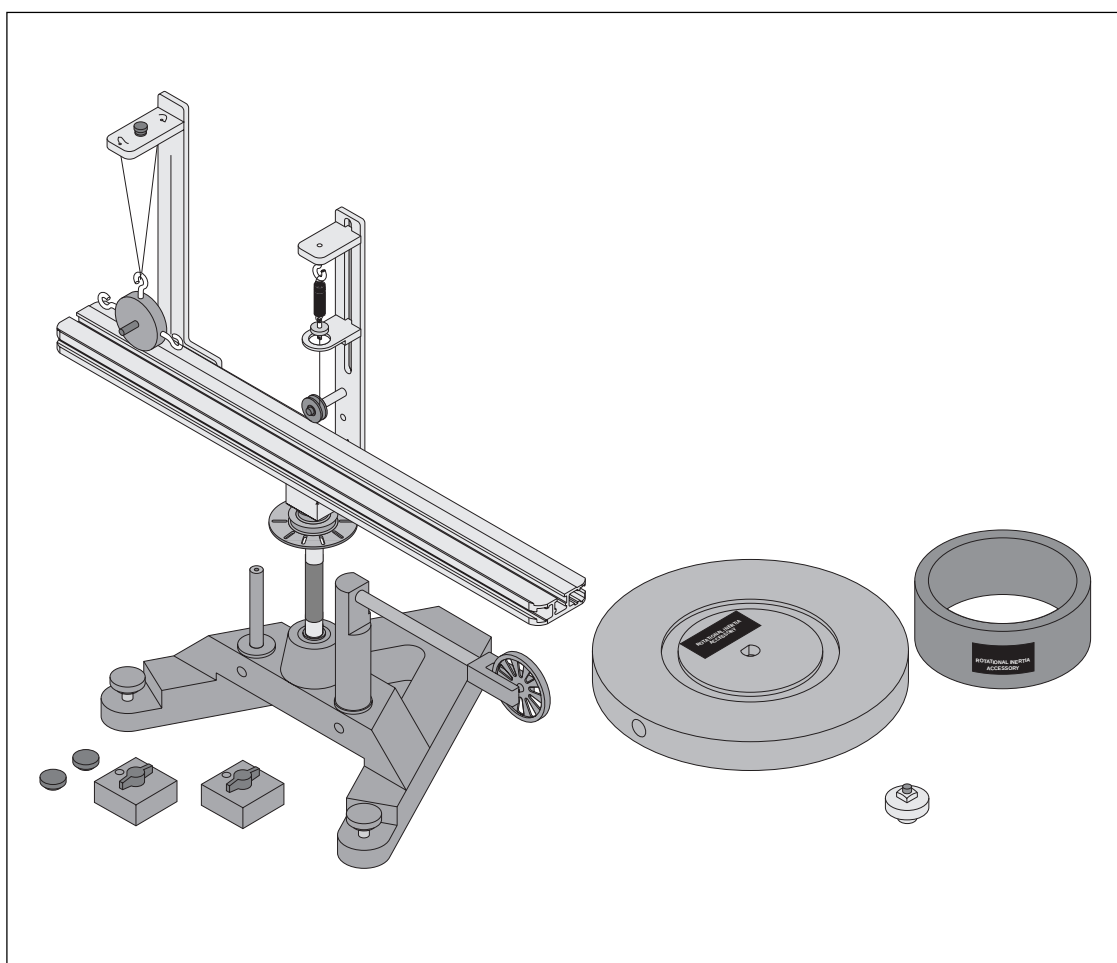


***Instruction Manual and
Experiment Guide for
the PASCO scientific
Model ME-8950***

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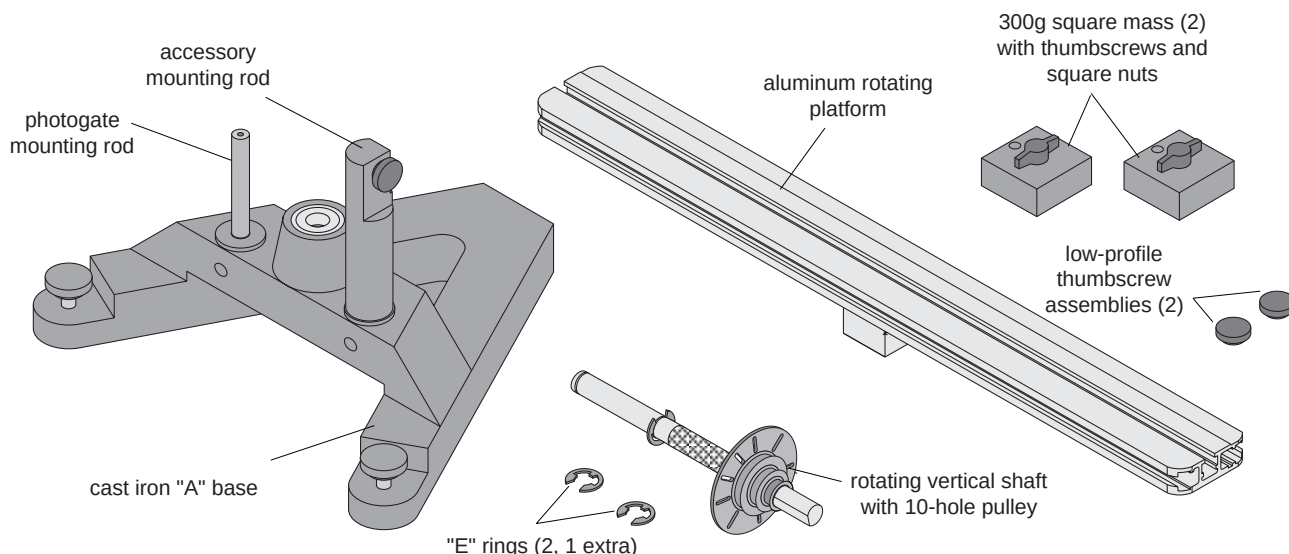
