Kepler's Laws of Planetary Motion

Unit: Dynamics (Forces) & Gravitation

NGSS Standards: N/A

MA Curriculum Frameworks (2006): 1.1, 1.2

AP Physics 1 Learning Objectives: N/A

Knowledge/Understanding Goals:

- understand terms relating to angular position, speed & velocity

Skills Goals:

- solve problems using Kepler's Laws

Language Objectives:

- Accurately describe and apply the concepts described in this section using appropriate academic language.

Notes:

Problems involving Kepler's laws have not been seen on the AP Exam.

The German mathematician and astronomer Johannes Kepler derived the laws and equations that govern planetary motion, which were published in three volumes between 1617 and 1621.

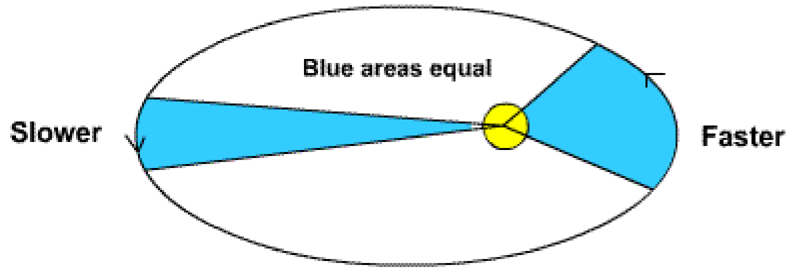
Kepler's First Law

The orbit of a planet is an ellipse, with the sun at one focus.

Use this space for summary and/or additional notes.

Kepler's Second Law

A line that joins a planet with the sun will sweep out equal areas in equal amounts of time.



I.e., the planet moves faster as it moves closer to the sun and slows down as it gets farther away. If the planet takes exactly 30 days to sweep out one of the blue areas above, then it will take exactly 30 days to sweep out the other blue area, and any other such area in its orbit.

While we now know that the planet's change in speed is caused by the force of gravity, Kepler's Laws were published fifty years before Isaac Newton published his theory of gravity.

Kepler's Third Law

If T is the period of time that a planet takes to revolve around a sun and $\bar{r}$ is the average radius of the planet from the sun (the length of the semi-major axis of its elliptical orbit) then:

$$\frac{T^2}{\bar{r}^3} = \text{constant for every planet in that solar system}$$

As it turns out, $\frac{T^2}{\bar{r}^3} = \frac{4\pi^2}{GM}$, where G is the universal gravitational constant and M is the mass of the star in question, which means this ratio is different for every planetary system. For our solar system, the value of $\frac{T^2}{\bar{r}^3}$ is approximately $9.5\times10^{-27}\,\frac{\text{s}^2}{\text{m}^3}$ or $3\times10^{-34}\,\frac{\text{y}^2}{\text{m}^3}$.

Use this space for summary and/or additional notes.