# SOLAR SYSTEM MODELS

(credit NIRCam E/PO team; Carolyn Hollis)

Scientists create models to explain and share their understanding of the world. Often these are descriptions in their mind of how systems work also known as conceptual models. They may also build physical model or design computer models. These models have their limitations. Physical models are constrained by the nature of their materials and computer simulations are limited in their complexity. Here we will explore five models of the solar system that can be used with young people. Each has its limits and its strengths. Each model tells us something about the solar system, but equally, each leaves out information.

The final pages have the models in a format that can be printed off and given to youth to explore in small groups. You might want to flip ahead and familiarize yourself with each model. Some of these pages have an answer key, so think about when you want to give out that information. Discussion is really important to prevent misconceptions and develop a strong understanding. To assist with that discussion, the next section is a collection of discussion questions and presentation notes.

## Photographic Model notes:

The simplest model, it asks the students to order the photographs of objects from the center of the solar system outward. This shares some similarities to the papier-mâché solar system many of us made as children. It has the advantage of also giving visual information about these objects. As the teacher, you must decide which objects you want to include. I like to include a comet and an asteroid. Will you include Earth's moon? Moons of other planets? Eris or other icy bodies beyond Pluto?

As the students place the photos in order starting with the sun ask the students to share what they already know about each object.

There are many sources of excellent images. Nasa.gov may be the most accessible.

**Extensions:**

Science

Learn how comets and asteroids are named.

Explore why the planets look the way they do. What are they made of? What features are on them? How were the features made?

Learn about telescopes and their light gathering ability.

Choose a planet: what space missions have explored it?
Learn more about a space mission. What instruments were included?
Plan your own space mission. Where would you go? What equipment would you take?

Language & Culture
Read about the Greek gods planets were named for.
In US we see a man in the moon, what do people in other countries see in the moon?
Read stories from other cultures about the moon.
Look at the moon. What do you see? Write a story about how that creature came to be in the moon.
Imagine a time in the future, you are the first team of astronauts to land on a planet. What problems will you need to overcome? What will you discover? Write a magazine article telling of your adventure.

## Diameter Model notes:

This model combats misconceptions about the relative size of the planets. Most students do not realize how tiny Earth is compared to Jupiter. It is an excellent opportunity to develop the math concept of scale and develop skills in measuring with a metric ruler.

**Discussion questions:**
How many Earths would reach across Jupiter?
How big would the sun be in this model? (The sun's diameter is 100 times that of Earth)
How are the rocky planets similar?
Why are the outer planets called gas giants?
Some scientists think Pluto should be designated a dwarf planet. Why do you think that is?

**Extensions:**
Arrange the circles in order from the sun.
Look up the diameter of Earth's moon and moons of other planets. Convert the diameter to this scale. Draw circles to represent these objects. How do they compare to Earth?
Make a bar graph to compare diameters. How does the graph relate to the circles?

## Bead and String Model notes:

This is a distance model. It is important to note that the scale is different than in Diameter Model. The sizes of the planets are not in scale. Each planet is represented by an identical bead. If the solar system were shrunk to this scale the planets would not be the size of beads – they would no longer be visible. A common misconception is to imagine the planets are evenly spaced. Help the students notice the inner planets are crowded together relatively speaking.

**Extensions:**

How far is the nearest star outside our solar system? If you were to add it to the model, how much string would you need?

## Mass Model notes:

This model asks students to compare the relative mass (weight) of the planets. Easy and inexpensive to make, this model needs to be prepared ahead of time. It is particularly valuable for people who learn by touching and doing (also known as kinesthetic learners). Notice how much more "stuff" is in Jupiter as compared with Earth. How does Earth compare to Pluto?

## Gravity Model notes:

Every object exerts a gravitational force on every other object. The strength of that force is determined by two things: mass and distance. The greater the mass, the greater the force of gravity. If you double the mass you double the force. If you could take 2 earths and squeeze them together into a ball the size of the earth, aliens standing on that world would experience twice the gravitational pull. Distance from the center of an object reduces the gravity by the square of the distance. In other words if you move 10 times further away from the center, the gravity is reduced by 100 times. (This is called the inverse square law.) If you imagine the earth as a marshmallow in the cosmic microwave, when it puffs up to twice the diameter the creature living on Marshmallowland will experience ¼ gravity. When we look at the gravitational force of planet, we need to take into account both the mass and the density. Working with two variables makes this a more complex idea. These variables work opposite to each other. The mass of Uranus is approximately 15 times that of earth –increasing the gravity by a factor of 15. How ever the diameter is approximately 4 times greater – decreasing the gravity by a factor of 16 (that is 1/16 of the original gravity). In the case of Uranus these factors nearly balance out giving a gravitational force close to Earth's.

**Extensions:**

Have the students jump 3 times and average their results before computing their jumping ability on other planets.

Have students graph their data.

Students can average class data or graph class data.

Find the mass and diameter of the sun. Compare these to Earth and compute the gravity relative to Earth.

If Uranus were squeezed to the size of Earth, we noted that the gravity would be 15 times that of earth. If Jupiter were squeezed the same way, what would the gravity be on the surface? What if we inflated Mercury to earth size?

## Summary questions:

What information do you get from each model?

What difficulty would we have presenting all this information in one model?

# Photographic Model of the Solar System

By Carolyn Hollis

**Materials**:
Collection of photographs

**Directions:**
Can you identify these objects in our solar system?
With your team, place them in order from the sun.

What do you know about these objects? Are all of them planets? Which objects are most alike?

