Tutorial

Relationship between orbital distance and orbital period[⊕]

We have studied Kepler's Three Laws that empirically describe the orbits of the planets around the Sun. These laws operate when the central star is so massive that it totally dominates everything else combined. We will find out later in this course that our solar system is not typical of planetary systems in general.

In this activity we turn things around a bit by starting with a planetary system unlike our own. We will assume that the closer planet to this sun-like star is much like Jupiter, while the more distant planet is Earth-like in size and density. Use this information to answer the next four questions, making the best guesses you can.

1. Which of the two planets will move around the star in the least amount of time? Why?

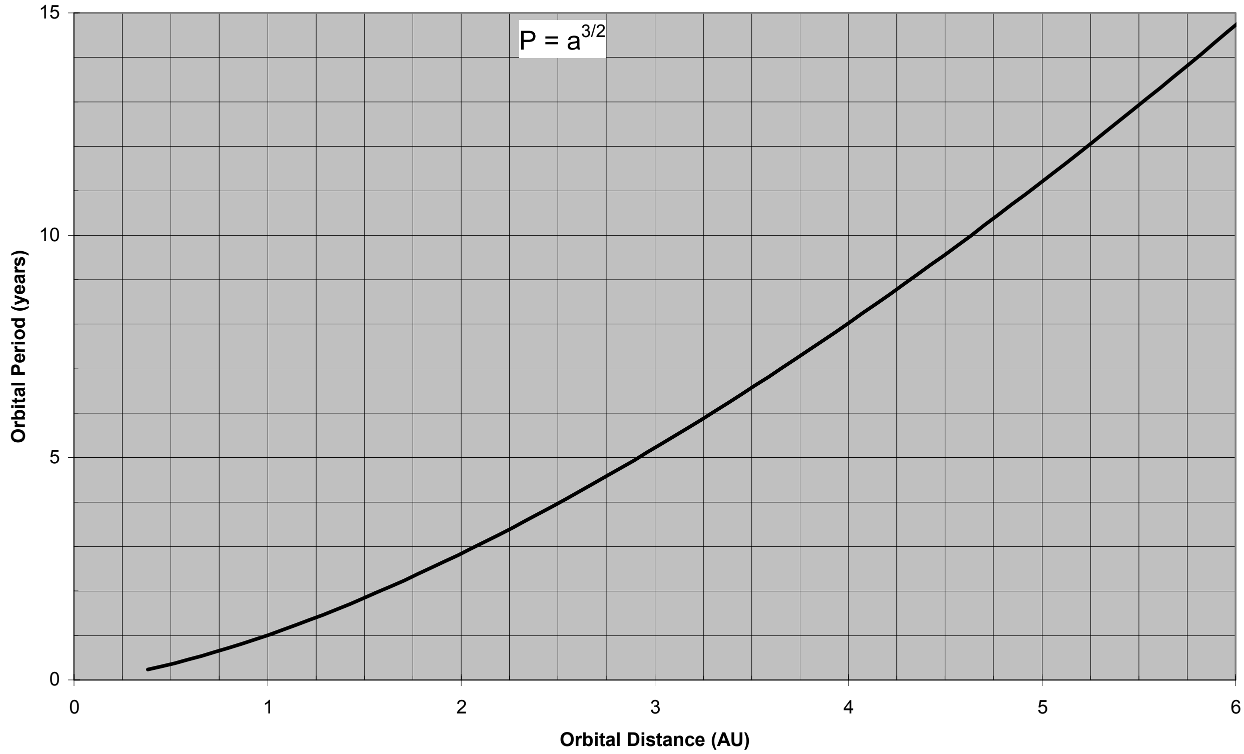
2. Let's say, by some weird perversion of nature, these two planets were to switch positions. Would your answer to the previous question change? Why or why not?

3. Let's get rid of the Earth-like planet, and move the Jupiter-sized planet out to that distance. Would the orbital period of this planet increase, decrease, or stay the same? Explain your answer.

