



Rotary Motion Sensor

Model No. CI-6538

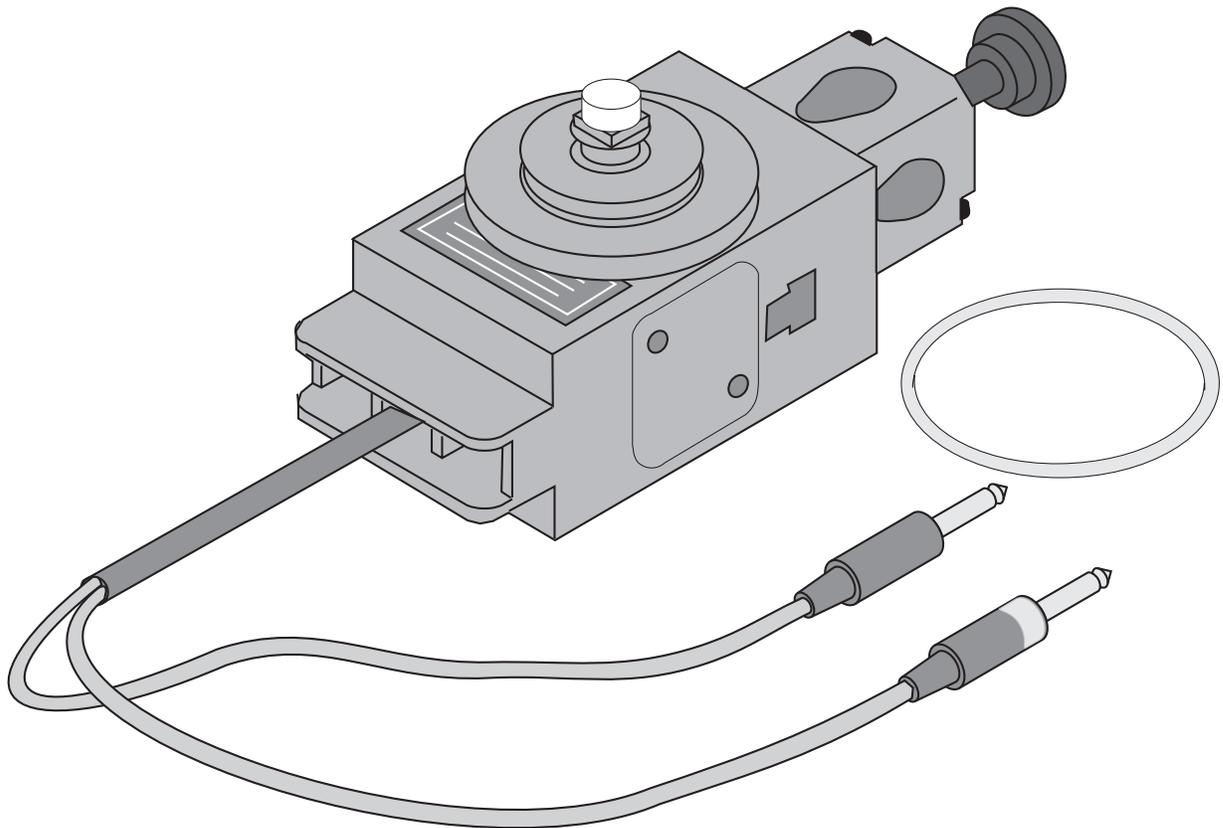


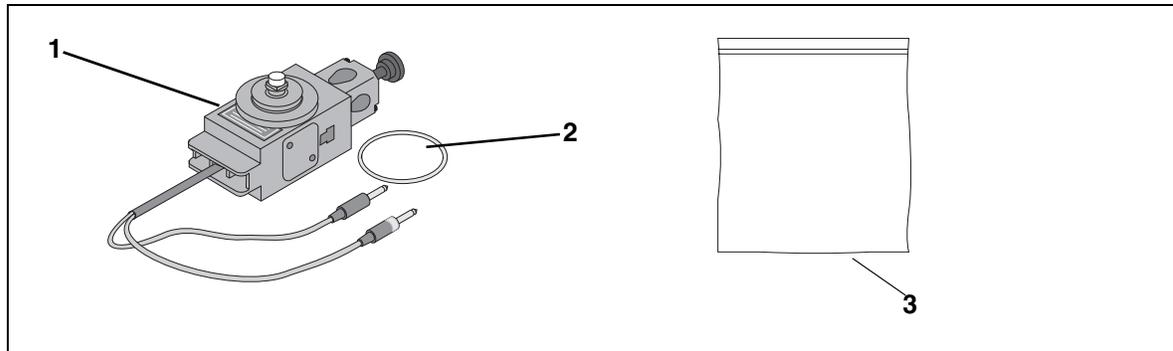
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Rotary Motion Sensor

Model No. CI-6538

Equipment List



Included Equipment	Replacement Model Number*
1. Rotary Motion Sensor	CI-6539
2. O-ring	NA
3. Ziplock Bag	NA

*Use Replacement Model Numbers to expedite replacement orders.

NA = not sold separately from PASCO

Additional Equipment Required	Model Number
Any PASCO data acquisition device (<i>ScienceWorkshop</i> ® 500 interface, <i>ScienceWorkshop</i> 750 SCSI or 750 USB interface)	CI-6400 or CI-6450 or CI-7599
A computer	NA
DataStudio® Software	CI-6470C

Optional Items	Part Number
Rotary Motion Sensor Experiment Manual	021-06053

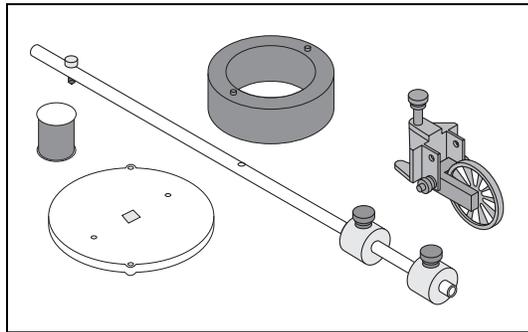
Optional Accessories

Mini-Rotational

Accessory

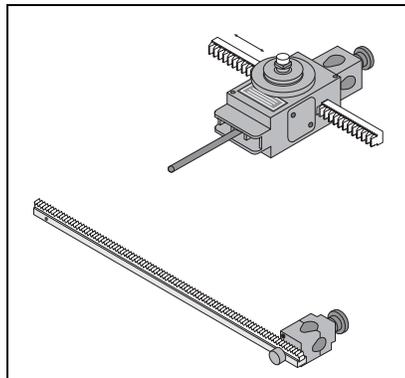
The PASCO CI-6691 Mini-Rotational Accessory is used to perform rotational inertia experiments, conservation of angular momentum experiments, and pendulum experiments. Included are an aluminum disk, a steel

ring, a long thin rod, and two brass masses which can be attached at any point on the thin rod to act as point masses. (For instructions on attaching this accessory, see “Equipment Setup” in this manual).



Linear Motion Accessory

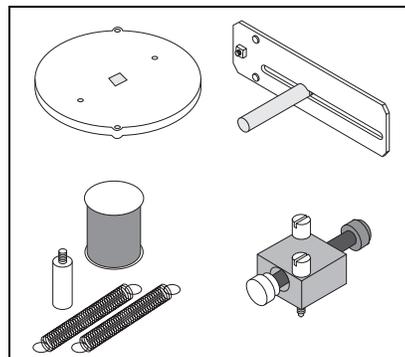
The PASCO CI-6688 Linear Motion Accessory is a 21 cm long rack that is inserted into the t-slot in the side of the RMS to convert a linear motion into a rotary motion. The teeth on the rack engage a gear inside the RMS, causing it to rotate as the rack is pushed through the slot. The rack may be inserted into either side of the RMS. Sensors can be mounted to the rack using the rod clamp which can be attached to either end of the Linear Motion Accessory rack. (For instructions on using this accessory, see “Equipment Setup” in this manual).



