Ring and Disk

P3-3540

BACKGROUND:

In rotating systems, the rotational inertia is analogous to the mass in linear systems. Rotational inertia depends on the mass and how the mass is distributed around the point of rotation: the farther away, the higher the rotational inertia. Rotational inertia, like mass, resists acceleration. The higher the rotational inertia, the more torque it takes to cause rotational acceleration.

*When a body rolls down, it has linear acceleration in downward direction. The friction, therefore, acts upward to counter sliding tendency as shown in the figure. This friction constitutes an anticlockwise torque providing the corresponding angular acceleration as required for maintaining the condition of rolling (if linear velocity is increasing, then angular velocity should also increase according to equation of accelerated rolling).**

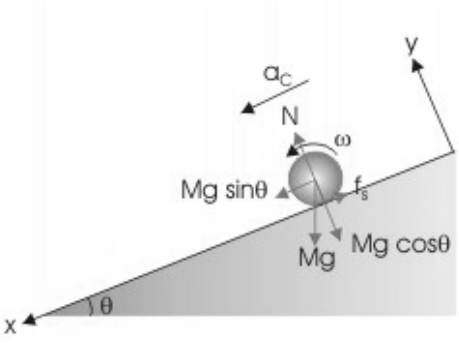

Figure 1*

Note that it is static friction that applies the torque to the rolling object. Static friction in this example is a self-adjusting force that depends on the weight and motion of the object. Its exact analysis is complex and can be found in detail at the source cited below. A simple approach approximates that the torque on both objects is essentially equal.

The disk has its mass evenly distributed from the center to the edge. The ring has its mass concentrated at the edge, and thus has greater rotational inertia. The following equation, analogous to Newton's Second Law (F=ma) relates torque, rotational inertia, and angular acceleration.

$$\tau = I\alpha$$

$$\alpha = \frac{\tau}{I}$$

The ring's larger rotational inertia causes its angular acceleration to be lower. Therefore, when accelerated by the same torque as the solid disc, it loses the race.

INSTRUCTIONS:

1. Construct a simple inclined plane.
2. Hold the two wheels at the top and ask students to predict which will reach the bottom first. Note that the wheels are the same mass and the same radius.
3. Release the wheels from the same point and observe that the solid disk reaches the bottom first.

BIBLIOGRAPHY:

* Singh, S. Rolling along an incline, Connexions Web site. http://cnx.org/content/m14312/1.9/, Apr 17, 2007.

RELATED PRODUCTS:

Rotating Platform (P3-3510). 40cm diameter platform for use with hand weights or our bicycle wheel for rotational studies.

Rotating Lab Stool (P3-3610). 64cm high stool with 30cm diameter rotating seat.