Activity 12: The Reasons for Seasons

Grade Levels: 6-9

Educational research has shown that understanding why it is warmer and the days are longer in the summer than in the winter is very difficult for students. This activity approaches this subject by having the students observe and record the Sun's path through the sky in each of the seasons. At each step they predict what they think they will observe next. They then try to explain why the Sun's path varies throughout the year. Finally, they use a model Earth ball to visualize how the tilt of the Earth's axis causes the variation in the Sun's path with the change in seasons.

Organization: Individual Task

Reasoning Level: Concrete to Formal

Activity Strategy: Direct Information - Synthesizing

Behavioral Objectives: By the end of the lesson, students should be able to:

1. Describe the apparent daily path of the Sun during the four seasons.
2. Explain why the Sun's daily path changes during the year.
3. Predict the rising and setting point for the Sun for different seasons.
4. Explain why days are longer in the summer and shorter in the winter.

Presentation

Engage the students in a discussion about where we see the Sun in the sky. Ask if the Sun is always at the same height (altitude) above the horizon at noon throughout the year. Ask where the Sun rises and sets, and whether or not the direction of sunrise and sunset stays the same every day, or changes throughout the year.

Tell the students that they will be collecting data on the Sun's apparent path, including not only the height at noon, but also the length of day and the position of sunrise and sunset throughout the year. Hand out the data sheets. Tell the students that they will have to estimate the sunrise and sunset directions by looking at the N, S, E, W markers on the horizon. In addition, they will need to estimate the Sun's position at noon by observing its altitude (in degrees) between the zenith and the horizon (point out the meridian line).

Show the Sun's path for the 1st day of summer, fall, winter, and spring (Use the equinoxes and solstices to represent the seasons since the most extreme paths of the Sun are observed on those dates.) In each case, have the students ***predict sunrise, noon, and sunset*** before showing the Sun's path on that date. As the Sun traverses the sky on each of those dates, the students mark its positions at sunrise, noon, and sunset on their data sheets (Reasons for the Seasons Worksheet).

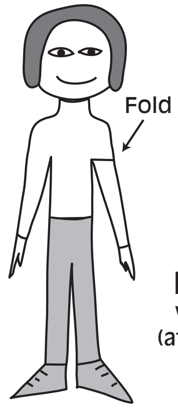
Materials

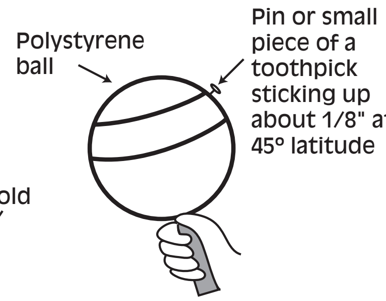
- **markers to indicate the predicted position of sunrise/sunset on the dome (these could be pieces of cardboard with paper clips on the back for planetariums with coves or sheets of paper hung with masking tape or "Post-It®" style notes)**
- **a white light in the center of the planetarium to represent the Sun, an Earth globe that will turn on its axis, and a small paper or toy figure of a person with a movable arm (see illustration) fastened to the Earth globe.**
- **a meridian line projector for measuring the altitude of the Sun at noon. In portable planetaria, you can tape marker papers every 10 degrees along the meridian by partly deflating the dome until the zenith can be reached, taping the 90° mark there, and slowly reinflating the dome while putting up markers at 80°, 70°, and so forth along an imagined meridian line towards the southern horizon. Extreme accuracy is not critical.**
- **North, East, South and West horizon markers (optional: mark every 10° in between those markers). The best pattern is having East and West each be marked 0°, with North and South being 90°.**
- **data on the length of day at solstices and equinoxes at your latitude. This may be found in newspapers or observers' handbooks with sunrise and sunset listings.**

For each student

- **a pencil**
- **a copy of the worksheet, p. 48.**
- **a clipboard or other writing surface**
- **a 3" polystyrene "Earth ball" on a pencil or stick with a pin or piece of toothpick stuck in at about latitude 45° (see diagram next page).**

On each date, have student volunteers mark the positions of sunrise and sunset on the cove or side of the dome with a "Post-It®" or other method. *(Optional: You may extend the chart on the worksheet to include columns for your students to write sunrise and sunset positions, or have the students verbally describe sunrise and sunset positions on a chart on a separate page.)* After each day, announce the hours of daylight for that day and have the students write that number of hours in the table on their data sheets.