Chaos Accessory

The PASCO CI-6689 Chaos Accessory consists of an aluminum disk (identical to the one provided with the Mini-Rotational Accessory), a mass which attaches to the edge of the disk to form a physical pendulum, two springs for putting tension in the thread, a mounting bracket for mounting the RMS to the PASCO Introductory Dynamics

System tracks (1.2 meter ME-9435A or 2.2 meter ME-9458), and an adjustable-gap magnet which attaches

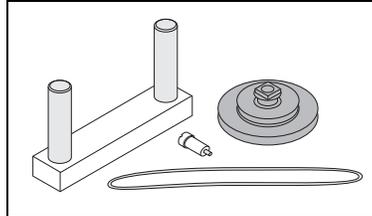


to the side of the RMS to provide variable magnetic damping. (For instructions on using this accessory, see “Equipment Setup” in this manual).

The Chaos Accessory is a driven damped physical pendulum. Various types of phase plots can be made as the driving frequency, driving amplitude, initial conditions, and the amount of damping are varied.

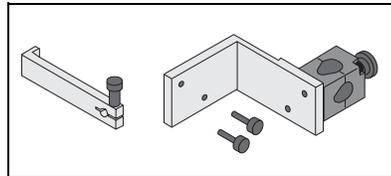
“A” Base Rotational Adapter -

The CI-6690 “A”-base Rotational Adapter is used to mount the Rotary Motion Sensor to the “A” base of the ME-8951 Rotating Platform or the ME-8960 Gyroscope. The RMS provides higher resolution than a Smart Pulley, and precession of the Gyroscope can be plotted since the RMS keeps track of direction of rotation. The adapter includes a mounting bracket, a shoulder screw, a drive belt (o-ring), and a 3-step Pulley. (For instructions on attaching this accessory, see “Equipment Setup” in this manual).



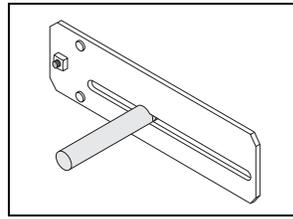
RMS/Gyroscope Mounting Bracket

The PASCO ME-8963 RMS/Gyroscope Mounting Bracket attaches the Rotary Motion Sensor to the ME-8960 Gyroscope so the angle of nutation can be detected. (For instructions on attaching this accessory, see “Equipment Setup” in this manual).

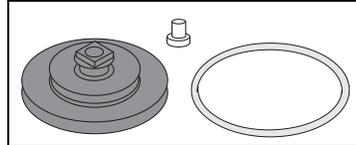


IDS Mount Accessory

The PASCO CI-6692 IDS Mount Accessory is a bracket that allows the Rotary Motion Sensor to be attached to the Introductory Dynamics System tracks.

**3-Step Pulley Accessory (CI-6693)**

The PASCO CI-6693 3-step Pulley Accessory includes an additional pulley for mounting a 3-step Pulley on each end of the Rotary Motion Sensor rotating shaft. It also includes an o-ring.

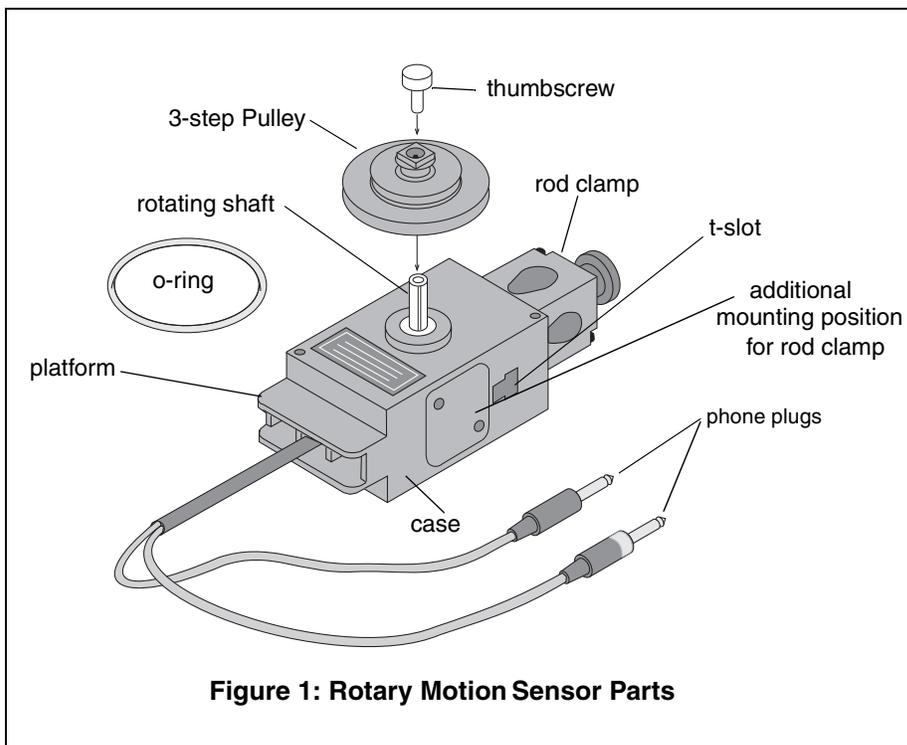


Introduction

The PASCO CI-6538 Rotary Motion Sensor is a bidirectional position sensor designed for use with the PASCO *ScienceWorkshop*[™] 750 Interface. It contains an optical encoder which gives a maximum of 1440 counts per revolution (360 degrees) of the Rotary Motion Sensor shaft. The resolution can be set in the ScienceWorkshop software to 360 or 1440 times per revolution (1 degree or 1/4 degree). The direction of rotation is also sensed.

The Rotary Motion Sensor has two phone plugs which plug into any two adjacent digital channels on the 750 interface box.

The rod clamp can be mounted on three sides of the sensor case, allowing the Rotary Motion Sensor to be mounted on a rod stand in many different orientations. The 3-step Pulley keys into the rotating shaft and can be mounted on either end of the shaft. A rubber o-ring is intended to be slipped over the largest pulley step so the RMS can be pressed against a surface to sense the relative motion between the sensor and the surface. The end of the Rotary Motion Sensor where the cord exits the case provides a platform for mounting a clamp-on Super Pulley. The t-slot in either side of the RMS is for inserting the optional Linear Motion Accessory rack. This allows you to measure linear motion over the length of the rack.

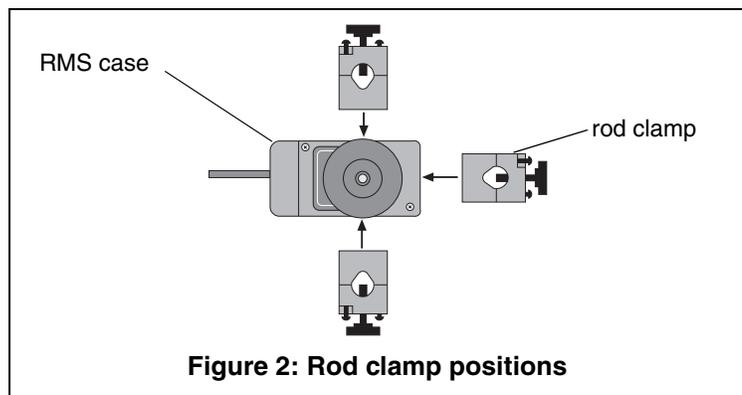


General Setup Options

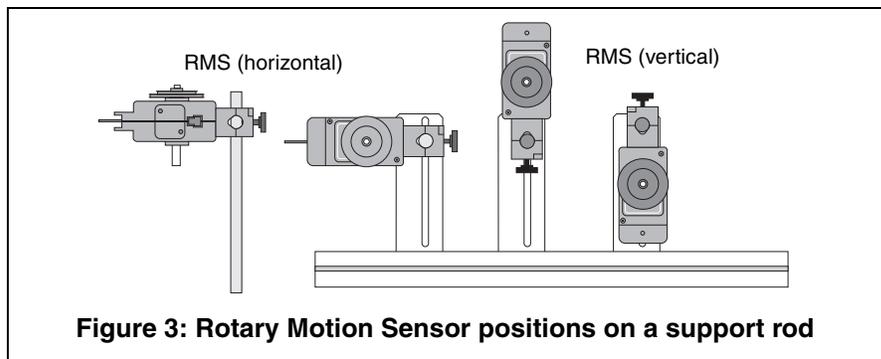
1) Mounting the Rotary Motion Sensor (RMS)