# Dot Model of the Solar System

By Carolyn Hollis

**Materials**:
Paper, pencils, metric rulers

**Directions:**
1. On separate pieces of paper, draw a circle to represent each planet. Be sure to label each of your drawings with a planet letter. Use the scale column of the chart for the diameter of the circles. Your group only needs to make one set of circles.
Strategy: There are many ways to draw circles. Here is one. 1) With your ruler draw a line the length of the diameter. 2) Turn it into an X by drawing a similar line across it. 3) Draw a circle by connecting the ends of the X.

2. Discuss the model with your group. Think about what you already know about the planets. Decide which circle represents each planet. Can you arrange the planets in order from the sun?

Planet Data

| Planet letter | Planet Diameter | Scale Diameter | Name of planet |
|---|---|---|---|
| A | 12.76 K km | 13 mm | |
| B | 143.0 K km | 143 mm | |
| C | 6.79 K km | 7 mm | |
| D | 4.88 K km | 5 mm | |
| E | 49.5 K km | 50 mm | |
| F | 2.37 K km | 2 mm | |
| G | 120.5 K km | 121 mm | |
| H | 51.1 K km | 51 mm | |
| I | 12.1 K km | 12 mm | |

**Answers**: (Planets are listed alphabetically)
A Earth; B Jupiter; C Mars; D Mercury; E Neptune; F Pluto; G Saturn; H Uranus; I Venus

# Bead and String Model of the Solar System

By Carolyn Hollis

**Materials:**
10 beads plus 1 sun bead, 4 meters of string, meter stick

**Directions**:
1. Tie the sparkly bead on one end of the string. This will represent the Sun.
2. Using the scale distances from the chart, tie a bead on the string to represent each planet. Notice these are distances from the Sun. Be sure you are making all of your measurements from the Sun bead.
3. Discuss your observations. What have you noticed about the solar system? How does this model compare to other models you have made?

**Planet Data**

| Planet | Distance from sun | Scale distance from Sun |
|---|---|---|
| Mercury | 0.4 AU | 4 cm |
| Venus | 0.7 AU | 7 cm |
| Earth | 1.0 AU | 10 cm |
| Mars | 1.5 AU | 15 cm |
| Asteroid Belt | 2.8 AU | 28 cm |
| Jupiter | 5.0 AU | 50 cm |
| Saturn | 10.0 AU | 100 cm |
| Uranus | 19.0 AU | 190 cm |
| Neptune | 30.0 AU | 300 cm |
| Pluto | 39.0 AU | 390 cm |

# Mass Model of the Solar System

By Carolyn Hollis

**Materials:**
Prepared and labeled bags of rice

**Directions:**
Each bag represents the mass of one of the planets in the solar system.

- Think about what you know about the planets.
- Decide which bag represents each planet.
- Arrange the planets in order from the Sun.

## Required Advance Preparation and Answer Key

Materials:
Rice, Ziploc bags, and measuring cups and spoons to prepare bags
Marker to label bags

Preparation
Use this table to prepare the bags. This also is an answer key.

| Planets | Earth mass/ Conversion factor | Amount of rice | Label |
|---|---|---|---|
| Mercury | 0.055 | 8 grains of rice | D |
| Venus | 0.814 | 2/5 tsp. of rice (a scant ½ tsp.) | I |
| Earth | 1 | ½ tsp. | A |
| Mars | 0.107 | 16 grains of rice | C |
| Jupiter | 318 | 3 ½ cups | B |
| Saturn | 95.18 | 14 ½ Tablespoons | G |
| Uranus | 14.54 | 2 ½ Tablespoons | H |
| Neptune | 17.14 | 2 Tbs. 2 ½ tsp. | E |
| Pluto | 0.0021 | 4/5 of a grain of rice (a large piece of a grain of rice) | F |

# Gravity in the Solar System

By Carolyn Hollis

**Materials**: Tape measure hung vertically on a wall. The bottom needs to be in reach of all students. The top must be above jumping reach of the students.

**Directions:**

We can compare the effect of gravity by computing how high we can jump on different worlds. Gravity is an attractive force that holds us to Earth. If the gravity is less the strength of our legs will let us jump higher. If the force of gravity increases we can't jump as high.

All objects exert a gravitational force on every other object. The strength of this force is based on two things. 1) The size of the object. The greater the mass of the object the more force it exerts. 2) Your distance from the center of the object. The greater the distance from the center of the object the weaker the gravitational force it exerts on you. It is the relationship between the mass of a planet and its diameter that determines the gravitational force you would experience standing on its surface.

Work with a partner to determine how high you could jump on each planet.

- Reach as high as you can on the tape measure. Record the number you touch.
- Have your partner watch as you jump and touch the tape measure. Your partner will tell you the number you reached.
- Subtract the initial and jump numbers to determine how high you can jump on earth.
- Divide by the relative gravity/ conversion factors on the chart to determine how high you could jump on other planets.

| Planet | Relative gravity/conversion factor | Height you can jump |
|---|---|---|
| Mercury | 0.4 | |
| Venus | 0.9 | |
| Earth | 1 | |
| Mars | 0.4 | |
| Jupiter | 2.4 | |
| Saturn | 1.1 | |
| Uranus | 0.9 | |
| Neptune | 1.2 | |
| Pluto | 0.1 | |