

CHAPTER 20 Formation of the Solar System

SECTION

4

Planetary Motion

BEFORE YOU READ

After you read this section, you should be able to answer these questions:

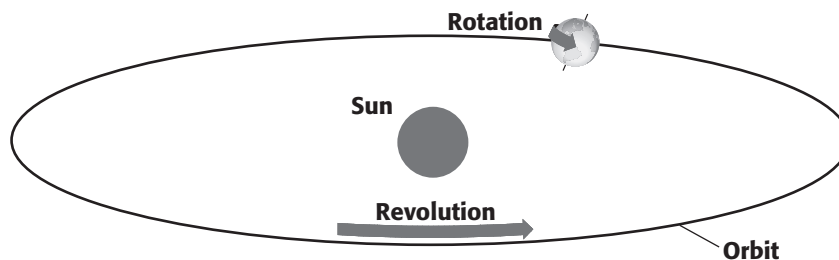
- What is the difference between rotation and revolution?
- What are Kepler's three laws of planetary motion?
- How does gravity affect the orbits of planets?

**National Science
Education Standards**
ES 3b

How Do Scientists Describe the Motions of the Planets?

Remember that the Earth, like all planets, spins on its axis. Scientists use the term **rotation** to describe the motion of a body spinning on its axis. As the Earth rotates, different parts of its surface face the sun. It is daytime in the part that faces the sun. It is night in the part that faces away from the sun. At any time, only one-half of the Earth faces the sun.

In addition to rotating, all planets move around the sun. The path that a planet follows around the sun is called its **orbit**. One complete trip around the sun is called a **revolution**.



The amount of time it takes for a planet to complete one revolution is called its *period of revolution*. Each planet has a different period of revolution. For example, Earth's period of revolution is 365.24 days. Mercury's is only 88 days.



Summarize After you read this section, make a chart describing Kepler's laws of planetary motion.

Critical Thinking

1. Infer Venus rotates more slowly than the Earth. On which planet does daytime last longer?

TAKE A LOOK

2. Describe What are two ways that planets move?

SECTION 4 Planetary Motion *continued*

What Do We Know About How Planets Move?

Scientists have not always known how the planets move. Until the 1600s, scientists did not know the shapes of the planets' orbits or their periods of revolution accurately.

In the 1600s, a German scientist named Johannes Kepler made detailed observations of the motions of the planets. After analyzing his observations, he developed three laws of planetary motion. Kepler's observations and calculations were so accurate that scientists still use his laws today! ✓

READING CHECK

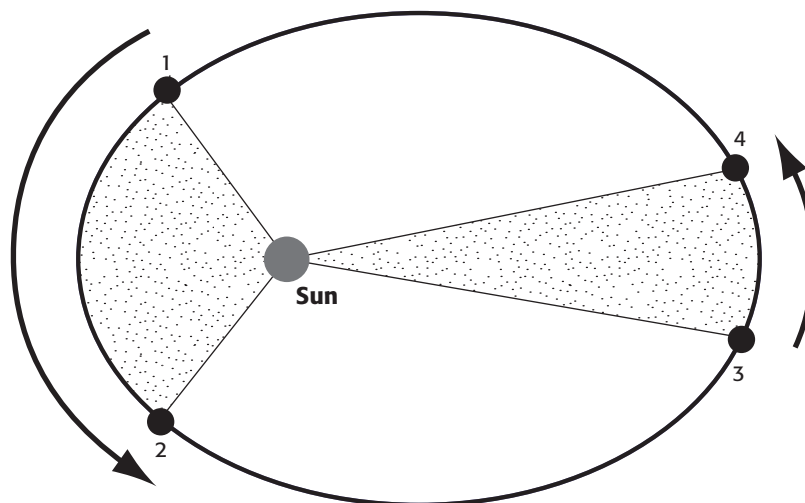
3. Describe How did Johannes Kepler come up with his three laws of planetary motion?

KEPLER'S FIRST LAW

Kepler carefully observed the path that Mars takes through the sky. When he analyzed his observations, he found that Mars' orbit is not a perfect circle. Instead, it is shaped like an *ellipse*, or oval. Kepler's first law of planetary motion states that the orbits of all planets are ellipses.

KEPLER'S SECOND LAW

Kepler reasoned that the planets must move through their orbits faster in some places than in others. To understand why this is so, look at the figure below. The distance between point 1 and point 2 is longer than the distance between point 3 and point 4. The planet takes the same amount of time to travel both distances. Therefore, the planet must be moving faster between points 1 and 2 than between points 3 and 4. This is Kepler's second law.



