available at (http://mcdonaldobservatory.org/teachers/classroom), and this activity was taken from (http://stardate.org/sites/default/files/pdfs/teachers/ShadowPlay.pdf).

ACTIVITY - KINESTHETIC ASTRONOMY (Part 1 – 3)

PART 1 - THE KINESTHETIC CIRCLE

This part involves having students participate in the kinesthetic circle, which has them actively move around to see why the constellations appear to move through the sky. The students observe the movement of the constellations as they rotate on their own axis. The students also observe different constellations at night, when they are in different parts of the circle during different times of the year.

PART 2 - WILL WE SEE THE SAME STARS IN THE US TONIGHT THAT PEOPLE IN CHINA SAW LAST NIGHT?

This part involves using the kinesthetic circle to help students realize that the path of the stars does not change that much from night to night. The stars seen at night slowly change as the earth moves around the sun over the year. Students are also introduced to the concept that people at the same latitude on opposite sides of the earth will see almost all of the same stars each night.

PART 3 - WHO CAN SEE ORION WHEN?

This part involves having the students practice observing in the kinesthetic circle which constellations they see on the horizon at sunrise and sunset. The students are told which constellations Orion is between, and then they are able to work out during what times of the year Orion is visible in the night sky.

Cherilynn Morrow and Michael Zawaski have developed a program called Kinesthetic Astronomy, which has students take an active role in modeling the movement of the earth with their body orbiting the sun and the orbit is surrounded by an outer circle of the zodiac constellations. The program is part of the Space Science Institute (http://www.spacescience.org/index.php).

Directions: http://www.spacescience.org/education/extra/kinesthetic_astronomy/KASkTimeAug04_lr.pdf

Assessements: http://www.spacescience.org/education/extra/kinesthetic_astronomy/KAAssessmentSkyTimeAug04_lr.pdf

Props: http://www.spacescience.org/education/extra/kinesthetic_astronomy/KAPROPSAug04.pdf

ACTIVITY – WHAT PATTERNS ARE IN THE SKY?

In this activity students make and learn how to use a planisphere to help them become familiar with the constellations in the night sky and review how the constellations move through the night sky.

Uncle Al's Sky Wheel is a straightforward planisphere with instructions that teachers can print off to have their students quickly assemble. The planisphere does a good job of allowing students to control the motion that they learned about in the kinesthetic circle to see what happens to the constellations in the sky throughout the night. The star wheel can be found on NASA's Kepler site: http://kepler.nasa.gov/education/starwheel/

ACTIVITY – VISIT FROM THE SOONERTARIUM

Contact Professor Wisniewski (wisniewski@ou.edu) at the University of Oklahoma about having graduate students come out to your school with the Soonertarium to review the astronomy state standards in a whole new way.

NGSS Standards for 5th Grade Curriculum:

http://www.nextgenscience.org/5ss-space-systems-stars-solar-system

Students who demonstrate understanding can:

5-ESS1-2. **Represent data in graphical displays to reveal patterns of daily changes in length and direction of shadows, day and night, and the seasonal appearance of some stars in the night sky.** [Clarification Statement: Examples of patterns could include the position and motion of Earth with respect to the sun and selected stars that are visible only in particular months.] [*Assessment Boundary: Assessment does not include causes of seasons.*]

Disciplinary Core Ideas

ESS1.B: Earth and the Solar System

- The orbits of Earth around the sun and of the moon around Earth, together with the rotation of Earth about an axis between its North and South poles, cause observable patterns. These include day and night; daily changes in the length and direction of shadows; and different positions of the sun, moon, and stars at different times of the day, month, and year. (5-ESS1-2)

Science and Engineering Practices

Analyzing and Interpreting Data

Analyzing data in 3–5 builds on K–2 experiences and progresses to introducing quantitative approaches to collecting data and conducting multiple trials of qualitative observations. When possible and feasible, digital tools should be used.

- Represent data in graphical displays (bar graphs, pictographs and/or pie charts) to reveal patterns that indicate relationships. (5-ESS1-2)

Engaging in Argument from Evidence

Engaging in argument from evidence in 3–5 builds on K–2 experiences and progresses to critiquing the scientific explanations or solutions proposed by peers by citing relevant evidence about the natural and designed world(s).

- Support an argument with evidence, data, or a model. (5-PS2-1),(5-ESS1-1)

Crosscutting Concepts

Patterns

- Similarities and differences in patterns can be used to sort, classify, communicate and analyze simple rates of change for natural phenomena. (5-ESS1-2)

Cause and Effect

- Cause and effect relationships are routinely identified and used to explain change. (5-PS2-1)

Scale, Proportion, and Quantity

- Natural objects exist from the very small to the immensely large. (5-ESS1-1)

ACTIVITY – PATH OF SHADOWS

Materials:

Chalk — Ruler or Meterstick

Watch

Choose a sunny day to take the students out to a paved area away from trees and buildings in the early morning, around lunch, and later in the afternoon.

Safety: It is important to remind the students frequently to not look directly at the sun since it can damage their eyes.

Early Morning:

1.) Have one member of the group stand still like a statue so that his shadow can be traced.

2.) Using the chalk draw an outline around the shoes of the person who is acting like the statue in the group.

3.) Now draw an outline of the shadow of the person on the ground.

4.) Measure and record the distance from the feet of the statue to the end of the shadow. Remember to include units.

Distance: _________

5.) Draw a smiley face in front of the statue's shoes to represent which way the statue is facing.

6.) Draw an arrow from the statue's shoes pointing towards the direction of the sun. **Remember not to look directly at the sun because it can damage your eyes.**

7.) Write down the time that I say next to the arrow pointing towards the sun.

8.) Write the name of the statue next to the smiley face that you drew.

Around Noon:

9.) Have the same person who acted as the statue earlier stand on the outline of their feet with their face pointing towards the smiley face.

10.) Draw an outline of the shadow of the person on the ground.

11.) Measure and record the distance from the feet of the statue to the end of the shadow. Remember to include units.

Distance: __________

12.) Draw an arrow from the statue's shoes pointing towards the direction of the sun. **Remember not to look directly at the sun because it can damage your eyes.**

13.) Write down the time that I say next to the arrow pointing towards the sun.

Late Afternoon:

14.) Have the same person who acted as the shadow earlier stand on the outline of their feet with their face pointing towards the smiley face.

15.) Draw an outline of the shadow of the person on the ground.

16.) Measure and record the distance from the feet of the statue to the end of the shadow. Remember to include units.

Distance: _______________

17.) Draw an arrow from the statue's shoes pointing towards the direction of the sun. **Remember not to look directly at the sun because it can damage your eyes.**

18.) Write down the time that I say next to the arrow pointing towards the sun.

Questions:

19.) Sketch a picture of the chalk outline in the space to the right.

Make sure to include the direction of the sun for each observation.

It might be helpful to take a picture of one groups chalk outlines, if you have a smartboard that you could use to display the picture to the class during the discussion in the classroom.

20.) What did you notice about the direction of the sun and the direction of the shadow?

Students should have noticed that changing the location of the sun changed the location of the shadow, and that the sun and the shadows should have always been on opposite sides of the statue. In other words, the shadow outline should be a continuation of the line pointing towards the direction of the sun.

21.) Why did the length of the shadow change?

Students will probably say something about the changing position of the sun causing the shadow to change. Try to have them justify their explanations with specific observations from the activity. For example, when the sun is low in the sky the shadow is long, and when the sun is high in the sky, the shadow is short. You may want to ask them to draw out the path of the sun through the sky during the day. It is suggested that this discussion take place right before activity two where the students will explore how to change the size and direction of a shadow with a flashlight inside the classroom. It could be beneficial to leave this as an open question for the students to explore further in the next activity after the students have discussed different possibilities. The students could use their experiences to form a hypothesis of what will happen in activity two when the flashlight is held in different positions.

ACTIVITY – PATH OF SHADOWS

Early Morning:
1.) Have one member of the group stand still like a statue so that his shadow can be traced.
2.) Using the chalk draw an outline around the shoes of the person who is acting like the statue in the group.
3.) Now draw an outline of the shadow of the person on the ground.
4.) Measure and record the distance from the feet of the statue to the end of the shadow. Remember to include units. Distance: _________
5.) Draw a smiley face in front of the statue's shoes to represent which way the statue is facing.
6.) Draw an arrow from the statue's shoes pointing towards the direction of the sun. R**emember not to look directly at the sun because it can damage your eyes.**
7.) Write down the time that I say next to the arrow pointing towards the sun.
8.) Write the name of the statue next to the smiley face that you drew.

Around Noon:
9.) Have the same person who acted as the statue earlier stand on the outline of their feet with their face pointing towards the smiley face.
10.) Draw an outline of the shadow of the person on the ground.
11.) Measure and record the distance from the feet of the statue to the end of the shadow. Remember to include units. Distance: __________
12.) Draw an arrow from the statue's shoes pointing towards the direction of the sun. R**emember not to look directly at the sun because it can damage your eyes.**
13.) Write down the time that I say next to the arrow pointing towards the sun.

Late Afternoon:
14.) Have the same person who acted as the shadow earlier stand on the outline of their feet with their face pointing towards the smiley face.
15.) Draw an outline of the shadow of the person on the ground.
16.) Measure and record the distance from the feet of the statue to the end of the shadow. Remember to include units. Distance: _______________
17.) Draw an arrow from the statue's shoes pointing towards the direction of the sun. R**emember not to look directly at the sun because it can damage your eyes.**
18.) Write down the time that I say next to the arrow pointing towards the sun.

Questions:

19.) Sketch a picture of the chalk outline in the space to the right. Make sure to include the direction of the sun for each observation.

20.) What did you notice about the direction of the sun and the direction of the shadow?

21.) Why did the length of the shadow change?

ACTIVITY – EXPERIMENTING WITH SHADOWS

Group Materials:

Flashlight
6" Ruler (15cm)
Dowel Rod (1 cm Segment)
Plastic Hemisphere
Foam Board

Divide the students into groups of 2-3 students each with the set of materials listed above. Have the students assemble the materials at their desks.

1.) Place the foam board on the desk with the rectangle's long sides being horizontal.
2.) Center the ruler in the rectangular box.
  -Make sure that the students understand that they will be using the centimeter marks on the ruler.
  -Centimeters will be easier in the exploration because students will be required to subtract decimals which should be easier than subtracting fractions.
3.) Locate the middle of the ruler, and place the 1 centimeter dowel rod on top of it.
4.) Place the plastic hemisphere on top of the foam board with 0^o on the plastic hemisphere lined up with 0^o on the foam board.

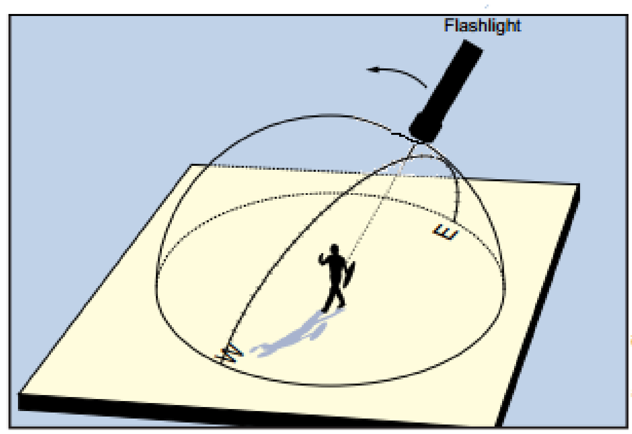
Demonstrate to the class that one member in the group will need to hold down the plastic hemisphere to avoid having the plastic hemisphere slide while another student holds the flashlight against the plastic dome. The students do not want to push the flashlight into the dome to deform it, but the plastic dome is a quick way to make sure that the flashlight is at the same distance and correct orientation as the students explore.

Turn on a small light in another part of the room or leave the door to the classroom open to avoid the classroom being completely dark if all of the flashlights were turned off. Have the students turn on their flashlights, and turn off the overhead lights.

Explore how to create the shadows of the object under the plastic dome, and answer the questions below.

1.) Where is the shadow relative to the sun (the flashlight)?

The flashlight (the sun) is above the shadow, but the shadow and the horizontal direction to the flashlight (the sun) should be in the same line like what was observed outside in activity one.

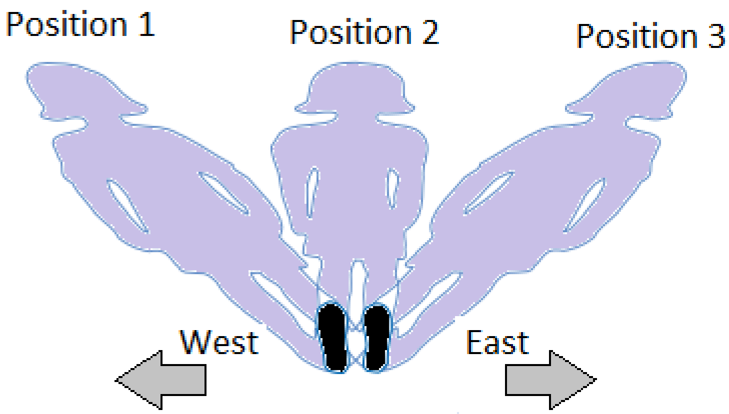


2.) How do you change the direction of the shadow?

Students should explore to show that the shadow is always on the opposite side of the object as the flashlight (the sun). If the shadow is in the west (left side) the flashlight (the sun) is in the east (right side).

3.) How do you make the shadows longer or shorter?

Students should explore to show that when the flashlight (the sun) is lower in the sky the shadows are long, and when the flashlight (the sun) is higher in the sky the shadows are short.



4.) How can you make the shadows move like they did outside as shown in the picture to the left?

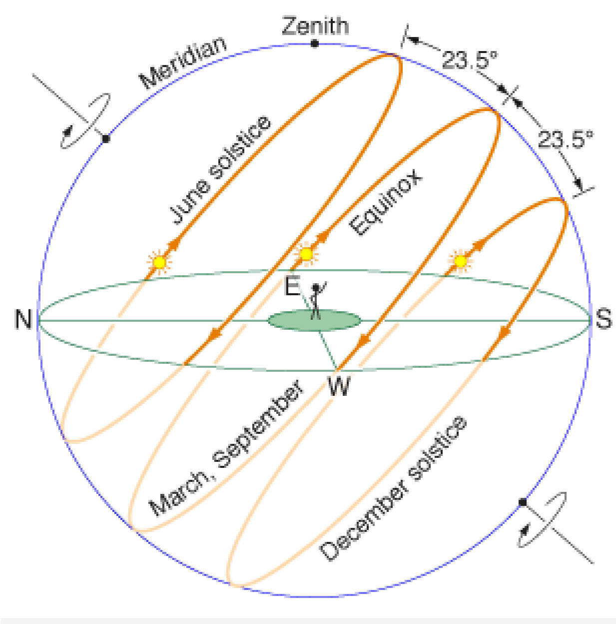
Hints on direction of the flashlight (the sun):

-Where should the flashlight (the sun) be in the sky to cast a northwest shadow in the morning?
The flashlight (the sun) should start in the southeast in the morning.
-Where should the flashlight (the sun) be in the sky to cast a shadow north around noon?
The flashlight (the sun) should be in the south.
-Where should the flashlight (the sun) be in the sky to cast a northeast shadow in the evening?
The flashlight (the sun) should end in the northwest in the evening.

