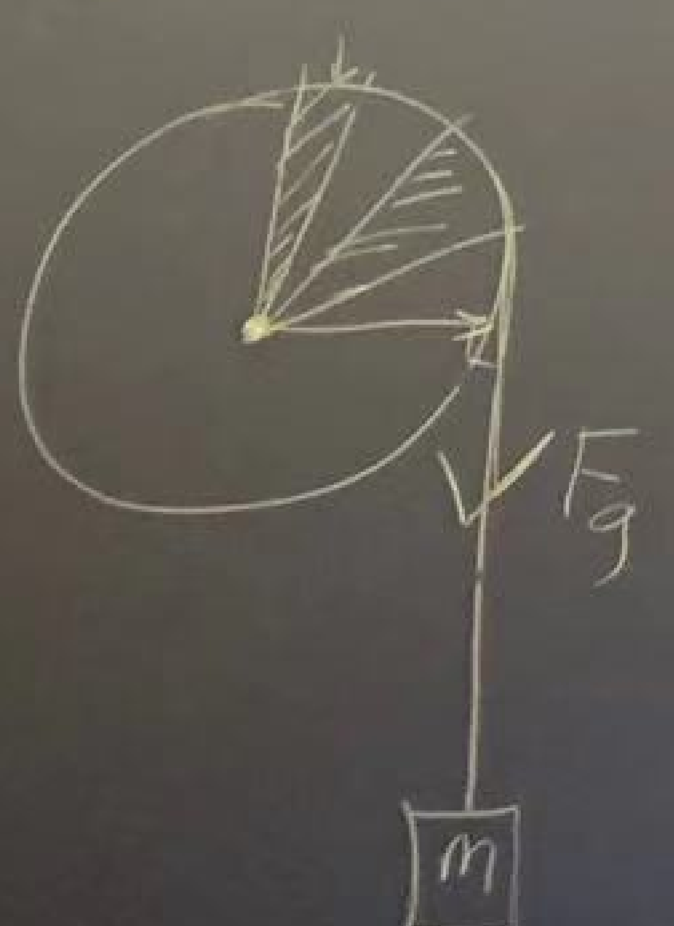
$$I = \frac{1}{2} M R^2$$

#



$$\tau = rF\sin\theta$$
$$= rF$$

$$v_T = r\omega$$

2. ANGULAR ACCELERATION

For linear dynamics Newton's second law states that F = ma, where 'F' is the force, 'm' is the mass and 'a' is the acceleration. For rotational dynamics the relation becomes:

$$\Gamma = I \alpha$$

where 'Γ', the torque is Fr (force times radius), 'I' is the moment of inertia, and 'α' is the angular acceleration.

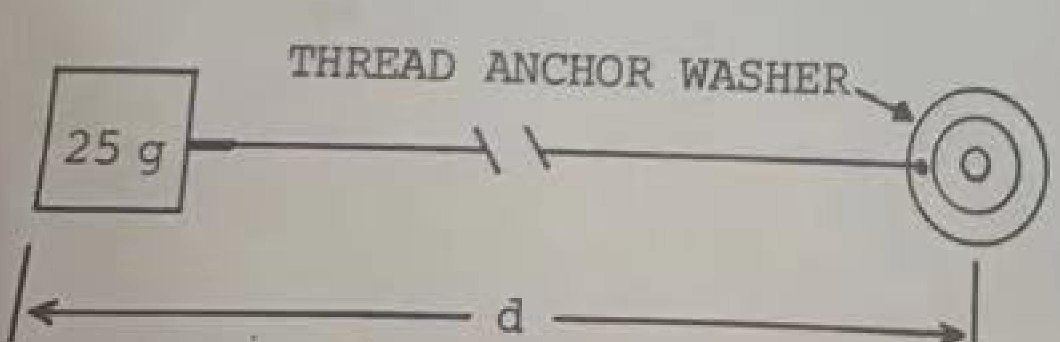
In the following experiments we will measure the angular acceleration as a function of force, torque, and moment of inertia.

