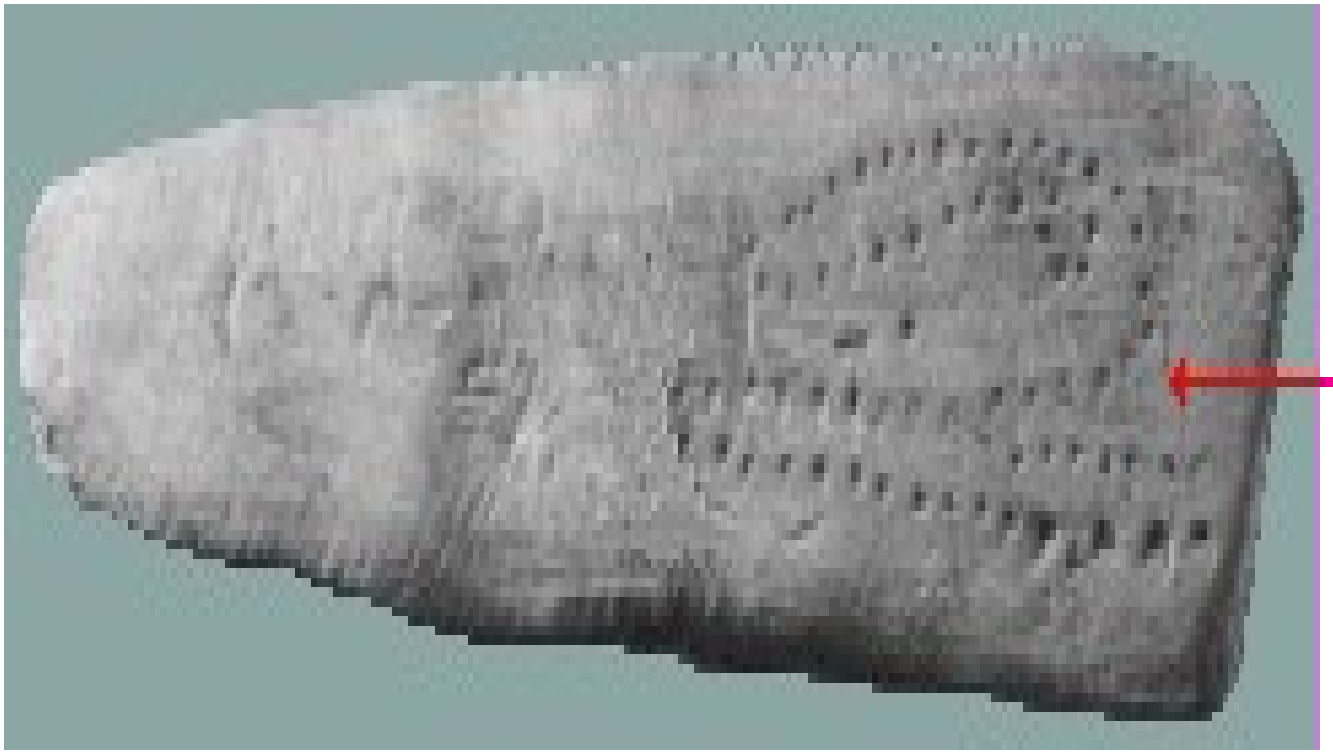

Welcome!
GSC 1580: Astronomy
Instructor: JoDee Baker
Credit: NASA

The Development of Astronomy:

From Ancient to Modern Concepts

30,000 B.C.: Roughly the time humans began to use the night sky as a tool to keep track of time.



possible sequence of moon phase changes over 2 months

Ancient Concepts of the Earth

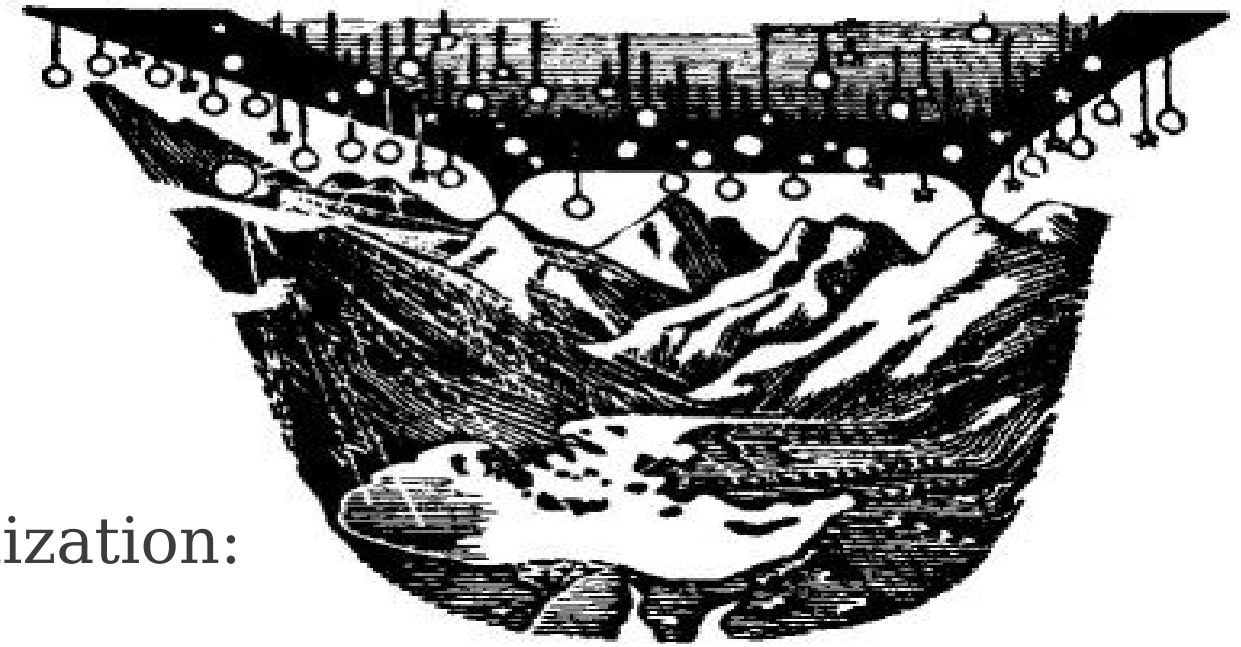
Most Ancient civilization believed the following about Earth:

1) The shape of the Earth was FLAT!

2) Geocentric System: Earth Centered System

The definition of “Universe” changed with civilization.

Ancient Concepts of the Earth



Credit: Simanek (2006)

Egyptian Ancient Civilization:

Universe:

Nile Valley and Mediterranean Sea

- Egypt was at the center of this Universe

- Earth was square with mountains on edges to support the sky

Ancient Concepts of the Earth

Japanese Ancient Civilization:

According to *The Chronicles of Japan*:

-Flat Earth with dry land floating as if on oil on water

Chinese Ancient Civilization:

- Flat Earth that was square.

- Heavens were round.

Ancient Concepts of the Earth

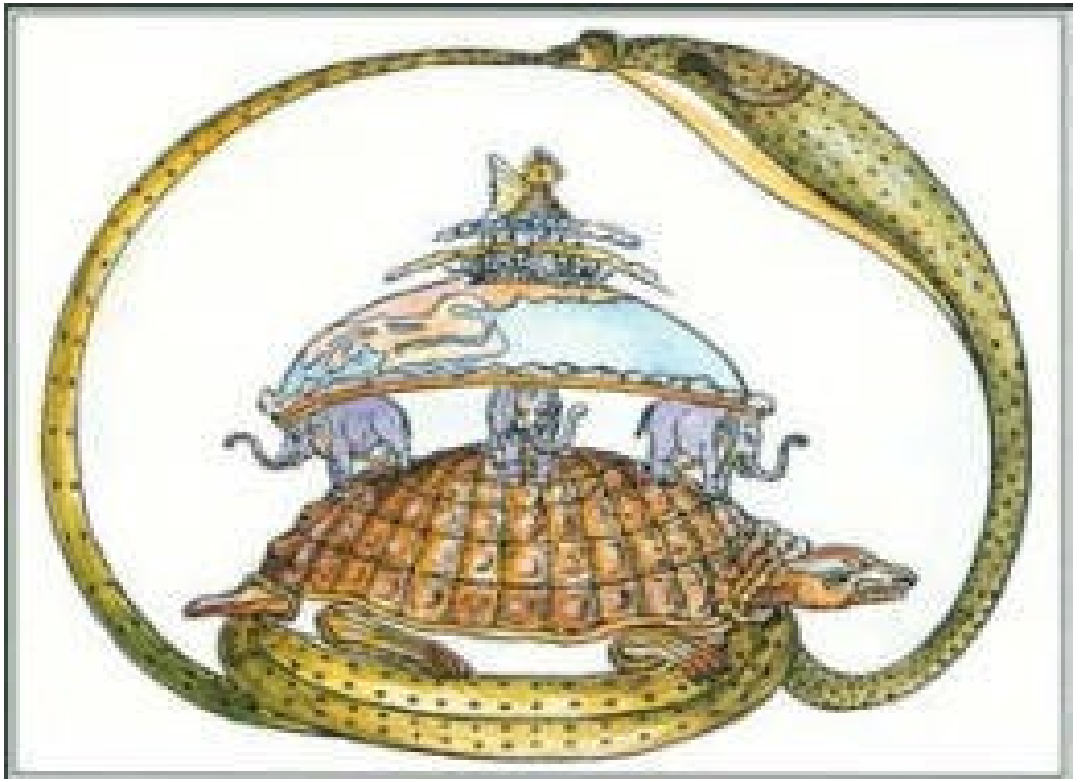
Hindu Civilization:

- Curved Earth sitting on the backs of four elephants.