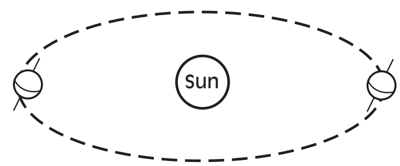




Person Figure
with moveable arm
(attach to Earth globe)

After all the dates are completed, ask the students to draw the Sun's path for each date from sunrise to sunset. The path for each season should include a smooth curved line through the sunrise point, noon position, and the sunset point.

Ask the students to study their charts and see if they can suggest a reason to explain these changes. After a discussion of possible explanations, tell the class that a long time ago, astronomers found out that the reason that the Sun appears to take such a different path through the sky in different seasons is due to the way the Earth is tilted as it travels around the Sun. Using the white light as the "Sun" and the Earth globe, demonstrate that the north pole of the Earth always points towards the north star, or Polaris. Holding the globe, walk around the Sun, keeping the north pole of the Earth pointed towards the north star. Point out that as the Earth travels around the Sun, the north pole of the Earth's axis is tilted towards the Sun in the summer, and away from the Sun during the winter. Tape the small figure of a person to the globe (at your home latitude) and point out how the person would see the noon Sun higher in the summer and lower in the winter. This can be made more apparent if the figure has a movable arm to point toward the Sun. In the summer, the arm points high up, while in the winter, the arm points much lower.



The Earth's axis of rotation is tilted by 23 1/2° with respect to the Earth's orbit around the Sun.

Your students can see the model better if you hand each student an "Earth ball" with a pin representing a person on it.

1. Have the students tilt their balls towards the Sun (summertime), rotate it until the person is experiencing noon (closest to the Sun), If the person pointed towards the Sun with his arm, would he be pointing high or low in the sky? Do the same for the wintertime Sun at noon. Would he be pointing his arm higher or lower?
2. Have the students slowly rotate their Earths and see the pins move alternately from night to day. They can see that summer nights are shorter than winter nights.
3. Another interesting observation in this model is comparing the length of the shadow of the pin at noon in different seasons.

