KEPLER’S LAW

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Think About It…

How would Earth be different if its orbit was more oval than circular?

Earth's Orbit and Kepler's Laws

How do Kepler's laws describe Earth's orbit?

Johannes Kepler (1571-1630)

- Kepler based his three laws of planetary motion on the earlier foundations provided by Copernicus
- Kepler was the assistant to Tycho Brahe
- Brahe afraid that Kepler would surpass him assigned him the daunting task of solving Mars orbit. This Martian data was the key piece needed to solve the motion of all the planets

Kepler's Laws…

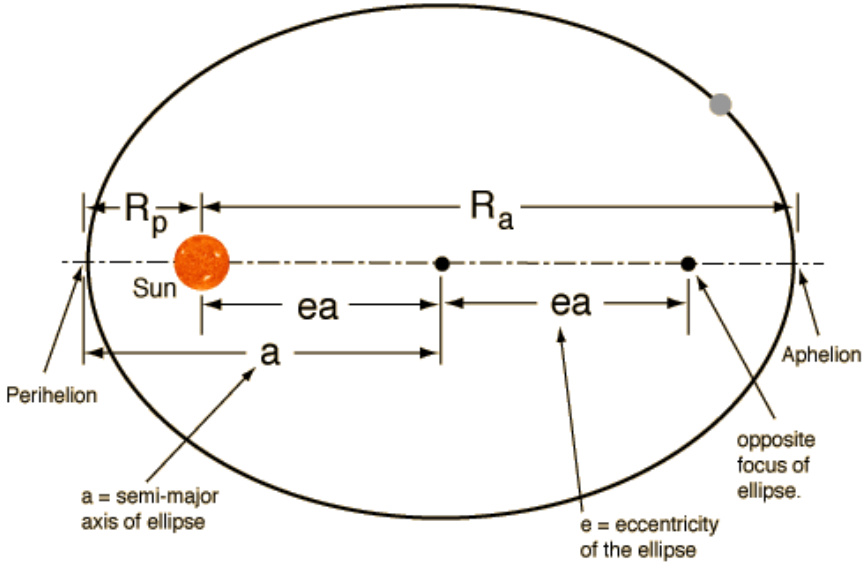
Johannes Kepler, working with data painstakingly collected by Tycho Brahe (from 1576-1601) without the aid of a telescope, developed three laws which described the motion of the planets across the sky.

http://www.nmspacemuseum.org/halloffame/images.php?image_id=131

Unless otherwise noted, the info on the slides on Kepler's laws was taken from the following website: http://hyperphysics.phy-astr.gsu.edu/hbase/kepler.html

II. A-1.Kepler's First Law…

- The Law of Orbits or Law of Ellipses: All planets move in elliptical orbits, with the sun at one focus.
- An **ellipse** is an oval shape that is centered on two points (called foci) instead of a single point.



$R_a = a(1+e)$ $R_p = a(1- e)$

What is an ellipse?

- An ellipse has two foci.

- An ellipse has two axes.
  - The long one is called the major axis
    - Half of it is called a semi-major axis
  - The short one is called the minor axis.

HANDS-ON ACTIVITY!!

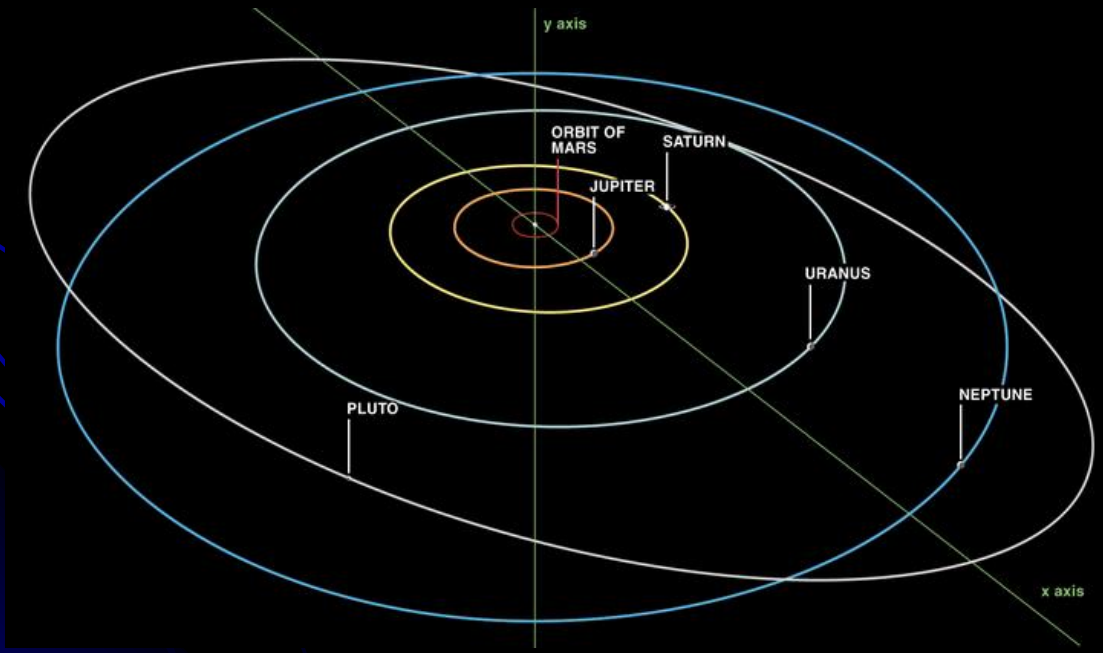
- Planetary Orbits:

