ACTIVITY 5

The Earth-Moon System

OBJECTIVES

To further develop their understanding of the sizes and distances involved in the Earth-Moon system, students will create a three-dimensional scale model of the Earth and its natural satellite.

The students

- estimate the size of the Moon in relation to a given Earth globe
- investigate the difference in volume between the Earth and Moon by seeing how many Moons are needed to create one Earth
- use models to demonstrate distances between the Earth, Moon, and artificial satellites

SCHEDULE

About 40 minutes

VOCABULARY

artificial satellite
natural satellite

MATERIALS

For each student

1	Activity Sheet 5

For each team of four

1	ball, foam, large
3 sticks	clay, modeling
1	marble
1	measuring tape
1	ruler, metric*
1 pair	scissors*
1	toothpick

For the class

8	bags, plastic, reclosable
4	photos, Earth from Moon
4	photos, Moon from Earth
1	poster, Moon Map
1 roll	string

* provided by the teacher

Ready to go!!

PREPARATION

1. Make one copy of Activity Sheet 5 for each student.
2. Use one of the pairs of scissors to cut a length of string 4 m (13 ft) long for each team of four.
3. Display the Moon Map poster in the classroom for reference during this and subsequent activities.

DONE!

BACKGROUND INFORMATION

Students often have misconceptions regarding the actual sizes and distances involved in the Earth-Moon system, since most illustrations are not accurate to scale. Even though the Moon is among the largest of the ***natural satellites*** in our solar system, it appears relatively small in size next to Earth. The diameter of the Moon is one-quarter of Earth's diameter. The Moon's volume is one-fiftieth of Earth's. And the distance from Earth to the Moon equals about 30 Earth diameters. These ratios are visually impressive and are usually quite a surprise to students even if they know the numbers representing the measurements.

▼ **Activity Sheet 5**

The Earth-Moon System

1. Draw how large you think Earth and the Moon are, relative to each other.

Drawings will vary.

2. If the Moon is one clay ball, how many clay balls of equal size will be needed to make an accurate model of the Earth?

Prediction: ________ balls Actual: 50 balls

3. How far apart should the Earth and Moon be in the model?

Prediction: ________ cm Actual: 225 cm

4. Add dots to show where you think artificial satellites would be in your drawing above.

Guiding the Activity

1 Divide the class into teams of four. Distribute a copy of **Activity Sheet 5** to each student and a large foam ball and one photo of either type to each team. Have teams study their photos and then trade with another team so that each team sees both photos. Then ask, **How large do you think the Moon is, relative to the Earth?** Have each student draw a prediction on their activity sheet and one member from each team draw a prediction on the board.

Explain that the true diameter of the Moon is almost one-fourth that of Earth. Tell teams to review their predictions in light of this information and to revise the Moon on their activity sheet if necessary. A member of each team may revise their prediction on the board, if they like.

Next, distribute a marble to each team. Explain that this marble corresponds to the correct size of the Moon compared to the

Additional Information

Allow students to discuss predictions with team members. The predictions on the board should demonstrate that most people have a misconception about the size of the Moon.

Although students' activity sheets may become quite messy as they continue predicting and revising, their final product will remind them of how much their understanding of the Moon and Earth has progressed.

Guiding the Activity

foam ball (Earth). Ask, **How does this marble compare with the size you predicted the Moon would be?**

Additional Information

Even if students grasp the idea that the diameter of the Earth is four times that of the Moon, seeing the discrepancy in volume that this results in is usually quite a surprise.

2 To investigate the question of volume, give each team three packages of clay. Each team should use all three sticks of clay to make clay balls that are about the same size as the marble. Next, students should group all the balls into one team pile.

The exact number of clay balls is not important. Three sticks of clay should produce about 60 balls, with each student making about 15 balls.

Then tell students to set aside one of the balls to serve as a model of the Moon. Ask, **How many Moons do you think will fit into Earth? If this one ball is a model of the Moon, how many of the remaining balls do you think will be needed to make an accurate model of the Earth?**

Have students record individual predictions on their activity sheet while one member of each team records a team prediction on the board.

Solicit an oral prediction from each team. Then have them construct a model Earth from the clay balls to match their prediction (Figure 5-1). Have all the teams hold up their models. Ask, **Is your model Earth the same size as the foam ball Earth?**

Some teams may use almost all of the balls for their model, which is about right. If 50 clay balls are used, the clay model Earth should be about the same size as the large foam ball Earth. The exact number of clay balls used will vary depending on the size of each of the balls. If no one was close to being right, have teams add to their models until at least one team is close.

