Spin to Win

How can we use rotational motion to our advantage?

You have probably seen athletes spin basketballs and make them balance on their fingers. You may have even tried it yourself. Maybe you have watched your favorite Thunder player jump, catch a high pass, and then windmill slam dunk. Have you ever wondered what keeps the ball from flying out of a player's hand during such a dramatic dunk or how spinning the ball keeps it balanced on a finger? Let's explore these kinds of movements.

HERE'S WHAT YOU'LL NEED:

- **2 1-liter bottles filled with water**
- **Chair that spins, like an office or desk chair**
- **Stopwatch**
- **Journal**
- **Something to write with**
- **1 can of broth*** *(chicken noodle soup can work for this too)*
- **1 can of condensed cream soup***
- **Ramp** *(a ramp can be made with simple things you may find in your classroom like a stack of books and a table)*
- **Masking tape or Post-It Notes**
- **Can opener for cans without pull tabs**

Optional:

- **Things with mass. Of course, everything has mass — but for this activity, things like tiny weights, marbles, pennies, playdough, etc.**
- **Hot glue or tape**

Pro-tip: Remove the labels from the soup cans and use the tape and the marker to mark one can of soup "A" and one can "B" before starting this activity.

WARMUPS

Start with the empty chair like an office chair that spins. Give it gentle push so that it rotates without moving forward or backward. **Does it move easily? How does it spin? How difficult is it to keep it moving?**

Next, sit in the chair. Use your foot to give yourself a push to spin, or ask a friend to give you a gentle push. **Do you and the chair move easily? How do you spin compared to the empty chair? Is it more or less difficult to keep moving than it was before?**

Let's continue this experiment with a little bit of a twist. Grab two 1-liter water bottles and return to the chair. With the bottles held close to your body, use your foot to give yourself a push, or ask a friend to give you a gentle push to start the chair spinning. Use the stopwatch to record how long you spin. **How do your movements here compare to the earlier trials? Did you find it more difficult to start or stop?** Repeat the activity three times. Record your findings in your journal.

Repeat the activity again, but this time instead of holding the bottles near your body, hold the bottles out with your arms fully extended. Record your observations and compare them with what you you've experienced so far. Repeat the activity three times. Use the stopwatch to note how long you spin with each push. Record your findings in your journal.

When you sat with the bottles close to your body and when you sat with the bottles extended far from your body, was the mass of you, the chair, and the bottles the same? If it is the same amount of stuff as before, then the mass hasn't changed. **What has changed?** Write down your explanation next to your recorded times.

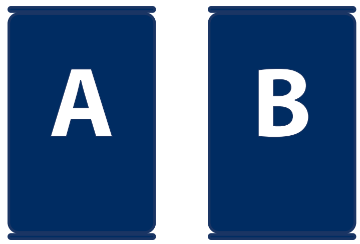
When scientists want to learn things they are very careful to change only one thing at a time. This allows to test the difference that just that one thing makes. This one thing is called the **variable.**

Repeat the activity again, but this time introduce a different variable. Holding the bottle with your arms fully extended, use your foot to give yourself a little push, or ask a friend to give you a gentle push. As soon as you are moving well, pull the bottles back in toward your body. Did you speed up or slow down? Repeat the activity three times. Use the stopwatch to record how long you spin with each push. Record your findings in your journal.

You may have noticed some athletes like ice skaters use a similar technique when they pull their arms in once they have started spinning. **How does changing the position of the bottles affect how long or fast you spin? How would you explain it scientifically?** Record your explanation in your journal.

GAME TIME

Now that you have witnessed how mass and placement of mass can affect how something spins, it's time to perform an experiment. For this activity you will need two cans of soup labeled "A" and "B."

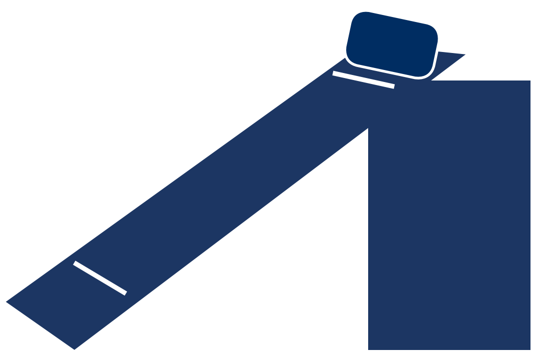


You will need a ramp. Ramps are relatively simple to make. A board with one end popped up on a box makes a great ramp. A table can be made into a ramp by stacking old books under the legs of one side of the table. You'll want to make sure both legs are elevated about the same height.

Mark the starting line and the finish line on the ramp with masking tape or Post-It Notes.

Start with soup can "A." Examine the can without opening it. Hold it and gently shake it. What do you think the contents inside might look like? In your journal, record your observations.

Set soup can "A" on its side so it is inclined to roll down the ramp. Hold it in place, so it is just on the higher side of the starting line. Ask a friend to start the stopwatch when you let go of the can and stop the stopwatch when it passes the finish line. Create a table in your journal. Repeat the activity two more times. Record the times on your table in your journal.



