

Reading: Chapter 2, Section 2.2 and 2.4;

Problem Set #2: Due Tomorrow/Monday in recitation

Problem Set #3: Available now, due next Friday/Monday

Brief review of last time: The Moon's Orbit & Eclipses

- Moon's Orbit and Eclipses
 - eclipses possible only when New/Full moon is at a node
- Anatomy of a Shadow
- Circumstances of eclipses
- Lunar eclipse: Sun at one node, Moon at the other (at full moon)
- Solar eclipse: Sun at one node, Moon at the same (at new moon)

Today: Early Science - prehistory forward

- Motions of the Planets:
 - concluding the discovery of our solar system
- Early Science
 - prehistoric discoveries: visual observations - motivations

Ancient Calendars and Calculators

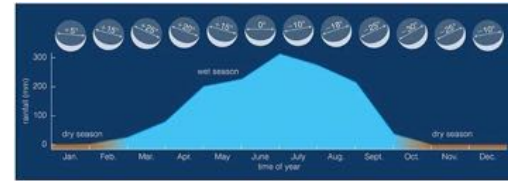
- Chichen Itza, Yucatan (Mexico): Annual "Calendar"



The Early Days...

• Prehistoric Discoveries

- Motivation: Calendar = survival
Cosmology = order = higher being



- Ecliptic + Zodiac paths of planets and Sun
- Solstice seasons
- Saros cycle eclipses



Ancient Calendars and Calculators

- Chichen Itza, Yucatan (Mexico): Annual "Calendar"



Ancient Calendars and Calculators

- Ecliptic / Equinox / Eclipse marker: Stonehenge



Ancient Calendars and Calculators

- Ecliptic / Equinox / Eclipse marker: Stonehenge

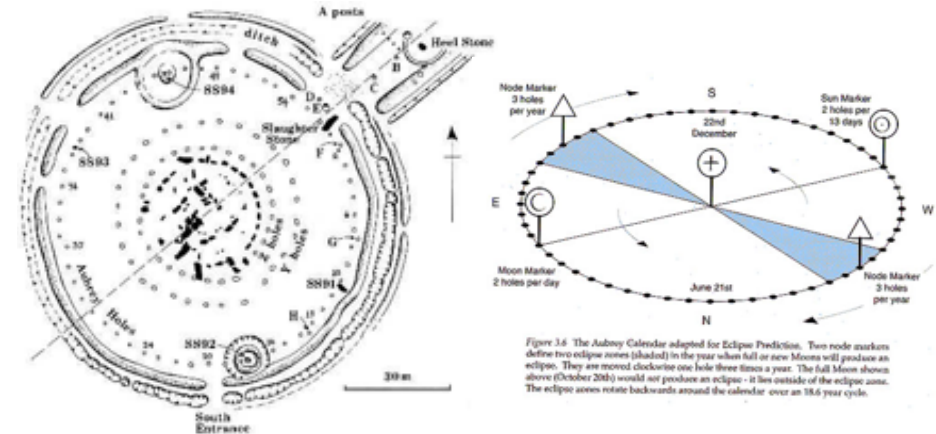


Figure 3.6 The Aubrey Calendar adapted for Eclipse Prediction. Two node markers define two eclipse zones (shaded) in the year when full or new Moons will produce an eclipse. They are moved clockwise one hole three times a year. The full Moon shown above (October 20th) would not produce an eclipse - it lies outside of the eclipse zone. The eclipse zones rotate backwards around the calendar over an 18.6 year cycle.

