

Why do hurricanes go counterclockwise in the northern hemisphere?

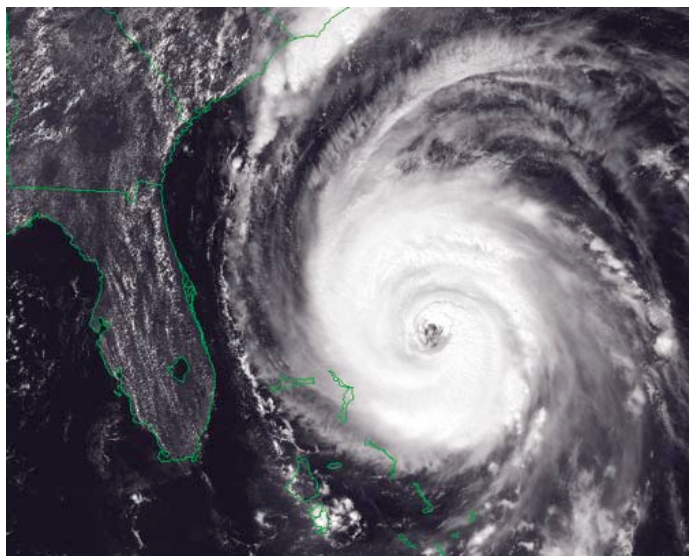
A laboratory experiment from the Little Shop of Physics at Colorado State University



Overview

The Coriolis force is part of the reason that hurricanes in the Northern Hemisphere rotate counterclockwise. If the Earth didn't spin, we would have wicked 300 mph winds from the tropics to the poles and back again. The Earth does spin however, and in the mid-latitudes, the Coriolis force causes the wind—and other things—to veer to the right. It is responsible for the rotation of hurricanes.

But the Coriolis force on earth only works on very large scales. It doesn't affect such small things as toilets and sinks. You may have heard of people claiming that toilets and sinks swirl counterclockwise in the Northern Hemisphere and clockwise in the Southern Hemisphere due to this force. As cool as that would be, it's just not true. It turns out that the way the water swirls has to do with a number of conditions such as the



As the air moves toward the low pressure region in the center, the Coriolis force causes a rightward deflection—leading to the counterclockwise rotation of the hurricane.

Necessary materials:

- One foam ball
- A large area to form a circle with your students
- An even number of participants

You may want to demonstrate with just 2 to 6 people in the circle before attempting this with your class. It is also helpful to have a few adults participating in the circle. This activity will be successful if students understand the directions and also are dexterous enough to catch a ball. We know! We tried this with 4th graders and eventually they caught on to how this worked and what was happening.

shape of the bowl and the way the water enters the bowl. Alistair B. Fraser lists other goofy examples people attribute to the Coriolis force in the different hemispheres, including, the way dogs circle before lying down, and the way women's ringlets curl. The website is called Bad Coriolis and can be found at www.ems.psu.edu.

Theory

So what is the Coriolis force? Let's look at a scenario before discussing it further.

Imagine two people playing catch. They are running in a straight line, parallel to each other and tossing the ball back and forth. The ball is easy to catch because they are always directly across from each other. Now, let's make this game more complicated. Our

two players opt to continue their game of catch, but decide to run in a circle where they are still across from each other. As they circle counterclockwise, the ball is tossed. Rather than go directly to the catcher, the ball appears to veer to the right. They try it again and the same thing happens. They think something mysterious is pushing the ball to the right. When they ask their friends who have been watching the game, the friends say the ball went straight and the two players just missed it. What is going on?

Why did the players think the ball veered to the right, yet their friends watching from the sidelines, clearly saw that the ball traveled a straight path. It all has to do with frame of reference and Newton's 1st Law: All objects in motion stay in motion unless acted upon by an outside force. The ball does travel in a straight line... but the players don't!

The Coriolis force is an example of a fictitious force, and can be compared to another such force, the centrifugal force. You most likely have felt this while riding in a car. You are traveling straight ahead in a car, when suddenly the driver has to make a sharp left turn. Your body continues to travel forward, but it feels as if your body is pushing out on the car door. Actually, the car door is pushing in on you!

