EXPERIMENT 10
ROTATIONAL DYNAMICS

I. THEORY

The purpose of this experiment is to determine the experimental moment of inertia of a body by accelerating it rotationally, and compare the experimental moment of inertia with the theoretical moment of inertia.

The object we wish to find the moment of inertia of is a composite of a disks and axle, which are coaxial solid cylinders.

Both the disk and the axle are made of the same material and therefore have the same density. By measuring the length (height) and diameter of each cylinder and the total mass, the mass of each can be calculated. We can then calculate the theoretical moment of inertia of each cylinder and the disk-axle system.

To find the moment of inertia of the system experimentally, we wrap a string of negligible mass around the disk and attach a hanging mass (or driving mass) to the other end. By timing how long it takes the mass to fall to the ground, we can calculate both the acceleration of the driving mass and the angular acceleration of the disk-axle system.

By applying Newton's Second Law to the driving mass, we can determine the tension in the string and the torque exerted by the string on the two disk system. If there were no friction at the axle, this would be the only torque on the system.

We will assume that the friction at the axle exerts a constant torque, independent of the mass attached to the string. We can estimate this torque by finding how large of a driving mass is needed for the disk to turn with a constant angular velocity once the driving mass is set in downward motion.

Once we know the net torque on the disk and its angular acceleration, we can calculate an experimental value for the moment of inertia of the system.

II. LABORATORY PROCEDURE

- Place the inertia apparatus on the laboratory table, allowing the edge of the disk to stick out over the edge of the table.

- Determine the amount of mass that must be attached to the string so that the disk will rotate at a constant angular velocity once the driving mass is set into downward motion.

- Attach one of the larger driving masses provided to the string and measure the time it takes for the driving mass to fall a known distance to the floor. If you want accurate results, should you use a larger or small driving mass, a large or small distance?

- Remove the disk and axle from its support. Measure the diameters and lengths (or heights) of the large disk and axle. Return the disk and axle to its support.

- Record the combined mass of the disk and axle stamped on the disk.

III. CALCULATIONS

Show all of your work for the following calculations.

- Calculate the theoretical moment of inertia of the disk-axle system.

- Calculate the frictional torque (assumed constant) exerted on the system.

- Calculate the acceleration of the driving mass.

- Calculate the angular acceleration of and the net torque on the disk-axle system. From these, determine the experimental value for the moment of inertia.

- Find the percent difference between the theoretical and experimental values calculated for the disk-axle system.