Hints on the height of the flashlight (the sun):

-Where should the flashlight (the sun) be in the sky to cast a long shadow in the morning?
The flashlight (the sun) should start low in the sky in the morning.
-Where should the flashlight (the sun) be in the sky to cast a short shadow around noon?
The flashlight (the sun) should be high in the sky around noon.
-Where should the flashlight (the sun) be in the sky to cast a long shadow in the evening?
The flashlight (the sun) should end low in the sky in the evening.

Putting all of these ideas together the students should make tilted arcs around the plastic sphere like those shown in the figure to the right. The three arcs in the figure represent that the sun rises higher in the sky during the summer and lower in the sky during the winter. The longer path (number of hours of daylight) during the summer is one of the reasons that the summer is warmer than the winter. The reasons for the seasons are covered in much more detail in 7th grade science, but the appendix at the end of this teacher's guide does supply additional information in case an interested student brings up any questions. The focus of this unit is on the path of the sun through the sky during one day, which means that varying the maximum height of the arc is not part of the model.



http://physics.weber.edu/schroeder/ua/SunAndSeasons.html

To get a better idea of how the sun moves across the sky we are going to collect some quantitative data about the length of the shadow when the sun is at different positions in the sky. To simplify the measurement we are going to move the flashlight from east to west along the ridge in the plastic dome to create a shadow that is in line with the object.

Measure the length of the shadow at each of the locations listed below, and record the lengths in the table. Use a negative sign in front of the length of the shadow to represent that the direction of the shadow has changed. Remember to hold the flashlight against the plastic dome when you are taking measurements to make sure that the flashlight is at the right distance and that it is shining in the right direction. This will help make sure that the data that you collect is consistent so that if you did the same measurements tomorrow you would get similar results.

	Angle Above East Horizon	Length of Shadows (Centimeters)
Position 1	20°	4.2
Position 2	40°	1.9
Position 3	60°	1.0
Position 4	80°	.06
Hypothesis 1:	90°	0
Position 5	100°	-.05
Position 6	120°	-1.2
Position 7	140°	-1.8
Hypothesis 2:	160°	-3.8

To understand the data better we are going to set up a bar graph to show the relationship between the angle and the length of the shadow.

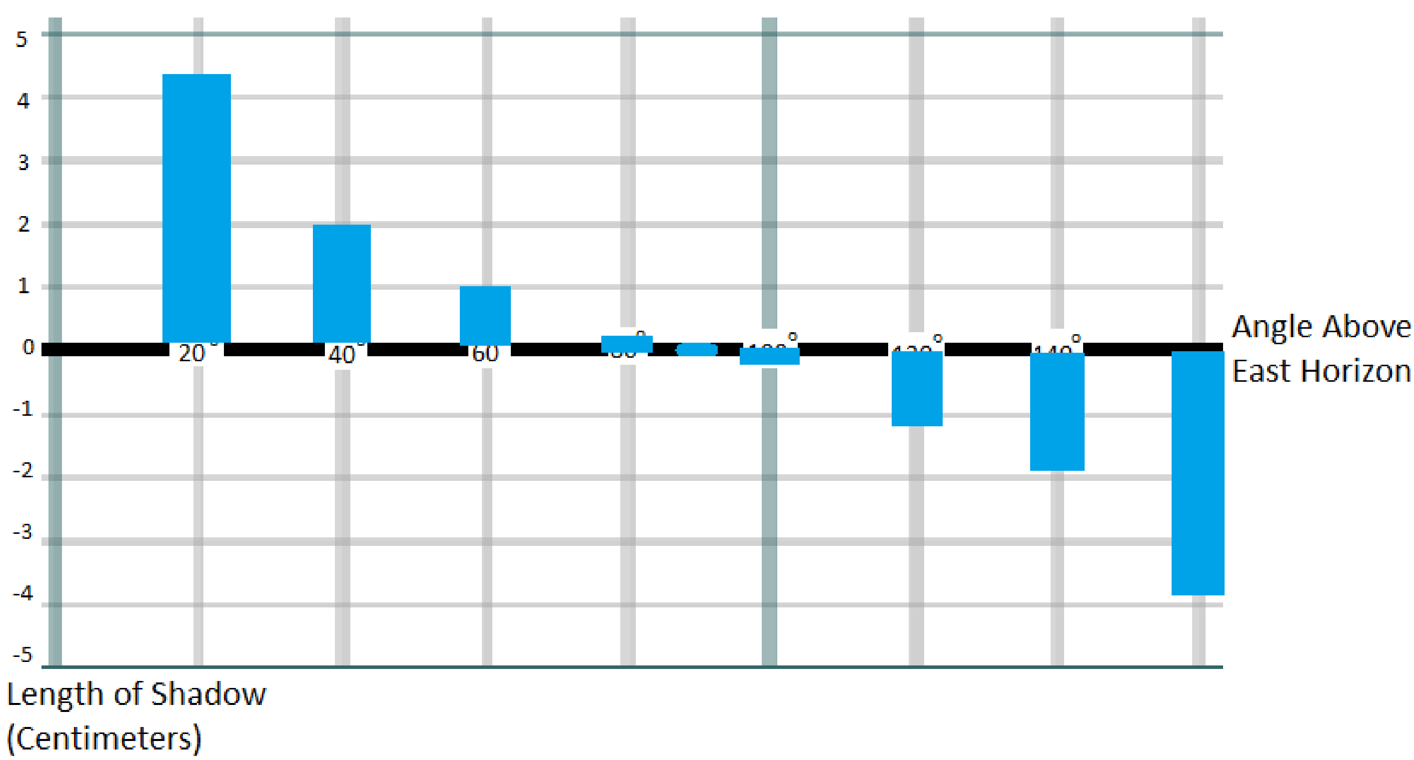
It is suggested that you walk through an example of how to set up the first few data points before having the students complete their own graph while you go around to check progress and answer questions.

1.) Draw a dash (a short horizontal line) above each position to record the length of the shadow. If the length of the shadow was negative this means that it was going in a different direction. So, make the dash below the thick horizontal axis to represent the change in direction.

2.) Draw vertical lines from the edges of the dashes to the thick horizontal axis to make rectangles.

3.) Fill in the rectangles.

Bar Graph of Length of Shadow at Different Positions



Interpreting the Graph

1.) What patterns do you see in the bar graph?

Hints:

In the beginning is the shadow getting longer or shorter?
In the end is the shadow getting longer or shorter?
How does the movement of the flashlight relate to the length of the shadow?

In the beginning which direction is the shadow facing?
In the end which direction is the shadow facing?
How does the movement of the flashlight relate to the direction of the shadow?

2.) Based on the patterns that you found, what do you hypothesize the length of the shadow would be when the flashlight was held directly over the object at 90° above the east horizon? Hypothesis: _around 0 cm_check_

3.) Measure the length of the shadow at 90° to check your hypothesis. Length of Shadow: ______around 0 cm___

4.) Put a check next to your prediction if it was close, and put an X next to your prediction if it was not close.

5.) Add the length of the shadow at 90° to the table between the 80° row and the 100° row.

6.) Add the length of the shadow at 90° to the bar graph by drawing a rectangle between 80° and 100°.

7.) Make a new hypothesis about the length of the shadow when the flashlight was held at 160° above the east horizon. Hypothesis: ___around 4 cm_check___

8.) Measure the length of the shadow at 160° to check your hypothesis. Length of Shadow: ___around 0 cm___

9.) Put a check next to your prediction if it was close, and put an X next to your prediction if it was not close.

10.) Add the length of the shadow at 160° to the table in the row after 140°.

11.) Add the length of the shadow at 160° to the bar graph by drawing a rectangle to the right of 140°.

Bar Graphs visually show the relationship between the data, which can help us pick out patterns that help us make predictions.

12.) Summarize the pattern that we found between the direction of the shadow and the location of the flashlight.

Students should have noticed that changing the location of flashlight (the sun) around the plastic hemisphere (the sky) changed the direction of the shadow, and that the sun and the shadows should have always been on opposite sides of the dowel rod. In other words, the shadow should be in a line pointing towards the direction of the sun. The flashlight (the sun) started in the east and created a shadow in the west, and the flashlight (the sun) ended in the west and created a shadow in the east.

13.) Summarize the pattern that we found between the length of the shadow and the direction of the flashlight.

Students should say something about how changing the height of the flashlight (the sun) causes the shadow to change length. The shadow is long in the morning and evening when the flashlight (the sun) is low on the plastic hemisphere (the sky), and the shadow is short around noon when the flashlight (the sun) is high on the plastic hemisphere (the sky).

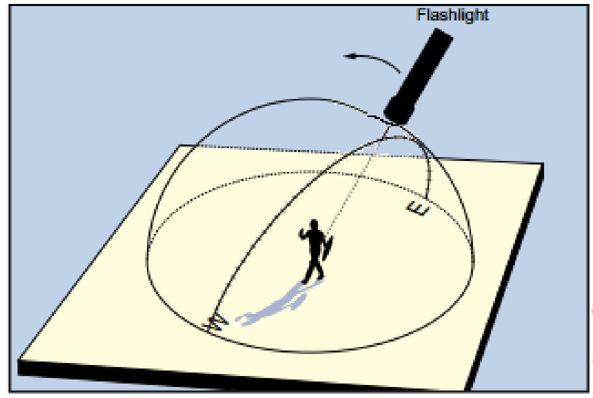
ACTIVITY – EXPERIMENTING WITH SHADOWS

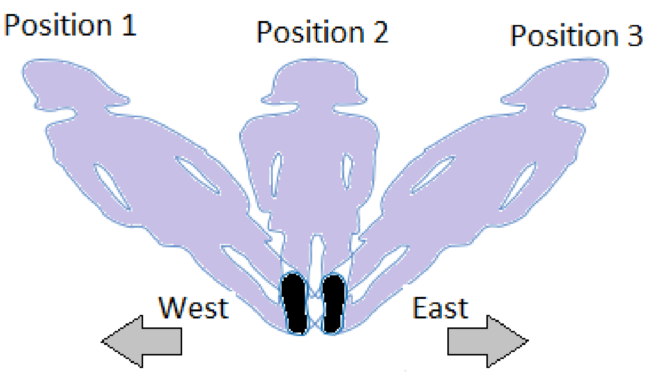
Explore how to create the shadows of the object under the plastic dome, and answer the questions below.

1.) Where is the shadow relative to the sun (the flashlight)?

2.) How do you change the direction of the shadow?

3.) How do you make the shadows longer or shorter?





4.) How can you make the shadows move like they did outside as shown in the picture to the left.

To get a better idea of how the sun moves across the sky we are going to collect some quantitative data about the length of the shadow when the sun is at different positions in the sky. To simplify the measurement we are going to move the flashlight from east to west along the ridge in the plastic dome to create a shadow that is in line with the object.

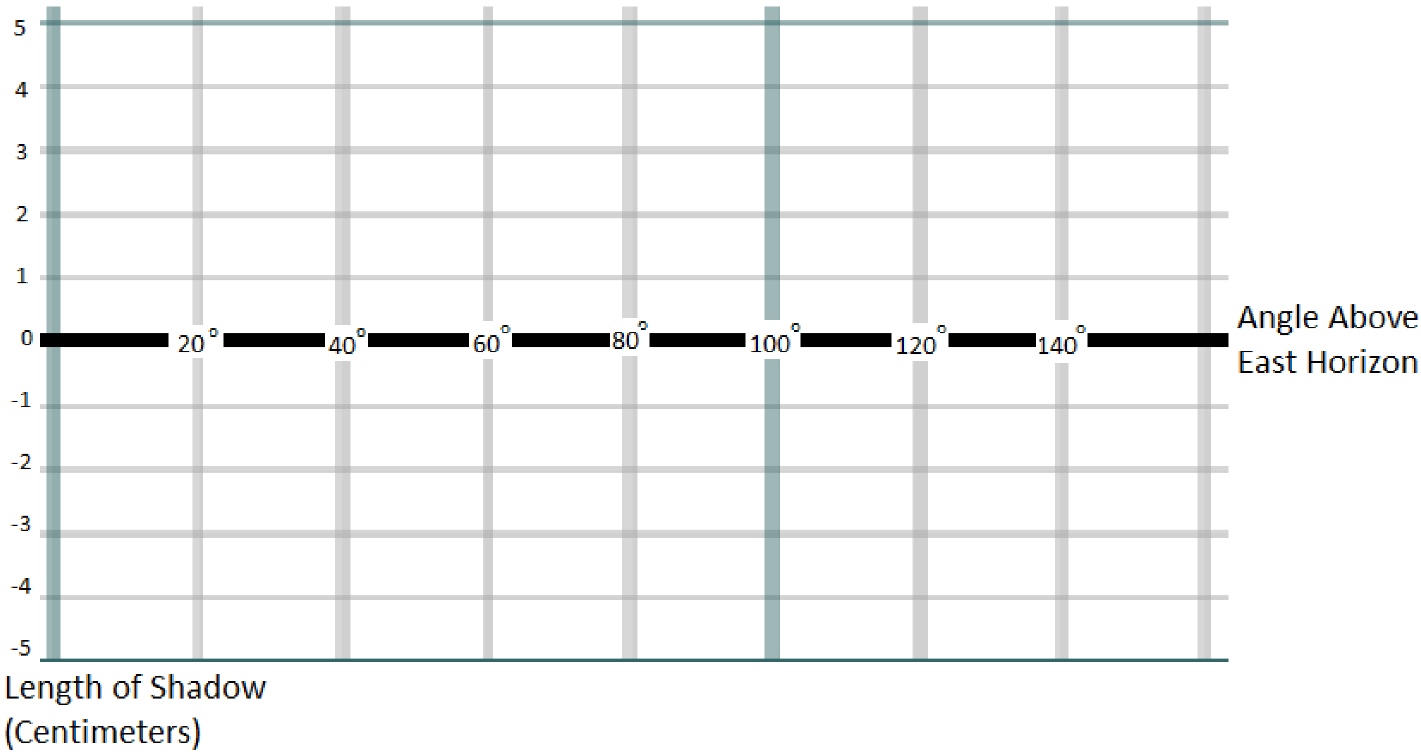
Measure the length of the shadow at each of the locations listed below, and record the lengths in the table. Use a negative sign in front of the length of the shadow to represent that the direction of the shadow has changed. Remember to hold the flashlight against the plastic dome when you are taking measurements to make sure that the flashlight is at the right distance and that it is shining in the right direction. This will help make sure that the data that you collect is consistent so that if you did the same measurements tomorrow you would get similar results.