Doing the Experiment

- Have your group form a circle. Have each person point to their partner directly across from them, so they know whom they will toss the ball to.
- Have them take turns tossing the ball underhanded to their partners, so they get a feel for how hard they need to toss the ball to get it across the circle.
- Explain to the class that they will now turn their bodies to the right and start circling to the east, just like the Earth in its orbit. They will continue to toss toward their partner, but the ball can only be caught if it comes directly to an individual. The partner is not supposed to reach across and grab it from someone else.
- Students will soon see that the ball starts out aimed at the partner, but by the time it reaches the other side, is caught by the person to the right of the partner.
- It should appear as if the ball is veering to the right, by the participants in the circle.

Summing Up

The Coriolis force is a complicated concept that is difficult for many to grasp. Be patient and give your students as many experiences as you can with this concept. You may want to show them video clips to reinforce this activity. If you can find a merry-go-round in your area, use it with your students to reinforce this concept.

For More Information

CMMAP, the Center for Multi-Scale Modeling of Atmospheric Processes: <http://cmmmap.colostate.edu>

Little Shop of Physics: <http://littleshop.physics.colostate.edu>

Centripetal Critter Coaster

Students get to see centripetal force in action as it keeps stuffed critters from falling while being swung overhead.



Grade Level

- 4th - 8th

Science Focus

- centripetal force
- centrifugal force
- gravity

Time Required

- 15 minutes

Supplies

There are enough materials in the kit to run up to ten cooperative groups.

Per Cooperative Group

- 1 flying disk with three ropes attached
- 1 stuffed critter

A Special Word About Safety

This activity has students swinging disks over their heads at a pretty good speed. Clearly, this activity needs to be done in an open area, where the students swinging the disks can be well away from each other and from anything the disk might run in to. The disks and the critters are soft, but you should still take care that no one gets hit with a swinging disk! Try the activity yourself first and think about how this will work with your class. If you are uncomfortable with having your students do this - or if you don't have a place that this activity can be done safely - do this as a demonstration activity.

Doing the Activity

- Have the students remember and discuss the “Curve Ball” experiment. They should remember that the ball goes in a straight line unless there is force that keeps it going in a circle. Remind them that the force on the ball pushes it toward the center of the circle; this is the centripetal force.
- Have one student in each cooperative group stand well clear of the other students, hold the knotted end of the ropes, and swing the disk in a vertical circle over his or her head:



The motion will be like an inverted loop in a roller coaster. After one student has done this, each student in the group should try this motion. Have them practice this motion; they will need to do this later.

- Have the students discuss the motion. The motion is a circle, so there is acceleration; the velocity changes. Have them discuss what other experiments involved a change in velocity.
- Now, the students are going to add the stuffed critter to the situation. Have one student in each group hold the knotted end of the ropes so that the disk hangs down. Now, another student should place the critter in the center of the disk. The student holding the ropes should stand well away from the other students, and then swing the disk in a vertical circle. The challenge is this: can they swing the critter in a vertical circle without having the critter fall off the disk? This is just like the loop on a roller coaster, as we mentioned before, but this time with a passenger! If the students are careful, it is pretty easy to keep the critter safely seated on the disk.
- Have every student in each group try this activity; this is an activity that students must feel to be able to understand.
- Discuss what force keeps the critter in place - some suggestions for questions are below.

Active Questioning, Explanation, and Discussion

1. Which force keeps the critter moving in a circle?
2. What force keeps the critter in place? (In this case, we are going to think about the force that the critter feels. We know that since the motion is in a circle, there is a centripetal force. This force is provided by the ropes, which keeps things going in a circle. But the critter feels something else: it feels an outward push, and so will feel pushed into the disk. This apparent force is called the *centrifugal force*. The critter will feel pushed hard into the disk, and so will not fall off - even when it is upside down! Note that the centrifugal force isn't a real force. What the critter really feels is its inertia: it would like to move in a straight line, but it is not. It is this that leads to the feeling of a centrifugal force.)
3. Think about what the critter feels. If you were riding the disk, what would you feel? Why doesn't the critter fall off the disk when the disk is over your head? (As noted, the critter feels a force pushing it into the disk. This is the force that holds it in place.)
4. Why doesn't the critter fall off even when the disk is upside down? Gravity is pulling down... what is pushing it up? Would the critter stay on the disk even if you were swinging

