Moon Phases and Eclipses

Suggested Grade Level(s): Middle School
Estimated class time: one class period

Summary

An essential factor in the understanding of the gravitational bending of light was the discovery that the gravity of the sun's mass could cause a distant star to appear as if it was actually in a different location. Einstein predicted that the light from a far away star would be bent, but it could only be seen during a solar eclipse when the light of the sun between Earth and the distant star did not blind the observer. In this activity you will create a solar eclipse, a lunar eclipse, and learn more about why the moon appears differently from one night to the next.

Objectives

- Students will demonstrate both a solar and lunar eclipse and explain the differences and similarities of both.
- Students will explain why Einstein used a particular solar eclipse to demonstrate that extreme gravity can bend light.

National Standards

National Science Standards

- NS.5-8.1 SCIENCE AS INQUIRY

  As a result of activities in grades 5-8, all students should develop--
  - Abilities necessary to do scientific inquiry
  - Understandings about scientific inquiry
- NS.5-8.4 EARTH AND SPACE SCIENCE

  As a result of their activities in grades 5-8, all students should develop an understanding
  - Structure of the earth system
  - Earth in the solar system

Knowledge Prerequisite

- Students should be familiar with the concepts of the sun-earth-moon system and should also be aware that other stars exist far beyond our solar system.
- Students should have read the 1919 Cosmic Times articles about Einstein's predictions.

Materials

- Photographs or slides which show the real moon in several different phases
- Plastic foam ball about the size of a grapefruit (to be the moon)
- Pencil or short dowel rod about the size of a pencil
- A bright light such as a lamp without the shade (to be the sun)
- A very small, dim light such as those found on a key chain (to be the distant star)
- Paper and a pencil to record what you observe
- A very dark room
- A camera to photograph a panorama of your horizon

Procedure:

I. Engagement

Ask the students to draw a picture of the moon showing the way it looked the last time they remember seeing it. This will probably produce several different views. Show the students the photographs of the moon phases in no particular order and ask them to write why they think the moon looks different at different times. Allow the students to share their thoughts with the class. A very common misconception is that the shadow of the earth causes the moon phases. Don't contradict that thought, but do draw a picture on the board which shows the Earth, its shadow, and the moon in various positions on its trip around the earth.

II. Exploration

Explain that the ball will represent the moon and the lamp will be the sun. Their eyes will be an observer from earth. Allow them to experiment with the ball and lamp to recreate the condition they drew in the first activity. Then ask them to reproduce at least two other conditions similar to the images you showed them in the photographs.

III. Explanation

Remind the students that when scientists do research, they try to follow an experimental plan, which can be repeated by other researchers in their own laboratories. Now we will all try to complete the same procedure to see if we can find an explanation for the phases of the moon.

Set up the light (turned off) in a position so that you can stand about 2 meters in front of it, have enough room to hold your arm out straight in front of you, and be able to rotate a full 360-degree circle. Push the pencil into the foam ball so that it makes a little stem handle to hold the ball up enough to keep your fingers out of the ball's shadow. Place the smaller light on the opposite side of the lamp from you and high enough so that it appears to you to be about 1cm above the lamp bulb. Now turn the bright bulb on.

Stand facing the bright light holding your moon ball straight out in front of you. Your eyes are an observer on earth looking at the sun. Very bright isn't it? Can you see detail on the moon ball? Can you see the little distant starlight? (1) Now slowly raise the moon

ball until its shadow falls across your face. This is a SOLAR ECLIPSE! The sunlight is blocked by the shadow of the moon, which is located between the sun and the earth. In this eclipsed position, can you now see the smaller light peaking from behind the lamp? Before, the lamplight totally overpowered the smaller light, but now your eye or telescope can see it. However, can you see any of the lighted side of the moon? (2)This is called the NEW MOON stage and a solar eclipse can only occur at this phase. Does the shadow of the moon ball cover all of your face? (3) Einstein needed to find a solar eclipse occurring in a place where people could reasonably visit and he needed a clear day to observe the sky for the few minutes the moon shadow blocked the bright sun. A very rare event indeed!

Slowly turn to your left just enough so that a little sliver of light appears along the edge of your moon ball. This stage of the moon cycle is called the WAXING CRESCENT and occurs about 3 days after the new moon stage. Continue to turn to your right until half of the moon ball facing you is lit and half is dark. This stage is called the FIRST QUARTER moon because you can see only half of the half or a quarter of the moon.

Continue turning to your left until almost, but not all, of the visible moon is lighted. This "fat" stage of the moon is called the WAXING GIBBOUS.

Finally continue turning to the left until all of the lighted side of the moon is visible. This we know is the FULL MOON stage. You may need to hold the ball up above your head a little for the light to actually shine on the ball. If you lower the moon ball until your own shadow covers it, you have created a LUNAR ECLIPSE. This happens when the moon is in the Earth's shadow. Raise and lower the moon a few times to be sure that you understand the Full moon stage and the lunar eclipse. Notice that your body (the earth) casts a much larger shadow than the earth did. The moon can move across the sky for a longer time while still remaining in the earth shadow and everybody on the nighttime side of the earth can see the eclipse. Unfortunately Einstein could not use a lunar eclipse to test his theory. Why not? (4) Think about the difference between the mass of the moon and of the sun.

Continue turning until you pass through the WANING GIBBOUS stage, the THIRD QUARTER, the WANING CRESCENT, and finally back to the NEW MOON STAGE. While facing the bright lamp, practice raising and lowering the moon a few times to simulate the SOLAR ECLIPSE. Only during the SOLAR ECLIPSE can you see the smaller, dimmer light from beyond the sun.

Repeat the experiment, but draw a picture of the moon in each of its phases.

Now write a short paragraph to explain why Einstein needed to have a solar eclipse in order to see the apparent displacement of a distant star because the mass of our sun bent the light coming from it

IV. Extension and Evaluation

Using the date for the moon phase when you are doing this activity, ask the students to predict the moon's appearance on several upcoming dates. For instance, if the full moon was on Jan. 3, what would the moon look like on Jan. 19 or 25? You can also ask the students to predict the date of a future phase, for instance, "When should we expect the next waxing crescent if today is the full moon?" Do these predictions as an in-class activity.

If you begin your space unit with the moon, you can have the students keep a moon log for the remainder of your time in space or for at least one month. Many resourceful students will find web pages, which will show the moon phase for a particular date. They can produce a complete moon log for the month, regardless of the weather, in one sitting at their computer. You can use the computer data to see if it matches their predictions, but encourage them to actually look at the sky. If they do their logs at the same time of evening each day, they will realize that not only the phase of the moon changes, but also its position in the sky. If the students have access to a digital camera, they can make a photograph of the panoramic horizon at their home and then DRAW the moon on successive nights at the same time.

Teacher Notes

1. The sunlight is very bright because it would be daylight for your observer, possibly close to noon. The moon is not very visible and you can't see the little light at all because the brightness of the lamp overpowers everything.
2. No, because it is facing away from you.
3. Probably not, because the ball is small and does not cast a large shadow. The real moon is also small and does not cast a very large shadow on the earth. The chance of a solar eclipse occurring at any given spot on the earth is fairly rare. The rotation of the earth also means that the moon shadow does not stay in one place more than a few minutes.
4. Light from a distant star passing close by our very small moon would not be deflected enough to measure because the mass of the moon is so little. The mass of the sun was large enough to cause a deflection, although very small.
5. Remind the students that this activity creates a model of the earth- moon-sun system. Models often help us to understand a concept better, but they come with a danger of creating a mindset that may not actually represent what is real. The lamp in this model does NOT affect the light from the tiny laser beam.