	Angle Above East Horizon	Length of Shadows (Centimeters)
Position 1	20°	
Position 2	40°	
Position 3	60°	
Position 4	80°	
Position 5	100°	
Position 6	120°	
Position 7	140°	

To understand the data better we are going to set up a bar graph to show the relationship between the angle and the length of the shadow.

1.) Draw a dash (a short horizontal line) above each position to record the length of the shadow. If the length of the shadow was negative this means that it was going in a different direction. So, make the dash below the thick horizontal axis to represent the change in direction.
2.) Draw vertical lines from the edges of the dashes to the thick horizontal axis to make rectangles.
3.) Fill in the rectangles.

Bar Graph of Length of Shadow at Different Positions



Interpreting the Graph

1.) What patterns do you see in the bar graph?

2.) Based on the patterns that you found, what do you hypothesize the length of the shadow would be when the flashlight was held directly over the object at 90° above the east horizon? Hypothesis: ________________

3.) Measure the length of the shadow at 90° to check your hypothesis. Length of Shadow: ________________

4.) Put a check next to your prediction if it was close, and put an X next to your prediction if it was not close.

5.) Add the length of the shadow at 90° to the table between the 80° row and the 100° row.

6.) Add the length of the shadow at 90° to the bar graph by drawing a rectangle between 80° and 100°.

7.) Make a new hypothesis about the length of the shadow when the flashlight was held at 160° above the east horizon. Hypothesis: ________________

8.) Measure the length of the shadow at 160° to check your hypothesis. Length of Shadow: ________________

9.) Put a check next to your prediction if it was close, and put an X next to your prediction if it was not close.

10.) Add the length of the shadow at 160° to the table in the row after 140°.

11.) Add the length of the shadow at 160° to the bar graph by drawing a rectangle to the right of 140°.

Bar Graphs visually show the relationship between the data, which can help us pick out patterns that help us make predictions.

12.) Summarize the pattern that we found between the direction of the shadow and the location of the flashlight.

13.) Summarize the pattern that we found between the length of the shadow and the direction of the flashlight.

ACTIVITY – WHAT MAKES DAY AND NIGHT?

Materials:
Portable Work Light with No Shade
Ruler

Put the students in a big circle around an uncovered lamp in the middle of the room. The overhead lights should be off, but a small additional source of light in the room is suggested for safety. Choose one student to help demonstrate, and have them hold a ruler so that it sticks out from their chest so that it creates a shadow to help demonstrate the ideas to the class.

It might be better to just ask the students the questions and have them summarize the results at the end rather than having all of the students write down the answers during the discussion. Ask the class the following questions.

1.) What are different ways that you can make the length of the ruler's shadow longer or shorter?

All suggestions should be encouraged, and the class should be asked to evaluate if the suggestion would change the lengths of the shadow. All ideas could be written on the board, and the teacher could put checks or X's as the class decided if they would work or not. Once the class hypothesized if the ideas would work or not the teacher could demonstrate each to verify the class hypothesis.

Possible Answers:

-Move the lamp (the sun) around the person (the earth).

If the students do not come up with this one the teacher could ask how shadows were created in activity two. The students should answer by moving the flashlight (the sun) around the person.

-Make the person (the earth) turn in place, but keep the lamp (the sun) in the same place.

If the students do not come up with this one the teacher could ask the students how to change the length of the shadow without moving the sun (the lamp). This could be followed up with a question about how to put the ruler into darkness without moving the sun.

-Walk in a straight line past the lamp (the sun).

-Block out part of the light with an outstretched hand.

2.) If the lamp is the sun, is the ruler experiencing day or night right now?

If the student is facing the lamp, the ruler should be in the light (daytime).

3.) How can you make the ruler change from day to night and night to day?

The students are trying to explain how to have the ruler face the lamp and face away from the lamp. The students should come up with both the explanation that the lamp (the sun) could move around (orbit) the person (the earth) and that the person (the earth) could spin in place (on its axis) with the lamp (the sun) in the same place. However, it is actually the earth that orbits around the sun. It could be a good time to show the following :

Earth Orbiting Sun Animation
http://www.classzone.com/books/earth_science/terc/content/visualizations/es0408/es0408page01.cfm

Solar System Animation
http://www.youtube.com/watch?v=z8aBZZnv6y8

It should be explained that the answer that seems obvious is not always the right answer. From our perspective on the earth it looks like the sun does orbit around the earth, like we saw when we moved the flashlight around the object to change the shadows in activity two. It looks like the sun moves through the sky while the earth remains in place. However, from the bigger perspective of the solar system it is the earth that is rotating around the sun. This alternative view that the earth was orbiting the sun was proposed as early as the 3rd century BC by Aristarchus of Samos, but it was not fully explained until the 16th century when Nicolaus Copernicus proposed a mathematical model of a heliocentric (sun centered) system.

4.) How does day turn into night?

The students should be able to explain that the earth spinning on its own axis creates day and night.

Beginning of kinesthetic model:

This activity will help the students understand the movement of the earth about the sun, and in the next lesson it will be expanded to help students understand the movement of the constellations in the sky. You can have one student put on the oversized earth shirt in the kit to show the class how the sun rises in the east and sets in the west as the student rotates counterclockwise in front of the lamp.

Have the student that is helping demonstrate put his right hand over his heart, but have him continue to hold the ruler in his left hand against his chest. He should spin counterclockwise in place, which is in the direction his right hand is facing. Have the class call out to stop the student momentarily as he passes through sunrise, noon, sunset, and midnight. Have the students take notice of the movement of the shadow as the student spins.

Once the majority of the class is able to tell the demonstrating student where to stop at each time have the rest of the class spread out in the circle and spin in place with a ruler on their chest. Walk through calling out sunrise, noon, sunset, and midnight as the students turn to each location a few times. Make sure that all of the students are turning counterclockwise. Once the students have the hang of doing it in place you could show the earth orbiting the sun animation, and have the students try to spin on their own axis (the path of the earth during a day) while orbiting about the sun (the path of the earth during a year).

You could ask the students how long it takes the earth to complete own rotation about its own axis (1 day = 24 hours), and how long it takes the earth to complete one orbit around the sun (365 days = 1 year).

ACTIVITY – WHAT MAKES DAY AND NIGHT?

1.) What are different ways that you can make the length of the ruler's shadow longer or shorter?

2.) If the lamp is the sun, is the ruler experiencing day or night right now?

3.) How can you make the ruler change from day to night and night to day?

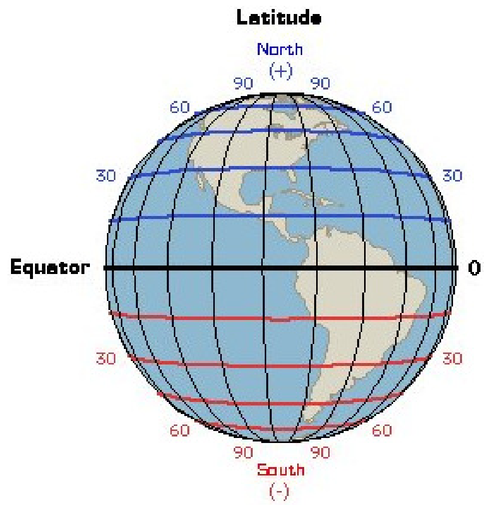
4.) How does day turn into night?

Appendix

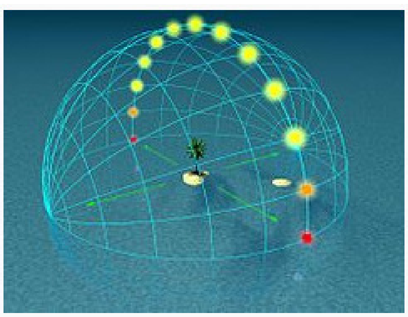
Additional Information about the Path of the Sun at Different Times and Locations

The Sun's Daily Path Viewed from Different Locations on the Earth:

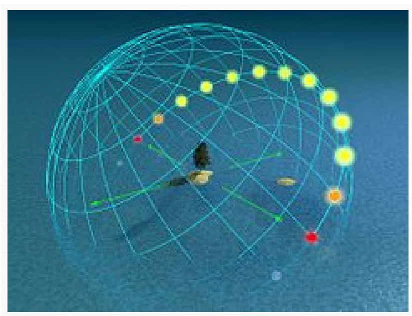
Where the sun appears in the sky is dependent on the latitude of the observer on the earth. Latitude measures the distance north or south of the equator. During an equinox the sun would appear directly overhead to an observer at the equator but to another observer at 50° latitude the sun would appear to be 40° above the horizon at the same time. An observer standing at one of the earth's poles would disagree with both of the other observers because to him the sun would appear to be just below the horizon during the equinoxes.



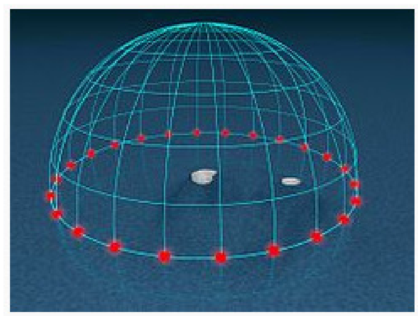
http://rootshunt.com/tesla369withreligion/tesla369withreligion.htm



At 0° latitude (the equator) the sun would be directly overhead during the equinoxes.



At 50° latitude the sun would be 40° above the horizon during the equinoxes.



At 90° latitude (the pole) the sun would be just below the horizon during the equinxes.

http://en.wikipedia.org/wiki/Equinox

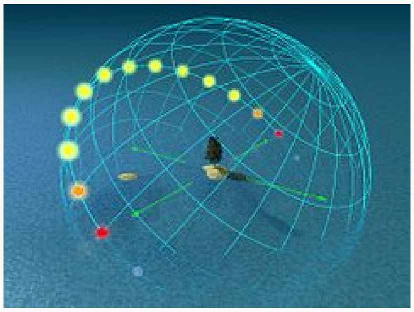
The Sun's Daily Path at Different Times of the Year Viewed from the Same Location on the Earth:

Norman, Oklahoma is at a latitude of 35° N of the equator, which is why the sun is never directly overhead. The most Northern latitude where the sun is able to appear directly overhead occurs at the Tropic of Cancer (23° N of the equator). Where the path of the sun in the sky appears to change throughout the year as shown in the picture below. The sun's apparent path seems to begin bending towards the North Pole from the December solstice to the June Solstice, and then appears to begin bending towards the South Pole from the June solstice to the December solstice. The sun's apparent path can only be directly overhead in latitudes between the Tropic of Cancer and the Tropic of Capricorn because they mark the extremes of sun's apparent path during the year.

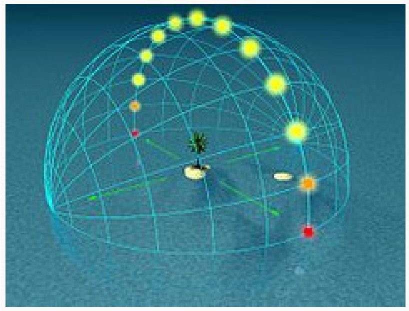
-The Tropic of Cancer is located 23° N of the equator, and the sun will appear directly overhead during the June solstice.

-The Tropic of Capricorn is located 23° S of the equator, and the sun will appear directly overhead during the December Solstice.

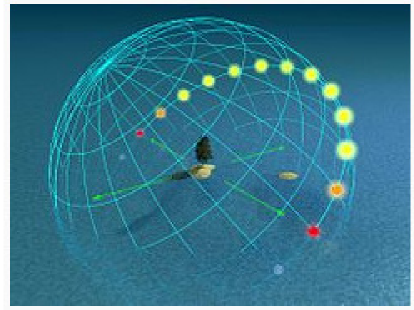
The Change in the Sun's Apparent Path Through the Sky Viewed from the Equator



The path of the sun will move from its extreme southern path in the sky during the December Solstice to directly overhead during the Vernal Equinox



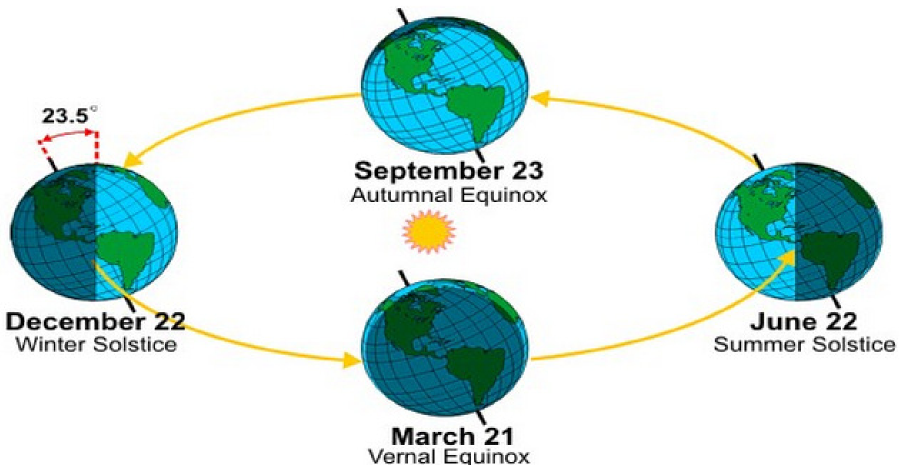
At the equator during the Vernal Equinox the sun's path is directly overhead. This is also true during the Autumnal Equinox.



The path of the sun will move from directly overhead during the Vernal Equinox to its extreme northern path in the sky during Summer Solstice.

http://en.wikipedia.org/wiki/Equinox

But wait. We know that the earth is actually the one that is orbiting the sun. In our model of the solar system the sun is fixed in the middle. Day and night are caused by the rotation of the earth about its own axis, but the apparent movement of the sun is caused by the fact that the earth's axis is tilted at 23.5° pointing towards the North Star.