a) Mounting the RMS on a Support Rod

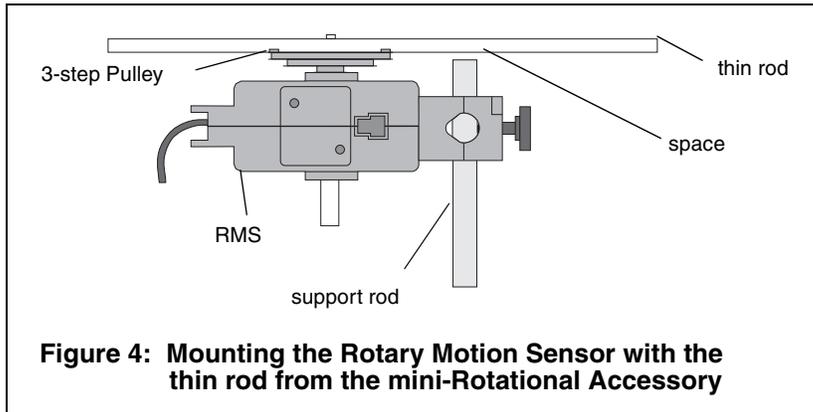
The Rotary Motion Sensor can be mounted on a support rod using the supplied rod clamp. The rod clamp can be mounted in three different locations on the Rotary Motion Sensor: at the end opposite the cable and on either side of the case. A Phillips screwdriver is required to remove the two screws that hold the rod clamp on the Rotary Motion Sensor case.



It is possible to mount the RMS horizontally on a support rod, with the 3-step Pulley facing up or vertically, with the pulley facing forward.

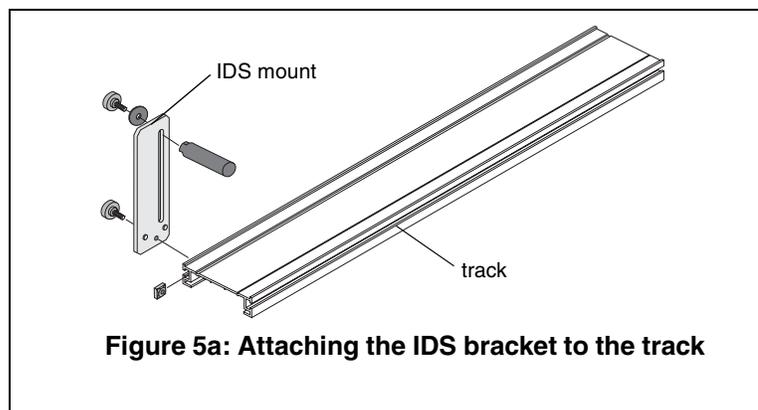


***Note:** When setting up the rotational inertia experiment with the thin rod for the mini-rotational accessory, the Rotary Motion Sensor must be mounted at the top of the support rod, so that the support rod does not interfere with the rotation of the thin rod.*

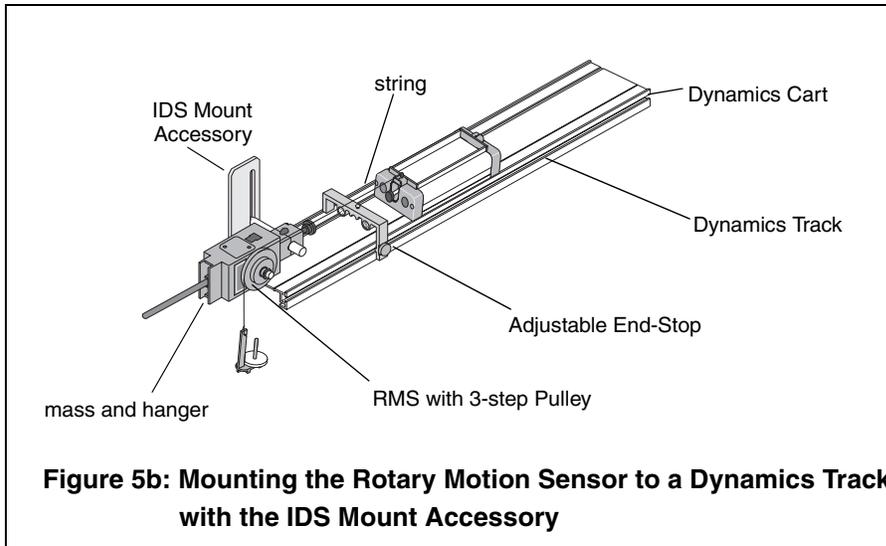


b) Mounting the RMS to a Dynamics Track

The Rotary Motion Sensor can be mounted to a Dynamics Track using the IDS Mount Accessory. To mount the RMS to the track, do the following: a) Slide the square nut into the insert on the side of the track. b) Slide the horizontal rod from the IDS mount through the hole on the clamp of the RMS. Tighten the screw on the RMS clamp to hold the rod in place. c) Tighten the screw on the IDS mount to the square nut in the track. (See Figures 5a and 5b.)

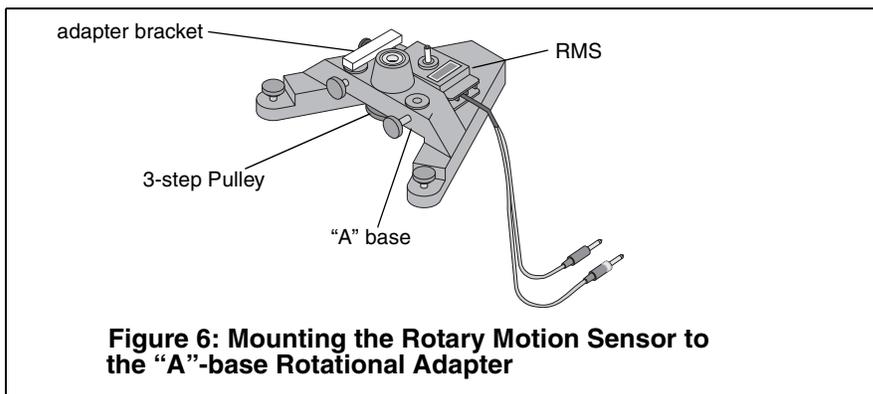


The Rotary Motion Sensor can be used as a “Smart Pulley” in this configuration by threading a string over the Rotary Motion Sensor pulley and hanging a mass on the string.



