DEVICE   Human Gyroscope Wheels Demonstration

**TOPIC**   Rotational Mechanics

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

$$if \ \sum \tau_{ext} = \frac{d\mathfrak{L}}{dt} = 0$$

$$then \ \mathfrak{L} = constant;$$

$$\mathfrak{L}_i = \mathfrak{L}_f \Rightarrow I_i \omega_i = I_f \omega_f = constant.$$

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.
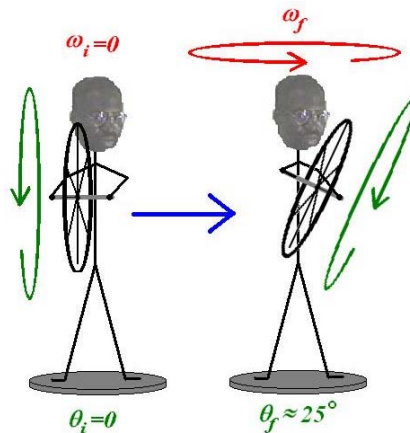
DESCRIPTION   The human gyroscope is used to demonstrate conservation of angular
                      momentum. The demo makes use of a free standing bicycle wheel with
                      a diameter of at least 65 cm. The wheel is accompanied with a rotating
                      platform, ideally 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?

DEVICE   Moment of Inertia Using Cylinders

TOPIC   Rotational Mechanics

THEORETICAL   The moment of inertia of an object is a measure of how the mass of the rotating object is
BACKGROUND   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:

$$I_{disk} = \frac{1}{2} M_{disk} R_{disk}^2$$

where I_{disk} is the moment of inertia of the disk, M_{disk} is the mass of the disk, and R_{disk} is
the radius of the disk. For a hoop with a mass equal to the disk, the equation becomes
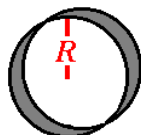
$$I_{hoop} = M_{hoop} R_{hoop}^2$$

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.
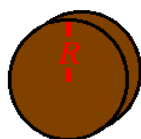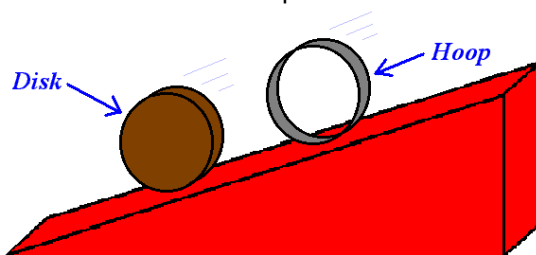
$$I_{disk} = \frac{1}{2} M_{disk} R_{disk}^2$$

$$R_{Disk} \approx R_{Hoop} \, , \quad M_{Disk} \approx M_{Hoop} \qquad I_{Disk} = \frac{1}{2} I_{Hoop}$$

$$I_{hoop} = M_{hoop} R_{hoop}^2$$

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.

SUGGESTIONS