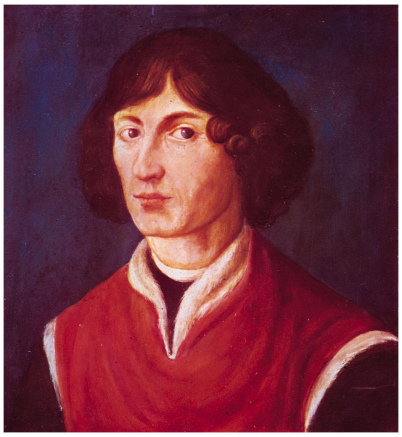
RENAISSANCE ASTRONOMY

Questions

How do scientists choose between competing theories?

Let's stretch our minds! – How big is the Universe?

Nicholas Copernicus



Nicholas Copernicus
[1473 - 1543, Poland]

Trained in law and medicine, but his interest was in math and astronomy. He developed the **heliocentric** (Sun-centered) model, and he published his results in the *De Revolutionibus*.

Postulates include: (a) the Universe is spherical and (b) motions of objects were combinations of uniform circular motion.

Observations & Results

A. Reasoned that the apparent rotation of the Celestial Sphere could be accounted for by assuming that the Earth rotated about a fixed axis while the Celestial Sphere was stationary.

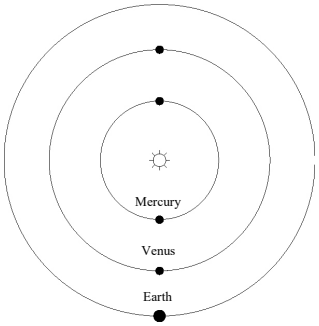
B. Determined the Earth is 1 of 6 (then known) planets circling the Sun, in the order Mercury, Venus, Earth, Mars, Jupiter, and Saturn.

C. Recognized that objects nearer to the Sun had faster orbital speeds, which accounts for retrograde motions.

D. Computed the scale of the Solar System.

Inferior Planets

Superior Conjunction

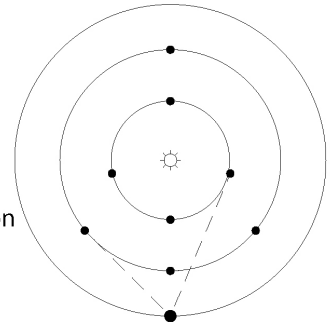


Inferior Conjunction

Inferior Planets

Superior Conjunction

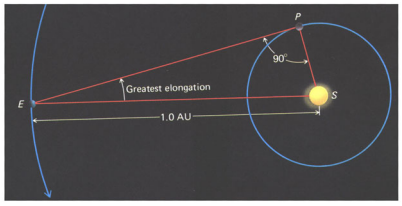
Greatest Eastern Elongation



Greatest Western Elongation

Inferior Conjunction

Inferior Planet Distance



At Greatest Elongation, the view from the Earth to the planet's orbit is a tangent line. Therefore, that angle is 90°. The angle from the Earth-Sun line to the Earth-tangent line is observed. The Earth-Sun distance is 1 AU.

Example:

$$\frac{1\ \text{AU}}{\sin 90^\circ} = \frac{X}{\sin 15^\circ}$$

$$X = \sin 15^\circ = 0.26\ \text{AU}$$

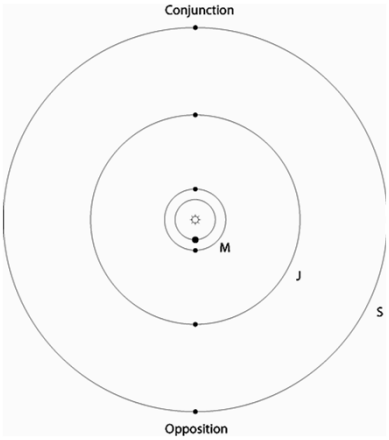
Average Distances

Table 4–2 Average Distances of the Planets from the Sun

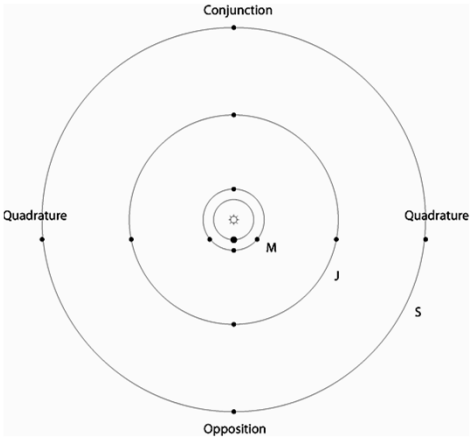
Planet	Copernican value (AU*)	Modern value (AU)
Mercury	0.38	0.39
Venus	0.72	0.72
Earth	1.00	1.00
Mars	1.52	1.52
Jupiter	5.22	5.20
Saturn	9.07	9.54
Uranus	—	19.19
Neptune	—	30.06
Pluto	—	39.53

**1 AU = 1 astronomical unit = average distance from the Earth to the Sun.*

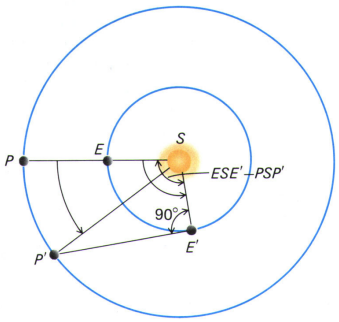
Superior Planets



Superior Planets



Superior Planet Distance



Need to know the Time it takes to go from point E (opposition) to point E' (quadrature). Angles PSP' and ESE' are determined from Time. Earth-Sun distance is 1 AU.

