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Solar System in a Can: Solar System Models (Using Proportions in a Big Way)

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Equipment: table of planetary properties, calculators, rulers, tennis ball, Solar System Can

Most textbooks do not treat solar system models at all well since the distances are so much larger than the radii of the planets. It is almost impossible to create a physical model which does justice to both sets of measurements since astronomical numbers are, well, astronomical.

Look up the data for the planets' body radius and orbit radius.

Planet or object	Actual radius of the body (kilometers)	Actual radius of the orbit (km)
Sun	6.96×10^5	xxxxx
Mercury	2440	58×10^6
Venus	6050	108×10^6
Earth	6375	150×10^6
Mars	3395	228×10^6
Jupiter	71400	778×10^6
Saturn	60000	1427×10^6
Uranus	25400	2871×10^6
Neptune	24300	4497×10^6

1. Thinking about a scale for a scale model of the bodies of the planets:

a) Let's figure it out. Consider the extremes.

The planet with the largest size (radius) is ____Jupiter____________

The planet with the smallest size (radius) is ____Mercury___________

The ratio of the largest size to the smallest size planet?=_71400/2440__=__ 29.3 in decimal form

So, if we made a model in which the smallest planet had a radius of 1 centimeter, then the largest planet would have a radius of ___29.3_____ cm.
On this paper draw a really small circle to represent the smallest planet, then draw a big circle (properly measured) to represent the largest planet to the same scale. Wow!
If you had drawn the small circle with radius = 1 cm, would the large circle fit? (Yes, No)

b) Consider a different scale model where the sun is represented as a tennis ball. Estimate the size of Jupiter in this model. (golf ball, grape, chick pea, pea, poppy seed, invisible)
__________________ Draw a circle this size here:

Now estimate the size of the Earth in this same model and draw a circle here:

c) Number sense
Since ratios are an important part of this activity, let's think carefully about some specific examples. Fill in the answers in this table.

$\frac{5}{5} = 1$	$\frac{17}{17} = 1$	$\frac{254}{254} = 1$	$\frac{1526799}{1526799} = 1$	$\frac{Km}{Km} = 1$

Generalized conclusion: Anything divided by itself equals one.

d) More number sense
Multiplication is also important in calculating scale models. Fill in the answers in this table.

4 x 1 = 4	1 x 4 = 4	1 x 71400 = 71400	1 x 696000 = 696000

Generalized conclusion: Multiplying anything by one makes no change.

e) How to calculate a scale model from actual measurements
Suppose there are two objects called A and B. (Later you can choose A to be Jupiter, etc)
Suppose that you already know the actual radius of each of these bodies in kilometers, and call these numbers $Actual_A$ and $Actual_B$.
Also suppose that we have already decided on the scale model size of object B and call this number $Scale_B$.

Now we can set up a proportion to represent the four numbers

$$\frac{Scale_A}{Scale_B} = \frac{Actual_A}{Actual_B}$$

Let's do an example. Suppose that we want to calculate the scale model radius of Jupiter in a model in which the sun is chosen to be a tennis ball (radius = 3.3 cm).

Let us choose object A to be Jupiter, and object B to be the sun.

Then $\frac{\text{Scale}_{\text{Jupiter}}}{3.3\text{ cm}} = \frac{71400\text{ km}}{696000\text{ km}}$

If we multiply both sides of this equation by "3.3 cm" then we get

$$\frac{\text{Scale}_{\text{Jupiter}}\text{ x }3.3\text{ cm}}{3.3\text{ cm}} = \frac{71400\text{ km x }3.3\text{ cm}}{696000\text{ km}}$$

Do you remember what (3.3 cm) / (3.3 cm) is??? Yes, it is just one.

Calculate the $\text{Scale}_{\text{Jupiter}}$, the radius of Jupiter in the particular scale model: _.34___ cm.
Draw a circle here with this radius:
What object might represent Jupiter here?

f) Calculate the ratios and fill in this table, then try this model on an overhead projector.

Planet or object	**Actual Radius of the body (kilometers)**	**Radius of the body, in this model (cm)**	**Suggested object and drawn circle**
Sun	696000	3.3 cm	Tennis ball
Mercury	2440	.01	Poppy seed
Venus	6050	.03	Poppy seed
Earth	6375	.03	Poppy seed
Mars	3395	.02	Poppy seed
Jupiter	71400	.34	Chick pea (Garbanzo bean)
Saturn	60000	.28	Pea
Uranus	25400	.12	Pepper corn
Neptune	24300	.12	Pepper corn

2. **Thinking about what scale to use for both the orbits and the diameters of the planets.** (This is the really tough job.)

a) Which is the smallest planet body? ____Mercury______________________

What is the ratio of the largest to the smallest length (Neptune's orbit radius divided by the body radius of Mercury) ___4497 x 10^6_/ 2440 = 1.84 million_________
This is a **huge number**, and expresses the difficulty of our problem.

b) Let's use the same scale as the one we used above, where the sun is a tennis ball. Discuss with your team how to set up the proportion. Fill in this table.

Planet or object	Radius of the orbit (kilometers)	Suggested object	Radius of the orbit, in this model (m)
Sun		Tennis ball	xxxx
Mercury	58 x 10^6	Poppy seed	2.8
Venus	108 x 10^6	Poppy seed	5.1
Earth	150 x 10^6	Poppy seed	7.1
Mars	228 x 10^6	Poppy seed	10.8
Jupiter	778 x 10^6	Garbanzo bean	36.9
Saturn	1427 x 10^6	Pea	67.7
Uranus	2871 x 10^6	Pepper corn	136
Neptune	4497 x 10^6	Pepper corn	213

c) Now let's try this model outside. (Every teacher can take this model home with them in a film canister.) Conclusion: The solar system is mostly empty space!

3. Extensions:

a) What scale would be suitable for a football field?
b) What scale would be suitable for your town?
d) Where is the largest solar system model in the USA? (When is their bike tour?)
e) Where is the largest solar system model in the world?

An interesting way to make a big scale is to use the speed of light
a) How many minutes does it take sunlight to reach the Earth?
b) What is your normal walking speed?
c) How far would you walk in that length of time?
d) How about a model using a car's speed of 55 miles/hour?

For your models calculate where the nearest star beyond the sun would be. This usually surprises people.