Simulating the Solar System

This activity is designed for students in grades five through eight. It can be presented by teachers with no special preparation in science. "Simulating the Solar System" is keyed to some of the concepts in the planetarium program, "Red Planet Mars," so it will probably be most effective if presented just before or just after visiting the planetarium. Each teacher may wish to adapt the language and pace of the activities to his or her particular class of students.

Objectives

The primary objective of this activity is to increase the students' understanding of the appearance and movements of the stars and planets. After the lesson, the students will be able to explain or demonstrate:

1. What a planet looks like in the night sky.
2. How to find out if a given point of light in the night sky is really a star or a planet.
3. Why a planet appears to "wander" among the background stars.
4. How to use a model to figure out why the stars and planets appear to move as they do.

Before the Lesson

1. Arrange to move outdoors for the last part of the activity.
2. Draw three large boxes on the chalkboard. Use white or yellow chalk to draw stars in each of the boxes as shown on page 2. These drawings show the planet Saturn as it moves through the constellation Leo. All the stars should be the same size except for the bright star Regulus (in the lower right). Stars should be in the same positions in all three boxes except for the starlike object that is really Saturn (just above Regulus in the first picture). Another option which has the advantage of reusability is to make three large posters.
3. Cover the second two boxes with sheets of paper taped over them. If using posters, stack the three posters together on the chalk tray so Star Pattern #1 is showing, with Patterns #2 and #3 hidden behind it.

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Part A. Observing a Planet

Stars and planets both look like points of light in the nighttime sky. Stars are huge hot balls of gas like the Sun. Planets are cooler balls of material like the Earth. Planets circle around stars in "orbits" and are almost always much smaller than stars. It takes the Earth one full year to complete its orbit around the Sun.

Here is a picture of the planet Saturn among the stars.

Which one of these points of light do you think is Saturn?

Direct students' attention to sky picture #1, and invite them to guess which dot is Saturn. Most students will guess the bright dot.
Hide picture # 1.
Show picture #2.

Here is another picture made one month later, showing the same part of the sky.

Can you see anything different about it? Would you like to take a second guess about which one of these points of light is Saturn?

Let's compare with last months picture side by side.

Expose pictures #1. and #2 side by side.

Where do you PREDICT Saturn will appear one month later?

Allow time for students to answer your question.

Well, let's see if you are right.

Expose picture #3.

Here is how this pattern of stars appeared one month later. Who would like to describe how Saturn "wanders" against the background stars?

The planets appear to wander at different speeds and in different directions from month-to-month. Teachers who would like to learn more about these motions are encouraged to consult a "sky calendar" article in one of the many astronomy periodicals.

Through a telescope, a star appears very bright, but it is still just a point of light. A planet, however, is much closer to us, so we can see details on it. Let's look at this wandering point of light and see what it looks like through a telescope.

Point to the "star" that has changed its position. Show a poster, projection, or a picture of Saturn.

Part B. Simulation Activity

Have the students go outdoors and stand in a large circle, about 40 feet in diameter (close enough to hear you).

Now we will do an activity to see why the planets seem to wander among the stars. First, we need two volunteers to stand in the center of our circle to play the parts of the Sun and Earth.

Have the Sun stand in the very center of the circle, and the Earth stand about five feet away.

Imagine that all of you in the circle are stars. Like the real stars, each of you has a name. If you want to appear even more like the stars, space yourselves around the circle so the Earth sees groups, or **constellations** of stars.

The students move a little closer or further apart so they are spaced unevenly around the circle. Optional: have the students hold signs which represent the various constellations. (See PASS Volume 2, "What's Your Sign?")

Earth, please turn so you can see the Sun. What time of day is it for your face? [Noon.] Now turn so it is night for your face. Please point out some stars whose names you know!

The student playing Earth points to three or four classmates and says their names.