Example:

If it takes 120 days to go from E to E', then angle ESE' = 120 / 365.25 x 360°.

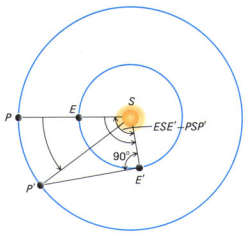
Do the same for PSP' and compute the angle P'SE'. Then use the Law of Sines.

Example

Earth: P = 365.25 days Mars: S = 780 days (Opp to Opp)

Observe that Opposition to Quadrature = 95 days

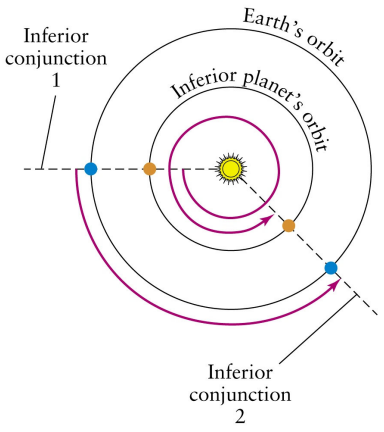
Earth Angle = 94° Mars Angle = (95 / 780) x 360 = 44°



$$\frac{1\ \text{AU}}{\sin[90 - (94-44)]^\circ} = \frac{X}{\sin 90^\circ}$$

$X = 1 \ / \ \sin 40^\circ = 1.56\ \text{AU}$

Synodic Periods: Inferior Planets



Inferior Planets will make one more orbit than the Earth before they realign.

$$\frac{1}{P} = \frac{1}{E} + \frac{1}{S}$$

P = planet's sidereal period
E = Earth's sidereal period
S = planet's synodic period

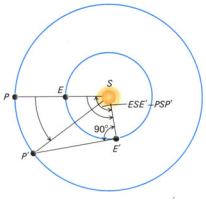
Synodic Periods: Superior Planets

The Earth will make one more orbit than the Superior Planets before they realign.

$$\frac{1}{P} = \frac{1}{E} - \frac{1}{S}$$

P = planet's sidereal period
E = Earth's sidereal period
S = planet's synodic period

Example:
Jupiter



S = 398.9 days = 1.092 years

1 / P = 1 / 1 – 1 / 1.092 = 0.084

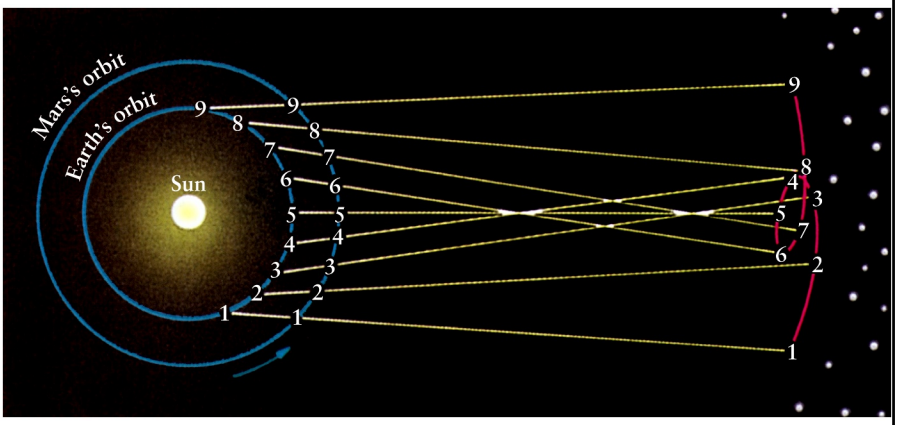
P = 1 / 0.084 = 11.87 years

Synodic & Sidereal Periods

Table 4-1 Synodic and Sidereal Periods of the Planets

Planet	Synodic period	Sidereal period
Mercury	116 days	88 days
Venus	584 days	225 days
Earth	—	1.0 year
Mars	780 days	1.9 years
Jupiter	399 days	11.9 years
Saturn	378 days	29.5 years
Uranus	370 days	84.0 years
Neptune	368 days	164.8 years
Pluto	367 days	248.5 years

Retrograde Motion Explained



Observations & Results

E. But because Copernicus used circular motion, he still needed epicycles for "details" of planetary motion.

The heliocentric model of Copernicus did not prove that the Earth revolves around the Sun. In fact, with some adjustments, the old Ptolemiac system could have accounted as well for the motions of the planets in the sky. But the Ptolemiac cosmology was clumsy and lacked the beauty and symmetry of its successor.

Copernicus made the Earth an astronomical body, which brought a kind of unity to the Universe. Also, his new cosmology had the revolutionary implication that the **Earth was small, while the Universe was large**.