

Light from the Sun

The Sun is the primary source of light in the Solar System. In this activity the Sun will be represented by the light bulb in the ceramic stand. Plug the light bulb in and place it in the center of a dark room.

1. Are objects closer to the Sun illuminated at the same level as objects farther away? (Try using one of the Styrofoam balls as an object.)

Imagine a spherical surface (like a soap bubble) surrounding the Sun. All of the light energy the Sun puts out must travel through this surface. It doesn't matter if the bubble is small (just above the Sun's surface) or large (at the orbit of Pluto): the *rate* at which solar energy travels through the surface is the same. If this troubles you, think of a pipe with water flowing through it. If you put water in at a constant rate of one gallon per minutes, the rate at which water exits the pipe must also be one gallon per minute. Even if you make the end of the pipe bigger or smaller, the rate at which water exits is still one gallon per minute.

In the case of the Sun, something does change as the bubble gets bigger — the surface area. Now, the intensity of light is defined as the rate of energy flow divided by the area it passes through. The same amount of energy passing through a larger area has a lower intensity than if it were passing through a smaller area. (This is one reason why lasers are so useful: they focus all of their energy through a small area, producing extremely high intensities.)

2. The surface area of a sphere is proportional to the square of its radius. The Sun's intensity is 1361 watts per square meter at the orbit of the Earth. (This quantity is called the *solar constant*.) What would the Sun's intensity be for a planet twice as far away from the Sun as the Earth?

Eclipses

For this part of the activity, your head will represent the Earth, and a Styrofoam ball will represent the Moon. (None of this is to scale, of course.) Hold the Moon directly between the (light bulb) Sun and the Earth, blocking the light. This situation represents a *solar eclipse*. The scales aren't right in this model, but in reality the Moon's size in the sky is about the same as the Sun's. (The Moon's size in the sky varies slightly because of its eccentric orbit.) When the Moon appears larger than the Sun, a *total solar eclipse* is possible. When the Sun appears larger than the Moon, only an *annular eclipse* is possible. In this kind of eclipse, the Sun appears as a ring (annulus) around the edges of the Moon.

Next, turn and face away from the Sun, holding the Moon in the Earth's shadow. This situation represents a *lunar eclipse*. In reality, the Moon never completely goes dark because red light refracted through the Earth's atmosphere illuminates the Moon, making it appear orange-red.

3. Why aren't there solar and lunar eclipse every month? (Think about the tilt of the Moon's orbit.)

Phases of the Moon

For this part of the activity, your head still represents the Earth, and a Styrofoam ball still represents the Moon. Face the Sun — this is high noon. To simulate the rotation of the Earth, spin to your left. When you're facing directly away from the Sun, it is midnight.

While facing the Sun, hold the Moon out towards it, but not necessarily lined up with it. The side of the Moon you can see should be unlit, corresponding to a new moon. Next, turn counter-clockwise 45° (as seen from above) while moving the Moon with you.

4. What phase does the moon appear to be in now?

Now, spin the Moon on its axis in a counter-clockwise direction (as seen from above). This simulates the rotation of the Moon.

5. Does the appearance of the Moon change as you spin it?

6. Are the phases of the Moon caused by its own rotation?

Next, simulate the revolution of the Moon around the Earth by turning yourself counter-clockwise while moving the Moon with you. (This is equivalent to following the Moon in its orbit so that it's always overhead.) When you're back to your starting position, one month has gone by.

7. Does the appearance of the Moon change as it revolves around the Earth?

8. Are the phases of the Moon caused by its revolution around the Earth?

Revolve the Moon around the Earth until the phase of the Moon is full.

9. Where on Earth is it noon? (The Sun is highest in the sky at noon.)

10. Is it possible to see a full Moon at noon? Why or why not?

The seasons

For the final part of this activity, the Styrofoam ball will represent the Earth. First, use a pencil to mark Troy's location on the Earth, which is at a latitude of approximately 43° N.

Now, hold the Earth level with the Sun, with the axis vertical. The Earth has an axial tilt of about 23° , so you should tip the Earth toward the Sun by that amount. For the rest of this activity, keep the Earth in this orientation with respect to the room.

Spin the Earth on its axis (again, counter-clockwise as seen from above). You should see that locations at different latitudes have days of different lengths.

11. Is there a place on Earth where the Sun never sets? where the Sun never rises? If you say yes, specify where.

Next you will simulate the motion of the Earth around the Sun. Move the Earth around the Sun in a circle (counter-clockwise as seen from above). Remember to keep the Earth tilted with respect to the room, not the Sun.

12. How does the length of the day at the latitude of Troy change over one revolution (a year)?

13. When the Earth is halfway around the Sun from its starting position, is there a place where the Sun never sets? where the Sun never rises? If you say yes, specify where.

Now make sure you are within a couple feet of the Sun. Look closely at the illuminated portion of the Earth.

14. Is the intensity of sunlight at the surface of the Earth the same everywhere? If you say no, specify where it is greatest, and where it is lowest.

The Earth's orbit is slightly eccentric, so the Earth-Sun distance varies slightly over the course of a year. Vary the model Earth's distance from the Sun by a couple inches.

15. Is there a noticeable change in solar intensity at the surface?

16. Given what you've observed, what is the more likely cause of the seasons: the Earth's axial tilt, or its varying distance from the Sun?

