

## Rotational Inertia Lab 01-29-04

Name \_\_\_\_\_ 0

**Purpose:** You will find the rotational acceleration of several rotating “point” masses and use that acceleration to calculate the rotational inertia of the rotating masses. This will be compared to the predicted values.



### Procedure:

#### PART A: - Acceleration of empty bar

1. Load the lab program “rotinert.ds”. This will load the Data Studio program and the Rotational Inertia data taking activity.
2. You will be graphing  $v$ , the linear velocity of the falling mass, versus time. The slope of this graph will give us the linear acceleration,  $a$ .
3. The radius of the largest step pulley on the top of the Rotary Motion Sensor (RMS) is 2.39 cm.
4. Measure the mass of each brass mass with thumb screw. RECORD the masses to the nearest 0.1 grams. Do not put the masses on the rotating bar yet.
5. Place a 20 g mass (with center hole) on the 5.3 gram gray plastic hanger.
6. Make sure the string is over the smart pulley (the slotted one). The smart pulley should be aimed at the left edge of the large pulley. Do not straighten it. Why?
7. Carefully rotate the disk and bar mounted on the RMS **clockwise** (as viewed from above) so the black thread winds onto the lower step pulley. Make sure it does not go onto the pulley above or onto the axle below! It is very important that the thread be wound correctly. If it doesn't look right, unwind it and wind it again.
8. When the mass and hanger have been raised close to the pulley, stop winding. One lab partner should hold the bar at this position. If the hanging mass is swinging, stop it.
9. Start the data run by clicking on “Start”. Wait until you see data recording on your graph, (about 1/2 second) quickly release the bar without pushing it, allowing the mass to fall.
10. When the falling mass hits bottom, click “Stop”.
11. Stop the spinning bar (gently) so the string does not become tangled.
12. Starting at about the fifth non-zero dot, highlight (downward) the previous non-zero dots in yellow by clicking and dragging. (Do not include any zero dots). Make sure you use the arrow cursor, not the hand cursor. Also, do not use the stretch tool, which looks like a spring with arrows on the end.

- Click on “Fit” at the top of the graph. (Use Graph 1 for Part A and Graph 2 for Parts B through E). Select “Linear fit”. RECORD the slope (which gives acceleration). Keep all sig. figs.
- After you have recorded the data, click on “Fit” and turn off the “Linear fit”. Also delete all previous data.
- Rewind the bar and make two more runs.

### **PART B: - Acceleration of bar with one mass**

- Make sure you use Graph 2 for parts B through E.
- Now place a single mass on the rotating bar so its end is exactly flush with the end of the bar and the thumbscrew is pointing up.
- RECORD the radius to the center of the mass from the axis of rotation.
- Repeat steps 6 to 15 above, but in step 12, highlight the straight part.

### **PART C: - Acceleration of bar with two masses**

- Make sure you use Graph 2 for parts B through E, but in step 12, highlight the straight part.
- Now place the two masses on the rotating bar so their ends are exactly flush with the end of the bar and the thumbscrews are pointing up.
- RECORD the radius to the center of the masses from the axis of rotation. They should be the same.
- Repeat steps 6 to 15 above, but in step 12, highlight the straight part.

### **PART D:**

- Make sure you use Graph 2 for parts B through E, but in step 12, highlight the straight part.
- Now place the a single mass on the rotating bar so its center is at a distance exactly half as large as that recorded in step 17.
- RECORD the radius to the center of the mass from the axis of rotation.
- Repeat steps 6 to 15 above, but in step 12, highlight the straight part.

### **PART E:**

- Make sure you use Graph 2 for parts B through E.
- Now place the two masses on the rotating bar so their centers are at a distance exactly half as large as that recorded in step 17.
- RECORD the radius to the center of the masses from the axis of rotation. They should be the same.
- Repeat steps 6 to 15 above, but in step 12, highlight the straight part.

