Binary Planetary Systems

Overview: A binary system exists when objects approach each other in size (and gravitational fields), the common point they rotate around (called the center of mass) lies outside both objects and they orbit around each other. Astronomers have found binary planets, binary stars, and even binary black holes. Students will know that the path of a planet around an object is due to the gravitational attraction between the object and the planet.

What to Learn: The path of a planet around the Sun is due to the gravitational attraction between the Sun and the planet. This is true for the path of the Moon around the Earth, and Titan around Saturn, and the rest of the planets that have an orbiting moon.

Materials

- Soup cans or plastic containers with holes punched (like plastic yogurt containers, butter tubs, etc.)
- String
- Water
- Sand
- Rocks
- Pebbles
- Baking soda
- Vinegar

Experiment

1. Thread one end of the string through one of the holes and tie a strong knot. Really strong.
2. Tie the other end through the other hole and tie off.
3. Go outside.
4. Fill your can partway with water.
5. Move away from everyone before you start to swing your container in a gentle circle. As you spin faster and faster, notice where the water is inside the container.
6. Now empty out the water and replace it with rocks. Spin again and fill out the data table.
7. To make carbon dioxide gas, you'll need to work with another lab team. Cover the bottom of your container with baking soda. Add enough vinegar so that the bubbles reach the top without overflowing. Wait patiently for the bubbles to subside. You now have a container filled with carbon dioxide gas (and a little sodium acetate, the leftovers from the reaction). Carefully pour this into the empty container from the other lab team. They can spin again and record their results. When they are done, borrow their container and give them yours so they can fill it for you.

Binary Planetary Systems Data Table

When filling out the third column, notice how hard or easy it was to spin the container, what it felt like, which way it faced, etc. Record everything you can about each one.

Item in the Can	**State of Matter** *(solid, liquid, or gas?)*	**What did you notice?**
Water		
Rocks		
Sand		
Air		
Pebbles		
Carbon Dioxide Gas		

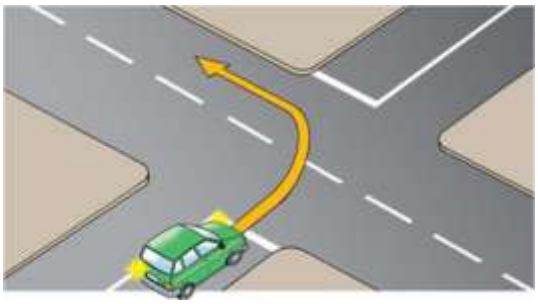
Reading

The path of a planet around the Sun is due to the gravitational attraction between the Sun and the planet. This is true for the path of the Moon around the Earth, and Titan around Saturn, and the rest of the planets that have an orbiting moon.

Charon and Pluto orbit around each other due to their gravitational attraction to each other. However, Charon is *not* the moon of Pluto, as originally thought. Pluto and Charon actually orbit around each other. Pluto and Charon also are tidally locked, just like the Earth-Moon system, meaning that one side of Pluto is always faces the same side of Charon.

Imagine you have a bucket half full of water. Can you tilt a bucket completely sideways without spilling a drop? Sure thing! You can swing it by the handle, and even though it's upside down at one point, the water stays put. What's keeping the water inside the bucket?

Before we answer this, imagine you are a passenger in a car, and the driver is late for an appointment. They take a turn a little too fast, and you forgot to fasten your seat belts. The car makes a sharp left turn. Which way would you move in the car if they took this turn too fast? Exactly – you'd go sliding to the right. So, who pushed you?



No one! Your body wanted to continue in a straight line, but the car is turning, so the right side car door keeps pushing you to turn you in a curve – into the left turn. The car door keeps moving in your way, turning you into a circle. The car door pushing on you is called centripetal force. Centripetal means "center-seeking**."** It's the force that points toward the center of the circle you're moving on. When you swing the bucket around your head, the bottom of the bucket is making the water turn in a circle and not fly away. Your arm is pulling on the handle of the bucket, keeping it turning in a circle and not letting it fly away. That's centripetal force.

Think of it this way: If I throw a ball in outer space, does it go in a straight line or does it wiggle all over the place? Straight line, right? Centripetal force is the force needed to keep an object following a curved path.

Remember how objects will travel in a straight line unless they bump into something or have another force acting on them, such as gravity, drag force, and so forth? Well, to keep the bucket of water swinging in a curved arc, the centripetal force can be felt in the tension experienced by the handle (or your arm, in our case). Swinging an object around on a string will cause the rope to undergo tension (centripetal force), and if your rope isn't strong enough, it will snap and break, sending the mass flying off in a tangent (straight) line until gravity and drag force pull the object to a stop. This force is proportional to the square of the speed - the faster you swing the object, the higher the force.

Exercises

1. How is spinning the container like Pluto and Charon?
2. What would happen if we cut the string while you are spinning? Which way would the container go?
3. What happens if we triple the size of your container and what's inside of it?

Answers to Exercises: Binary Planetary Systems

1. How is spinning the container like Pluto and Charon? (You are always facing the same side of the container, just like Pluto and Charon are always facing the same sides of each other.)

2. What would happen if we cut the string while you are spinning? Which way would the container go? (In a straight line tangent to the curve at the moment we cut the string.)

3. What happens if we triple the size of your container and what's inside of it? (It takes more energy to swing a larger load around. For one object to orbit another, they must have strong gravitational attraction to move that much mass around.)