PROCEDURE

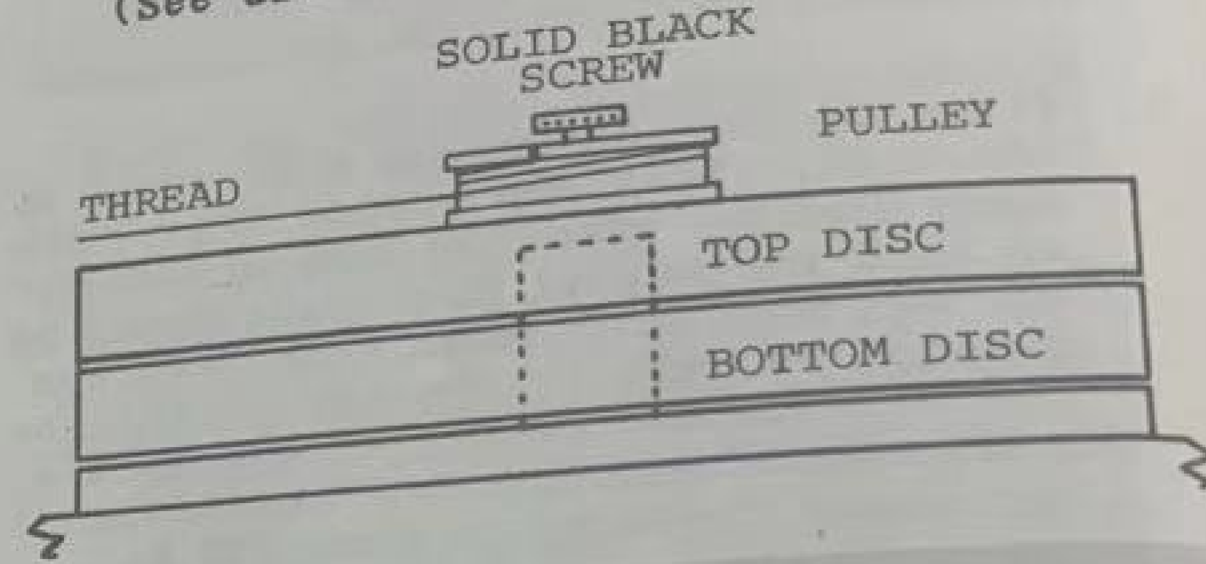
USE AN AIR PRESSURE OF 9 psi IN THIS EXPERIMENT.

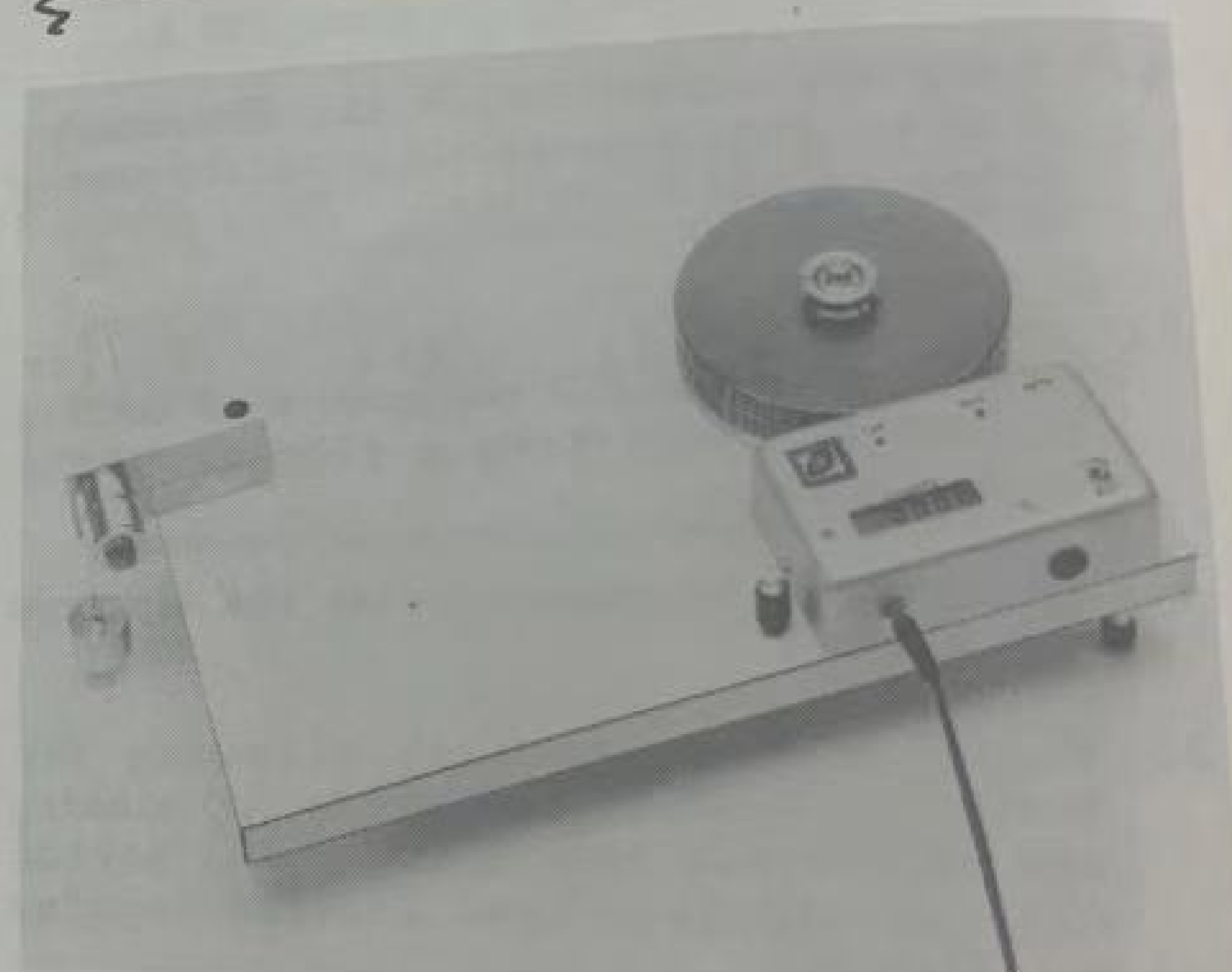
1. Set up the apparatus using BOTH steel discs. Make certain the hose clamp under the display housing is open (does NOT pinch the plastic tubing) so that the bottom disc rests firmly on the bottom plate.

