Demonstrating Eclipses & Shadows
Teacher Resource

Grade Level **K-12**

Objectives

1. The student will explain the movement of the sun and the moon, in relation to lunar and solar eclipses.
2. The student will illustrate the movement of the sun and the moon, in relation to lunar and solar eclipses.
3. The student will demonstrate the use of 21st century technology with a document camera.

National Standards

NS.K-4.1; NS.5-8.1; NS.9-12.1	Science as Inquiry
NS.K-4.4; NS.5-8.4; NS.9-12.4	Earth and Space Science
NS.K-4.5; NS.5-8.5; NS.9-12.5	Science & Technology
NT.K-12.1	Basic Operations and Concepts
NT.K-12.3	Technology Productivity Tools
NT.K-12.6	Technology Problem-Solving & Decision-Making Tools

Teacher Background Information

In this lab, the student will see how the movement of the sun and moon relate to a solar and lunar eclipse. In this case, the sun will be a handheld flashlight or a mounted wall light, the moon will be a small Styrofoam ball and the Earth will be a larger Styrofoam ball. There are some other important details to remember to make this activity reflect reality in nature.

- ❖ The Earth travels around the Sun once approximately every 365.25 days (which is why we have a Leap Year every fourth year.)
- ❖ The Earth's orbit is an ellipse, not a circle around the sun
- ❖ The Earth rotates around its own axis every 24 hours in a counterclockwise direction (as viewed from the North Pole.)
- ❖ The Moon orbits around the Earth also in a counterclockwise direction, every 29.53 days

Ultimately light on the Earth's surface comes from the Sun. Moonlight, which does light the Earth at night, is in fact reflected light from the Sun; the Moon acts like a large reflector in the sky. The Moon has an elliptical orbit around the Earth of about 30 days (29.53 days or 29 days, 12 hours, 44 minutes). The Moon exhibits different phases each month, depending upon the relative position among the Sun, Moon, and Earth. A *Full Moon* occurs when the Sun and Moon are on opposite sides of the Earth. We see a *New Moon* or a *Dark Moon* when the Moon is on the same side of the Earth, and little or no light is reflected onto the Earth's surface.

If the Moon is perfectly lined up in front of the Sun for a short period of time, on Earth we experience a Solar Eclipse. We do not observe a solar eclipse every month because the plane of the Moon's orbit around the Earth is tilted by about 5 degrees with respect to the plane of Earth's orbit around the Sun. Thus, when new and full Moons occur, the Moon usually lies to the north or south of a direct line through the Earth and Sun. Although an eclipse can only occur when the Moon is either new (Lunar) or full (Solar), it must also be positioned at (or very nearly at) the intersection of Earth's orbit plane about the Sun and the Moon's orbit plane about the Earth. This happens about twice per year, and so there are between 4 and 7 eclipses in a calendar year. Most of these are quite insignificant; major eclipses of the Moon or Sun are rather rare.

What most people do not realize is that such an eclipse is not visible in the same way across the whole earth. Rather a given Solar Eclipse may be more or less complete dependent upon where on the Earth the observer is located. A full Solar Eclipse in South Africa may be a minimal or negligible eclipse in New York. As the Moon in its normal rotation passes around the Earth, it will generate a shadow on the Earth's surface. Normally the moon's full shadow only covers a belt on the earth's surface of about 269 Kilometers (169 miles) wide. Similarly, a Lunar Eclipse occurs when the Earth comes between the Sun and the Moon, blocking light from reaching the moon, and since it is a reflective surface, the moon becomes "dark" since no sunlight reaches it.

Discussion is best in this unit if conducted while the Styrofoam Balls are being moved. By the end of the demonstrations students should be able to discuss and answer questions such as:

- What is a Solar Eclipse?
- What is a Lunar Eclipse?

- ❖ Why are scientists all going to a specific location in order to see a maximum or full Solar Eclipse?
- ❖ Why don't we have a Solar Eclipse and a Lunar Eclipse each month?
- ❖ Why does the position of the observer on the Earth's surface modify what sort of an eclipse they actually see at that location?
- ❖ Why shouldn't we ever stare directly at a Solar Eclipse?
- ❖ Which way and how often does the Earth revolve around the Sun?
- ❖ Which way and how often does the Moon revolve around the Earth?
- ❖ In which direction does the Earth revolve around its axis?

