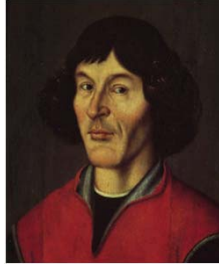


The Copernican Revolution The Beginning of Science—16 Sept



Nicholas Copernicus
(1473-1543)



Tycho Brahe
(1546–1601)



Johannes Kepler
(1571–1630)

Columbus 1492 Jamestown 1607

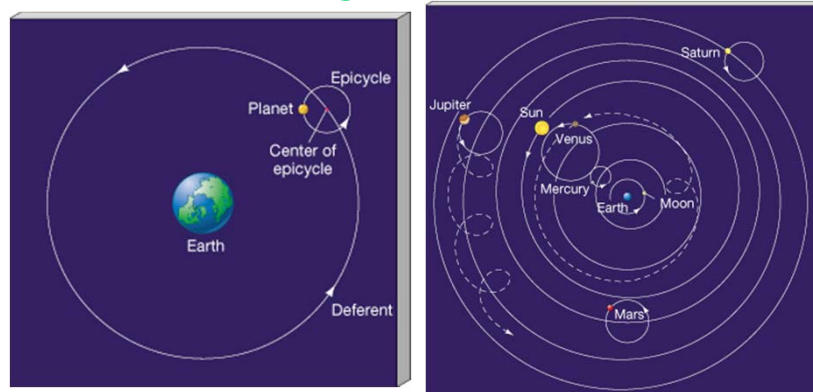
Announcements

- Homework 1
 - If you have a grading dispute, state your case on the front of the paper and turn it in.
 - Grades are on angel.
 - Answers will be on angel before the end of the day.
- Homework 3
 - Due Fri, 23rd
 - No papers after 1:00pm, Mon, 26th, when answers will be posted on angel.
- Test 1, Wed, 28th
 - Low stakes. To calibrate your efforts.
 - Test 1 counts for 5% of grade; Tests 2 & 3 each count for 14%.
 - Practice Test (test from 2010) is on angel.
 - Link is on Syllabus on angel
 - Missouri Club
 - Tues, 27th, 7:40-8:40, BPS1420
 - Common cheat sheet
 - Send me formulas for cheat sheet by 10pm on 27th.

Cosmology of Greek Astronomers

- Aristotle: The natural motion of “base” objects is to come to rest. The natural motion of “heavenly” objects is to move in a circle at constant speed.
- The earth and things on the earth are base objects. They do not move.
- The sun and moon are heavenly objects. Therefore they move in a circle at constant speed.

Ptolemy's Model in *Syntaxis* (*Almagest*), 140AD



- Earth is at the center. Earth is immobile.
- Planets move on an epicycle. Epicycle moves on a deferent. Double motion allows retrograde motion.
- The deferents of Venus & Mercury are on the line between the sun and Earth.

Copernicus

- Aristotle & Ptolemy
 - The natural motion of “base” objects is to come to rest. The natural motion of “heavenly” objects is to move in a circle at constant speed.
- Copernicus
 - De Revolutionibus Orbium Coelestium, (*On the Revolutions of the Celestial Spheres*) 1543
 - The Earth is not at the center. The Earth is not immobile.
 - The sun is at the center. The planets orbit the sun.



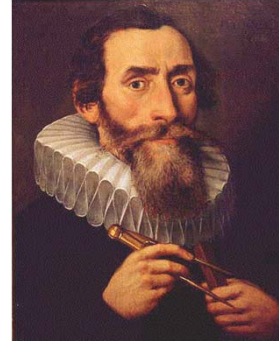
Nicholas Copernicus
(1473-1543)

Copernicus: A simple explanation is better than a more complicated one.

- Ptolemy: Earth is stationary and therefore special.
- Ptolemy: A planet moves in two ways. It moves on an epicycle, and the epicycle moves on a deferent.
- Ptolemy: For Venus and Mercury, the deferents are stuck on the line between the earth & sun.
- In what way is Copernicus' model simpler on each point?

