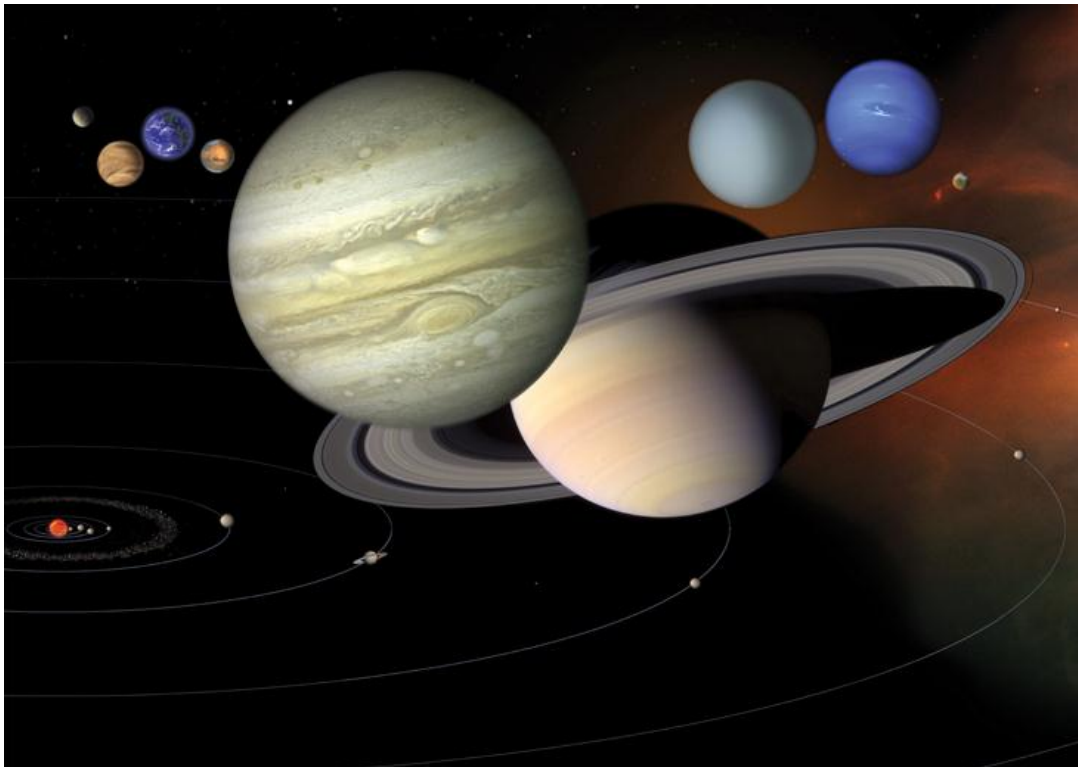


Explore the Galaxy | Student Activity (Grades 6 – 8)

Identifying Solar System Patterns

Names of Group Members: _____

Using telescopes and spacecraft, astronomers can collect information from objects too big or too far away to test and study in a lab. This is fortunate, because it turns out that sizes and distances in space are huge! Using this data, scientists analyze solar system objects like planets and moons to look for patterns or relationships. One very useful form of analysis is to graph the characteristics of these objects. When graphed relative to one another, you can see that there are some very interesting relationships among our planets and their characteristics.



The 8 planets and dwarf planet Pluto at their correct relative sizes and distances from the Sun.
(Image © NASA)

Activity

Your group has been chosen as the scientific team on a voyage to visit all 8 planets in our solar system. You will each need to choose 1 role:

- 1) **Navigator/Team Leader**- your job is to sort through the cards and decide their order as you go through the data. You are also responsible for finding the correct data to give to the recorder.
- 2) **Recorder**- your job is to collect and record all the data you need to complete your analysis. Make sure you keep all the data organized into the correct data tables (with units!).
- 3) **Investigator**- your job is to plot the data on the graphs and to lead the discussion of the graphs and their associated questions.

Identifying Solar System Patterns

You will need...

- 1) A set of planet cards – 1 for each of the 8 planets
- 2) A ruler
- 3) A pencil
- 4) A calculator (optional)

During your expedition, you and your team of scientists have made and recorded many observations about each planet. Each piece of data has been documented on the appropriate planet card. Your task is now to review and analyze this data in order to recognize trends. Once you establish these patterns, you will use that information to make inferences about other objects in the solar system.