- Elephants on turtles

- Turtle on cobra

- India is the center of the Universe.



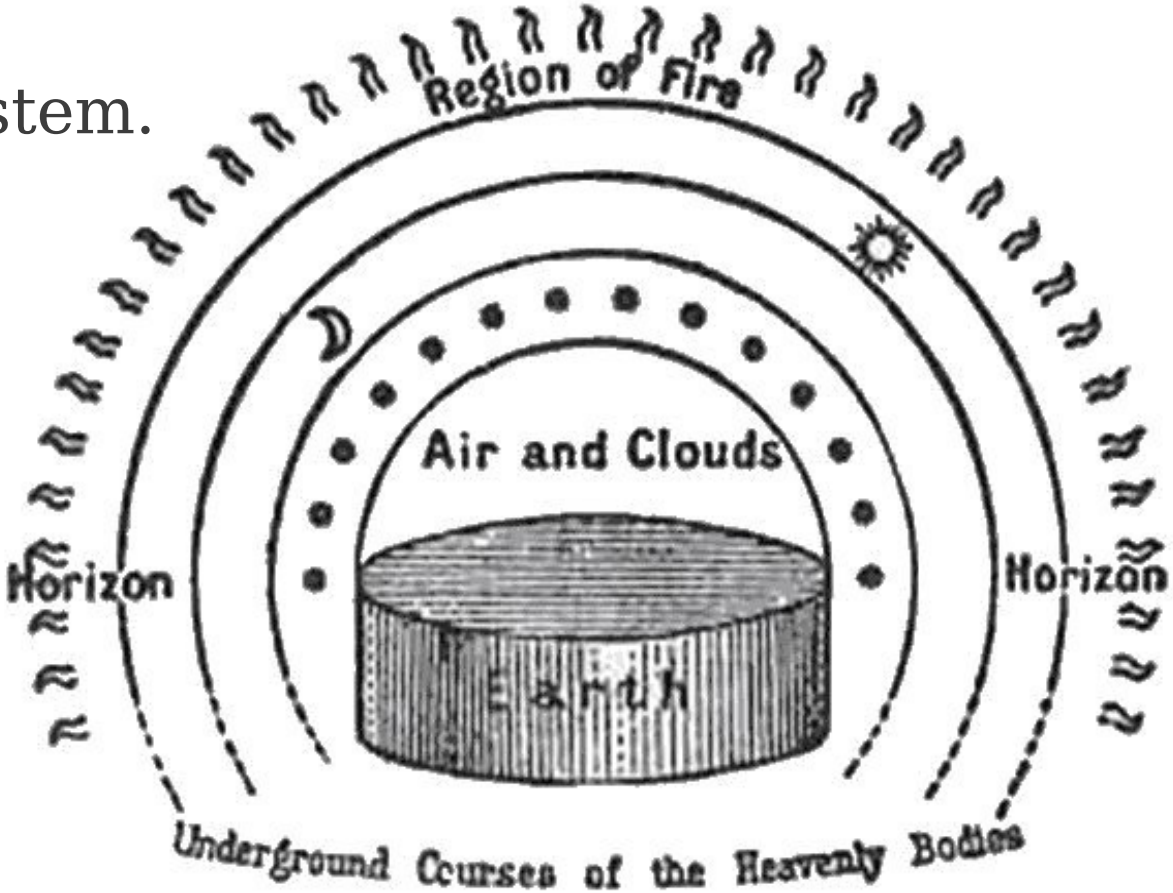
Ancient Concepts of the Earth

Greek Ancient Civilization:

Anaximander:

- First to suggest a cylindrical slab shape for Earth.

- Still geocentric system.



Ancient Concepts of the Earth

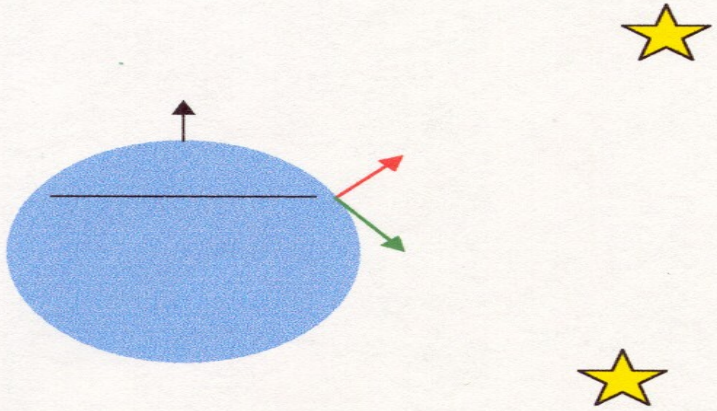
What evidence is there that the Earth is spherical?

Evidence for a spherical Earth.

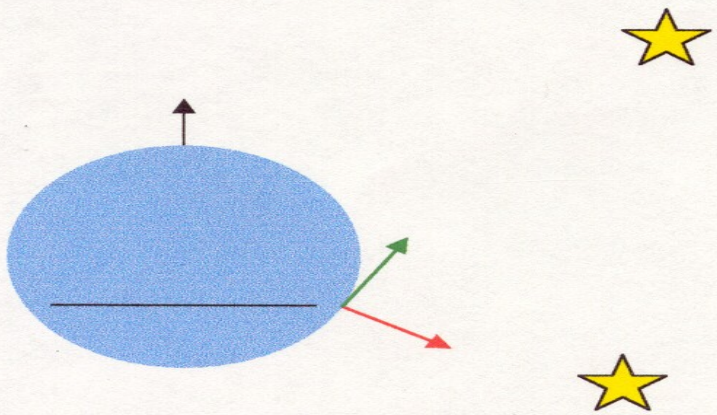
The Altitude of Stars as Seen from Different Latitudes

From a location moderately far north, such as the latitude of Kingston, one may see one star overhead and a seond low on the southern horizon (figure (a)). If one travels some hundreds of miles south, the altitudes change (figure (b)).

(a)



(b)

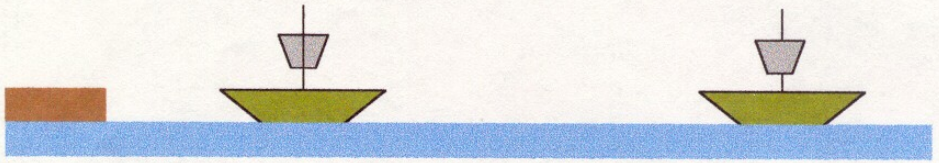


Evidence for a spherical Earth.

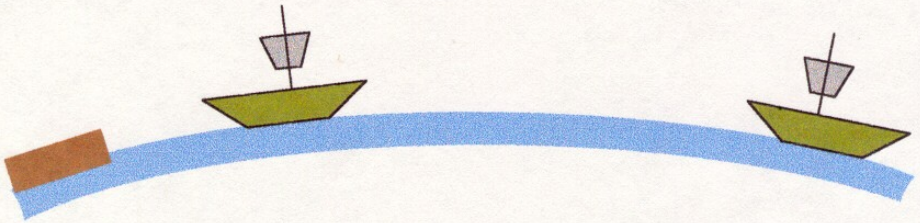
The Behaviour of Ships Leaving Shore

The observer on the wharf sees the ship dwindle in size in each case, but the curvature of the Earth means that we can see the masts but not the hull of the distant ship.

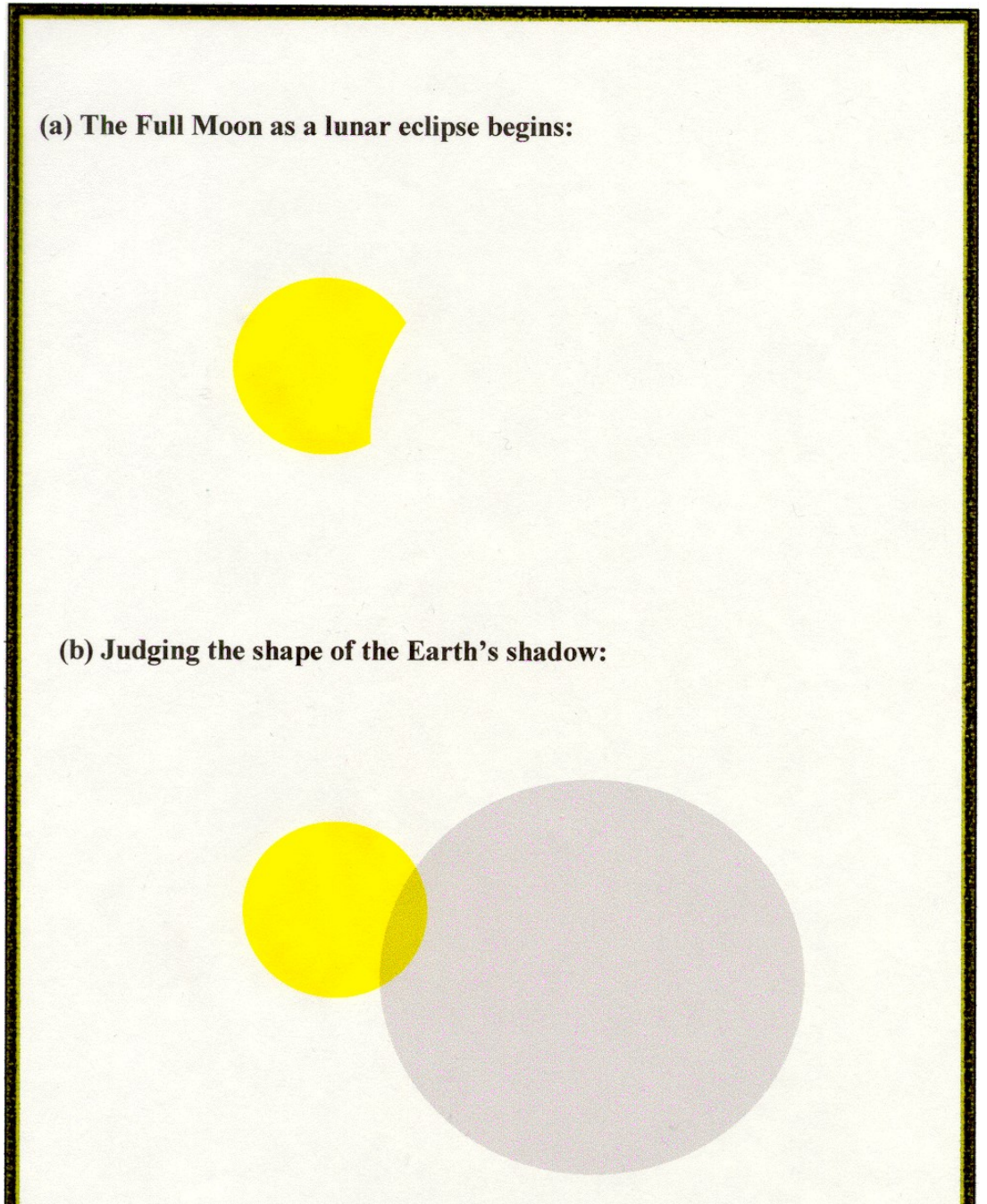
(a) If the Earth were flat:



(b) …but the Earth is round, so:



Evidence for a spherical Earth.



Evidence for a spherical Earth.

Pictures of the Earth itself!

Evidence for a spherical Earth.

Pictures of the Earth itself!

Evidence for a spherical Earth.

Eratosthenes

- Determined size of Earth by using difference in altitude of the noontime sun at two different locations.

- Eratosthenes:

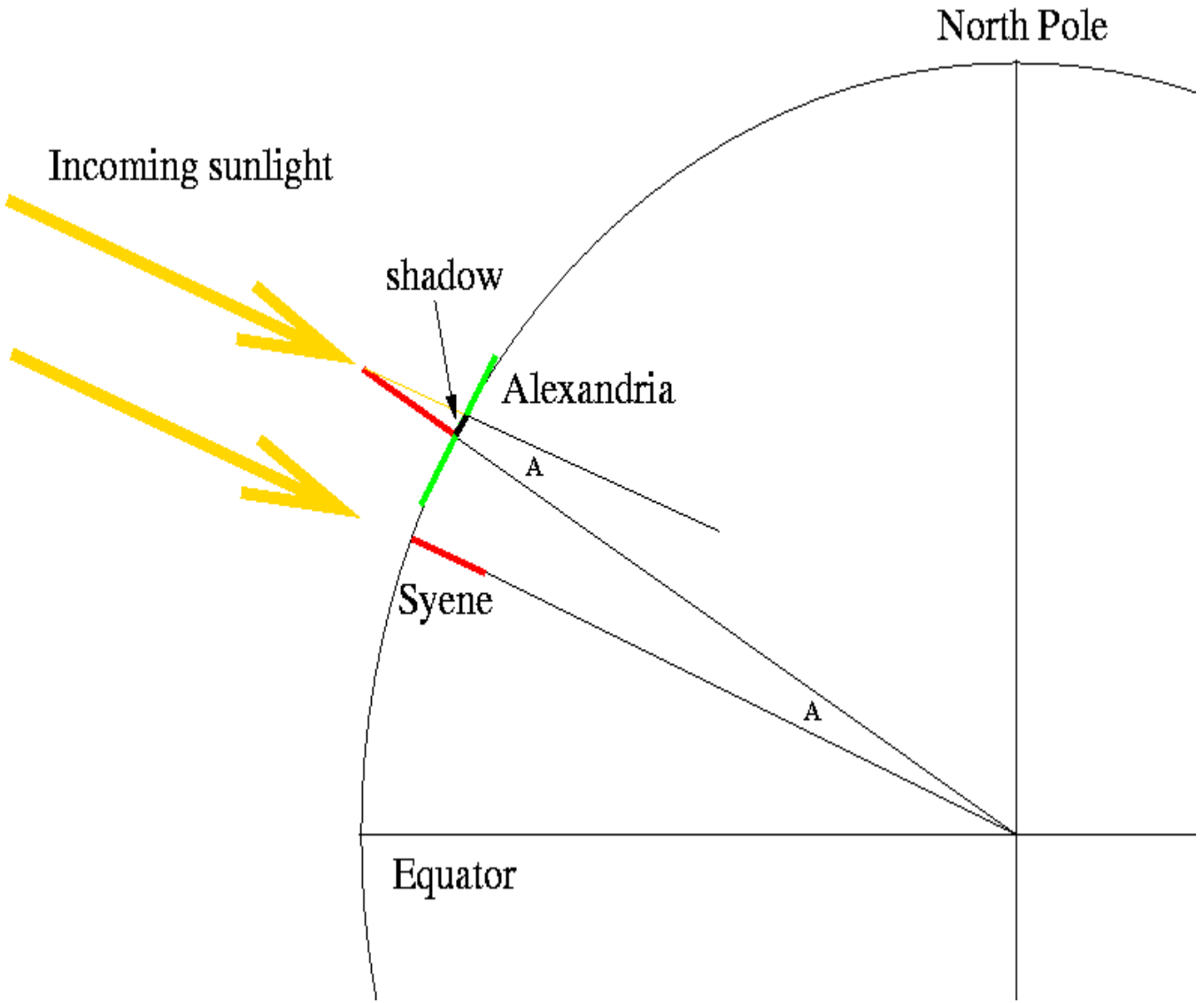
Circumference = 40,000 km

Diameter = 12,800 km

- Actual at Equator :

Circumference = 40,075.16 km

Diameter = 12,756.32 km


North Pole
Incoming sunlight
shadow
Alexandria
A
Syene
A
Equator

Resolving the Earth's Place in the Universe

Early Models

4,000 B.C. : Mesopotamian astronomers use ziggurats as observatories for time/seasons.

Amongst the first to take notice of “wandering stars”.

Structures where also used as temples.

Wandering Stars

Ancient Greek Civilization:

Planetos: wanderers

- This is where the term planet is derived from.

Wanderers included:

Sun
Moon
Mercury
Venus
Mars
Jupiter
Saturn

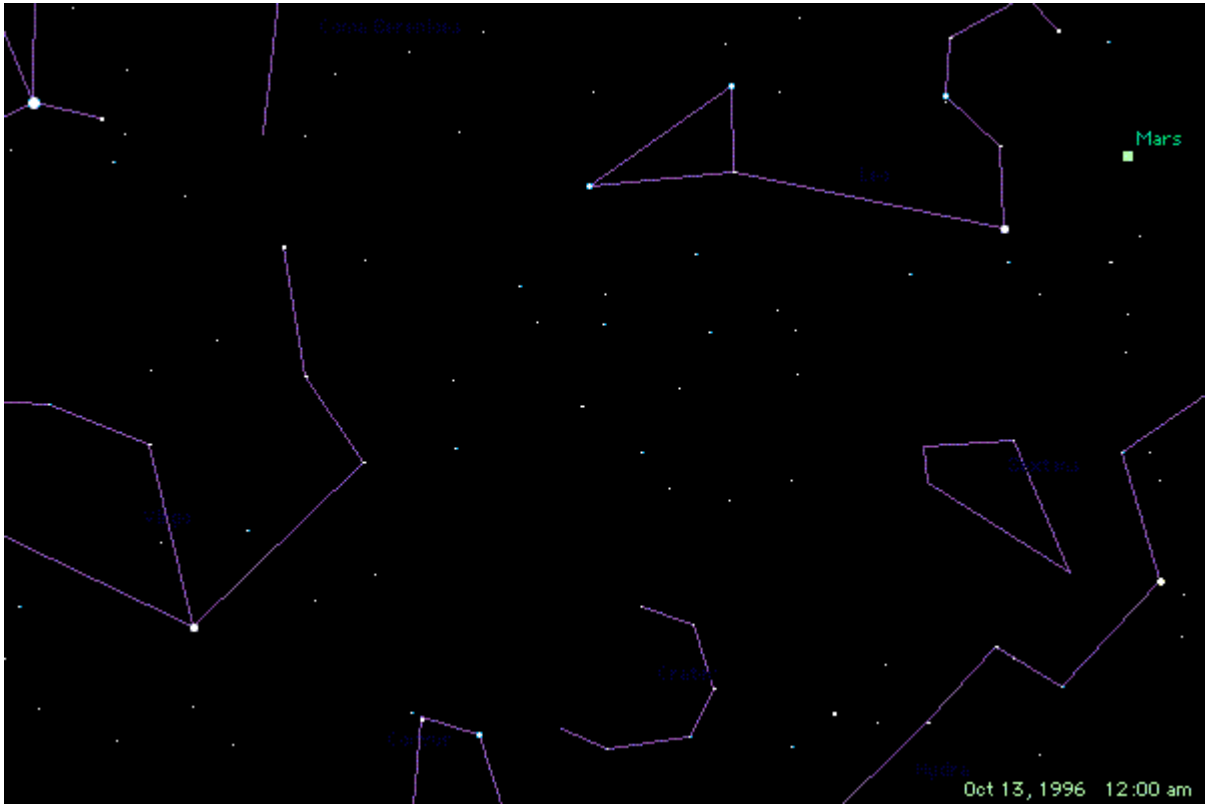
Wandering Stars

The wanderers gave us the names of our days of the week:

Day of the Week	Wanderer
Sunday	Sun
Monday	Moon
Tuesday	Mars
Wednesday	Mercury
Thursday	Jupiter
Friday	Venus
Saturday	Saturn

Let's pause to look at how the Planets move on the plane of the ecliptic against the night sky.

