Demo 07-10 Bike Wheel Precession

A bicycle wheel spinning on a long axle is supported at one end of the axle by a rope, as shown in *Figure 1*. The external torque caused by the force of gravity on the wheel causes it to precess.† When it is supported by a rope at the other end of the axis, it precesses in the opposite sense.

Figure 1

† Sutton, *Demonstration Experiments in Physics*, Demonstration M-187, Precession. Freier and Anderson, *A Demonstration Handbook for Physics*, Demonstration Mu-14, Spin Flipping.

Bike Wheel Precession / Script *Demo 07-10*

When we spin this bicycle wheel by pulling on a string wrapped around the axle, we give the wheel angular momentum. If we release one of the handles on the wheel and hold it only by the rope on this handle, there will be an unbalanced torque on the wheel due to its weight. How will the wheel react?

The bike wheel precesses.

If we suspend the bike wheel from the other handle, the wheel precesses in the opposite direction.

Equipment

1. Rim-loaded bicycle wheel with handles mounted on its axle, each with a different color rope attached (this bicycle wheel has the start-up disc/peg as described earlier).
2. Start-up spring.
3. Support cradle.

Demo 07-11: Gyroscope with Adjustable Weights

A small gyroscope is balanced by a weight whose radius can be adjusted, as shown in *Figure 1*.† When the spinning gyroscope is balanced no precession occurs. If the weight is repositioned along the arm, unbalancing the system, the gyroscope will precess. The direction of precession depends on whether the weight is closer to or farther away from the pivot than the balance point.

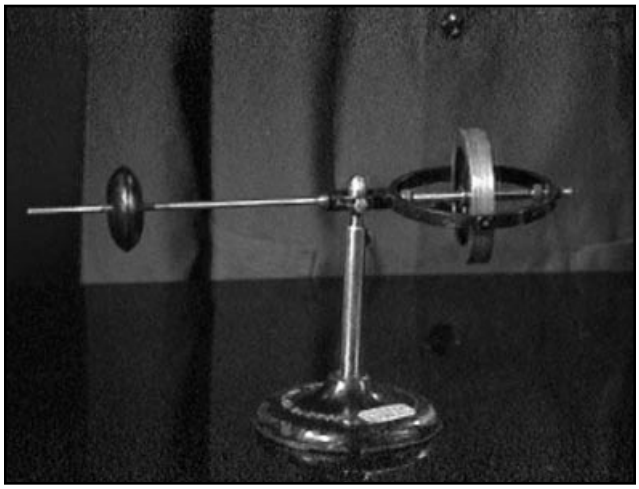

Figure 1

† Sutton, *Demonstration Experiments in Physics*, Demonstration M-188, Fundamental Precession Equation.
Freier and Anderson, *A Demonstration Handbook for Physics*, Demonstration Mu-2, Precession of a Gyroscope.

Gyroscope with Adjustable Weights / Script *Demo 07-11*

A gyroscope is mounted on a pivot and counterweighted so that it is balanced when the weight is in the right position.

If we spin the gyro counterclockwise as seen from the pivot, its angular momentum vector points in toward the pivot.

If the weight is now moved outward from the balance position, the gyro precesses counterclockwise.

If we move the weight in closer than the balance position, the direction of precession reverses.

Equipment

1. Gyroscope with long adjustable counterbalance arm/support system.
2. Same start-up motor/disc as described previously.

Demo 07-12 Bike Wheel on Gimbals

A bicycle wheel is mounted so that it rotates freely on a set of gimbals, as shown in *Figure 1*. Weights are positioned at various points along the extended axle, and the resulting precession observed.