Next examine soup can "B." Is it noticeably different than soup can "A"? What do you think the contents inside might look like? Record you observations in your journal.

Repeating the same process used with can "A," test can "B." Record all three rolling times in your table along noting this can as "B" instead of "A."

After you have tested both cans of soup, add up the times it took each can of soup to reach the finish line from the starting line, divide this number by three. This will give you the average time it took can "A" and can "B" to travel the distance from the starting line to the finish line. Record these averages in your table.

Open the cans to examine their contents. Were your predictions about what the contents of each can would look like correct? What about the contents of the cans do you think affected the amount of time it took each can to cross the finish line? How do you think the contents within in the soup cans may have moved while it was spinning down the ramp?

ANALYZE THE REPLAY
What happened?

Using what you observed in the Game Time activity, make a prediction of how an emptied soup can will travel down the ramp. Using what you have learned about mass and where it is located on a spinning object, do you think an empty can will move faster or slower than the other cans? Record your prediction.

Empty and rinse both cans. Repeat the Game Time activity with the empty cans. Record all three times and find the average time the can took to travel from the starting line to the finish line. Was your prediction correct?

Think about basketball and what you have observed in these activities. Which of these cans is a basketball most like? Imagine how spinning a basketball on your finger might be different if it was filled with a fast moving liquid or slower moving thick soup. Do you think spinning a basketball with a solid rubber core would be more or less difficult than spinning a basketball filled with air? Imagine a basketball having greater mass. Would jumping up and catching a basketball with greater mass be more or less difficult than a regular basketball? Why? Imagine a basketball filled with water, much like a water balloon or the can of soup with runnier contents. Do you think a basketball player could catch it in mid-air and windmill dunk? Do you think the basketball would be hard to handle? Discuss your thoughts based on your observations from the activities you performed.

OVERTIME
Let's take it further

We have witnessed that the position of mass affects how quickly something gets moving, the speed at which things roll, and how difficult they are to stop. Let's put this information in action.

For this activity you will use the ramp, the stopwatch, and an empty soup can from **Game Time.**

What modifications can you make to the empty can that will allow it to reach the finish line as quickly as possible? You may use pennies, playdough, marbles, tiny weights, or whatever you can find to attach to the can with tape or hot glue. Use what you have learned so far to help you position any additional mass you add. Test your time with each adjustment you make. Draw your designs in your journal and record the times. You may find that some of your adjustments may actually slow the can down. When that happens investigate the variable and reflect on what you witnessed in these activities. It's all part of the design and engineering process.

COACH'S CORNER
Additional information and explanations for parents and educators

As scientists, we often simplify the world to help us better understand it. Motion is one of the areas we simplify. When you toss a ball the motion of the ball is moving in a straight line, spinning, being pulled on by gravity, slowed by air resistance, and being affected by numerous other things. Looking at everything affecting the ball at the same time can be confusing and messy. Limiting our observations to one type of motion by controlling the variables is how we do science.

Changes in motion can be thought of as a balance between things that cause change and things that resist change. For example, when you spin the chair the force of your push causes the change. Due to **inertia** the chair initially resists moving, but once in motion, inertia is also the reason the chair stays in motion until outside forces bring it to a stop. Inertia explains why resting objects tend to stay at rest and why moving objects tend to stay moving. Simply stated, more force results in more change, and more inertia results in less change.

When things are spinning, or in rotation, the balance between things that cause motion and things that resist change are is more complex. Force that changes spin is called **torque.** Mass and location of the mass both resist change. If there is more mass located at the center point of a something that spins it is easier to get it moving or cause change. If the mass is located away from the center point of something that spins it is more difficult to get it started moving and it is also much harder to get it to stop moving. A spinning basketball keeps spinning on your finger for a long time because it is a hollow shell with most of the ball's mass in the ball's outer skin, while the inside is filled with air. This makes it spin longer than a solid foam basketball would.

Change in motion is called **acceleration. Newton's Second Law** explains the greater the mass of an object the greater amount of force needed to make that object accelerate. Think about the difference between rolling a basketball and a bowling ball. When acceleration happens in a spinning motion rather than a straight line, the location of the mass has an effect on the amount of motion resisted. This was experienced when moving the two 1-liter bottles of water when spinning on the chair.

This activity can be done by asking for donations of empty soup cans and done by opening only two soup cans to show the contents inside. This will allow the activity to be performed at stations and use less supplies. Things added to the empty cans can be removed at the end of the activity to be reused again.

DO YOU WANT TO LEARN MORE?

Research: Acceleration, inertia, momentum, Newton's Second Law, rotational motion, torque, variables, velocity

OKLAHOMA ACADEMIC STANDARDS - SCIENCE

STANDARD		3RD GRADE	4TH GRADE	5TH GRADE	6th Grade
PS2-1	Motion and Stability: Forces and Interactions	●		●	
PS2-2	Motion and Stability: Forces and Interactions	●			
PS3-1	Energy		●	●	
MS-PS2-5	Motion and Stability: Forces and Interactions				●
MS-PS3-1	Energy				●
MS-PS3-2	Energy				●