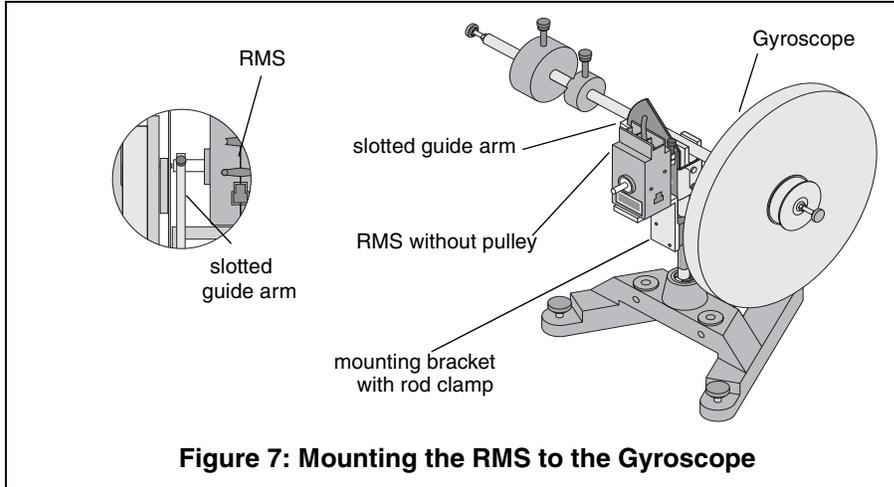
c) Mounting the RMS to the “A” base

The Rotary Motion Sensor can be mounted to the Rotating Platform or the Gyroscope using the “A”-base Rotational Adapter. This allows the precession angle of the Gyroscope to be detected.



d) Mounting the RMS to the Gyroscope

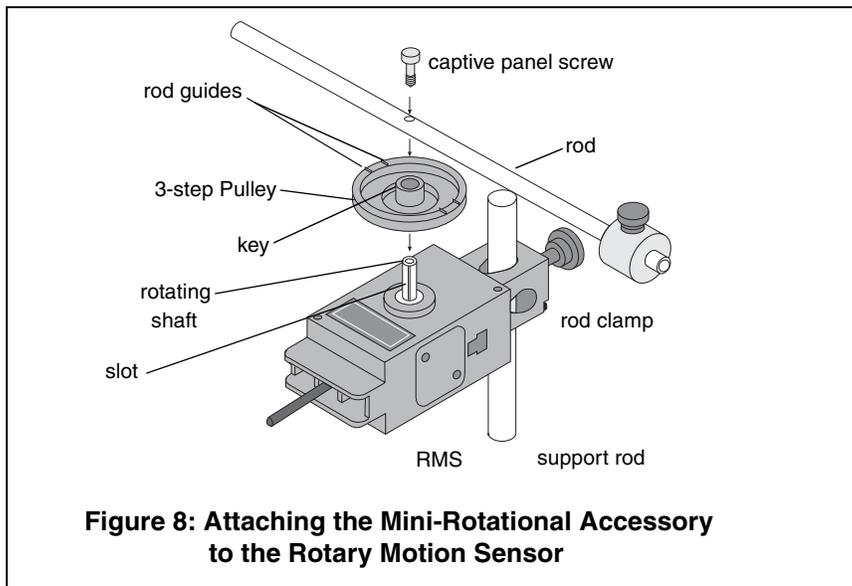
The Rotary Motion Sensor can be mounted to the Gyroscope using the RMS/Gyroscope Accessory. This allows the nutation angle of the Gyroscope to be detected.



Attaching Accessories to the Rotary Motion Sensor (RMS)

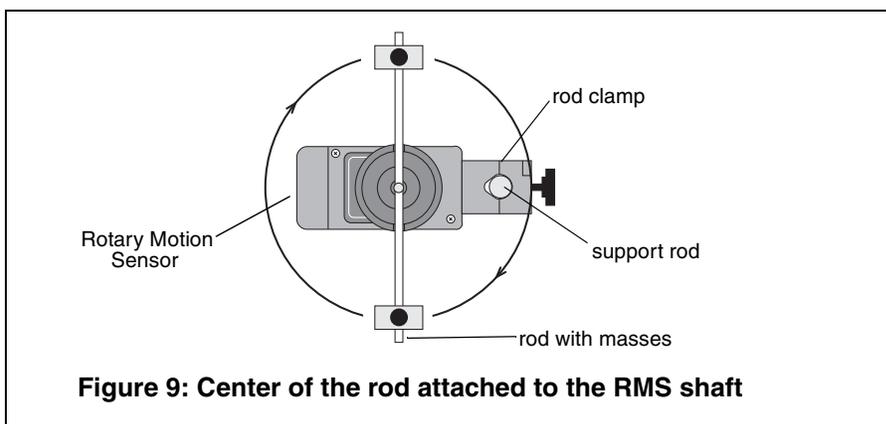
a) Attaching the Mini-Rotational Accessory to the RMS

To attach the thin rod to the RMS, orient the 3-step Pulley so the rod guides on the underside of the pulley face up. The 3-step Pulley and the rotating shaft on the RMS are keyed to assemble only in one position. Assemble the apparatus as illustrated.

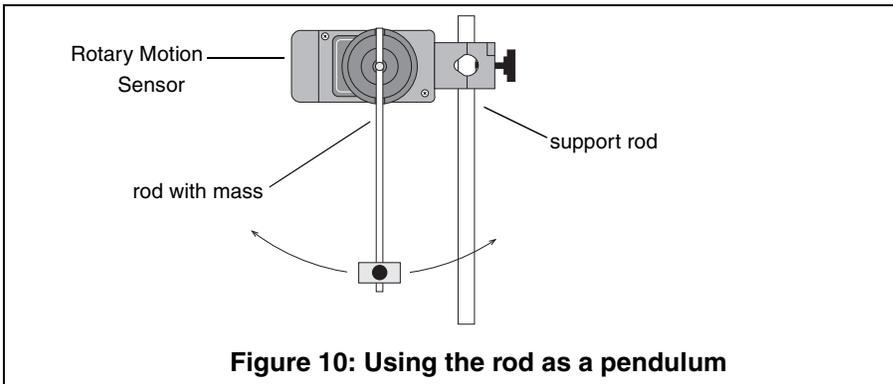


The rod can be used for two purposes:

- The center of the rod can be attached to the RMS rotating shaft and used with the point masses to find the rotational inertia of point masses.

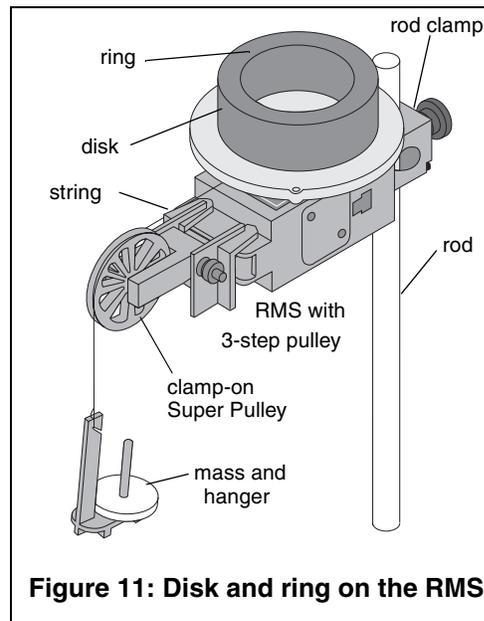


- The end of the rod can be attached to the Rotary Motion Sensor rotating shaft to use it as a pendulum.



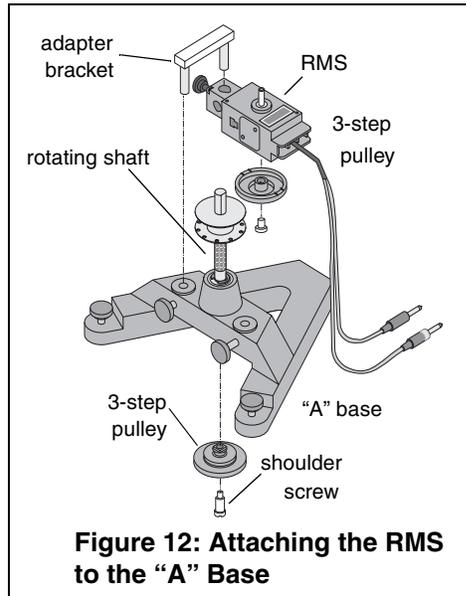
Using the Disk and Ring

For rotational inertia experiments, wrap around string attached to a mass around the 3-step pulley included with the Rotary Motion Sensor. Hang the mass over the clamp-on Super Pulley to accelerate the apparatus. Perform a conservation of angular momentum experiment by dropping a ring onto the rotating disk.