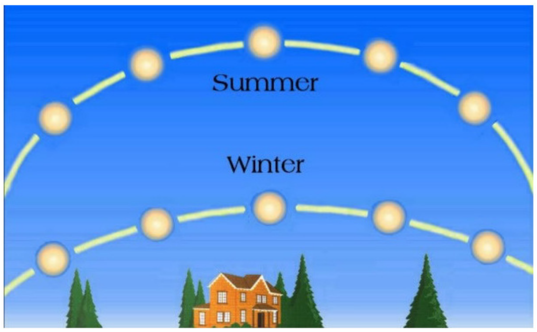


http://www.srh.noaa.gov/oun/?n=climate-seasons

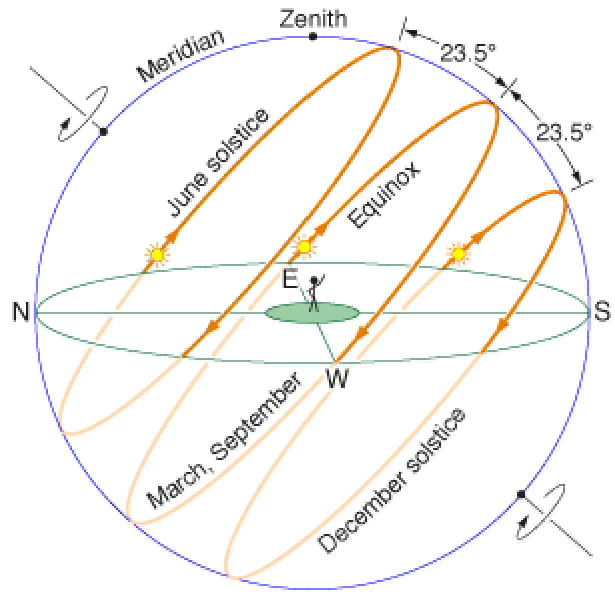
Since the tilt of the earth's axis does not change this means that the northern hemisphere is tilted towards the sun during the June Solstice as shown in the right side of the picture, and the southern hemisphere is tilted towards the sun during the December Solstice as shown in the left side of the picture. The bending of the sun's path towards the North Pole from the December solstice to the June Solstice is not caused by the sun's movement or a change to the tilt of the Earth's axis. It is caused by the tilted Earth being on different sides of sun, which makes the sun's path appear to have moved from the southern sky to the northern sky.

Height of the Sun in the Sky:

The height of the sun in the sky is higher in the summer and lower in the winter because of the tilt of the earth. The earth's tilted axis will be covered in 7th grade, when the students talk about the reasons for the seasons. The tilt causes the northern hemisphere to experience more hours of sunlight during the summer in June than in the winter in December, while the southern hemisphere experiences its summer in December and its winter in June since the number of hours of sunlight are flipped in the hemispheres, which is caused by which hemisphere is tilted towards or away from the sun.



http://www.cathylaw.com/astronomy/sunspath.html



http://physics.weber.edu/schroeder/ua/SunAndSeasons.html

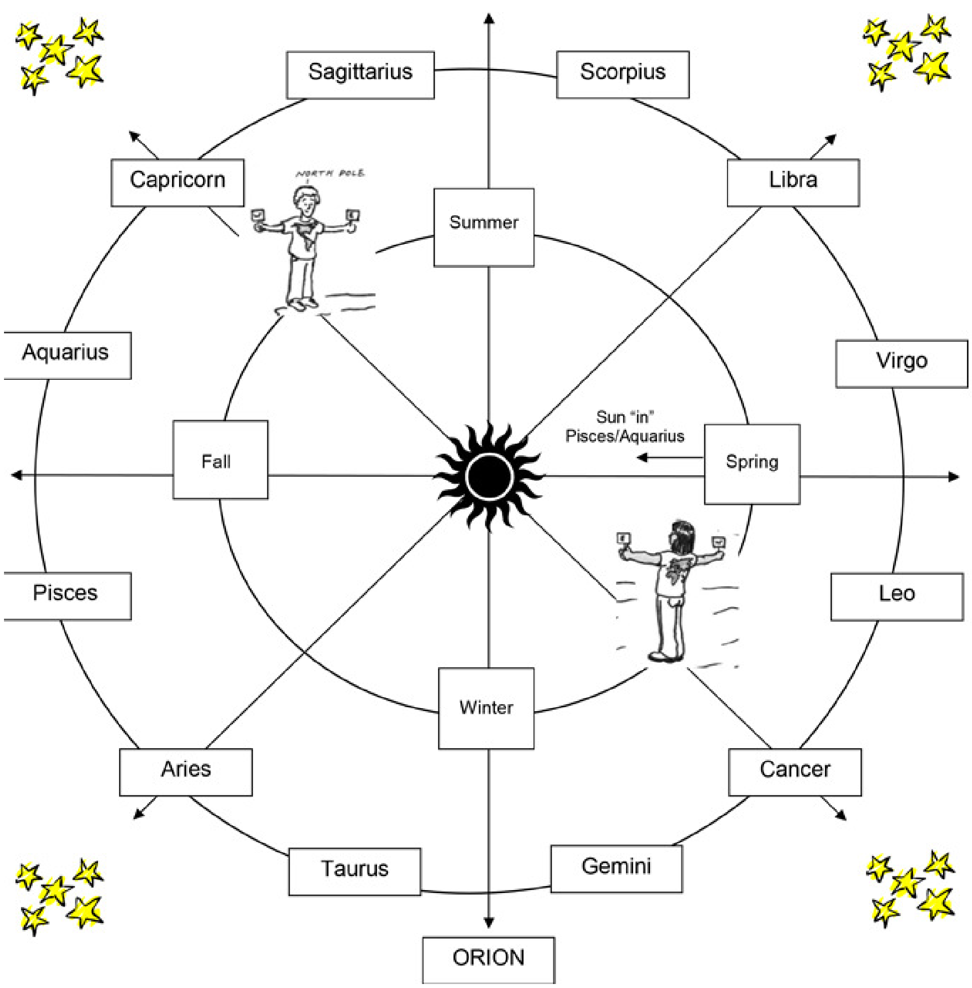
A solar motion demonstrator was included in the kit to help model how the path of the sun changes at different times of the year and at different latitudes, but these concepts will be covered more in the 7th grade.

ACTIVITY – KINESTHETIC ASTRONOMY

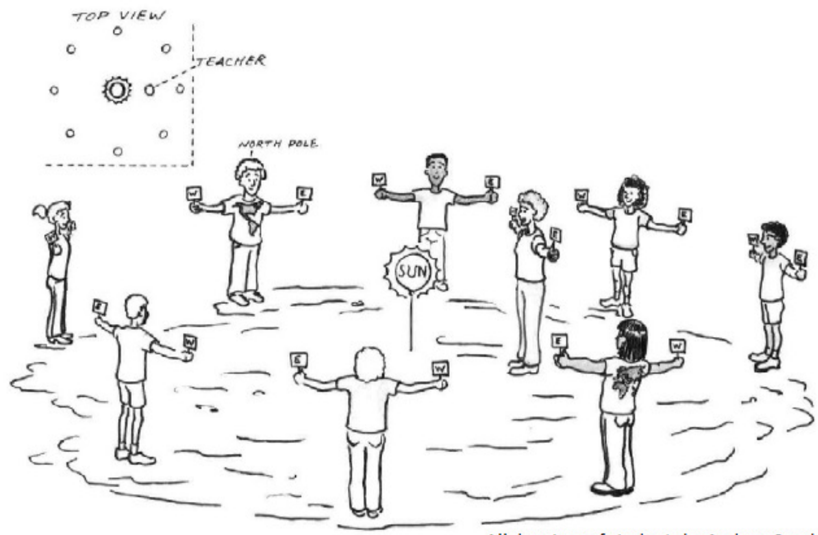
The following is a set of modified instructions to Morrow and Zawaski's Kinesthetic Astronomy. The following instructions focus on the rotation of the earth about its own axis in a day, the orbit of the earth around the sun in a year, and the apparent movement of the constellations as the earth spins on its axis and orbits the sun. The tilt on the earth's axis and all discussion of the seasons was removed from these 5th grade instructions because these concepts are covered in the 7th grade NGSS standards, which closely follow the OASS standards. For the full instructions go to the following website: http://www.spacescience.org/education/extra/kinesthetic_astronomy/download.html.

Part 1: THE KINESTHETIC CIRCLE

1.) Signs representing the constellations of the Zodiac should be assembled and placed before students arrive. If no chairs are available to tape the constellation signs to, then the students could be broken into two groups where one group holds the signs the first time through the activity before switching with the other group to run through the activity a second time. Place a student in the center of the circle to represent the sun. Giving the student a bright yellow shirt to throw on over their clothes could help the students visualize the system.



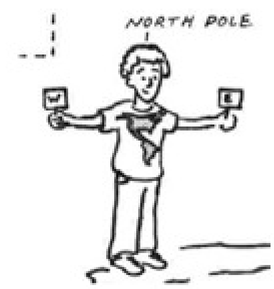
2.) Ask students to arrange themselves in a circle around the central person representing the Sun. This Kinesthetic Circle of students should be inside the ring of signs representing the Zodiac constellations (the Zodiac constellations are not depicted in the diagram to the right). Students should have room to rotate with their arms outstretched to the sides.



All drawings of students by Andrew Sanchez

3.) Tell students that each of their bodies represents planet Earth. Have one student put on the oversized yellow shirt to represent the sun at the center with the signs representing the constellations of the Zodiac.

4.) Students should be standing around the Kinesthetic Circle, facing the center. Remind students that each of their bodies represents the entire planet Earth. Give each student both an "E" and "W" sign. Have one student put on the oversized earth shirt to help the students visualize the east and west directions.



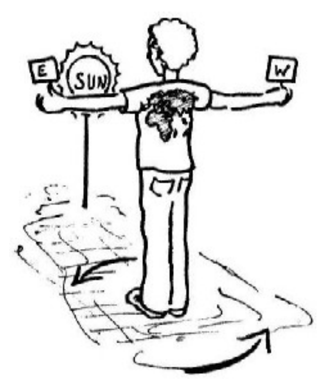
5.) Tell students to put their "E" sign in their "eastward" hand and the "W" sign in their "westward" hand. [Students should have their "E" in their left hand to indicate an eastward direction and their "W" in their right to indicate westward.]

TEACHER TIP: Be alert for students who are having trouble visualizing which way is eastward and reversing the "E" and "W" signs. It is very valuable to have a globe or inflatable Earth that can be placed at any students' belly with the US facing outward. Students can look down and see which arm is extending toward NY and which arm is extending toward California.

This section begins with making the connection between Earth's rotation and the times of day. It demonstrates why the Sun appears to rise in the east and set in the west and how different parts of Earth can experience different times of day at the same moment. The section goes on to explore whether stars rise and set.

6.) Ask: "How does the Sun appear to move in the sky?" [Rises in the east; Sets in the west. Topic covered in Shadow Play Lesson.]

7.) Have students face directly toward the symbolic Sun with their arms outstretched – "E" in the left hand and "W" in the right hand. Ask: "What time would it be along a line that runs down the middle of the front of you?" (Gesture with a karate-chop motion of your hand from the middle of your face down along the front of you) [Noon or Midday.]



8.) Ask: "Why is it midday?" [The Sun is midway between east and west.]

9.) Tell students: "The line that runs north-south, midway between your east and west is called your ***meridian.***" Ask everyone to show you their meridian. [Hands moving up and down the middle of the front of their bodies.]

10.) Tell students: "When the Sun is directly out in front of you at noon, it is 'on your meridian'".

11.) Have students face directly away from the Sun with their arms outstretched to the sides. Ask them: “Is the Sun on your meridian?” [No] Ask: “What time is it at your meridian?” [Midnight] “What would you see?” [Stars]

12.) While students are still in their midnight positions, ask: “What time is it along a line that runs along the middle of your back?” [Noon] “What would people there see in the sky? [The Sun]

13.) Call students’ attention to how it can be different times at different places on Earth, and how there are 12 hours between their front and back.

14.) Return students to face the Sun (i.e. “noon” or “midday at their meridian”). With arms outstretched, have students look down along their “E” arm. Tell them that the student to their left is “low in their east.”

15.) Next have students look down their “W” arm. Tell them that the student to their right is “low in their west.”

16.) Demonstrate to students that what is visible to them at any given time includes what can be seen down along their “E” arm, panning out in front of them through their meridian, and over to looking down along their “W” arm. What’s behind their arms is out of sight.

17.) Have students make a 90-degree turn toward their east (toward their “E” arm). Ask: “What is low in your east?” [A constellation of the Zodiac.] “What is low in your west?” [The Sun]

18.) Ask: “What time of day is this when the Sun is low in your west?” [Sunset]

19.) Ask: “Why is this sunset?” [Because the Sun is disappearing in the west.] Remind students that they can turn their head to look down their arm and see the Sun low in their western sky.

20.) Ask: “Why does the Sun seem to disappear in the west?” [Because I turn away from it.]

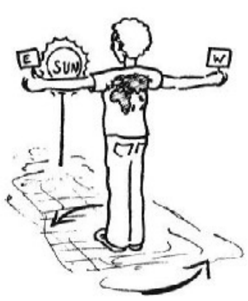
21.) Return to noon. Ask: “So which way does Earth turn so that the Sun appears to set in the west and rise in the east (i.e. re-appear in front of their outstretched “East” (left) hand as they continue to turn). Give students time to work out the answer, using trial and error if need be. Give them a minute or so to compare their thoughts with their neighbors.

Now guide everyone in rotating through a complete day. Start with the noon position, facing the Sun. Command students in sequence:

“Go to sunset.” Ask: “About what time is this?” [~ 6 pm]

“Go to midnight.” Ask: “What do you see in your sky?” [Stars]

“Come to sunrise.” Ask: “What do you see in your sky?” [The Sun low in the east.] Remind students to look out along both arms as well as in between. “About what time is this?” [~ 6 am]



NOON

SUNSET

MIDNIGHT

SUNRISE

22.) Return to noon. Ask: "What do we call this turning of Earth that causes the Sun to rise and set?" [Rotation.] Define and demonstrate the term "Rotation" as the spin of a body around an axis, just as students spin around the axis of their bodies with their heads as North Poles.

23.) Ask: "How long does it take Earth to rotate around one time?" [24 hours = 1 day]

24.) Define the term "Rotational Period" as the *time* it takes a body to spin on its axis.