COMPLETE ROTATIONAL SYSTEM



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\$10.00

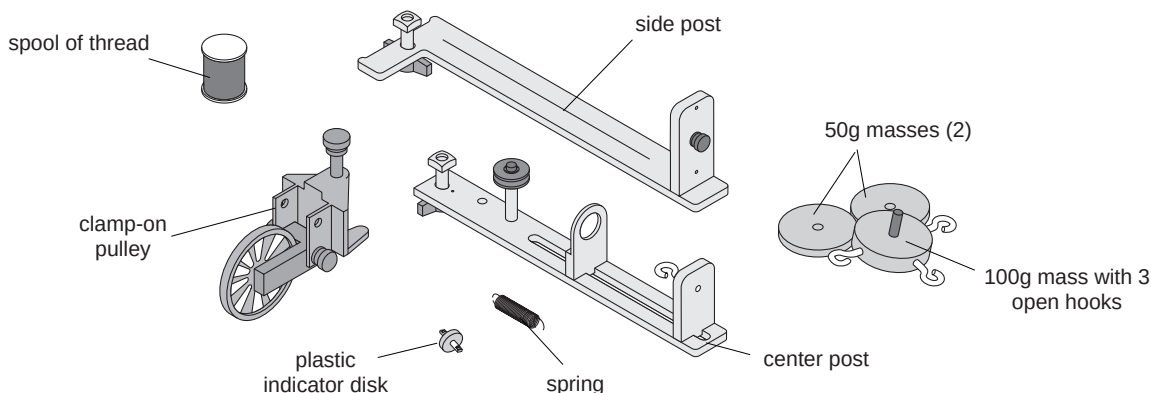
Equipment



ME-8951 Rotating Platform Equipment

The ME-8951 Rotating Platform Includes the following:

- PASCO cast iron "A" base with rotating shaft and pulley with 10 holes
- aluminum track
- two square masses (about 300 g) with thumb screw and square nut
- two additional low-profile screws and square nuts to act as stops for the square mass in the Conservation of Angular Momentum experiment
- accessory mounting rod for mounting the 10-spoke pulley or the optional Smart Pulley photogate head
- accessory mounting rod for mounting PASCO Photogate (ME-9498A, ME-9402B or later)



ME-8952 Centripetal Force Accessory Equipment

The ME-8952 Centripetal Force Accessory includes:

- center post that supports an indicator mechanism which consists of a small pulley, a movable spring holder, a movable indicator, a spring, and a plastic indicator disk
- side post for hanging hooked mass
- mass (100 g) with 3 open hooks
- 2 additional 50 gram masses
- clamp-on pulley
- 1 spool of thread

Assembly

ME-8951 Rotating Platform

Assembling the Rotating Platform

- ① Insert the cylindrical end of the shaft into the bearings on the top-side of the A-shaped iron base. Secure the shaft in place by inserting the "E" ring in the slot at the bottom of the shaft. See Figure 1.
- ② Mount the track to the shaft and tighten the thumb screw against the flat side of the "D" on the shaft. See Figure 1.

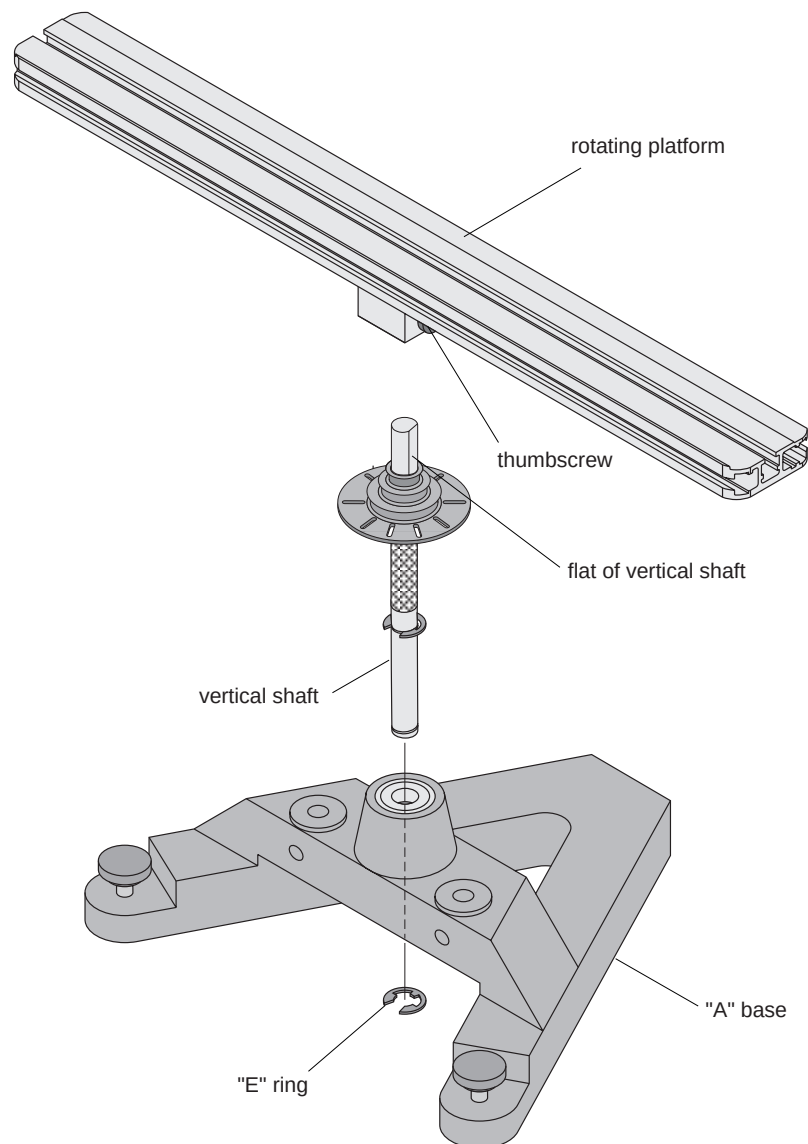


Figure 1: Attaching the Vertical Shaft to the Base and Rotating Platform Assembly