4. Imagine that the Earth-like planet returns, but is now in the **same** orbit as the Jupiter-like planet. Amazingly enough, their orbital positions never intersect and so they never collide. Is this scenario possible? Explain.

[⊕] Adapted from Lecture-Tutorials for Introductory Astronomy; Adams, Prather, Slater; ©Pearson Prentice Hall; 2005

Orbital Period versus Orbital Distance



Kepler's laws apply to any planetary system as long as the central star is much more massive than any of the planets. The above graph shows how the orbital period and orbital distance are related.

5. Simply stated, does a planet's orbital period increase, decrease, or stay the same as its orbital distance is increased?

6. How far from the central sun-like star does a planet orbit if it has an orbital period of 1 year? _________

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? ____________

8. Based on your answers to 6 & 7, which of the following best describes how a planet's orbital period will change (if it does at all) when its distance from the central star is doubled? The planet's orbital period will

a. decrease by half. b. not change. c. double. d. more than double.

Here are the details for the 8 of the 9 planets in the solar system:

Planet	Orbital Distance (AU's)	Orbital Period (Years)	Planet Mass (x Earth)
Mercury	0.38	0.24	0.06
Venus	0.72	0.61	0.82
Earth	1.00	1.00	1.00
Mars	1.52	1.88	0.11
Jupiter	5.20	11.86	318
Saturn	9.54	29.46	95.2
Uranus	19.19	84.10	14.53
Neptune	30.07	164.86	17.15

9. What is the name of the planet that you identified the orbital distance for in question 6? ______________

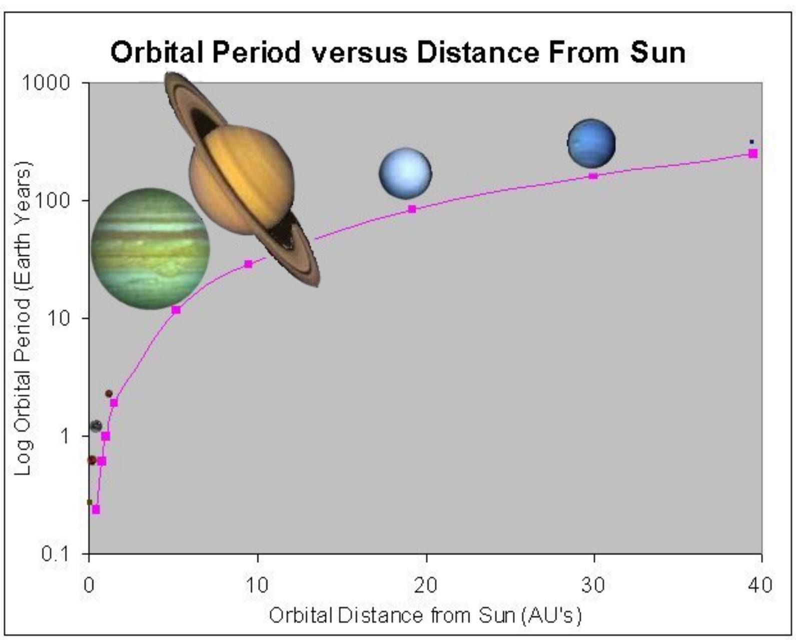
10. Consider the information provided in the table and on the graph and choose the answer below that best describes the effect that a planet's mass has on its orbital period.

a. Planets that have small masses have longer orbital periods than planets with large masses.
b. Planets with the same mass will also have the same orbital period.
c. Planets that have large masses have longer orbital periods than planets with small masses.
d. A planet's mass does not affect its orbital period.

11. Explain your reasoning for the answer you chose in question 10, and give a specific example from the table or the graph to support your choice.

12. Review your answers to questions 1 – 4. Do you still agree with the answers you provided? Modify your answers on that page so that they more correctly reflect what you have learned from this exercise.

The relationship between orbital period and orbital distance for the planets in the solar system. Note that the orbital period is now expressed in logarithmic form.



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