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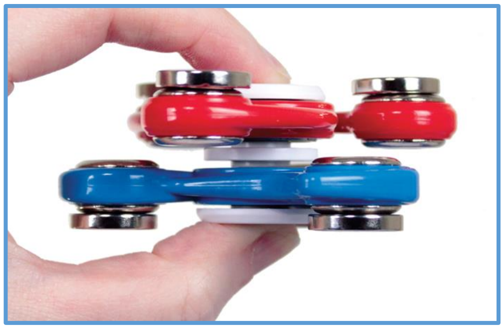
Double Hand Spinners

PHY-270



In this kit:

2 Spinners
2 Connectors
6 Neodymium Ring Magnets *

* Additional **Neodymium Ring Magnets** are available in packs of 25.

Background:

Newton's First Law of Motion generally tells us an object will remain at rest—or in motion—unless it is acted upon by an external force. This means a spinner sitting motionless on a surface will remain motionless unless we apply a force and spin it. Similarly, according to Newton, once the spinner is spinning, it will remain spinning unless acted on by an external force.

Keeping the First Law in mind, examine the external forces acting on the spinner to slow it down. The friction present in the central bearing is one external force that acts on your spinner. Air resistance is another. Even gravity will have an effect as it pulls downward on the spinner, causing an increase in friction. All of these together explain why your spinner doesn't keep going forever.

Newton's Second Law of Motion is a bit more complicated to explain, but no less important with regard to the spinner. Generally, it says that how fast an object speeds up or slows down depends on how big the object is and how much force you use to make the object move—or to make it stop moving.

When compared to a small, light spinner, a big, heavy spinner will require more force to get moving, but it will spin longer—everything else being equal. The mass at the ends of the three arms are a direct influence here. Since the weight is at the end of the arms, it causes the spinner to appear to be (from a physics point of view) a solid disk about the same diameter as the ends of the arms.

Newton's Third Law of Motion is easy to understand: For every action there is an equal and opposite reaction. In very general terms we can say that the better the spinner's bearings, the longer it will spin. The heavier it is, the longer it will spin. The less air resistance, the longer it will spin.

Hand Spinner Experiment

Instruct your students to work in pairs. One student should set the spinner flat on a table and place a pointer finger on the spinner's center disk to hold it steady. With the other hand, spin it. (Remind students to take away their pointer fingers once their spinners are in motion.)

The second student should time how long it spins and record the time on the data sheet on page 3. Each pair should repeat this experiment at least two or three times. Instruct students to find the average of their times by adding them all up and then dividing by the number of trials.

Example:

Trial #	Added Weight	Time of Spin	Average of Trials
1	--	92 seconds	92 + 76 + 83 = 251 251 / 3 = 83.6
2	--	76 seconds	
3	--	83 seconds	

Next, instruct your students to attach two magnets to the top of each arm of their spinner. Repeat the experiment above. They should conduct the same number of trials as they did without the magnets attached, and take the average again.

Ask the class: *What do you notice?* They should have observed that the trials with the additional mass (magnets) had longer spin times than the earlier trials without added weight.

Extension:

You can take this experiment even further. Students can steadily add more mass by taping coins or washers to the arms of their spinner instead of—or in addition to—the magnets. Each time they add more mass, they should re-run the experiment. Eventually a point will be reached where the extra mass does not further increase the spin time. This is due to the effect of friction and gravity working together.

Hand Spinner Data Table

Trial #	Added Weight	Time of Spin	Average of Trials

Other Activities

Types of Energy Transfers:

We can observe another type of energy the spinners give off as they spin. Spin the spinner as fast as you can, and hold it up to your ear, edge side on. You will probably hear the rushing sound of the bearings, but you should also be able to notice a lower humming sound. That is sound energy resulting from the arms of the spinner, which causes micro changes in air pressure.

Because the pressure changes are occurring ever more slowly, the frequency of the hum falls as the spinner slows down. The energy required to produce both sounds is another drain on the energy you put in to the spinner, and is also acting to slow it down.

Additional Observable Effects:

With the spinner rotating quickly, hold the center tab between your thumb and forefinger. Twist your hand left and right (or forward and back). You should observe a noticeable resistance. This is due to an effect known as **Angular Momentum**. This is related to Newton's First Law—the object in motion (the spinner) wants to keep going in the same direction, so you must exert a fair amount of force to get it to change.

Angular momentum is the same principle involved in gyroscopes (our **Classic Gyroscope**, for example). Interestingly, when a force is applied to a spinning object, it reacts to that force 90 degrees away from where the force was applied.