Towards a more complete Universe

- Early Science: The (500 BCE - 150 CE)**
 - spherical Earth (Pythagoras)
 - relative distances of Sun, Moon, Earth (Aristarchus, 300BCE)
 - size of the Earth (Eratosthenes)

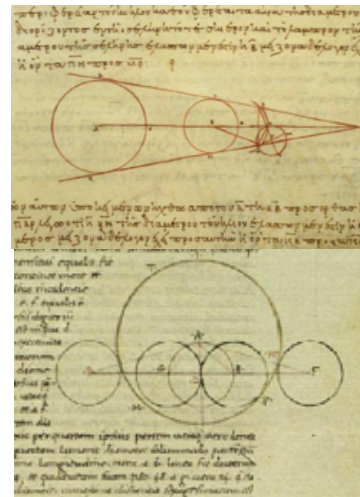


Figure 3. Relative position of the Moon in the quarter phase (this figures is not to scale).

- at precise moment of 1st/3rd quarter:
 - measure angle α
- this will be less than 90 degrees
- $90 - \alpha$ is angular size of Moon's orbit as viewed from the Sun
- $(\text{Moon distance}) / (\text{Sun distance}) = \cos(\alpha)$
- Aristarchus measured 87 degrees; actual answer is 89.86 degrees.

Towards a more complete Universe

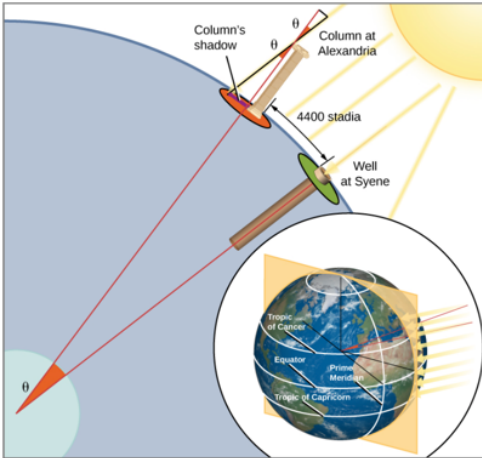
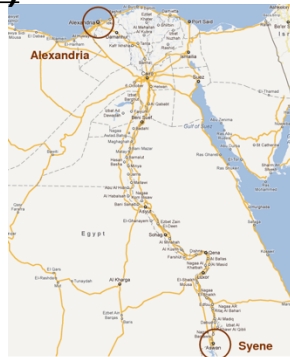
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- with results from 1st/3rd quarter:
 - calculate size of Earth's shadow at moon's distance
 - measure how many moons fit
 - find relative size of Moon, Earth, Sun

Towards a more complete Universe

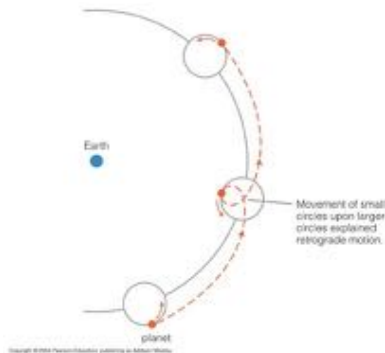
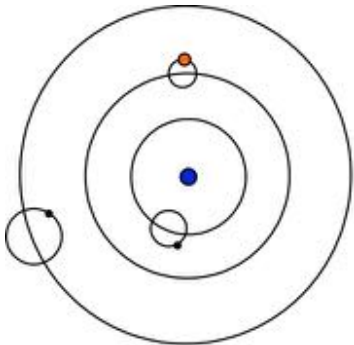
- **Early Science: The (500 BCE - 150 CE)**
 - spherical Earth (Pythagoras)
 - relative dimensions of Sun, Moon, Earth (Aristarchus, 300BCE)
 - **size of the Earth (Eratosthenes, 250 BCE)**



- noon Sun shines straight down well in Syene (near Aswan)
- Angle at Alexandria = 7 degrees
- Syene <-> Alexandria distance is 7/360 of the circumference of the Earth
- $360 \times 800\text{km} / 7 = 41,000\text{km}$
- true circumference is 39,800 km

Philosophy + some observation culminated in

- Ptolemy's computational scheme for celestial motion
 - Earth -centered
 - Uniform, circular Motion
 - Epicycles



towards the modern view

- 1200s: Ptolemy's method off by several *degrees*
 - response: add more epicycles . . .



