Distance to the Moon

Background

In astronomy, distances and sizes are...astronomical. One must travel hundreds of thousands of miles to visit even the closest planetary neighbor in the Solar System, our Moon. However, this is a small leap relative to the millions of miles between the Earth and other planets.

Because of its proximity, the Moon has been visited frequently by spacecraft. It takes only a few days to reach the cratered satellite from Earth. Unmanned spacecraft in the forms of orbiters, lunar landers, and rovers have been visiting the Moon since the late 1950's, and continue to make unexpected discoveries. The Moon has even hosted human astronauts for brief stays of a few days during the late 1960's and early 1970's—so far the only object close enough to the Earth to make such an exploration possible.

While the manned Apollo missions required a supporting cast of thousands back at Earth, it doesn't take a rocket scientist to calculate the distance to the Moon. All one needs is a basic understanding of geometry and knowledge of the diameter of the Moon. In this activity, students will use a simple observation of the Moon and a few calculations to determine for themselves the lunar distance.

Topic

Lunar Distance

Objectives

Students will:

- Predict the distance between the Earth and Moon using a globe and a softball.
- Determine the actual distance to the Moon.

Overview

In this activity students will first try to determine the location of the Moon using a globe and softball for their scale model. In the second part of this activity students will construct a Moon viewer and they will calculate the distance to the moon.

Key Question

How far away is the Moon?

Key Concept

- The distance to the Moon can be determined without ever leaving the Earth.

Materials & Preparation

Part 1

- Index card
- Transparent tape
- 2 meters of string
- Metric ruler

Part 2

- 15 meters of string
- Softball
- 16" diameter globe or Earth ball
- Scissors

Part 1 Demonstration

1. Review how to solve for a variable in an equation.
2. Students will create a Moon viewer by cutting a 1cm diameter half-circle in the edge of an index card. Be careful in measuring and cutting the shape to ensure a more accurate Moon distance measurement.
3. Have students tape the end of a 2 meter long string to the bottom center of the semi-circular cutout.
4. Students will then tape the card to a window through which they can view the Moon. This can be done during the daytime or at night, as long as the Moon is visible through the window. The activity is easier when the phase is near full, although keep in mind that the full Moon does not rise until about 6:00 in the evening.
5. Have students sight the Moon through the semi-circular cutout of their Moon viewer while holding the string next to their eyes.
6. They will have to adjust their distance from the Moon viewer and let the string slide through their fingers to keep it taut. They have reached the correct distance when the Moon appears to just fill the cutout.
7. On the string, have the students mark the location of their eye with an ink pen. Students will measure the distance, in centimeters, from the Moon viewer to their eye and record this measurement.

8. Discuss with students how the triangles with the Moon and the Moon viewer are similar, and what this means about their bases and heights.
9. Students will then perform the calculations to find the distance from the Earth to the Moon:

$$\frac{\text{The distance to the Moon}}{\text{Diameter of the Moon}} = \frac{\text{The distance to your eye from the viewer (in centimeters)}}{\text{Diameter of the Moon viewer (1 cm)}}$$

10. The light from each side of the Moon forms a triangle with the location of the eye. The Moon viewer creates a scaled version of that triangle. Since both of these triangles are similar triangles, their bases and heights are proportional.
11. To solve for the unknown of the Moon distance multiply both sides of the equation by the diameter of the Moon. This leaves the final equation the students need:

$$\text{The distance to the Moon} = \frac{\text{The distance to your eye from the viewer (in cm's)} \times \text{Diameter of the Moon}}{\text{Diameter of the Moon viewer (1 cm)}}$$

The diameter of the Moon is 3476 kilometers. Calculate the distance to the Moon using this equation.

12. When completed, the students should get answers close to 384,000 kilometers. DO NOT GIVE THIS ANSWER AWAY. Use it only as a method to gauge the students' understanding of the material.

Part 2 Demonstration

1. Assign students to groups of four.
2. Discuss the distances between the Earth and other celestial bodies such as the Moon, Sun and planets.
3. Place a globe or ball representing the Earth near one corner of the room. Ask each group to come to a consensus as to where to place the Moon (softball) so that it is at the correct scaled distance.
4. Send one member of each group to stand at the location decided on by the group, placing the Earth and the Moon in a position relative to their size and distance from each other.
5. After each group has decided where to place the Moon, take the 15 meter-long string and wrap it around the globe nine and a half times. Cut off any excess string. The resulting length of the string will approximately equal the distance to the Moon (384,000 km).
6. Stretch out the string so one end of the string lies at the center of the Earth and the other end lies at the center of the Moon. Have the groups check their original prediction of the location of the Moon.
7. Now to give students some pespective, fold the string in half and cut it. Repeat nine times until the string is about a half-inch long. This is the distance to the Hubble Space Telescope (400 miles) from the surface of the earth. It is also the distance to where the Space Shuttle orbits.
8. To give students perspective of this distance, place the piece of string on a map so they can see the distance relative to home. For example if you were in Washington DC the distance to the Shuttle would be closer than the distance to Florida.

Management

- Divide students into cooperative groups.
- One 50-minute class period.

The Full Moon does not rise until 6:00 at night. You may choose to do this activity around the First Quarter Moon, which is clearly visible under clear skies during the afternoon hours, although the results may not be as accurate. Alternatively, you may simply send the activity home with students as a take-home project. If the students do not have a Moon-facing window, they may choose to mount the index card on a stick or other temporary device and perform the activity outdoors.

Transfer/Extension

1. The Sun appears to be the same size as the Moon in the sky. However, the Sun is actually about 400 times as wide as the Moon. What is the distance to the Sun?

STUDENT WORKSHEET

Distance to the Moon

Student Procedures

1. Create a Moon viewer by cutting a 1 cm diameter half-circle in the edge of an index card. Be careful in measuring and cutting the shape to ensure a more accurate Moon distance measurement.
2. In your data table record the diameter of your half-circle.
3. Use tape to attach the end of a 2 meter long string to the bottom center of the semi-circular cutout.
4. Tape the card to a window through which you can view the Moon. This can be done during the daytime or at night, as long as the Moon is visible through the window. (See your teacher for alternatives if you cannot view the Moon this way.)
5. Sight the Moon through the semi-circular cutout of your Moon viewer while holding the string up to your eye level.
6. Slowly adjust your distance from the Moon viewer and let the string slide through your fingers to keep it taut. You have reached the correct distance when the Moon appears to just fill the cutout.
7. Mark the location of your eye on the string with an ink pen. Then, measure the distance, in centimeters, from the Moon viewer to your eye.

The distance to the Moon = $\frac{\text{The distance to your eye from the viewer (in centimeters)}}{\text{Diameter of the Moon viewer (1cm)}}$ X Diameter of the Moon

Data Table	
Diameter of half circle of the Moon viewer	
Distance from your eye to Moon viewer	
Diameter of the Moon	3476 km
Distance to the Moon	

8. To solve for the unknown of the Moon distance use the equation. (Be sure to show your work.)

Questions and Conclusions

1. How did the prediction you made for the lunar distance match up to the actual distance?
2. Compare the orbit of the Space Shuttle with that of the Moon. Why do you think we have returned humans to Earth orbit many more times than the Moon? Do you think we will ever send humans to the Moon again? Why or why not?
3. Can you think of any other situations where knowing how to calculate distances (using this method) might be helpful?
4. Research the actual distance from the Earth to the Moon and check your results.