



## 26.1 Johannes Kepler

*Johannes Kepler was a mathematician who studied astronomy. He lived at the same time as two other famous astronomers, Tycho Brahe and Galileo Galilei. Kepler is recognized today for his use of mathematics to solve problems in astronomy. Kepler explained that the orbit of Mars and other planets is an ellipse. In his most famous books he defended the sun-centered universe and his three laws of planetary motion.*

### Early years in Germany



Johannes Kepler was born December 27, 1571, in Weil der Stadt, Wurttemberg, Germany, now called the “Gate to the Black Forest.” He was the oldest of six children in a poor family. As a child he lived and worked in an inn run by his mother’s family. He was sickly, nearsighted, and suffered from smallpox at a

young age. Despite his physical condition, he was a bright student.

The first school Kepler attended was a convent school in Adelberg monastery. Kepler’s original plan was to study to become a Lutheran minister. In 1589, Kepler received a scholarship to attend the University of Tubingen. There he spent three years studying mathematics, philosophy, and theology. His interest in math led him to take a mathematics teaching position at the Academy in Graz. There he began teaching and studying astronomy.

### Influenced by Copernicus

At Tubingen, Kepler’s professor, Michael Mastlin, introduced Kepler to Copernican astronomy. Nicolaus Copernicus (1473-1543), had published a revolutionary theory in, “On the Revolutions of Heavenly Bodies.” Copernicus’ theory stated that the sun was the center of the solar system. Earth and the planets rotated around the sun in circular orbits. At the time most people believed that Earth was the center of the universe.

Copernican theory intrigued Kepler and he wrote a defense of it in 1596, *Mysterium Cosmographicum*. Although Kepler’s original defense was flawed, it was read by several other famous European astronomers of the time, Tycho Brahe (1546–1601) and Galileo Galilei (1546–1642).

Kepler published many books in which he explained how vision, optics, and telescopes work. His most famous work, though, dealt with planetary motion.

### Working with Tycho Brahe

In 1600, Brahe invited Kepler to join him. Brahe, a Danish astronomer, was studying in Prague, Czechoslovakia. Every night for years Brahe recorded planetary motion without a telescope from his observatory. Brahe asked Kepler to figure out a scientific explanation for the motion of Mars. Less than two years later, Brahe died. Kepler was awarded Brahe’s position as Imperial Mathematician. He inherited Brahe’s collection of planetary observations to use to write mathematical descriptions of planetary motion.

### Kepler’s Laws of Planetary Motion

Kepler discovered that Mars’ orbit was an ellipse, not a circle, as Copernicus had thought. Kepler published his first two laws of planetary motion in *Astronomia Nova* in 1609. The first law of planetary motion stated that planets orbit the sun in an elliptical orbit with the sun in one of the foci. The second law, the law of areas, said that planets speed up as their orbit is closest to the sun, and slow down as planets move away from the sun. Kepler published a third law, called the harmonic law, in 1619. The third law shows how a planet’s distance from the sun is related to the amount of time it takes to revolve around the sun. His work influenced Isaac Newton’s later work on gravity. Kepler’s calculations were done before calculus was invented!

### Other scientific discoveries

Kepler sent his book in 1609 to Galileo. Galileo’s theories did not agree with Kepler’s ideas and the two scientists never worked together. Despite his accomplishments, when Kepler died at age 59, he was poor and on his way to collect an old debt. It would take close to a century for his work to gain the recognition it deserved.



## Reading reflection

1. Why was Copernicus' idea of the sun at the center of the solar system considered revolutionary?
2. Explain how Brahe helped Kepler make important discoveries in astronomy.
3. How was Kepler's approach to astronomy different than Brahe's and Galileo's?
4. Kepler discovered that Mars and other planets traveled in an ellipse around the sun. Does this agree with Copernicus' theory?
5. Describe Kepler's three laws of planetary motion.
6. Kepler observed a supernova in 1604. It challenged the way people at the time thought about the universe because people did not know the universe could change. When people have to change their beliefs about something because scientific evidence says otherwise, that is called a "paradigm shift." Find three examples in the text of scientific discoveries that led to a "paradigm shift."