

Kepler's Laws—8 Sept

- The discovery of the laws of motion, the first science.
 - De Revolutionibus Orbium Coelestium*, Copernicus, 1543
 - Astronomia Nova*, Kepler, 1609
 - Philosophiae Naturalis Principia Mathematica*, Newton, 1687
- How Kepler figured out the path of Mars from Tycho's observations. Discovery of his three laws.



Kepler at 39, Sternwarte Kremsmünster
<http://members.nextra.at/stewar/>

Copernicus	1473–1543
Columbus sails	1492
Tycho Brahe	1546–1601
Shakespeare	1564–1616
Johannes Kepler	1571–1630
Jamestown	1607
King James Bible	1611
Harvard College	1636
Isaac Newton	1642–1727

- Reading assignment has changed: Read the handout.
- Maximum number of point on Hwk 1 is 28.

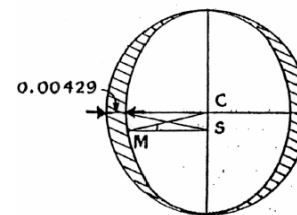
Kepler Solves Mars Orbit

- Kepler's *Astronomia Nova*, 1609, in *Sleepwalkers*, by A. Koestler.
- Kepler describes the orbit: "The conclusion is simply that the planet's path is not a circle—it curves inward on both sides and outward again at opposite ends. Such a curve is called an oval. The orbit is not a circle, but an oval figure." —Ch. 44
- "What happened to me confirms the old proverb: a bitch in a hurry produces blind pups... But simply I could not think of any other means of imposing an oval path on the planets. When these ideas fell upon me, I had already celebrated my new triumph over Mars without being disturbed by the question whether the figures tally or not." —Ch. 45



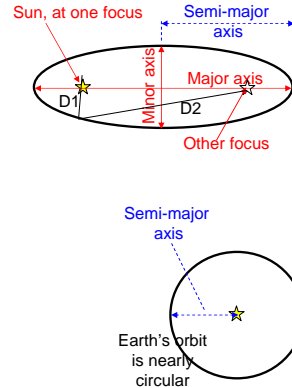
Kepler discovers Kepler's First Law of Planetary Motion

- "... I was wondering why and how a sickle of just that thickness (0.00429) came into being. While this thought was driving me around, while I was considering again and again... that my apparent triumph over Mars has been in vain, I stumbled entirely by chance on the secant of the angle $5^\circ 18'$, which is the measure of the greatest optical elongation. When I realized that this secant equals 1.00429, I felt as if I had been awakened from a sleep..." —Ch. 45 (a year's work later)



Kepler's First Law of Planetary Motion 1605

- The path of a planet is an ellipse.
 - Ellipse is figure for which $D1+D2$ does not change
 - The sun is at one focus.
 - Eccentricity = (dist between foci)/(major axis)
- Modern extension
 - The path of an object controlled by the sun's gravity is an ellipse, parabola, or hyperbola.
 - The sun is at one focus.



Kepler's Second Law 1602

- The line joining the planet and the sun sweeps out equal areas in equal amounts of time
 - Planet moves slowly when it is far from sun
 - Planet moves rapidly when close to sun

[Kepler2ndLaw](#)

Third Law 1618

- The size and periods of the planetary orbits are related by $P^2 = a^3$
 - where P is the period in years and
 - a is the half of the major axis in astronomical units
- 1. A 10th object (planet?) was found beyond the orbit of Pluto. ___ has the shorter period.
 - Pluto
 - 10th object
 - Not enough information to answer

3rd Law
<http://web.cuug.ab.ca/~kmccclary/fastSolar.html>

Questions concerning Kepler's Laws

- A planet's path is an ellipse with the sun at one focus.
- A planet "sweeps" out the same area in an equal amount of time.
- The planets' periods P and semi-major axes a are related by $P^2 = a^3$
- A planet, which has an almost circular orbit, and a comet, which has a highly elliptical orbit, have the same periods. Draw their orbits on a single picture.
 - Grading: sun's position
 - Grading: lengths of major axes.
 - Grading: lengths of minor axes.

Questions concerning Kepler's Laws

- A planet's path is an ellipse with the sun at one focus.
 - A planet "sweeps" out the same area in an equal amount of time.
 - The planets' periods P and semi-major axes a are related by $P^2 = a^3$
- A planet, which has an almost circular orbit, and a comet, which has a highly elliptical orbit, have the same periods. Draw their orbits on a single picture.
 1. Grading: sun's position
 - A. Centered for comet
 - B. Offset for comet
 2. Grading: lengths of major axes.
 - A. Same for both
 - B. Different
 3. Grading: lengths of minor axes.
 - A. Same for both
 - B. Different