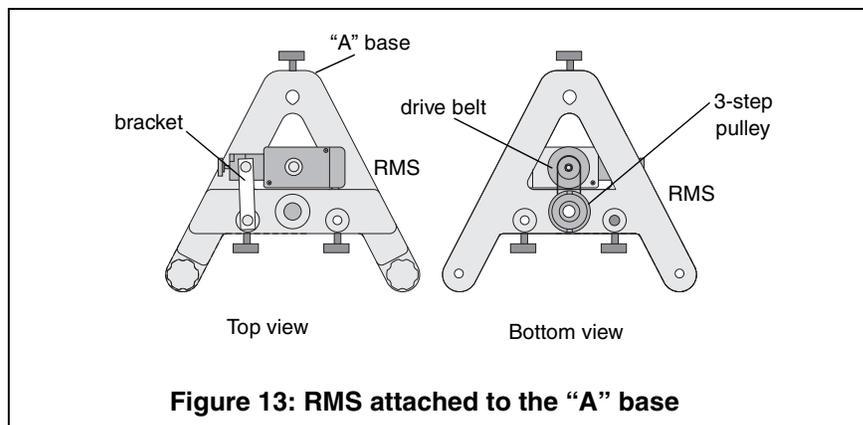


b) Attaching the "A" Base Rotational Adapter Accessory to the RMS

The drive belt links the 3-step Pulley mounted on the "A" base to the 3-step Pulley on the RMS. For a one-to-one correspondence, connect the two pulleys using the o-ring on the middle step of each pulley. Each revolution of the Rotating Platform or Gyroscope corresponds to one revolution of the RMS. If desired, a 5-to-1 ratio can be attained by putting the o-ring on the top or bottom steps.



The pulley attaches to the underside of the rotating shaft with the shoulder screw. Please note the pulley orientation illustrated in Figure 13. The bracket connects to the "A" base of the Rotating Platform or the Gyroscope and to the RMS rod clamp.



c) Using the Chaos Accessory with the RMS

The Chaos Accessory is a driven damped physical pendulum. Various types of phase plots can be made as the driving frequency, driving amplitude, initial conditions, and amount of damping are varied.

The adjustable magnet attaches to either side of the RMS (See Figure 14) The mass attaches to the edge of the disk to form a physical pendulum.

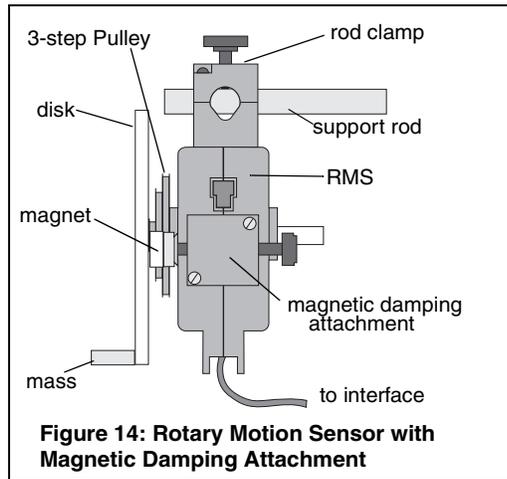


Figure 14: Rotary Motion Sensor with Magnetic Damping Attachment

A PASCO ME-8750 Mechanical Oscillator/Driver is also required to drive the Chaos Accessory. The 1.2 m Dynamics Track is used as a convenient way to mount and align all the components (See Figure 15). However, if a Dynamics Track is not available, components can be mounted on a separate rod stand.

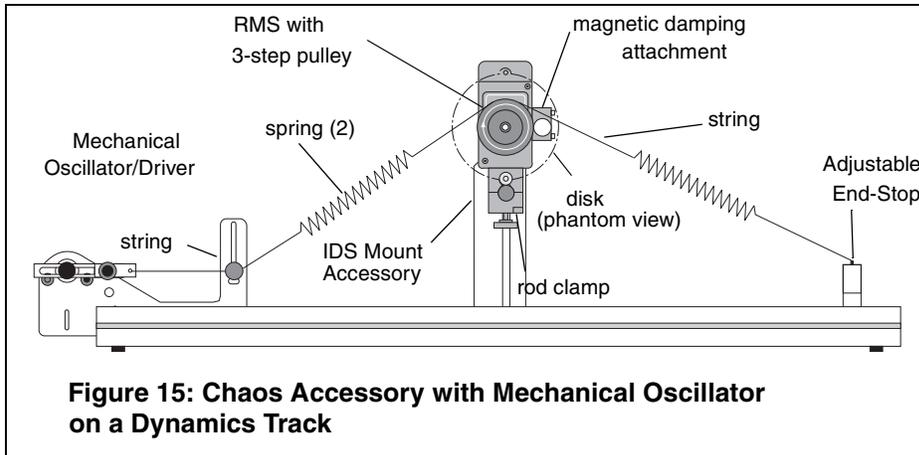


Figure 15: Chaos Accessory with Mechanical Oscillator on a Dynamics Track



Note: The sample rate should be as fast as possible. If the sample rate is too fast, lines in the graph become chunky.

Using the Rotary Motion Sensor with Data Collection Software

To operate the Rotary Motion Sensor, you must plug it into the *ScienceWorkshop 750* interface and perform the necessary setup in DataStudio. Calibration of the sensor is not required, but optional for those who wish better accuracy. For calibration instructions, see Appendix B of this manual.

1. Insert the two stereo phone plugs into any two adjacent digital channels (1 and 2 or 3 and 4) on the 750 interface box.

Note: If the direction of movement of the Rotary Motion Sensor produces a negative displacement when you desire a positive displacement, simply reverse the order of the plugs in the channels.

2. Open DataStudio. When the "Welcome to DataStudio" window appears, double click "Create Experiment."
3. In the Sensors list of the Experiment Setup window, drag the Rotary Motion Sensor icon to the digital channels on the picture of the interface in the setup window. (To open the setup window, click the **Setup** button on the main toolbar.)
4. Double click on the Rotary Motion Sensor icon to open the Sensor Properties dialog.
5. In the General tab of the Sensor Properties dialog, accept the default sample rate or change the rate using the plus and minus buttons.
6. In the Measurement tab of the Sensor Properties dialog, select the desired measurements and units.
7. In the Rotary Motion Sensor tab of the Sensor Properties dialog, select the desired resolution (360 or 1440). Under "Linear Calibration," select the type of accessory you will use.

Note: The required resolution depends on the rate at which the Rotary Motion Sensor will rotate during the experiment. See the "Suggested Experiments" section of this manual for suggested resolutions. In general, if the RMS will turn quickly during the experiment, select 360 divisions per rotation, so that the data rate will not be too high. If the RMS will turn slowly during the experiment, and a finer resolution is required, choose 1440 divisions per rotation.

Experiment 1: Rotational Inertia of a Point Mass

Equipment Required	
ScienceWorkshop® 750 Interface (CI-6450 or CI-7599)	Rotary Motion Sensor (CI-6538)
Mini-Rotational Accessory (CI-6691)	Mass and Hangar Set (ME-9348)
Base and Support Rod (ME-9355)	Triple Beam Balance (SE-8723)
Paper clips (for masses <1 g)	Calipers

Purpose

The purpose of this experiment is to find the rotational inertia of a point mass experimentally and to verify that this value corresponds to the calculated theoretical value.