- the disk really slowly? (Again, it's the centrifugal force that holds the critter in place. It is the circular motion that causes this force - so if the motion is too slow, the force is too small, and the critter won't stay on the disk! You can try this, if you would like.)
4. Have the students think about relationships to other experiments - such as the cup race. When you turned a corner, what happened to the water? Why? What force made the water want to slosh out? (This experiment is nicely understood as an example of centrifugal force. When you go around a corner, the water wants to keep moving in a straight line. So it will feel a centrifugal force that will make it want to slosh out of the cup. The only way to keep it from sloshing is to tip the tray to compensate, or else to go really slowly!)
 5. When have you felt this kind of force? Think about going around a circle in a car. How about a merry-go-round? Roller coasters?

Other Experiment Extensions To Try

1. This one should be done outside. The students can try the same activity using a cup of water on the tray instead of the critter. Once they master swinging the cup of water around in a circle like a roller coaster (in the vertical plane), have them try swinging it over head like a lasso (in the horizontal plane).
2. The students can also try swinging their arms around in a circle really fast. This will force a lot of blood down into the hand. Make sure the students have plenty of room all around them so they don't swing their arm into a desk or another student. The veins in their hands will swell from the excess blood - it feels a little strange, but looks really cool!
3. Instead of using the tray with a cup of water, they can swing a bucket of water around in a circle.
4. What keeps you in place when you're swinging on the swings in the playground? What would happen if you put a tennis ball loosely in your lap and went on the swings? Do you think the ball will stay in place?
5. Think of other places that centripetal and centrifugal forces can be observed: in a clothes washer or dryer, the water and mud that spins off a bicycle tire, going around a corner in a car.

Activity 3: Waiter Water Challenge

Supplies

There are enough materials in the kit to run up to ten cooperative groups.

Per Cooperative Group

- 1 cup
- 1 tray
- 1 stopwatch
- water
- sidewalk chalk (optional)



Doing the Activity

Special Note: *This activity is best outside as there is a high probability of water spills.*

- Prior to this activity, you'll want to delineate a course for the Waiter Water Challenge. You can use sidewalk chalk to draw a path, or use some other method, such as tape, to mark a course with both start and finish lines. We recommend that you use two straight parallel paths at first, while students are trying this out. They can race to the end of their path, turn around, and return to the next relay member of their team.
- Explain to students that their teams will use what they have learned about acceleration in the last two activities to compete with other teams in a relay race. Each member of the team will have a chance to act as waiter, carrying a tray with a full water glass on it. The goal is to not spill a drop, but also get to the finish line as quickly as possible.
- Remind students that in the last activity they varied their walking pace to study acceleration. They also tried to move at a constant velocity so the colored liquid in the accelerometer stayed level. Review what happened to the liquid in the accelerometers when they moved forward or stopped quickly.
- Have two teams line up at the starting line.
- Give the first student in each relay team a tray with a cup placed in the center. Fill the cup up to the top with water.
- Use the stopwatch to time the race and challenge each group of students to walk or run the course with the cup on the tray in the least amount of time, spilling the least amount of water.

Active Questioning, Explanation, and Discussion

1. What did you have to do while running the course to not spill any water (think about the hand held accelerometers)? (The best is to move at a constant velocity, because once you undergo an acceleration then it causes the water to spill.)
2. Are there other ways you can keep the water from spilling other than adding a lid to the cup? (You can tip the tray in the opposite direction of your movement to keep the water from spilling.)
3. How are velocity and acceleration related? (Acceleration is a change in velocity.)

Other Experiment Extensions To Try

1. Build your own accelerometer using an empty pop bottle. Fill the bottle half way with water and add a couple of drops of your favorite food coloring. Then add baby oil all the way to the top of the bottle. Screw the lid on tightly and seal the cap with tape or hot glue. Tip the bottle sideways and your accelerometer is ready to use. You can use your accelerometer to test acceleration in a car,

airplane, or when you're walking around town.

2. Create or have student groups help you create one or several outdoor courses for students to walk through carrying a tray and a cup of water. The course should have lots of turns and can even involve going around objects and walking backwards. A path could be created in an area with lots of sand, or a path could be drawn on asphalt or sidewalks with the sidewalk chalk.