TEACHER TIP: As enrichment, you may alert students to the enjoyment of trying to "sense" Earth's rotation during a sunrise or sunset. For example, when the Sun is low in the east, its apparent rising motion seems more rapid because you have the horizon as a reference to measure its progress. It is then fun to try to reverse the usual perception of the Sun moving, and instead try to perceive Earth turning toward the East thus making the Sun appear to rise.

25.) Confirm that students are relating Earth's rotation to different times of day. Have them start at noon with outstretched arms and then make a 45° turn toward the east. [This is midway between noon and sunset, and students often need a reminder not to turn 90° to sunset.]

26.) Ask: "What time of day is this for you?" If needed, follow up with: "Is it before or after noon?" [After noon.] "Is it before or after sunset?" [Before] "So about what time is it?" [About 3pm.] "Is the Sun in the eastern or western sky?" [Western]

27.) Tell students: "Go to 3am." If needed, follow up with: "Is it before or after midnight?" [After.] "Is it before or after sunrise?" [Before] [Students turn to the east (left), until facing about 45° past midnight.]

28.) Have students return to 3pm. Ask: "What is the time along a line down the middle of the back of you, say in China?" [3am – twelve hours later.]

29.) Ask: "What is today's date in the US at 3pm?" "What would be the date in central China where it is 3am?" [Tomorrow's date.]

30.) Have students complete the worksheet **"Kinesthetic Times of the Day"** as homework or in-class assessment.

<u>Do Stars Appear to Rise and Set?</u>

31.) Ask: "What do we call the patterns of stars we see in the sky?" [Constellations] "What are some examples of constellations?" [Orion, Big Dipper, Zodiac names like Leo and Scorpius.]

32.) Ask: "Between what times of day do we see stars other than the Sun?" [After sunset until before sunrise.] "Why?" [The sky is dark – the Sun is not visible.]

33.) Ask: "Will these stars and constellations appear to rise and set?" [Show of hands: "yes" or "no". Most students respond with "no", and if queried will explain that the stars are "fixed".]

34.) Have students rotate *just past* the sunset position. [The Sun is out of view behind their right (west) hand.]

35.) While at the sunset position, have students turn their head and choose a constellation sign (or other object in the learning environment) that is low in their eastern sky (down the "E" arm).

36.) Have students *slowly* rotate to midnight and pause. Ask: "What happened to your chosen constellation?" "Is it still low in the east?" [No. It's in front of me…on my meridian.]

37.) Have students rotate slowly onward from midnight to sunrise while keeping an eye on their chosen constellation. Ask: "Where is your constellation now?" [Low in my west.]

38.) Return to noon position. Ask again: “Do stars appear to rise and set?” [Show of hands: “yes” or “no”. Many more students should indicate “yes”. If not, then repeat Steps 34-37.]
39.) Ask: “Why do the stars appear to rise and set?” [Because Earth rotates. The same reason as the Sun appears to rise and set.]

40.) Invite students to observe the motion of the stars at night and report their observations. Just after dark they can use where the sun has set or Polaris to tell directions (N, S, E, and W). Tell them to notice where a constellation or bright star is relative to some earthly feature such as a building, tree top, or ridge. Then before they go to bed, they can look again to see how the constellation or star has “moved” in the sky. Camping trips are great for this making this observation! [The Sun and stars appear to move at the rate of Earth’s rotation = 15° per hour, which is the same thing as “360° per 24 hours”. This amount of movement can be estimated by an open hand <u>with arm outstretched</u>: Fifteen degrees of arc in the sky is about the distance between the tip of the index finger and the tip of the pinky finger with the hand spread open.]

TEACHER TIP: Four questions often arise during this part of the lesson: FAQ 1: Do the stars themselves move? FAQ 2: How do we explain the motion of stars that do not appear to rise or set but that can be seen all night and all year round (such as the Big Dipper)? FAQ 3: Do people at different latitudes [say, the North Pole, the equator, and the South Pole] see the same collection of stars when they look up at night? FAQ 4: If the Sun is a star, why is it so much brighter than the other stars? *Answers appear in the FAQ section of the Lesson Plan.*

The Astronomical Meaning of a Year

This part of the Sky Time lesson uses kinesthetic techniques to introduce Earth’s orbit around the Sun and to construct the meaning of “orbital period.”

<u>Earth’s Orbit of the Sun</u>

41.) Have students stand in the Kinesthetic Circle around the “Sun”. Ask: “Who has a birthday closest to today?” Identify this student and present him or her with a birthday hat (optional).

42.) Ask the birthday person: “How many trips around the Sun have you made in your life?” [Pause to allow time for <u>everyone</u> to reflect on this question, making the connection between their age in years and the time it takes for Earth to make one trip around the Sun.]

43.) Randomly ask a few other students how many trips around the Sun they have made; or if learners are of comparable age, poll them: “How many have made 10 to 11 trips?” “How many have made 11 to 12 trips?” “How many have made 12 to 13 trips around the Sun?”

44.) Tell students that Earth’s “trip” around the Sun is called an “orbit”. Ask: “What is the shape of Earth’s orbit around the Sun?” [An almost perfect circle.] Point out that this means Earth is always about the same distance from the Sun. (NOTE: Actually, Earth is a tiny bit closer to the Sun in Northern Hemispheric winter, but this does not cause the seasonal changes.)

45.) Define and demonstrate the difference between “orbit” and “rotation” carefully. Ask: “How many times does Earth *rotate* around its axis during one *orbit* around the Sun?” [365 times = 365 days.] (NOTE: Ask the question in this way to connect “time” and Earth’s motions.)

TEACHER TIP: As you move forward in the lesson, insist that students use the terms “orbit” and “rotation” correctly as they address questions and make their explanations.

46.) Tell students they will complete one year for Earth <u>without tilting toward Polaris</u>. Ask: “Do you think it’s a good idea to rotate *all* 365 times as you orbit?” [No, just a few times.]

47.) Ask: “Which way does Earth orbit around the Sun?” Give students a hint and give them time to explore: HINT: “After the New Year, you would see Taurus in the night sky, and then later in the year you would see Leo in the night sky. Still later you would see Scorpio.”

48.) Poll students: “How many say Earth orbits clockwise around the Sun?” “How many say counterclockwise?” [Confirm that Earth’s orbit is counterclockwise around the Sun.]

TEACHER TIP: Before having students perform the year, check to be sure that there are not obstacles they might trip over. If you are working with more than a dozen or so students, you can invite those who would like to rotate and orbit more quickly to take two steps toward the “Sun” to form an inner circle. Those who want to rotate and orbit more slowly can remain in the outer circle. For larger groups a half-year may be a better option.

49.) Say: “Let’s make a year happen! Start with rotation toward your “E” arm, and then begin to move in orbit around the Sun as well.” [Ensure all students are rotating and orbiting in the proper sense. Enjoy their smiles. Contain students who are moving recklessly.]

50.) Allow time for recovery and re-focus attention. Ask: “How long does it take Earth to orbit the Sun?” [1 year = 365 days] Define the term “Orbital Period” as the *time* it takes one body to orbit another body. Ask: “What is Earth’s orbital period?” [1 year or 365 days]

51.) Give students the **“Rotation vs. Orbit” Student Worksheet** as homework or in-class assessment.

TEACHER TIP: All of the kinesthetic circle activities could be done on the same day, but it is recommended that the class stop here after finishing Part 1 for the first day. Part 1 could then be reviewed when the class came back to the kinesthetic circle to do Part 2 and Part 3, and each of the parts has a separate worksheet accompanying it.

KINESTHETIC TIMES OF DAY

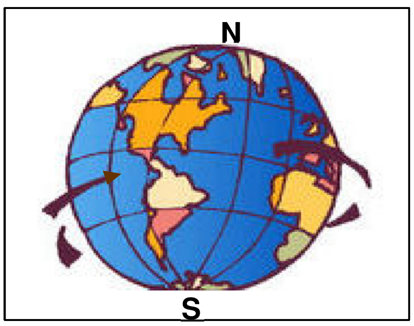
Name ______________________

Write the correct times of day for the boy rotating below.
Choose from: **SUNRISE, SUNSET, NOON or MIDNIGHT**

1. ______________ **2.** ________________ **3.** _______________ **4.** _______________

ROTATION VS. ORBIT

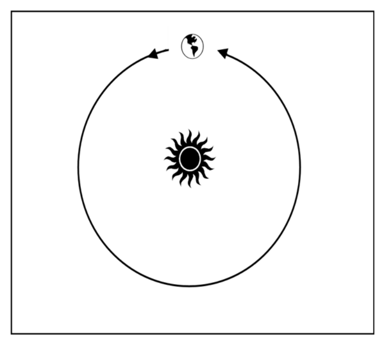
Fill in the blanks below



Earth turns about its own axis. We call this movement _____________.

Earth takes ________ hours to rotate around. We call this length of time Earth's rotational period.

Earth moves around the Sun. We say that Earth _______________ the Sun. Earth takes __________days to go once around. We call this length of time Earth's orbital period.



KINESTHETIC TIMES OF DAY

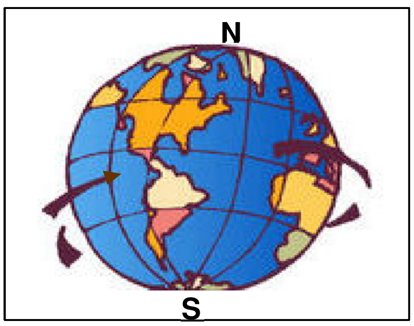
Name ______________________

Write the correct times of day for the boy rotating below.
Choose from: **SUNRISE, SUNSET, NOON or MIDNIGHT**

1. ___Noon_______ **2.** ____Sunset______ **3.** ____Midnight___ **4.** ___Sunrise_____

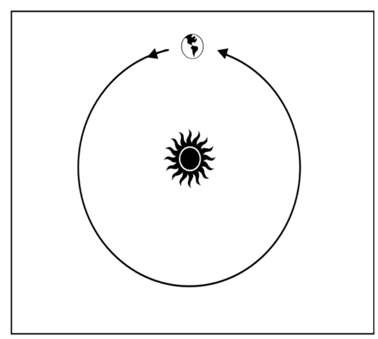
ROTATION VS. ORBIT

Fill in the blanks below



Earth turns about its own axis. We call this movement ___rotation___.

Earth takes ____24___ hours to rotate around. We call this length of time Earth's rotational period.



Earth moves around the Sun. We say that Earth _____orbits_____ the Sun. Earth takes ____365___days to go once around. We call this length of time Earth's orbital period.

Part 2 - ACTIVITY – WILL WE SEE THE SAME STARS IN THE US TONIGHT THAT PEOPLE IN CHINA SAW LAST NIGHT?

Students should be at noon around the Kinesthetic Circle with “E” and “W” signs. The Zodiac ring must be in place.

52.) Set the inquiry: “Do you think we will see pretty much the same stars in the US tonight that people in China saw last night?” After a few seconds, poll students with a show of hands for a “yes” or “no” response. [Usually many students respond with “no” and if queried will explain that China is on the other side of Earth so we cannot see the same stars as they do.]

TEACHER TIP: This question is not confined to consideration of the US and China. The more general question is whether people on one side of Earth will see pretty much the same stars tonight that people on the other side of Earth (at the same latitude) saw last night.

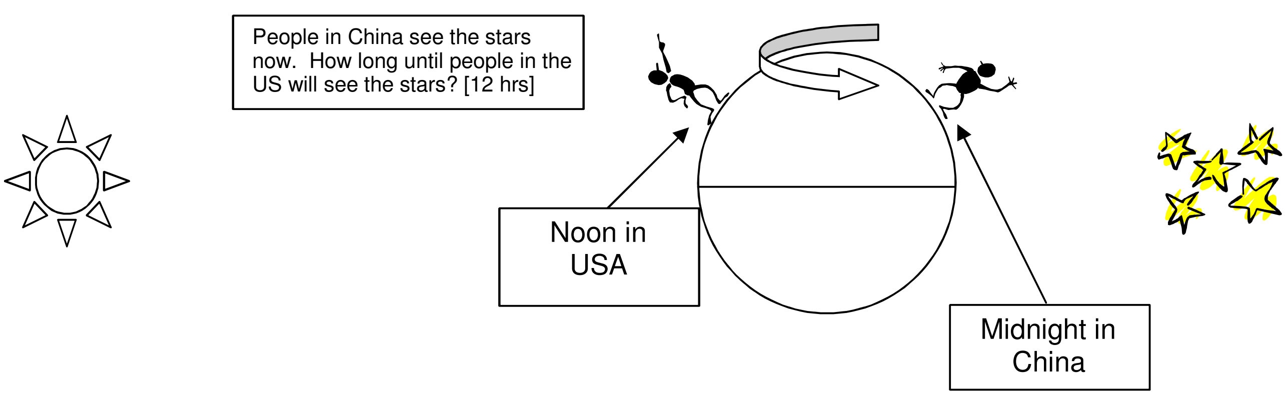
53.) Ask: “How much does Earth move in its orbit of the Sun during one rotation (in one day)?” Lead their reasoning with follow-up questions: “How many degrees in a circle?” [360°] “How many days in one full orbit?” [365 days] “So about how many degrees of orbit in one day?” [About one degree per day.]

54.) Have students demonstrate about how much they would move in orbit during one rotation of Earth. [Inching just a tad in a counterclockwise direction around the “Sun”.]

55.) Have students start at noon. Ask: “What time is it in China?” [Midnight.] “What are the people there seeing in their sky?” [The stars. Have students look over their shoulders and note at least one constellation.] “What are we seeing in the US?” [The Sun at noon.]

56.) Have students rotate to midnight. Ask: “How long did it take for us to rotate to this position?” [Lead students to the answer of 12 hours = ½ day] Ask: “How much does Earth move in its orbit during this time?” [about ½º]

57.) Give each student a copy of the worksheet, **“The Night Sky in China.”** Have students work in pairs to conduct their own investigation into the inquiry: “Do you think we will see pretty much the same stars in the US tonight that people in China saw last night?” Tell students to assume that the people in China and the US are located at the same latitude. [This is important because the stars that can be seen in the sky are different for different latitudes. See FAQ 3.]



Name: ____________________

The Night Sky in China

1. Do you think people in the US will see pretty much the same stars tonight as people in China saw last night? **Circle one: YES NO**

STOP!* RECORD AND KEEP YOUR ANSWER ABOVE. THEN GO ON TO SEE IF YOUR ANSWER CHANGES OR STAYS THE SAME BY THE END. *LET'S GO!

