EXPERIENCE 4.4

Modeling the Moon

Overall Concept

Now that students understand the order of the lunar phases and the length of the cycle, the typical question they bring up is, “What causes the phases?” This experience allows students to understand the cause by building on the modeling activity from Chapter 1 in which the students’ heads were the Earth and a lightbulb at the front of the room was the Sun. The Moon is now added to the model—in the form of a small Styrofoam ball attached to a pencil. This allows the students to explore the relationships among the Earth, Moon, and Sun to understand what causes lunar phases.

Objectives

Students will

1. be able to identify the order of the Moon’s phases from one full Moon to the next; and
2. demonstrate how the Moon’s position around the Earth (relative to the Sun) creates the phases.

Advance Preparation

Be sure there is plenty of space for students to stand with a hand stretched out and to spin around as they work through this experience. Check that the lamp or lightbulb for the model Sun works properly and can be placed high in the front of the room for everyone to see it. The room you use

MATERIALS

For the class:

- Lightbulb on a stand or clamp (or a lamp with its shade removed); a 60 W bulb is best for this experience
- Extension cord
- A room that can be made completely dark

One per student:

- Smoothfoam or Styrofoam ball or light-colored sphere for each student (as a model Moon)

Teacher note: Smoothfoam balls have a denser, smoother surface that works better for this activity, but they are often harder to find than Styrofoam balls. Either will work. Places on the web that sell Smoothfoam or Styrofoam balls include Michaels (www.michaels.com) or Smoothfoam.com (www.smoothfoam.com/category/balls.html). Staples and other similar companies also carry them online.
- Pencil
- “Moon Phase Activity Sheet” (p. 310)
- Astronomy lab notebook

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for this experience needs to be completely dark, which often means you have to switch rooms or spend time putting up black plastic sheets, dark tablecloths, or poster boards to cover light leaks in your classroom.

Procedure

1. Review the results of Experience 4.3, “Observing the Moon,” which showed that the Moon goes through a sequence of phases. Work with the students to review the order of the phases from one full Moon to the next. Discuss some of the students’ predictions about what causes the lunar phases, if this was explored in earlier discussions.

2. Tell the students that since we cannot go to outer space to observe the Moon orbiting Earth and the change in phase, we will use a model to learn what causes the Moon phases. Make the room completely dark and place the lamp at the front. Remind students of safety near the hot lightbulb and electrical cord. Have students stand facing the lamp. Make sure they are spread out enough that light from the lamp reaches each student. If you did Experience 1.5, you can remind students that this activity will be an extension of their model Sun–Earth system. The lamp still represents the Sun and their heads still represent Earth, with their noses being the students’ hometown.

3. Review what they learned from the model of the Earth and Sun developed in Chapter 1. Ask students to stand so it is noon in their hometown (noses-at-noon). If disagreement occurs as to what position this would be, have students discuss until it is agreed that noon is when their nose is pointed toward the model Sun. Next, ask them to stand so it is midnight at their noses. They should turn so that they face away from the Sun.

4. Students should recall which way Earth rotates on its axis from the experiences in Chapter 1. If students did not do those experiences or do not remember them, you will need to review a few things. Determine which way north, south, east, and west are for their model Earths (their heads). If their hometown (nose) is in the Northern Hemisphere, north is the top of their heads, south is their chins, east is to their left, and west is to their right. From prior knowledge and their Moon observations, they should know
that the Sun rises in the east. Have the students place their open hands on the sides of their heads, acting as horizon blinders. Have them determine which way Earth rotates so that the Sun rises over their left (eastern) hand. After some trial and error, they will be able to determine that the Earth rotates from right to left in their model, with their right shoulder moving forward (Figure 4.16).

FIGURE 4.16
Diagram showing how the students should stand in the model

Student turns this way

5. Ask students to stand so it is sunrise and then so it is sunset. Practice the ideas of sunrise, noon, midnight, and sunset until you feel that the students have a good understanding of these relative positions. This is a good review of what they learned in Chapter 1, and it gives them some practice with the model before introducing the Moon.

6. Distribute one “Moon ball” to each student. Have them stick a pencil into the ball to make it easier to hold and observe the phases of the Moon in the model. If there is already a hole in the ball from previous use, tell them to use that one and not make a new one. Have students hold the model Moon at arm’s length. Allow time for students to explore how the Sun’s light reflects off the model as they place their Moons in different positions around the Earth. This is a good time to tell students that the Moon orbits the Earth in a counterclockwise direction when
looking down on the Earth and Moon from above the North Pole. As they explore the different lunar phases, remind them to always have the Moon move in the correct direction.