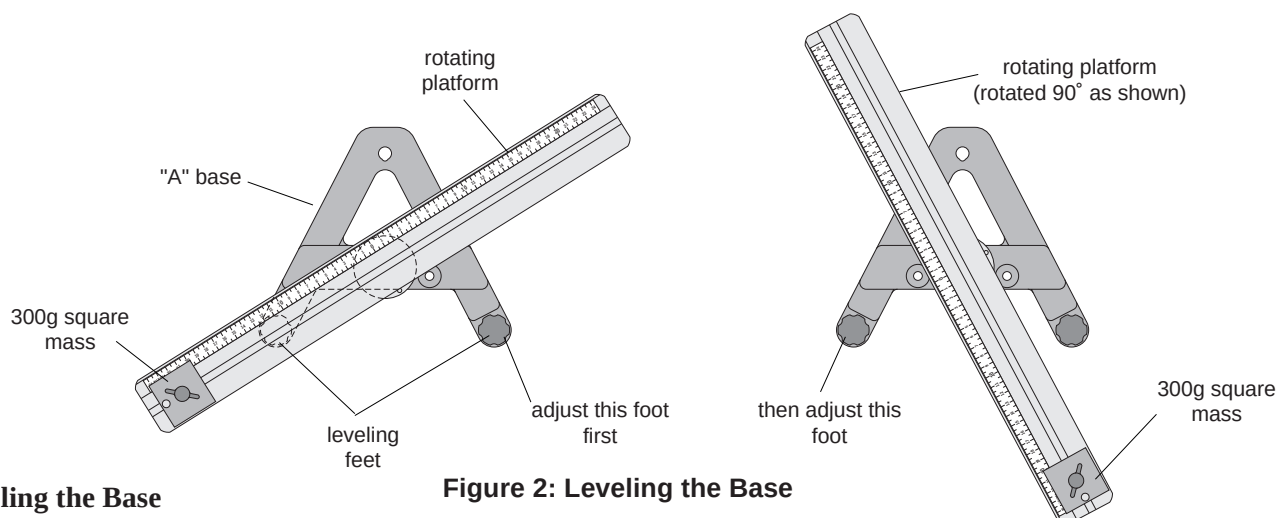


Figure 2: Leveling the Base

Leveling the Base

Some experiments (such as the Centripetal Force experiments) require the apparatus to be extremely level. If the track is not level, the uneven performance will affect the results. To level the base, perform the following steps:

- ① Purposely make the apparatus unbalanced by attaching the 300 g square mass onto either end of the aluminum track. Tighten the screw so the mass will not slide. If the hooked mass is hanging from the side post in the centripetal force accessory, place the square mass on the same side.
- ② Adjust the leveling screw on one of the legs of the base until the end of the track with the square mass is aligned over the leveling screw on the other leg of the base. See Figure 2.
- ③ Rotate the track 90 degrees so it is parallel to one side of the "A" and adjust the other leveling screw until the track will stay in this position.
- ④ The track is now level and it should remain at rest regardless of its orientation.

Installing the Optional Smart Pulley Photogate Head

The black plastic rod stand is designed to be used in two ways:

- It can be used to mount a Smart Pulley photogate head to the base in the correct position to use the 10 holes in the pulley on the rotating shaft to measure angular speed.
- It can be used to mount a Smart Pulley (with the pulley and rod) to the base to run a string over the pulley.

