~ LPI Education / Public Outreach Science Activities ~

Golf Ball Phases

Modeling Lunar Cycles

Ages: 5th grade – high school

Duration: 30 minutes

Materials:

- A golf ball for each student
- One golf tee for each golfball
- Hot glue gun or superglue
- A fluorescent blacklight at least 12" long (blacklight bulbs will not generate enough light to conduct this activity)
- A darkened room

Overview —

Students explore the dynamics of lunar phases to develop an understanding of the relative positions of our Moon, Earth, and Sun that cause the phases of the Moon as viewed from Earth. Using a golf ball glowing under the ultraviolet light of a "blacklight" makes it easier to see the phases of the Moon.

Objective —

The students will:

- Demonstrate the Moon's phases in their correct order using a golf ball and blacklight to model the Moon and Sun.
- Describe the relationship between the pattern of lunar phases and the cause of lunar phases.

***Before You Start*:** Students should already have been introduced to:

- the scale (relative size and distance) of the Earth-Moon system (for instance, in the modeling activity at http://www.lpi.usra.edu/education/workshops/phasesSeasons/HowFarMoon.pdf),
- the names and order of the lunar phases (for example in Oreo Moon Phases: http://www.lpi.usra.edu/education/workshops/phasesSeasons/OreoPhases.pdf),
- the inclination of the Moon's orbit around the Earth (the Moon orbits the Earth at a 5 degree inclination or tilt, compared to the Earth's orbit around the Sun),
- and the Sun's role as the source of light for Moon phases.

Ordinary golf balls will glow (fluoresce) under the black light; no special modifications are needed. Use a hot glue gun or superglue to glue a golf tee to the bottom of each golf ball, to make it easier to hold and observe the phase.

Prepare to darken the room by closing blinds or covering windows.

Activity —

STEP 1: MODEL THE MOON'S MOTION FIRST FOR THE STUDENTS.

1. Choose a student to hold the golf ball and tee representing the Moon. The student's head will represent our Earth. Choose another student to stand with the blacklight representing the Sun. Turn out the room lights. Before turning on the "Sun," ask the students to observe the golf ball.
   - *Does the golf ball make its own light?* (No)
   - *Does our Moon make its own light?* (No)

2. Turn the blacklight on and have the student with the golf ball hold it low (waist-high), between the student and the light, so that the blacklight is shining on the part of the golf ball facing away from the student. Ask the student to describe the appearance of the "Moon."

   - *What is the blacklight doing to the golf ball?* (It makes the golf ball glow, or fluoresce.) *Does the Sun make the Moon glow like this?* (No, it just shines on the Moon, lighting it up. We are using the blacklight and golf ball as a model, to make it easier to see the different shapes of the Moon that the Sun's light reflects.)
   - *What does he observe about the Moon? Is the part of the Moon we see from Earth illuminated?* (No)
   - *What part is illuminated?* (The part facing the "Sun" that they cannot observe from "Earth")
   - *What phase of the "Moon" is he observing from "Earth"?* (The new Moon)

3. Ask the student holding the "Moon" to slowly turn to his left (counterclockwise) 90° while raising the golf ball to shoulder-height, keeping the Moon at arm's length. Explain that our model is exaggerating the Moon's inclination—that the Moon doesn't orbit the Earth in line with the Sun, but its orbit is tilted 5 degrees relative to the Earth's orbit around the Sun.

   - *As the Moon revolves around the Earth, what happens to its appearance? How does the illumination of the Moon change as viewed from the Earth?* (It increases to 1st Quarter)

4. Ask the student holding the "Moon" to continue turning counterclockwise and raising the golf ball, until the ball is 180° away from the blacklight and above the student's head.

   - *What phase of the Moon is he observing when the Moon has orbited halfway around the Earth?* (A full Moon)

5. Ask the student holding the "Moon" to slowly turn another 90° to his left while lowering the golf ball to shoulder-height, keeping the Moon at arm's length.

   - *What phase of the Moon is he observing now, when the Moon has orbited three quarters of the way around the Earth?* (3rd quarter, or last quarter Moon)

STEP 2. STUDENT EXPLORATION

1. Once the students are comfortable with the motion of the Moon, starting low in front of the lamp and turning counterclockwise while raising the golf balls above their heads for full Moon, have each student take a golf ball and model the motions of the Moon, while the teacher holds the blacklight. [Note: about 15 students can fit around a blacklight tube; this exercise can be repeated for the remaining students, or a second blacklight can be positioned at the other side of the classroom so that all students can participate simultaneously.]

2. Have the students observe the changing illumination of the Moon, repeating the exercise so that each Moon phase is revealed. Start with the new Moon and have the students rotate their bodies (causing their "Moon" to revolve around them) in steps of 45 degrees, pausing at each of the eight phases (waxing crescent, 1st quarter, waxing gibbous, full, waning gibbous, 3rd quarter, waning crescent) to invite the students to share their observations about the illumination and to identify the phase.
   - *Why are we moving the "Moon" down to our waist height for New Moon and up to above our heads for Full Moon?* (We are exaggerating the Moon's inclination of 5 degrees, so that the Moon isn't eclipsed by our heads each month.)

3. Open student exploration: The teacher can provide the students with a series of lunar phase observations (for example, waning crescent and then first quarter), and the students can be invited to replicate the pattern of lunar phases observed by moving the golf ball to various positions, and hypothesize the relationship between the Moon's motion and the changing lunar phases.