One question that usually comes up and must be addressed is how high the model Moon should be held. If it is held at head height, there will be an eclipse (instead of a full Moon) during each orbit of the Moon around the student’s head. Help the students develop the idea that they did not observe a lunar eclipse during Experience 4.3, and generally people make a big deal about eclipses. Therefore, they probably do not occur every month. Students should then conclude that they have to hold the Moon balls up high so the balls are exposed to the Sun’s light throughout their orbit around Earth. The topic of eclipses is covered in Experience 4.5, “Modeling Eclipses,” and in Experience 4.6, “How Often Do Eclipses Occur?” In Experience 4.6, they will learn that the Moon’s orbit is not aligned with the Earth’s orbit around the Sun (or relative to the circle that the Sun appears to make among the constellations in the course of a year, which is how we on Earth perceive our motion around the Sun). As a result, the Moon is usually either above or below the Sun in the sky. But if you plan to do Experience 4.6, you may not want to give away the answer while you help them with the current activity.

7. Help students find a few of the phases of the Moon with which they are already familiar, such as a full Moon, a new Moon, and the first and third quarters. A new Moon occurs when the Earth, Moon, and Sun are aligned, and the Moon is between Earth and the Sun. A full Moon occurs when the three bodies are aligned, and the Earth is between the Moon and the Sun (Figure 4.17, p. 308).

Teacher note: Students will have many questions as they explore. Try not to answer directly. Encourage them to explore their questions using the model before providing an answer.

There is a common misconception that Earth’s shadow causes the phases, and some of your students may try to involve the shadow of their heads in the modeling. If students are trying to produce the different phases by hiding parts of the Moon with shadows of their heads, you will need to address this. Students should also come to recognize, possibly with some assistance, that they cannot generate the shape of the different phases by using the shadow of Earth.
8. After students explore finding the phases, choose one lunar phase and ask the students to determine what position in the Moon’s orbit they must place their Moon to achieve that particular phase. Full Moon is a good phase to start with. Encourage students to compare their positions and discuss differences. Ask a student who has the correct position to explain why it is correct. By walking around the classroom, you can check for understanding by seeing if all the students are holding their Moons in the same position.

9. Have students model other phases, for example, first quarter, third quarter, and new Moon. Use the terminology introduced in Experience 4.3 when requesting a particular phase, such as waning gibbous and third quarter.

FIGURE 4.17
A diagram of the Moon phases in relation to the Sun and Earth

The inner sequence shows the Moon’s relative position to the Earth and the Sun as viewed from outer space, above the solar system. Students are asked to produce a portion of this diagram on the “Moon Phase Activity Sheet.” The outer sequence shows the Moon as seen from Earth. For example, you would see the waning crescent (lower right) as a small slice of the Moon illuminated on the left side. A waxing crescent, upper right, would have the right side of the Moon illuminated.
10. Allow time for students to experiment with the movement of the Moon—always moving it in a counterclockwise direction around the Earth. They can observe their own model as well as other students’ models. This activity is very powerful and can answer many questions that the students generate about the motion of the Moon and its appearance in the sky.

**Teacher note:** Students may find it helpful to change the model slightly to answer certain questions. If one student holds the Moon ball and another student is Earth, they can more easily see Earth spinning on its axis while the Moon is barely moving in its orbit. How much of a circle does the Moon travel each 24 hours? (About 1/29th or 1/30th of a circle.) So everyone on Earth basically sees the same phase on the same night.

11. Now have students work together in small groups as they each complete the “Moon Phases Activity Sheet.” The goal is for them to produce a diagram similar to the one in Figure 4.17. These drawings should be kept in their astronomy lab notebooks.

12. After completing the diagrams, ask students to write down in their astronomy lab notebook the causes of the changing Moon phases. *(The movement of the Moon around Earth and the relative positions of the Sun, Earth, and Moon cause the phases. The spinning Earth—the student’s head—makes the Moon rise and set each day, but this does not affect the phase of the Moon.)* Encourage them to use diagrams in their explanations.

13. Check student diagrams and explanations for the causes of phases. Ask students if they are sure that their observations and the model support their diagrams and statements. If discrepancies arise, have students go back to the model to further clarify the concepts.

**Teacher note:** If you have not already used the first evaluate experience (Experience 4.10, “Lunar Phases Revisited”), now is a good time to do Experience 4.10 to assess student understanding of lunar phases.
Moon Phase Activity Sheet

This diagram represents a view you would see looking down from above at your head when you are modeling the Moon orbiting Earth. Darken the areas on each Moon that are not illuminated by the Sun. Then label each Moon phase as you would see it when your nose (on Earth) is pointed directly at it.

Be sure to use the Moon phase terms: new Moon, full Moon, first quarter, third quarter, waxing crescent, waning crescent, waxing gibbous, and waning gibbous.