

Title: Eclipse! Similar Triangles in Space

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Subject(s): Mathematics, Space Science

Topic(s): Eclipses, Triangulation, Geometry, Earth Science, Sun, Moon, Earth

Grade/Level: 6-8

Objective:

By the end of this lesson, students will be able to

- solve for missing sides of in similar triangle proportions.
- explain what an eclipse is and why eclipses occur.

Summary of Lesson: Students will explore what happens during a solar eclipse as they learn about similar triangles.

Time Allotment: 2 45-minute class periods

Procedures/Instructions:

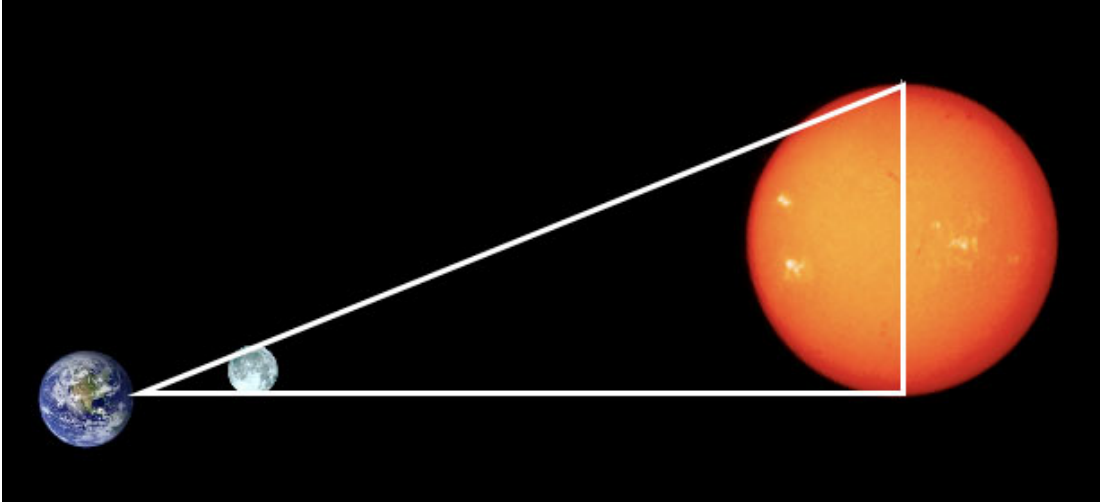
Despite how they look in the sky, the Sun and Moon are not the same size – the Sun has a diameter of about 1,400,000 kilometers and the Moon has a diameter of about 3,476 kilometers. The reason that the Sun and Moon look approximately the same size is that the Sun is much farther away from Earth than the Moon is. The Sun is approximately 150,000,000 kilometers away from Earth, and the Moon is approximately 384,403 kilometers away from Earth.

From our point of view on Earth, the Sun and the Moon make similar triangles in space. The image below is not to scale.



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As with all similar triangles, we can find proportional relationships in the sizes and distances from Earth to the Moon and to the Sun. For example, if we ask the question “how many Moons would fit between Earth and the Moon?” we would answer the question by dividing the Moon’s distance by the Moon’s diameter. (Answer: approx. 108) If we ask the question “how many Suns would fit between Earth and the Sun?” we would answer by dividing the Sun’s distance by the Sun’s diameter. (Answer: approx 108) These ratios are approximately the same.

Similarly, the ratios of diameter to distance both equal approximately 0.009. Likewise, the ratios of Moon Diameter to Sun Diameter and Moon Distance to Sun Distance are both approximately 0.0025.

Since the Moon and Sun form similar triangles in space and, therefore, appear to be the same size, Earthlings have the opportunity to observe a solar eclipse, where the Moon passes in front of the Sun, blocking it from our view. We can simulate a situation like this using balls and/or various round objects on Earth.

1. Students will work in groups of three.
2. Ask students what they know about the Moon and about the Sun. Ask them which one is bigger. Ask them how they know that one is bigger. Remind them that they both look the same size in the sky, and ask how one could be bigger if they both look the same size. Ask students what a solar eclipse is.
3. Give each group a ping-pong ball and a baseball.
4. Explain that 1 person in each group will be a person on Earth. One person will hold and position the ping-pong ball (Moon), and the third person will hold and position the baseball (Sun).

5. Students should find a position for the ping-pong ball and a position for the baseball so that both balls appear to be the same size to the person standing on "Earth."
6. Each person in the group should take a turn standing at "Earth" to make sure that they agree that both balls look the same size. They want to be able to make an "eclipse" with the 2 balls, but just barely.
7. When all members of the group agree and the 2 balls are in position, they should measure the distance from "Earth" to the ping-pong Moon and the distance from the "Earth" to the baseball Sun.
8. Students should complete the student sheet.
9. Discuss as a class. Though some groups will have different distant measurements, all groups should have approximately the same ratios of distances (Distance to Ping-Pong : Distance to Baseball = 0.05) and all groups should have approximately the same ratios of diameters (Diameter of Ping-Pong : Diameter of Baseball = 0.05)
10. Explain the concept of similar triangles as applied in the situation of the balls. Do Student Sheet ("Similar Triangles") as a class. As a class, discuss and find relationships within the similar triangles formed by the Earth, Moon, and Sun. Use questions like those in the "Background Information" section.
11. Continue with the extension activity, if desired.