2. What is Earth's rotational period (in hours)? _______________

3. What is Earth's orbital period around the Sun (in days)? _______________

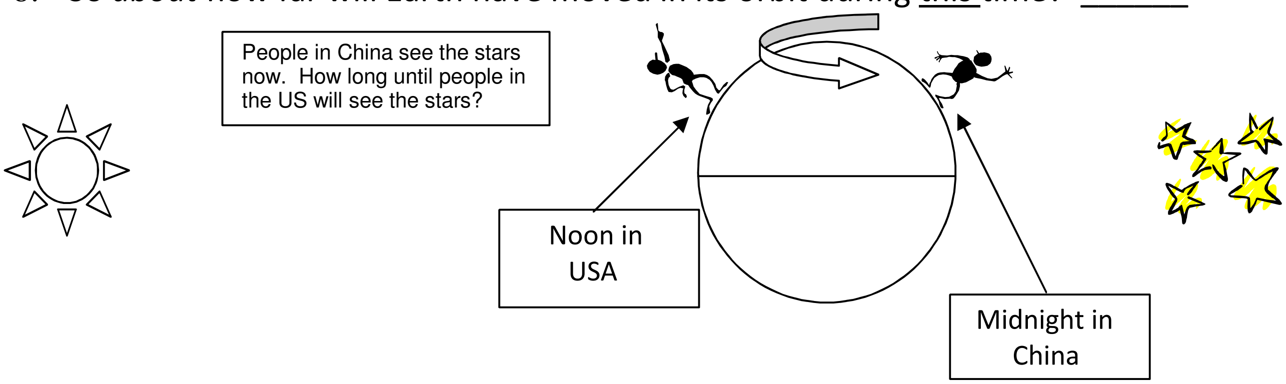
4. How many times does Earth rotate during one orbit of the Sun? ___________

5. How many degrees are in a circular orbit? ____________º

6. So *about* how many degrees does Earth move in orbit in one day? _______º Explain:

7. Look at the diagram. How long will it take for Earth to rotate from noon in the USA (midnight in China) to midnight in the USA (noon in China)? ______ hrs?

8. So *about* how far will Earth have moved in its orbit during this time? ______ º



9. Will people in the US see pretty much the same stars tonight as people in China saw last night? **Circle one: YES NO**

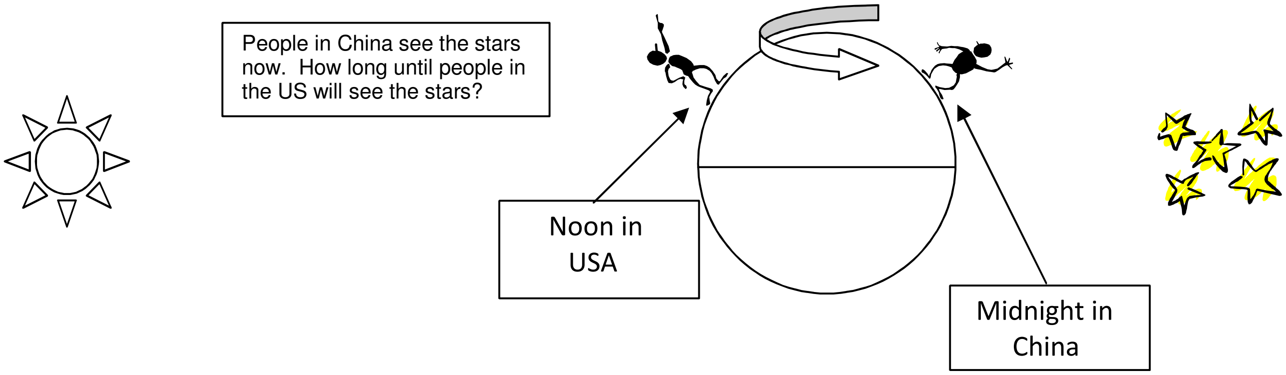
Name: ____________________

The Night Sky in China

1. Do you think people in the US will see pretty much the same stars tonight as people in China saw last night? Yes

STOP! RECORD AND KEEP YOUR ANSWER ABOVE. THEN GO ON TO SEE IF YOUR ANSWER CHANGES OR STAYS THE SAME BY THE END. LET'S GO!

2. What is Earth's rotational period (in hours)? ______24________
3. What is Earth's orbital period around the Sun (in days)? ___365__________
4. How many times does Earth rotate during one orbit of the Sun? ___365_____
5. How many degrees are in a circular orbit? _________360_º
6. So *about* how many degrees does Earth move in orbit in one day? ______1_º Explain:
7. Look at the diagram. How long will it take for Earth to rotate from noon in the USA (midnight in China) to midnight in the USA (noon in China)? ___12_hrs?
8. So *about* how far will Earth have moved in its orbit during this time? _____.5_ º



9. Will people in the US see pretty much the same stars tonight as people in China saw last night?

Yes, the people in the US will see much the same stars as people in China saw last night. This is because in the time it take the earth to go from night to day, the earth has only moved about .5^{o} in its orbit around the sun. So, the earth is still facing much the same stars at night. Think of how little you have moved around the kinesthetic circle during half a rotation if it takes 365 rotations to revolve around the sun.

TEACHER TIP: It is recommended that Part 3 be done later in the unit after the students have seen Orion be used as an example when talking about the luminosity and apparent magnitude of the stars.

Part 3 - WHO CAN SEE ORION WHEN?

Students should be at noon around the Kinesthetic Circle with "E" and "W" signs. The Zodiac ring should be in place. Use the **Answer Key for Teachers.**

58.) Place the **"Orion sign"** as far away as practical in a direction between Gemini and Taurus. Remind students that stars rise and set and thus appear in different parts of the sky as the night progresses. Set the inquiry: "Can we see Orion every night of the year? What times of the night is Orion visible from your position?"

59.) Show how students can explore this question by using the Fall Equinox student as a demonstration model. Start at noon. Ask: "Can he/she see Orion?" [No, it is setting in the west, but the Sun is up so we cannot see it.]

60.) "Go to sunset." "Can he/she see Orion?" [No, looking in the wrong direction.]

61.) "Go to midnight." "Can he/she see Orion?" [Yes, it's just rising in the east.]

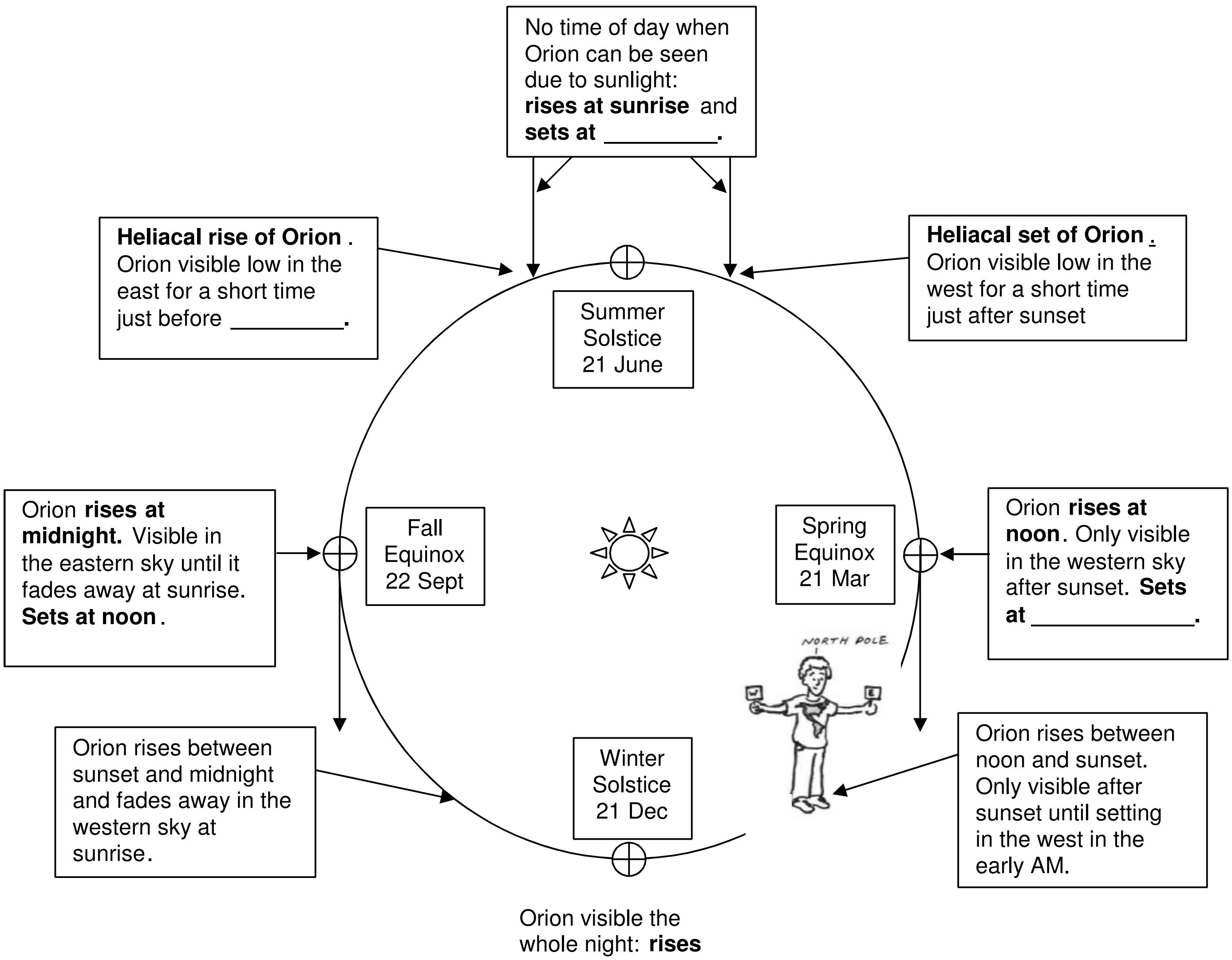
62.) "Come to sunrise." "Can he/she see Orion?" [Yes, it's on the meridian.] Return to noon and have students note that Orion is in the sky, but would fade from view at sunrise.

63.) Have all students rotate with arms outstretched to explore whether they could see Orion at some time during the night at the time of year represented by their orbital position. [The student at the Winter Solstice will be able to see it from sunset to sunrise. The students at or near the Summer Solstice will not be able to see the constellation at any time of day because the Sun is between them and Orion. Every other student can see Orion for a time during their nighttime hours. The closer they are to the Winter Solstice, the more hours Orion will be visible. The closer they are to the Summer Solstice, the fewer hours Orion will be visible.]

64.) Work as a class to finish "Who Can See Orion When?" worksheet.

WHO CAN SEE ORION WHEN?

Find and fill in the *5 blanks* using kinesthetic techniques.
Confirm the information given in the other boxes.



Orion visible the whole night:

rises at __________ and

sets at __________ .

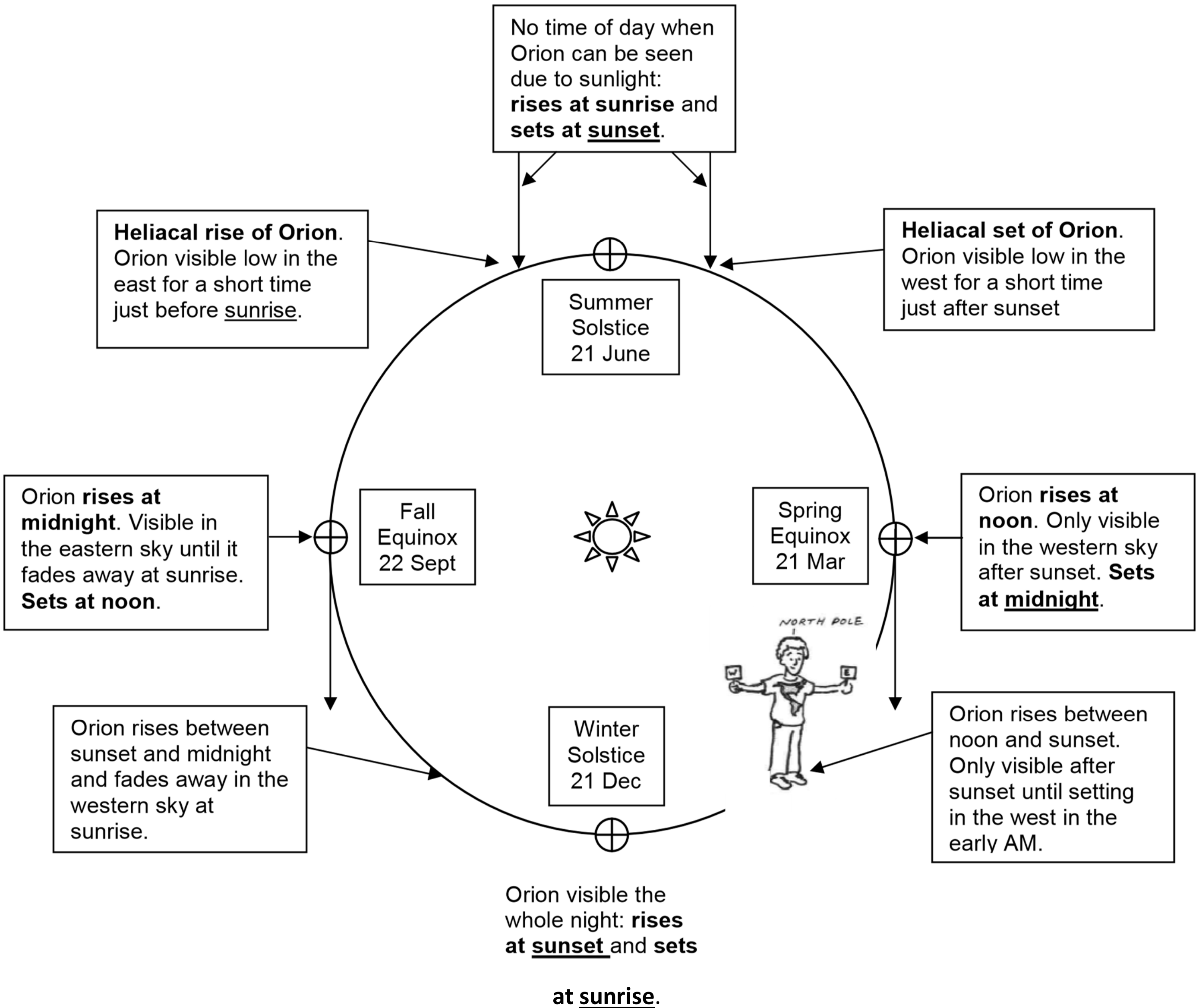
This diagram is NOT to scale. Place the Orion diagram as far away as is practical.

