Lecture 4

Weds: * Read 2.1 - 2.3

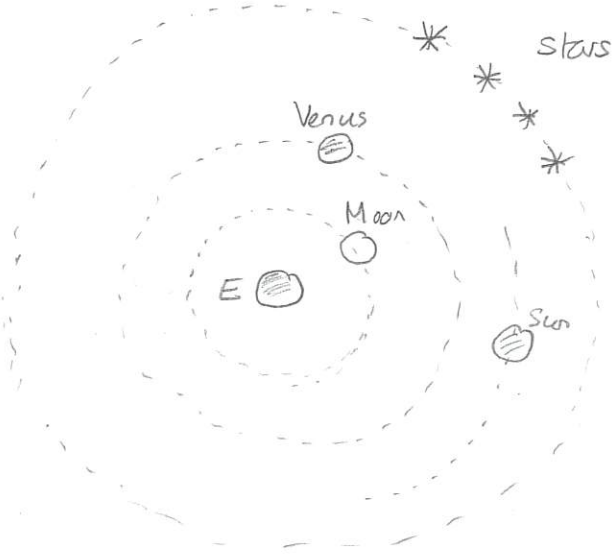
* NEED text for course

Fri: * HW turn in by 5pm

Geocentric model of the solar system

We construct models of the solar system and check these against observations. A simple geocentric model has the following components.

1) Earth is fixed (stationary at the center of the solar system
2) Sun, Moon, and the planets all orbit in circular paths
3) Each planet has its own distinct orbital radius and orbits at its own fixed angular rate (angle per hour/day)



4) The stars are furthest away and fixed relative to each other. They orbit at different rates to the Sun, Moon, planets.

We now need to:

Use model to predict behavior of objects in solar system → Check predictions against observations

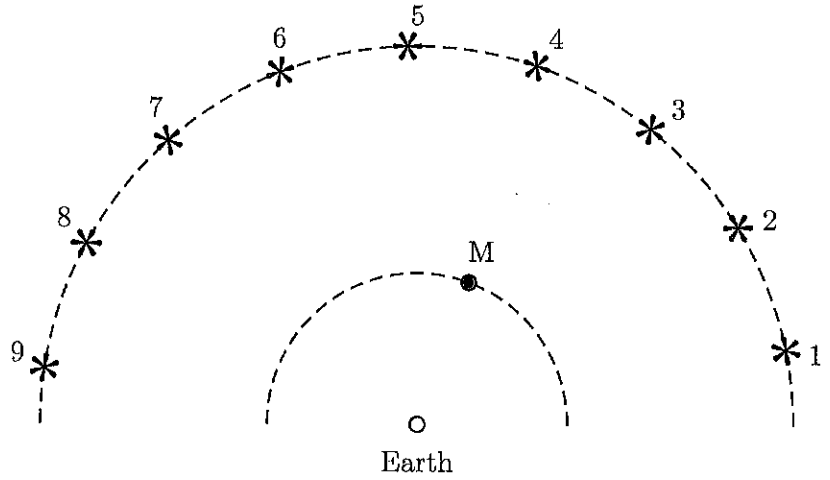
Quiz 1

Concepts of Physics: Class 4

28 August 2023

1 Geocentric model predictions

Consider Mars (labeled M) in a geocentric model. The stars (labeled 1,2,3,...) are arranged as illustrated. Assume that Mars and the stars orbit counterclockwise along each of the illustrated circular trajectories. One can observe the apparent position of Mars against the background stars when viewed from Earth. On one particular day, Mars and stars are arranged as illustrated.



a) Suppose that Mars orbits at faster (angular) rate than the stars do; this means that in a given day Mars orbits through a larger angle than the stars. When viewed from Earth, how does the position of Mars appear to change against the background stars? Explain your answer, preferably with a diagram that you draw accurately.

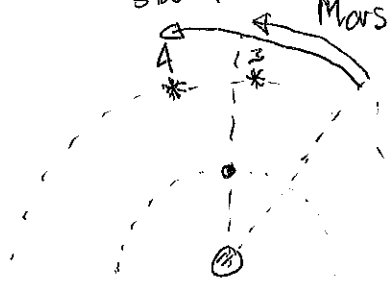
b) Suppose that Mars orbits at slower (angular) rate than the stars do; this means that in a given day Mars orbits through a larger angle than the stars. When viewed from Earth, how does the position of Mars appear to change against the background stars? Explain your answer, preferably with a diagram that you draw accurately.

a) Sketch when they have orbited at a later time

Stars, planets change by same angle

Mars always in front of 4

b. Later



It appears to be in front of a different star in order

4-3-2-1

These simple geocentric models predict:

> Any planet appears to move against the background stars and the direction of motion is always the same.

When the apparent position of any planet is observed there are periods where it appears to reverse direction. This is

> Retrograde motion ~ reversal of direction of apparent motion of planet when viewed from Earth

Demo: APOD Saturn Image

The conclusion then is

> The simple geocentric model is incorrect because its predictions about planetary motion contradict the observed retrograde motion of any planet.