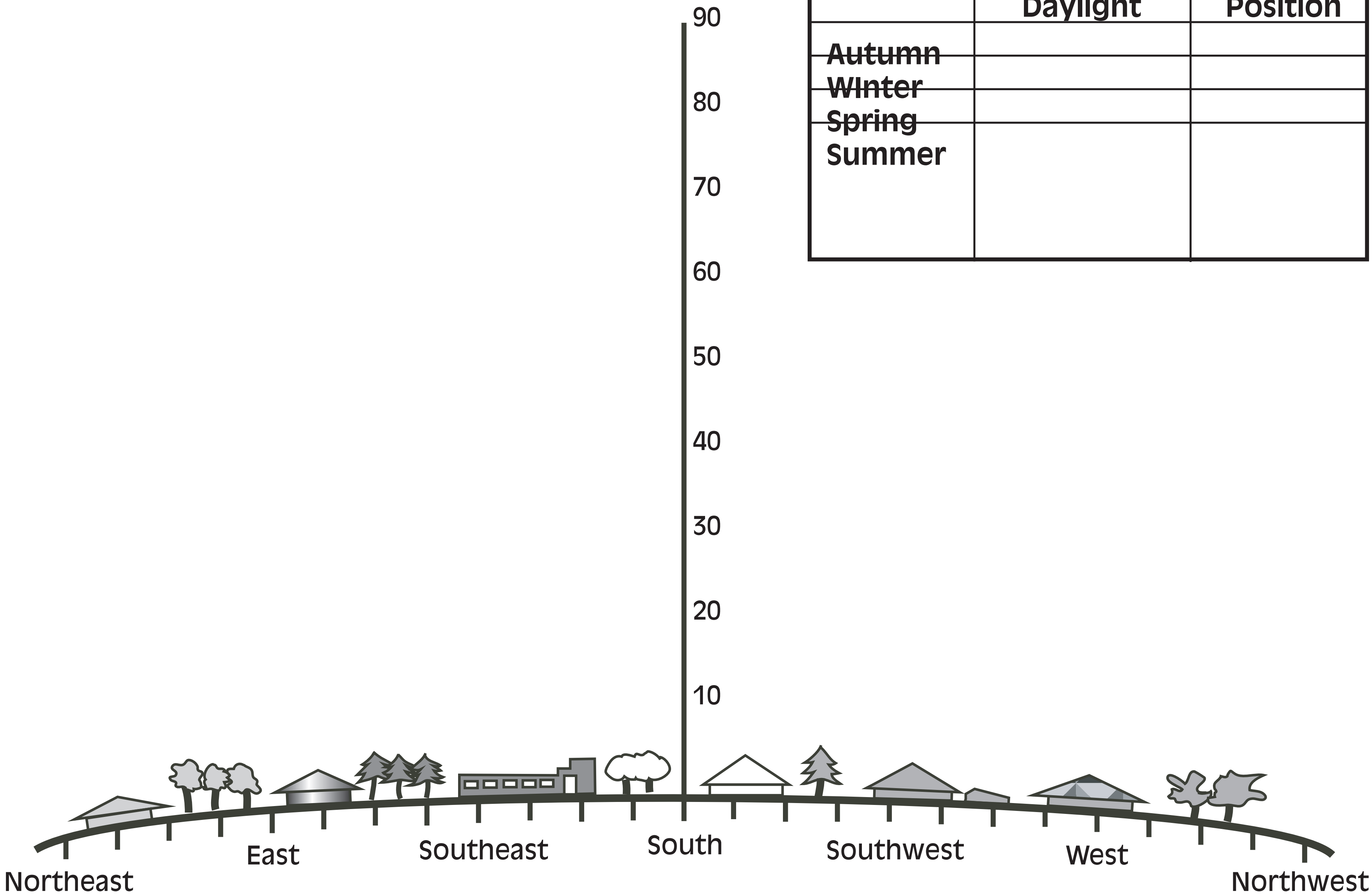
Finally, have your students use their observations of the sky and Earth model to explain why it is hotter in the summer than in the winter, even though the Earth is slightly closer to the Sun in the winter time. One explanation they may think of is that the days are longer in the summer, allowing the Earth to heat up more. That is correct, but it is only part of the story. Another reason is that when the Sun is higher in the sky, its light is more concentrated on given areas of Earth.

To illustrate, you may try one of the ideas on page 49 for a follow-up session.

The Reasons for the Seasons—Worksheet

Name ______________________ Date ____________

Season	# Hours of Daylight	Noon Position
Autumn		
Winter		
Spring		
Summer		



Follow-Up Activities

1. Prepare a grid to project onto your large Earth globe. The grid can be either a grid slide projected through a slide projector, or an overhead projector transparency. An easy way to make a grid is to photocopy a sheet of graph paper onto transparency and either cut a small piece of it to put in a slide mount or use the whole sheet on an overhead projector.

   In class, first project the grid onto a flat surface (chalkboard, wall, etc.). Each box represents a unit of light and heat from the Sun and all the boxes are equal in size when they start out from the Sun. Have the students notice that all the boxes are the same size. If the Earth were flat, then all parts of the Earth would receive equal amounts of light and heat. Let's see what happens with a round Earth. Project the grid onto the Earth globe. ***Are all the boxes the same size?*** (No.) ***Where are they the smallest?*** (The parts facing most directly towards the Sun.) ***Where are they the largest?*** (Near the poles and parts not facing as directly towards the Sun – places where it's early morning or late afternoon.) ***Remembering that each box contains the same amount of heat and light, who would be hotter, a person standing in a region with smaller boxes, or a person standing in a region with larger boxes?*** (The region of smaller boxes would get hotter because more heat is concentrated there, while in regions where there are larger boxes, the heat is being "spread out.")