To Orion

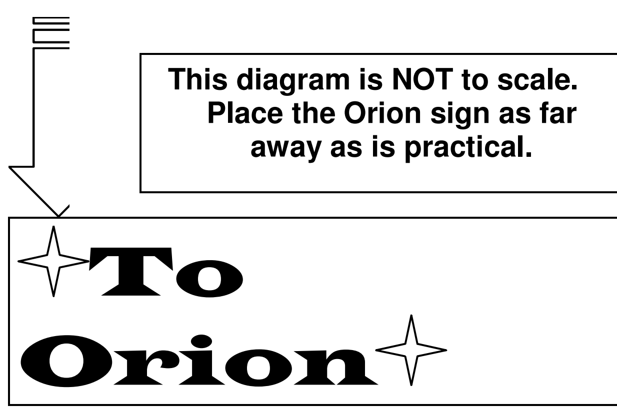
WHO CAN SEE ORION WHEN?

Answer Key for Teachers

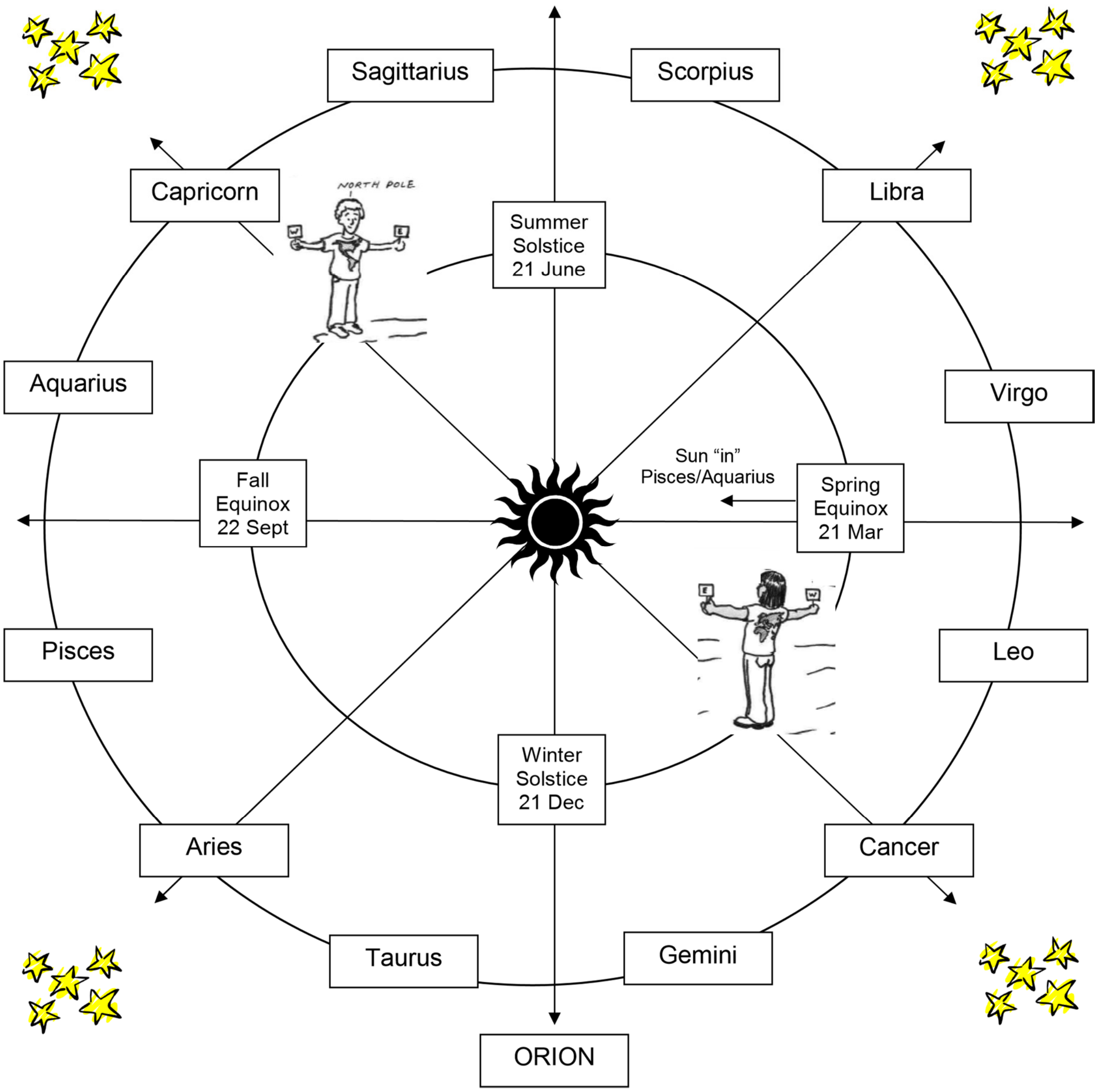
Use kinesthetic techniques to confirm Orion's visibility.



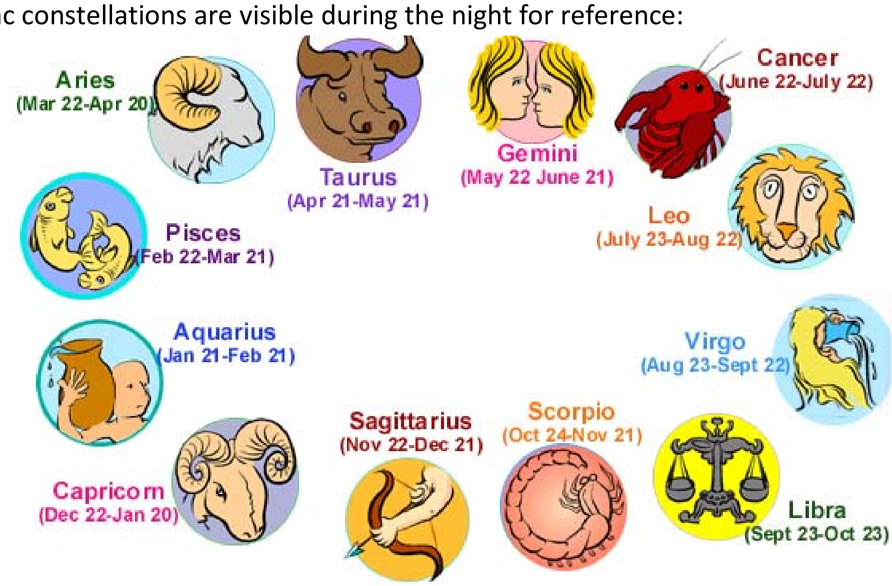
This diagram is NOT to scale. Place the Orion sign as far away as is practical.



Kinesthetic Circle with Solstices and Equinoxes:



List of when the zodiac constellations are visible during the night for reference:



http://www.indiaparenting.com/zodiac/zodiaccircle.jpg

FREQUENTLY ASKED QUESTIONS (FAQ) FOR THE SKY TIME LESSON

FAQ 1: The patterns of the stars (constellations) appear to rise and set because of Earth's rotation, but do the stars themselves move?

Yes, all stars do move, but because they are so far away their motion is imperceptible to us with the naked eye, and thus the patterns of stars (the constellations) will appear unchanged for many lifetimes.

FAQ 2: Why is it that some constellations (such as the Big Dipper at northern and midlatitudes) do not appear to rise or set, but can be seen all night and all year round?

Because Earth rotates around an axis pointed toward Polaris, the objects in the sky will all appear to move around this star. If you were at the North Pole, where Polaris appears directly overhead in the sky, no stars would rise or set, but the dome of the sky would appear to rotate around parallel to the horizon. At lower latitudes, those stars appearing closest to Polaris in the sky still would not rise or set, but instead would appear to move in circles around Polaris. Those stars appearing farther away from Polaris (e.g. farther south in the sky) will still be moving in circles around Polaris, but these circles intersect the horizons and thus the stars appear to rise and set. So, if you are at 40°N latitude, then Polaris appears 40° above the northern horizon, and stars that appear within 40° of Polaris (such as those in the Big Dipper) will appear to move around Polaris without rising or setting. These are called *circumpolar* stars. Your latitude dictates which stars will be circumpolar and which stars will appear to rise and set.

FAQ 3: Do people at different latitudes [say, the North Pole, the equator, and the South Pole] see the same collection of stars when they look up at night?

No. Earth is spherical, and thus when we are at different latitudes we are looking out in different directions in space when we look directly up overhead. Using a globe (or other spherical object) and a small doll or action figure, you can show how the direction of "directly overhead" changes as the doll is positioned at different latitudes from pole to pole.

FAQ 4: If the sun is a star, why is it so much brighter than the other stars?

Other stars are much farther away than our sun. The Sun is about 100 million (100,000,000) miles away, but even the nearest star is about 24 trillion (24,000,000,000,000) miles away. The light we receive from a particular star depends on how far away it is.

FAQ 5: Where do I find Polaris in the sky?

At the North Pole, Polaris appears directly overhead in the sky. At lower latitudes Polaris appears closer to the northern horizon. Polaris is located above the northern horizon by the same number of degrees as the north latitude at your location. For example, if you are at 40°N latitude, then Polaris appears 40° above the northern horizon. If you are at the equator, then Polaris is on the northern horizon (0° above the northern horizon). In the Southern Hemisphere, Polaris is not visible at all because it is below the northern horizon. Polaris is 500 light years away.

ACTIVITY – WHAT PATTERNS ARE IN THE SKY?

An electronic copy of the star wheel has been included with these instructions below along with a completed example of the starwheel supplied in the kit. In addition, here is a link to the original site:

http://www.lawrencehallofscience.org/starclock/skywheel.html

Standing here on the Earth which is rotating, we see everything in the sky wheeling around us once every 24 hours. Each object in the sky appears to move 15° westward every hour as Earth rotates. (15 °/hr = 360°/24 hrs). Follow the instructions on the printed starwheel sheet to assemble Uncle Al's Planisphere. To help reinforce these ideas and familiarize the students with the constellations of the Zodiac (the constellations that move in the ecliptic path of the sun) the students will make and learn how to use a planisphere. The websites suggests using cardstock to produce a more durable planisphere that will last longer, but regular paper will work for a temporary planisphere that students will be able to use for the lesson. Have the students assemble the planisphere following the instructions on the templates.

To find a constellation in the sky using the Star Wheel, have the students follow these steps:

What date and time of night?

Rotate the Star Wheel in the Star Holder until your desired time of night lines up with the desired date.

Which horizon is the constellation closest to?

Find the constellation on the Star Wheel and note which horizon it is closest to.

How do I make it right-side up?

Orient the Star Holder so that the horizon the constellation is near is at the bottom. This will allow that part of the sky to look right-side up to you. For example, if your constellation is closest to the northern horizon, flip the Star Holder upside down so that you are reading northern horizon at the bottom of the oval.

How high is the constellation in the sky?

Is the constellation closer to the zenith (center of the map) or closer to the horizon?

What shape is the constellation?

Memorize the pattern of stars in the constellation.

Can I see the constellation in the sky?

Once you are done using the planisphere in the classroom encourage the students to take it home and use it to identify constellations in the night sky. If you are looking at a constellation near the eastern horizon, you hold the planisphere with the eastern horizon closest to you. It is helpful to tilt the planisphere up above your head so that the planisphere is in the sky next to the constellations. The eastern horizon of the planisphere should be in front of you and the western horizon of the planisphere should be behind you.

For the following questions have the students move the star wheel to the correct date and time, but then move the wheel slightly back and forth to see what constellations are rising or setting in the sky. Remember that the stars will rise above the eastern horizon and set above the western horizon.

Rotate the Star Wheel to June 1st at 8pm.

1.) What constellation are rising in the east?

Scorpius and Aquila

2.) What constellation is setting in the west?

Orion

3.) What constellation is closest to the zenith (highest place in the sky; center of the map)?

Ursa Major

Rotate the Star Wheel FORWARD 3 hours (to 11pm standard time on June 1st).

4.) What constellations are rising in the east?

Capricornus and Aquarius

5.) What constellations are setting in the northwest?

Gemini and Cancer

6.) What constellation is closest to the zenith (highest place in the sky; center of the map)?

Draco

Rotate the Star Wheel FORWARD 3 hours (to 2am standard time on June 2nd).

7.) What constellations are rising in the east?

Pisces and Aries

8.) What constellations are setting in the west?

Virgo and Libra

9.) What constellation is closest to the zenith (highest place in the sky; center of the map)?

Lyra

Rotate the Star Wheel FORWARD 3 hours (to 5am standard time on June 2nd).

10.) What constellations are rising in the west?

Gemini and Orion

11.) What constellation are setting in the Northwest and Southwest?

Bootes and Sagittarius

12.) What constellations are the closest to the zenith (highest place in the sky; center of the map)?

Cepheus and Cygnus

Notice that there is one star in the sky which does not seem to change its position ever. It's at the tip of the handle of the Little Dipper, (Ursa Minor), and is called *Polaris*, or the *North Star*. Now some more questions to test your Star Wheel driving skill:

13.) What constellations are near the zenith on New Year's Eve at 11 p.m.?

Perseus and Auriga

14.) In what month is the Big Dipper (Ursa Major) highest in the sky at midnight?

March

15.) About what time is Leo setting (in the northwest) on the summer solstice (about June 21)?

Somewhere starting around 9:30pm to fully setting around 12pm.

ACTIVITY – WHAT PATTERNS ARE IN THE SKY?

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1.) What constellation are rising in the east?