Before you begin your analysis, the Navigator/Team Leader should familiarize the group with the information for each planet. Do you see any interesting data or relationships? In the table below, record at least 2 pieces of data your group found interesting and 2 relationships you see among the planets.

Interesting Data? <i>Describe any information that surprises you.</i>	Interesting Relationships? <i>When you put the cards in order did anything stand out?</i>
1)	1)
2)	2)

Explore the Galaxy | Student Activity (Grades 6 – 8)

Identifying Solar System Patterns

Lab Notebook

On the following pages you will organize your observations into data tables and create two graphs to help analyze the trends (patterns) in the data.

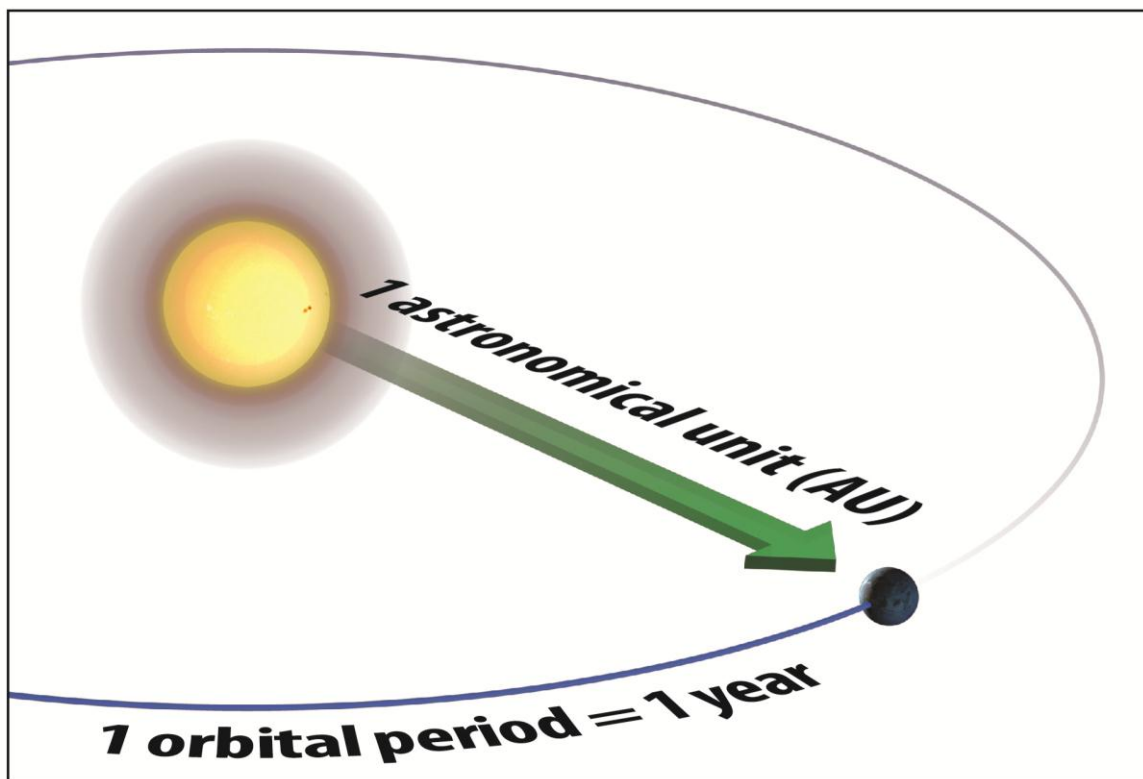
REMEMBER TO RECORD ALL UNITS IN DATA TABLES & GRAPHS

Notes on units!

Space is so big that scientists have to use interesting units to describe the huge distances and sizes. Here are explanations of some of the units you will be using:

Astronomical unit (AU)- An *astronomical unit* is based on the distance between the Earth and the Sun (approximately 93 million miles, or 150 million kilometers), and is often used to measure the distances of the objects from the Sun. 1 AU = 93 million miles.