Retrograde motion: Apparent backward motion of an object path in the night sky over a period of time.



Pythagoras

- 569 B.C. - 475 B.C.
- Thought of as first pure mathematician

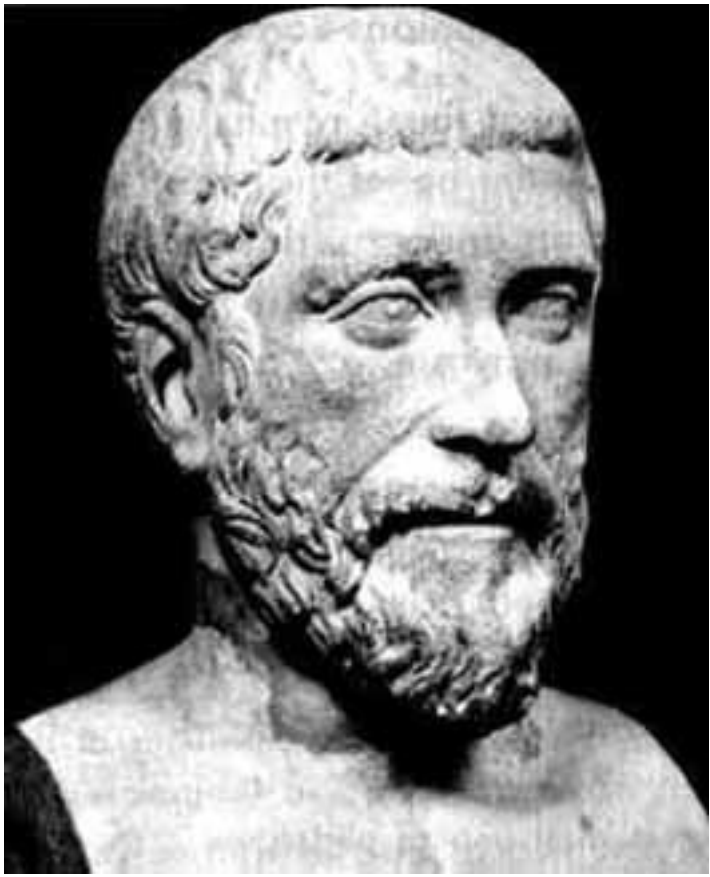
- Followers called Pythagoreans

- Contribution to Astronomy:

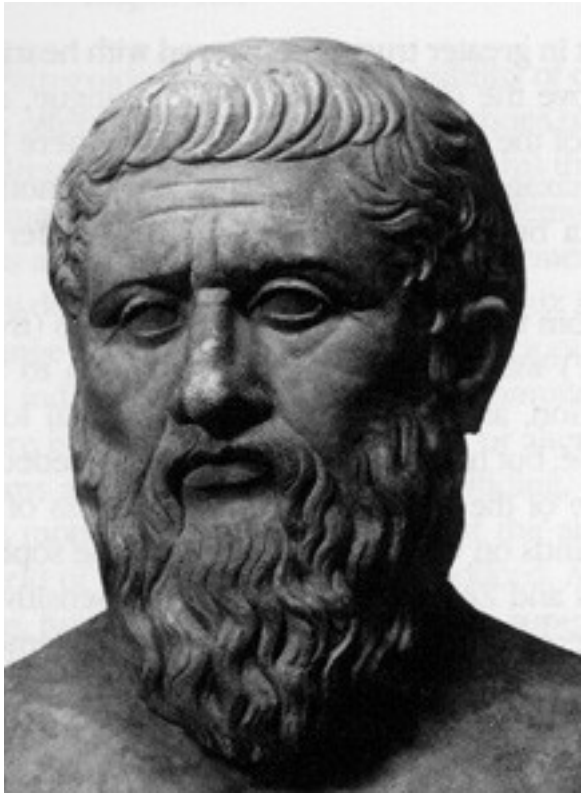
    - Crystalline Sphere theory:

        Round Earth surrounded by 5 crystal spheres.

    -“Music of the Spheres”



Plato: 472 B.C. - 327 B.C.



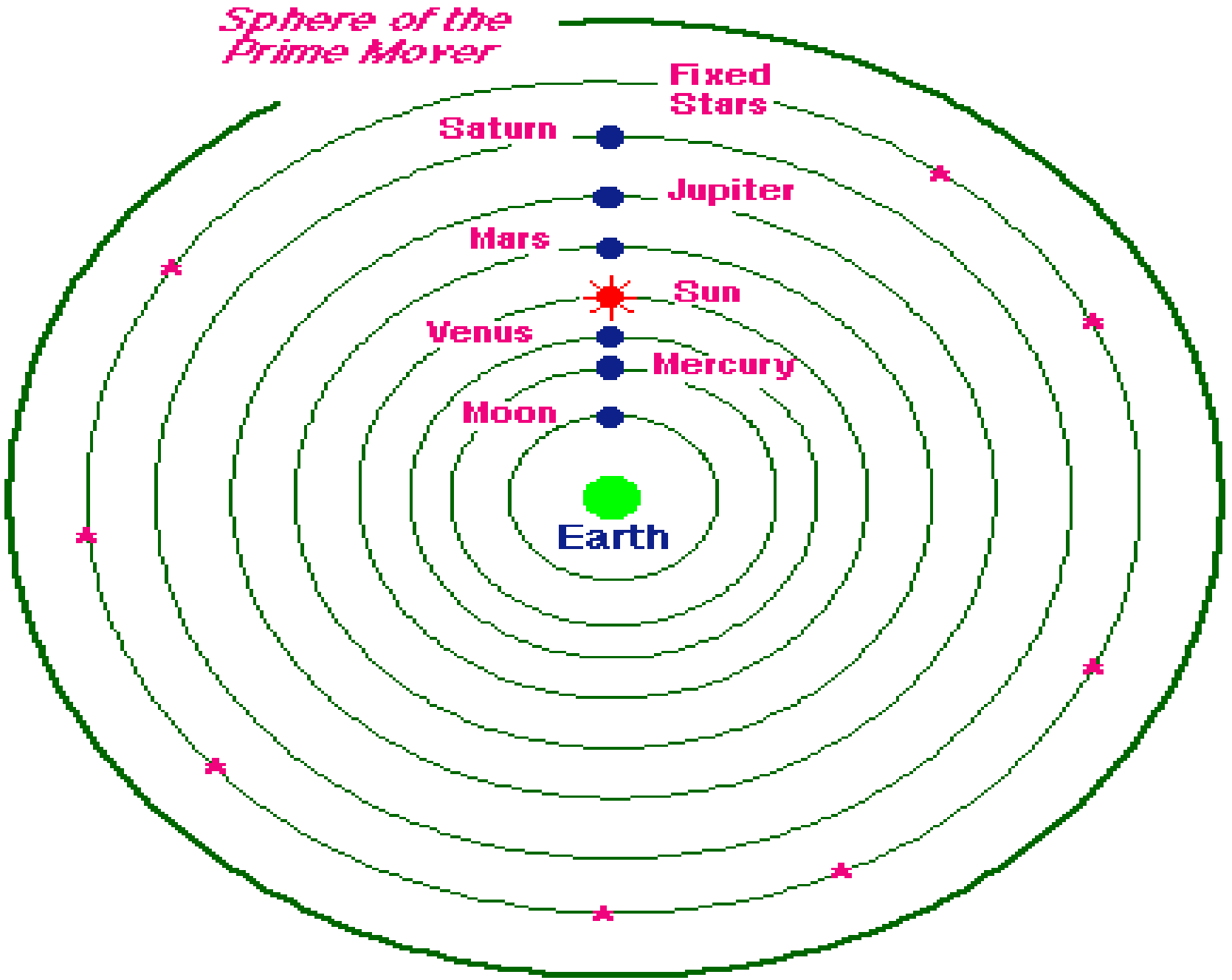
- Platonic Solids
  Mathematical construction of the elements (Earth, Wind, Water, and Fire.)

- Dodecahedron model of Universe

Aristotle

- 324 B.C. - 322 B.C.

- Believed Earth was fixed
- Updated Crystalline Sphere to contain 55 concentric circles



Aristotle's Universe

Aristarchus

- 310 B.C. - 230 B.C.

Attempted to:

Measured size of moon using Earth's shadow.

