Golf Ball Phases and Embroidery Hoop Eclipses

Ages:
5th grade – high school

Duration:
30 minutes

Materials:
- A golf ball for each student
- (optional) one golf tee for each golfball
- (optional) hot glue gun
- A blacklight
- A darkened room
- An embroidery hoop or something similar (rigid and oval) for each team of students

Overview —

In the first half, 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 actual phase of the Moon.

In the second half, students adjust their orbits of their moons to gain a deeper understanding of eclipses.

Objective —

The students will:
- Demonstrate the Moon's phases in their correct order using a golfball and blacklight to model the Moon and Sun.
- Demonstrate that eclipses occur during two periods each year, modeling the Earth-Moon system's motion around the Sun.

Before You Start: Do not introduce this topic unless the students already understand the size and distance of the Earth and Moon to scale, the tilt of the Moon's orbit around the Earth, and the Sun's role as the source of light for Moon phases.

Use a hot glue gun to glue a golf tee to the bottom of each golf ball.

Prepare to darken the room by closing blinds, etc.

Activity —

Step 1: Model the Moon's motion first for the students.

1. Choose a student to hold the golf ball representing the Moon. The child'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 light on and have the student with the golf ball hold it low in front of them, between the student and the light. Ask the student with the "Moon" to describe its appearance.
   - *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")
   - *Based on this observation, does the Moon really have a "dark" side?* (No)
   - *What phase of the "Moon" is he observing from "Earth"?* (The new Moon)

3. Ask the student holding the "Moon" to slowly turn 90° while raising the golf ball to shoulder-height, keeping the Moon at arm's length.
   - *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)

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4. Ask the student holding the “Moon” to continue moving and raising the golf ball, until the ball is 180° away from the blacklight and just over 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° 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 moving up to 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.

2. Have the students observe the changing illumination of the Moon, repeat the exercise so that each Moon phase is revealed. Start with the new Moon and have the students rotate 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 make observations about the illumination and to identify the phase.

Step 3. Modeling Eclipses

1. After the students are comfortable with the motion of the Moon, remind them that the Moon’s orbit isn’t a perfect circle—it’s an ellipse.
   - *What are some objects that have elliptical shapes?*

2. Show the students an embroidery hoop. Hold the hoop at an angle to the blacklight that mimics the positions that the students have been moving their golf balls—low in the front and high in the back. Ask the students about the effect this orbit has on the Moon’s appearance.
   - *Will the Moon block the Sun for people on Earth when it moves in this orbit? Will the Earth block the sunlight from reaching the Moon in this orbit?* (no)

3. Explain that the Moon’s orbit remains tilted as the Earth orbits the Sun. Walk with the embroidery hoop around the blacklight, stopping when you have moved one quarter of the way around the Sun. Have a student demonstrate the motion of the Moon with a golf ball from this position for the class.
   - *Now when the Moon is low, what is its phase? Where will it be at new Moon? What will people on Earth see?* (People on the right part of the Earth will see solar eclipse)
   - *Two weeks later, when the Moon is at full, what will people on Earth see?* (A lunar eclipse, visible to everyone on the part of the Earth facing the Moon)

4. Continue moving the embroidery hoop around the blacklight, rotating the blacklight as needed. Stop at another quarter of the way around the Sun. Discuss the Moon’s appearance with the class.
   - *Will the Moon block the Sun for people on Earth when it moves in this orbit? Will the Earth block the sunlight from reaching the Moon in this orbit?* (no)

5. Continue moving the embroidery hoop around the blacklight, rotating the blacklight as needed. Stop at the 3rd quarter of the way around the Sun. Discuss the Moon’s appearance with the class.
   - *Now when the Moon is low, what is its phase? Where will it be at New Moon? What will people on Earth see?* (People on the right part of the Earth will see solar eclipse)
   - *Two weeks later, when the Moon is at full, what will people on Earth see?* (A lunar eclipse, visible to everyone on the part of the Earth facing the Moon)
   - *How much time has past since we had the last solar eclipse and lunar eclipse?* (6 months)

6. Let the students practice moving their golf balls from these different locations, modeling both lunar and solar eclipses. Ask them to demonstrate the position of the Moon during a solar eclipse, and then a lunar eclipse.
   - *What is the Moon’s phase for a solar eclipse?* (new)
   - *What is the Moon’s phase for a lunar eclipse?* (full)

7. Conclude by letting them know that sometimes the Moon brushes through just part of the Earth's shadow, resulting in a partial lunar eclipse, and sometimes the Moon only covers part of the Sun, resulting in a partial solar eclipse. There are a total of 5 to 7 eclipses each year; some of these are partial eclipses, often a month apart.

EXTENSIONS —

Conduct the kinesthetic activity *Paper Plate Moon*, requiring the students to correctly position themselves and the Moon phase they carry relative to the Earth and Sun.

BACKGROUND —

Understanding the cause of lunar phases is a spatially complex topic that confuses many people. Instructors should take care not to rely upon two dimensional models and should require all students to model the phases for themselves. Most activities, including this one, can accidentally reinforce misconceptions if not done carefully; for instance, if students do not hold the "full moon" high enough, they can create an eclipse that might be confused with the new moon.

A resource that might be useful to examine before this lesson is *Learning about Phases of the Moon and Eclipses: A Guide for Teachers and Curriculum Developers,* http://aer.noao.edu/AERArticle.php?issue=7&section=2&article=2

TIES TO STANDARDS —

Connections to the National Science Standard(s)
Content Standard D Earth and Space Science, (grades 5—8): Most objects in the solar system are in regular and predictable motion. Those motions explain such phenomena as the day, the year, phases of the moon, and eclipses.

Principles & Standards for School Mathematics
Geometry Standard for Grades 3-5: Specify locations and describe spatial relationships using coordinate geometry and other representational systems
Reasoning and Proof: Instructional programs from PK through grade 12 should enable all students to make and investigate mathematical conjectures

Texas TEKS
Scientific investigation and reasoning. The student uses critical thinking, scientific reasoning, and problem solving to make informed decisions and knows the contributions of relevant scientists. The student is expected to:

(A) in all fields of science, analyze, evaluate, and critique scientific explanations by using empirical evidence, logical reasoning, and experimental and observational testing, including examining all sides of scientific evidence of those scientific explanations, so as to encourage critical thinking by the student;
(B) use models to represent aspects of the natural world such as a model of Earth's layers;
(C) identify advantages and limitations of models such as size, scale, properties, and materials;

3rd grade Science Concept Standards (TEKS)
(8) Earth and space. The student knows there are recognizable patterns in the natural world and among objects in the sky. The student is expected to: (C) construct models that demonstrate the relationship of the Sun, Earth, and Moon, including orbits and positions…

4th grade Science Concept Standards (TEKS)
(8) Earth and space. The student knows that there are recognizable patterns in the natural world and among the Sun, Earth, and Moon system. The student is expected to:
(C) collect and analyze data to identify sequences and predict patterns of change in shadows, tides, seasons, and the observable appearance of the Moon over time.

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; and
(C) relate the position of the Moon and Sun to their effect on ocean tides.