

The Universe
Astronomy
Lesson 7

Planets and their Motions

Since the time of Copernicus, Kepler, and Galileo, we have learned a lot more about our solar system. We have discovered two more planets—Uranus and Neptune—over 150 moons, and many asteroids and other small objects.

So, what exactly is a planet? A **planet** is a massive, round body orbiting a star. For our solar system, this star is the Sun. A **moon** is an object that orbits a planet.

So, why isn't Pluto a planet anymore? When Pluto was first discovered in 1930, it was considered our 9th planet. What we didn't realize at the time was that Pluto has a moon Charon that orbits very close to Pluto. In fact, what we were seeing in 1930 was Pluto and Charon together, and combined they looked like a single, large planet. However, as our technology improved and we developed more high-powered telescopes, we realized that Charon and Pluto were two separate objects and Pluto itself is not large enough to be classified as a planet. According to our modern-day definition, a planet must:

- Orbit a star
- Be shaped like a sphere
- Be small enough that it isn't a star itself
- Have cleared the area of its orbit of smaller objects (in other words, there can't be rock debris in its orbit)

Objects that only meet the first three criteria, like Pluto, are considered dwarf planets.

The Size and Shapes of the Orbits

The planets of our solar system vary greatly in their size and the size of their orbits around the Sun. For instance, Jupiter is about 10 times the size of Earth, and Earth is about three times the size of Mercury. [This is a great place to show the image of the relative sizes of the planets].

The orbits of the planets are nearly circular, but we know from Kepler, that, in fact, they are slightly elliptical. The inner planets—Mercury, Venus, Earth Mars—all orbit the Sun inside of the Asteroid Belt, a region heavy in asteroids orbiting the Sun. Outside the asteroid belt, we have the outer planets—Jupiter, Saturn, Uranus, and Neptune—whose orbits around the Sun are quite large. Finally, outside of the orbits of Neptune and Pluto, we encounter the Kuiper Belt, another accumulation of asteroids, rocks, and metals orbiting the Sun. While the Kuiper belt is similar in composition to the Asteroid Belt, it is far larger—almost 20 times the side of the Asteroid Belt and 200 times as massive!

Notice, that, in general, the farther the planets are from the Sun, the larger their orbits, and, therefore, the larger their planetary year.

The Role of Gravity

Planets are held in their orbits by the force of gravity.

(Demonstration: tie or tape a small ball (tennis ball, rubber bouncy ball, foam ball, etc.) to the end of a 5 foot piece of string. Swing the ball around the top of your head. Ask students: “If I were to let go of the string, what would happen to the ball?” [Response – it would fly off in a straight line] But, the force that the string is exerting by pulling on the ball keeps the ball moving in a circle. The motion of a planet is very similar, except the force pulling the planet is the force of gravity between the planet and the Sun. This particular gravitational force has a special name: Centripetal Force. It is the force, of the string, that makes the ball move in a curved as opposed to straight path. In the case of the planets, the centripetal force is gravity.)

Every object is attracted to every other object by gravity. The force of gravity between two objects depends on how much mass the objects have and how far apart they are. When you are sitting next to a friend, there is gravitational force between you and your friend, but it is far too weak for you to detect. In order for the force of gravity to be strong enough to detect, at least one of the objects has to have a lot of mass. You can feel the force of gravity between you and Earth because Earth has a lot of mass. The distances from the Sun to the planets are very large. But the force of gravity between the Sun and each planet is very large because the Sun and the planets are very large objects. The force of gravity also holds the moons in orbits around the planets.

Same Plane and Same Direction

Notice that in our pictures of the solar system, all of the planets lie in the same plane and orbit the Sun in the same direction. This is not a fluke, and the reasons give us clues about the formation of our solar system.

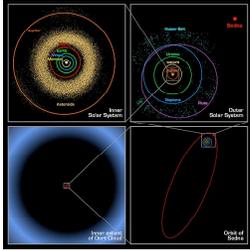
The most widely accepted hypothesis about the formation of the solar system is known as the **Nebular Hypothesis**. According to this hypothesis, our solar system formed about 4.6 billion years ago from the collapse of a giant cloud of gas and dust, called a **nebula**. The nebula was made of mostly hydrogen and helium, but there were heavier, trace elements like carbon and silicon as well.

The nebula was drawn together by gravity. As the nebula collapsed, it started to spin. As it collapsed further, the spinning got faster, like an ice skater spins faster when she pulls her arms to her sides during a spin. This effect, called the conservation of angular momentum, along with the forces of gravity, pressure, and radiation, caused the nebula to form a disk shape. In this disk, the planets formed, and this is why all of the planets are found in the same plane and orbiting the Sun in the same direction.

Images used for this lesson:

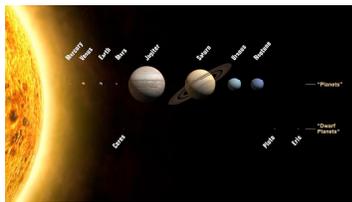


Scaled distance from the Sun image of the planets
Source: <http://commons.wikimedia.org/wiki/File:Solar-system.png>
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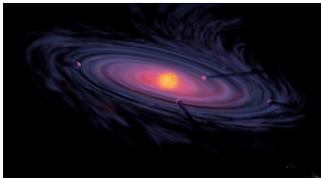
Scaled Planetary Orbits

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Relative Size of Planets in our Solar System

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Nebular Disk

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