Kepler's laws of Planetary Motion

Johannes Kepler was a 16^{th} century astronomer who established three laws which govern the motion of planets around the sun. These are known as Kepler's laws of planetary motion.

1. **The Law of Orbits:** All planets move in elliptical orbits, with the sun at one of the foci.
2. **The Law of Areas:** A line that connects a planet to the sun sweeps out equal areas in equal times.
3. **The Law of Periods:** The square of the period of any planet is proportional to the cube of the semimajor axis of its orbit.

Kepler's laws were derived for orbits around the sun, but they apply to satellite orbits as well. The detailed description is given bellow,

1. **Kepler's first law:**

The planets move in elliptical orbits around the sun, with the sun at one of the two foci of the elliptical orbit. This means that the orbit or path of a planet around the sun is an ellipse i.e. an oval-shaped and not an exact circle. An elliptical path has two foci and the sun is at one of the two foci of the elliptical path. This law is important for us as it helps us discover if other stars have planets.

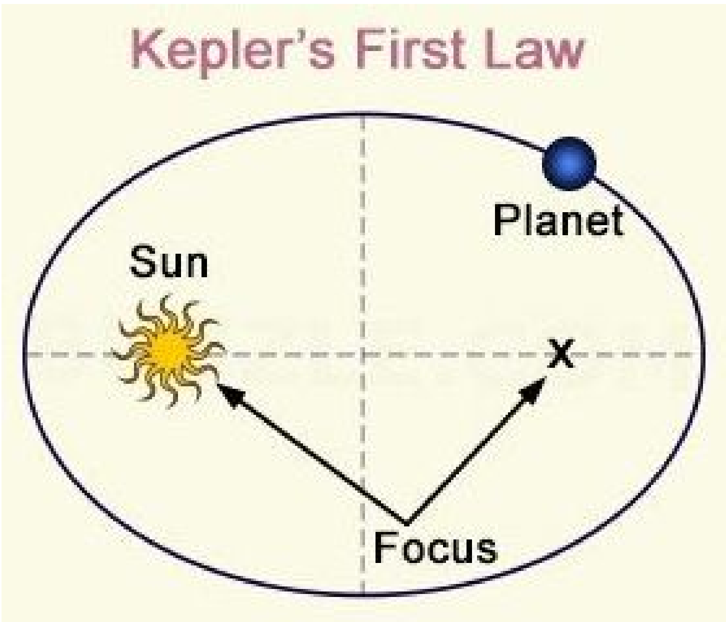


Figure-1

2. **Kepler's second law:**

Each planet revolves around the sun in such a way that the line joining the planet to the sun sweeps over equal areas in equal intervals of time. We know that a planet moves around the sun in an elliptical orbit with sun at one of its focus. Now, since the line joining the planet and the sun sweeps over equal areas in equal intervals of time, it means that a planet moves faster when it is closer to the sun and moves slowly when it is farther from the sun.