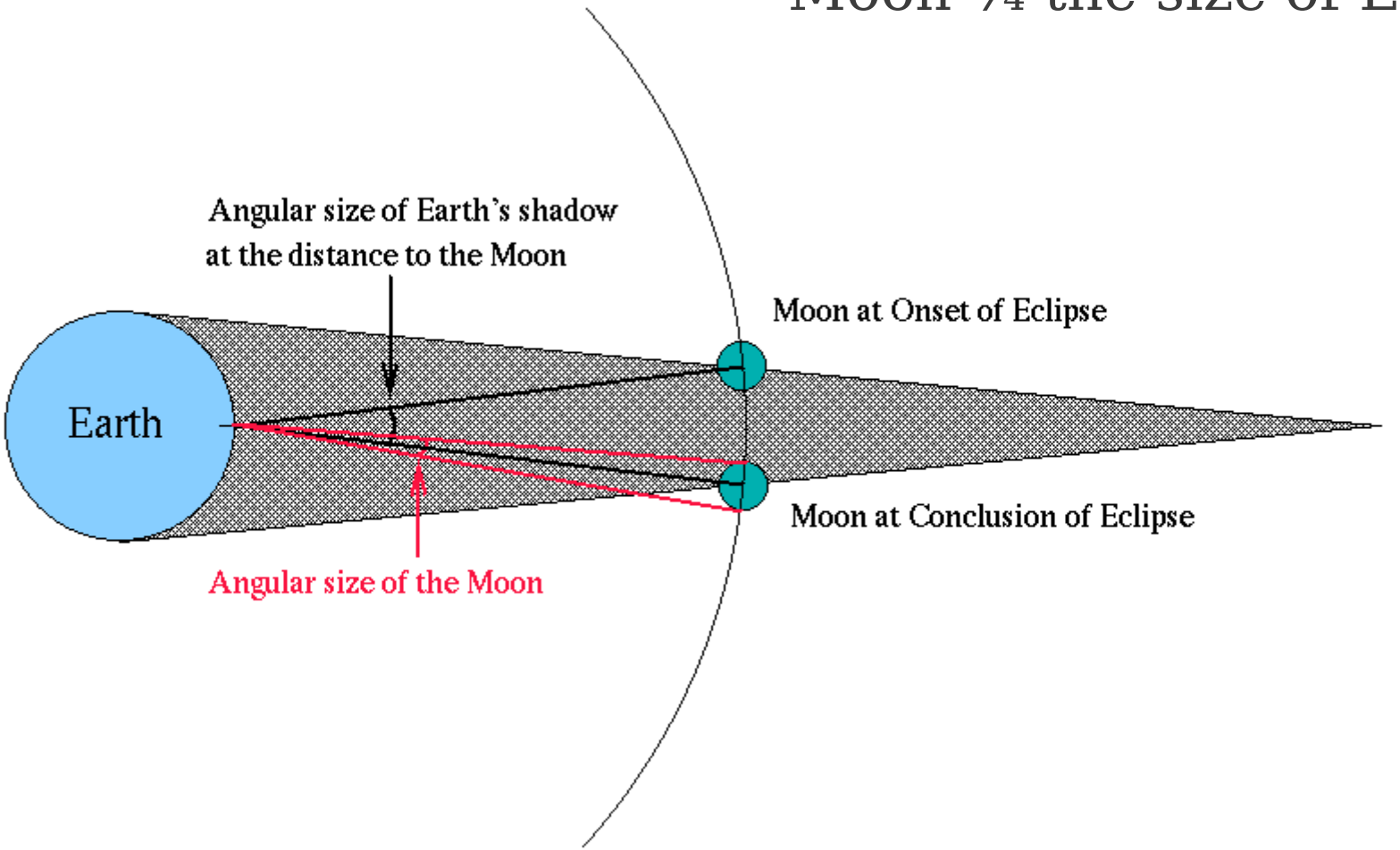
Measure the distance to the Sun.

Aristarchus Calculates:

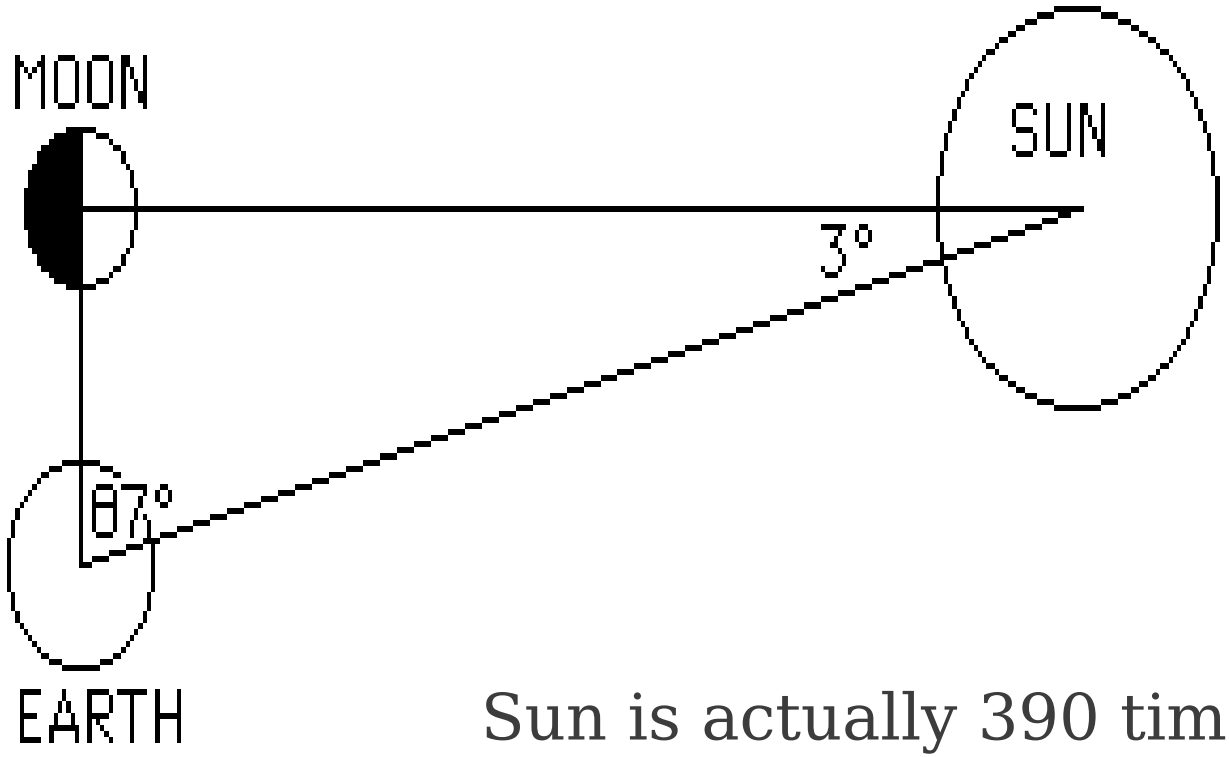
Moon ½ size of Earth

Actual:

Moon ¼ the size of Earth



Aristarchus estimated distance of the Sun by taking the the angle that the half-lit moon makes with the sun. He claimed the sun was 19 times further away than the moon.



Sun is actually 390 times further away than the moon.

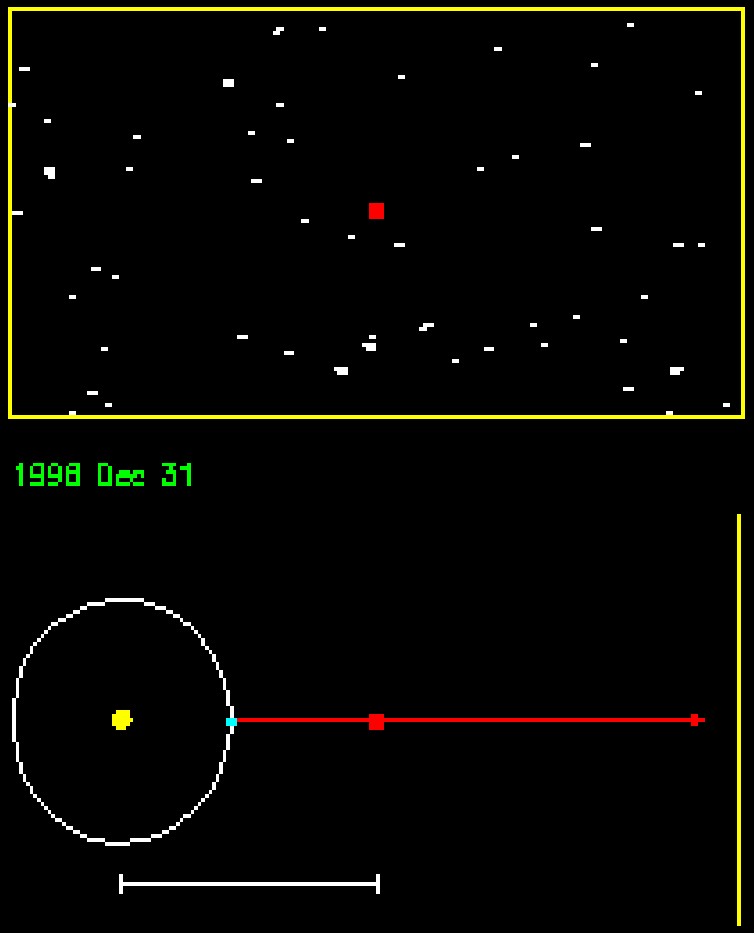
Aristarchus

- First to propose the Heliocentric Model:
  Sun Centered Solar System/Universe

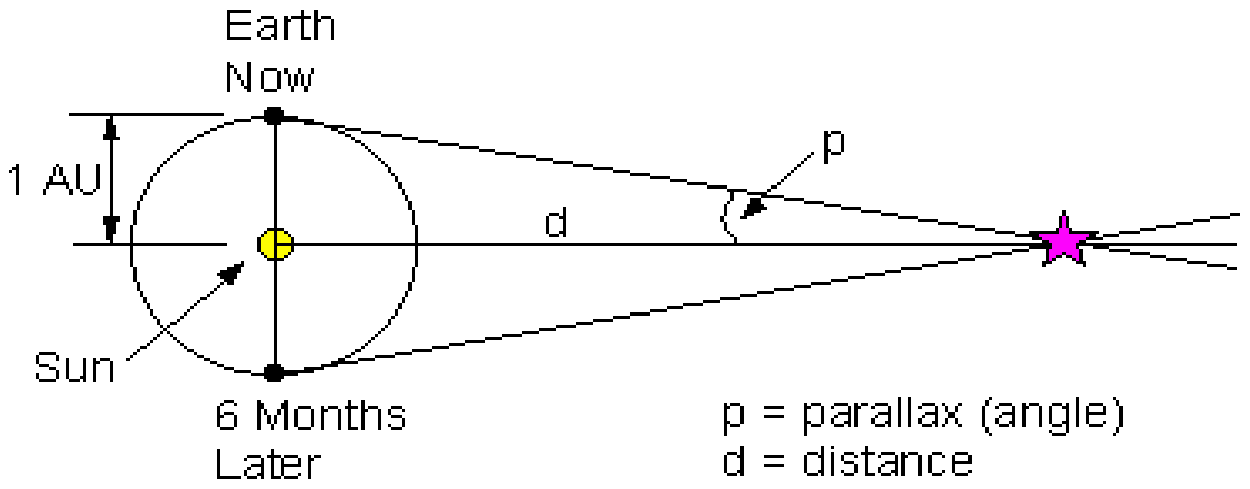
- Parallax:

  The apparent shift of an object against a background due to a change in observer position.