Orbital Period- The *orbital period* is the amount of time it takes a planet to orbit the Sun once. For example, the Earth's orbital period is 1 year, because it takes 1 year for the Earth to travel completely around the Sun.



Identifying Solar System Patterns

Graph #1: Temperature vs. Distance from the Sun

- 1) Place the planet cards in order according to their distance from the Sun, with the planet closest to the Sun (the one with the smallest distance) on the left and the planet farthest from the Sun (the largest distance) on the right. Arrange the other planets in between according to the data.
 - a. Record the names of the planets in distance order in the first column of **Data Table 1**.
 - b. Record the distance listed on the planet card in the second column (labeled “X”). Don’t forget to record units!

DATA TABLE 1		
	X	Y
Name of Planet	Distance (unit: _____)	Temperature (unit: _____)

- 2) Shuffle the cards. Now place the cards in order from coldest to hottest, with the coldest planet on the left and the hottest planet on the right. Remember, negative numbers mean temperatures even colder than 0°C!
 - a. Record the order of the planets you see in the space below:

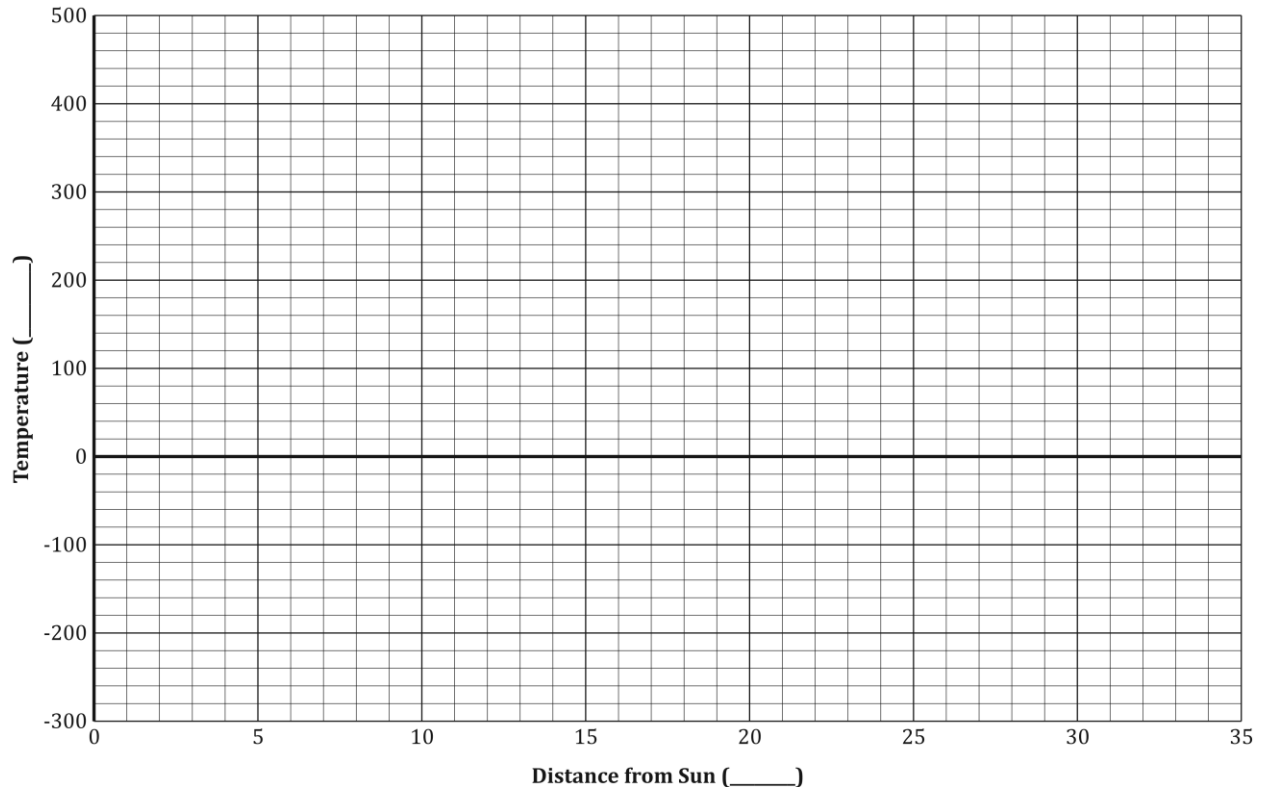
Is this the same order you recorded in the X column? If not, why do you think it might be different?