Extension: Students will measure the diameter of a paper plate and calculate how far away the paper plate must be in order to "eclipse" it behind the baseball if the baseball is 1 meter (100 centimeters) away. Then, students will measure out that distance to test it out and see how accurate their calculations were.

Instructional Materials:

- Ping Pong Balls (1 per group of 3 students)
- Baseballs (1 per group of 3 students)
- Paper Plates
- [Student Sheet](#) (1 per student)
- Open space

National Science or Mathematics Standards:

Science

Unifying Concepts and Processes

CONTENT STANDARD: K-12

As a result of activities in grades K-12, all students should develop understanding and abilities aligned with the following concepts and processes

- Systems, order, and organization
- Evidence, models, and explanation

Earth and Space Science

CONTENT STANDARD D:

As a result of activities in grades 5-8, all students should develop an understanding of

- Structure of the earth system
- Earth in the solar system

Mathematics

Number and Operations Standard

Instructional programs from pre-kindergarten through grade 12 should enable all students to—

- Compute fluently and make reasonable estimates

Algebra Standard

Instructional programs from pre-kindergarten through grade 12 should enable all students to—

- Represent and analyze mathematical situations and structures using algebraic symbols

Geometry Standard

Instructional programs from pre-kindergarten through grade 12 should enable all students to—

- Analyze characteristics and properties of two- and three-dimensional geometric shapes and develop mathematical arguments about geometric relationships
- Specify locations and describe spatial relationships using coordinate geometry and other representational systems
- Use visualization, spatial reasoning, and geometric modeling to solve problems

Measurement Standard

Instructional programs from pre-kindergarten through grade 12 should enable all students to—

- Understand measurable attributes of objects and the units, systems, and processes of measurement
- Apply appropriate techniques, tools, and formulas to determine measurements

Assessment Plan:

Students will be assessed based upon their completed worksheet and how well they have worked as a group.

Eclipse: Similar Triangles in Space

Student Sheet

Instructions

1. Work in a group of 3 people.
2. One person will represent a person standing on Earth. One person will move and position the "Moon" ping-pong ball. One person will move and position the "Sun" baseball.
3. Find a position for the "Earth" person, the "Moon" ping-pong ball, and the "Sun" baseball so that the ping-pong ball and the baseball appear to be about the same size. One way to check this is to try to "eclipse" the baseball with the ping-pong ball - to make the baseball disappear behind the ping-pong ball.
4. Complete the equations below.

Information

PING-PONG BALL DIAMETER = 0.4 cm BASEBALL DIAMETER = 7.4 cm

PING-PONG DISTANCE = _____ cm BASEBALL DISTANCE = _____ cm

Ratios and Proportions

Ping-Pong Diameter : Baseball Diameter = _____ : _____ = _____ : 1

Ping-Pong Distance : Baseball Distance = _____ : _____ = _____ : 1

Ping-Pong Diameter : Ping-Pong Distance = _____ : _____ = _____ : 1

Baseball Diameter : Baseball Distance = _____ : _____ = _____ : 1

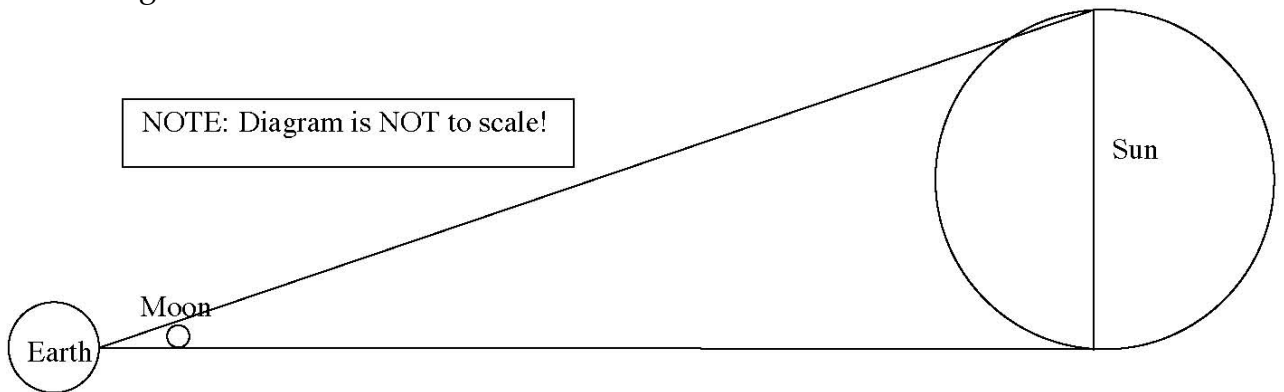
Observations

What observations can you make about the ratios you found above?

