DEVICE  Human Gyroscope Wheels Demonstration

TOPIC  Rotational Mechanics

THEORETICAL BACKGROUND  The underlying principle here is the conservation of angular momentum, which states that the total angular momentum of a body is constant if the resultant external torque acting on the body is zero:

\[
\text{if } \sum \tau_{\text{ext}} = \frac{d\mathcal{L}}{dt} = 0
\]

then \( \mathcal{L} = \) constant;

\[
\mathcal{L}_i = \mathcal{L}_f \Rightarrow I_i \omega_i = I_f \omega_f = \text{constant}.
\]

Suppose our lab coordinator holds the axle of a spinning bicycle wheel while standing on a rotating platform. He and the platform are initially at rest while the wheel spins on a horizontal plane. As he begins to rotate the wheel in progressive sessions to 180° about its center, he and the platform begin to rotate. This is due to the fact that the total angular momentum of the system—the wheel, Mr. Robinson, and the platform—must be conserved.

DESCRIPTION  The human gyroscope is used to demonstrate conservation of angular momentum. The demo makes use of a free standing bicycle wheel with a diameter of at least 65 cm. The wheel is accompanied with a rotating platform, ideally with low frictional bearings, and a willing volunteer. The wheel should have handles on each end of the axis.

PROCEDURE  Performing this experiment may require the aid of a teacher’s assistant.

1. Find a clear area in the classroom or laboratory to place the rotating platform.
2. Place both feet firmly on the platform.
3. The TA should begin rotating the wheel at this point. Once a constant angular velocity has been established with the wheel, s/he should hand it to the person on the platform.
4. Begin rotating the wheel clockwise and then counter-clockwise.

SUGGESTIONS  We have a dual bicycle wheel in our demo closet, that is there are two wheels attached to the same axis. Perform the above experiment with this wheel set and consider the following questions: What would happen if both wheels spin in the same direction; one spins clockwise while the other spins counter-clockwise?
THEORETICAL BACKGROUND

The moment of inertia of an object is a measure of how the mass of the rotating object is distributed about its axis of rotation. A common definition for moment of inertia is that the measured quantity of rotational inertia determines the resistance an object has to free rotation. If an object has all of its mass evenly distributed around its rotational axis, like the solid disk, then its resistance to rotation is the same for all radial distances parallel to the rotational axis. Consider the following equation:

\[ I_{\text{disk}} = \frac{1}{2} M_{\text{disk}} R_{\text{disk}}^2 \]

where \( I_{\text{disk}} \) is the moment of inertia of the disk, \( M_{\text{disk}} \) is the mass of the disk, and \( R_{\text{disk}} \) is the radius of the disk. For a hoop with a mass equal to the disk, the equation becomes

\[ I_{\text{hoop}} = M_{\text{hoop}} R_{\text{hoop}}^2 \]

Here the mass of the hoop is not evenly distributed around the rotational axis. However, its mass is located on the outer edge further away from the axis of rotation, causing the hoop to rotate with a greater amount of resistance comparable to the solid disk.

DESCRIPTION

The use of cylindrical objects effectively demonstrates the concept of rotational inertia for objects of like masses, but differing mass orientations. The apparatus includes a solid disk and a ringed hoop, each weighing approximately the same. A flat wooden board propped by a wooden plank about 3 inches thick is used to make an incline.

PROCEDURE

1. Construct an incline using flat board and a plank.
2. Mass the disk and hoop.
3. Predict whether or not the hoop will reach the bottom first.
4. Choose one:
   4.1. EITHER release the disk and hoop at the same time measuring the time each takes to reach the bottom with a stopwatch;
   4.2. OR using a stopwatch release first the disk and then the hoop.
5. Compare the time each took to reach the bottom and re-evaluate your prediction.