- b. Record the temperature data for each planet in the third column of Data Table 1 (labeled “Y”). If the order has changed, make sure you record the appropriate data with the right planet!

Identifying Solar System Patterns

Use data table 1 to create a graph of distance from the sun vs. temperature. Plot distance on the X axis and temperature on the Y axis. Remember to record your units on the appropriate axis! Finally connect the points with a smooth curve.

Distance vs. Temperature



Questions

- 1) Describe the trend or pattern of the graph.
- 2) What do you think causes this trend?
- 3) There is one planet that does not fit the trend. Which is it? Why do you think it doesn't fit?

Identifying Solar System Patterns

Graph #2: Distance vs. Orbital Period

- 1) Place the planet cards in order according to their distance from the Sun, with the planet closest to the Sun (the one with the smallest distance) on the left and the planet farthest from the Sun (the largest distance) on the right.
 - a. Record the names of the planets in distance order in the first column of **Data Table 2**.
 - b. Record the distance listed on the planet card in the second column (labeled “X”). Don’t forget to record units! *Hint: You already did this once before. How can you easily transfer the information?*

DATA TABLE 2		
	X	Y
Name of Planet	Distance (unit: _____)	Orbital period (unit: _____)

- 2) Shuffle the cards. Now place the cards in order from shortest to longest orbital periods, with the shortest orbital period on the left and the longest orbital period on the right.
 - a. Record the order of the planets you see in the space below:

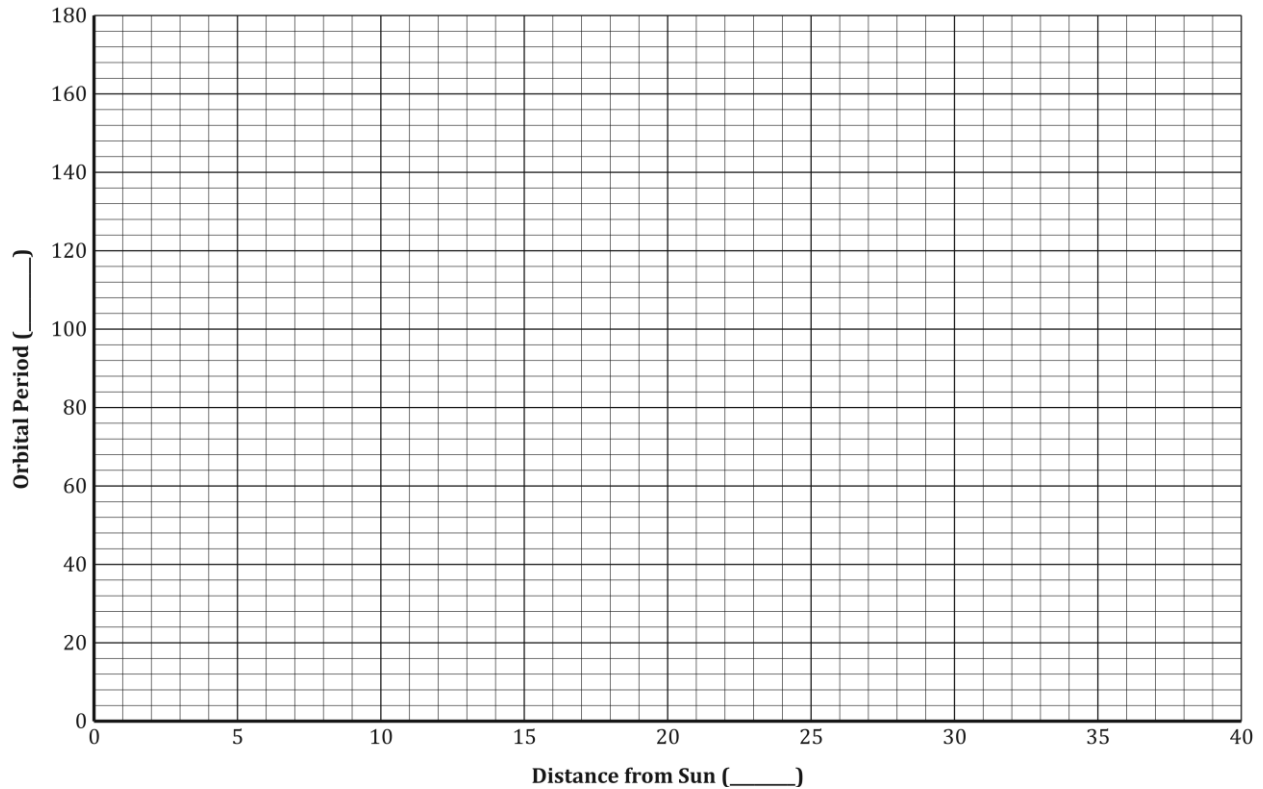
Is this the same order you recorded in the X column? If not, why do you think it might be different?