Parallax



Measuring Distance by Parallax



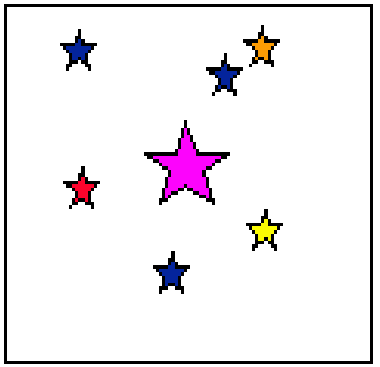


Photo taken now

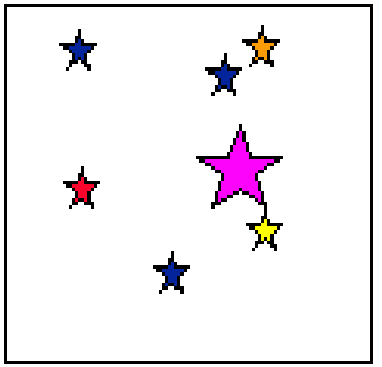


Photo taken 6 months later

Ptolemy

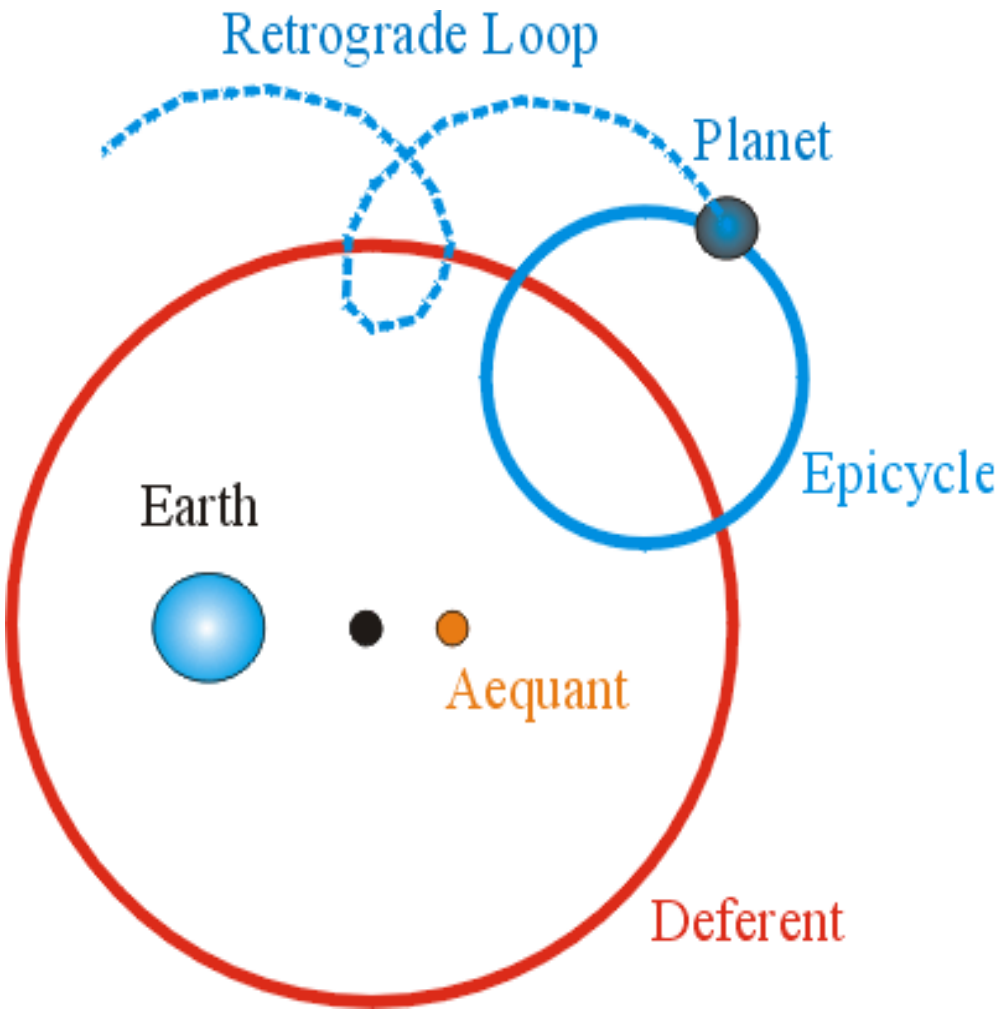
- 85 B.C. - 165 A.D.

- Wrote 13 book series “Almagest” means Greatest Compilation.

- Geocentric System

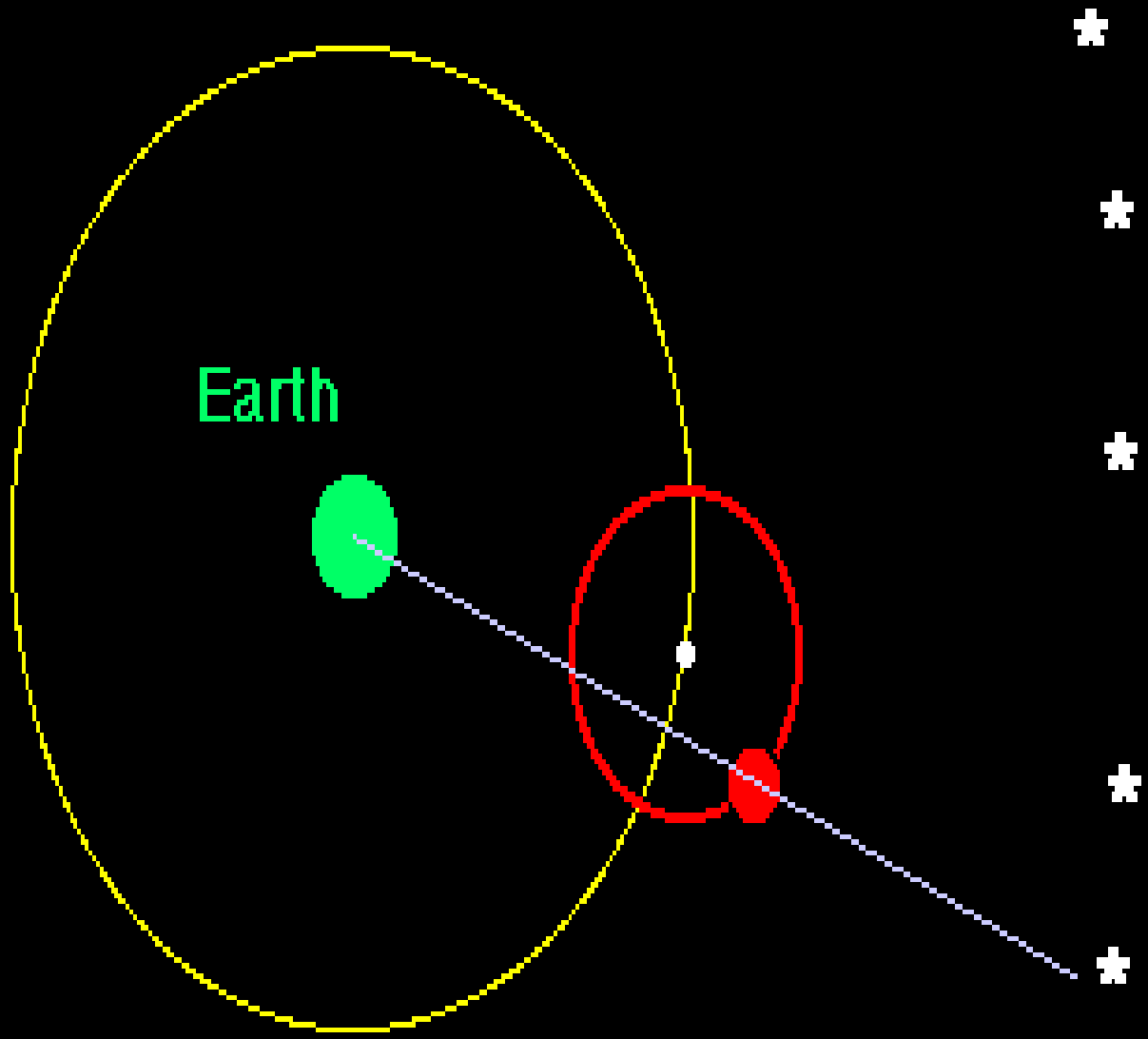
- Greatest Contribution: Epicycles to explain retrograde motion.

