611-1850 (40-210) Counterpoise Gyroscope

Description:
What is a gyroscope? Gyroscopes are an interesting apparatus that operate on the principle of angular momentum. The heart of the mechanism is a heavy steel rotor mounted to a low friction shaft. This rotor is very heavy on the edges but composed of thin, lightweight metal in the center, which serves to concentrate the mass on the rim. This concentration of mass at the outer edge helps to give the rotor a high angular momentum; a simple disc is too uniform, with the mass evenly distributed. The rotor is mounted to a shaft that attaches to a gimbal ring surrounding the rotor. The shaft utilizes PTFE cone bearings that drastically reduce friction, helping the rotor spin for a long period of time. The gyroscope can be used free standing or in the included housing.

Operation:
There are a number of ways to use your counterpoise gyroscope. To get a feel for the power of angular momentum, remove the gyroscope from its housing and hold it in your hand. The housing is flexible, which allows easy removal of the gyroscope. You activate the mechanism by threading the included string into the hole of the rotor shaft and winding it around a number of times. Pull the string forcefully, and the rotor will spin at a great rate. Hold the gyroscope in your hand and try to rotate it. You will find that it is very easy to turn the gyroscope in the same direction that the rotor is spinning. Next, try turning it perpendicular to the direction of the rotor. You will find that although the rotor doesn't weigh much, its momentum is so powerful that this operation requires a surprising amount of force. Since the rotor will spin for several minutes, you can pass the gyroscope from student to student so they can all feel this affect.

To use the counterpoise feature of this item, place the gyroscope into its housing. Note that the housing contains two slots and two holes for the pins on the gyroscope to fit into. For this purpose, you will need to use the holes to hold the gyroscope so that it doesn't fall out of the housing. For the first experiment, balance the whole system. You can do this by sliding the small brass weight on the tail of the apparatus. Next, leave the gyroscope in a position where it can freely rotate, and spin it. You will find that while the rotor is spinning, it does not impart any motion to the system.

For the second experiment, repeat the above steps, but this time, use the included pin to lock the gyroscope into place. Now that the rotor can only spin in one direction, an interesting thing will happen. To observe, use the sliding mass to overbalance the gyroscope in either direction. As the rotor spins, the imbalance will cause the gyroscope to produce a torque around the center axis.

Why? Imagine the rotor as a collection of particles. All objects prefer to move in straight lines, and only behave otherwise when a force is applied to them. This is Newton's first law, expressed as the equation F=ma, or force equals mass times acceleration. The gyroscope rotor is solid and held together by atomic forces, so the particles can't escape. Therefore, when the rotor is spun, all the particles must move in a circular path. According to Newton's laws, velocity is composed of a magnitude and a direction. It takes a large amount of force to change the direction of a fast moving object, even one whose speed is constant. Therefore, even though the gyroscope is spinning at a nearly constant speed, the particles in the rotor are constantly changing direction. A change in direction is equivalent to an acceleration, which in turn implies a force. Remember F=ma. In this case, the mass of the rotor multiplied by the acceleration equals the force. Since the velocity of the rotor is very high, the acceleration must also be high. This in turn provides a surprisingly powerful force. When you twist the gyroscope with your hands, you can feel this force.

All gyroscopes, due to their high inertia, will keep the rotor pointed in the original direction it was spun in. As the brass weight causes the gyroscope to sink below or rise above the original plane it was set in, the high inertia of the rotor will cause the gyroscope to seek its original position. The weight makes this impossible. The rotor will therefore be confined to the only motion possible for it: rotating about the central axis.

The counterpoise gyroscope also demonstrates the principles of angular momentum. Angular momentum is similar to linear momentum, except it describes particles moving in circular paths. Angular momentum of a particle about a given origin is defined as:

$$L = \sum RmV$$

L= the angular momentum of the particle,
R= the distance of the particle from the reference point,
m= the mass of the particle,
V= the velocity of the particle.

