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True Scale Solar System Models

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Schneider, Stephen E., "True Scale Solar System Models" (2007). *STEM Earth Central*. 3.
Retrieved from https://scholarworks.umass.edu/stem_earth/3

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STEM Earth Central 2007

Models of the Solar System

Objectives:

- To construct a true scale model of the solar system
- To understand the size of Earth relative to the Solar System
- To comprehend the sizes of planets versus the spaces between them

In a true scale model of the solar system, the real distances of planets from the sun and the diameters of the sun and planet must be divided by the same number. The scale for that true scale model can be represented with the formula:

$$\text{Scale} = \text{Real Size} \div \text{Model Size}$$

Sample Problem: What is the scale of a model automobile, which is 0.15 meters long if the real automobile is 5.4 meters long?

$$\text{Scale} = \text{Real Size} \div \text{Model Size}$$

$$\text{Scale} = 5.4 \text{ m} \div 0.15 \text{ m}$$

$$\text{Scale} = 36$$

Question 1: What happened to units in the scale calculation?

Question 2: What does the value for scale indicate?

A. Calculate a Value for a Scale Model of Earth's Orbit

1. Draw a circle on a sheet of paper. This circle will be a model of Earth's orbit. Note: We are assuming, for this activity, that Earth's orbit is circular, which isn't a bad approximation. Measure and record the radius of your model of Earth's orbit (in meters to the nearest hundredth of a meter)
2. Earth's orbit has a real radius of 149.6 million kilometers. Convert the value for Real Orbit Radius (in meters) into scientific notation.

For example: 326 thousand kilometers = 326,000,000 meters = 3.26×10^8 meters

3. Calculate the value for scale for the model of Earth's orbit that you have drawn on a piece of paper. Be sure to organize your work.

Steps 1: Write the formula.

Step 2: Place values, with proper units, into the formula.

Step 3: Calculate your final answer.

B. Calculate the Diameter of a Model of Planet Earth

Use the value for scale from Section A scale to calculate the diameter of a model of planet Earth.

Question 3: How would you rewrite the Scale Formula used in Section A to calculate the diameter of a model of Planet Earth?

Question 4: What would be the diameter of the model of Planet Earth?

- A. in meters? B. in centimeters?

Question 5: How big would you need to make Earth's orbit to make a reasonable scale model of its orbit?

C. Explore an outdoor area on the UMass Campus for a True Scale Model

Now that you've seen what a challenge it is to show the Earth and its orbit to the same scale, let's multiply the problems! What we'd like to be able to do is build a true scale model of the entire Solar System. Now we have the opposite problem—if we make the Earth's orbit big enough to see the Earth, we may make the outer parts of the solar system too big to be practical.

Uranus and Neptune are so far from the sun (and from Earth) that they cannot be seen in the evening or night sky without the use of a telescope. However, Mercury, Venus, Mars, Jupiter, and Saturn can sometimes be seen in the night sky without the use of a telescope. One way to construct a True Scale Model of the solar system that would include Mercury, Venus, Earth, Mars, Jupiter, and Saturn is to select an outdoor area that is large enough so that models of a number of planets can be seen from one location. To do so, you need to measure the distance across that open area (in meters) on the UMass campus.

Question 6: What is the distance (in meters) across the open outdoor area?

If your were to put a model of the sun at the center of the open area, then the distance from the model of the sun to the edge of the open area would represent the orbit radius of Saturn.

Question 7: What would be the value for the scale for the model of the solar system? Show your step calculation beginning with the formula for scale. Show operations with units as well.

VERY Important Note: You can avoid confusion between a planet's own radius and the radius of its orbit around the sun by instead referring to the planet's **distance** from the sun.

Planet	Real Diameter (km)	Model Planet Diameter (meters)	Real Distance from Sun (AU)	Real Distance from Sun (million km)	Model Distance from Sun (meters)
Sun	1,390,000		--	--	
Mercury	4880		0.387	58	
Venus	12,104		0.723	108	
Earth	12,742		1.000	150	
Mars	6780		1.524	228	
Ceres (dwarf)	942		2.766	414	
Jupiter	139,822		5.203	778	
Saturn	116,464		9.539	1,429	
Uranus	50,724		19.182	2,871	
Neptune	49,248		30.06	4,504	
Pluto (dwarf)	2274		39.53	5,913	
Eris (dwarf)	2400		67.67	10,120	

D. Determine model planet diameters and distances for the campus model.

We can use the Google Earth overlays (see Science Scope article) to choose a good size for the solar system model. From our model, we can fill in (at least) one of the values in the table above for the model orbit radius of one of the planets.

Question 8: What is the scale for this model?

- Fill in the rest of the Data Table to record the model orbit radii and model planet diameters for our true scale model of the solar system.

E. Choosing a much larger value for scale:

Question 9: What size area around your school is familiar to your students?

Question 10: What would be the scale for a model of the solar system that would fit within this area?

If you set up a scale of 500,000,000 to 1, in the resulting model the Earth will be the size of a large marble. However, this model of the solar system will require a land area with a diameter of approximately 20 kilometers. (For this scale, in the Google Earth overlay, you would set the length of the "1000 X Sun's diameter" scale bar to about 2.78 km.)