2. Place the apparatus on as high a table as practical (1.5 m would be excellent) so that the accelerating mass can fall a maximum distance. The cylinder air bearing should hang over the edge of the table so that the mass can fall freely. Measure the distance from the cylinder air bearing to the floor and ADD 25 cm. Call this total 'd'. Cut a piece of thin, flexible thread about 10 cm longer than 'd'. Tie one end to the 25 g mass supplied with the unit. Tie the other end to the hole in the thread anchor washer. The distance from the mass to the anchor washer should be 'd'. (See diagram.)

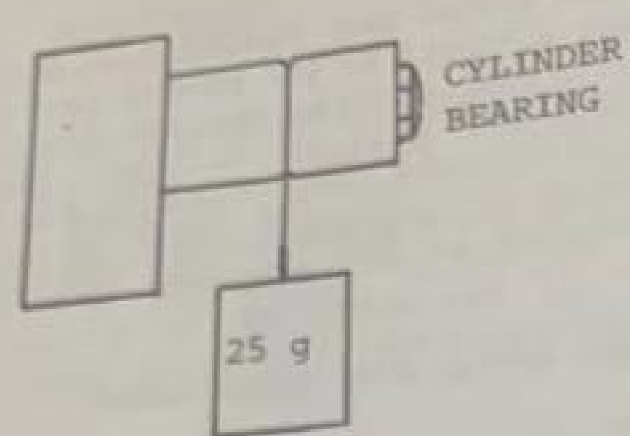


3. Using a SOLID, BLACK cap screw secure the thread anchor washer and small pulley to the hole in the center of the top disc. The thread anchor washer fits into the recess of the pulley and the cap screw goes through the hole in the washer, pulley, and into the threaded hole in the top disc. The thread should fit through the slot of the pulley, run over the groove in the cylinder air bearing, suspend the accelerating mass. (See drawing.)





4. By gently turning the upper disc (make certain the compressed air is connected to the apparatus) wind the thread around the pulley until the top of the 25 g mass is level with the bottom of the cylinder air bearing bracket. (See drawing.) Hold the top disc stationary for a moment and then release it, not imparting any initial velocity. The falling mass should accelerate the disc. When all the thread has unwound from the pulley the mass will reverse direction and the thread will wind up on the pulley.



5. As soon as the top disc is released begin recording measurement of frequency.

You will want to set the switch to TOP. The electronics will count the number of bars on the edge of the disc for a one second period. This measurement will be made exactly every two seconds.

6. NOTE Althoug the first measurement made does not necessarily begin the instant the top disc is released the measurement is still valid. However, do not use the last measurment made, just before the mass has come to the bottom of its travel. The mass may have reached the end of its travel during this measurement period and the result will be an inaccurate measurement.

7. Hopefully you will have at least three or four measurements of average velocity as the mass accelerated the disc.

8. Convert the measurements of frequency to average angular velocity. Knowing the amount of time between measurements you should be able to calculate the angular acceleration.

9. Look up the formula in your textbook for the moment of inertia of a cylinder. (The disc is actually a cylinder since there is a finite hole in the center.) Make the necessary measurements on the disc, use a scale to determine the mass, and calculate the moment of inertia.

10. Use a scale to measure the mass of the accelerating mass. Measure the radius of the pulley and determine the torque applied to the disc.

QUESTIONS

1. Is the $\Gamma = I\alpha$ relation verified?

2. There are some secondary effects which could affect the measurement you have just made. Make some calculations and determine if these factors are significant (greater than 1%)

A. In addition to accelerating the disc the falling mass also accelerates the cylinder air bearing. The moment of inertia of this bearing should be calculated and compared with the moment of inertia of the disc. Since the cylinder air bearing should not be disassembled except for cleaning the New dimensions of the rotating cylinder are given here. Inner radius: ~~0.77 cm.~~ .93cm Mass: ~~26 g.~~ 17.71g Outer radius: 1.25cm.

B. The thread used has a finite thickness and effectively increases the radius of the pulley, and therefore affects the torque. Is this effect significant?

C. Calculate the moment of inertia of the pulley. Is it significant compared to the moment of inertia of the disc?

D. One further consideration is energy loss due to air friction. We will examine this more closely in another part of this experiment.

FURTHER EXPERIMENTS

1. Repeat the above experiment by changing the torque applied to the disc. First change the accelerating mass by adding 10 or 20 g to the 25 g mass. Again measure the angular acceleration and see if the $\Gamma = I\alpha$ relation is correct.

Repeat the measurement using the 25 g weight and the larger pulley supplied with the unit.

2. Repeat the above experiment by changing the moment of inertia of the disc. Close the hose clamp under the display housing so that the clear plastic tubing is pinched closed. This should allow the bottom disc to float freely on the bottom plate. Now replace the SOLID, BLACK cap screw (holding the pulley to the top