Orbital Period

- The orbital period of a planet is the length of time it takes for it to travel a complete orbit around the sun. (a year!)

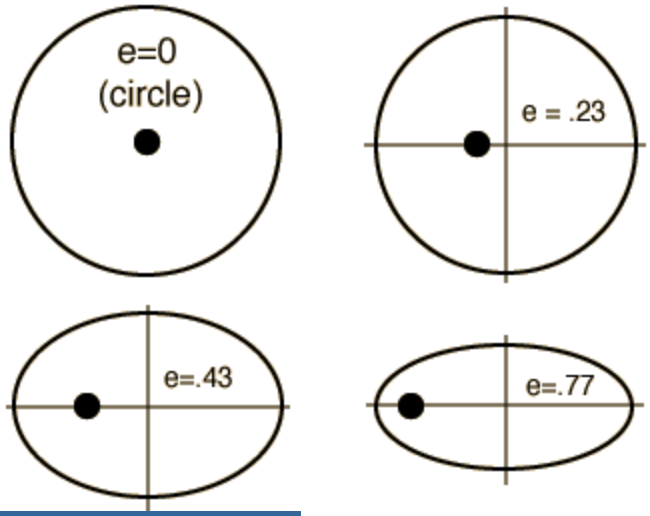
Orbit Eccentricity…

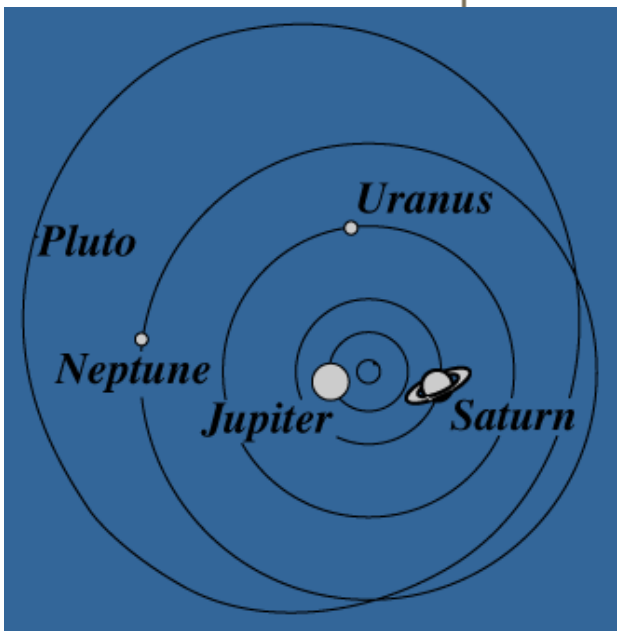
- The eccentricity of an ellipse can be defined as the ratio of the distance between the foci to the major axis of the ellipse. The more eccentric an orbit, the more of an oval it is.
- The eccentricity is zero for a circle.
- Pluto (no longer considered a planet by astronomers) has a large eccentricity.