- b. Record the orbital period for each planet in the third column of Data Table 2 (labeled “Y”). If the order has changed, make sure you record the appropriate data with the right planet!

Identifying Solar System Patterns

Use data table 2 to create a graph of distance vs. orbital period. Plot distance on the X axis and orbital period on the Y axis. Remember to record your units on the appropriate axis! Finally connect the points with a smooth curve.

Distance vs. Orbital Period



Questions

- 1) Describe any trends or patterns you see in this graph.
- 2) What do you think causes this trend?
- 3) The asteroid belt orbits between Mars and Jupiter. Using the data you have collected, estimate how long you think it would take an asteroid in this belt to orbit once around the Sun (its orbital period).
- 4) Pluto orbits the Sun at a distance of 39.5 AU. Use the graph to predict what Pluto's orbital period might be.

Identifying Solar System Patterns

Additional Observations

- 1) Group the planet cards by composition. How many groups do you have? Look at the other properties. Do the planets in these groups have other things in common (list at least 2 things)?
- 2) Put the planets in order by the number of moons they have, with fewest moons on the left. Are there any other properties that correlate with this order? (*Hint: What is responsible for keeping these moons in orbit around the planets?*)
- 3) Just as you start your journey back to Earth, you receive a radio transmission. A new planet may have been discovered between Uranus and Neptune! Create a card for this new planet. Imagine what it might look like and sketch the planet in the box below. Fill in a name for this new planet and predict the values for each type of data.



PLANET NAME:

Distance from Sun: _____ AU

Diameter: _____ km

Mean temperature: _____ °C

Number of moons: _____

Orbital period: _____ years

Composition: _____

Explore the Galaxy | ANSWER KEY
Identifying Solar System Patterns

Graph #1: Temperature vs. Distance from the Sun

- 1) Place the planet cards in order according to their distance from the Sun, with the planet closest to the Sun (the one with the smallest distance) on the left and the planet farthest from the Sun (the largest distance) on the right. Arrange the other planets in between according to the data.
 - a. Record the names of the planets in distance order in the first column of **Data Table 1**.
 - b. Record the distance listed on the planet card in the second column (labeled "X"). Don't forget to record units!

DATA TABLE 1		
	X	Y
Name of Planet	Distance (unit: AU)	Temperature (unit: °C)
Mercury	0.4	167
Venus	0.7	464
Earth	1	15
Mars	1.5	-65
Jupiter	5.2	-110
Saturn	9.5	-140
Uranus	19.2	-195
Neptune	30.7	-200

- 2) Shuffle the cards. Now place the cards in order from coldest to hottest, with the coldest planet on the left and the hottest planet on the right. Remember, negative numbers mean temperatures even colder than 0°C!
 - a. Record the order of the planets you see in the space below:
Neptune, Uranus, Saturn, Jupiter, Mars, Earth, Mercury, Venus

Is this the same order you recorded in the X column? If not, why do you think it might be different?

