

● ACTIVITY 4

Studying the Phases of the Moon

Learning Goals

Understanding the phases of the Moon requires visualizing the Earth-Moon-Sun system in three dimensions. In this activity, you will develop this ability by learning how to

1. successfully replicate the motions of the Earth and Moon, as well as their positions with respect to the Sun at each lunar phase.
2. explain the continuity of the Moon phases worldwide.
3. use an Earth-Moon figure to disprove a common misconception that Moon phases are caused by Earth's shadow.
4. correctly order the phases of the Moon.

Key terms: rotate, revolve, new Moon, waxing crescent, first quarter Moon, waxing gibbous, full Moon, waning gibbous, third quarter Moon, waning crescent

Step 1—Background

The Earth, Moon, and Sun form an interconnected, moving system. The Earth **rotates** on its axis while it **revolves** around the Sun, which is also rotating. The Moon rotates on its axis, once for each time it revolves around the Earth. You may better understand the phrase “revolves around” if you replace it with “orbits.” Stating “The Moon rotates around the Earth” or “The Earth rotates around the Sun” is incorrect.

Perhaps you have been taught about the phases of the Moon and how those phases depend on the Earth-Moon-Sun relative positions and our view of the Moon at each of those positions. Maybe you had to memorize the names of the phases—**new Moon, waxing crescent, first quarter Moon, waxing gibbous, full Moon, waning gibbous, third quarter Moon, waning crescent**. This activity should lead you to a better understanding of the cause of the phases of the Moon.

1. Complete the following statements using *revolves* or *rotates*.
 - The Earth _____ once every 24 hours.
 - The Moon _____ once on its axis for every revolution around Earth.
 - One year is the amount of time it takes Earth to _____ around the Sun.
 - The Moon _____ around the Earth in approximately 29.5 days.

Step 2—The Continuity of the Phases of the Moon

You will use a model of the Earth-Moon system to explore the phases of the Moon as they are seen on Earth every day. Take a full sheet of paper and crush it into a ball to represent Earth. Next, take one-quarter of a sheet of paper and crush it into a smaller ball to represent the Moon. You will start with a new Moon, the same geometry as shown in **Figure 4.1**. The Moon moves nearly 12° in its orbit every 24 hours (360° divided by a rounded-off 30 days in a month). For simplicity, consider all locations to mean those for viewers in the Northern Hemisphere—those who see the Moon located in the southern part of the sky as it crosses the meridian.

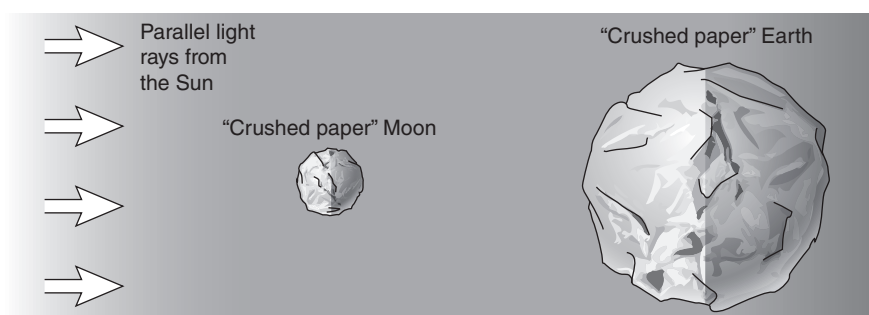


FIGURE 4.1

Place the models of the Earth and the Moon on **Figure 4.2**, found in the appendix. Imagine the sunlight coming from the front of the classroom. Orient your paper so that the “Day 0 & 30” location on the graph is toward the “Sun.” Set Earth on the center of the polar graph, and then place the Moon around the edge of the polar graph in the position of new Moon. Make Earth rotate through 1 day while moving the Moon in its orbit (revolving) 12° during each day.

2. Starting with a new Moon, rotate the paper Earth once. For this model, do all locations on Earth see approximately a new Moon (that is, if we could actually “see” a new Moon)?