Theory

Theoretically, the rotational inertia, I , of a point mass is given by $I = MR^2$, where M is the mass, and R is the distance the mass is from the axis of rotation. Since this experiment uses two masses equidistant from the center of rotation, the total rotational inertia will be

$$I_{total} = M_{total}R^2$$

where $M_{total} = M_1 + M_2$, the total mass of both point masses.

To find the rotational inertia experimentally, a known torque is applied to the object and the resulting angular acceleration is measured. Since $\tau = I\alpha$,

$$I = \tau/\alpha$$

where α is the angular acceleration, which is equal to a/r (a = linear acceleration), and τ is the torque caused by the weight hanging from the thread that is wrapped around the 3-step Pulley.

$$\tau = rT$$

where r is the radius of the chosen pulley about which the thread is wound, and T is the tension in the thread when the apparatus is rotating.

Applying Newton's Second Law for the hanging mass, m , gives

$$\Sigma F = mg - T = ma$$

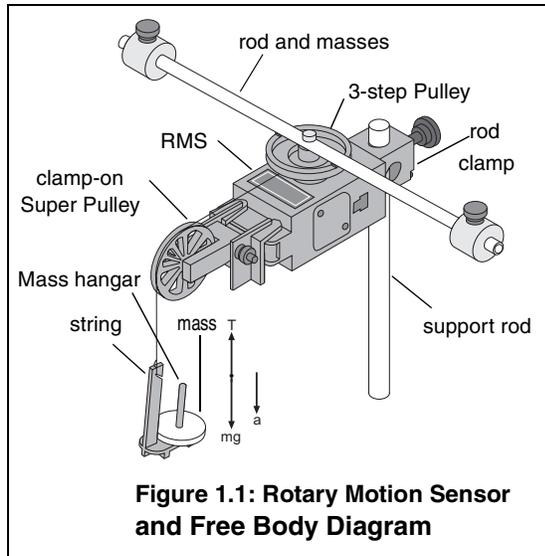
(see Figure 1.1). Solving for the tension in the thread gives:

$$\mathbf{T = m(g - a)}$$

After the angular acceleration of the mass (m) is measured, the torque and the linear acceleration can be obtained for the calculation of the rotational inertia.

Experiment Setup

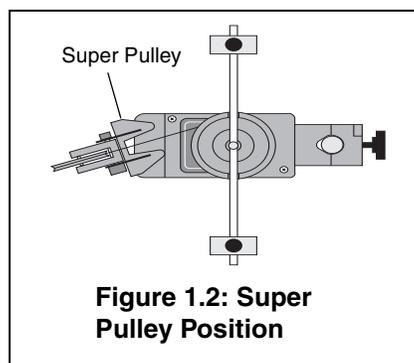
1. Attach a mass on each end of the rod (part of the Mini-Rotational Accessory) equidistant from the rod center. You may choose any radius you wish.
2. Tie one end of the string to the Mass Hanger and the other end to one of the levels of the 3-step Pulley on the RMS.
3. Mount the thin rod to the pulley on the Rotary Motion Sensor. Please note the orientation of the 3-step Pulley.



4. Mount the RMS to a support rod and connect it to a computer. Make sure that the support rod does not interfere with the rotation of the accessory rod. See Figure 1.1.
5. Mount the clamp-on Super Pulley to the Rotary Motion Sensor.
6. Drape the string over the Super Pulley such that the string is in the groove of the pulley and the Mass Hanger hangs freely (see Figure 1.1).

Note: The clamp-on Super Pulley must be adjusted at an angle, so that the thread runs in a line tangent to the point where it leaves the 3-step Pulley and straight down the middle of the groove on the clamp-on Super Pulley (Figure 1.2).

7. Adjust the Super Pulley height so that the thread is level with the 3-step pulley.



Procedure

Part I: Measurements for the Theoretical Rotational Inertia

1. Weigh the masses to find the total mass M_{total} and record in Table 1.1.
2. Measure the distance from the axis of rotation to the center of the masses and record this radius in Table 1.1.

Table 1.1: Theoretical Rotational Inertia Data

Total mass	
Radius	

Part II: Measurement for the Experimental Method

a) Finding the Acceleration of the Point Masses and Apparatus

1. Open DataStudio and create an experiment.
2. In the Sensors list of the Experiment Setup window, click and drag the Rotary Motion Sensor icon to the two digital ports that the RMS is plugged into on the interface.
3. In the Experiment Setup window, double click on the Rotary Motion Sensor icon to open the Sensor Properties dialog.
4. In the Measurement tab of the Sensor Properties dialog, select "Angular Velocity (rad/s)."
5. In the Rotary Motion Sensor tab, select 360 divisions/rotation, and choose the appropriate pulley in the Linear Calibration menu; click OK.
6. Put the 50 g mass on the Mass Hanger and wind up the thread. Click on the **Start** button; then release the 3-step Pulley, allowing the mass to fall. Click the **Stop** button to end the data collection.

HINT: Click the Stop button before the mass reaches the floor or the end of the thread to avoid erroneous data.

7. In the Graph Display window, click on the Statistics button; then select the linear curve fit from the pop-up menu.

The slope of the linear fit represents the angular acceleration (α) and should be entered in Table 1.2.

b) Measure the Radius

- Using calipers, measure the diameter of the pulley about which the thread is wrapped and calculate the radius. Record in Table 1.2.

c) Finding the Acceleration of the Apparatus Alone

In part IIa, “Finding the Acceleration of the Point Mass and Apparatus,” the apparatus is rotating and contributing to the rotational inertia. It is necessary to determine the acceleration and the rotational inertia of the apparatus by itself, so this rotational inertia can be subtracted from the total, leaving only the rotational inertia of the point masses.

- Take the point masses off the rod and repeat the procedure under “Finding the Acceleration of the Point Mass and Apparatus” for the apparatus alone. You may need to decrease the amount of the hanging mass, so that the apparatus does not accelerate so fast that the computer cannot keep up with the data collection rate.
- Record the data in Table 1.2.

Table 1.2: Experimental Rotational Inertia Data

	Point Mass and Apparatus	Apparatus Alone
Hanging Mass		
Slope		
Radius		

Calculations:

- Calculate the experimental value of the rotational inertia of the point masses and apparatus together and record in Table 1.3.
- Calculate the experimental value of the rotational inertia of the apparatus alone. Record in Table 1.3
- Subtract the rotational inertia of the apparatus from the combined rotational inertia of the point masses and apparatus. This will be the rotational inertia of the point masses alone. Record in Table 1.3.
- Calculate the theoretical value of the rotational inertia of the point masses. Record in Table 1.3.

5. Use a percent difference to compare the experimental value to the theoretical value. Record in Table 1.3.

Table 1.3: Results

Component	Rotational Inertia
Point Masses and Apparatus Combined:	
Apparatus Alone:	
Point Masses (experimental value):	
Point Masses (theoretical value):	
Percent (%) Difference:	

Experiment 2: Rotational Inertia of Disk and Ring

Equipment Required	
ScienceWorkshop® 750 Interface (CI-6450 or CI-7599)	Rotary Motion Sensor (CI-6538)
Mini-Rotational Accessory (CI-6691)	Mass and Hangar Set (ME--9348)
Base and Support Rod (ME-9355)	Triple Beam Balance (SE-8723)
Paper clips (for masses <1 g)	Calipers

Purpose:

The purpose of this experiment is to experimentally find the rotational inertia of a ring and a disk and to verify that these values correspond to the calculated theoretical values.

