MODELING THE ORBITS OF THE PLANETS

Level

Grades K - 5

Learning Goals

Make a scale model of the orbits of the outer planets.
Explore unique properties of Pluto’s orbit.

National Science Education Standards

Unifying Concepts & Processes: Systems, Order and Organization
Standard A: Abilities Necessary to do Scientific Inquiry
Standard D: Objects in the Sky

Materials per student

1 paper clip
Scissors
Glue, glue stick, or tape
Pencil and crayons or markers
Student sheets copied onto cardstock (if possible, but paper is ok!)

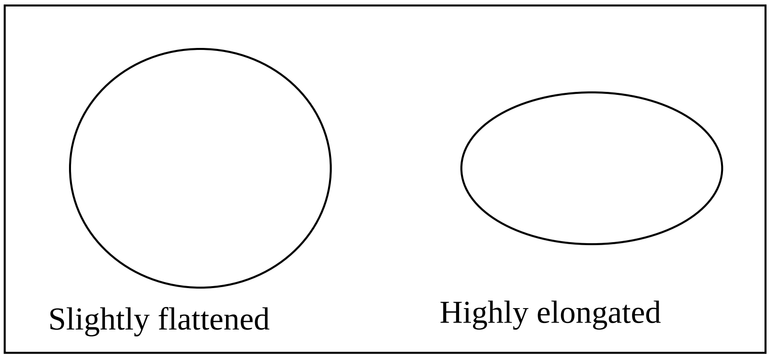
Teacher Overview

Background Information

The term Outer Planets refers to the five planets that orbit the Sun beyond the Asteroid Belt. The Outer Planets include: Jupiter, Saturn, Uranus, Neptune, and Pluto. The Inner Planets are: Mercury, Venus, Earth, and Mars. The planets are known to travel around the Sun along **elliptical orbits**—a term that simply means that the shape they trace out as they go around the Sun is an **ellipse**. (See Figure 1.) An ellipse is similar to a circle, but it is elongated along one axis. The circle is a special case of an ellipse in which the distance from the center to the edge in any direction is the same. The more elongated an ellipse is, the higher its **eccentricity**. An eccentricity of 0 is the special case of a circle, while eccentricities near 1 describe extremely elongated ellipses.

If it were possible to look down on the orbits of the planets from above Earth's North Pole, the planets would be moving in a counterclockwise direction. The planets are locked into orbits around the Sun because of the gravitational force the Sun exerts on the planets. If we were able to somehow turn off the Sun's gravity, the planets would cease traveling along elliptical paths around the Sun, and instead continue along straight line paths in the direction they were just moving!

Figure 1.

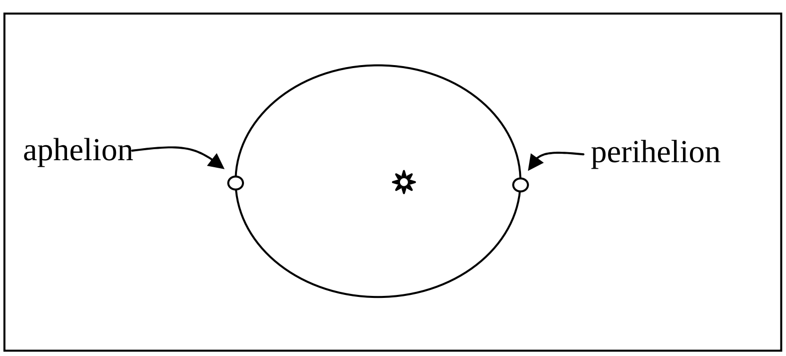


What's special about Pluto? The orbits of all the planets are elliptical, but they are close to being circular and are not very elongated. Pluto's orbit is the most elongated of all! Note, however, that although Pluto's orbit is the most elongated, it still appears relatively circular.

Since the planets have elliptical and not circular orbits, they are not always the same distance away from the Sun. At one point in their orbit, they are at **perihelion**, their point of closest approach to the Sun, and at another point, they are at **aphelion**, the point farthest from the Sun. (See Figure 2.) The more circular an orbit is, the more similar the distances are between the Sun and planet at perihelion and aphelion. If an orbit were circular, the perihelion and aphelion distances of the planets would be equal.

What's special about Pluto? The elliptical orbit of Pluto is flattened enough so that at some points in its orbit it is not the farthest planet! For approximately 20 years out of Pluto's 249 year trip around the Sun, Pluto is actually closer to the Sun than Neptune. But don't worry, the two planets will never crash because whenever Pluto crosses Neptune's orbit, Neptune is on the other side of the Sun.

