Pocket Solar System

GRADE LEVEL	3rd -8th; California Content Standards for 3rd, 5th, 6th – 8th
SUBJECTS	Earth & Space Science, Using Models, Scale
DURATION	Preparation: 5 minutes Activity: 20 minutes
SETTING	Classroom

Objectives

Students will be able to:
1. Describe the relative distances between the orbits of the planets.
2. Recognize that objects in the solar system are very far from each other.

Materials

- strips of register tape (one meter per student)
- round stickers (5 large & 5 small per student)
- pencils

Scientific Terms for Students

orbit: The path followed by an object in space as it goes around another object; to travel around another object in a single path.

planet: In the solar system, a planet is a large round object that orbits the Sun and has cleared out most of the other objects in its orbit.

dwarf planet: A large round object that orbits the Sun but is NOT the dominant object in its orbit.

solar system: The Sun and all of the planets, comets, etc. that revolve around it.

Background for Educators

Models and illustrations of the Solar System often misrepresent the true scales and distances involved. The difficulty lies in the vast difference between the relative sizes of these objects and the distance between them. For example, an accurate model using a 1" sphere to represent the Sun results in a distance to Pluto of over 350 feet (more than a football field away), and most of the planets would appear no larger than tiny specks.

It is usually beneficial to address these two dimensions separately, using one model to compare planet sizes and another to illustrate relative distances from the Sun. By combining this activity with the activity "Worlds in Comparison", teachers can address the misconceptions prevalent in our depictions of the Solar System.

Distances in the solar system are difficult even for astronomers to picture, as they are far beyond our normal experience on Earth. For example, the distance from Earth to the Sun is about 93 million miles –

to travel an equivalent distance on Earth, you would need to circle the globe 3,700 times! For the inner planets, the distances to the Sun are similar, ranging from ½ to 1 ½ times that of Earth, but the outer planets are much, much farther away – a fact that is often glossed over in textbook illustrations. This activity creates a simple model that more accurately illustrates the distances to planetary orbits relative to each other.

One way to think about these concepts is to compare the relative distances of the other planets from the Sun to that of the Earth. Astronomers use the mean distance of the Earth to the Sun as a standard unit, called an *astronomical unit,* or AU. Using this standard, the approximate average distances for each of the planets (and some dwarf planets) are:

Mercury	.5 AU
Venus	.7 AU
Earth	1 AU
Mars	1.5 AU
Ceres	2.5 AU
Jupiter	5 AU
Saturn	9.5 AU
Uranus	20 AU
Neptune	30 AU
Pluto	40 AU

This lesson was originally developed by Amie Gallagher, Raritan Valley Community College, and adapted by Suzanne Gurton and Anna Hurst, Astronomical Society of the Pacific, 2008.

Teacher Prep

Pre-cut one meter strips of register tape and divide out groups of stickers for each participant.

Introduction

For any scale model activity, it is useful to start by exploring the notion of models. Playthings, such as dolls or toy cars, can be a useful reference for talking about scale models.

Pull out a folded, completed sample of the model from your pocket. Point out that the planets never appear in a straight line like this in order out from the Sun, but this is just a reminder of the radius of the orbits. The planets would be found somewhere along a circle this far from the Sun. If you have a board with a thumbtack, you can tack it to the board at the Sun and show or draw out the orbits.

Activity Procedure

1. Distribute the register tape and stickers to each student and lead them through the following steps.

2. **Sun & Pluto (on the edges):** Make a mark 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. Even though Pluto has been reclassified as a dwarf planet it serves as a useful reference point here. We can use it as the first example of such a dwarf planet ever found, just as we'll use Ceres to represent the asteroid belt later on.
3. **Uranus (1/2):** Fold the tape in half, crease it, unfold and lay flat. Place a large sticker at the halfway point. You can ask for guesses as to which of the planets might be at this halfway point. Label the sticker Uranus.
4. **Saturn (1/4) and Neptune (3/4):** 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).
5. **Jupiter (1/8):** 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.
6. **Asteroid Belt (1/16):** 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 in the outer solar system. 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 you should label this Ceres to represent the Asteroid Belt.
7. **Earth (inside 1/32), Mars (outside 1/32) :** 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 Ceres) and a small sticker for Mars just outside the fold (closer to Ceres and the Asteroid Belt) and label them.
8. **Mercury & Venus (between Earth & Sun):** Place small stickers for Mercury and then Venus, between the Earth and Sun, pretty much dividing the space into thirds and label them as Mercury closest to the Sun and Venus closest to the Earth.

Wrap-Up

At the end of the discussion, be sure to have everyone put their names on their tapes and fold them up to put it in their pockets. But before you put them away, here are some questions you might ask to get participants thinking about insights they can get from building this model.

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 ones 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 Eris, the largest dwarf planet would go on this model? *At 97 AU, it would more than double the size of the model. Pluto is on average 40 AU.*
5. On this scale (1 m = 40 AU) 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 (4.2 miles) 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 AU (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 ly x 63,240 AU/ly x 1 m/ 40 AU = 6640.2 m = about 7 km.]

California Science Content Standards

Grade Three

Earth Sciences

4d. Students know that Earth is one of several planets that orbit the Sun and that the Moon orbits Earth.

Grade Five

Earth Sciences

5b. Students know the solar system includes the planet Earth, the Moon, the Sun, eight other planets and their satellites.

Next Generation Science Standards

Middle School

MS-ESS1-2: Develop and use a model to describe the role of gravity in the motions within galaxies and the solar system

MS-ESS1-3: Analyze and interpret data to determine scale properties of objects in the solar system