Circle **Yes** or **No**

3. Each time Earth rotates, 1 day passes, and the Moon moves 12° . Move the Moon counter-clockwise in its orbit, and rotate Earth once. Repeat this process (move the Moon 12° in its orbit, and rotate Earth once) until first quarter Moon (7.5 rotations of Earth). Do all locations on Earth see close to a first quarter Moon, over the course of one rotation of Earth?

Circle **Yes** or **No**

4. Move the Moon and rotate Earth until the alignment is Sun-Earth-Moon (Moon on the “Day 15” mark). What is the phase of the Moon? _____

5. Do all locations on Earth see this phase, or very close to this phase, over the course of one rotation of Earth?

Circle **Yes** or **No**

6. Continue another 7.5 days. What is the phase of the Moon? _____

7. Do all locations on Earth see close to this phase, over the course of one rotation of Earth?

Circle **Yes** or **No**

8. Briefly summarize your answers for questions 1–7, explaining how the phases of the Moon are similar for all locations on Earth over the course of one Earth rotation, throughout the time the Moon revolves. By doing so, you will also show that the phases of the Moon are continuous.

Step 3—Phases and Earth’s Shadow

A common misconception is that the phases of the Moon are caused by Earth’s shadow. **Figure 4.3** depicts the orbit of the Moon around Earth. The orbit is shown in perspective, from an angle between edge-on and directly above the orbit. The Sun is far off the paper to the left. Earth’s shadow is shown to scale. The plane of the Moon’s orbit is tilted with respect to the plane of Earth’s orbit. Twice per year, the Moon is in the plane of Earth’s orbit **AT THE SAME TIME** that it is in new or full phase. It is at these times that eclipses can happen. Otherwise, eclipses cannot occur because the shadow of Earth is above or below the Moon.

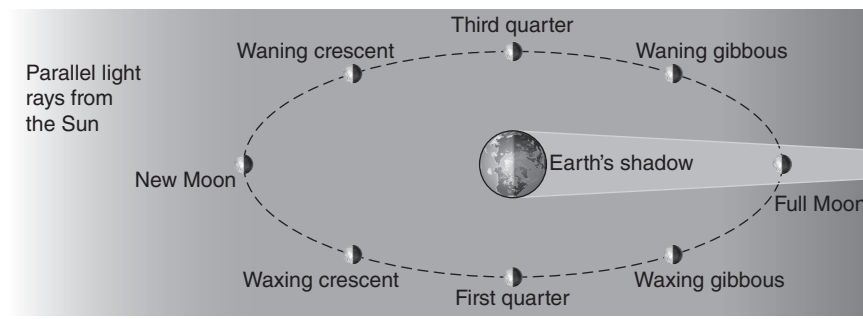


FIGURE 4.3

9. First quarter Moon is shown in **Figure 4.4**. Draw the shadows of the Earth and Moon. Use the shape of Earth's shadow in Figure 4.3 as a guide.

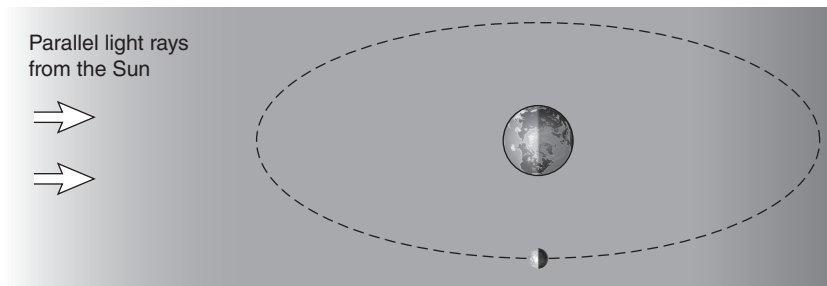


FIGURE 4.4

10. A photograph of a first quarter Moon is shown in **Figure 4.5**. Where is the Sun in this image? Where is Earth? Is there any way for Earth's shadow to darken the left side of the Moon (from our point of view) during its first quarter? Explain, taking into consideration the position of the Sun and the Earth relative to the Moon in this photograph.



