Lecture 9

Learning Goals:
By the end of class today you should be able to …

•Explain how the size and shape of the Earth were first determined
•Describe the early theories about the Solar System
•Explain why some planets appear to move in retrograde motion.

Reading for Today: Units 10.3, 11

Shape of Earth
•Ancient Greeks understood Earth is spherical
•Aristotle (384 – 322 B.C.E.) used simple observations to support this.

Making the Case: Why the Earth is Spherical
•Earth's shadow during a lunar eclipse is curved
•The stars that are visible change as you move from North to South on the Earth.
•A ship on the horizon can be seen to disappear hull first.

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Size of the Earth
•Eratosthenes (276 – 195 B.C.E.) was first to measure the size of the Earth
•He heard that at noon on the summer solstice in Egyptian town Syene, the Sun casts no shadow.
–Proof: Sunlight reaches bottom of deep well
•But in Alexandria on the same day, the Sun does cast a shadow.
•Then, knowing the distance between Syene and Alexandria and using geometry

What does this allow you to measure about the Earth?

Distance from Syene to Alexandria = 5000 stadia (1 stadium ≅ 0.16 kilometer)

•Dist = 5000 stadia
•7° ≈ 1/50 of a circle
→ Circ. = 5000 x 50 = 250,000 stadia
•In modern units
Circ. ≈ 40,000 km
Diameter ≈ 13,000 km

•This is approx. the size of the Earth as we know it today! (12756 km)

The Wandering Stars
•Planet comes from Greek planetai meaning wanderers.
•Planets move against background stars because
–Their own orbital motion around the Sun
–The Earth's orbital motion around the Sun

•Watching Mars for example, for several months, it clearly doesn't move in the sky like the Sun and Stars.

•Sometimes planets undergo **Retrograde motion** – 'backward moving' (east-to-west) against background stars.
•Normal Prograde motion (west-to-east) against stars

Historical Picture of the Solar System
•In the sky, everything looks like it's moving around the Earth
•From the earliest Greeks
–Geocentric models

What does Geocentric mean?

•Greek Eudoxus (400 – 347 BCE) postulated that celestial objects are on concentric crystal spheres revolving around the Earth.

•Bodies moving fastest (e.g. Moon) are on inner spheres closest to Earth.

•But can this explain the retrograde motion of Mars?

Geocentric Model
•Ptolemy developed a geocentric model which did predict the planets positions reasonably well.
•He proposed the planets moved on a small circle **(epicycle),** which in turn moved on a larger circle.

Ptolemy's Geocentric Model
•Daily motion due to rotation of larger circle
•Retrograde motion occurs when epicycle carries planet in reverse direction

•Discrepancies remained, this epicycle model didn't quite work
•More complex models were devised with slightly better agreement between predictions and observed planet positions

•Ultimately rejected because it was so complicated, didn't seem plausible

•Occam's razor: If two scientific ideas explain a phenomenon equally well, prefer the simpler one.
•Philosopher William of Occam in 1300's said:

> "Entities must not be unnecessarily multiplied"

Nicolas Copernicus
•Polish physician and lawyer (1473-1543)
•Tried modifying geocentric models of the Solar system, but couldn't match the data on planetary positions
•Proposed a heliocentric (Sun centered) model for the solar system.

Heliocentric Model
•Copernicus showed a heliocentric model was a simpler model to explain retrograde motion.

Where is Earth's place in a heliocentric model?

How is this different from a geocentric model of the Solar System?

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Now Retrograde Motion is Easy to Explain
•Mars takes longer to orbit the Sun than the Earth does
• We see Mars in retrograde when Mars is opposite the sun.

Heliocentric Model
•Placed Sun at center of Solar System
•Moved Earth to be just one of the planets
•Explains retrograde motion of the planets
•Placing Sun at center, based on observations, Mercury & Venus must orbit inside Earth's orbit
•Determine relative sizes of Planetary orbits