EDUCATOR QUESTIONS —

To explicitly connect this activity to the science and engineering practices and the cross-cutting concepts, consider a class discussion around questions to review what the students did, their observations, and their conclusions:

- *What phenomenon does this model simulate? What are the limitations of this model?*
  (Answers regarding the phenomenon could include: the motions of the Moon; the Moon's phases; possibly eclipses; the Earth-Moon system. Limitations include, but are not limited to: the model does not accurately reflect the scale of the Earth-Moon system, it exaggerates the inclination of the Moon's orbit, it uses the ultraviolet light and the paint of the golf balls to make them glow rather than just reflecting the light of the "Sun.")
- *What was the scale of your model? Why did this model need to be scaled in order to observe this phenomenon?*
  The size of the golf ball Moon is about ¼ the width of our "Earth" heads, but the distance of an arm's length is much too short. If we correctly scaled this by having someone move the golf ball many feet away, we would not still be able to see the phases clearly.
- *What does your model demonstrate about the components of your system?*
  Students may have a variety of ways to express their thoughts on this complex relationship between models and this system. This model demonstrates that the Sun's light illuminates different parts of the Moon as it orbits the Earth, which we see as different phases.
- *How does the pattern of lunar phases relate to the cause of lunar phases?*
  Students may have a variety of ways to express their thoughts. This model demonstrates that the Sun's light illuminates different parts of the Moon as it orbits the Earth, which we see as different phases.

EXTENSIONS —

Conduct the kinesthetic activity *Paper Plate Moon* (see http://www.lpi.usra.edu/education/workshops/phasesSeasons/PaperPlateMoonPhase.pdf) requiring the students to correctly position themselves and the Moon phase they carry relative to the Earth and Sun.

BACKGROUND —

This activity is intended as a formative assessment after some initial lunar phase activities have been conducted. This activity can demonstrate the students' abilities to apply their understanding of lunar phases in a new way. Understanding the cause of lunar phases is a spatially complex topic that confuses many people. Instructors should take care not to rely exclusively upon two dimensional models and should require all students to model the phases for themselves. Most activities can accidentally reinforce misconceptions if not done carefully.

Students with a thorough understanding of why we see lunar phases will (possibly after some practice) be able to take a lunar phase and position themselves correctly relative to the other phases and the "Earth" and "Sun." The person holding the New Moon plate should be positioned between the Earth and Sun, facing the Earth. The student holding the Full Moon plate should be positioned on the far side of the Earth, relative to the Sun, again facing the Earth.

Why do we see lunar phases?
The "amount" of Moon that we see as we look from Earth changes in a cycle that repeats about once a month (29.5 days). The relative positions of our Sun, Earth, and Moon, cause these changes. The side of the Moon facing the Sun is always illuminated, just like Earth's daylight side is illuminated by the Sun. From our perspective on Earth, we see different parts of the Moon's illuminated surface as the Moon orbits the Earth. Additional information is available at http://www.lpi.usra.edu/education/skytellers/moon_phases/about.shtml.

ADDITIONAL RESOURCES—

Space Place: The Moon's Phases in Oreos
http://spaceplace.nasa.gov/oreo-moon/en/
This article explains the monthly variations in the Moon's appearance as seen from Earth. Directions for using Oreo cookies to illustrate the four major phases of the Moon are provided. The article is targeted to children ages 10-12.

Explore: Marvel Moon
Background: http://www.lpi.usra.edu/education/explore/marvelMoon/background/
Activities: http://www.lpi.usra.edu/education/explore/marvelMoon/activities/
This informal education program explores NASA's investigations into the ongoing saga that has shaped our Moon. Discover our scientific, cultural, and personal understanding of Earth's nearest natural neighbor.

Sustainable Trainer Engagement Program: Lunar Phases
http://www.lpi.usra.edu/education/step2012/participant/lunar_phases/
This website has activities and resources for teaching lunar phases to middle school students.

Moon Posters
http://www.lpi.usra.edu/education/moon_poster.shtml
Three posters, designed for students in 6th through 9th grades, explore how the Moon formed and changed through time, spacecraft missions measuring different wavelengths of light reflected off the Moon's surface, and how we can use the available materials to support future lunar outposts.

Unknown Moon Institute
http://www.lpi.usra.edu/education/workshops/unknownMoon/agenda.html
This website has a series of activities, data sets, and resources for high school classroom teachers, related to lunar exploration, lunar science, and lunar phases.

TIES TO STANDARDS —

Next Generation Science Standards

Performance Expectation MS-ESS1-1. Develop and use a model of the Earth-sun-moon system to describe the cyclic patterns of lunar phases, eclipses of the sun and moon, and seasons.

Disciplinary Core Idea: ESS1.A: The Universe and Its Stars

- Patterns of the apparent motion of the sun, the moon, and stars in the sky can be observed, described, predicted, and explained with models. (MS-ESS1-1)

Disciplinary Core Idea: ESS1.B: Earth and the Solar System

- The solar system consists of the sun and a collection of objects, including planets, their moons, and asteroids that are held in orbit around the sun by its gravitational pull on them. (MS-ESS1-2),(MS-ESS1-3)
- This model of the solar system can explain eclipses of the sun and the moon. Earth's spin axis is fixed in direction over the short-term but tilted relative to its orbit around the sun. The seasons are a result of that tilt and are caused by the differential intensity of sunlight on different areas of Earth across the year. (MS-ESS1-1)

Science and Engineering Practices: Developing and Using Models

- Develop and/or use models to describe and/or predict phenomena.

Crosscutting Concepts: Patterns

- Patterns can be used to identify cause-and-effect relationships. (MS-ESS1-1)

Texas Science Standards

8th grade Science Concept Standards (TEKS)

(7) Earth and space. The student knows the effects resulting from cyclical movements of the Sun, Earth, and Moon. The student is expected to:

(B) demonstrate and predict the sequence of events in the lunar cycle.