At this point, we can use one of the special features of the Double Hand Spinners. Connect the two spinners together at the center, following the instructions on the back of the package. Once you have them paired, spin one clockwise, the other counter-clockwise.

You will find that the Angular Momentum we just observed has now been canceled out. This is due to the motion of the two spinners' nearly equal masses canceling out one another.

Other Activities

continued

Fun with Magnetic Forces:

Before beginning this demonstration, carefully determine the polarity of all six of the magnets. With the two spinners connected, apply one magnet to each outward arm of both spinners. Arrange them so the magnets on one spinner are attracting those on the second spinner. While holding one spinner still, gently set the other one in motion. Then release the one being held. As the spinning one slows, the second spinner will follow in synchronization.

Reverse the polarity of the magnets on one of the spinners by turning them over. Again, spin only one of the spinners while temporarily holding the second one steady. Observe the behavior. The repulsion will cause the two spinners to “stutter step” with first one advancing and then the other.

Take the pair of spinners back apart but keep the magnets in place. Be sure to reattach the center disks. Place them, magnet side up, close to each other on a flat surface free of metal, and gently spin both. You will have to experiment with the distance between the spinners—they need to be close enough for the magnets to interact, but far enough apart so they do not pull together (about 1.5 - 2 cm).

Try rotating them in the same direction, opposite directions and also reversing the polarity of the magnets. The results are fascinating!

Other Tricks and Tips

The Wagon Wheel Effect:

If you have ever observed a spoked, spinning object like a wagon wheel or an airplane propeller, you may have noticed that it appears to reverse direction or even stop under certain conditions. The easiest way to observe this with a spinner is to take a video of it, and watch the playback. The reason for this is rather complex. Further information is readily available online.

How to Increase the Speed of the Spinner:

Use a can of compressed air with the “straw” concentrator on it. Spin your spinner to get it moving. Aim the straw at the edge of the outer arm and blast it with the compressed air. You will see, hear, and feel the spinner rapidly accelerate. Many of the Newtonian effects detailed above will be magnified, given that we have introduced so much more energy into the spinner.

Take Your Lesson Further

As science teachers ourselves, we know how much effort goes into preparing lessons.
For us, "*Teachers Serving Teachers*" isn't just a slogan—it's our promise to you!

Please visit our website for more lesson ideas:

TeacherSource.com/lessons

Check our blog for classroom-tested teaching plans on dozens of topics:

http://blog.TeacherSource.com

To extend your lesson, consider these Educational Innovations products:

25 Pack of Neodymium Magnets (M-187)
These neodymium ring magnets are 0.711 in. OD x 0.125 in. thick, 0.375 in. ID (17 mm OD x 3 mm thick, 10 mm ID). Great for doing magnetic levitation, making magnet structures, or just making absolutely sure that your shopping list will stay on your refrigerator... during an earthquake. Each package contains 25 of these amazing magnets.

Centripetal Spinner (PHY-250)
The prettiest demonstration of centripetal force and inertia we've ever seen! This perky, iridescent device reflects a dazzling rainbow as it spins. Twirl the stick and the thin ribbons spread into a bubble shape. The faster you spin, the wider the bubble becomes! It can be gently twisted by hand to make a delicate 'flower' that neatly tucks itself into a tight ball. Endlessly fascinating!

Classic Gyroscope (GYR-270)
The toy gyroscope has been in production since 1917 and has been a classic educational tool for generations. Use the power of physics to balance the gyroscope on its pedestal, a fingertip, the edge of a glass, or even a string. Gyroscopes are used in robotics, space exploration, and they are even used to stabilize movie cameras. Each gyroscope is packed in a clear styrene box with starting string, pedestal, and instructions for several amazing tricks.

Flow Ring (PHY-265)
Constructed from a single strand of thin, flexible metal, the Flow Ring is both a kinetic sculpture and a mesmerizing flow toy. With one look, you'll see why it has been called a "4th dimensional Slinky." Folds flat and pops open into a beautiful 3D geometrical shape. Slip it on your arm or a rope and watch its translational energy change to rotational energy! Centripetal forces cause the ring to expand as it spins faster. The result is remarkable: the Flow Ring begins spinning while simultaneously falling, creating the illusion of a silver bubble. The secret is in how the metal is wrapped—the ribbon coils through itself, forming a torus knot. Get ready to be astonished as you watch this spherical toroid ring roll, bend, and flow.