To Use the Photogate Head Only:

- ① To install, first mount the black rod to the base by inserting the rod into either hole adjacent to the center shaft on the base.
- ② Mount the Smart Pulley photogate head horizontally with the cord side down. Align the screw hole in the photogate head with the screw hole in the flat side of the black rod. Secure the photogate head with the thumb screw. See Figure 3.
- ③ Loosen the thumb screw on the base to allow the black rod to rotate. Orient the rod and photogate head so the infrared beam passes through the holes

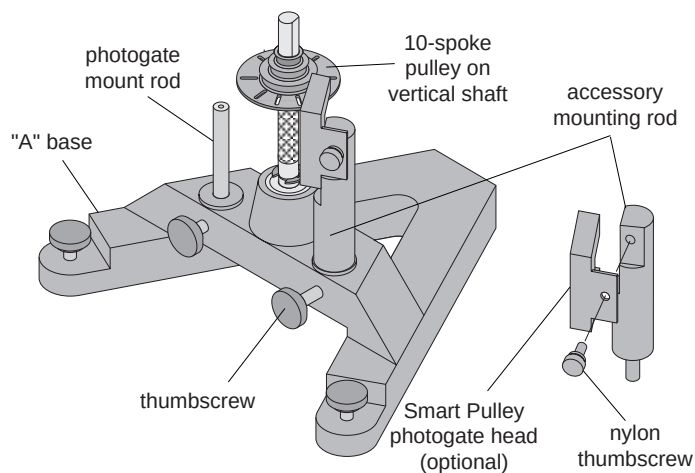


Figure 3: Using the Accessory Mounting Rod With the Smart Pulley

in the pulley. If the photogate head is powered by a computer, you can tell when the photogate is blocked by watching the LED indicator on the end of the photogate. The photogate head should not be rubbing against the pulley. When the head is in the correct position, tighten the bottom screw to fix the rod in place.

To use the entire Smart Pulley with rod or the Super Pulley with rod:

- ① Insert the Smart Pulley rod into the hole in the black rod and tighten the set screw against the Smart Pulley rod. See Figure 4.
- ② Rotate the black rod so the string from the pulley on the center shaft is aligned with the slot on the Smart Pulley.
- ③ Adjust the position of the base so the string passing over the Smart Pulley will clear the edge of the table.

To mount a PASCO Photogate on "A" base:

- ① Mount PASCO Photogate on threaded end of rod (rod height may be adjusted with thumbscrew).
- ② Slide non-threaded end of photogate mount into hole in base, clamp in place with thumbscrew.

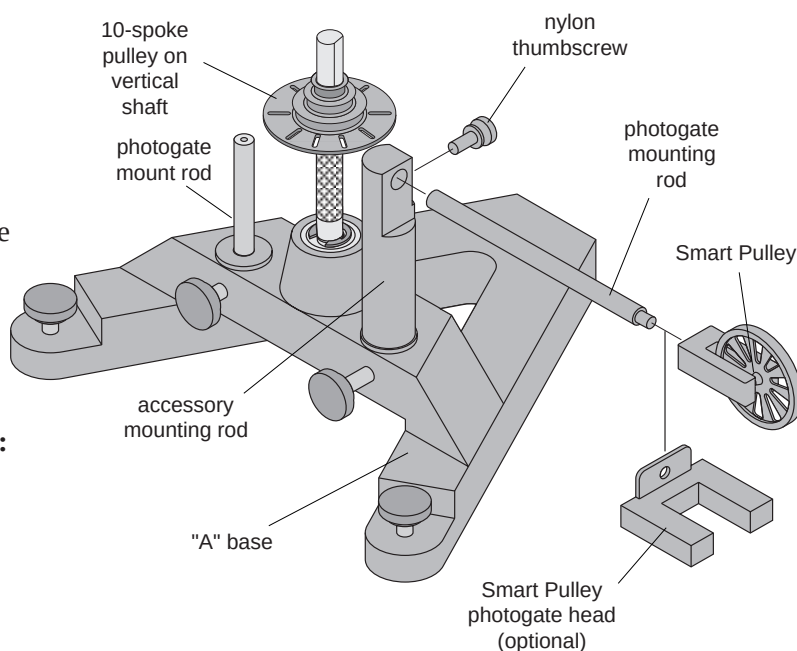


Figure 4: Using the Accessory Mounting Rod With the Photogate Mounting Rod and/or Smart Pulley

