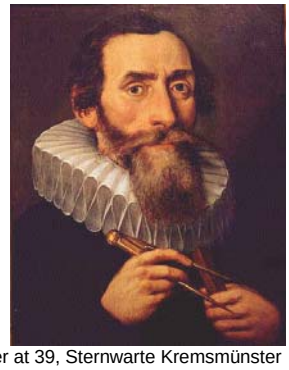
Kepler's Laws—17 Sep

- Public observing
  - MSU Observatory. Go south on Farm Lane to the end, then turn right.
  - Fri & Sat 9:00-11:00
- Read pages in Galileo's *Starry Messenger* for Mon
  - See link on syllabus
  - How Galileo discovered moons of Jupiter
- 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
- Kepler's three laws.



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

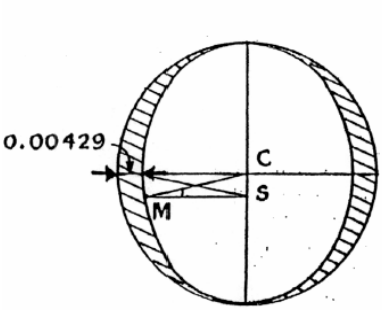
Copernicus	1473–1543
Columbus sails	1492
Tycho Brahe	1546–1601
Shakespeare	1564–1616
Johannes Kepler	1571–1630
Jamestown	1607
King James Bible	1611
Harvard College	1636
Isaac Newton	1642–1727

Kepler Solves Mars Orbit

- Kepler's *Astronomia Nova*, 1609, translated 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

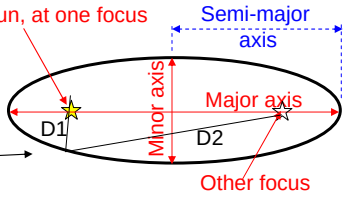
Kepler discovers Kepler's First Law of Planetary Motion

- "… 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° 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)

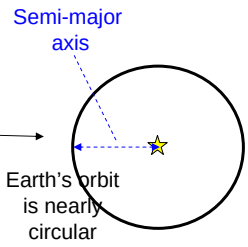


Kepler's First Law of Planetary Motion 1605

- 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)

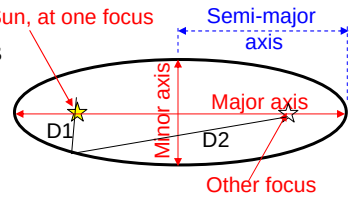


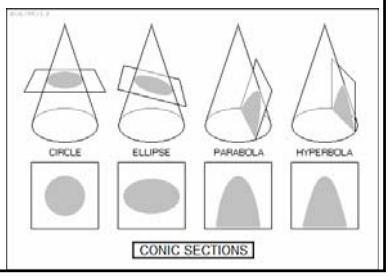
1. For this ellipse, the eccentricity is approximately
   A. 0
   B. 0.1
   C. 0.3
   D. 0.7
   E. 0.9
2. Same question for



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.
  - All are related shapes.
    - Sections of a cone.
  - The sun is at one focus.





www.vectorsite.net/tpecp_05.html

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.
   A. Pluto
   B. 10th object
   C. Not enough information to answer

3rd Law
http://web.cuug.ab.ca/~kmcclary/fastsolar.html

Questions concerning Kepler's Laws

- K1: A planet's path is an ellipse with the sun at one focus.
- K2: A planet "sweeps" out the same area in an equal amount of time.
- K3: 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
2. Grading: lengths of major 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

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

  $P^2=a^3$

Mar 20, 2004 06:49	186.4 days	
Sept 22, 2004 16:30		179.1days
Mar 20, 2005 12:33		

- Summer is long and winter is short: more precisely, the length of time from the spring equinox to the fall equinox is longer than that from the fall equinox to the spring equinox. Recall that the sun is north of the equator in summer, and its is on the equator on the equinoxes.
- Q: Draw the Earth's orbit so as to account for this.