Name: _____ Date: _____

Student Exploration: Solar System

Vocabulary: atmosphere, ellipse, gas giant, gravity, inner planet, orbit, outer planet, planet, rocky planet, solar system, year

Prior Knowledge Questions (Do these BEFORE using the Gizmo.)

1. Name all the **planets** you can think of. _____

   _____

2. What object is at the center of the **solar system**? _____

3. What force keeps the planets from flying out of the solar system? _____

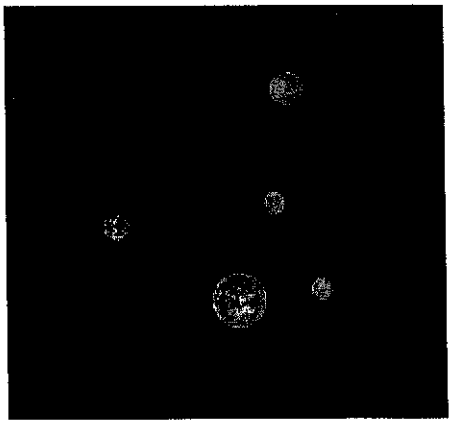
Gizmo Warm-up

On the *Solar System* Gizmo, check that the ORBIT tab is selected. At first you can only see the four **inner planets**. The distances of the planets to the Sun are to scale, but sizes are not.

1. Move the cursor over each planet to learn its name. What are the four inner planets?

   _____

   These planets are called **rocky planets** because their surfaces are rocky.



2. Click the "–" button (upper right) three times to zoom out. What are the names of the four **outer planets**?

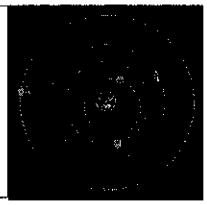
   _____

   These planets are called **gas giants** because they are essentially huge balls of gas.

3. Before 2006, while Pluto was still considered a planet, people used this saying to remember the nine planet names: "My very excellent mother just sent us nine pizzas."

   Come up with a new sentence to help remember the eight planet names, in order.

   _____

Activity A: **Planetary orbits**	Get the Gizmo ready: • Check that the ORBIT tab is still selected. • Click the "**o**" button to reset the zoom level. • Be sure that the **Speed** is set to **Slow**. • Turn on **Show orbits**.	

Question: How long is a year on each planet?

1. Observe: The path a planet takes around the Sun is its **orbit**. Planets move in orbits because of the Sun's **gravity**, a force pulling inward toward the Sun. Click **Play** (▶).

   A. What is the shape of orbits? _____

   The actual shape of an orbit is an **ellipse**, or flattened circle. Planetary orbits are only slightly flattened so that they look almost perfectly circular to the naked eye.

   B. Which planet's orbit looks the least like a circle? _____

2. Measure: Click **Reset** (↺). Now you will measure how long it takes each planet to orbit the Sun. Notice that the date shown below the simulation is today's date.

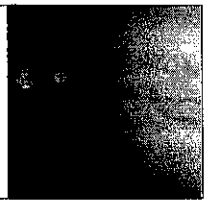
   - Drag an **arrow** from the left of the Gizmo and place it next to Mercury.
   - Click **Play**. When Mercury completes one orbit (reaches the arrow), click **Pause**.
   - Record **Today's date** and the **One orbit date** in the first row of the table below.
   - Do the same steps for each planet, filling in the table as you go.
     - For the outer planets, zoom out (–) and increase the **Speed** of the simulation.

Planet	Today's date	One orbit date	Year length
Mercury			months
Venus			months
Earth			years
Mars			years
Jupiter			years
Saturn			years
Uranus			years
Neptune			years

3. Calculate: A **year** is the time it takes a planet to complete one orbit. Use your data to estimate the **Year length** for each planet. Use time units of Earth years or Earth months. Why does it take the outer planets so long to orbit the Sun? Try to come up with 2 reasons.

   _____

   _____

Activity B: **Comparing planets**	Get the Gizmo ready: • Select the SIZE tab.	

Question: What are the interesting features of each planet?

1. Observe: Look closely at the diagram of planets. Based on the diagram, list the planets from smallest to largest:

   _____ (smallest) _____ _____ _____

   _____ _____ _____ _____ (largest)

2. Compare: How do the four rocky planets compare to the four gas giants in size?

   _____

3. Analyze: Most planets are surrounded by layers of gas called an **atmosphere**. Click on each planet and read about it. Focus on information about each planet's atmosphere.

