Experiment 5:

Angular Momentum and Centripetal Motion:

To understand the meaning of angular momentum in terms of a rotating object. Demonstrate centripetal motion and Newton's First law of motion.

1. A playground swing with long chains
2. A small, sturdy bucket with a secure handle
3. Water
4. One strip of paper for each child plus a few extra strips (1 inch wide, 11 inches long)
4. Tape
5. Writing utensils

Genesis 1:1 tells us that "In the beginning, God created the heavens and the earth."

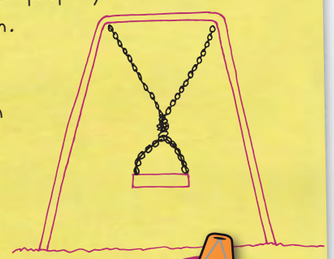
God set everything in motion when He created the universe. One of the kinds of motion we see is spinning motion. Can you think of anything that spins or moves in a circle? (ballerina, ice skater, earth on its axis, spinning basketball, etc). Today, we are going to experiment with **angular momentum** and **centripetal motion**.

- Angular momentum is how an object spins on its axis. Think of a top spinning in place.
- Centripetal motion is circular motion. Think of a satellite orbiting the earth or a stone tied to a string being swung in a circle.

Swing & Angular Momentum:

Hazards: make sure the swing is sturdy. Instruct children to hold on tight.

Use a baby swing if child is too young to hold on properly. The children will be dizzy after experiencing angular momentum.



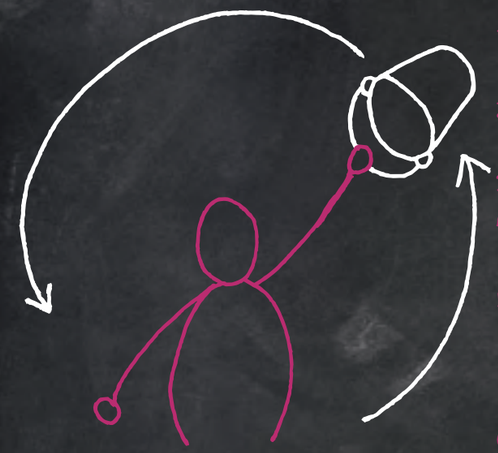
1. Ask a child to sit in the playground swing.
2. While standing stationary, spin the child in the swing seat in order to wind the chains up, up, up (at least 5 or 8 turns).
3. Form a hypothesis: What will happen when the swing is released?
4. Test the hypothesis. Release the swing and let the child spin. Say, "ANGULAR MOMENTUM" as the swing spins.
5. Let the children take turns, saying "ANGULAR MOMENTUM" every time the swing spins.

Inertia:

1. This is the same as Activity 1, except have the child extend his legs and torso out before the swing is released.
2. Release the swing. Then ask him or her to tuck his or her arms and legs in. (This decreases the child's inertia and increases his or her rate of rotation).
3. What happened to the speed of the spin?
4. Next, wind the chains up again. Form a hypothesis: What will happen to the speed of the spin if the child begins the spin with arms and legs tucked in, then extends his or her body half way through the spin? (This increases the child's inertia and decreases his or her rate of rotation).

Centripetal Motion

Swinging a bucket full of water: Best if done outside



1. Fill the bucket about half way with water.
2. Form a hypothesis: Can the bucket be turned upside down without the water spilling?
3. Let the children test their hypothesis.
4. Ask the children to stand back for safety.
5. Then the teacher demonstrates that the bucket can be quickly swung in a vertical circle without spilling the water.
6. Be careful not to swing the bucket too slowly.

Is the water in the bucket defying gravity? Gravity is still pulling down on the water, even when it is above your head. According to Newton's first law of motion, objects in motion tend to remain in motion unless acted upon by an outside force. This is known as inertia. The water's inertia is pulling it in a straight path (imagine if you suddenly released the handle of the spinning bucket). However, gravity is pulling the water down toward the earth. While the water is falling, the bucket is falling with it. By swinging the bucket, you provide the force to overcome the force of gravity. This is centripetal force. It keeps the bucket and water moving around a circular path as directed by your arm (the radius). It pulls the bucket and water toward the center of the circle and keeps them from following the straight path of inertia. Centripetal motion is simply movement in this circular path. (Note to teachers: The force that pushes the water toward the outside of the circle, keeping it in the bucket, is centrifugal force. The force that pulls the bucket toward the center of the circle is centripetal force).

God's Love Möbius Circle

ACTIVITY 4

Depending on the dexterity of the students, this can be done as a demonstration or as a student activity.