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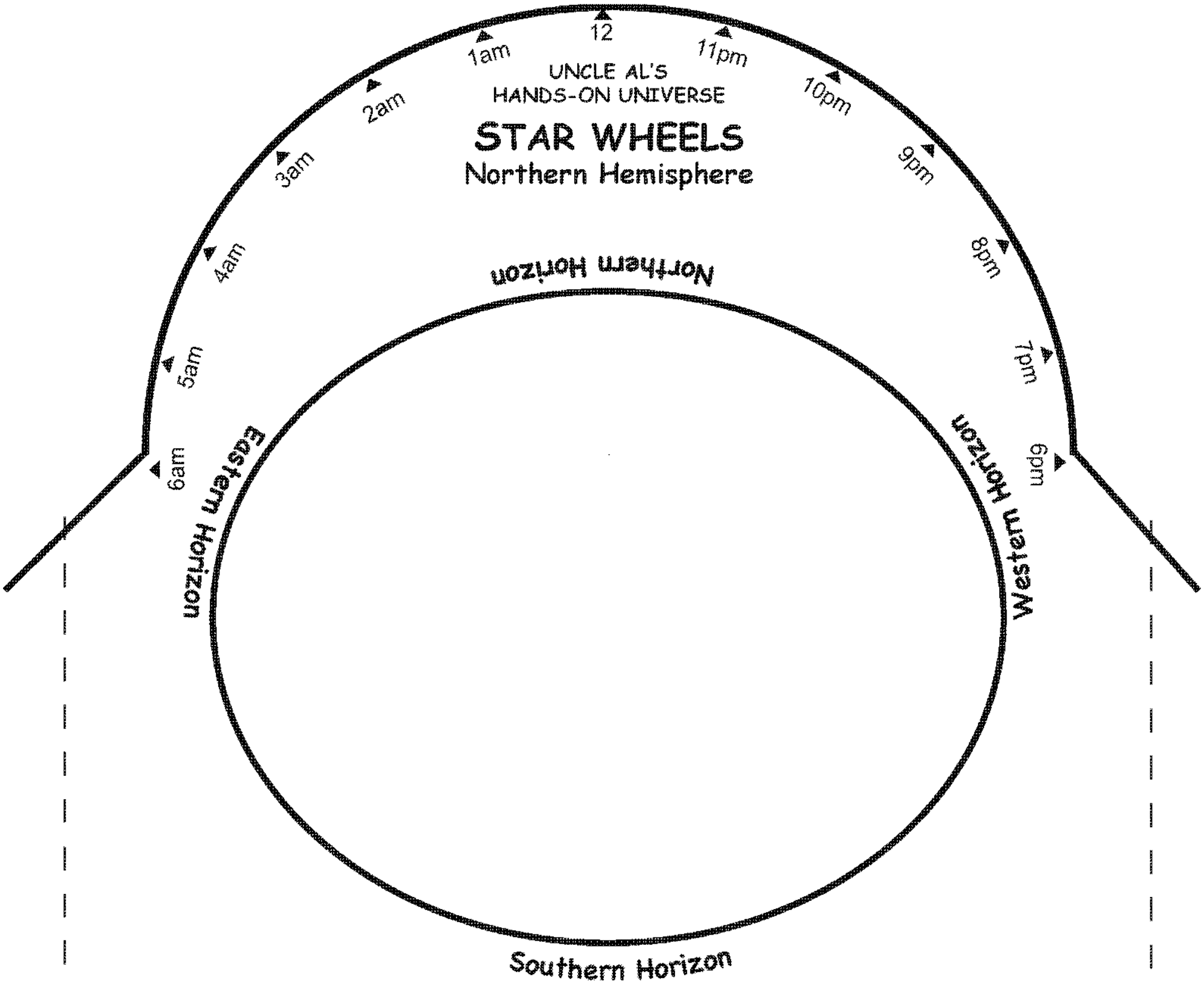
Star Wheel Holder



Version: May 2009

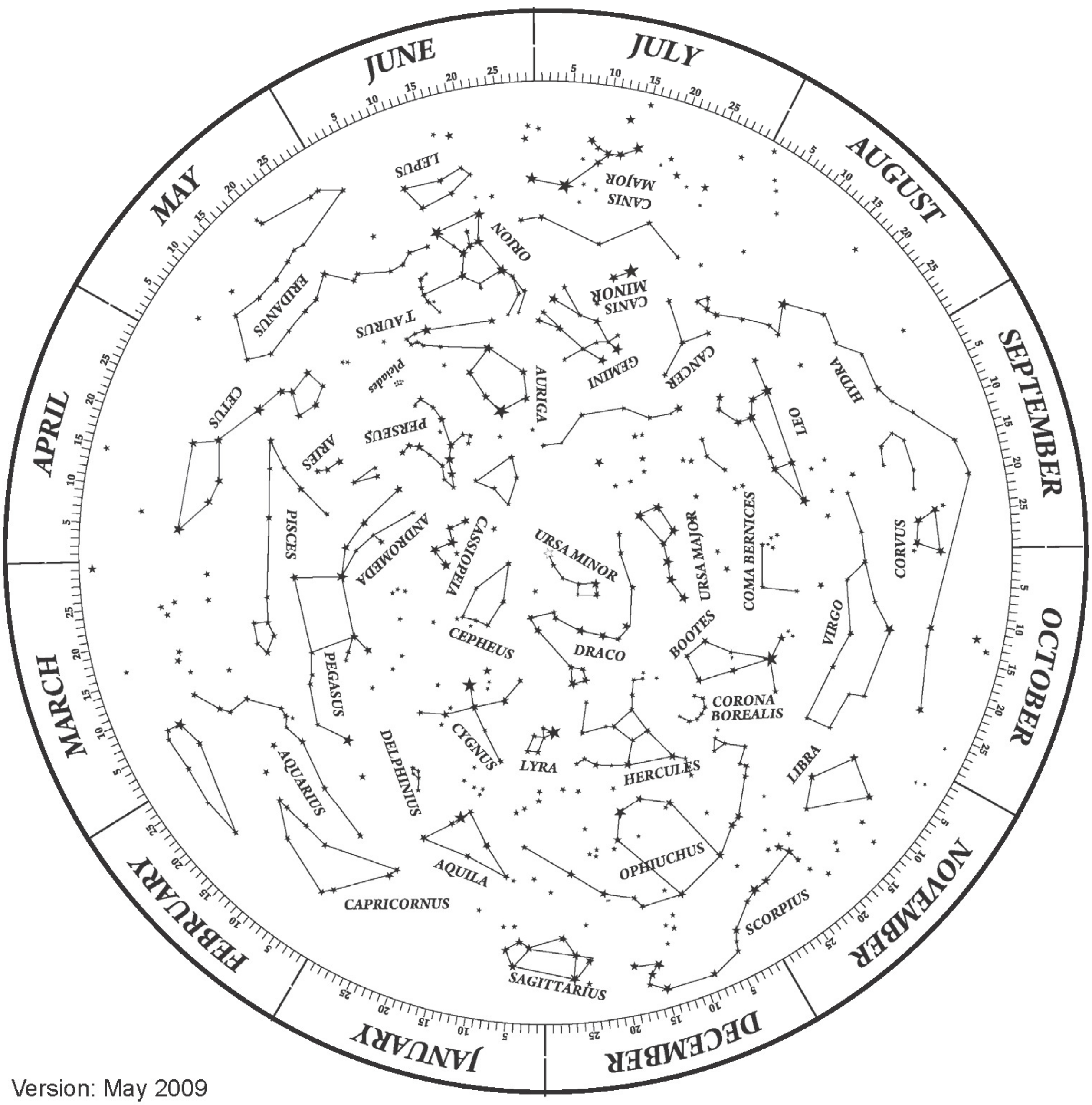
Instructions for Using Uncle Al's Star Wheels

1. Align your date and time, and then look up at the sky
2. Locate the constellation you want to find on the map.
3. Turn your map so the horizon it is closest to is at the bottom.
4. The star positions in the sky should match those on the wheel.

Uncle Al's Star Wheels are based on LHS Sky Challengers created by Budd Wentz and available through LHS Museum Store

510-642-1016 http://www.lhs.berkeley.edu/pass/ast110&111&121.html

Download Uncle'Al's Sky Wheels from http://lhs.berkeley.edu/hou/img/uncleal



Version: May 2009

INSTRUCTIONS FOR ASSEMBLING UNCLE AL'S STAR WHEELS

Step 1: Print out all pages either on heavy cardstock or paste them onto a file folder or any other sturdy piece of cardboard.

Step 2: Cut along the black outer circle of the Star Wheel and along the solid lines on the Star Wheel Holder. Remove the interior oval shape on the Star Wheel Holder.

Step 3: On the Star Wheel Holder, fold the cardboard along the dashed lines.

Step 4: Tape or staple along the edges of the Star Wheel Holder forming a pocket.

Step 5: Place the Star Wheel in the Star Wheel Holder.

Uncle Al's HOU Star Wheels are based on LHS Sky Challengers created by Budd Wentz and available through the LHS Discovery Corner Store 510-642-1016
http://lhs.berkeley.edu/pass/AST110&111&121.html
Download Uncle'Al's Sky Wheels from http://lhs.berkeley.edu/starclock/skywheel.html

The following article goes over some history of the planisphere along with some limitations of using it.

Star-Finding with a Planisphere
By Alan M. MacRobert
http://www.skyandtelescope.com/astronomy-resources/star-finding-with-a-planisphere/

The movements of the stars have taxed the human intellect throughout the ages — from ancient Babylonians seeking to predict sky events, to Greek philosophers wrestling with the structure of the universe, to beginning amateurs today trying to point a new telescope at the Andromeda Galaxy.

At first, the turning of the celestial sphere perplexes everyone who takes up skywatching. Sooner or later the picture snaps into place and the whole setup becomes obvious. But those who think the sky's motion is inherently simple should try explaining to a beginner why every star follows a different curved path across the sky at a different speed. And why do some stars move from west to east while most move east to west? Can you explain why some constellations turn somersaults during the night while others just tilt from side to side?

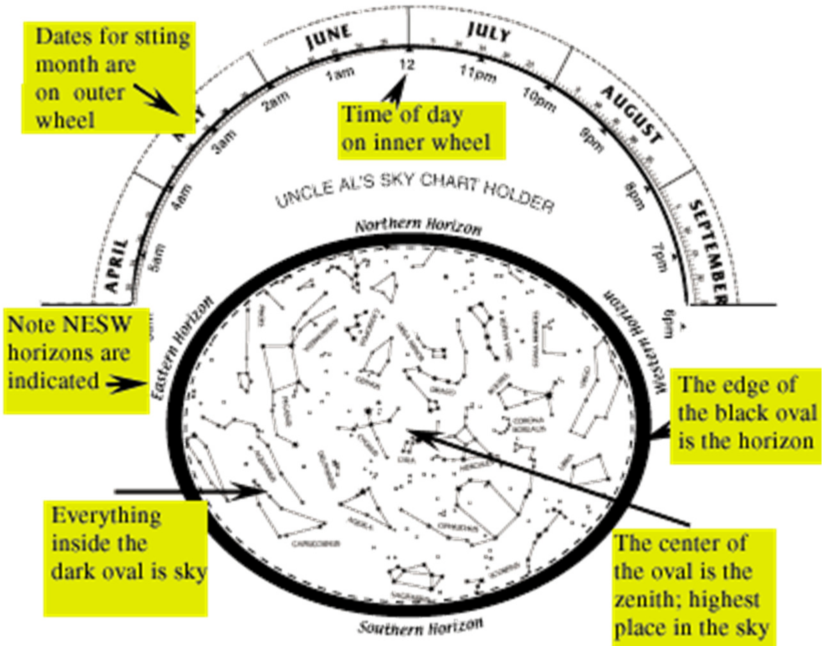
To bring the sky's motion down to Earth, astronomers for millennia have built little mechanisms that duplicate it. A working model not only illustrates how the sky turns but can help locate objects at any given time. The simplest sky model is a planisphere.

Untold numbers of these star finders have been designed and published in the last century. Even the most experienced observers rely on them, especially at unfamiliar hours of the night. The word "planisphere" simply means flat sphere. It incorporates a map of the sky that pivots at the celestial pole. As the map revolves around the pivot, it slides under a mask that represents your horizon. Turning the map mimics the apparent daily motion of the sky, complete with risings and settings at the horizon edges.

Ancient Origins

The basic idea behind the planisphere was used in ancient Rome. The architect and engineer Vitruvius, writing around 27 B.C., described a star map engraved on a solid plate and a horizon mask that rotated over it to show the risings and settings of celestial bodies. A water clock turned the mask once a day to keep up with the sky. Nearly two centuries later, Claudius Ptolemy analyzed the map projections used for such devices in his treatise Planisphaerium. Modern planispheres are direct descendants of the astrolabe, which is used (among other things) to find the user's latitude using the date, time and height of the sun. By the end of the Middle Ages astrolabes were the universal trademark of astronomers and astrologers.

Astrolabes were commonly used to sight on the Sun and stars to tell time. The invention of accurate clocks allowed the procedure to be reversed. If you knew the time, you could use this kind of device to find stars. And that is how planispheres have been employed ever since.



Using a Planisphere

In principle nothing could be simpler. You turn a wheel to put your time next to your date, and presto, there's a custom-made map of the stars that are above your horizon for that moment. The edge of the oval star map represents the horizon all around you, as you would see if you were standing in an open field and turned around in a complete circle. Notice that the directions are clearly printed around the horizon. The part of the map at the oval's center represents the sky directly overhead. This point in the sky is called the zenith.

Several complications can throw beginners off. A planisphere's map is necessarily small and distorted. It compresses the entire celestial hemisphere above and around you into a little thing you hold in your hand. Star patterns appear much bigger in real life than on the map, which, if you think about it, makes a lot of sense.

Moving your eyes just a little way across the map corresponds to swinging your gaze across a huge sweep of sky. For example, your fist held up at arm's length covers about 10° of sky. The whole sky is 180° from horizon to horizon. The east and west horizons may look close together on a planisphere, but of course when east is in front of you west is behind your back. Glancing from the map's edge to center corresponds to craning your gaze from horizontal to straight up, that is from 0° to 90°.

To use the planisphere hold it out in front of you as you face the horizon. Twist it around so the map edge labeled with the direction you're facing is down. So if you are facing west, the word 'west' should be down. The correct horizon on the map will match the horizon in front of you. Now you can compare stars above the horizon on the map with those you're facing in the sky.

Fine Points

A further complication is that an individual planisphere works correctly for only one narrow range of latitudes on Earth. Fortunately, many models are made in several editions, each for a particular latitude range. The one you will use is intended for viewers who are near 40° N latitude. Scarborough is at about 43° N latitude and this is quite close enough.

There's the matter of daylight saving time, and correcting for it. When this is in effect (from the first Sunday in April to the last Sunday in October in most parts of the United States), remember to "fall back" to standard time by subtracting an hour from what your clock says before you set the planisphere's dial.

In fact, if you just want to know which constellations are up and where they are, a planisphere's limitations can largely be overlooked. It's remarkable that such a simple working model of the sky can work so well.

Adapted from text by Alan MacRobert from his site at http://www.astro-tom.com/.
Alan MacRobert is a senior editor of Sky & Telescope magazine and an avid backyard astronomer.