ME-8952 Centripetal Force Accessory

Center Post Assembly

Assemble the center post as shown in Figure 5:

- ① Attach one end of the spring to the spring bracket and connect the indicator disk to the other end of the spring. Insert the spring bracket into the slot on the center post and tighten the thumb screw.
- ② Tie one end of a string (about 30 cm long) to the bottom of the indicator disk and tie a loop in the other end of the string.
- ③ Insert the indicator bracket into the slot on the center post, placing it below the spring bracket. Tighten the thumb screw.
- ④ Attach the pulley in the higher of the two holes on the center bracket.
- ⑤ Insert the thumb screw at the bottom of the center post and attach the square nut.

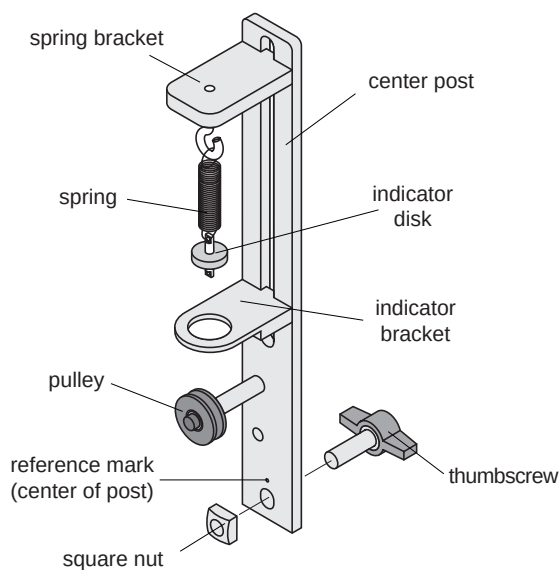


Figure 5: Center Post Assembly

Side Post Assembly

Assemble the side post as shown in Figure 6:

- ① Insert the thumb screw at the bottom of the side post and attach the square nut.
- ② Using a string about 30 cm long, tie the string around the screw head on the top of the side post. Then thread the other end of the string down through one of the holes in the top of the side post and then back up through the other hole. Do not pull the string taut.
- ③ Loosen the screw on the top of the side post and wrap the loose end of the string around the threads of the screw and tighten the screw.

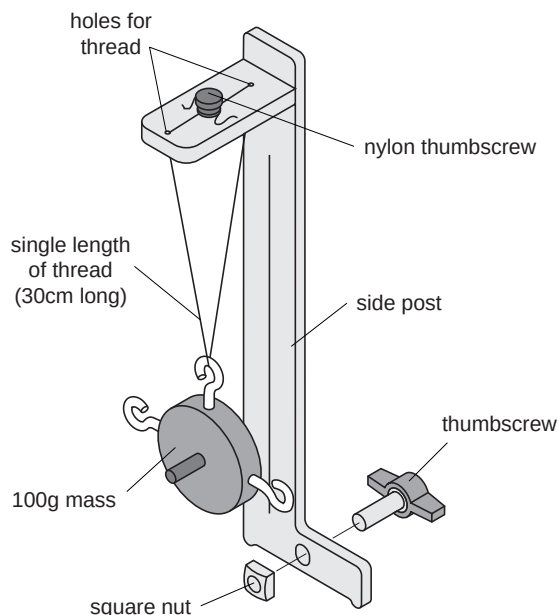


Figure 6: Side Post Assembly

Threading the Centripetal Force Accessory

- ① Mount the center post in the T-slot on the side of the track that has the rule. Align the line on the center post with the zero mark on the rule and tighten the thumb screw to secure it in place. Then mount the side post on the same side of the track. See Figure 7.
- ② Hang the object from the string on the side post and adjust the height of the object so the string coming from the center post will be level.