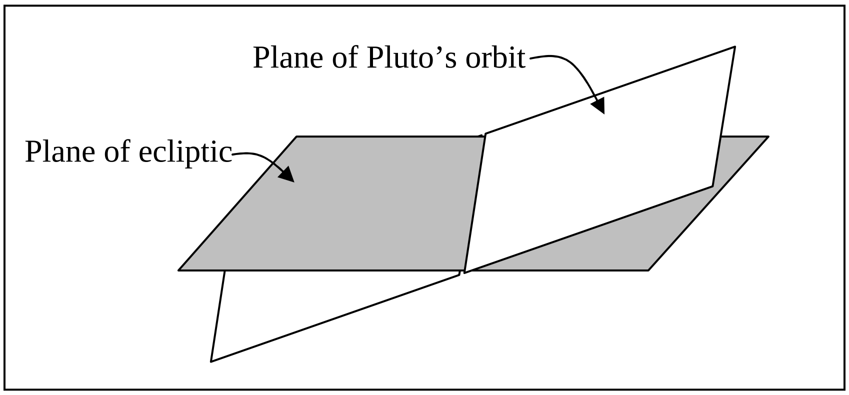
Figure 2.



All of the planets, except for Pluto, orbit the Sun approximately in a plane, called the **plane of the ecliptic**. A simple way of envisioning this is to imagine the Sun and planets (except for Pluto) as balls. If the ball representing the Sun were placed on a table, and the balls representing the planets (except for Pluto) were rolled around the Sun on the table, all of the balls, and hence, all of the planets (except for Pluto) would be orbiting the Sun on a plane. The ball representing Pluto would travel around the Sun too, but sometimes it would be above the table, and then dip down below the table before coming above the table again.

What's special about Pluto? Pluto does not orbit the Sun on the same plane as all the other planets. Its orbit is inclined, or tilted, by 17º. Because of this tilt, Pluto is located above the plane of the ecliptic for part of its orbit and below the ecliptic for the remainder of the time.

Figure 3.



Directions

1. Have students color the planets before cutting them out.
2. Ask students to cut all the shapes following the instructions on the Student Activity Sheets.
3. Glue planets onto the edge of the correct planet's orbital disk.
4. Have students unbend one end of their paperclip.
5. Using this end of the paperclip, have students poke a hole through the point marked "Sun" on each of the orbital disks. Work from the outer planets, inward (i.e. first poke hole through Pluto's orbital disk, next through Neptune's, etc.).
6. Ask students to bend the long end of the paperclip back into place so the planets' orbital disks don't fall off.

Discussion and Investigation

As students are finishing up, watch how they play with their model. Consider asking some of the following questions.

1. Q: I notice that <<student’s name>> is spinning the planets around the Sun (paper-clip) on the model. How does that model what is happening out in space?
    a. The planets orbit around the Sun.
2. Q: Assume that Earth’s North Pole is up. Which direction are you spinning the planets around the Sun? Which way models what happens in our Solar System? Clockwise or Counterclockwise?
    a. When viewed from above Earth’s North Pole, the planets move in a counterclockwise direction. See animation: http://pluto.jhuapl.edu/common/content/videos/animations/PKB_MissionTrajectory.mov
3. Q: On your model, where would the orbits of Mercury, Venus, Earth, and Mars be located? What is different about the sizes of these inner planets’ orbits compared to the orbits of the outer planets?
    a. Mercury, Venus, Earth, and Mars would be drawn inside the orbit of Jupiter, with Mercury closest to the Sun and the rest of the planets with slightly larger orbits, respectively. Their orbits are so small on the model, and they are very small in comparison to the orbits of the outer planets (Jupiter and beyond) in the Solar System.
4. Q: Can you use your model (and the special hole you cut out in Pluto’s orbit) to show how Pluto’s orbit is tilted in comparison with the orbits of the other planets?
    a. Pluto’s orbit is inclined, or tilted, with respect to the orbits of the other planets by about 17°. This is a moderate amount that you will have to show students.
5. Q: Using our models, let’s write on the chalkboard the order of the planets, from closest to the Sun to farthest.
    a. Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune, Pluto
    b. Some students may recall or see that sometimes Neptune is farther from the Sun than Pluto—if this comes up discuss it. If not, ask about it.
6. Q: Use your model and spin the orbit of Pluto until Pluto is at perihelion (the point closest to the Sun). Now, show Pluto at aphelion (the point farthest from the Sun).
7. Q: Did you know that spacecraft have traveled to all the planets except for one? Which one do you think has not been visited?
    a. Pluto!
8. Q: A space mission called New Horizons will launch (or has launched!) from Earth in 2006 heading for Pluto. How long do you think it will take for it to get there? What grade will you be in?
    a. The trip will take between 9 and 14 years, depending on the launch date. See real-time progress of New Horizons at: http://pluto.jhuapl.edu