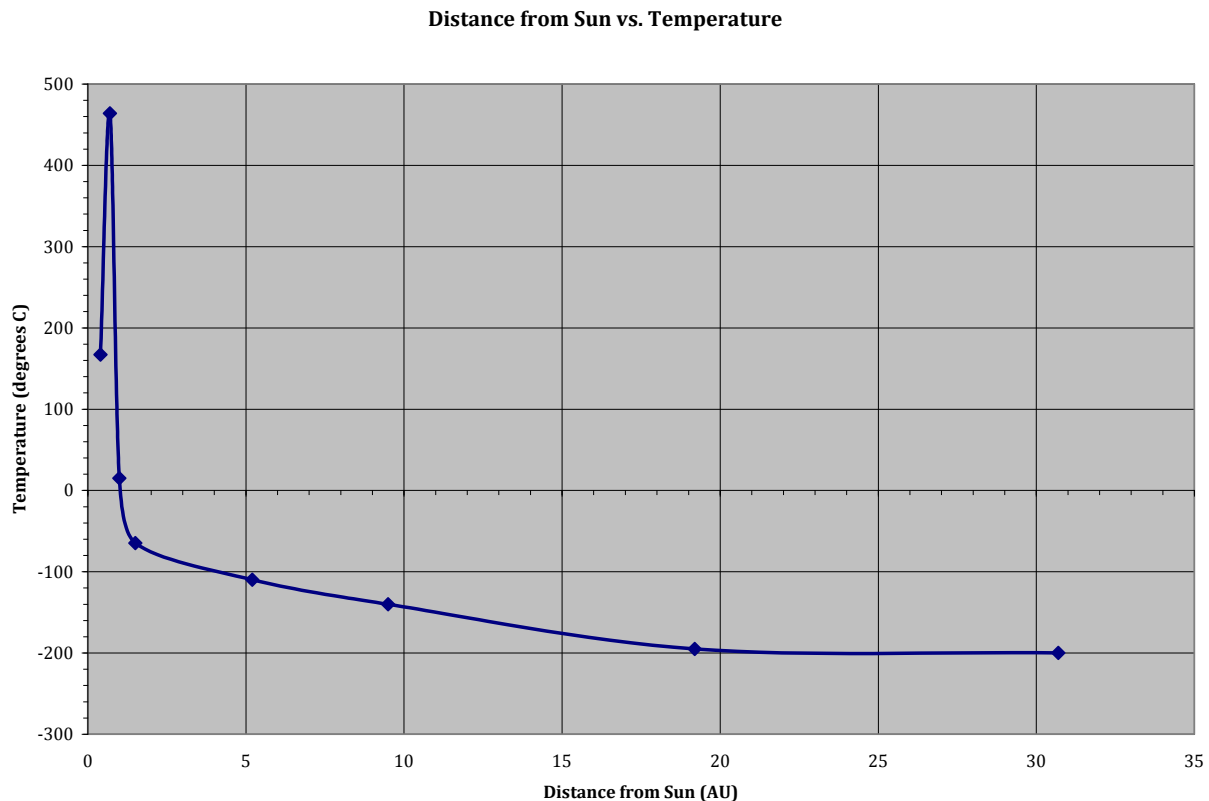
No. It is different because temperature decreases the farther you get from the Sun.

- b. Record the temperature data for each planet in the third column of Data Table 1 (labeled "Y"). If the order has changed, make sure you record the appropriate data with the right planet!

Explore the Galaxy | ANSWER KEY

Identifying Solar System Patterns

Use data table 1 to create a graph of distance from the sun vs. temperature. Plot distance on the X axis and temperature on the Y axis. Remember to record your units on the appropriate axis! Finally connect the points with a smooth curve.



Questions

1) Describe the trend or pattern of the graph.

The temperature trend decreases sharply and then flattens out as you get further from the Sun. The planets are getting colder and colder.

2) What do you think causes this trend?

The Sun is the main source of heat and energy for a planet's atmosphere and surface. Therefore, the further away from the Sun a planet is, the less energy it receives, and the colder its average surface temperature will be.

3) There is one planet that does not fit the trend. Which is it? Why do you think it doesn't fit?

Venus does not fit. Venus has a thick atmosphere composed mainly of the greenhouse gas carbon dioxide. This gas absorbs radiation and does not allow it to escape the atmosphere, trapping it on the surface and significantly heating the planet. As a result, the planet's temperature is affected by additional variables beyond simple distance.

