

## Scale of the Solar System

### Modeling the Solar System (Size, distance, composition)

#### Take home points:

- Models can help us compare characteristics of planets.
- Planets have measurable properties, such as size, mass, and composition.
- An object's density cannot be determined by its size alone (larger objects are not necessarily more or less dense), but also depends on its mass.
- Things in the Solar System (and Universe) are really far apart!

#### Materials:

For each model:

- 1 meter length of cash register tape
- 10 round stickers: five large and five small
- pencil or marker

**Warm-up Questions:** In this lesson we again use the concept of scale models.

(1) What's a model? *We use models to help us represent objects and systems so that we can study and understand them more easily.*

(2) Explain how the scale models will work. Size, Distance. (Sun - Pluto) *By "a scale model" in this case, we mean a model that has smaller parts but parts that are relatively the same size and distance to each other as the real planets, dwarf planets, asteroid belt, and Sun.* Ask students about other models that they have encountered.

(3) What is the first thing on our scale ? (Sun)

4) What are the names of the planets in the solar system?

- *Starting with those closest to the Sun, the planets are Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, and Neptune.*

#### Pocket Solar System:

1. Place a sticker on each end of the tape, one large and one small, right at the edge. Label the large one Sun and the small one Pluto.
2. Fold the tape in half, crease it, unfold and lay flat. Place a large sticker at the half-way point. You can ask for guesses as to which of the remaining 8 planets might be at this half-way point. Label the sticker Uranus.
3. Fold the tape back in half, then in half again. If there are mixed ages, give those with some knowledge of fractions the opportunity to show off by asking "What is half of a half?" Unfold and lay flat. Place large stickers at the quarter mark and 3/4 marks and label as Saturn (closer to the Sun) and Neptune (closer to Pluto).
4. Fold back into quarters, then in half one more time. This will give you eighths. Unfold and lay flat again. Place a large sticker for Jupiter at the 1/8 mark (between the Sun and Saturn), and label.
5. No need to fold the whole thing up again. If you take a look, you've got the 4 gas giants and Pluto all on there. For the remaining terrestrial planets, you'll only need 1/2 of the first 1/8th! That's the inner 1/16th of your meter. Fold the Sun out to meet Jupiter to mark the 1/16th spot. A planet does not go here, but the Asteroid Belt does. Draw this with a pencil.
6. At this point, things start getting a little crowded and folding is tough to get precise distances, so fold the remaining 1/16th in half and crease at the 1/32nd spot. Place a small sticker for the Earth just inside this fold (between the Sun and Asteroid Belt) and a small sticker for Mars just outside the

fold (closer to the Asteroid Belt) and label them

7. Place small stickers for Mercury and then Venus, between the Earth and Sun, pretty much dividing the space into 1/3rds and label them as Mercury closest to the Sun and Venus closest to the Earth.

### **Discussion Questions**

1. Are there any surprises? Look how empty the outer solar system is: there is a reason they call it space! And how crowded the inner solar system is (relatively speaking).

2. Do you know anything about the physical properties of the planets that are spread out versus the ones that are crowded in close to the Sun? All the inner ones are small and rocky and the outer ones are gassy giants (except small icy Pluto).

3. Given this spacing, why do you think little rocky Venus can outshine giant Jupiter in the night sky? Both are covered with highly reflective clouds and although it is much smaller Venus is also much, much closer.

4. Does anyone know where the 10th planet, 2003UB313, will go? At 97 A.U., it would more than double the size of the model. Pluto is on average 40 A.U. (A.U. stands for Astronomical Unit, roughly the mean distance from the Earth to the Sun. 1 AU = 149,597,870.691 kilometers, or about 93 million miles.)

5. On this scale (1m = 40a.u) where would the nearest star be? After some guesses you could bring out your pocket calculator to use in getting how far away the star would be. This allows you to talk about how far is a light year and do the calculations to find that the next nearest star is about 7 km (4.2miles) away. They could then take out a local map to see what is that far away from where the presentation is happening.

[Calculations: A light year, the distance light travels in one year, is about 63,240 A.U. (about 9,460,000,000,000 km). The nearest star is Proxima Centauri (visible from the Southern Hemisphere), at 4.2 light years. So,  $4.2 \text{ ly} \times 63,240 \text{ A.U./ly} \times 1 \text{ m/ } 40 \text{ A.U.} = 6640.2 \text{ m} = \text{about } 7 \text{ km.}]$

### **Composition**

Blue - ice/liquid

Gray/Black - metal

Brown - rock

Red - Gas

(Or make your own color code)

Use colored pencils or markers to denote what the planets are made of. Refer to the chart. Draw an inner circle on each of the planets to represent the core. The rest of the sticker should represent the inner composition. Draw an outline of the planet to represent the surface. You can also draw the atmosphere.

### **Size/Density Demonstration**

Materials:

Jupiter - potato

Saturn - unpeeled orange

Uranus - plum

Neptune - lime

Earth - blueberry

Venus - small grape

Mars - navy bean

Mercury - uncooked orzo pasta

Pluto - pea  
Bucket of water

Size:

1) Present the fruits and other foods to the children and explain that you will use them to model the physical properties of the planets. Discuss one important property of the planets represented by this model: size.