   Put a piece of tape or a push pin at your city's location on the globe. Show the class how the grid boxes shining on the Earth change as the Earth is tilted towards the Sun (summer orientation) and then away from the Sun (winter orientation). ***During which season does our city receive more concentrated sunlight?*** (Summer.) That is a reason why it is hotter in the summer than in the winter.

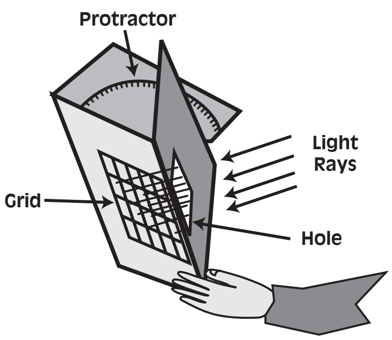
2. With STARLAB this can be made into a student activity rather than a demonstration by using the same "Earth balls" that were used before. Prepare a grid transparency wrapped into a cylinder to replace the star cylinder. Alternatively, make an opaque cylinder out of manila cardstock and, using a large push pin, make an series of holes around the "equator" of the cylinder. Light from the main star bulb shining through these holes produce standard size "light circles" that will function as units of light as the grid boxes did in Follow-Up activity (1).

   Start by having the students catch the grid boxes or light circles on flat pieces of paper. Have them note that the light boxes or circles are all the same size. Then go through the same sequence of questions used in Follow-Up activity (1), except that students can examine their own Earth globes in addition to a single large globe that the teacher handles.

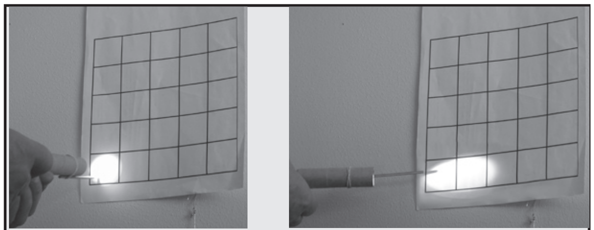
3. Prepare a class set of "Light Angle/Area Measuring Tools" by copying the bottom half of page 50 onto cardstock and cutting them out as shown (alternatively, provide your students with scissors and have them make their own). Cut along the dashed lines and fold along the dotted lines.

   Face the square window hole towards the white light "Sun" and position the paper so that a square of sunlight falls on the gridlines on the worksheet with the grid at 90° to the light rays. This is like the way the Sun hits the ground in the summer around noon (students recorded the real angle on the Reasons for Seasons worksheet). Count how many squares the sunlight covers. Now change the angle between the grid and the light rays (taking care to keep the square hole facing straight towards the Sun). This simulates how sunlight hits the ground in the wintertime. Again, count how many squares the sunlight covers. (More area is covered.)

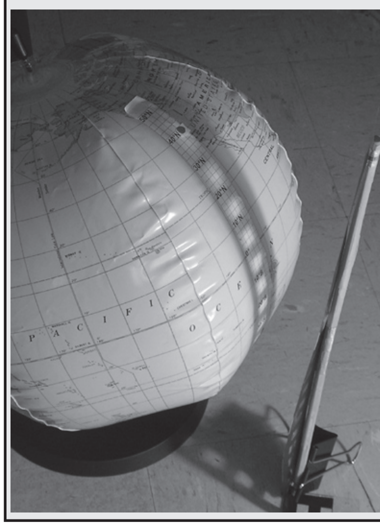
Explain that while there is still the same amount of sunlight coming through the square, it is spread over a larger area of "ground," so the ground receives less heat. That is another very important reason why it is colder in the winter. The Sun is lower in the sky, so its light hits the ground at a lower angle than in the summer. The lower the angle of sunlight, the more the light is spread out, giving less heat for a given area of ground.



Cut along dashed lines.
Fold along dotted lines.



Alternative ways to illustrate how the angle of incidence of Sun's rays on the ground affects intensity of light. Above: Using a flashlight with an extension tube to make a clean round beam, shining on a grid, and a rod to make the distance fixed.



Left: Make a mask with a vertical column of 1-cm square holes and have a light shine through the holes onto a globe.