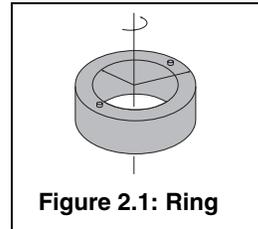


Figure 2.1: Ring

Theory

Theoretically, the rotational inertia, I , of a ring about its center of mass is given by:

$$I = \frac{1}{2}M(R_1^2 + R_2^2)$$

where M is the mass of the ring, R_1 is the inner radius of the ring, and R_2 is the outer radius of the ring. See Figure 2.1.

The rotational inertia of a disk about its center of mass is given by:

$$I = \frac{1}{2}MR^2$$

where M is the mass of the disk and R is the radius of the disk. See Figure 2.2.

To find the rotational inertia experimentally, a known torque is applied to the object and the resulting angular acceleration is measured.

Since $\tau = I\alpha$,

$$I = \frac{\tau}{\alpha}$$

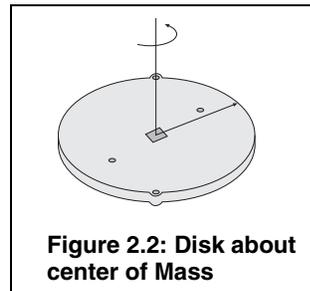


Figure 2.2: Disk about center of Mass

where α is the angular acceleration, which is equal to a/r (a = acceleration), and τ is the torque caused by the weight hanging from the thread that is wrapped around the base of the apparatus.

$$\tau = r\mathbf{T}$$

where r is the radius of the pulley about which the thread is wound, and T is the tension in the thread when the apparatus is rotating.

Applying Newton's Second Law for the hanging mass, m , gives

$$\Sigma\mathbf{F} = \mathbf{mg} - \mathbf{T} = \mathbf{ma}$$

(see Figure 2.3). Solving for the tension in the thread gives:

$$\mathbf{T} = \mathbf{m}(\mathbf{g} - \mathbf{a})$$

Once the angular acceleration is measured, the torque and the linear acceleration can be obtained for the calculation of the torque.

Setup

1. Mount the RMS to a support rod and connect it to the interface.
2. Mount the clamp-on Super Pulley to the Rotational Motion Sensor.
3. Tie one end of the string to the Mass Hanger and the other end to one of the levels of the 3-step Pulley on the RMS.
4. Drape the string over the Super Pulley such that the string is in the groove of the pulley and the Mass Hanger hangs freely (see Figure 2.3).

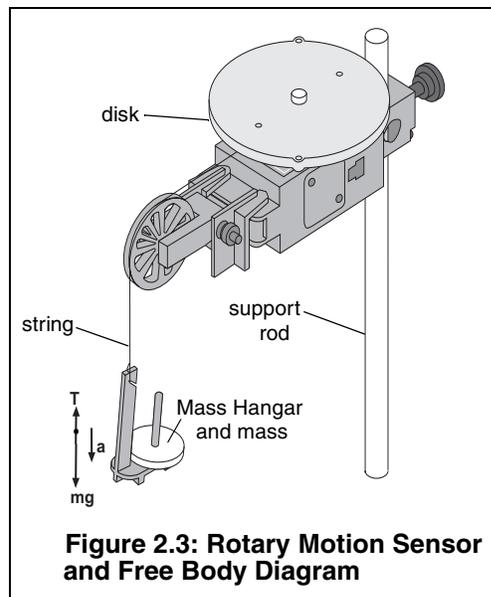
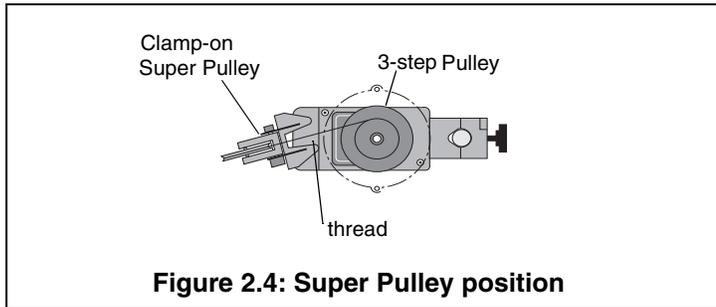


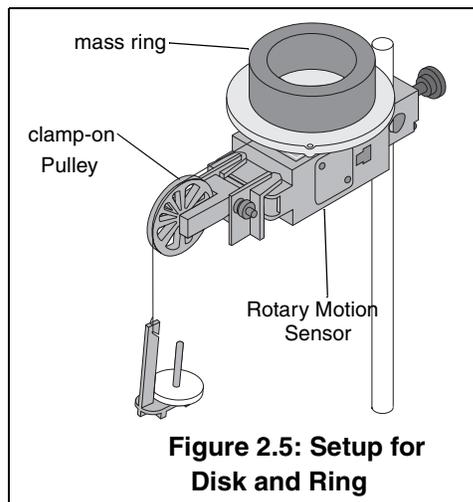
Figure 2.3: Rotary Motion Sensor and Free Body Diagram

NOTE: The clamp-on Super Pulley must be adjusted at an angle so the thread runs in a line tangent to the point where it leaves the 3-step Pulley and

straight down the middle of the groove on the clamp-on Super Pulley. (see Figure 2.4)



5. Place the disk directly on the pulley as shown in Figure 2.5.
6. Place the mass ring on the disk, inserting the ring pins into the holes in the disk as shown in Figure 2.5.



Procedure

Measurements for the Theoretical Rotational Inertia

1. Weigh the ring and disk to find their masses and record these masses in Table 2.1.
2. Measure the inside and outside diameters of the ring and calculate the radii, R_1 and R_2 . Record in Table 2.1.
3. Measure the diameter of the disk and calculate the radius, R , and record it in Table 2.1.

Table 2.1: Theoretical Rotational Inertia

Mass of ring	
Mass of disk	
Inner radius of ring	
Outer radius of ring	
Radius of disk	

Measurements for the Experiment Method

a) Finding the Acceleration of the Ring and Disk

1. Open DataStudio and select "Create Experiment."
2. In the Sensors list of the Experiment Setup window, click and drag a RMS Sensor icon to the first of the two consecutive digital ports that the RMS is plugged into on the interface.
3. Double click the RMS icon in Experiment Setup window to open the Sensor Properties dialog box.
4. In the Measurement tab of the Sensor Properties dialog, select "Angular Velocity (rad/s)."
5. In the Rotary Motion Sensor tab of the Sensor Properties dialog, ensure that the Divisions/Rotation radio button is in the 360 position, and select the appropriate pulley in the Linear Calibration pop-up menu; click OK.
6. Put the 50 g mass on the Mass Hanger and wind up the thread. Click on the **Start** button; then release the 3-step Pulley, allowing the mass to fall.
7. Click the **Stop** button to end the data collection.

HINT: Click the stop button before the mass reaches the floor or the end of the thread to avoid erroneous data.

8. In the Graph Display window, click on the **Statistics** button; then select the linear curve fit from the pop-up menu. The slope of the linear fit represents the angular acceleration (α) and should be entered in Table 2.2.

b) Measure the Radius

1. Using calipers, measure the diameter of the pulley about which the thread is wrapped and calculate the radius. Record in Table 2.2.

Table 2.2: Experimental Rotational Inertia Data

Parameter	Ring and Disk Combined	Disk Alone
Hanging mass		
Slope		
Radius of pulley		

c) Finding the Acceleration of the Disk Alone

1. In "Finding the Acceleration of Ring and Disk," both the disk and the ring are rotating; therefore, it is necessary to determine the acceleration and the rotational inertia of the disk by itself so this rotational inertia can be subtracted from the total, leaving only the rotational inertia of the ring.
2. Take the ring off the rotational apparatus and repeat the steps under "Finding the Acceleration of Ring and Disk" for the disk alone.