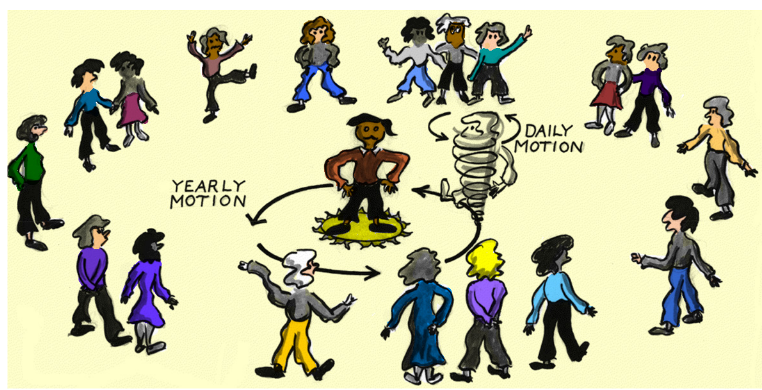
How should the Earth move so that a whole week of time goes by? How should the Earth move so that a whole year goes by?

At least one or two students in the class will probably be able to suggest that in one week the Earth would turn around seven times while standing in the same spot, or moving a bit along in its orbit.

To demonstrate a year, the Earth will have to walk around the Sun while at the same time spinning around.

Earth, please demonstrate one year by walking all the way around the Sun in your orbit. If you get dizzy, we'll pretend you turned around 365 times as you walked in one complete circle.

Now I have a problem for you to figure out. I will divide the class into two groups. I want each group to make its own model of the Solar System, with the Earth, Sun, Stars, AND SATURN. You must decide where Saturn should be and how it should move. When we get back together again, I want each group to demonstrate why Saturn appears to "wander" against the stars. Any questions?



Divide the class into two groups and assign areas for them to work in. Let the students choose who will play the Earth, Sun, and Saturn, and discuss how the planets should move. The students may want to know how long Saturn's day is (10 hours) or how long it takes for Saturn to go around the Sun (about 29 Earth years), but this information is not vital for this activity. Allow the teams to work until they have solved the problem (probably five to fifteen minutes.)

Come back and form a large circle again. Who would like to explain why Saturn appears to wander against the stars, while your teammates act out the Solar System?

The students may discover either or both of the following explanations for why the planets appear to wander against the stars: First, the planets are VERY much closer to Earth than are the stars, so a slight change in the Earth's location will make planets appear to move with respect to the stars. Second, the planets are moving in their own orbits as well, so the direction an Earth observer must look to see another planet is always changing. It is not important for the teacher to explain these concepts in detail, but rather to let the students explain and demonstrate their ideas while the other students comment.

Now it's the second team's turn. Who is the explainer? The Earth? The Sun? . . .

Scale Model of the Solar System

(2 inches = 1 million miles)

Planet	Size*	In Model	Distance**	In Model***
Sun	864,000	(1.7") ping pong ball	0	0
Moon	2,000	(.004") tiny grain of sugar	0.25	0.5”
Mercury	3,000	(.006") small grain of sugar	36	6’ 0”
Venus	7,500	(.015") large grain of sugar	67	11’ 0”
Earth	8,000	(.016") large grain of sugar	93	15’ 6”
Mars	4,000	(.008") medium grain of sugar	142	23’ 6”
Jupiter	89,000	(.18") large mustard seed	483	80’
Saturn	75,000	(.15") small mustard seed	886	148’
Uranus	29,000	(.058") cake decoration	1,783	297’
Neptune	28,000	(.056") cake decoration	2,787	454’
Pluto	2,000	(.004") tiny grain of sugar	3,670	612’ †
Nearest Star	800,000	(1.6") ping pong ball	24,000,000	760 miles

* Approximate diameter in miles. A good exercise: convert this whole table to metric units.