Kepler attacks Mars

- 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



What is fake on Tycho?

Tycho Brahe's Observations

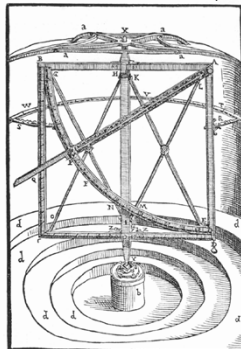
- On Uraniborg, Tycho measured positions of the planets for 20 years
- Highly accurate & reliable
 - Accuracy limited by human eye, not by instruments. Superseded only with telescopes.
 - Tycho measured & compensated for instrument flexure, the biggest error.



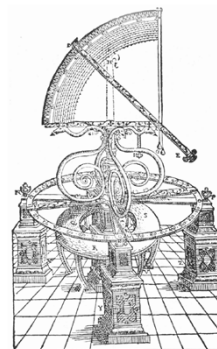
Uraniborg.



Great quadrant (1582)

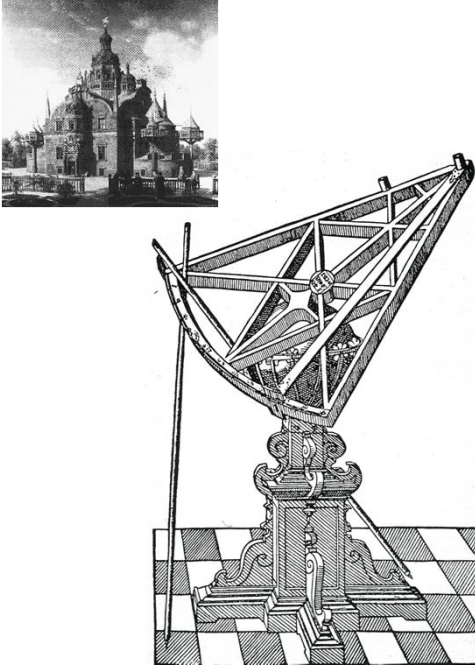



Revolving steel quadrant, 2 m radius (1588)



Brass azimuthal quadrant, 65 cm radius (ca 1576)

Sextants at Uraniborg

Great quadrant (1582)

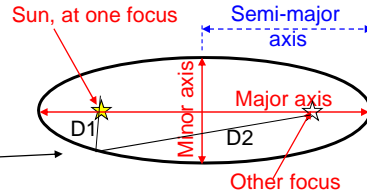
Kepler & Tycho

Their meeting at Benatek (in Chechoslovakia): ...on 4 February 1600, Tycho de Brahe and Johannes Keplerus, co-founders of a new universe, met face to face, silver nose to scabby cheek. Tycho was fifty-three, Kepler, twenty-nine. Tycho was an aristocrat, Kepler a plebian. —Koestler, *The Sleepwalkers*, p302

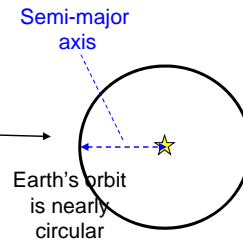


Kepler's First Law of Planetary Motion 1605

- 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

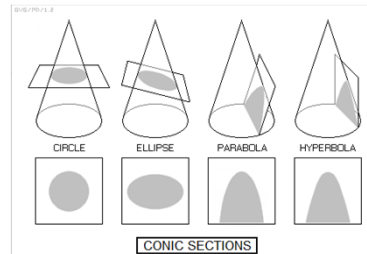
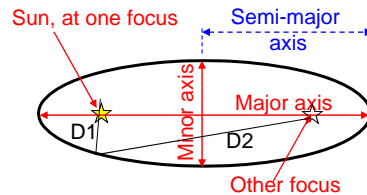


2. Same question for



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

3rd Law information to
<http://web.cuug.ab.ca/~kmcclary/fastSolar.html>
 answer