Lab 8: Whirly Twirly Time

There are very few machines and situations that don't have spinning parts. From helicopters to ice skaters; cell phones to racecars, they all require a thorough understanding of rotational motion. One of the most difficult things to grasp is the concept of moment of inertia. In this lab you will have to carefully analyze 5 situations that involve a significant contribution by the moment of inertia.

Complete the steps that start with the "*" while you are at each station. This will minimize the time each group has to wait on each other. After you have completed the last station (or while you are waiting for the group in front of you), go back and complete the other steps.

Newton's 2nd law (for rotational motion) Part 1

1. *The mass of the grey rotating disk is 875.5 grams. Carefully measure the <u>diameter</u> to find <u>radius</u> of the grey disk. Record the data on the chart.
2. Calculate the moment of inertia of the grey disk. Record the data on the chart.
3. *The hanging mass (m_1) is 100 grams. Measure the radius of the aluminum pulley around which the m_1's string is wrapped and record the data.
4. Find an equation for the tension in the string. Hint: Draw a free body diagram of the falling mass only and apply Newton's <u>linear</u> 2nd law.
5. *Carefully measure the height m_1 will fall and record the data.
6. *Allow m_1 to fall, carefully recording the time it takes to hit the ground. Record 4 times on the data sheet and also calculate the average time.
7. Using the <u>linear</u> 'fantastic 4' equations, calculate the linear acceleration of m_1, which is the same as the tangential acceleration at the radius of the aluminum pulley.
8. Calculate the angular acceleration of the aluminum pulley-grey disk assembly.
9. Using Newton's <u>angular</u> 2nd law, the tension from step 4, and the angular acceleration from step 8, find the moment of inertia of the aluminum pulley-grey disk assembly. Hint: draw a free body diagram of the rotating aluminum pulley-grey disk assembly.
10. Now find the moment of inertia of just the aluminum pulley.

Newton's 2nd law (for rotational motion) Part 2

1. *The mass of each grey rotating disk is 875.5 grams. Record the radius of the grey disks as measured in part 1.
2. Calculate and record the moment of inertia of each grey disk.
3. *Both hanging masses (m_1 and m_2) have a mass of 550 grams. Measure the radii of each aluminum pulley about which each string is attached and record the data (call the smaller one r_2).
4. *Carefully measure the height that the falling mass (m_1) will fall. Notice the other mass does <u>not</u> travel the same distance!
5. *Carefully record the time it takes for the mass to fall (record 4 measurements).
6. Using the techniques you learned in "Newton's 2nd Law (for rotational motion) Part 1," calculate the rest of the information on the chart. Notice that the angular acceleration is the same for both pulleys.

Inclined Plane

1. *Turn on the photo gates by setting them to "Gate" mode.
2. *There are 70 grams hanging over the edge (m_1). Measure the mass of the sled, flag, and hook, and record the mass of the fully loaded sled.
3. *Measure the two positions (x_1 and x_2) of the front edge of the sled at which the photo gate sensor light is first triggered.
4. *Measure the height of the track at those same two positions. (h_1 and h_2).
5. *Measure the flag width.
6. *Turn on the air track to max power.
7. *Pull the sled to a point before the first photo gate.
8. *Reset the photo gates.
9. *Allow the sled to slide, and record both the t_1 and the t_{total} (multiple attempts may be required to collect clean data).
10. Knowing that t_1 and t_2 (which is $t_{total} - t_1$) are the times it took for the flag to pass each photo gate, and since you know the width of the photo gate, you can find the speed of the sled at each position (assume constant speed under the photo gates).
11. *Measure the radius of the pulley.
12. Using energy considerations, calculate the moment of inertia of the pulley.

Atwood's Machine Revisited

1. Record the Moment of inertia of the aluminum pulley-grey disk assembly you found in parts 1 and 2.
2. *Measure the outer diameter of the iron hoop and record its radius.
3. *m_1 is 550 grams and m_2 is 450 grams. Measure the height m_1 will fall. Notice the height m_2 will rise <u>is</u> the same in magnitude.
4. *Record 4 measurements of the time it takes m_1 to fall.
5. Calculate the final speeds of the masses at the end of the fall.
6. Calculate the final angular velocity of the aluminum pulley-grey disk-iron hoop assembly.
7. Using conservation of energy or fantastic 4, calculate the moment of inertia of the iron ring.

Demolition Derby Again

1. *Level the stand
2. *Turn the photo gate on by turning the switch to "Pend."
3. Record the values of the moment of inertia of the aluminum pulley-grey disk assembly (disk1) and just the grey disk (disk2)
4. *Give disk 1 a good spin, and quickly push the reset button on the photo gate base. This will give you the time it takes disk1 to make 2 revolutions.
5. *Quickly, gently, and carefully drop disk2 onto disk 1 (while it is still spinning). Immediately after the system stabilizes click the reset button on the photo gate. Record the time takes for the system to rotate through 2 revolutions.
6. You may have to repeat steps 4 and 5 a few times until you are satisfied that you did it quick enough.
7. Calculate the initial and final angular speeds using the photo gate information.
8. Calculate the final angular speed based on conservation of angular momentum concepts
9. Find the percent error between the two angular speeds.