Explore the Galaxy | ANSWER KEY
Identifying Solar System Patterns

Graph #2: Distance vs. Orbital Period

- 1) Place the planet cards in order according to their distance from the Sun, with the planet closest to the Sun (the one with the smallest distance) on the left and the planet farthest from the Sun (the largest distance) on the right.
 - a. Record the names of the planets in distance order in the first column of **Data Table 2**.
 - b. Record the distance listed on the planet card in the second column (labeled “X”). Don’t forget to record units! *Hint: You already did this once before. How can you easily transfer the information?*

DATA TABLE 2		
	X	Y
Name of Planet	Distance (unit: AU)	Orbital period (unit: Earth years)
Mercury	0.4	0.2
Venus	0.7	0.6
Earth	1	1
Mars	1.5	1.8
Jupiter	5.2	11.9
Saturn	9.5	29.5
Uranus	19.2	84.1
Neptune	30.7	164.8

- 2) Shuffle the cards. Now place the cards in order from shortest to longest orbital periods, with the shortest orbital period on the left and the longest orbital period on the right.
 - a. Record the order of the planets you see in the space below:
Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune

Is this the same order you recorded in the X column? If not, why do you think it might be different?

Yes.

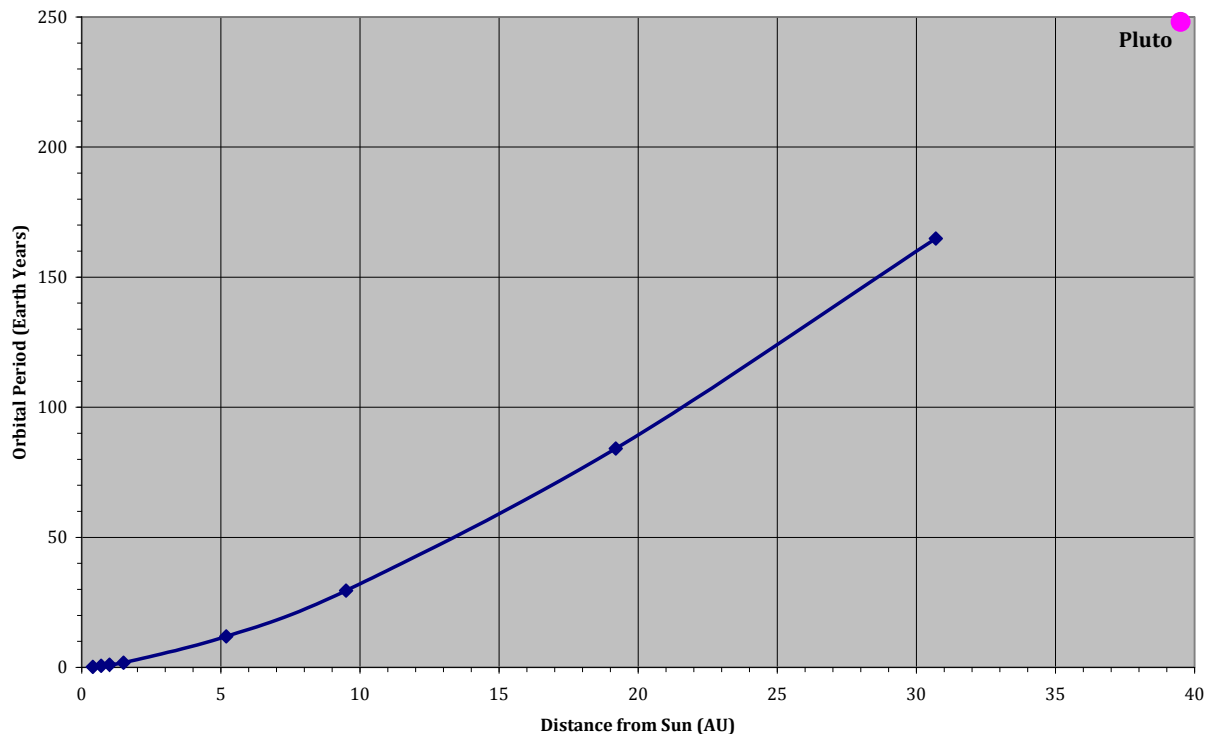
- b. Record the orbital period for each planet in the third column of Data Table 2 (labeled “Y”). If the order has changed, make sure you record the appropriate data with the right planet!