▲ *Figure 5-1. How many Moons would fit into Earth?*

Tie off with a paper clip!

Guiding the Activity

Additional Information

Hold up the model closest in size to the foam ball Earth and explain that because these two models are nearly the same size, we have demonstrated approximately how many Moons are required to fill the same volume as Earth. Tell students that in actuality about 50 of the clay balls are needed to make an accurate model of Earth because Earth has 50 times the volume of the Moon.

Point out that our Moon is among the largest moons of any planet so most planets would require many more of their moons to equal their volume.

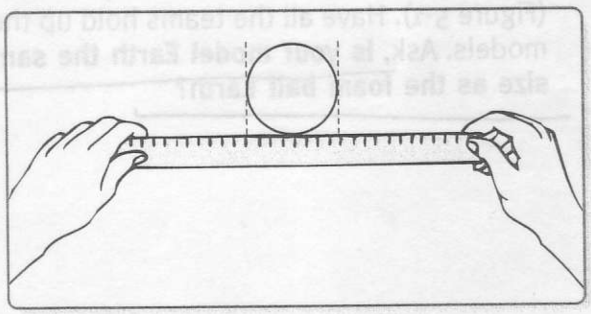
Have students revise their models and drawings to accurately represent the size of the Moon and Earth.

3 Next, ask, **How far do you think the distance should be between Earth and the Moon in our scale models?** Have students record their predictions on their activity sheets.

Have each team make an oral prediction and demonstrate this distance to the class by holding up their models in the position they think is correct.

After the teams have made their estimates, give each team a ruler. Have each team measure the diameter of their foam ball Earth. (See Figure 5-2.)

Help students who need assistance.



▲ *Figure 5-2. Measuring Earth's diameter.*

Give each team a length of string, a measuring tape, ~~a pair of scissors~~, and a toothpick. Tell students to measure out a length of string equal to the diameter of the Earth model. Holding the string at the diameter mark, students then should fold the string back on itself repeatedly, until they have a total length equal to 30 times the diameter of Earth.

Be sure that teams include the original diameter itself as they count to 30.

Tell teams to cut their string at the measured-out length.

Tie off with a paper clip!

Tell teams to stretch out their strings, placing the Earth model at one end and the Moon model at the other. In this way, they will create a model of the Earth-Moon system that is accurate to both size and distance.

Guiding the Activity

Additional Information

Have students measure the string with their measuring tapes and record its length on their activity sheets. Ask, **How did the actual scale distance between Earth and Moon compare with your predictions?**

Allow students time to express their surprise or other responses. Students may be interested to know that the true diameter of Earth is about 12,800 km (8,000 mi) and the mean distance from Earth to the Moon is about 380,000 km (230,000 mi).

4 Write *satellite* on the board. Ask, **What is a satellite?**

Students may know that a satellite is an object that orbits a planet.

Ask, **Does anyone know the name of the first satellite to orbit Earth?**

Students may answer with the name of an early artificial satellite, but probably will say that they do not know. The answer actually is the Moon.

Write *natural satellite* and *artificial satellite* on the board. Explain that the Moon is a **natural satellite.** But point out that Earth also has many smaller manufactured satellites, or **artificial satellites,** that are used for communication, weather monitoring, and other data collection purposes.

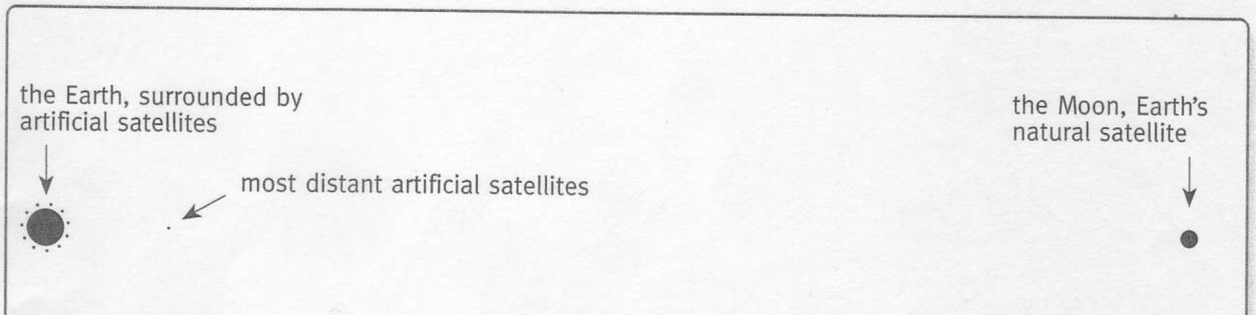
Approximately 3,000 artificial satellites are currently in orbit around Earth.

