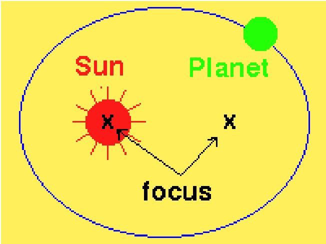
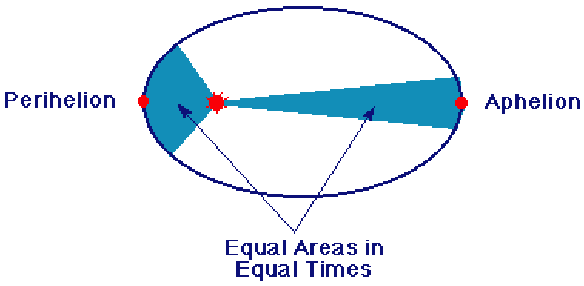
KEPLER'S LAWS

BASICS

- 3 laws to describe the motion of a planet around the Sun.
- It can be applied for all the satellites.
- Empirical laws: the theory was developed later by Newton.
- 1^{st} law: the orbits of the planets are ellipses, with the Sun at one focus of the ellipse



- 2^{nd} law: the line joining the planet to the Sun sweeps out equal areas in equal times as the planet travels around the ellipse



- 3^{rd} law: The ratio of the squares of the revolutionary periods for two planets is equal to the ratio of the cubes of their semimajor axes

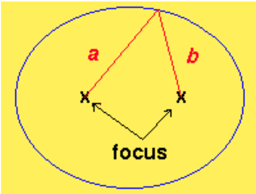
$$\frac{{T_1}^2}{{a_1}^3} = \frac{{T_2}^2}{{a_2}^3} = C^{st}$$

- When the orbit is circular, the semimajor axis becomes the radius.
- The 2^{nd} law shows that the speed of a planet (distance travelled divided by the time needed to travel this distance) is not a constant: it will increase when you get closer to the Sun.
- The constant in the 3^{rd} law depends on the mass of the Sun. If you apply this law to a planet with its satellites, the constant will depends on the mass of the planet.

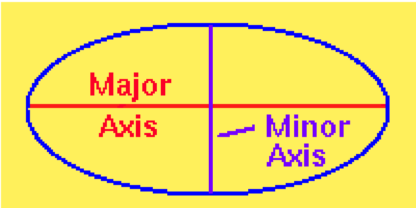
- A classic mistake linked to the 1st law: to think that we are in summer when we are closer to the Sun. It's the opposite because it's mainly linked to the Earth's inclination

ADVANCED

- For an ellipse there are two points called foci (singular: focus) such that the sum of the distances to the foci from any point on the ellipse is a constant. a + b = constant.



  That defines the ellipse in terms of the distances a and b.
- The long axis of the ellipse is called the ***major axis***, while the short axis is called the ***minor axis***. Half of the major axis is the ***semimajor axis***. The length of a semimajor axis is often called the size of the ellipse. It can be shown that <u>the average separation of a planet from the Sun as it goes around its elliptical orbit is equal to the length of the semimajor axis</u>. Thus, by the "radius" of a planet's orbit we usually mean the length of the semimajor axis.



LINKS

- Astronomy:
  - Old civilizations already started to study the Universe
  - Galileo's telescope allowed better observations (Moon's surface, Jupiter's satellites, …)
  - Empirical laws with Kepler
  - General laws with Newton (3 laws and gravity)

  - Other tools now: we analyze the electromagnetic waves that we receive from the Universe (spectrum of absorption to know the chemical elements in a star atmosphere, Doppler effect with the blue shift/red shift to know if a galaxy or a star is getting closer or is getting further, …)
- You can explain the spectra of emission an absorption
- You can explain the Doppler effect with a drawing and say that it helped to prove the Big Bang theory
- Evolution of science: mechanic
  - Aristotle thought that a force is necessary to have a motion
  - Galileo thought that a force is necessary to change a motion and proposed the law of inertia
  - Kepler observed the motions of planets and satellites and proposed 3 empirical laws
  - Newton developed Galileo's ideas and explained the Kepler's laws
  - Einstein and his theory of special relativity (twin paradox)
- Evolution of science: structure of the matter
  - The Greeks with a philosophical approach: there must be an elementary component of the matter that **you can't divide** (literally "atomos")
  - Thomson with the model of the plum pudding: negatively charged particles i.e. electrons embedded or suspended in a sphere of positive charge (electrons presented as plums inside the bowl of pudding)
  - Rutherford's experiment: alpha particles sent through a gold foil showed that a big part of the atoms was void. There should be a positive nucleus at the center and electrons turning around (just like a planet with satellites)
  - New models with electrons represented as a kind of cloud around the nucleus
- Evolution of science: link with the global warming controversy