ANGULAR VELOCITY AND ACCELERATION EXPERIMENT

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Instructions

Theoretical Resolution for mass-disk system

As it is seen in figure 1, free-body diagram shows us that the net force along z direction must be equal to mass times acceleration.

$$mg - T = ma \tag{1}$$

And in figure 2, the net torque on disk must be equal to moment of inertia times angular acceleration.

$$Tr = I\alpha \tag{2}$$

As the rod is stretched, the angular acceleration times radius of pulley is equal to the acceleration of mass "m".

$$\alpha r = a \tag{3}$$

Leaving "T" alone and substitute in equation 1, one get the following;

$$mgr = (I + mr^2)\alpha \tag{4}$$

So, here torque in the booklet will be calculated by using this formula
"$\tau = mgr$"
Students will draw "τ" vs "α" and the slope of this graph will give $I + mr^2$. As, the mass in hanger is too small (10 gram), the "mr^2" part is negligible. So they will get moment of inertia of disk.

Theoretical Resolution for Moment of Inertia of Disk

As it is shown in figure 4, We can divide the disk into infinitesimally thin rings and the sum of all will give the total moment of inertia.

$$I = \int \mathrm{d}mr^2 = \int_{R_2}^{R_1} \frac{m2\pi r\mathrm{d}r}{\pi R_1^2 - \pi R_2^2} r^2 = \int_{R_2}^{R_1} \frac{2m}{R_1^2 - R_2^2} r^3 \mathrm{d}r$$

$$= \frac{2m}{4(R_1^2 - R_2^2)}(R_1^4 - R_2^4) = \frac{m}{2(R_1^2 - R_2^2)}(R_1^2 - R_2^2)(R_1^2 + R_2^2)$$

$$I = \frac{m}{2}(R_1^2 + R_2^2)$$

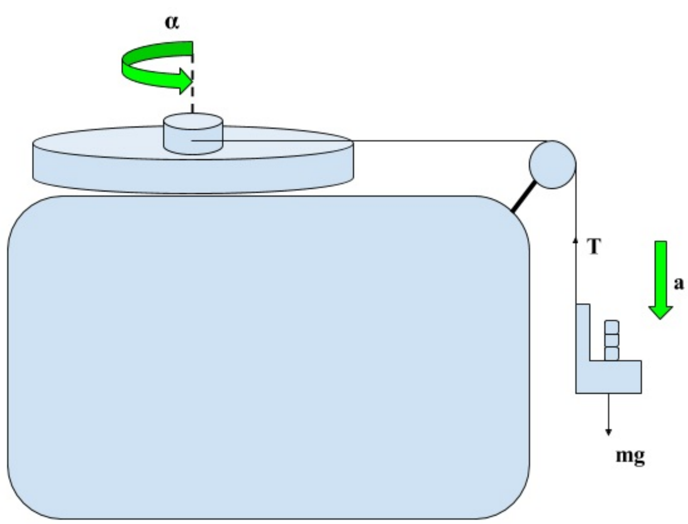

Figure 1: The experimental setup from a side

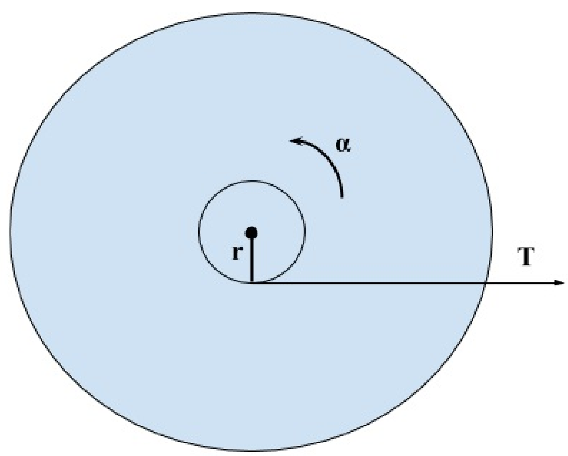

Figure 2: The experimental setup from the top

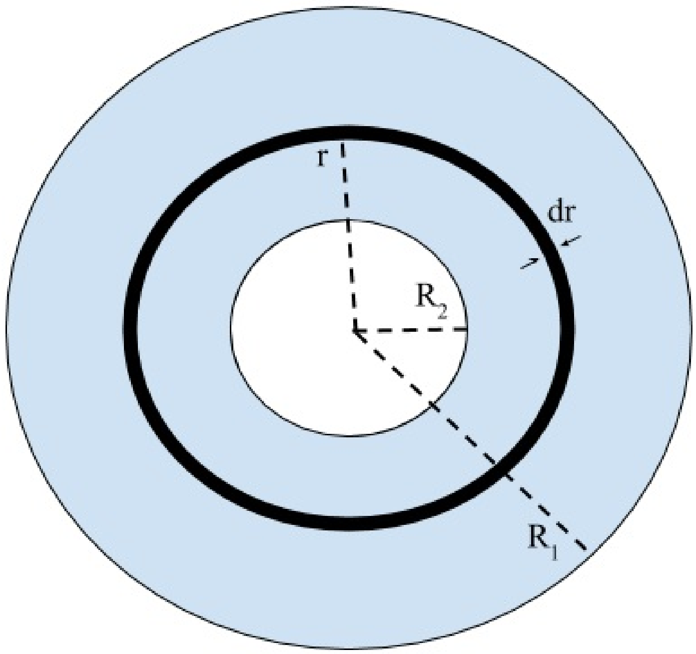

Figure 3: Moment of Inertia for a disk with the inner radius R_2 and the outer radius is R_1