MATERIALS

Document Camera

Personal Computer

Interactive White Board/Projector

Modeling Clay (golf ball sized piece)

Styrofoam Ball (approximately 5 cm)

Styrofoam Ball (approximately 10 cm)

(2) Ball Point Pens or (2) 20 cm Doweling Rods

Flashlight (optional, but useful)

Meter or Yard Stick (or any other meter or yard long straight object)

PROCEDURE

Activity 1 *Demonstrating a Solar Eclipse*

1. Place ball of clay on one tip of a dowel rod or pen. *Clay will be used to hold the doweling rod or pen upright so that the "Earth" is stationary in place.*
2. Place the 10cm Styrofoam *("Earth")* ball on the other end of the dowel rod or pen.
3. Position the document camera above and to one side of the "Earth". *Turn on the document camera and project the image, so the entire class can see what happens on the Earth's surface as the activity progresses.*
4. At this point, it may be helpful to darken the room a bit to maximize the "Sun", but

be careful not to make it so dark that there is not enough light to allow the camera to work.

5. Turn on a flashlight and position it about 0.5 m from the "Earth".
6. Have a student hold the flashlight (Sun) or fix it permanently in position above the "Earth".
7. Hold the "Moon" about 20 cm from the surface of the "Earth" *(side away from the light)*.
8. Assuming the top of the "Earth" is the North Pole, rotate the moon counterclockwise (simulating actual movement) toward the front of the "Earth".
9. As the moon moves, be sure that you are creating shadows on the "Earth's" surface *(make sure the camera is positioned to clearly capture the shadows).*
10. The total eclipse occurs as the "Sun's" light disappears entirely from the surface of the "Earth."

Activity 2 *Latitudes*

Take note that only certain areas (latitudes) experience the full total eclipse at one time.

1. Set up the Ken-A-Vision document camera as in Activity 1.
2. Conduct the experiment again, this time demonstrating how shadows only cover a part of the "Earth's" surface. *(Width of the shadow will vary based on the distance the "Moon" is held above the "Earth's" surface – Further away, larger the shadow).*
3. Explain to the class: As the Earth rotates the Moon's shadow sweeps across the surface and totally covers only about 269 km (169 miles) at one time. For this reason, only certain areas experience a total Solar Eclipse at a given time, while the rest of the Earth experiences a partial eclipse. Astronomers will travel to a specific location during an eclipse in order to study the full Solar Eclipse.

Activity 3 *The Moon's Shadow*

1. Introduce this activity, by asking the class to make a prediction to this question; does the Moon's shadow always hit the Earth?

2. Most of the time during a new Moon, the Moon's shadow doesn't reach the Earth because of the 5 degree tilt-variance noted in the Teacher Background notes above.
3. Position the document camera so it is focused on the larger Styrofoam Ball “Earth”.
4. Using a meter or yard stick, find the approximate straight line between the light source and the “Earth”.
5. Now place the “Moon”, the “Sun”, and the “Earth”. Notice that the closer the “Moon” is to being on the straight line path, the ‘better’ or stronger the eclipse. If the “Moon” is slightly above or below the straight line beam of the light, the shadow may miss the “Earth” completely. This demonstrates why there is not an eclipse every month.

Activity 4 *Lunar Eclipse*

1. Reverse which of the Styrofoam Balls is fixed in place in the clay ball that is acting like a base. i.e. now place the doweling rod or pen holding the smaller Styrofoam ball into the clay.
2. Reposition the document camera to capture a Lunar Eclipse, by focusing the camera on the “Moon’s” surface. *(You can also try the experiment by having the camera be the “Moon” as you move the “Earth” over it, and demonstrate how the “Moon” (in this case the camera) is completely in the shadow).*
3. Now move the large Styrofoam ball, “Earth”, between the light source and the “Moon”. Again be sure to be absolutely realistic that the “Earth” is moving counterclockwise on the “Moon”. Because of its larger size, the “Earth” casts a shadow on the entire “Moon”, because it has blocked all light from reaching the “Moon”.
4. Have students visualize what is seen of the Moon by an observer on the Earth.

PRESENTATION

Have students prepare a lab report including the data, images, and video to give a presentation on the interactive white board or projector for the class.

EXTENSION

- What causes the seasons? This can be demonstrated by placing a knitting needle or dowel rod through a new Styrofoam ball to outline the Earth's axis. Focus the document camera, from above, on a stationary Styrofoam ball (held by the clay as above). Now holding the "Earth" by its axis (tilted about 19 degrees off of vertical = actual tilt of Earth), and rotate it around the fixed Styrofoam ball ("Sun") or an incandescent light in a socket, moving in a counterclockwise direction. The Earth's northern hemisphere will be in the sun on one side of an elliptical orbit, and at the point 180 degrees from there the southern hemisphere will get more sun.
- This could be a good moment to introduce other concepts about celestial movements such as:
  - ✓ Northern end of Earth's axis always points to the North Star.
  - ✓ Planetary movement with relationship to each other and the Sun