** Average distance in millions of miles from sun, except for the moon entry which refers to distance from earth.

*** In feet (‘) and inches (“).

† In point of fact, Pluto is now slightly closer to the Sun than Neptune in its current position in its noncircular orbit. It will again become the furthest planet from the Sun in 1999, as it was before 1979 when it became “the 8th planet.”

Follow-Up Activities

> **Note**
>
> Ron Hipschman of the Exploratorium in San Francisco, California, has created a Web page containing a "Make a scale model of the Solar System" calculator/chart. The page requires a JavaScript capable browser. It is located at http://www.exploratorium.edu/ronh/solar_system/.
>
> You may find other WWW links for solar system models at the "Solar System Scale Model Meta Page" at http://www.vendian.org/mncharity/dir3/solarsystem/.

1. Have the students extend their simulation of the solar system to include three, four, or even nine planets.
2. Have the students make a scale model of the solar system. We suggest the following procedure developed by Bob Risch and Jim Vickery, Co-Directors of the Jeffco Planetarium, Lakewood, Colorado, for their School District's Curriculum Guide. First, the students make models by selecting small objects to represent the planets. These can be taped to cards with cellophane tape and labeled. Then, the students can go out to the playground with measuring sticks to illustrate the distance scale of the solar system. They may be surprised at how much "space" there is in space! The scale recommended by the Jefferson County Curriculum Guide is printed on page 29 with permission of the developers.
3. Gerald Mallon of the Methacton School District Planetarium suggests a larger scale initially to compare the Earth and Sun. He uses a blue marble for the earth, and asks students to guess the size of the Sun. The Sun is then introduced as a 3-foot-diameter weather balloon! (Such balloons are available from Edmund Scientific Co., Barrington, New Jersey.)
4. Sheldon Shafer from the Lakeview Museum of Arts and Sciences suggests the following activity for students to do during the school bus ride to the planetarium:

Use the ride to establish a scale model of the solar system, with size and distance to the same scale, where your school is Pluto and the Sun is at the planetarium. The following chart will help you and/or your students work out the mathematics:

D is the distance (in miles) from your school to the planetarium.

> Example: if your school is 10 miles from the planetarium, the Earth would be 1.35 inches in diameter and about 1/4 mile from the planetarium (9-3/4 miles from your school).

Planet	Miles from School	Scale Size of Planet (in inches)
Pluto	0	0.033 x D
Neptune	0.24 x D	0.51 x D
Uranus	0.51 x D	0.54 x D
Saturn	0.76 x D	1.27 x D
Jupiter	0.87 x D	1.51 x D
Mars	0.96 x D	0.072 x D
Earth	0.9738 x D	0.135 x D
Venus	0.98 x D	0.127 x D
Mercury	0.99 x D	0.052 x D
Sun	D	14.7 x D

5. Interplanetary Olympics

Gravity is a force (or pull) which attracts matter in the universe to all other matter. All bodies in the universe, even planets and stars, are affected by gravity. By lifting an object, you can feel the force of gravity between that object and the Earth. Your own weight is a measure of the force of gravity between you and the Earth.

Planet	Gravity Factor	Your Weight
Pluto	0.03	
Neptune	1.23	
Uranus	0.93	
Saturn	1.07	
Jupiter	2.87	
Mars	0.38	
Earth	1.00	
Venus	0.90	
Mercury	0.38	
Sun	27.80	
Moon	0.16	

By doing some simple calculations, you can determine your weight on the Sun, planets, and moon. Simply multiply your weight by the gravity factor in the table below. Note that Earth has a gravity factor of 1, often referred to as 1 "g."

You can also compare distances objects in Olympic events would travel. The objects can be human, such as in high jump or long jump, or they can be inanimate such as shot put, discus, javelin. Your students can, for example, throw a rubber ball "shot put" and measure the distance it travels. To compute the corresponding distance if the Olympic event were taking place on another planet, simply divide by the gravity factor in the table. The column "Your Weight" in the table can be replaced by "Distance," or "Height," depending on the particular event.