http://solarsystem.nasa.gov/multimedia/display.cfm?IM_ID=175

Examples of Ellipse Eccentricity



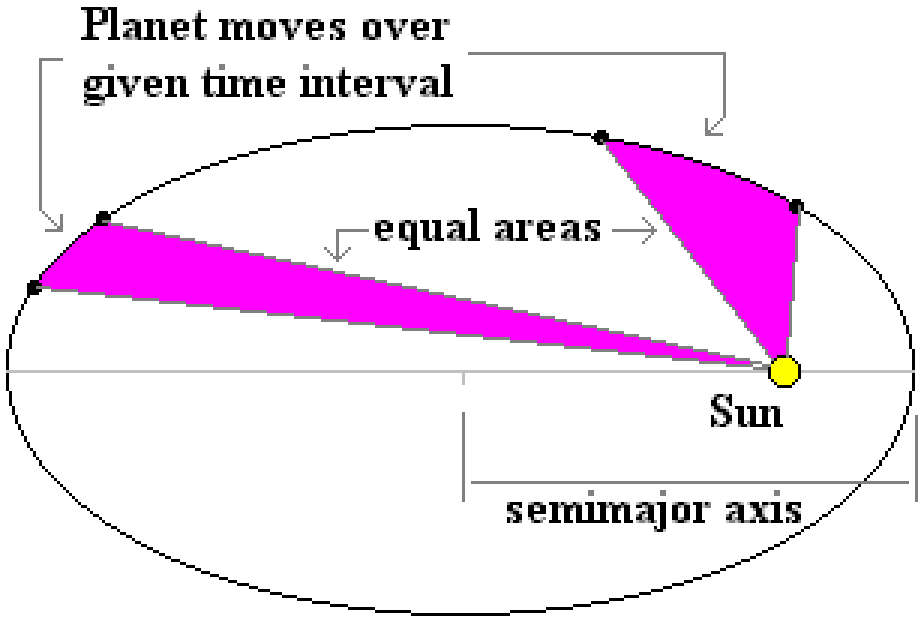


Planetary orbit eccentricities

Mercury	.206
Venus	.0068
Earth	.0167
Mars	.0934
Jupiter	.0485
Saturn	.0556
Uranus	.0472
Neptune	.0086
Pluto	.25

Kepler's Second Law…

- The Law of Areas: A line that connects a planet to the sun sweeps out equal areas in equal times.



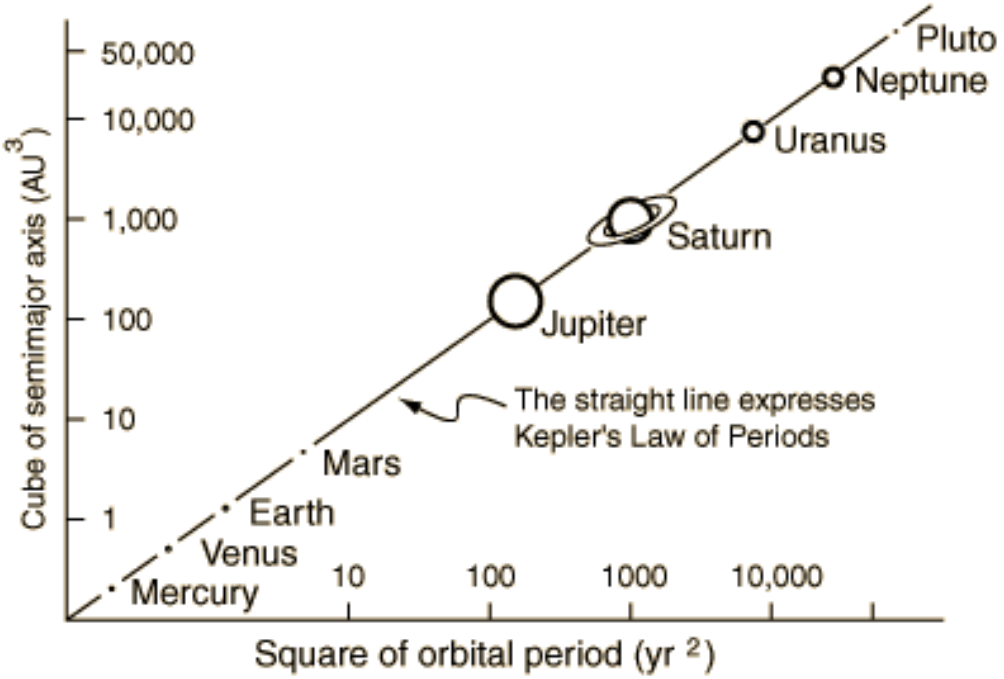
http://www.mathacademy.com/pr/prime/articles/kepler/index.asp

- Planets move fastest when they are at their closest point to the Sun (called *perihelion*) and slowest when they are at their farthest point from the Sun (called *aphelion*).

