

# OPERATING INSTRUCTIONS

## Simple Form Gyroscope No. 74780

### 1. Introduction

The gyroscope is based on the principle that a mass rotating steadily around its axis will tend to resist changes in the direction of its axis due to the conservation of angular momentum. The Simple Form Gyroscope (74780) can be used to demonstrate this principle and to facilitate discussion of gyroscopic degrees of freedom.

### 2. Description

The Simple Form Gyroscope consists of a brightly-finished cast-metal wheel, 5.5cm in diameter, mounted in a heavy wire frame. The inner portion of the wheel is perforated to reduce its mass. The Gyroscope also includes a support stand on a base. The stand has a socket at the top for holding the gyroscope. A spinning cord is also included with this apparatus.

### 3. Theory

The behavior of the gyroscope is well known. When the center wheel is spun rapidly, the gyroscope can be supported easily by one end of the central post. If its support is moved about, a spinning gyroscope will still maintain its upright position. It will resist any attempt to change the direction in which its axis of rotation is pointing.

The stability of the gyroscope is due to its construction. The heavy concentration of the mass of the wheel along its outer edge gives it an especially high moment of inertia. It is thus highly inclined to maintain its orientation, and resists any force applied against it. Some gyroscopes, such as the Bicycle Wheel Gyroscope (74786), have so high an angular momentum that they will make a person trying to tip them actually spin in the opposite direction. This conservation of angular momentum is at the core of the gyroscope's stability.

If placed with its axis of rotation perfectly vertical, the Simple Form Gyroscope will remain upright. But if it is placed at an angle, the axis of rotation itself will begin moving in a circular fashion around a vertical axis. This motion is the familiar *precession*. It is caused by the torque applied when the axis is moved. Precession can also be caused by gravity. When the wheel is not spinning, the gyroscope falls over. In motion, as it slows, its angular momentum decreases. Since the angular momentum gives the gyroscope its stability, it begins to fall as it would if it were not spinning at all. This motion changes the angle of the axis of rotation and causes precession.

In either case, precession gives the gyroscope a restoring torque acting against the applied torque which helps it maintain its stable rotation longer. The change in angular momentum is therefore zero.

The properties of the gyroscope are basic demonstrations of the laws of classical mechanics and rotational motion. The introduction of "gyroscopic" degrees of freedom into discussions of atomic and nuclear physics lends new understanding to those fields and new importance to the gyroscope. The

motion of the gyroscope can be described in extensive detail with a great deal of mathematical sophistication. For further information, you may wish to consult a good physics textbook, an encyclopedia, or a book on the subject, such as Becker's *Introduction to Theoretical Mechanics* (McGraw Hill).

#### **4. Operation**

Set the gyroscope base on a flat, even surface. Insert one end of the spinning cord barely into the hole in the central shaft. Turn the wheel so that the string winds completely around the shaft.

Hold the gyroscope in one hand and pull firmly on the string with the other to turn the wheel. It is best to increase the speed of the pull as the string unwinds, in order to achieve the maximum speed of rotation. The end of the spinning gyroscope may be placed in the socket at the top of the support stand to observe the gyroscope.

It is also possible to observe the gyroscope without putting it in the stand. It may be balanced on the end of a finger or a pencil, which can then be moved about freely. Note that even when the angle of the support to the vertical is changed, the gyroscope remains upright. Holding the ends of the gyroscope in each hand and changing the angle of the axis of rotation demonstrates the gyroscope's resistance to such change. The degree of stability of the gyroscope can also be demonstrated by resting its end on a tautly stretched piece of string. Raising or lowering one end of the string will cause the spinning gyroscope to "walk" along it.

#### **5. Maintenance**

The Simple Form Gyroscope needs no special maintenance. If you should experience any difficulty with this piece of equipment, please contact Central Scientific Company, giving details of the problem. To ensure better service, please do not return any apparatus to Central Scientific Company until we have sent you authorization.

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