   A. Of the rocky planets, which have well-developed atmospheres?

      _____

   B. Which has only a thin atmosphere? _____

   C. Which has no atmosphere at all? _____

   D. Which planets are mostly "made of" atmosphere? _____

      _____

4. Analyze: How is the size of a planet related to the thickness of its atmosphere? Explain.

   _____

   _____

5. Extend your thinking: Which planet do you think would be easiest for humans to colonize some day? Explain. _____

   _____

   _____

Name: _____ Date: _____

Student Exploration: Solar System Explorer

Vocabulary: astronomical unit, dwarf planet, eccentricity, ellipse, gas giant, Kepler's laws, orbit, orbital radius, period, planet, solar system, terrestrial planet

Prior Knowledge Questions (Do these BEFORE using the Gizmo.)

1. List all of the **planets** you can think of in our **solar system**. Try to list them in order from closest to farthest from the Sun.

   _____

2. Which planets are most like Earth? Which are most different from Earth? Explain.

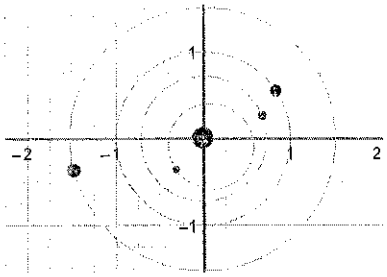
   _____

   _____

   _____

Gizmo Warm-up

The *Solar System Explorer* Gizmo shows a model of the solar system. All of the distances, but not the sizes of the planets, are shown to scale. To begin, turn on **Show orbital paths** and click **Play** (▶). You are looking at the four inner planets.



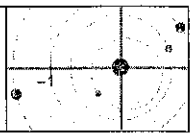
1. In which direction do planets go around the Sun, clockwise or counterclockwise? _____

2. An **orbit** is the path of a body around another body. What is the shape of the planetary orbits around the Sun? _____

3. Click **Pause** (⏸). You can see the name of each planet by holding your cursor over the planet. What is the order of the eight planets, starting from the Sun? Click the "zoom out" button (−) to see the outer planets and Pluto, which is classified as a **dwarf planet**.

   _____

   _____

Activity A: Classifying planets	Get the Gizmo ready: • Click **Reset** ( ).	

Question: How are planets classified?

1. Think about it: How do you think astronomers group planets? _____

   _____

2. Gather data: Select **Mercury** from the **Solar system** menu at left. Turn on **Additional data**. In the table below, record Mercury's **Mass**, **Mean radius**, and **Density**. Then repeat for each of the other planets as well as the dwarf planet Pluto. Include units.

Planet	Mass ($\times 10^{23}$ kg)	Mean radius (km)	Density (g/cm^3)
Mercury			
Venus			
Earth			
Mars			
Jupiter			
Saturn			
Uranus			
Neptune			
Pluto (dwarf planet)			

3. Analyze: What patterns do you notice in your data table? _____

   _____

   _____

4. Analyze: Based on the data you have collected, how would you divide the planets into two groups? Explain your reasoning. (Note: Do not include Pluto in these groups.)

   _____

   _____

   _____

(Activity A continued on next page)

Activity A (continued from previous page)

5. Classify: Astronomers classify the eight planets in our solar system into two groups: **terrestrial planets** and **gas giants**. Terrestrial planets have rocky surfaces, while gas giants are composed mainly of gas. Based on your data, classify each planet as a terrestrial planet or a gas giant. (Hint: Look at the density of each planet.)

Mercury:	_____	Jupiter:	_____
Venus:	_____	Saturn:	_____
Earth:	_____	Uranus:	_____
Mars:	_____	Neptune:	_____

6. Summarize: Compare the masses, radii, and densities of the terrestrial planets and the gas giants.

   A. What do the terrestrial planets have in common? _____

   _____

   _____

   B. What do the gas giants have in common? _____

   _____

   _____

7. Extend your thinking: Why doesn't Pluto fit into either the terrestrial planet group or the gas giant group? _____

   _____

   _____

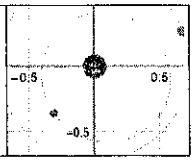
8. Think and discuss: Why do you think the inner planets are small and dense, while the outer planets are gas giants? If possible, discuss your ideas with your classmates and teacher.

   _____

   _____

   _____

   _____

Activity B: Planetary orbits	Get the Gizmo ready: • Click **Reset**. • Click the "zoom in" button (⊞) several times to zoom in as far as possible.	

