Planetary Motions

Class Thought Experiment

Imagine that you have made a scientific discovery that you know would change the way all of humankind looks at the Universe. BUT your discoveries contradict everything that has been thought of as “TRUE” for hundreds of years.

Even worse, your new boss doesn’t like you very much, keeps data hidden from you, and he very strongly believes in the old way of looking at the universe.

What would you do? How would you go about getting credit for your discovery? (think about government, religion, media, scientific community, publishers, etc.)

As small groups, decide what step (or steps) you would take to get credit for your discovery. After, each group will read out their answers to the class.

Copernicus

• How did Copernicus go about getting credit for his heliocentric model?
Copernicus

How did Copernicus go about getting credit for his model?

Copernicus, worried that publication of his model would lead to trouble with the Roman Catholic Church, let his results trickle out slowly. He released a short handwritten summary to only a few astronomers. It was eventually published, with the help of one of these astronomers. He received a copy of the published manuscript on his deathbed.

http://www.maa.org/devlin/devlin_3_00.html

Recall: Kepler’s 1st Law

The planets, including Earth, revolve around the sun in elliptical orbits. The sun is at one focus of the ellipse, the other is empty.

Recall: Kepler’s 2nd Law

The line joining a planet to the Sun sweeps out equal areas in equal times as the planet travels around the ellipse.
Orbital Period

Planet Period = Time to complete 1 full orbit around the sun.

Class Action!

The earth's orbital period is:

A) 31 days
B) 365.25 days
C) 24 hours
D) 60 seconds
Semi-Major Axis

The **semi-major axis** is half the length along the longest part of the ellipse.

![Diagram of semi-major axis](image)

Class Action!

In the ellipse shown below, the semi-major axis is

A) 8 AU  
B) 5 AU  
C) 4 AU  
D) 2.5 AU

![Diagram of ellipse with labeled semi-major axis](image)
Kepler’s 3rd Law
The ratio of the squares of the revolutionary periods (P) for two planets is equal to the ratio of the cubes of their semi-major axes:

\[
\frac{P_1^2}{P_2^2} = \frac{R_1^3}{R_2^3}
\]

Kepler’s 3rd Law
• The size of the orbit determines the orbital period
  - planets that orbit near the Sun orbit with shorter periods than planets that are far from the Sun

The Second and Third Laws
• The Second Law tells us what a particular planet does when it orbits a Star
  - The planet will move faster when it is close to the Sun and slower when it is farther from the Sun
• The Third Law tells us how the orbital periods are related to the orbital distances for all the planets in the Solar System
  - planets that are in an orbit located near the Sun have short orbital periods
  - planets that are in an orbit located far from the Sun have long orbital periods
Kepler’s 2nd Law

- The speed a planet travels during its orbit is related to the distance from the star
  - When the planet is near the sun the planet goes faster than when the planet is farther from the sun

Kepler’s 3rd Law

- The size of the orbit determines the orbital period
  - Planets that orbit near the Sun orbit with shorter periods than planets that are far from the Sun

Kepler’s 3rd Law

- The size of the orbit determines the orbital period
  - Planets that orbit near the Sun orbit with shorter periods than planets that are far from the Sun
  - Mass of planet does not matter
Class Action!

If a small weather satellite and the large International Space Station are orbiting the Earth at the same altitude above the Earth’s surface, which object takes longer to orbit around the Earth?

A) The large space station  
B) The small weather satellite  
C) They would take the same amount of time

Kepler

How did Kepler go about getting credit for his model?

Kepler’s boss, Tycho Brahe, was a supporter of the geocentric model of our solar system. Brahe had the best planetary data, but he kept it secret so Kepler couldn’t really test his ideas. Brahe allowed Kepler to look at his Mars data, but not copy it for his own use. The Mars data was enough to give him a foundation for his laws. After Brahe’s death, Kepler was finally able to get the data he needed to make the calculations. He published his ideas in a book.

Lecture Tutorial

• Break up into groups of 2-3  
  – NO MORE THAN 3  
• In your group, work through the following:  
  – Kepler’s 3rd Law (pages 25-28)  
  – Discuss the answers – don’t be silent!  
• I will be roaming around if you need help...  
• If your group finishes, check your answers with another group & begin Newton’s Law & Gravity (pages 29-31)
Class Action!

Which of the following best describes what would happen to a planet’s orbital speed if its mass were doubled but it stayed at the same orbital distance?

A) It would orbit half as fast  
B) It would orbit less than half as fast  
C) It would orbit twice as fast  
D) It would orbit more than twice as fast  
E) It would orbit with the same speed

Summary

Kepler’s 3rd Law describes how the orbital periods are related to the orbital distances for all planets in the solar system.

$P_1^2 = \frac{P_2^2}{R_1^3}$

BUT, Kepler’s ideas were largely ignored or disbelieved until after his death, when Newton came along...