# Scale Models

## Solar Eclipse

The Moon will cover up the Sun early tomorrow, briefly turning day to night. Unfortunately, though, it'll happen while it's already night here in the United States, so we'll miss out on the show.

The event is a total solar eclipse. It happens thanks to a coincidence in the way the solar system is laid out: Even though the Sun is about 400 times wider than the Moon, it's also about 400 times farther away. So when the geometry is just right, the Moon can just cover the solar disk.

As the Sun disappears, the air gets cooler, and the sky turns dark. The Sun's hot but thin outer atmosphere, the corona, forms delicate streamers of light around the Moon. And the first or last moment of sunlight can form a "diamond ring" — a thin ring of light around the Moon, with a bright burst where sunlight streams through canyons or between mountains.

The Moon's orbit is tilted a little, so most months the Moon passes just above or below the Sun, and there's no eclipse. But two or more times a year, the Moon's orbit lines up just right, creating an eclipse. Many eclipses are partial, so the Moon appears to only nick the Sun. But this month it goes right across the heart of the Sun, creating a beautiful eclipse.

The total eclipse is visible along a thin path that runs through China and Russia, across the tip of northern Greenland, and just into Canada. The partial eclipse is visible across a much wider area, but it doesn't include the U.S.

*This is the transcript of a StarDate radio episode that aired July 31, 2008. Script by Damond Benningfield, Copyright 2008.*

*Without being informed of the expected product, the students will make a Play-doh model of the Earth-Moon system, scaled to size and distance. The facilitator will reveal the true identity of the system at the conclusion of the activity. During the construction phase, students try to guess what members of the solar system their model represents. Each group receives different amounts of Play-doh, with each group assigned a color (red, blue, yellow, white). At the end, groups set up their models and inspect the models of other groups. They report patterns of scale that they notice; as the amount of Play-doh increases, for example, so do the size and distance of the model.*

### Materials

*On a central table for all to share*

- String
- Rulers or meter sticks
- Scissors (optional)

*For each group*

- One or more cans of Play-doh. All the Play-doh for a group should be the same color.
- Large paper sheet as a work surface for rolling and shaping the Play-doh

### Preparation

Color code each amount of Play-doh: red, 2 cans; blue, 1.5 cans; yellow, 1 can; white, 0.5 can. Divide students into groups of two to four members. Lay out materials for all groups to share in a central location. Distribute Play-doh and one large piece of paper to each group.

### Activity

*Introduce the problem*

Tell the groups that they will make a scale model of two members of our solar system. Do not reveal that it is the Earth and Moon — that's the surprise that makes this activity memorable. Along the way, they can make guesses about what the model represents.

*Divide the Play-doh*

Tell groups to divide their Play-doh into five equal pieces.
They may use whatever creative and clever means they can think of to solve this problem. Example solution: Roll the Play-doh into a long cylinder, then divide it into pieces. A 50-cm cylinder can be cut into 10-cm lengths, then formed into spheres. Tell groups to divide up one of the larger pieces into 10 equal size pieces; set one of these smaller pieces aside.

*Create two carefully sized pieces*

Tell each group to mash everything together (except the one small piece previously set aside) into one big sphere. Roll the remaining small piece into a little sphere.

*Make a guess*
After they have made two Play-doh spheres, ask each group to write down three guesses about what these solar system objects might represent. Discuss the guesses with the students. At least one student will guess they are Earth and the Moon. Next, ask them to make a guess of how far apart to put their Earth and Moon spheres to make a true model. A scientist follows up and tests guesses with observations and measurements.

*Measure the big sphere diameter; this is the diameter of Earth*
Tell each group to measure the diameter of the Earth sphere. They may cut the sphere in half. They may measure with a string and mark off the diameter or use a meter stick.

*Separate the big and little spheres*
After students have measured the Earth and Moon sphere diameters, ask each group to place the big and little spheres apart by 30 Earth-sphere diameters. Groups with the least Play-doh will probably be able to lay out their models on the table top. The two-can group might have to lay out its model on the floor.

*Inspect other models, compare, and analyze*
After all the groups have laid out their models, ask everyone to inspect other groups' models. Discuss the results. Models will differ in three main ways, besides the color of the Play-doh: the relative sizes of the Earth spheres, the relative sizes of the Moon spheres, and the distance between the spheres. But all of these differences are related to the same set of proportions. The ratios of Earth diameter:Moon diameter and Earth diameter: separation distance are the same for each model.

## Extend

The Sun is about 150 million km from Earth. Estimate how many Earth diameters and Earth-Moon distances in your system would be needed to put the Sun in your model. Compare the sizes of the Sun and the Moon's orbit around Earth.

## Background

| Earth to Moon Ratio | | | |
|---|---|---|---|
| | Earth | Moon | Ratio |
| Diameter (km) | 12,756 | 3,475 | 3.7 |
| Volume ($m^3$) $V = {}^4/_3 \pi r^3$ | $1.08 \times 10^{21}$ | $2.2 \times 10^{19}$ | 49 |

Since spherical volume is $4/3\ \pi r^3$, the ratio of Earth-to-Moon volume is 49.5. The mean separation between Earth and the Moon is 384,500 km. So the ratio of the Earth-Moon separation to Earth's diameter is:

$$\frac{384{,}500 \text{ km}}{12{,}756 \text{ km}} = 30 \text{ Earth diameters.}$$

In round numbers, Earth's volume is 50 times that of the Moon, and the Moon is about 30 Earth diameters away. The Sun is 11,759 Earth diameters, or 390 Earth-Moon distances away from Earth. The diameter of the Moon's orbit is twice the Earth-Moon distance (384,500 km x 2 = 769,000 km); the diameter of the Sun is 1,392,000 km. The Moon's orbital path around Earth is about half the diameter of the Sun.

**National Science Education Standards**

- Content Standard in 5-8 Earth Science (Earth in the solar system)
- Content Standard in 5-8 Science and Technology (Students should develop abilities of technological design)
- Content Standard in 5-8 Science as Inquiry (Abilities necessary to do scientific inquiry, Understanding about scientific inquiry)

# Scale Models

What are the relative sizes and distances of objects in the solar system? Students create two 'mystery objects' out of play-dough to learn about scale models.

## Grade Levels: 3-8

## Texas Essential Knowledge and Skills

Elementary and Middle School Science:

§112.14. grade-3(C) represent the natural world using models such as volcanoes or Sun, Earth, and Moon system and identify their limitations, including size, properties, and materials.

§112.18-19. grade 6-7 (b)-3(C) identify advantages and limitations of models such as size, scale, properties, and materials.

§112.20. grade 8 (b)-3(B) use models to represent aspects of the natural world such as an atom, a molecule, space, or a geologic feature.

§112.20. grade 8 (b)-3(C) identify advantages and limitations of models such as size, scale, properties, and materials.

Middle School Mathematics:

§111.24. grade 8 (b)-8(B) connect models of prisms, cylinders, pyramids, spheres, and cones to formulas for volume

Grade 9-12:

§111.34. Geometry (b)-11(B) use ratios to solve problems involving similar figures.

§111.34. Geometry (b)-11(D) describe the effect on perimeter, area, and volume when one or more dimensions of a figure are changed and apply this idea in solving problems.