26C Solar System

How big is the solar system?

It is difficult to comprehend great distances. For example, how great a distance is 140,000 kilometers (the diameter of Jupiter) or 150,000,000 kilometers (the distance from the Sun to the Earth)? An easy way to compare these distances is to create a *scale model*. For instance, a globe is a scale model of Earth and road maps are scale models of geographic regions. These scale models help us visualize the true sizes of objects and the distances between them.

In this investigation, you will compare an astronomical distance—like the distance from the Sun to Neptune—to a measurable distance—like the length of a football or soccer field. Using proportions, you will make a scale model of the distances of the planets from the Sun.

Materials

- Access to a large space with a length of 100 meters (a soccer field is ideal)
- A metric tape measure or a trundle wheel
- A variety of objects to represent the relative sizes of the planets (examples: softball, soccer ball, bowling ball, small plastic balls, inflatable beach balls). To represent the Sun and some of the larger planets may require imagination.
- Blank paper for making signs

1 Using proportions to determine scale distances

Neptune is an average distance of 4.5 billion kilometers from the Sun. We can use a proportion to determine a scale distance for our model. Assume the largest distance you can measure is 100 meters. The length of a soccer field is usually between 90 and 120 meters long. For this investigation, we will use 100 meters as the scale distance between the Sun and Neptune.

$$100 \text{ m} = 4{,}500{,}000{,}000 \text{ km}$$

If the distance from the Sun to Neptune equals 100 meters, where would you find the other planets? You can answer this question by setting up the following proportion where **x** is the distance from the Sun to any planet, in meters:

$$\frac{x}{\text{Distance of the Sun to planet}} = \frac{100 \text{ m}}{4{,}500{,}000{,}000 \text{ km}}$$

Mercury is 58,000,000 kilometers from the Sun. Using our proportion, we can find the scale distance:

$$\frac{x}{58{,}000{,}000 \text{ km}} = \frac{100 \text{ m}}{4{,}500{,}000{,}000 \text{ km}}$$

Cross-multiply and rearrange the variables to solve for x:

$$x = \frac{100 \text{ m}}{4{,}500{,}000{,}000 \text{ km}} \times 58{,}000{,}000 \text{ km} = 1.29 \text{ m}$$

Mercury is 1.29 meters from the Sun using this scale.

2 Determining scale distances for the other planets

Based on the example in Part 1, you would place Mercury 1.29 meters or 129 centimeters from the Sun in your 100-meter scale model. Use this example to help you calculate the placement of the other planets. Write the distance in meters for each planet in Table 1.

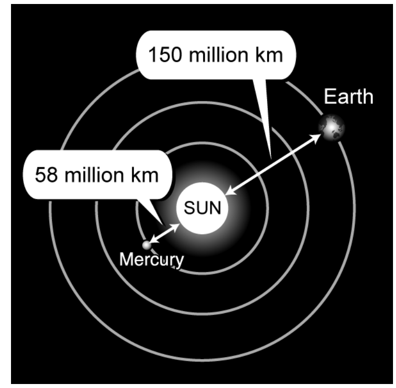
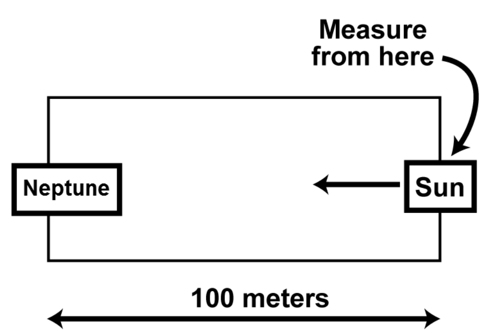


Table 1: Distance from the Sun

Planet	Actual distance to Sun (km)	Proportional distance from the Sun (m)
Mercury	**58,000,000**	**1.29**
Venus	108,000,000	
Earth	150,000,000	
Mars	228,000,000	
Jupiter	778,000,000	
Saturn	1,430,000,000	
Uranus	2,870,000,000	
Neptune	4,500,000,000	

3 Setting up the scale model

1. To begin, make signs for each of the planets and one for the Sun. In your scale model, a student in your class will hold the sign at each position of the planet.
2. In an area that is at least 100-meters long, identify the location of the Sun. A student will stand in this position with a sign that says “Sun.”
3. Measure 100 meters from the position of the Sun. At the 100-meter mark, a student will stand with a sign that says “Neptune.” In this model, 100 meters is the scale distance from the Sun to Neptune.



