

CP1 & honors
(not AP®)

Early Theories of the Universe

Unit: Gravitation

NGSS Standards/MA Curriculum Frameworks (2016): N/A

AP® Physics 1 Learning Objectives/Essential Knowledge (2024): N/A

Mastery Objective(s): (Students will be able to...)

- Describe early models of the planets and stars, including Copernicus’s heliocentric model

Success Criteria:

- Description accounts for observations of the time.

Language Objectives:

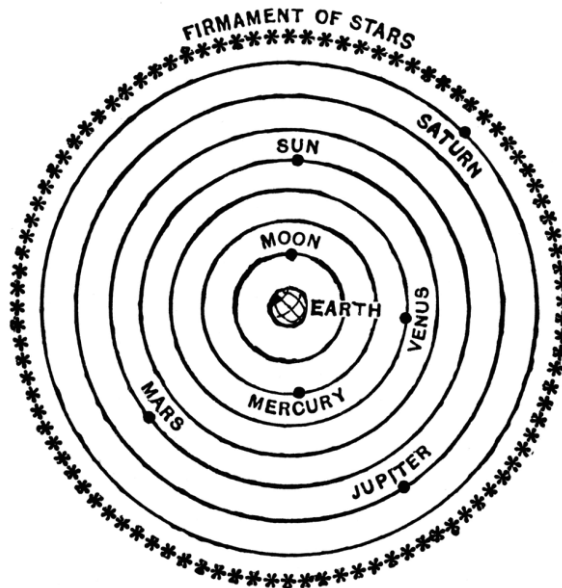
- Explain the primary differences between the geocentric (Earth-in-the-center) and heliocentric (sun-in-the-center) model.

Tier 2 Vocabulary: sphere, cycle, revolve

Notes:

Early Observations

Prior to the renaissance in Europe, most people believed that the Earth was the center of the universe. Early astronomers observed objects moving across the night sky, so they theorized that these objects must be orbiting around the Earth. Objects that moved more quickly across the sky must be closer, and objects that moved more slowly must be farther away.



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Stars, whose positions did not change from one night to the next were considered part of the “firmament”, which did not move.

Use this space for summary and/or additional notes:

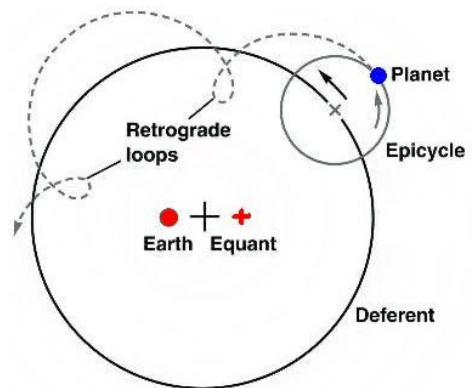
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Retrograde Motion and Epicycles

Early astronomers observed that planets sometimes moved “backwards” as they moved across the sky.

retrograde: apparent “backwards” motion of a planet as it appears to move across the sky.

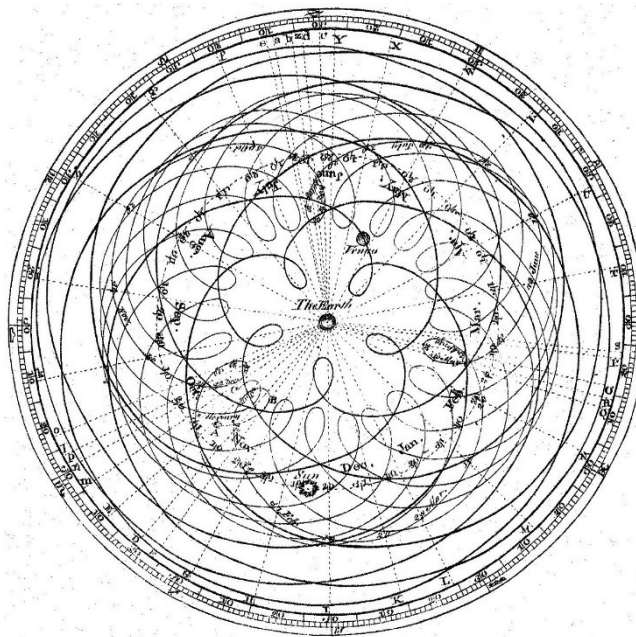
The ancient astronomer Claudius Ptolemy theorized that this retrograde motion must be caused by the planets moving in small circles, called *epicycles*, as they moved in their large circular path around the Earth, called the *deferent*.



deferent: the circular path around which the retrograde loops travel.

equant: a point in space such that the center of the deferent is midway between the Earth and the equant.

As more observations were made and more data collected, Ptolemy’s theory became unwieldy.



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Eventually, epicycle data was insufficient to describe the motion of the planets, so Ptolemy suggested that the epicycles themselves had smaller epicycles. The relationship between these additional epicycles was different for each planet.

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Heliocentric Theory

In 1532, Polish mathematician and astronomer Nicolaus Copernicus formulated a new heliocentric theory of the universe that placed the sun at the center and designated the Earth as one of the planets that revolve around the sun.

heliocentric theory: the theory that the sun (not the Earth) is the center of the universe.

The assumptions of Copernicus's theory were:

1. There is no one center of all the celestial circles or *spheres*.*
2. The center of the Earth is the center towards which heavy objects move[†], and the center of the lunar sphere (the moon's orbit). However, the center of the Earth is not the center of the universe.
3. All the spheres surround the sun as if it were in the middle of them, and therefore the center of the universe is near the sun.
4. The spheres containing the stars are much farther from the sun than the sphere in which the Earth moves. This far-away sphere that contained the stars was called the *firmament*.
5. The firmament does not move. The stars appear to move because the Earth is rotating.
6. The sun appears to move because of a combination of the Earth rotating and revolving around the sun. This means the Earth is just a planet, and nothing special (as far as the universe is concerned).
7. The apparent motion of the planets (both direct and retrograde) is explained by the Earth's motion.

Copernicus was afraid of criticism, and resisted publishing his work. It was ultimately published in a book entitled *On the Revolutions of the Heavenly Spheres* in 1543, around the time of his death. (It is unclear whether or not Copernicus ever saw a printed copy.)

The book went against the religious doctrines of the time, and in 1560 it was included in the newly-created *Index of Forbidden Books*. (Catholics were forbidden from printing or reading any book listed in the *Index*.) The book remained in the *Index* until 1758, when it was removed by Pope Benedict XIV. The *Index of Forbidden Books* was active until 1966.

* At the time, it was thought that planets and stars were somehow attached to the surface of a hollow sphere, and that they moved along that sphere.

† Remember that Copernicus published this theory more than 150 years before Isaac Newton published his theory of gravity.

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