Epicycle



Deferent- Large circle that sun moved on as well as each epicycle of each planet.

Epicycle- Circle planet moves on. By adjusting the size of the circle retrograde motion can be determined


Earth

Hypatia of Alexandria

- 350 A.D. - 415 A.D.

- First notable woman Mathematician.

- First notable woman Astronomer.

- Editor of a book on the commentary of Ptolemy's Almagest.

- Movie “Agora” is not necessarily historically accurate.

Copernicus

- 1473 - 1543
- Astronomer
- studied medicine
- Wrote one of the most influential books of scientific time:

“On the Revolution of the Celestial Orbs”

Copernicus

"On the Revolution of the Celestial Orbs"

Three Important Proposals:

1) Stars are stationary.

2) Heliocentric System

3) Heavenly bodies move in perfect circles at constant speeds.

- Retrograde motion is explained

Explanation of Retrograde Motion. Copernican Model

Retrograde Motion in the Copernican System

Tycho Brahe

- 1546 - 1601
- Wore a fake nose made of gold and silver.
- Made most precise observations by devising instruments before telescopes.

- Refuted Copernican Model.

- Supporter of the Geocentric Model.

Tycho Brahe

- His observations of Mars provided crucial data for Kepler.
- Measured parallax of a comet to show it was further than moon.
- Observed Supernova.

Kepler

- 1571 – 1630
- Assistant to Tycho Brahe.
- Described orbit of planets as ellipses.

- Devised three laws to explain planetary motion.

Kepler's Laws

Law 1: Planets move in elliptical orbits with the sun at one focus of the ellipse.

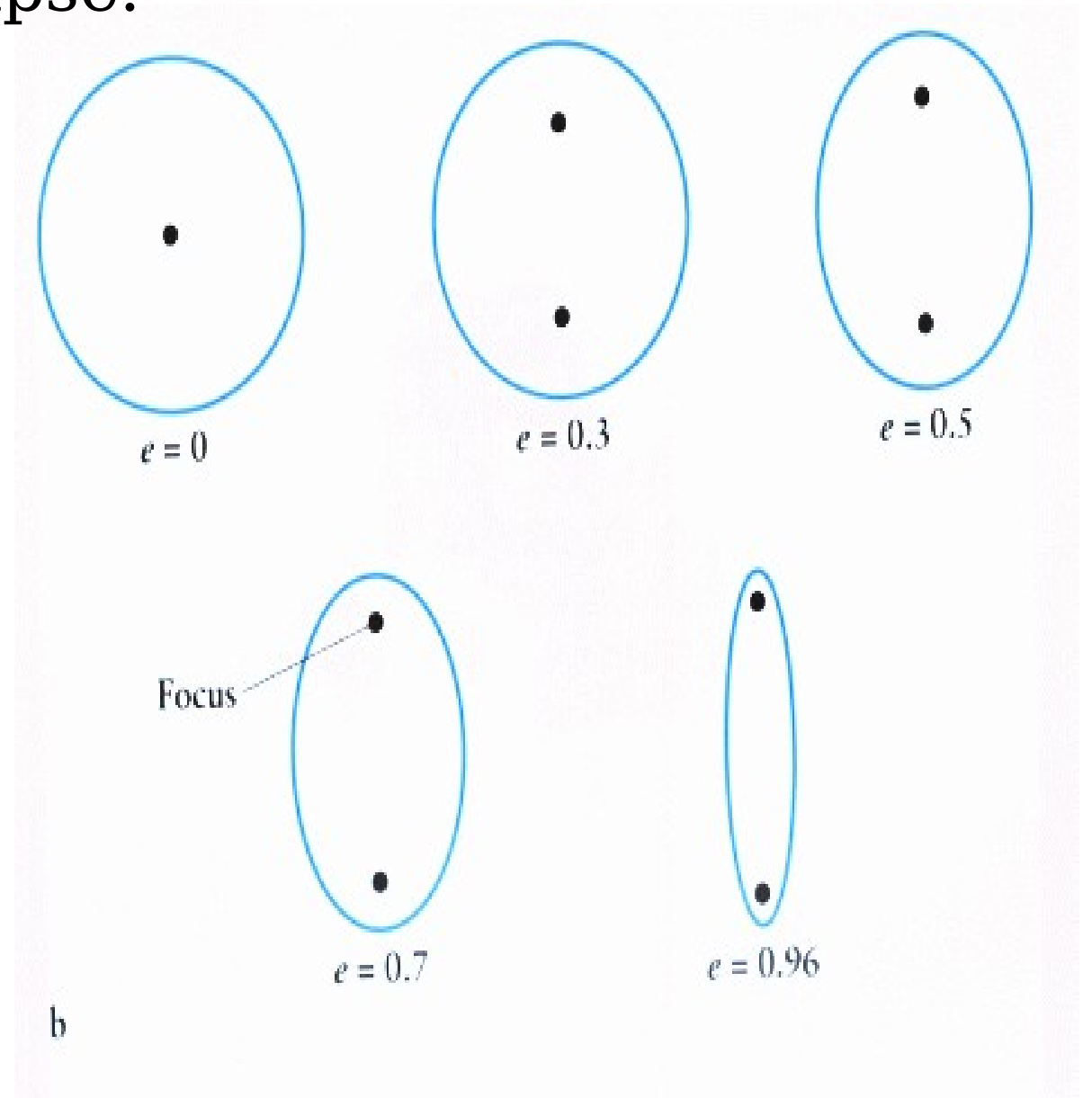
Ellipse: $(x^2/a^2) + (y^2/b^2) = 1$

Eccentricity:

e = 0: Circle

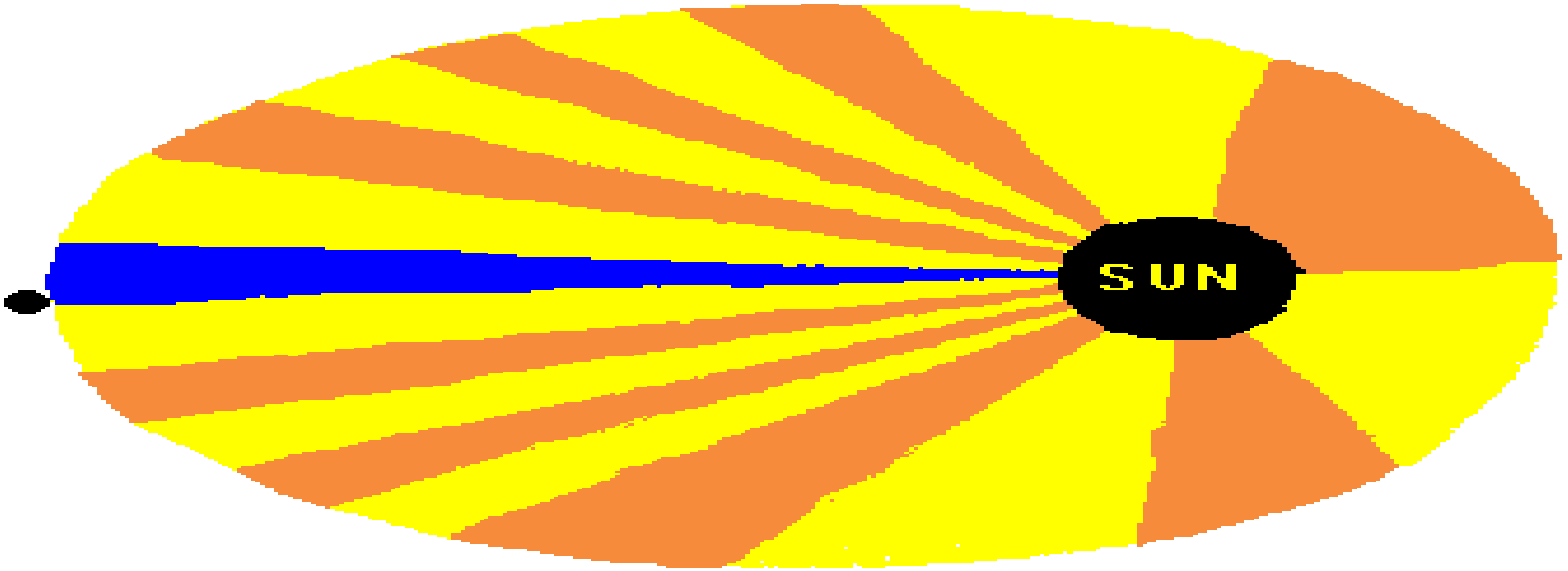
0<e<1: Ellipse

e = 1: Straight line
(flattened ellipse)



Kepler's Laws

Law 2: The orbital speed of a planet varies so that the line joining the Sun and the planet will sweep over equal areas in equal time intervals.



Kepler's Laws

Law 3: The amount of time a planet takes to orbit the Sun is related to it's orbit size, such that the Period, T, squared is proportional to the semi-major axis,r, cubed.

