Lesson Title: Modeling a Solar Eclipse

Subject	Grade Level	Timeline
Physical Science, Earth & Space Science	5 - 9	30 minutes

Objectives

This lesson investigates the alignment of the Earth, the Moon, and the Sun during a solar eclipse, and has students model that alignment with classroom materials.

Standards

Next Generation Science Standards
Middle School Physical Sciences Storyline
https://www.nextgenscience.org/sites/default/files/MS%20PS%20DCI%20Combined%206.13.13.pdf

Students who demonstrate understanding can:

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.

Materials

Clay (approximately 1 oz per group)
Yardstick (1 per group)
Toothpicks (2 per group)
Binder clips (2 per group)

Vocabulary

- Solar eclipse - the casting of the Moon's shadow onto the Earth, blocking view of the Sun for viewers on Earth or in near-Earth orbit.

Lesson Plan

Background for Teachers:

One of the hardest parts about learning how eclipses work is to be clear about the difference between a solar eclipse and a lunar eclipse. A solar eclipse is when our view of the Sun is being blocked by the Moon. For this to happen, the Moon has to be between the Earth and the Sun. In contrast, a lunar eclipse occurs when the Moon passes through the Earth's shadow in space. For that to happen, the Earth has to be between the Sun and the Moon. In both cases, the eclipse is caused by the alignment of those three bodies, so it can be easy to confuse which alignment causes which type of eclipse.

Another thing that can be difficult to understand at first is why eclipses don't occur more frequently. When students learn about the phases of the Moon, they should understand that the Moon is always half in Sunlight and half in darkness, and what phase we see is determined by where the Moon is compared to us. This may prompt the question of why there is not a solar eclipse every new Moon, and why there is not a lunar eclipse every full Moon.

That is exactly what would happen, if it were not for the fact that the Moon's orbit around the Earth is tilted about 5 degrees from the Earth's orbit around the Sun. That means that each month, the alignment of the Sun-Earth-Moon system comes close to creating both a lunar eclipse at full Moon and a solar eclipse at new Moon. But the exact alignment is more rare than that, with partial or total solar eclipses visible from *somewhere* on Earth on average about 2.4 times per year - and that somewhere doesn't always even reach a continent. Partial or total lunar eclipses happen about 1.5 times per year. See the Resources section at the end of this document for links to images and video of the Moon's tilted orbit.

Note: If possible, allow students to use direct sunlight as the light source when using their models to cast shadows. If weather or classroom conditions do not allow you to use the Sun then you may need to model the sun with a single lamp positioned at a distance. The more light sources present, the more difficult it will be to see the shadow from the model of the Moon projected onto the model of the Earth.

Student Activity

To model how the Moon's shadow creates a solar eclipse for Earth, you will create a model of the Earth-Moon system that is to scale.

1. Make a clay ball that is 1" diameter. This will represent the Earth in your model.
2. Make a smaller clay ball that is ¼" diameter. This will represent the Moon, which is about ¼ the diameter of Earth.
3. Stick a toothpick approximately halfway through each ball.
4. Use one binder clip to attach the toothpick that holds the larger ball to the yardstick, very close to the beginning of the yardstick.
5. Use a binder clip to attach the toothpick that holds the smaller ball to the yardstick at the 30" mark. The distance from the Earth to the Moon is approximately 30 times the Earth's diameter, so this creates a good model of the Earth-Moon system.
6. Align your Earth-and-Moon model with the Sun so that the small ball casts a shadow on the big ball.

Extensions

- The ISS orbits at an average altitude of approximately 250 miles. To scale, where would it be on your Earth-Moon model?

- The Earth-Moon system can also be approximated to scale with a basketball and a tennis ball or baseball. Can you measure these and calculate how far apart they would have to be to use them to create a scale model of the Earth-Moon system?

Resources

NASA Eclipse 2017 educational resources website: https://eclipse2017.nasa.gov/education

American Astronomical Society Educational Materials and Videos page: https://eclipse.aas.org/resources/educational-materials

- Tilt of Moon's orbit: https://svs.gsfc.nasa.gov/cgi-bin/details.cgi?aid=4324
- Tilt of Moon's orbit: https://eclipse.aas.org/sites/eclipse.aas.org/files/AAS-Workshop-2016.jpg

PBS Learning Media Solar Eclipses page: https://www.pbslearningmedia.org/resource/ess05.sci.ess.eiu.eclipse/solar-eclipses/#.WX-NatMrLOQ

National Air and Space Museum: Lightning Lesson

- https://www.youtube.com/watch?v=csBRqOuSCw8&list=PL6RlkQnoCx_VhRvL-NRicNDXd_8Q5iO2g&index=1