Orbital Period and Orbital Distance

Name: Solutions **Section:**

In this activity we will investigate the relationship between how long it takes a planet to orbit a star (orbital period) and how far away that planet is from the star (orbital distance). We will start by investigating an imaginary planetary system that has an average star like the Sun at the center. A huge Jupiter-like, Jovian planet named Moto orbits close to the star, while a small Earth-like, terrestrial planet named Spec is in a far away orbit around the star. Use this information when answering the next four questions.

1) Which of the two planets (Moto or Spec) do you think will move around the central star in the least amount of time? Why?

Moto because it is closer so its orbital speed is higher and it has a smaller orbit to traverse.

2) If Moto and Spec were to switch positions, would your answer to question 1 change? If so, how? If not, why not?

The answer would change to Spec because the orbital period depends only on the distance from star and the star's mass, so if Spec became the closer planet, it would orbit in the shorter time.

3) Do you think the orbital period for Moto would increase, decrease, or stay the same if it were to move from being close to the central star to being much farther away? Why?

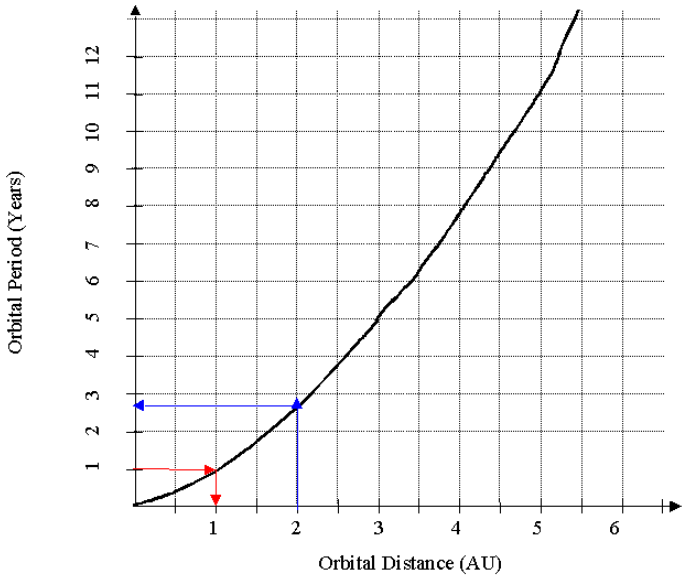
The orbital period would increase if Moto moved further away from the star because its orbital speed would decrease and it would have a larger orbit to traverse.

4) Imagine both Moto and Spec were in orbit around the central star at the same distance and that their orbital positions would never intersect (so that they would never collide). Do you think the two planets would have the same or different orbital periods? Why?

They would have the same periods because they would be orbiting the same star at the same distance.

Note that if Moto and Spec had masses that were similar to the star's rather than being much smaller than the star's, then the above discussion would be much more complicated because the gravitational forces of Moto and Spec would be comparable to the gravitational force of the star.

The graph below illustrates how the orbital period (expressed in years) and orbital distance (expressed in Astronomical Units, AU) of a planet are related.



5) According to the graph, would you say that a planet's orbital period appears to increase, decrease, or stay the same as a planet's orbital distance is increased?

The orbital period increases if the orbital distance is increased.

6) How far from the central star does a planet orbit if it has an orbital period of 1 year?

As shown in red, if a planet has an orbital period of one year, than it has an orbital distance of 1 AU.

7) How long does it take a planet to complete one orbit if it is twice the distance from the central star as the planet described in question 6?

As shown in blue, if a planet has twice the orbital distance = 2x1AU = 2AU, its orbital period is 2.8 years.

8) Based on your results from questions 6 and 7, which of the following best describes how a planet's orbital period will change (if at all) when its distance to the central star is doubled? Circle your choice.

a) The planet's orbital period will decrease by half.

b) The planet's orbital period will not change.

c) The planet's orbital period will double.

d) The planet's orbital period will more than double.

Review the lecture notes on Kepler including the extra link to the discussion of planets' orbital speeds if you need more help in understanding these answers.