



Distance to the Moon

Purpose

To calculate the distance between scale models of Earth and the Moon.

Background

As long as people have looked at the Moon, they have wondered how far away it is from Earth. The average distance to the Moon is 382,500 km. The distance varies because the Moon travels around Earth in an elliptical orbit. At perigee, the point at which the Moon is closest to Earth, the distance is approximately 360,000 km. At apogee, the point at which the Moon is farthest from Earth, the distance is approximately 405,000 km.

Distance from Earth to the Moon for a given date can be obtained by asking a local planetarium staff. Students interested in astronomy may enjoy looking at *The Astronomical Almanac* printed yearly by the U.S. Government printing office. When the Apollo 11 crew landed on the Moon on July 20, 1969, they were 393,309 km away from home.

In this activity students will use simple sports balls as **scale** models of Earth and the Moon. Given the astronomical distance between Earth and the Moon, students will determine the scale of the model system and the distance that must separate the two models.

The “Moon ABCs Fact Sheet” lists the Earth's diameter as 12,756 km and the Moon's diameter as 3,476 km. Therefore, the Moon's diameter is 27.25% of Earth's diameter. An official basketball has a diameter of 24 cm. This can serve as a model for Earth. A tennis ball has a diameter of 6.9 cm which is close to 27.25% of the basketball. (The tennis ball is actually 28.8% the size of the basketball.) These values are very close to the size relationship between Earth and the Moon. The tennis ball, therefore, can be used as a model of the Moon.

The scale of the model system is determined by setting the diameter of the basketball equal to the diameter of Earth. This is written as a simple relationship shown below:

$$24 \text{ cm} = 12,756 \text{ km}$$

Expressed more simply, 1 cm in the model system equals 531.5 km in space:

$$1 \text{ cm} = 531.5 \text{ km}$$

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Using this scale, the basketball-tennis ball separation in centimeters (**x**) is derived:

$$x = \frac{382,500 \text{ km}}{531.5 \text{ km}} = 719.7 \text{ cm}$$

The value **x** may be rounded to 720 cm and converted to meters so that the students need to place the basketball and tennis ball 7.2 m apart.

Preparation

Review and prepare materials listed on the student sheet.

If it is not possible to obtain an official-size basketball and tennis ball, then you can use other spherical objects or circles drawn on paper. Clay balls may be used as models. For example, for two clay balls, 10 cm diameter and 2.7 cm diameter, the scale is 1 cm = 1,275.6 km. At this scale, students need to separate the clay balls by 3 m.

In Class

Divide the students into cooperative groups. Students must keep track of units of measure.

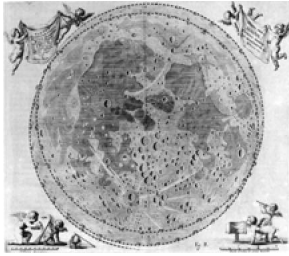
Wrap Up

Did the students have an accurate idea of the size relationship between Earth and the Moon before doing this activity?

Did the effect of separating the scale models help them visualize the distance to the Moon?

Extensions

1. How long did it take Apollo astronauts to travel to the Moon?
2. Have students measure the circumferences of various spheres so that each group uses a different pair of models.
3. Instead of using the average distance to the Moon, use the distance from July 20, 1969, to recall the Apollo 11 landing or use the distance for today.



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Key Word

scale

Materials

“Moon ABCs Fact Sheet”

sports balls

calculator

meter tape

Procedure

1. If Earth were the size of an official basketball, then the Moon would be the size of: another basketball? soccer ball? baseball? tennis ball? golf ball? marble?
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2. The diameter of Earth in kilometers is:
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3. The diameter of the Moon in kilometers is:
-

4. What percentage of Earth's diameter is the Moon's diameter?
-

5. Use the list below to change or confirm your answer to Question 1.

	<u>diameter in cm</u>
official basketball	24
size 5 soccer ball	22
official baseball	7.3
tennis ball	6.9
golf ball	4.3
marble	0.6

If Earth is a basketball, then the Moon is a:

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- Use an official basketball as a model of Earth. Use a second ball, the one you determined from Question 5, as a model of the Moon.
- Determine the scale of your model system by setting the diameter of the basketball equal to the diameter of Earth.

_____ cm = _____ km therefore,

1 cm = km

- If the distance to the Moon from Earth is 382,500 km, then how far apart must you separate the two scale models to accurately depict the Earth/Moon system?

Using the scale value in the box from Step 7, the model separation in centimeters (**x**) is derived:

$$x = \frac{\text{actual distance to the Moon in kilometers}}{\text{scale value in kilometers}}$$

$$x = \frac{\text{_____}}{\text{_____}}$$

x = _____ centimeters

The two scale models must be separated by _____ meters.

- Set up your scale model of the Earth/Moon system. Does it fit in your classroom?

Moon ABCs Fact Sheet

Property	Earth	Moon	Brain Busters
Equatorial diameter	12,756 km	3,476 km	How long would it take to drive around the Moon's equator at 80 km per hour?
Surface area	510 million square km	37.8 million square km	The Moon's surface area is similar to that of one of Earth's continents. Which one?
Mass	5.98×10^{24} kg	7.35×10^{22} kg	What percentage of Earth's mass is the Moon's mass?
Volume	---	---	Can you calculate the volumes of Earth and the Moon?
Density	5.52 grams per cubic cm	3.34 grams per cubic cm	Check this by calculating the density from the mass and volume.
Surface gravity	9.8 m/sec/sec	1.63 m/sec/sec	What fraction of Earth's gravity is the Moon's gravity?
Crust	Silicate rocks. Continents dominated by granites. Ocean crust dominated by basalt.	Silicate rocks. Highlands dominated by feldspar-rich rocks and maria by basalt.	What portion of each body is crust?
Mantle	Silicate rocks dominated by minerals containing iron and magnesium.	Similar to Earth.	Collect some silicate rocks and determine the density. Is the density greater or lesser than the Earth/Moon's density? Why?

Moon ABCs Fact Sheet

Property	Earth	Moon	Brain Busters
Core	Iron, nickel metal	Same, but core is much smaller	What portion of each body is core?
Sediment or Regolith	Silicon and oxygen bound in minerals that contain water, plus organic materials.	Silicon and oxygen bound in minerals, glass produced by meteorite impacts, small amounts of gases (e.g., hydrogen) implanted by the solar wind. No water or organic materials.	Do you think life ever existed on the Moon? Why or why not?
Atmosphere (main constituents)	78 % nitrogen, 21 % oxygen	Basically none. Some carbon gases (CO ₂ , CO, and methane), but very little of them. Pressure is about one-trillionth of Earth's atmospheric pressure.	Could you breathe the lunar atmosphere?
Length of day (sidereal rotation period)	23.93 hours	27.3 Earth days	How long does daylight last on the Moon?
Surface temperature	Air temperature ranges from -88°C (winter in polar regions) to 58°C (summer in tropical regions).	Surface temperature ranges from -193°C (night in polar regions) to 111°C (day in equatorial regions).	Why are the temperatures of Earth and the Moon so different?
Surface features	25 % land (seven continents) with varied terrain of mountains, plains, river valleys. Ocean floor characterized by mountains, plains.	84 % heavily-cratered highlands. 16 % basalt-covered maria. Impact craters-- some with bright rays, crater chains, and rilles.	Compare maps of Earth and the Moon. Is there any evidence that plate tectonics operated on the Moon?