Have students predict on their activity sheets how far from Earth most artificial satellites travel.

Each team also can hold up the Earth model and a tiny speck of clay to demonstrate a team prediction.

Then have teams take the tiniest dot of clay they can from their model Earth and hold it between Earth and the Moon, 20 cm (8 in.) from Earth. Explain that the position of this bit of clay represents the altitude of some of the most distant Earth satellites! (See Figure 5-3 for an accurate distance model of Earth's satellites.)

This distance corresponds to an altitude of about 35,000 km (22,000 mi) and is the distance of certain satellites that orbit Earth at the same rate at which Earth spins and, therefore, that maintain their position above the same spot on Earth at all times. The most common satellites of this kind are the weather satellites that produce the pictures seen on television weather reports.



▲ *Figure 5-3. An accurate distance model of Earth and its satellites (not accurate to size).*

Guiding the Activity

Tell teams to insert their toothpick into the clay model of Earth until less than 5 mm (0.2 in.) extends from the clay. Explain that this represents 500 km (310 mi), the height at which the space shuttle and most other satellites fly above Earth.

Ask, **How do space shuttle launches compare to the feat of traveling to the Moon?**

Additional Information

Allow students time to discuss this revelation and to revise their drawings to represent the positions of satellites accurately.

The Apollo Moon missions were the farthest trips ever made by human beings, more than 1,000 times as far as the average space shuttle height.

Reinforcement

Have students examine the photos of Earth from the Moon and the Moon from Earth. Next, ask each student to observe Earth from the Moon and the Moon from Earth in their scale models, by positioning their eye close to the object from which they would view. Discuss why the models look different from the photos.

Earth actually appears about four times larger in the Moon's sky than the Moon appears in Earth's sky. The fact that this is not the case in the photos is an illusion. There is no lawn chair in the Moon shot to help us judge the difference in size!

Science Notebooks

Have students place their completed activity sheets in their science notebooks.

Cleanup

Place one of the clay scale models on display in the classroom throughout the remainder of the module. Put the rest of the clay in the plastic bags provided. Return all other materials to the kit.

Connections

Science Challenge

Christopher Columbus discovered that steady winds, now called trade winds, blow from east to west in the southern Atlantic and from west to east in the northern Atlantic. Prior to Columbus's discovery, most sailors believed that winds were due to the whims of gods or demons. Scientists did not learn why trade winds exist until two centuries later. Challenge students to research Edmund Halley's and George Hadley's work to explain how Earth's rotation and orientation create the trade winds.

Science and the Arts

Perspective determines the apparent distance of objects. Display examples of medieval art, created before formal rules for perspective were developed, alongside Renaissance works that demonstrate perspective.

Then have team members take turns holding the model Moon at an appropriate distance from Earth while other team members view the model from various perspectives: a side view, the viewpoint from Earth, the viewpoint of someone traveling to the Moon, and the viewpoint from the Moon.

Science and Math

The distance from Earth to the Moon was first measured about 2,000 years ago by Hipparchus, a Greek astronomer, using parallax. He and a distant colleague both measured the angle between the Moon and a particular star on a particular night.

Have students hold a finger near the tip of their nose and view it, first closing one eye and then the other. Have them view an object across the room and a distant tree or building in the same way. Do the distant views vary by eye as much as the nearby finger? Explain that the difference between the view with one eye and the other is called parallax. Because the amount of parallax is greater for objects close to the viewer than for distant objects, an object's distance can be determined by its parallax.

Have students trace two circles near opposite ends of a sheet of paper to represent the Moon and Earth. Earth's diameter should be about 2 cm (0.75 in.) and the Moon's, about 0.5 cm (0.2 in.). Then they should draw a dot beyond and to one side of the Moon to represent a star and two separate dots on the side of Earth facing the Moon to represent two astronomers at different locations. Using a ruler, students should draw four straight lines, one from each astronomer to the star and one from each astronomer along the circumference of the Moon. Using a protractor, students should measure the angle between the Moon and the star from the perspective of each astronomer. What is the difference—the parallax—between them?

Then have students tape sheets of paper together so that the Moon can be 60 cm (24 in.) away, its actual scale distance. How does parallax change as the distance to the Moon increases?

Name______________________________ Date______________ **Activity Sheet 5**

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3. How far apart should the Earth and Moon be in the model?

Prediction: ________ cm **Actual: ________ cm**

4. Add dots to show where you think artificial satellites would be in your drawing above.