FIGURE 4.5

11. In science, a hypothesis can be disproved by only one actual observation that shows it is wrong. Combine your work with Figure 4.4 and the observation of Figure 4.5 and state how it is impossible for the phases of the Moon to be caused by Earth's shadow.

Step 4—Understanding the Order of Moon Phases

12. In **Figure 4.6**, the phases of the Moon are shown in random order. Starting with “k,” which represents a new Moon, sort the phases in the order they would occur, from new Moon to full Moon and back to new again. Write the corresponding letters in order below.

k											k
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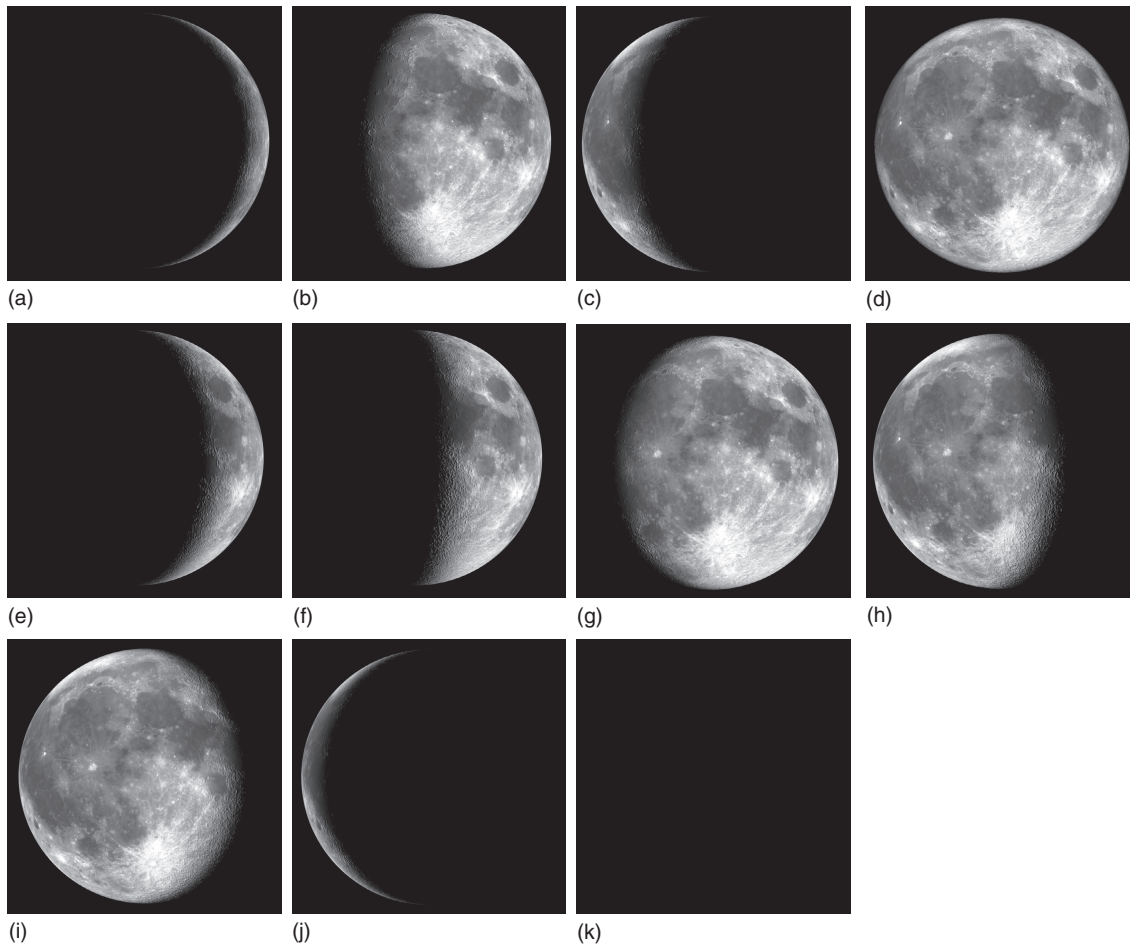


FIGURE 4.6

Step 5—Putting It Together

13. Summarize what you have learned about the phases of the Moon, using at least three of the key terms introduced in the learning goals.