Calculations

1. Record the results of the following calculations in Table 2.3.
2. Calculate the experimental value of the rotational inertia of the ring and disk together.
3. Calculate the experimental value of the rotational inertia of the disk alone.
4. Subtract the rotational inertia of the disk from the total rotational inertia of the ring and disk. This will be the rotational inertia of the ring alone.
5. Use a percent difference to compare the experimental values to the theoretical values.

Table 2.3: Results

Item	Rotational Inertia
Ring and disk	
Disk alone	
Ring alone	
% difference for disk	
% difference for ring	

Experiment 3: Conservation of Angular Momentum

Equipment Required	
ScienceWorkshop® 750 Interface (CI-6450 or CI-7599)	Rotary Motion Sensor (CI-6538)
Mini-Rotational Accessory (CI-6691)	Mass and Hangar Set (ME-9348)
Base and Support Rod (ME-9355)	Triple Beam Balance (SE-8723)
Paper clips (for masses <1 g)	Calipers

Purpose:

A non-rotating ring is dropped onto a rotating disk, and the final angular speed of the system is compared with the value predicted using conservation of angular momentum.

Theory:

When the ring is dropped onto the rotating disk, there is no net torque on the system since the torque on the ring is equal and opposite to the torque on the disk. Therefore, there is no change in angular momentum; angular momentum (L) is conserved.

$$L = I_i \omega_i = I_f \omega_f$$

where I_i is the initial rotational inertia and ω_i is the initial angular speed. The initial rotational inertia is that of a disk

$$I_i = \left(\frac{1}{2}\right)M_1R^2$$

and the final rotational inertia of the combined disk and ring is

$$I_f = \frac{1}{2}M_1R^2 + \frac{1}{2}M_2(r_1^2 + r_2^2)$$

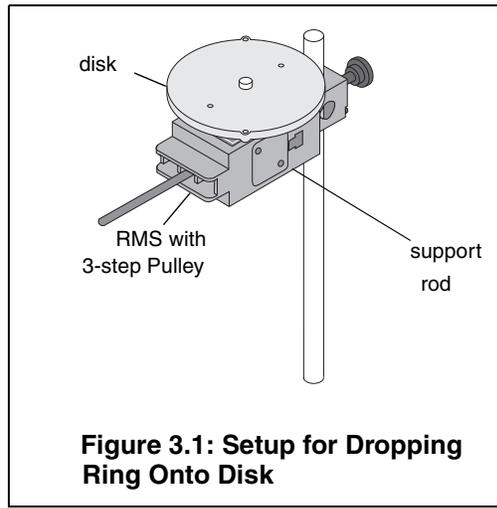
where r_1 and r_2 are the inner and outer radii of the ring.

So the final rotational speed is given by

$$\omega_f = \frac{M_1R^2}{M_1R^2 + M_2(r_1^2 + r_2^2)} \omega_i$$

Setup:

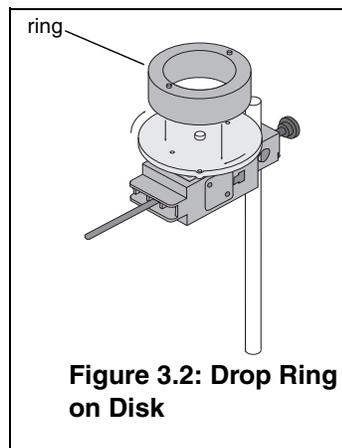
1. Mount the RMS to a support rod and connect it to a computer. Place the disk directly on the pulley as shown in Figure 3.1.
2. Open DataStudio.
3. In the Experiment Setup window, click and drag a Rotary Motion sensor icon to the first of the two consecutive digital ports that the RMS is plugged into on the interface.



4. In the Sensors list of the Experiment Setup window, double click the Rotary Motion Sensor icon to activate the Sensor Properties dialog box.
5. In the Measurement tab of the Sensor Properties dialog, select “Angular Velocity (rad/s)”; click OK.
6. In the Rotary Motion Sensor tab of the Sensor Properties dialog, select 360 divisions/rotation.

Procedure:

1. Hold the ring with the pins up just above the center of the disk. Give the disk a spin using your hand and click the **Start** button. After about 25 data points have been taken, drop the ring onto the spinning disk. See Figure 3.2.
2. Click on the **Stop** button to end the data collection.
3. Click on the Smart Tool and move the cursor to the data point immediately before the collision. Record the Angular Velocity at this point in Table 3.1. Move the cursor to the data point immediately after the collision. Record the Angular Velocity at this point in Table 3.1.
4. Weigh the disk and ring and measure the radii. Record these values in Table 3.1.



Analysis:

1. Calculate the expected (theoretical) value for the final angular velocity and record this value in Table 3.1.
2. Calculate the percent difference between the experimental and the theoretical values of the final angular velocity and record in Table 3.1.

Questions:

1. Does the experimental result for the angular velocity agree with the theory?

What percentage of the rotational kinetic energy was lost during the collision? Calculate the energy lost and record the results in Table 3.1.

$$\%KE \text{ lost} = \frac{\frac{1}{2}I_i\omega_i^2 - \frac{1}{2}I_f\omega_f^2}{\frac{1}{2}I_i\omega_i^2}$$

Table 3.1: Data and Results

Initial angular velocity	
Final Angular velocity (experimental value)	
Mass of ring (M_1)	
Mass of ring (M_2)	
Inner radius of ring (r_1)	
Outer radius of ring (r_2)	
Radius of disk (R)	
Final Angular Velocity (theoretical value)	
% Difference between final and angular velocities	
% KE lost	

Appendix A: Specifications

Rotary Motion Sensor	Description
3-Step Pulley	10 mm, 29 mm, and 48 mm diameters
Resolution	1 ⁰ and 0.25 ⁰
Accuracy	+/- 0.09 degrees
Maximum rotation speed	13 revs/sec at 1 ⁰ resolution 3.25 revs/sec at 0.25 ⁰ resolution
Default sample rate	10 samples/second
Maximum sample rate	1000 samples/second

Appendix B: Calibration of the Rotary Motion Sensor

Calibration of the CI-6538 *ScienceWorkshop*® Rotary Motion Sensor is not required. However, you can zero the CI-6538 Rotary Motion Sensor as follows:

1. Connect a *ScienceWorkshop* Rotary Motion Sensor and set the sensor to the zero position (See the instruction sheet or experiment guide provided with your Rotary Motion Sensor for instructions.)
2. With your mouse, associate the Rotary Motion Sensor icon to the interface in the Experiment Setup window.
3. In the Experiment Setup window, double click on the Rotary Motion Sensor icon.
4. From the Linear Calibration menu, select the appropriate choice and click the **OK** button. When you press the **Start** button, DataStudio automatically zeroes the Rotary Motion Sensor at the position you set in step 1.

Appendix C: Technical Support

For assistance with the CI-6538 Rotary Motion Sensor or any other PASCO products, contact PASCO as follows:

Address: PASCO scientific

10101 Foothills Blvd.

Roseville, CA 95747-7100

Phone: (916) 786-3800

FAX: (916) 786-3292

Web: www.pasco.com

Email: techsupp@pasco.com

Appendix D: Copyright and Warranty Information

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Limited Warranty

PASCO scientific warrants the product to be free from defects in materials and workmanship for a period of one year from the date of shipment to the customer. PASCO will repair or replace, at its option, any part of the product which is deemed to be defective in material or workmanship. The warranty does not cover damage to the product caused by abuse or improper use. Determination of whether a product failure is the result of a manufacturing defect or improper use by the customer shall be made solely by PASCO scientific. Responsibility for the return of equipment for warranty repair belongs to the customer. Equipment must be properly packed to prevent damage and shipped postage or freight prepaid. (Damage caused by improper packing of the equipment for return shipment will not be covered by the warranty.) Shipping costs for returning the equipment after repair will be paid by PASCO scientific.

Author:

Jon Hanks