- Which planets are the biggest? Which are the smallest? Closest to the size of the Earth?

2) Identify which of the objects corresponds to each planet and order them by distance from the sun.

Where is the asteroid belt? (between Mars and Jupiter)

3) If Jupiter is a potato (5.5 in), how big would the sun have to be? Size of a giant pumpkin (55 inch diameter) These diameters are reduced by a factor of 1 billion.

Density: Planet dunking!

1) **Discuss which of the models of planets has the most mass and which has the least.**

- What is mass? *Mass is the amount of "stuff" or material that an object has. This can include solid, liquid, and gas.*
- How can we estimate which fruits are the most massive? The least massive? *The children may offer that the most massive objects are "heavier," and the least massive objects are "lighter."*

It is true that the more something weighs, the more mass it has. Clarify that mass and weight are different, however. An object's mass does not change simply by changing its environment, but its weight can change. For example, a child's mass does not change when she enters a pool. Yet, the water's buoyancy helps her feel "lighter" while swimming and she is able to jump higher or lunge further as a result. Similarly, an astronaut's mass is the same whether he is on Earth or the Moon. His weight on the Moon is only a fraction of his weight on Earth.

2) **Invite the children to group the different models of the planets based on their estimated masses.** The groups may include "heavy" and "light," or a range of estimated masses. Invite them to record their estimates.

- Which of the fruits and food has the most mass? *One of the largest objects, such as "Jupiter" or "Saturn" should be heaviest.*
- Is Earth or Jupiter more massive? *Jupiter.*
- Is the largest fruit necessarily the most massive? *No, size and mass are two different things.*
- What are some examples of objects that have similar sizes (volumes), where one has a lot of "stuff" packed into it compared to the other? *The children may have a variety of ideas, such as ball bearings (compared to marbles), bricks (compared to wood blocks), a candy bar (compared to cotton candy), etc.*
- How do we describe objects that have a great deal of "stuff" (mass) for their size (volume)? *Dense.*

3) **Invite the children to describe the different planets' compositions.**

- What materials make up the planets? *The inner planets Mercury, Venus, Earth, and Mars are made of rocky material; the outer planets are composed of "gases."*

4) **In their journals, have the children record their notes and make predictions:** Which of the fruit "planets" will float and which will sink if placed in water? Have them consider, in general, which is more dense: rock or gas? Which planets are more dense: the rocky, inner planets or the gaseous outer giants?

- Have any of them heard that one of the planets would float, if it were placed in a large enough bathtub? *Saturn would float.*
- Why do they think this would happen?

5) **Begin the density experiment.** First, invite the children to state their predictions about what will happen when "Saturn" is placed in the water.

- Is this object light or heavy? Why? What is it made of? *It is heavy because it has a lot of mass.*
- Why might it float? Why might it sink? *It will feel "heavy" and so the children may guess that it will sink. Some may realize that this object has trapped air in it, which will help it to float.*
- What happened to "Saturn"? *It floated.*
- What might happen to the other planets if we put them into the water? *They will sink. Let the children place each of the other "planets" in the water, one at a time.*
- Why do the smaller, less massive "planets" like Mercury sink when Saturn floats? *The other "planets" are all denser than "Saturn."*

6) **Help the children compare the models of the planets to the characteristics of the planets.**

- Is Saturn big? Does it have a lot of mass? *Yes and yes.*
- How is the orange like Saturn? *It's bigger and has more mass than most of the other objects, yet it floated.*
- Why would Saturn float if it were placed in water? *It is made of a lot of gases that are lighter than water.*
- In this activity, which planet was the least dense? *Saturn.*
- Were the giant planets all less dense than water? *No, only Saturn was. Why not? The giant planets are made of mostly gas, but they are made of a LOT of gas! The gases are squished, or compressed, to a greater density, and even act like liquids or even solids.*
- The giant planets are made mostly of gas. What are Mercury, Venus, Earth, and Mars made of? *Rock.*
- In general, what can we say about what a planet is made of from its density? *The giant planets are less dense overall because they are made mainly of gases, and the inner rocky planets are more dense because they are made mainly of rock.*
- If we weighed our models, which planet would weigh the most (and has the most mass)? *Jupiter.*
- The least? *Mercury.*
- Which planets were the biggest? *Jupiter, followed by Saturn.* Smallest? *Mercury.*

Ask the children to write, in their own words, the relationship between mass, size, and density on their paper.

Reiterate that a planet's density is determined by a combination of its size and mass, and that we can't measure an object's density just by weighing it. Jupiter has the most mass and is very big, but is denser than Saturn.

### **Scale of the Universe Scavenger Hunt**

Go to <http://scaleofuniverse.com/> and let the kids explore the scale of the universe.

Have them fill out the scavenger hunt and ask them questions about the things that they're seeing. (If you click on different objects, a box pops up to give you more information.)

### **Wrap up questions**

- What is a model and why do we use them?
- What properties about planets did we learn today?
- What is one thing you learned today that surprised you?