611-0200 (40-202) Bicycle Wheel Gyroscope

In the weightless world of the space shuttle, the astronauts proved that a spinning gyroscope refused to change direction.

Warranty and Parts:

We replace all missing or defective parts free of charge. All products guaranteed free from defect for 90 days. This guarantee does not include accident, misuse, or normal wear and tear.

Introduction:

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.

If you stand on the **Science First**® friction-free rotating platform (40-226), you will begin to spin yourself.

This is useful both as a large-group demonstration that calls for volunteers from the audience as well as a "hands on" student lab.

A "gyroscope" is an apparatus with a spinning wheel supported beneath its center of gravity and isolated from any external torques. The angular momentum of the spinning wheel continues to point in one direction, even if the frame is tilted or rotated.

P/N 24-0202

Assembly:

In shipping, we have removed the handles to minimize the likelihood of damage.

To assemble the handles:

- Screw the handle onto the axle, tightening until it is fixed.

How to Use:

1. Hold the wheel by both handles so that nothing contacts the wheel. Have another person give it a robust spin.
   - The axis of the wheel will tend to move in a direction at right angles to the direction in which the turning force is applied. This is *precession*, in which **the axis turns slowly in the horizontal plane.**
   - Stand on a rotating platform, or sit on a rotating stool with your feet off the floor. Hold the Bicycle Wheel Gyroscope and tilt it vertically.
   - The stool or platform should start to turn if friction is low. Now try to tilt the wheel in the opposite direction.
2. Spin the wheel. Hang it from a hook mounted to the free end of a chain or rope. Hold the wheel so the axle is horizontal. Then let it go.
   - The axle should stay roughly horizontal while it moves slowly in a circle.

If your Bicycle wheel Gyroscope has a wobble to it, you may wish to use the procedure in the next column to reduce or eliminate it.

As you may know, all wheels made of rubber have some inconsistencies in their manufacture. These inconsistencies may cause a wobble in your Bicycle Wheel Gyroscope.

Theory:

Newton's Law of Motion explains how a gyroscope works. Newton's Law states that *the force required to change the motion of a body is determined by the rate of change of the body's momentum,* where **momentum** is defined as *the mass (m) multiplied by the velocity (v).* For a body of fixed mass, therefore, the force is given by mass multiplied the **rate of change of velocity.**

Ideally you can analyze a gyroscope by imagining a rotor made up of a large number of small "bodies" to each of which Newton's Laws should be applied. To simplify, let's study four representative pieces qualitatively. These pieces, **A, B, C** and **D**, are equally spaced around the rim of the rotor. *Figure 1* depicts the rotor with pieces **A, B, C,** and **D** at positions so labeled.

Imagine that a fraction of a second following the time at which the rotor attains the position depicted in *Figure 1*, the spinning rotor tilts about the X horizontal axis in such a way that the pieces are again located at positions A, B C, D etc. What forces were applied to bring this about?

According to Newton's Laws, **velocity** has both magnitude (i.e. speed) and direction. It takes a large force to change the direction of a fast-moving object. This is so even though its speed may be constant. In the case of the spinning gyroscope, the speeds are constant but some directions are changing.

Velocities are shown by arrows (direction of motion) in *Figure 1.*

The velocities of B and D are essentially unchanged, since both are merely displaced from 1 to 2. According to Newton's Law, no force was needed.

Piece C, in contrast, underwent a downward (negative Z) change in velocity, requiring a downward force at that point on the rim.

These two forces - upward at A and downward at C - constitute a torque around the Y (vertical) axis. Thus a torque about Y is necessary for a rotor with spin axis Z to rotate about an axis X. The directions involved maybe checked in group demonstrations. The faster the spin of the rotor, the higher the torque required to change its direction.

Conversely, where the amount of torque is fixed - as in the case of a weight applied to the rim - the slower the spin of the rotor becomes, the faster the precession that results.

A quantitative analysis of all parts of the rotor verify these conclusions, giving rise to mathematical expressions including vector calculus and the relation of torque to spin rate, rotation rate and rotor shape.

The velocities of each piece of rotor change in direction only. These forces do no work in the rotor since they are perpendicular to the direction of motion. As a result the spin rotational energy does not change during rotation.

Accessories:

- **611-0205 Rotating Platform** Turn your students into human gyroscopes with our wide, stable rotating platform. 16" (40 cm) in diameter, with a nonslip surface, it safely holds over 220 lbs (100 kg). Very low friction when supporting a weight of 100 pounds.

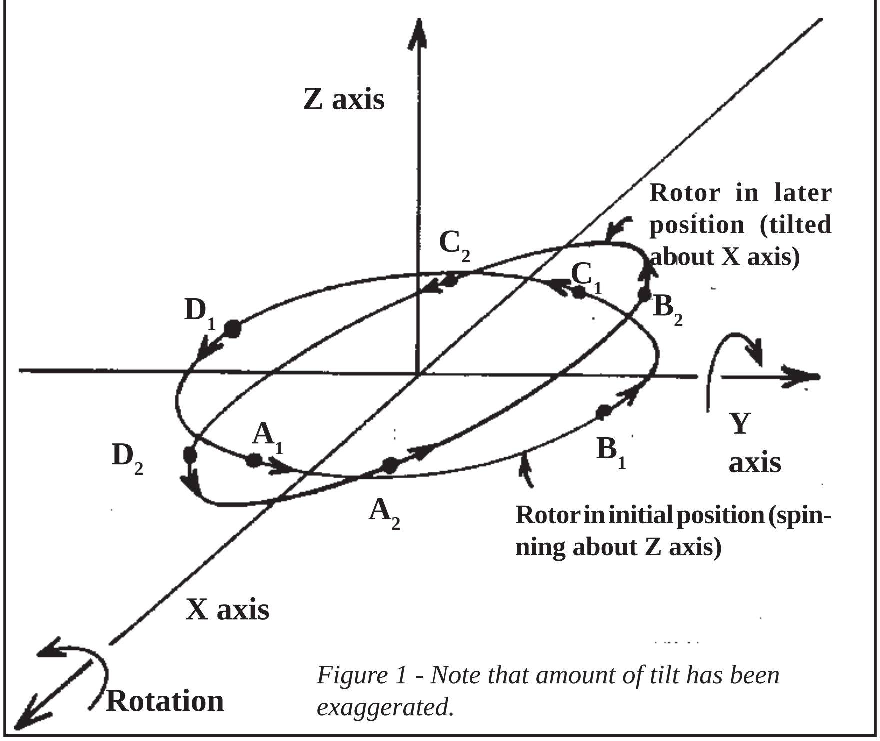

Figure 1 - Note that amount of tilt has been exaggerated.