### **Calculations:**

- We do not know the rotational inertia of the shaft, pulley, disk, and bar system (without masses on bar). Derive an equation for  $I_{\text{empty}}$  in terms of  $m_h$ ,  $R_p$ ,  $g$ , and  $a$ . Use Newton’s 2<sup>nd</sup> Law with both force and torque.

33. Using the data from Part B, calculate the rotational inertia of the single mass at the end of the bar (using an equation like  $I_{\text{empty}}$ ). RECORD this. Subtract  $I_{\text{empty}}$  from this and RECORD as rotational inertia of the rotating mass.
34. Using the data from Part C, calculate the rotational inertia of the two masses at the end of the bar (using an equation like  $I_{\text{empty}}$ ). RECORD this. Subtract  $I_{\text{empty}}$  from this and RECORD as rotational inertia of the rotating masses. What happened to the rotational inertia when the mass on the bar was doubled? (Compare steps **B** and **C**). **Answer this question and the following two questions on the bottom of the results table. Include the question in your answer. That is, “When the mass on the bar was doubled, the rotational inertia ...” Do not write the question.**
35. Using the data from Part D, calculate the rotational inertia of the single mass halfway in from the end of the bar (using an equation like  $I_{\text{empty}}$ ). RECORD this. Subtract  $I_{\text{empty}}$  from this and RECORD as rotational inertia of the rotating mass. What happened to the rotational inertia when the radius of rotation of the single mass was halved? (Compare **B** and **D**).
36. Using the data from Part E, calculate the rotational inertia of the two masses halfway in from the end of the bar (using an equation like  $I_{\text{empty}}$ ). RECORD this. Subtract  $I_{\text{empty}}$  from this and RECORD as rotational inertia of the rotating masses. What happened to the rotational inertia when the radius of rotation of the two masses was halved? (Compare **C** and **D**).
37. Later, after you have learned how to calculate the rotational inertia directly, RECORD these as the predicted rotational inertias. Calculate and RECORD the % errors.

## Rotational Inertia Lab Data and Calculations

### DATA:

Radius of step pulley (m)	Mass of hanger and 20g mass (kg)	Mass of Brass <sub>1</sub> (kg)	Mass of Brass <sub>2</sub> (kg)

#### Part A – empty bar

Acceleration (m/s <sup>2</sup> )	Average Acceleration (m/s <sup>2</sup> )

#### Part B – single mass at end of bar

Radius to c of m of mass (m)	Acceleration (m/s <sup>2</sup> )	Average Acceleration (m/s <sup>2</sup> )

#### Part C – two masses at end of bar

Radius to c of m of mass (m)	Acceleration (m/s <sup>2</sup> )	Average Acceleration (m/s <sup>2</sup> )

#### Part D – single mass halfway in

Radius to c of m of mass (m)	Acceleration (m/s <sup>2</sup> )	Average Acceleration (m/s <sup>2</sup> )

#### Part E – two masses halfway in

Radius to c of m of mass (m)	Acceleration (m/s <sup>2</sup> )	Average Acceleration (m/s <sup>2</sup> )

## CALCULATIONS:

### Part A – empty bar

Rotational Inertia ( $\text{kg}\cdot\text{m}^2$ )

### Part B – single mass at end of bar

Rotational Inertia ( $\text{kg}\cdot\text{m}^2$ )	Predicted Rotational Inertia ( $\text{kg}\cdot\text{m}^2$ )	Percent Error

### Part C – two masses at end of bar

Rotational Inertia ( $\text{kg}\cdot\text{m}^2$ )	Predicted Rotational Inertia ( $\text{kg}\cdot\text{m}^2$ )	Percent Error

### Part D – single mass halfway in

Rotational Inertia ( $\text{kg}\cdot\text{m}^2$ )	Predicted Rotational Inertia ( $\text{kg}\cdot\text{m}^2$ )	Percent Error

### Part E – two masses halfway in

Rotational Inertia ( $\text{kg}\cdot\text{m}^2$ )	Predicted Rotational Inertia ( $\text{kg}\cdot\text{m}^2$ )	Percent Error