The above equation shows that if the R-value is greater, the angular momentum must also be greater. This is the reason that the majority of the rotor's mass is concentrated at the rim. This requires a greater force to get the rotor spinning, but it yields more momentum. If the rotor was wider and all other factors were unchanged, the angular momentum of the rotor would be greater still. Were the rotor to suddenly shrink in diameter, the velocity would increase. As the angular momentum of a system increases, the force required to affect it's direction or magnitude also increases. For this reason, it is difficult to rotate the housing of the gyroscope against the direction the rotor rotates in. In fact, applying a torque to the housing of the gyroscope will cause the rotor to change direction, ending up perpendicular to its original direction!

Warranty and Parts:
We replace all defective or missing parts free of charge. Additional replacement parts may be ordered toll-free. We accept MasterCard, Visa, checks and School P.O.s. All products warranted to be free from defect for 90 days. Does not apply to accident, misuse or normal wear and tear. Intended for children 13 years of age and up. This item is not a toy. It may contain small parts that can be choking hazards. Adult supervision is required.

Benchmarks for Science Literacy				*National Science Education Standard*
Grades 9 – 12 **The Physical Setting**	**4B.1**	"The change in motion of an object is proportional to the applied force and inversely proportional to the mass."	Grades 9-12 **Physical Science Content Standard B.4-**Motions and Forces	"Objects change their motion only when a net force is applied. Laws of motion are used to calculate precisely the effects of forces on the motion of objects. The magnitude of the change in motion can be calculated using the relationship F = ma, which is independent of the nature of the force. Whenever one object exerts a force on another, a force equal in magnitude and opposite in direction is exerted on the first object." (p. 180)

May we suggest:

611-1220 Variable Inertia: Load two discs unevenly, roll together down an incline. Now you don't need mechanical aptitude to make rotational inertia make sense. Instantly change the distribution of mass in these 3-1/2" dia. plastic discs. Slip up to 8 solid steel balls into your choice of compartments inside. Replace the top, screw both halves together, and roll the weighted disc down a slope. Which is faster, with the mass toward the center or toward the rim? Why?

611-1830 Gyroscope with Gimbal Cradle: Explore the mysteries of inertial guidance, compasses and stabilization. Runs up to 2 minutes with little wobble because it's precision machined. Dynamically balanced 6 cm steel rotor, near-frictionless PTFE bearings. Includes: plastic base, molded rocker with Gimbal, pull cord & handle, weights, hook, instructions.

611-0200 Bicycle Wheel Gyroscope: When is a bicycle wheel a gyroscope? When you put a new "spin" on it! In the weightless world of the space shuttle, the astronauts proved that a spinning gyroscope refused to change direction. Now you can turn your students into human gyroscopes with our wide, stable rotating platform and bicycle wheel gyroscope. Instructions describe experiments in rolling friction and gyroscopic precession with sample questions.
This budget-priced lab is great with a **rotating platform** to bring gyroscopic forces to life. Our student-sized bicycle wheel turns freely on its axis and has large, comfortable handles at each end. Because mass is concentrated at the rim, you can tilt the spinning wheel to feel the force of rotation.

611-0205 Rotating Platform: Turn your students into human gyroscopes with our stable rotating platform. Now you can do the "skater's spin" without skates, rink or ice! Our 16" (40 cm) wide bright blue wooden disc has a nonslip surface and safely holds up to 220 pounds (100 kg). Intended for hands-on (or feet-on) use, it has very low friction with a weight of 100 pounds. Instructions with theory and sample questions.

611-1620 Variable Speed Rotator: Rotation is an interesting event. In addition to being essential to our modern age, it also produces a number on interesting effects. For example, the earth is an oblate sphere due to rotation. In the case of gyroscopes, rotation greatly increases the difficulty of turning one, because of the effects of angular momentum. Rotation can also be used to estimate the mass of a rotating object, by using the relationship between torque and revolutions.

611-1890 Maxwell's Wheel Apparatus: Investigate conservation of mechanical energy and momentum. Our wheel rolls to the top by means of string wound on its axle, then turns potential energy into kinetic and rolls back down. At the bottom, kinetic energy is converted into potential and the wheel rolls upward again. In an ideal world this would continue forever, but friction eventually sets in and the wheel will stop.