1543: Copernicus

- moved sun to center -----> Revolutionary!



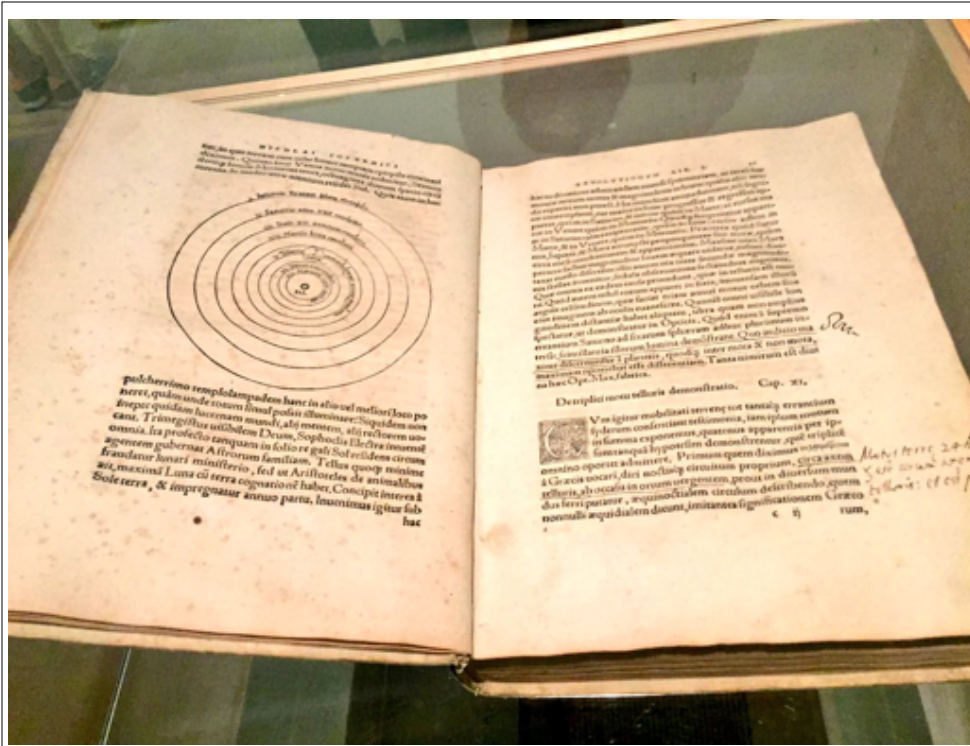
1580: Tycho Brahe

- precise positions of planets
- stars are fixed, therefore very distant
- sky is not immutable



1609: Galileo

- astronomer: telescopic studies show Copernicus was right
- physicist: experiments with Gravity



Looping Planets

North
East
West
South
Leo
Gemini
Cancer

Virgo
Libra
Sept. 2004
Mar. 2005
Jun. 2005
Sept. 2006
Dec. 2004
Dec. 2005

Dots represent Jupiter's approximate position at 1-month intervals. (Jupiter not to scale.)

North
South
East
West
Earth's orbit
Mars's orbit

North
South
East
West
Mars's orbit
Earth's orbit

North
South
East
West
Mars's orbit
Earth's orbit

planetary alignments (outer planet)

opposition (retrograde loop midpoint)

conjunction w/ Sun

The diagram shows a central Sun (yellow dot) with an inner blue circle representing Earth's orbit and an outer yellow circle representing the orbit of an outer planet. A blue dot on the inner circle represents Earth, and a yellow dot on the outer circle represents the outer planet. The Sun, Earth, and outer planet are shown in a straight line. On the left, the Sun and outer planet are on opposite sides of Earth, labeled "opposition (retrograde loop midpoint)". On the right, the Sun and outer planet are on the same side of Earth, labeled "conjunction w/ Sun".