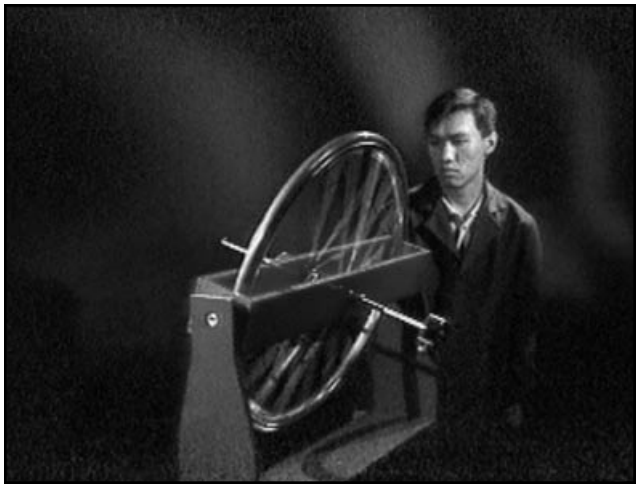

Figure 1

Bike Wheel on Gimbals / Script *Demo 07-12*

This bicycle wheel with a weighted rim is mounted in a pair of bearings so it is free to move in two directions. A pair of weights on the axle of the wheel can be adjusted so that the axle is either balanced or tips to one side.

We'll spin the wheel by hand with the weights initially balanced. What will happen if we move one of the weights outward so that the wheel is no longer balanced?

The wheel precesses.

If we move the weight further out, the precession rate increases.

If we move the other weight out to rebalance the wheel, the precession stops.

Pushing the first weight back to its original position makes the wheel precess in the opposite direction.

Equipment

1. Bicycle wheel with loaded rim mounted within a large, custom-built pair of gimbals with good bearings to minimize frictional losses; all supported above a stable base.
2. Wheel fitted with an identical pair of extension rods off each end of the axle, with each carrying one of a pair of identical weights and locking thumb screws.

Demo 07-13 Double Bike Wheel

Two identical bicycle wheels are mounted coaxially onto a rigid axle that is supported at one end, as shown in *Figure 1*. When both of the bicycle wheels rotate with the same angular speed in the same direction their angular momenta add together, and when released they precess as a unit around the fixed point. On the other hand, if they rotate in opposite directions their angular momenta cancel, and the system will not precess.† The wheels will fall downward on their axle.

Figure 1

† Gerard Lietz, Tony Benhof, and Robert Horton, Doing Physics—Physics Activities for Groups: A Double Wheel, *The Phys. Teach*. 22, 324-325 (1984).

Double Bike Wheel / Script

Demo 07-13

This pair of bicycle wheels is mounted on a common axle that is free to swing on a bearing.

When we spin both wheels in the same direction and then release them, the wheels precess horizontally instead of falling down.

If we now spin the two wheels in opposite directions at equal speeds, will they still precess?

They fall straight down. The two wheels spinning with equal but opposite angular velocities act as if they are not spinning at all.

Equipment

1. Two bicycle wheels with collinear axle supported from a single end that is free to pivot.
2. Large bearing support system with heavy stable base.
3. Several large clamps.
4. Rim marker on each wheel.

Demo 07-14 Motorized Gyroscope

A motorized gyroscope, shown in *Figure 1*, is used to illustrate the principles of vector angular momentum and torque.† The spinning gyroscope remains in a constant orientation until an external net force is exerted on the gyroscope. The relation between the direction of the force and the resulting precession is investigated on the video.

Figure 1

† Freier and Anderson, *A Demonstration Handbook for Physics*, Demonstration Mu-10, MITAC Gyroscope.

Motorized Gyroscope / Script

Demo 07-14

This motorized gyroscope will be used to show precession of a spinning object.

This heavy steel disc is rotated by a motor until it is spinning at about 1200 revolutions per minute.

When a force is exerted on the end of the axle shaft, the shaft and disc move to the right instead of down.

When we push the shaft up, it moves to the left.

What will happen if we try to push the shaft to the right?

The shaft moves up.

If we push the shaft to the left, it moves down.

If we hang this weight on the end of the shaft to provide a constant force, the disc precesses to the right at this speed. If we turn off the motor and let the disc slow down, will the rate of precession increase or decrease?

The rate of precession increases as the disc slows.

Equipment

1. Motorized gyroscope.
2. Length of rod.
3. Weight with string loop.