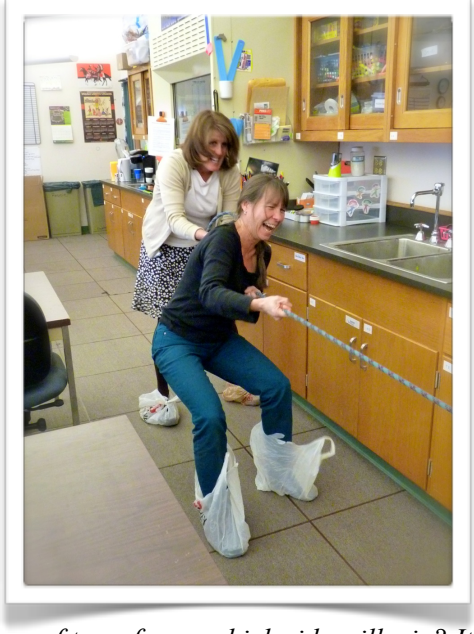
Friction Tug-of-War

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



In a game of tug-of-war, which side will win? It depends on the force of friction.

Grade Level

- Activities designed to address Kindergarten and 2nd Grade Standards

Science Focus

- Pulling
- Pushing
- Friction
- Molecules

Time Required

- 15 - 20 minutes

Overview

This exciting activity gives students a kinesthetic experience playing tug-of-war with the usual force of friction, and then replaying the game with one team wearing bags on their feet to reduce the force of friction.

Necessary materials:

- A long rope
- An area long enough for a tug-of-war game
- Painter's tape
- Plastic bags and pipe cleaners
- A sense of fun!

Theory

If Galileo were still alive, we'd have to thank him for pondering the force he named friction. It's a very important force to consider, and it's everywhere. When two objects touch and slide against each other, friction happens!

Let's think about what is happening at a molecular level. When two objects touch, they both compress and then push back on each other. For example, when you sit in your car, you are pushing down on the car seat, and the car seat is pushing back on you. The tiny particles (molecules) that make up both you and the car seat, compress and then push back, just like tiny springs. You explored this force, the normal force, in the last activity, when your students worked with poppers and pullback cars.

The difference with friction, is that the two surfaces are sliding across each other as they touch. When this happens, molecules tear apart! The molecules in each object don't want to be pulled apart, so they pull back, changing the motion of the two objects. The harder they push together, the more molecules get torn apart. Let's go back to the example of a person sitting in a car seat. When you get out of your car, you slide across the car seat. You will feel more or less friction, depending on the fabric of the car seat, and the fabric of your clothes. Some molecules are just "stickier" than others. I speak from experience! When I get out of a car with leather seats and I'm wearing shorts, there is a strong friction force, and I feel like I have to peel myself away from the seat. The molecules are really pulling back. When I slide out of a vehicle with bench polyester seats, I tear so many molecules apart, that static charges build up in my body, and I get quite a shock when I touch the gas pump (as do the gas station attendants)!

Doing the Experiment

Explain to your class that they are going to play a game of tug-of-war to learn more about forces. Choose an even number of students to be on each side of the rope. Have students spread themselves out on either side of the rope and pull lightly, so the rope is taut. Use painters' tape to mark the floor at the center point between team 1 and team 2. Explain that in the game of tug-of-war, one team must be able to pull the other team across that center tape line, thus winning the game.

Have the students in your class predict whether team 1 or team 2 will win and have them share their reasoning. They may say things like one team is stronger, or one team is bigger.

Now the exciting part! Begin the tug-of-war game and see who wins. There should be a lot of laughing and fun. Discuss the results and their thoughts on why it worked that way.

Now have students think about the forces happening in the game. Have the same teams recreate the start of the game, tugging gently on the rope, and then stop them in mid-action. Observe and think about what their bodies are doing as they tug on the rope, and discuss with your class.

You may have to ask questions that help them focus on forces. What are you doing with your hands on the rope? They are pulling on the rope. What pulls on you? Well, since we are pulling on the rope, the rope pulls back on us. What are your feet doing? They are pushing and sliding on the floor. What does the floor do? It pulls on you with friction!

Now have students on the winning team put plastic bags on both feet, and use pipe cleaners to tighten the bags around their ankles. Have the students play another game of tug-of-war, and see who wins this time. If you are wearing plastic bags on your feet, the rope wins and you lose. Discuss this new development with your students and find out why they think this happened. They may say that the bags are slippery which is true. Some molecules (your shoes) are stickier than other molecules (plastic bags). The stickier molecules don't want to tear apart, so they pull back with a bigger friction force. The plastic bags are less sticky, so the friction force is less.

Summing Up:

This is a great activity to help students experience and really focus on forces, especially the force of friction. We believe that thinking about friction at a molecular level helps everyone understand this important force.

For More Information

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

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