1. Circle 1: Use one strip of paper to create a simple circle. Tape it in place.
2. Circle 2: Use another strip of paper to create a second loop, but put a full twist in one end before taping it.
3. Circle 3: Use a third strip of paper to create a Möbius loop by simply putting a half twist in one end before taping it.
4. Ask children to examine the three circles of paper. How many sides do they have?
5. Hold up circle 1. This circle is like how God created Adam and Eve in the beginning. They were in complete union with Him. However, when they sinned, it caused separation from God. Use scissors to cut a straight line down the center of the circle to create two separate circles. This is what sin does, it separates us completely from God.
6. Hold up circle 2. But God still loved His children so much, that he sent Jesus to die for our sins. We are forgiven of the sin that separated us from God. Use scissors to cut a straight line down the center of circle 2. Hold up two linked circles. Now, nothing can separate us from God!
7. Hold up circle 3. God promises to love us, unconditionally. His love brings blessings to us, it does not matter how unlovable we may be.

> In Hebrews 13:5 , the Lord says, "Never will I leave you; Never will I forsake you."

Use scissors to cut a straight line down the center of circle 3. Hold up the single continuous circle. God's love is eternal and unfailing! Our Lord never changes.

8. Ask children to write Hebrews 13:5 on a strip of paper. Then tape it to create a Möbius loop.

APPLY IT

- Look for angular momentum as you go through your day: pinwheel, ice skater, spiraling football.
- Look for examples of centripetal motion as you go through your day. Like a car tire or bike tire spinning, a merry-go-round, Ferris wheel.

Further Bible Study:

- Separation from God: Genesis 3, Isaiah 59:2, Romans 3:23, Romans 6:23
- Jesus' sacrifice: Isaiah 53:5, Romans 4:25, 1 Peter 3:18
- God's love: Psalm 102:12, John 3:16, Romans 8:37-39, Ephesians 2:4-5, Romans 5:8

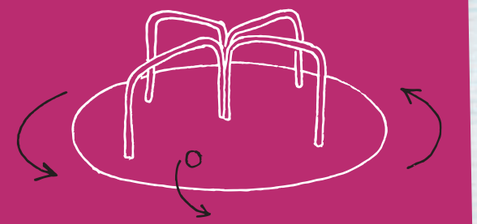
GO BEYOND

- Study the two scientists who independently discovered the Möbius loop, August Ferdinand Möbius and Johann Benedict Listing.

Angular Momentum:

- Watch a figure skater spin faster when her arms and legs are tucked in, then slower when she extends her arms and legs. This is a wonderful demonstration of conservation of angular momentum. She reduces her inertia by pulling in her arms, thus increasing her rate of rotation.

Centripetal Motion:



- Let your child try to swing the water around in the bucket. Alternatively, a tennis ball on a string demonstrates centripetal motion quite well.
- Find a playground merry-go-round. Spin it and let your child feel the circular motion and centrifugal force pushing them toward the outside edge of the circle.
  - Place a pebble on the outer edge of the still merry go round, begin spinning the merry go round. Slowly at first, then speed up until the pebble spins off. Ask, why did the pebble spin off? The centrifugal force overcame the friction and gravity that held the pebble to the merry go round.
  - Experiment with different size pebbles at various distances from the center. Allow your child to draw his own conclusions.
- Research the differences between centripetal force and centrifugal force.

Experiment 6:

Buoyancy of Boats

Understand buoyancy. Experiment with water displacement and buoyancy using student-created boats.

1. Clear plastic cups
2. Markers
3. 5-10 waterproof objects (some of which float and some of which sink)
4. Aluminum foil
5. Clay
6. Craft sticks
7. Scrap fabric
8. Toothpicks
9. Wax paper
10. Bowl or bucket of water
11. 50-100 pennies
12. Paper for each child
13. Pencils
14. Crayons

(Optional: glue, cotton balls, blue tissue paper).

Mark 4:35-41
Jesus Calms the Storm

That day when evening came, he said to his disciples, "Let us go over to the other side." Leaving the crowd behind, they took him along, just as he was, in the boat. There were also other boats with him. A furious squall came up, and the waves broke over the boat, so that it was nearly swamped. Jesus was in the stern, sleeping on a cushion. The disciples woke him and said to him, "Teacher, don't you care if we drown?"

He got up, rebuked the wind and said to the waves, "Quiet! Be still!" Then the wind died down and it was completely calm.

Mark 35:40, [Jesus] said to his disciples, "Why are you so afraid? Do you still have no faith?"

They were terrified and asked each other, "Who is this? Even the wind and the waves obey him!"

Have you ever been on a boat? The story says that "the waves broke over the boat, so that it was nearly swamped." What were the disciples worried about? What would happen if the boat was swamped or filled with water? Would you have been worried if you were in a boat that was filling with water?

Does a metal boat float or sink on water?

Does a metal nail float on or sink in water?

How can it be that a boat floats, but a nail sinks?