TAKE A LOOK

4. Identify Label the place in the planet's orbit where it is moving the fastest.

SECTION 4 Planetary Motion *continued*

KEPLER’S THIRD LAW

Kepler observed that planets that are far from the sun, such as Saturn, take longer to orbit the sun. This is Kepler’s third law of planetary motion.

How Does Gravity Affect a Planet’s Orbit?

Kepler never knew why planets orbit the sun. Another astronomer, Sir Isaac Newton, solved the puzzle. He combined the observations of earlier scientists with mathematical models to describe the force of gravity.

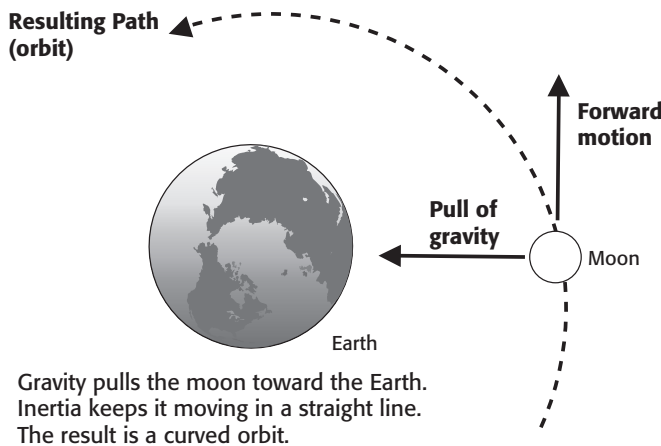
Newton observed that objects fall toward Earth. He reasoned that all objects are attracted to each other through the force of gravity. The strength of the force depends on two factors—the masses of the objects and the distance between them.

Newton’s *law of universal gravitation* describes how the force of gravity is related to these two factors. When the masses are large, the force of gravity is strong. When the objects are far apart, the force of gravity is weak.

ORBITS AND GRAVITY

If gravity is pulling on the moon, why doesn’t the moon fall to Earth? The answer has to do with the moon’s inertia. *Inertia* is an object’s resistance to changes in its speed or direction.

Gravity is like a string holding the moon in orbit around the Earth. Without gravity, the moon would move in a straight line away from the Earth. The moon’s orbit is a balance between its inertia and the force of gravity. This balance is the reason that all bodies in orbit, including the Earth, travel along curved paths.



STANDARDS CHECK

ES 3b Most objects in the solar system are in regular and predictable motion. Those motions explain such phenomena as the day, the year, phases of the moon, and eclipses.

Word Help: predictable
able to be known ahead of time

Word Help: phenomenon
(plural *phenomena*) any fact or event that can be sensed or described scientifically

5. Identify Relationships
How is the distance of a planet from the sun related to its period of revolution?

TAKE A LOOK

6. Explain Why doesn’t the moon move away from the Earth in a straight line?

Section 4 Review

SECTION VOCABULARY

<p>orbit the path that a body follows as it travels around another body in space</p>	<p>revolution the motion of a body that travels around another body in space; one complete trip along an orbit</p> <p>rotation the spin of a body on its axis</p>
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1. Compare How is rotation different from revolution?

2. Define Explain Kepler’s second law of planetary motion in your own words.

3. Describe Fill in the blank spaces in the table.

Factor	How it affects the force of gravity
Mass of the objects	
Distance between the objects	

4. Identify What two factors must be balanced in order for an object to remain in orbit?

5. Predict Consequences What would happen to an object in orbit around a planet if the planet’s force of gravity were stronger than the object’s inertia?

6. Apply Concepts Imagine a planet with two moons. Moon A is twice as far from the planet as moon B. Which moon will take longer to orbit the planet once? Explain your answer.

- The nebula would dissipate into nothing because gravity would not be strong enough to keep it together.

SECTION 2 THE SUN: OUR VERY OWN STAR

- the sun's outer atmosphere
- about 4.6 billion years
- protons, neutrons, electrons
- protons
- No, because they contain different numbers of protons.
- a process in which two or more nuclei fuse to form a new nucleus
- Helium-4 contains one more neutron than helium-3.
- cooler, dark spots on the photosphere
- changes in the sun's magnetic field
- 1950
- an extremely hot, bright region on the sun's surface

Type of solar activity	Description	How can it affect the Earth?
Sunspots	darker, cooler spots on the photosphere	It may cause climate change, but the connection is not clear.
Solar flares	extremely hot, bright region on the sun's surface	It can interact with the atmosphere and interfere with radio and television transmissions.

Review

- nuclear fusion
- From top to bottom: convective zone, core, radiative zone
- A deuterium nucleus collides with a hydrogen nucleus. The nuclei fuse to form a nucleus of helium-3. Two helium-3 nuclei collide. They fuse to form a nucleus of helium-4 and two hydrogen nuclei.
- circulation of gases and the sun's rotation
- solar flares and sunspots
- They interact with the atmosphere and can interrupt radio and television transmissions.

