Java Script

No, this one doesn't have anything at all to do with computer programming! Instead, the title refers to the coffee cups we will use to explore the concept of center of gravity and Nature's "desire" to make things move so the final configuration is in a state such that energy is minimized. Observations about circular motion will also be made.

To complete this activity, simple materials are used: four Styrofoam or plastic cups (the larger the better), a hot melt glue gun or some tape to fasten them together, and two meter sticks or any other straight sticks that are handy and over a foot or two long.

Commentary

Before you do anything else, roll the cup a bit on the table or floor. How would you describe its motion? Is one end rolling faster than the other? Does one end travel further than the other during one full revolution?

When objects undergo circular motion, the speed of a point some distance from the axis of rotation (or center) is equal to the distance from the center , or axis of rotation, multiplied by the angular rate of rotation. For instance imagine horses on a merry-go-round (carousel). Riding on the outer horses is more thrilling than doing so on the inner ones because the outer ones are going faster (little kids to the center!). If the outer horses are twice as far from the center, then they go twice as fast. The speed we are talking about here is called the tangential velocity. Someone standing on the equator is moving more rapidly due to the earth's rotation than someone in NYC. When a car goes around a turn the outer tires have to go faster than the inside ones, as the path is longer (and so the wheels have to spin faster). Why don't we twist our axle like a pretzel when this happens, then? That problem is solved using a set of gears invented long ago called a differential (the wheels can rotate differentially). Look under a truck or car and you will always see a round ball in the middle containing those gears. Our coffee cups can only go around a turn of just one radius, as then essentially consist of two wheels, a small one at the base and a large one at the open end.

The concept of center of gravity is introduced in other exercises in this book for static cases (equilibrium), like balancing a fork and spoon on the edge of a glass, and we will use it here to explore how it influences motion.

For complicated shapes like two cups glued together, the center of gravity may be difficult to locate, but we can use symmetry. It must be located on the central axis, since the are round. Remember that the center of gravity is also the balance point for objects. I think you get the idea now.

Why do mountains continue to get smaller with time? Skiers go down the hill rather than up? The limbs of a dead tree eventually fall to the ground? The Titanic, sitting on the ocean bottom, eventually turns to rust? Nature has a tendency to “wind things down”, or minimize energy. It gives a directionality to things. The examples above seem obvious, but they are all examples of this tendency to make the total energy of a system a minimum. This rule works in physics, chemistry, and all of the sciences. To build things up, someone has to do work and put energy into the system. In the case of a mountain, that energy is finally converted into mechanical energy as a weathered boulder (this happens over and over) rolls down the hill to reduce the size of the mountain. Lets keep this general rule in mind as we observe the motion of our cups.

Inquiry

Before proceeding, glue or tape two pairs of cups together, one pair with the bottoms fastened together and the other with the rims, or tops fastened together. Draw your shapes for future reference. Lets call one pair the “fat in the middle” pair and the other the “skinny in the middle” pair.

- Roll both assemblies across the table or floor and describe their motion. Which is easier to control?

- Now take two meter sticks and set them up so they are parallel and spaced (held upright so they form “tracks”) so that the distance between them is about half the total width of the cup assemblies. Roll both the skinny and fat objects down the center of the track you made. Which one tends most to follow a straight path? Explain why.

- Now we are going to make our sticks into a “vee” shape by taping one end of the pair of them together. Open up the vee so that you have a point on one end and the opening on the other end is the same width as the width of the cup assemblies. Prop up the open end of the vee on a book so it is a few centimeters higher than the other end. Now you have a track which is an inclined plane. Take the fat in the middle assembly and place on the lower end near the point. You may have to give it a nudge or reduce the angle of the hill a bit, but does it roll uphill?

- What is the **center of gravity** doing when the motion above “uphill motion” takes place?

- Now try and repeat the above with the skinny in the middle assembly. What does it do? What happens if you elevate the other end of the track instead? Record all observations.

- For both assemblies, try experimenting with medium, large and small angles between the “rails” of the vee. Record your observations in your portfolio. Does the speed at which the assemblies roll depend in some way on the size of the angle? Explain why you think what you observed happened.

- Try and find an **angle of inclination** for your tracks such that the cup assemblies will not roll at all, that is, they are in a stable equilibrium. Relate this angle to the geometry of the cup assemblies.

- Let’s think about the following (imaginary) situation and record the answers in the portfolio. Instead of cup assemblies, you use a large and a small ball. You place the balls, one at a time, on the rails of your inclined vee assembly. Will one or both roll uphill, downhill, or just sit there? If they do roll, which one would go the fastest? Explain your answer to this thought experiment in terms of what you’ve learned from the above activity. If you have access to a ball, try it and see what happens!

- Draw a conclusion about center of gravity and the way systems move as they try to reach a “minimum energy” state (where the potential energy is as small as it can get).

- Railroad cars have tapered wheels. Take a look at one on a toy train sometime. They are shaped somewhat like our cups with a big flare and larger diameter on the inside of the track. Explain how this might help when a train goes around a curve. This is a pretty clever innovation! Actually, the wheels and axle are much the same as our “fat in the middle” cup assembly but with the cups held together by a stick. The train experiences a force directed toward the outside of the curve, sometimes called centrifugal force (we’ve all felt this). Explain what happens to the center of gravity of the wheel and axle assembly when rounding a curve.