Name(s) and Alpha(s) Date

SP211 Lab 8
Rotational Kinematics and Dynamics

Equipment

The following equipment is necessary to complete this lab in the quantities listed in parentheses:

Pulley Attached to Centripetal Force Apparatus (1)
Big Slotted 500 g Masses (2)
Wingnuts (4)
Crossbar (1)
String (1 per room)
Mass Hook (1)
Slotted Mass Set for Hook (1)
Meter Stick (1)
Calipers (1)

You will also need Google Gemini to complete this lab.

Experiment 1: Predicting the Rotor's Moment of Inertia

1) Figure 1 displays the apparatus setup for this lab. Dismantle the crossbar at the top and measure the mass of the two masses. Record them in Table 1. Measure the mass of the four wing nuts together and determine their *average* mass. Record this in Table 1 as well. Finally, measure the mass of the rod that held the masses and the wing nuts and record that in Table 1.

2) Measure the length of the rod that held the masses and wing nuts. Record its length in Table 1. Reassemble the apparatus. Make sure r_1 and r_2, as depicted in Figure 1, are as close to the same value as you can make them. Note that r_1 and r_2 are measured from the center of the vertical axle to the center of the masses. Record your values for r_1 and r_2 in Table 1.

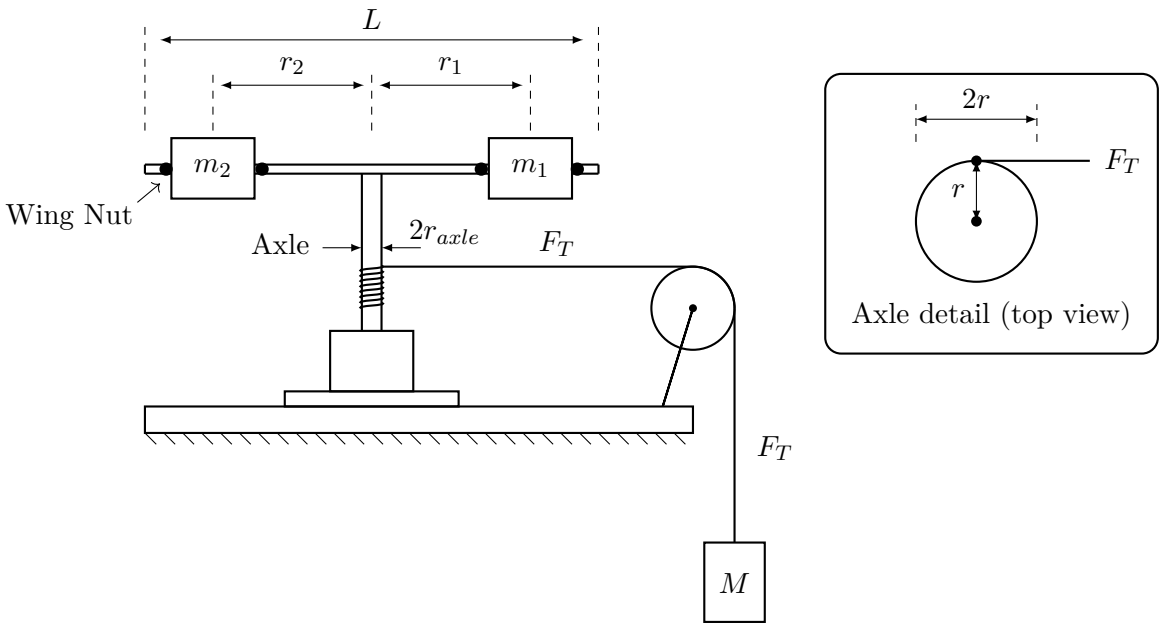


Figure 1: Our rotor apparatus setup.

Quantity	Measured Value
m_1	
m_2	
m_{rod}	
m_{wingnut}	
L	
r_1	
r_2	

Table 1: Measurements for predicting the rotor's moment of inertia.

3) Now we are going to calculate the moment of inertia of our apparatus. To do this, we are going to treat two wing nuts *plus* the mass they are holding in place as one particle. We have two masses that are each held on by two wing nuts, so we will need to do the calculation for their moments of inertia individually and then add them together with the moment of inertia of the rod. First, identify the equations that we can use to calculate the moment of inertia of a particle and the moment of inertia of a rod rotating in the manner of our setup. Record them below.

4) Next, calculate the moment of inertia of two wing nuts plus mass m_1 together as if they are all one particle. Show your work below. Do the same for m_2 plus two wing nuts. Then, calculate the moment of inertia of the rod. Finally, add up all three moments of inertia to find the net moment of inertia of the rotor. Show your work!

Quantity	**Measured Value**
I_{m_1}	
I_{m_2}	
I_{rod}	
I_{net}	

Table 2: Static determination of the rotor's moment of inertia.

Experiment 2: Determining the Rotor's Moment of Inertia Dynamically

1) Measure the diameter of the vertical axle on the apparatus. Record half of this as the radius of the axle in Table 3 below.

2) We will apply a torque to the axle to turn it by hanging a mass on a string that goes over the pulley and is wrapped around the axle at least 30 times. Select a moderate amount of mass to hang (e.g. about 200 g is sufficient). Weigh this mass, including its hanger, and record it in Table 3 as mass M.

3) Wrap the string around the axle 30 times, taking care to not overlap the string on itself. Drape the remainder of the string over the pulley and hang the mass M off it. Do not let the string unwind itself from the axle yet!

4) Using the timer on your phone, time how long it takes for the apparatus to spin at least 20 times when you let mass M drop. Record the number of revolutions (N) you allowed the apparatus to spin through and the time (t_N) it took to spin that many revolutions in Table 3. If this is difficult to do, you picked too large of a mass.

5) If you were careful to not allow the string to overlap itself when you originally wrapped

it around the axle, you can now use the radius of the axle you measured, the equation for the circumference of a circle, and the number of revolutions you allowed the apparatus to spin through to calculate the distance the mass M fell (Δh). Show your work!

Quantity	Measured Value
r_{axle}	
M	
N	
t_N	
Δh	
$\Delta\theta$	

Table 3: Measurements for the dynamic determination of the rotor's moment of inertia.

6) Calculate the number of radians the apparatus rotated ($\Delta\theta$) by using the number of revolutions you allowed the apparatus to spin through and the number of radians in a circle. Record this in Table 3 as well.

7) Using kinematics equations (both regular and rotational), calculate the linear acceleration of the hanging mass and the angular acceleration of the rotor. Hint: The system started with no initial velocity or angular velocity. Record these in Table 4 below. Show your work!

Quantity	Measured Value
a	
α	

Table 4: Linear acceleration of the hanging mass and angular acceleration of the rotor.

8) Draw a free body diagram of the hanging mass while it is accelerating downward. Use it and Newton's Second Law to determine the tension in the string (F_T).

9) The tension in the string (F_T) is the force causing the torque (τ) on the rotor. Now calculate that torque and record it below.

10) Next, use your torque and angular acceleration to calculate the moment of inertia of the rotor. Record your work below.

Question 1: What is the percent difference between your predicted moment of inertia (Experiment 1) and the moment of inertia you just dynamically measured (Experiment 2)?

Clean Up

Please return your lab station and the drawer of equipment to a clean and organized form. Follow any directions your instructor gives you about where to return equipment to when you are finished with the lab.