Do any of your numbers or ratios match (or almost match)? Which ones? Why do you think this is?

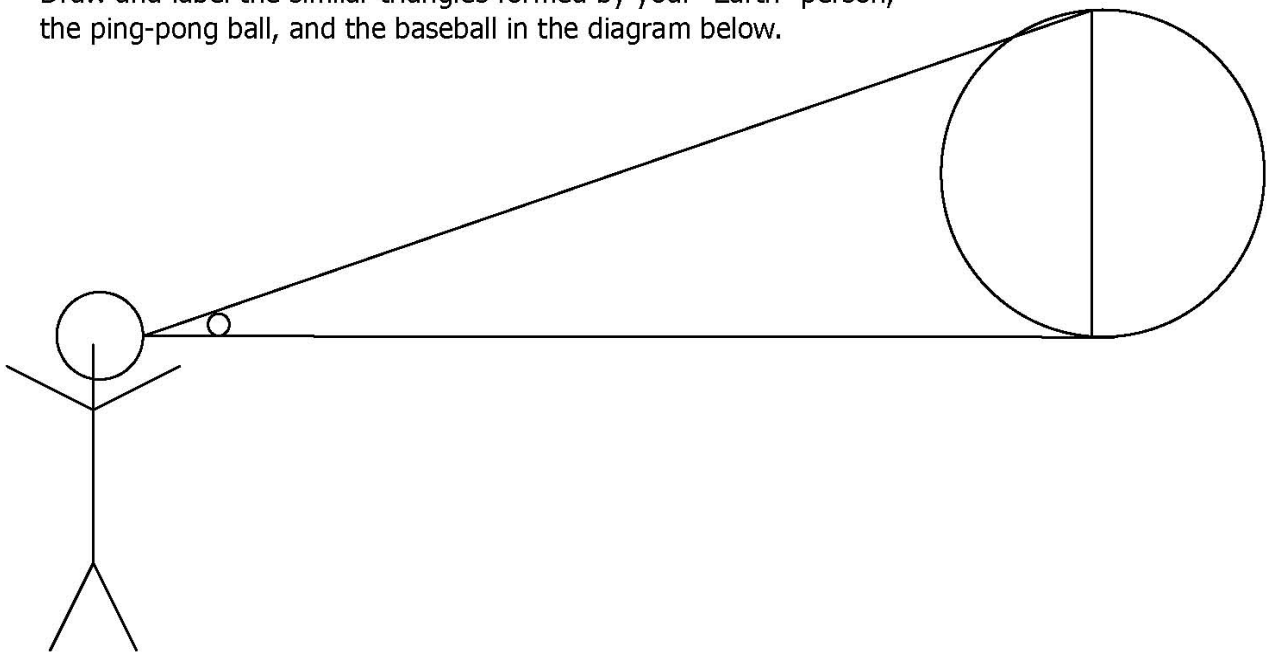
Similar Triangles

Eclipses occur because of similar triangles. Can you outline the similar triangles in the diagram below?



If the Moon has a diameter of 3,476 kilometers and the Sun has a diameter of 1,400,000 kilometers, and if the Moon is 384,403 kilometers away from the Earth, how far away from Earth is the Sun?

Draw and label the similar triangles formed by your "Earth" person, the ping-pong ball, and the baseball in the diagram below.



Eclipse: Similar Triangles in Space

Extension: PAPER PLATE CALCULATION

Information

BASEBALL DIAMETER = 7.4 cm
cm

PLATE DIAMETER = _____

BASEBALL DISTANCE = _____ cm

PLATE DISTANCE = 100 cm

Ratios and Proportions

Baseball Diameter : Plate Diameter = _____ : _____ = _____ : 1

You learned in the previous activity that the ratio of diameters and the ratio of distances should match since they are part of similar triangles. Therefore, the ratio above should match the ratio written below. Re-write your answer from the box above in the box below, and then cross-multiply to solve the equation and calculate how far away to place the paper plate (from your "Earth" person).

Baseball Distance	100 cm	=	_____
_____	_____		_____
Plate Distance	<i>P</i>		1

SOLVE FOR P:

Step 1: Cross-Multiply

$$100 \times 1 = \text{_____} \times P$$

Step 2: Divide

$$P = 100 / \text{_____} \text{ cm}$$

$$P = \text{_____} \text{ cm}$$

NOW TEST IT OUT!

Have one person in your group be "Earth." Place the baseball 100 cm away from

“Earth” and place the plate at the distance that you calculated above. Can the baseball “eclipse” the paper plate? If not, what do you think went wrong?