Kepler's Third Law…

- The Law of Periods: The square of the period of any planet is proportional to the cube of the semimajor axis of its orbit.

- This law arises from the law of gravitation. Newton first formulated the law of gravitation from Kepler's 3rd law.



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- What does this mean? This means that if you know how much time a planet's orbit around the Sun takes, you can easily know it's average distance from the Sun, or vice-versa!

- The closer a planet is to the Sun, the less time it takes for the planet’s orbit.

- Kepler's Third Law is written like this: $P^2=a^3$

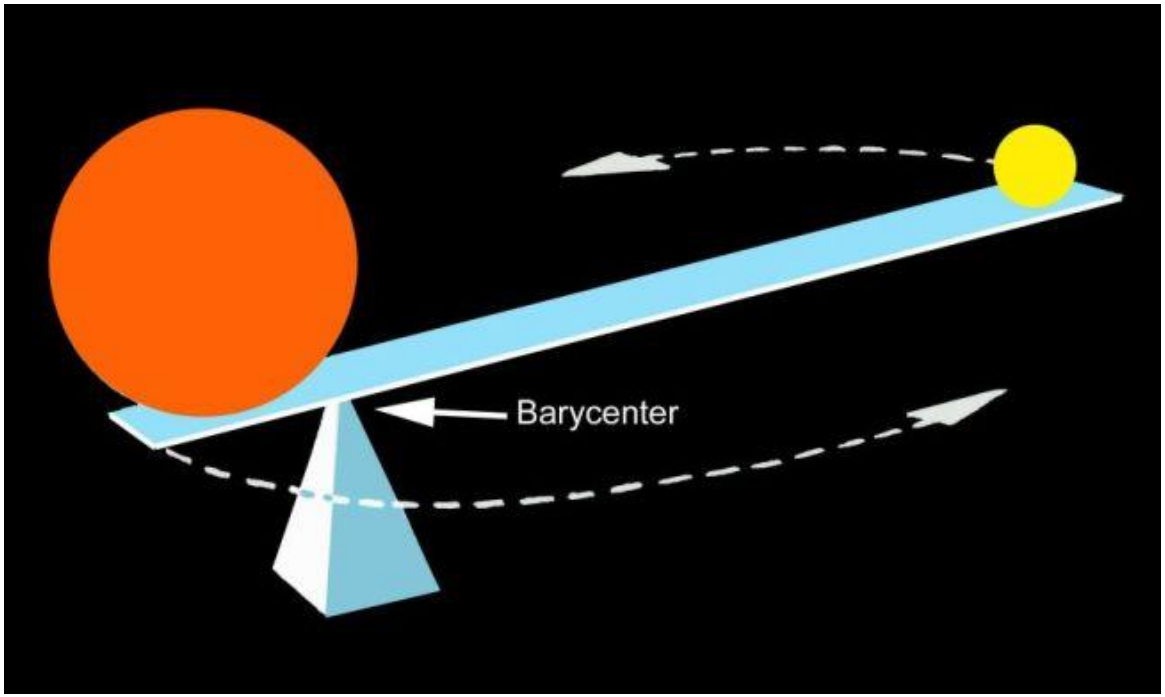
- P=the orbital period in Earth years
- A= the length of the semimajor axis (average distance from the Sun) in Astronomical Units.

Barycenter and Earth's Orbit…

- The law of universal gravitation states…
  - that every pair of bodies in the universe attract each other with a force that is…
    - proportional to the product of their masses and
    - inversely proportional to the square of the distance between them.

Barycenter and Earth's Orbit…

- A planet, such as Earth, actually orbits…
  - a point between it and the Sun called the center of mass
  - This center of mass is called the **barycenter**.



http://www.barewalls.com/pv-605547_Barycenter-Diagram.html

Barycenter

- This is the point between 2 objects where they balance each other.
- It is the center mass where two or more celestial bodies orbit each other.
- The sun although the center of the universe is not stationary, it moves as other planet's gravity "tug" on it. But it never strays too far from the solar system's barycenter.

- ***The Effect of the Moon***
- The moon has a noticeable effect on the earth in the form of tides, but it also affects the motion and orbit of the earth. The moon does not orbit the center of the earth, rather, they both revolve around the center of their masses called the barycenter. This is illustrated in the following animation.