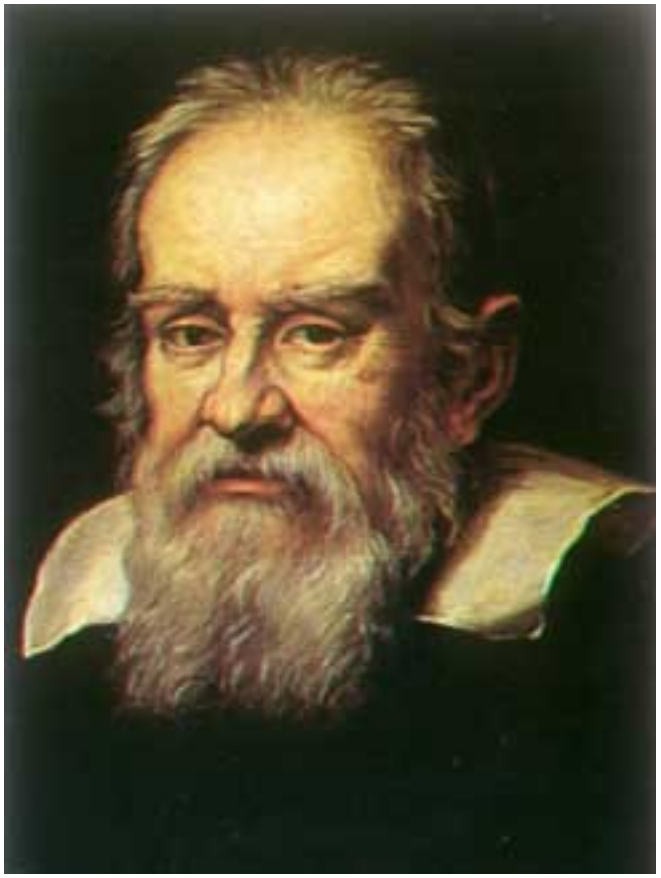
$$T^2 = kr^3$$

Kepler's Laws

Law 3

Planet	***Period (yr)***	***Ave. Dist. (AU)***	P^2/R^3
Mercury	.241	.39	0.98
Venus	.615	.72	1.01
Earth	1.00	1.00	1.00
Mars	1.88	1.52	1.01
Jupiter	11.8	5.20	0.99
Saturn	29.5	9.54	1.00
Uranus	84.0	19.18	1.00
Neptune	165	30.06	1.00
Pluto	248	39.44	1.00

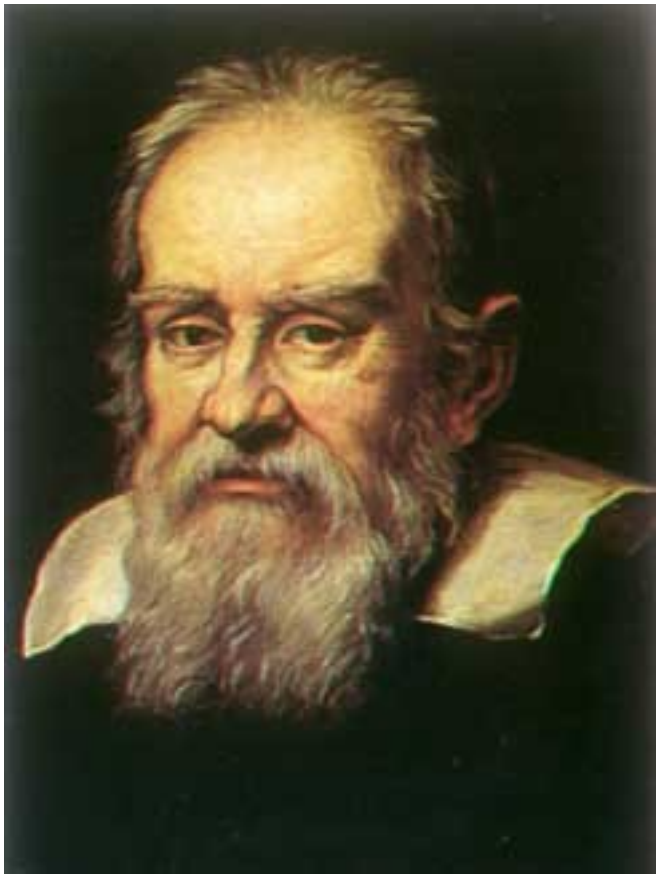
Galileo



- 1546 - 1642
- Supported Copernicanism
- Studied motions of:
    - celestial objects
    - bodies on Earth

- Did not invent the telescope
    - Hans Lippershey is credited with the invention of the telescope.

Galileo



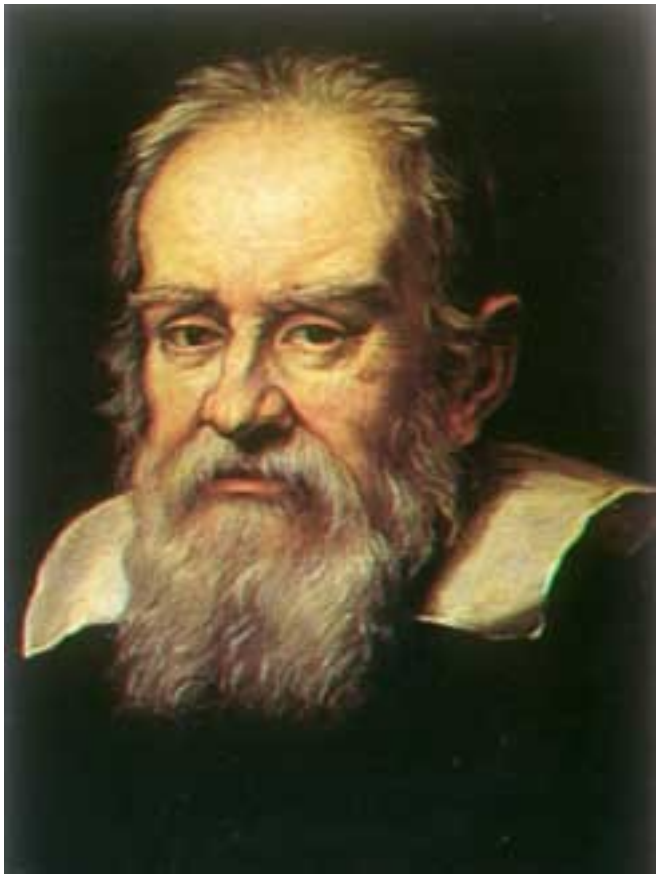
- First to study and interpret findings with telescope.

- First claim to seeing mountains on the Moon.

- First to see four bodies orbiting Jupiter
  - “the Medicean Stars”

- Observed the phases of Venus

Galileo



- From his studies of bodies on Earth he concluded:

formulas for kinematics

Inertia:

tendency of an object to remain in unchanging motion.

Newton

- 1642 - 1727

- Pioneer of modern methods of motion, optics, and “gravity”.

- Deduced mathematical methods for calculating gravity of spherical objects.

- Newton's Laws of Motion
  How bodies respond to forces.

Force: Push or a pull on an object.

Newtons Laws of Motion

First Law: (Inertia Law)

Every object will remain in a state of rest or motion in a straight line unless acted upon by an unbalanced force.

Second Law:

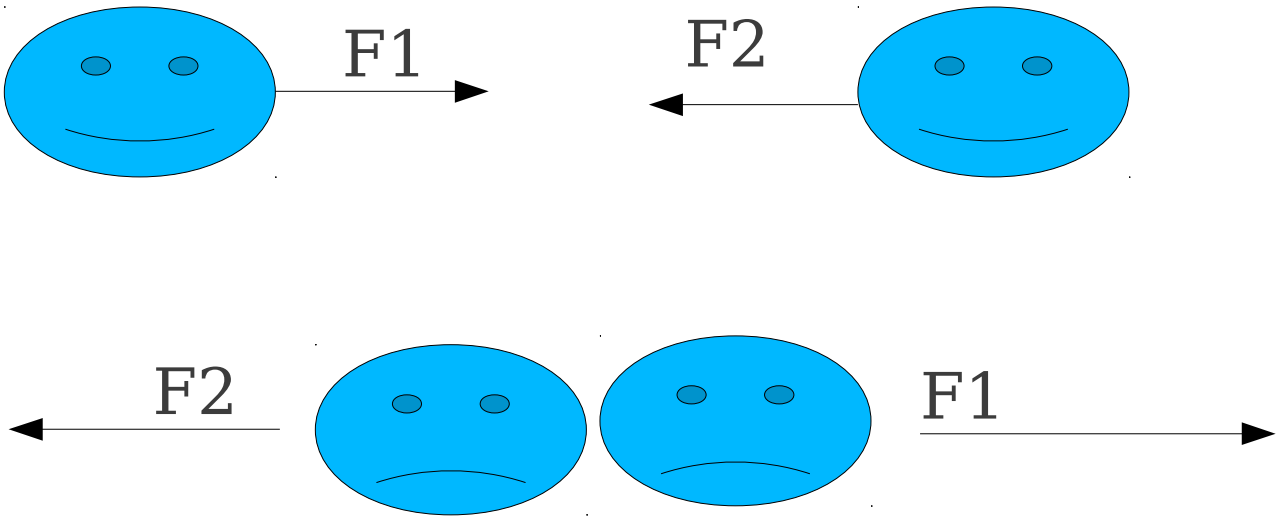
The acceleration of an object is directly proportional to the applied force and inversely to proportional to the mass.

$$F = \text{mass} * \text{acceleration}$$

Newton's Laws of Motion cont.

Third Law:

For every action there is an equal and opposite reaction.



Newton's Universal Law of Gravitation

Every object in the Universe is attracted to every other object with a force that is directly proportional to the product of their masses and inversely proportional to the square of the distances between them.

$$F = G \frac{m1*m2}{r^2}$$

Between the Sun and the Earth the force is:

$$F = 3.54 \times 10^{22} \text{ N}$$