4. Now, use the scale distances from Table 1 to find the locations of each planet. At the location of each planet, a student will stand with the appropriate sign. Then, answer the questions.

a. After constructing a model of it, what is your impression of our solar system?

b. Describe some disadvantages and advantages to this model of the solar system.

c. Alpha Centauri is the closest star to Earth at 274,332 AU. One astronomical unit is equal to 150 million kilometers. Where would you place this star in the 100-meter scale model?

d. The diameter of the Milky Way galaxy is known to be about 100,000 light years. One light year is 63,000 AU. How does the Milky Way compare using the 100-meter scale model?

4 Determining scale sizes of the planets

Mercury has a diameter of 4,880 kilometers. How big would Mercury be in your 100-meter scale model? You can use the same method to determine the scale diameter of Mercury that you used in Part 2:

$$\frac{x}{4{,}880\ \text{km}} = \frac{100\ \text{m}}{4{,}500{,}000{,}000\ \text{km}}$$

Cross-multiply and rearrange the variables to solve for x:

$$x = \frac{100\ \text{m}}{4{,}500{,}000{,}000\ \text{km}} \times 4{,}880\ \text{km} = 0.000108\ \text{m}$$

Based on the example above, the diameter of Mercury in a 100-meter scale solar system would be 0.000078 meters or 0.078 millimeters. For comparison purposes, a single human hair is about 0.1 millimeters in diameter or one-tenth of a millimeter.

Use the above proportion to calculate the diameters of the other planets as well as the Sun and Earth's moon. Write these values in units of meters in the third column of Table 2.

Table 2: Diameters of the planets, our moon, and Sun

Planet	Actual diameter (km)	Scale diameter (m)	Scale diameter (mm)
Sun	1,391,980		
Mercury	4,880	**0.000108**	
Venus	12,100		
Earth	12,800		
Moon	3,475		
Mars	6,800		
Jupiter	142,000		
Saturn	120,000		
Uranus	51,800		
Neptune	49,500		

Now, answer these questions.

a. How big is the Sun in this model in units of centimeters?

b. How much larger is the Sun's diameter compared with Earth's? How much larger is Earth's diameter compared with the moon's?

c. The smallest object that the human eye can see without magnification is 0.100 millimeters. Given this information, which planets would be visible to the human eye? Would you be able to see the Sun or the moon on this 100-meter scale model of the solar system?

d. What is your impression of how the size of the planets and the Sun compare with the size of the solar system?

5 Extension: Making a larger scale model of the solar system

In this part of the investigation, you will use common objects to compare the diameters of planets, the Sun, and Earth's moon in our solar system. For example, an Earth globe can represent the scale size of Earth. The diameter of the globe we will use is 30 centimeters.

1. If an Earth globe is used to represent the size of Earth, what would the sizes of the Sun and the other planets be? How big would the moon be? Use what you have learned in this investigation to calculate the scale diameters of the other planets, the moon, and the Sun. Fill in the third column of Table 3 with these values.

2. What objects could be used to represent each of the planets, the moon, and the Sun? Fill in the fourth column of Table 3 with your answers to this question.

Table 3: A scale model of the solar system

Planet	Actual diameter of planet (km)	Scale diameter of Sun or planet (cm)	Representative object and its diameter or length (cm)
Sun	1,391,980		
Mercury	4,880		
Venus	12,100		
Earth	**12,800**	**30 cm**	**Earth globe, 30 cm**
Moon	3,475		
Mars	6,800		
Jupiter	142,000		
Saturn	120,000		
Uranus	51,800		
Neptune	49,500		

Now, answer these questions:

a. How many times greater is 30 centimeters than 0.284 millimeters? These are the diameters of Earth for the two scale models you created.

b. Using your answer to question 5a, what would be the distance between the Sun and Neptune on this larger scale? Come up with a way to explain or model this distance.

c. Why is it challenging to make a scale model of the solar system that includes the distances between planets and the Sun and the sizes of the planets?