



## Downhill Race

Two cylinders that look the same may roll down a hill at different rates. **Two objects with the same shape and the same mass may behave differently when they roll down a hill. How quickly an object accelerates depends partly on how its mass is distributed. A cylinder with a heavy hub accelerates more quickly than a cylinder with a heavy rim.**

### materials

**2 identical round metal cookie tins** (such as those from butter cookies).

**10 large metal washers** (about 1/4 pound [112 g] each).

**Double-sided foam stick-on tape** (or adhesive-backed Velcro™).

**A ramp**

### assembly

(15 minutes or less)

Arrange five of the washers evenly around the outside rim of the bottom of one tin. Stack five washers in the middle of the bottom of the second tin. In both cases, secure the washers with tape or Velcro™.

### to do and notice

(15 minutes or more)

Place both tins at the top of the ramp. Be sure the tops are on. Ask your friends to predict which tin will reach the bottom of the ramp first. Release the tins and let them roll down the ramp. The tin with the mass closer to the center will always reach the bottom first.

### what's going on?

At the top of the ramp, both tins have identical potential energy, since both have the same mass and are at the same height. At the bottom of the ramp, each tin will have part of its original potential energy appearing as *linear* (or *translational*) *kinetic energy* and the rest appearing as *rotational kinetic energy*. Though both tins have the same total mass, each has this mass distributed differently. It is harder to get the tin with its mass distributed along the rim rotating than it is to get the tin with its mass concentrated at the center rotating. The tin with its mass at the rim will use a greater part of its original potential energy just to get rolling than will the tin with its mass concentrated at the center. Therefore the tin with its mass at the rim has less energy available to appear as translational kinetic energy, resulting in a lower linear speed. The tin with its mass concentrated around the rim will lose the race to the bottom of the ramp, and the tin with its mass concentrated at the center will win.

**etcetera** \_\_\_\_\_

The use of lightweight "mag" wheels on cars is related to translational and rotational kinetic energy. Imagine that you had two cars of equal overall mass, but one had lightweight "mag" wheels and a heavy chassis, and the other had heavy steel wheels and a light chassis. Given the same energy input, the "mag" wheel car would accelerate more rapidly, since less of the energy supplied would be needed to get the wheels rotating, and more would therefore appear as straight line motion of the car as a whole.

It is interesting to experiment with rolling cans of soup down an inclined plane. Solid soups roll down the incline at a slower rate than liquid soups. The liquid does not have to rotate with the can, so the potential energy of the liquid soup can go into linear motion, not into rotation of the soup.

This activity is related to the Downhill Race at the Newton's Corner exhibit at the Mid-America Science Museum. This activity and more can be found online at [http://www.exploratorium.edu/snacks/downhill\\_race/index.html](http://www.exploratorium.edu/snacks/downhill_race/index.html)