Explore the Galaxy | ANSWER KEY

Identifying Solar System Patterns

Use data table 2 to create a graph of distance vs. orbital period. Plot distance on the X axis and orbital period on the Y axis. Remember to record your units on the appropriate axis! Finally connect the points with a smooth curve.

Distance from Sun vs. Orbital Period



Questions

1) Describe any trends or patterns you see in this graph.

The farther you get from the Sun, the longer the orbital period. The inner planets are relatively close together, so that their orbital periods are similar. In comparison, the orbits of the gas giants are much more widely spaced, making the relative differences in their orbital periods much more significant.

2) What do you think causes this trend?

The planets orbit in concentric ellipses (most are almost circular). The farther out you go from the Sun, the longer the path of a particular planet around the Sun. A longer path leads to a longer amount of time necessary to go around the Sun. Another trend is that the planets closest to the Sun (Mercury, Venus, Earth, and Mars) are very close together, leading to very short (and relatively similar) orbital periods, whereas the planets farther from the Sun (Jupiter, Saturn, Uranus, and Neptune) are very spread out, leading to much longer orbital periods.

3) The asteroid belt orbits between Mars and Jupiter. Using the data you have collected, estimate how long you think it would take an asteroid in this belt to orbit once around the Sun.

Answers will vary but should be somewhere between **2-11 years**. The actual asteroid belt distance varies because it is made up of many individual objects, but the average is 2.7 AU. Therefore, the average orbital period of the asteroid belt is approximately 4.4 years.

4) Pluto orbits the Sun at a distance of 39.5 AU. Use the graph to predict what Pluto's orbital period might be. Answers will vary but should be in the **240-250 year** range. The actual orbital period of Pluto is 248.1 years.

Explore the Galaxy | ANSWER KEY

Identifying Solar System Patterns

Additional Observations

- 1) Group the planet cards by composition. How many groups do you have? Look at the other properties. Do the planets in these groups have other things in common (list at least 2 things)?

Answers may vary but there should be **two** groups- rocky & gas

Rocky composition similarities: small diameter, close to Sun, shorter orbital period, higher temperature, lower number of moons, no rings

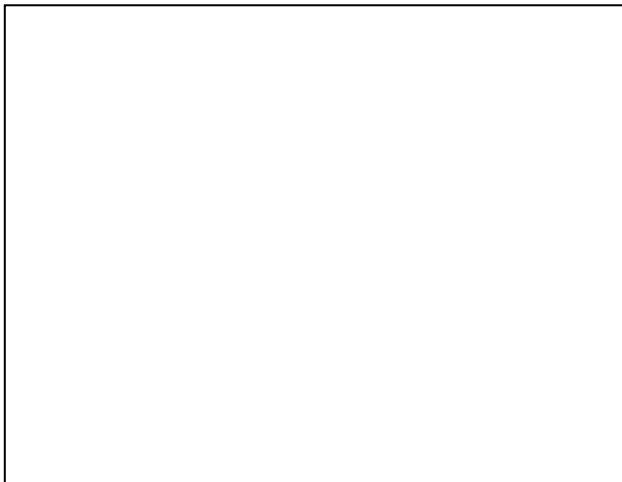
Gas composition similarities: larger diameter, further from Sun, longer orbital period, lower temperature (all below zero!), high numbers of moons, rings

- 2) Put the planets in order by the number of moons they have, with fewest moons on the left. Are there any other properties that correlate with this order? (*Hint: What is responsible for keeping these moons in orbit around the planets?*)

Mercury/Venus, Earth, Mars, Neptune, Uranus, Saturn, Jupiter

Larger diameter correlates with more moons (the larger the diameter, the more likely the planet is to have a higher mass. The force of gravity will be stronger with more massive planets, allowing them to capture more moons.)

- 3) Just as you start your journey back to Earth, you receive a radio transmission. A new planet may have been discovered between Uranus and Neptune! Create a card for this new planet. Imagine what it might look like and sketch the planet in the box below. Fill in a name for this new planet and predict the values for each type of data. **New planet data (answers may vary, acceptable ranges are listed below):**



PLANET NAME:

Distance from Sun: 20–30 AU

Diameter: 47,000–52,000 km

Mean temperature: -195 to -200 °C

Number of moons:
any number, probably more than 10

Orbital period: 85-164 years

Composition: Gas