Planetary Motion – Kepler's Third Law
Student Page

Purpose

To study applications of Kepler's Third Law of Planetary Motion.

Before you Begin

If a planet were twice as far away from the Sun as the Earth, predict how long would it take to orbit the Sun?

A.J.J.A.R. Programs Required

Kepler's Third Law (all versions)

Questions

Using the first "Kepler's Third Law" program:

1. If a planet were twice as far away from the Sun as the Earth, how long would it take to orbit the Sun?

Using the second "Kepler's Third Law" program:

2. Kepler's Third Law states that the period of a planet's orbit squared is equal to the length of the planet's semimajor axis cubed. For planets orbiting the Sun

   $P^2 = a^3$, where P is in years and a is in astronomical units.

   Using three examples provided by the A.J.J.A.R. program, calculate the period (in years) for the orbit given the orbital distance (in A.U.). Record both the orbital distance and the period you calculate.

Using the third "Kepler's Third Law" program:

3. Do the same as you did in the previous problem, only now calculate the average orbital distance (in A.U.) given the period (in years). Do this for three examples and record the period and the orbital distance you calculate.

Using the fifth "Kepler's Third Law" program:

4. Calculate the average orbital distance (in A.U.) for the two objects shown orbiting the Sun. Check your answers with the program. Record the period that you measured for each planet and the distance you calculated. Run two different simulations of this program to check your calculating accuracy.

Advanced Question

Using the sixth “Kepler’s Third Law” program:
Calculate the mass of the star based on the motion of the planets.

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Teacher Page

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Possible Answers to Before you Begin

This question can easily be answered using one of the A.J.J.A.R. programs. However, it is interesting to see what students' preconceptions will be. The majority of students believe that twice the distance from the Sun will result in twice the period, which is not the case.

A.J.J.A.R. Programs Required

Kepler's Third Law (all versions)

Answers to Questions

A planet twice as far away from the Sun as the Earth will take 2.83 years to orbit the Sun.

Questions 1-4 require students to use the special form of Kepler's 3rd Law of $P^2 = a^3$, which is the form of the equation used for objects orbiting the Sun, with P in years and a in A.U.

Answer to Advanced Question

In order to solve this problem, students will need to measure both the average orbital distance (in A.U.) and the period (in years). The mass of the star (in solar masses) is found using $\text{mass} = \frac{a^3}{P^2}$, where a is in A.U., and P is in years.

Additional Internet References

Kepler's Laws
http://www.cvc.org/science/kepler.htm
This site offers a good, overall description of each of Kepler's Laws.