This contradiction was known to the ancient Greeks. It was resolved using a complicated model due to Ptolemy (AD 100-170)

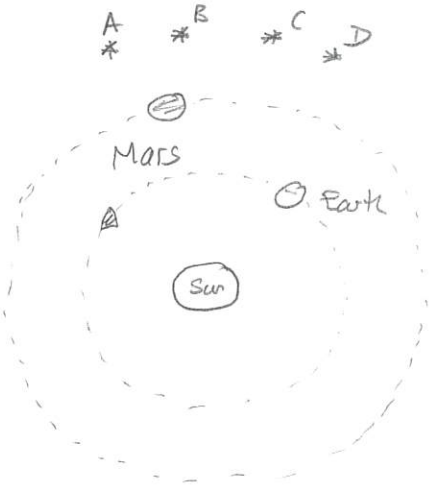
Demo: Foothills animation

Thurston video

Heliocentric models of the solar system

By the early 1500s simpler alternative models of the solar system, in which the planets orbited the Sun, emerged. These are heliocentric models. The simplest, due to Copernicus (in 1543), has these components:

1) Sun is fixed at the center of the Solar System
2) Stars are fixed and very distant
3) Each planet orbits in a circle around Sun
4) Earth rotates about its own axis



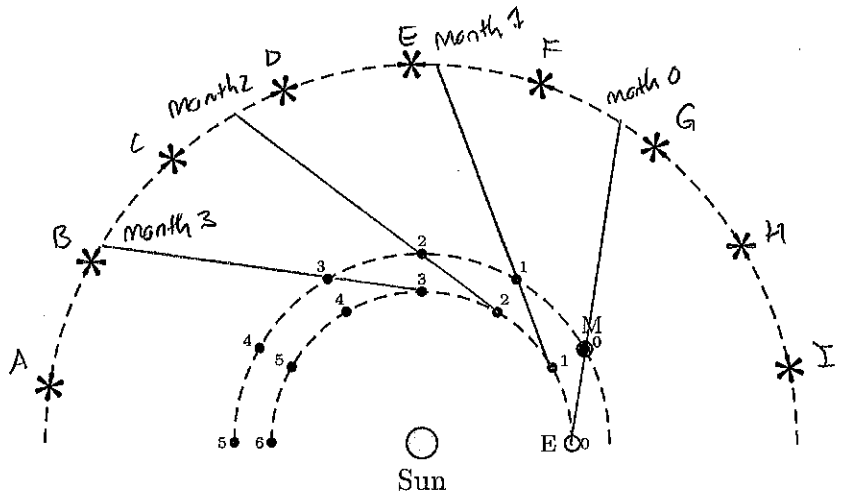
DEMO: Either - 2-D Solar system EduMedia
— The Sky 3-D

We now consider predictions based on two possibilities

1) all planets orbit at the same rate (1 yr to complete orbit)
2) planets orbit at different rates.

2 Heliocentric model predictions: same rates

Consider Mars (labeled M) in a heliocentric model. The stars (labeled 1,2,3,...) are arranged as illustrated. Assume that Earth and Mars orbit counterclockwise along each of the illustrated circular trajectories. One can observe the apparent position of Mars against the background stars when viewed from Earth. Assume that Earth and Mars orbit at *the same angular rate.* As the months pass, the positions of Earth and Mars are illustrated (e.g. they are at "1" after the first month, "2" after the second month, etc.)



a) When viewed from Earth, how does the position of Mars appear to change against the background stars? Does it appear to move in the same direction or not? Explain your answer, preferably with a diagram that you draw accurately.

b) Can this model explain the observed retrograde motion of Mars?

Ans: a) Draw lines of sight at each month.

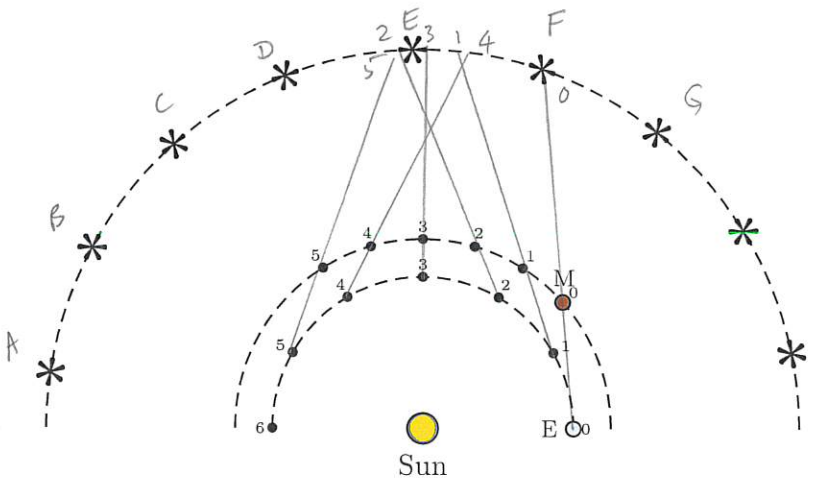
It appears to move in the same direction, in order

F → E → D → C → ....

b) No, Mars always appears to move in same direction against background stars

3 Heliocentric model predictions: different rates

Consider Mars (labeled M) in a heliocentric model. The stars (labeled 1,2,3,...) are arranged as illustrated. Assume that Earth and Mars orbit counterclockwise along each of the illustrated circular trajectories. One can observe the apparent position of Mars against the background stars when viewed from Earth. Assume that Earth and Mars orbit at *different angular rates.* As the months pass, the positions of Earth and Mars are illustrated (e.g. they are at "1" after the first month, "2" after the second month, etc.)



a) When viewed from Earth, how does the position of Mars appear to change against the background stars? Does it appear to move in the same direction or not? Explain your answer, preferably with a diagram that you draw accurately.

b) Can this model explain the observed retrograde motion of Mars?

Answer: a) It does. After month 2 and before 5 it appears to reverse direction (around star E, see diagram). It then resumes the earlier direction

b) It could

Slides: Show slides

DEMO: UNM Animation

We see then that

> The heliocentric model where planets orbit at different rates does predict that for any planet there will be periods of apparent retrograde motion.

In this sense the heliocentric model is better than the simple geocentric model. However, the model needs further details

1) radius of circular orbits
2) rates of orbits

These need to be used to predict motion and those again need to be checked against more detailed observations.