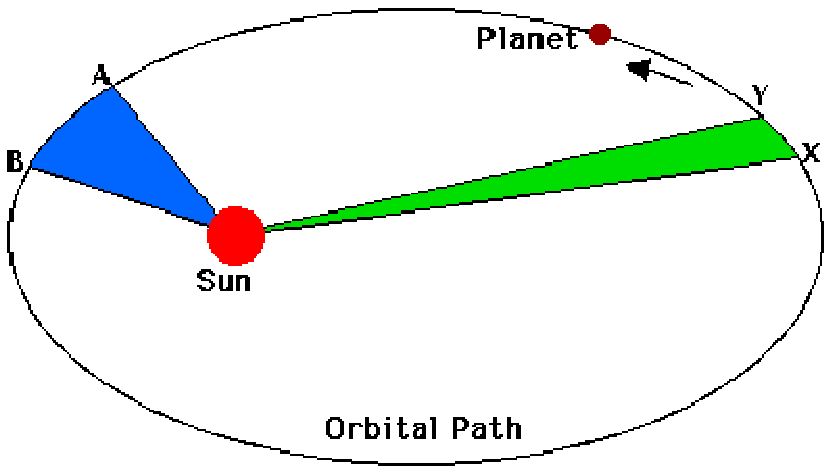


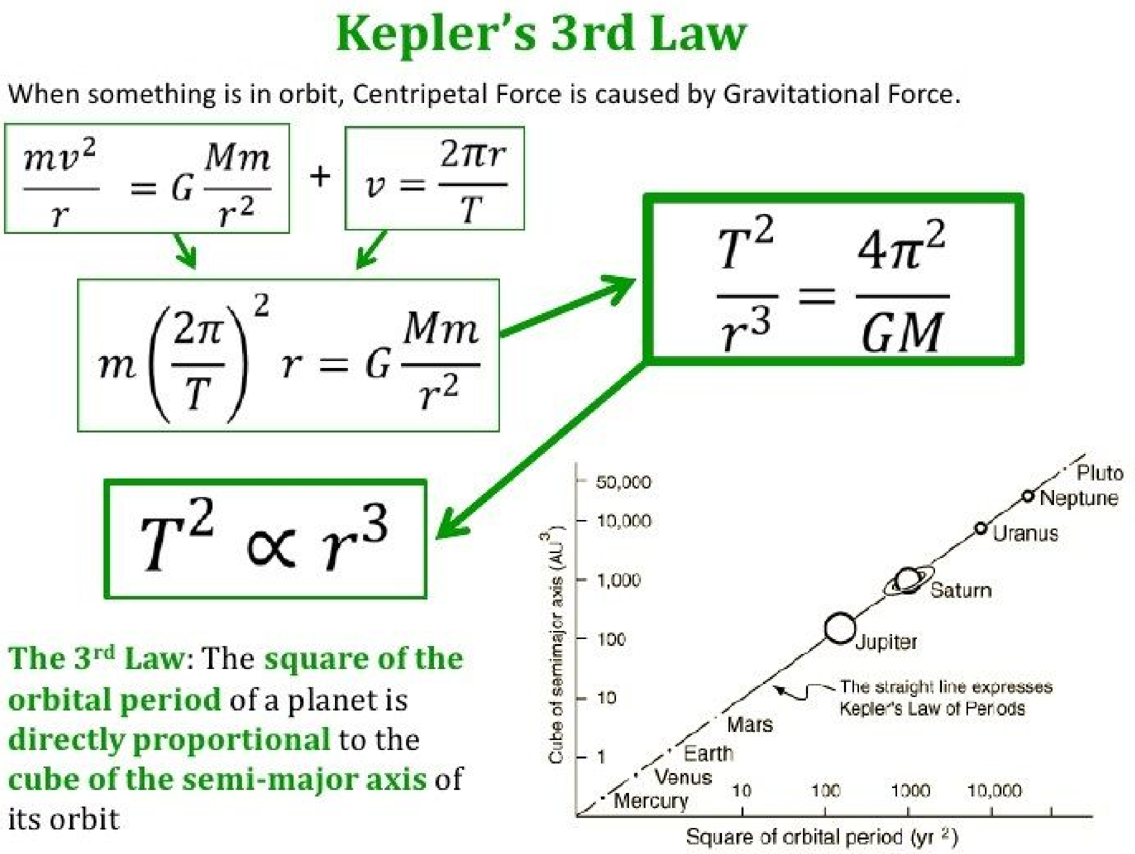
Figure-2

In the above figure a planet P is moving in an elliptical orbit around the sun. When the planet is nearer to the sun at position A, it travels faster and sweeps over an area ABC in time t. On the other hand, when the same planet is farther from the sun at position X, then it moves slowly but sweeps over an equal area XYC in the same time t. ***Thus the Kepler's second law states that a planet does not move with constant speed around the sun. The speed is greater when the planet is nearer the sun and less when the planet is farther away from the sun.*** A planet could move around the sun with constant speed only if its orbit were a true circle and not an ellipse.

3. **Kepler's third law:**

The cube of the mean distance of a planet from the sun is directly proportional to the square of time it takes to move around the sun. With the help of Kepler's third law of planetary motion we can show how long does it takes to reach Mars, how long would it take for a spacecraft from earth to reach the Sun.

Though Kepler gave the laws of planetary motion but he could not give an explanation about the motion of planets. It was Newton who showed that the cause of motion of planets is the gravitational force which the sun exerts on them. In fact, Newton used the Kepler's third law of planetary motion to develop the law of universal gravitation



Bode's Law

In 1766 the German astronomer Titius observed an interesting regularity among the mean distances of planets known at the time: with two notable exceptions, they seemed to follow a progression, which (when converted to astronomical units) gave the mean distance as $0.4+0.3\cdot2^n$, with n=0, 1, 2, 3... indicates the order of the planet from the Sun.

The Titius–Bode law (sometimes termed just Bode's law) is a hypothesis that the bodies in some orbital systems, including the Sun's, orbit at semi-major axes in a function of planetary sequence. The formula suggests that, extending outward, each planet would be approximately twice as far from the Sun as the one before. The hypothesis correctly anticipated the orbits of Ceres (in the asteroid belt) and Uranus, but failed as a predictor of Neptune's orbit and was