Water Displacement:

1. Give each student a clear cup half full of water. Have them use a marker to indicate the water level.
2. Have each student choose an object to drop in the water.
3. Form a hypothesis: What will happen to the water level when the object is dropped into the water? Mark your prediction on the cup with a line and write an "h" beside it for "hypothesis."
4. When forming a hypothesis or discussing an outcome, encourage the students to consider mass, size, and density.
5. Test the hypothesis by dropping the object into the water. Did it float or sink? How much did the water level change? Was your hypothesis correct?
6. Advanced students can use a ruler to measure and record how much the water level rises.
7. Water displacement is simply the amount of water that the object moves out of the way.
   a. If the object sinks completely, then the volume of water displaced is equal to the volume of the sinking object.
   b. If the object floats, then the weight of the water displaced is equal to the weight of the floating object.
   c. This is the principle of buoyancy, which states that an object partially or totally submerged in water displaces water according to how much it weighs. The water pushes up against the object with a force equal to the weight of the water it displaces.

Boat Float:

1. Ask each student to build a small boat out of aluminum foil, clay, craft sticks, scrap fabric, toothpicks, wax paper, and other similar materials. They can build multiple boats if they desire. Younger students will probably do better with only aluminum foil and a model boat to duplicate.
2. Form a hypothesis: Will the boat float or sink?
3. Test the hypothesis in the bowl of water.
4. Ask students to make improvements until each student builds a boat that will float.
5. In order for a boat to be functional, it must have buoyancy. That means it displaces a weight of water equal to the weight of the boat.

Sink the Boat:

1. Ask students to add pennies to their boat one at a time until the boat sinks.
2. Which boat held the most pennies? Why?
3. Explain that a boat becomes waterlogged when it tips over, leaks, or large waves wash over it. The air space inside the boat causes the boat to displace a large of volume of water, thus causing it to be buoyant. When the boat becomes waterlogged, the air is replaced with water. Therefore, the air is no longer displacing the water, and the boat sinks. The volume of water displaced is equal to the volume of the sinking boat.

In the Boat With Jesus:

Sometimes life is going along smoothly; everything is fine. Life is like a boat sailing quietly through a calm sea. Then a big storm blows up. Maybe someone we love gets very sick, maybe one of our parents loses his/her job, maybe a beloved pet dies. Have any of you ever encountered a storm?

Re read Mark 4:35-41. Where was Jesus? He was in the boat. If our faith is in Jesus, we will always face the storms with Him by our side. In life, we will face plenty of opposition and temptation. The storm may rock our boat, but it will never sink our boat. Nothing can take us away from Jesus; He is in the boat. We should never let the presence of a storm make us doubt the presence of Jesus.

In Mark 4:35-41, whose idea was it to cross the lake? It was Jesus's idea! He said, "Let us go over to the other side." The disciples were in the storm because they were following Jesus's instructions. Just because we find ourselves in a storm, it does not necessarily mean we have done something wrong. We do not always know why there are storms. Maybe God allows Satan to cause them, maybe God sends them to test us, maybe our world is just broken and full of storms, but God is so powerful, His purposes will always be served. Our faith will grow. God will use the storm to produce a good inside us.

Put your hope in the Lord, not in the boat. And do not be afraid.

1. Give each student a sheet of paper and crayons, pencils, and markers. Ask them to draw the boat (optional: glue craft sticks onto the paper to create a wooden boat).
2. Then, draw Jesus in the boat. Then, draw a picture of themselves in the boat looking peaceful.
3. Then, draw the waves (optional: glue blue tissue paper down to create a turbulent ocean).
4. Last, draw the wind and the storm (optional: glue down cotton balls as clouds and slices of foil as lightening).
5. Have children write, **"Why are you so afraid? Do you still have no faith?"** on their pictures.

Apply It

- Look for boats, ducks, floating leaves, floating bath toys, and other floating objects as you go through your week.
- While on dry land, ask your child to pick you up. It is impossible. Then, get into a swimming pool, lake, or hot tub. Ask your child to pick you up as you relax in the water. It is easy!
    - In the water, you displace the weight of water equal to your volume. Thus, the water pushes you up, helping the child lift you more easily than he or she can on land. This is buoyancy!
- Read and discuss James 1:2-8: "Consider it pure joy, my brothers and sisters, whenever you face trials of many kinds, because you know that the testing of your faith produces perseverance. Let perseverance finish its work so that you may be mature and complete, not lacking anything. If any of you lacks wisdom, you should ask God, who gives generously to all without finding fault, and it will be given to you. But when you ask, you must believe and not doubt, because the one who doubts is like a wave of the sea, blown and tossed by the wind. That person should not expect to receive anything from the Lord. Such a person is double-minded and unstable in all they do."

Go Beyond

Further study - Greek philosopher and scientist, Archimedes.

He observed that when he got in the bath tub, the water level rose. From this observation he developed **Archimedes' Principle**, which states that the buoyancy force pushing an object upward is equal to the weight of the water displaced by the object.

Next time your child takes a bath, mark the water line before and after he or she gets in the tub. Mention Archimedes' Principle.