SECTION 3 THE EARTH TAKES SHAPE

- gravity

Force	Effect
Gravity	<ul style="list-style-type: none"> attracted matter to the early Earth crushed rock at the early Earth's center
Heat	<ul style="list-style-type: none"> caused the inside of the early Earth to melt is a cause of volcanoes, earthquakes, and hot springs today

- The crust is thinner, less dense, and made of different materials than the mantle.
- Heat caused the rocks in the Earth to melt. Denser material sank to the center and became the core. Material that was less dense rose toward the surface and became crust and mantle.
- nitrogen and oxygen
- carbon dioxide and water vapor
- They released gases into the atmosphere.
- living things
- a process in which a living thing produces food and oxygen from water, carbon dioxide, and sunlight
- Molten rock on the early Earth's surface:
carbon dioxide, water vapor
Volcanoes: chlorine, nitrogen, sulfur, carbon dioxide, water vapor
Comets: oxygen, nitrogen, hydrogen
Living things: oxygen
- a mat of fossilized algae
- the processes of plate tectonics

Review

- heat and gravity
- From top to bottom: crust, mantle, core
- It caused oxygen levels to increase and carbon dioxide levels to decrease.
- Oxygen in the atmosphere reacted with sunlight to form ozone gas. The gas formed the ozone layer.
- about 4 billion years ago
- Rocks melted and cooled many times. Each time, the material with less density rose toward the surface. Eventually, enough had collected to rise above the Earth's surface, forming early continents. Plate tectonic processes have caused the continents to become larger with time.

SECTION 4 PLANETARY MOTION

- Venus
- rotation, revolution

3. He made and analyzed observations of planetary motions.
4. The point closest to the sun should be labeled.
5. The farther a planet is from the sun, the longer its period of revolution.
6. Gravity pulls it toward the Earth.

Review

1. Rotation describes the motion of a body spinning on an axis. Revolution describes the motion of a body orbiting another body.
2. The speed at which a planet is moving in its orbit is different at different places in the orbit.
3. Mass of the objects: As mass increases, the force of gravity increases.
Distance between the objects: As the separation increases, the force of gravity decreases.
4. inertia and gravity
5. The object would crash into the planet.
6. According to Kepler's third law, moon A will take longest to orbit because it is farthest away.

Chapter 21 A Family of Planets

SECTION 1 OUR SOLAR SYSTEM

1. planets, sun, moons
2. about 450 million km
3. about 250 light-minutes
4. Mercury
5. Mars
6. The planets in the outer solar system are, in general, larger and farther apart than those in the inner solar system.
7. Neptune

Review

1. about 58 million km
2. Mercury, Venus, Earth, Mars
3. Jupiter, Saturn, Uranus, Neptune
4. A light-hour is the distance light travels in an hour—about 1,080 million km.
5. Light-years are much longer than light-minutes or light-hours. Our solar system is too small to measure accurately in light-years.

SECTION 2 THE INNER PLANETS

1. They have a makeup similar to that of Earth.
2. density
3. The rotations are in opposite directions when viewed from above the North Pole.
4. 1 day
5. The thick atmosphere prevents visual observations, even from space probes.
6. its oceans
7. Period of revolution is 6 h longer than 365 days.
 $4 \times 6 \text{ h} = 24 \text{ h}$, or 1 day
8. Mars has a thinner atmosphere, and it is farther from the sun.
9. A Martian day is longer than an Earth day.
10. erosion and sediments
11. at the poles and possibly below the surface
12. It may have erupted over long periods of time.
13. evidence that water once existed on the Martian surface

Review

1. prograde

Planet	Distance from sun (AU)	Period of revolution
Mercury	0.38	58 Earth days, 19 h
Venus	0.72	243 Earth days, 16 h
Earth	1.00	365 Earth days, 6 h
Mars	1.52	687 Earth days

3. Features on the surface show that there may have been erosion or sedimentation like that caused by water on Earth. For liquid water to exist, there would have to be a warmer surface and a thicker atmosphere than there are now.
4. Planets that are farther from the sun take longer to orbit the sun.
5. Venus has a thicker atmosphere and a stronger greenhouse effect, making it hotter than the other inner planets.
6. If the Earth were too close to the sun, liquid water would boil away.

SECTION 3 THE OUTER PLANETS

1. Four of the following: hydrogen, helium, ammonia, methane, water
2. its period of rotation
3. about 29 times
4. ice, dust
5. It does not reflect enough light.