Introduction: Johannes Kepler (1571–1630) was a German astronomer who spent years poring over a vast store of planetary data compiled by his predecessor, Tycho Brahe. After many incorrect theories and other setbacks, Kepler at last determined the beautifully simple physical laws that govern orbiting bodies. These rules are now known as **Kepler's laws**.

Question: What rules describe the size and shape of planetary orbits?

1. Observe: Select **Mercury** from the **Solar system** menu. Look at Mercury's orbit.

   A. What do you notice? _____

   B. Is Mercury always the same distance from the Sun? _____

   Kepler's first law states that an orbit is in the shape of a slightly flattened circle, or **ellipse**. While a circle contains a single point at its center, an ellipse contains two critical points, called *foci*. The Sun is located at one focus of a planet's orbit.

2. Gather data: The **eccentricity** of an ellipse describes how "flattened" it is. A circle has an eccentricity of 0, and a flat line segment has an eccentricity of 1.

   A. Look at the data displayed at left. What is the eccentricity of Mercury's orbit? _____

   B. Zoom out to look at the other orbits. Which object's orbit is even more eccentric than the orbit of Mercury? _____

3. Observe: Zoom in all the way, and select **Mercury** again. Check that the simulation speed is **Slow** and click **Play**. Observe the speed of Mercury as it goes around the Sun.

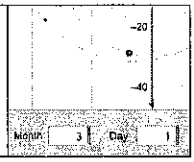
   What do you notice? _____

   _____

   Kepler's second law states that a planet speeds up as it gets closer to the Sun, and slows down as it moves farther away.

4. Confirm: Charge the speed to **Fast** and zoom out to observe Pluto. Does Pluto follow Kepler's second law? Explain. _____

   _____

Activity C: **Planetary periods**	Get the Gizmo ready: • Click **Reset**. • Zoom out as far as possible. • Set the speed to **Fast**.	

Introduction: Kepler's third law describes the relationship between a planet's **orbital radius**, or its mean distance from the Sun, and the planet's **period**, or amount of time to complete an orbit.

Question: How does a planet's orbital radius relate to its period?

1. Predict: How do you think the period of a planet will change as its distance from the Sun increases? _____

   _____

2. Observe: Click **Play**, and observe the orbits of all the planets. What is the relationship between the speed of planets and their distance from the Sun? _____

   _____

   _____

3. Measure: Click **Reset** and zoom in as far as possible. Click **Play**, and then **Pause** when Earth is aligned with either the grid's *x*-axis or *y*-axis. Note the starting time below.

   Then click **Play**, and then click **Pause** again when Earth is in exactly the same position. Note the ending time below.

Starting time	Month: _____	Day: _____	Year: _____
Ending time	Month: _____	Day: _____	Year: _____

4. Calculate: What is Earth's period? _____

   Earth takes 12 months to complete an orbit, so Earth's period is 12 months, or one year.

5. Measure: The distance units shown are the grid are called **astronomical units** (AU). Look at Earth's orbit. How far is Earth from the Sun in AU? _____

   As you can see, one astronomical unit is equal to the mean Earth-Sun distance, which is approximately 150,000,000 kilometers.

(Activity C continued on next page)

Activity C (continued from previous page)

6. Gather data: Use the **Additional data** display to find the orbital radius and period of each planet. Record this data in the first two columns of the table below. Include units.

Planet	Mean orbital radius (AU)	Period (Earth years)	R^3	T^2
Mercury				
Venus				
Earth				
Mars				
Jupiter				
Saturn				
Uranus				
Neptune				

7. Analyze: What happens to the period as the orbital radius increases? _____

_____

8. Calculate: Kepler discovered a very interesting relationship between the cube of each planet's orbital radius and the square of its period. Use a calculator to find the cube of each planet's orbital radius, and record these values in the "R^3" column of the table. Record the squares of the periods in the "T^2" column.

   How do the numbers in the "R^3" and "T^2" columns compare? _____

   _____

   Kepler's third law states that the cube of the orbital radius is proportional to the square of the period for any orbiting body. If the orbital radius is measured in astronomical units and the period is measured in Earth years, the numbers are nearly identical.

9. Predict: Pluto has an orbital radius of 39.529 AU. Based on Kepler's third law, what is the approximate period of Pluto's orbit? _____

   (Hint: Find the cube of the orbital radius first, and then take the square root.)

10. Confirm: Look up Pluto's actual period in the Gizmo. What is it, and how does it compare to the calculated value? _____