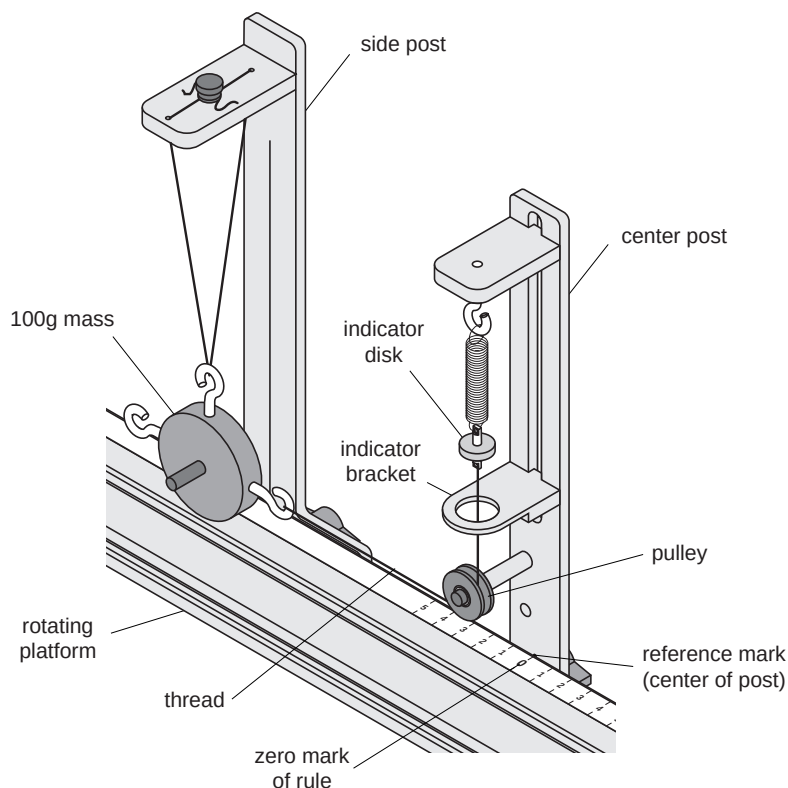


Figure 7: Threading the Centripetal Force Accessory

Experiment 3: Centripetal Force

EQUIPMENT NEEDED

- | | |
|--|---|
| <ul style="list-style-type: none"> - Centripetal Force Accessory (ME-8952) - stopwatch - graph paper (2 sheets) - string | <ul style="list-style-type: none"> - Rotating Platform (ME-8951) - balance - mass and hanger set |
|--|---|

Purpose

The purpose of this experiment is to study the effects of varying the mass of the object, the radius of the circle, and the centripetal force on an object rotating in a circular path.

Theory

When an object of mass m , attached to a string of length r , is rotated in a horizontal circle, the centripetal force on the mass is given by:

$$F = \frac{mv^2}{r} = mr\omega^2$$

where v is the tangential velocity and ω is the angular speed ($v = r\omega$). To measure the velocity, the time for one rotation (the period, T) is measured. Then:

$$v = \frac{2\pi r}{T}$$

and the centripetal force is given by:

$$F = \frac{4\pi^2 mr}{T^2}$$

Setup

Level the "A" base and rotating platform as described in the ME-8951 assembly section on page 5.

Procedure

Part I: Vary Radius (constant force and mass)

- ① The centripetal force and the mass of the hanging object will be held constant for this part of the experiment. Weigh the object and record its mass in Table 3.1. Hang the object from the side post and connect the string from the spring to the object. The string must pass under the pulley on the center post. See Figure 3.1.

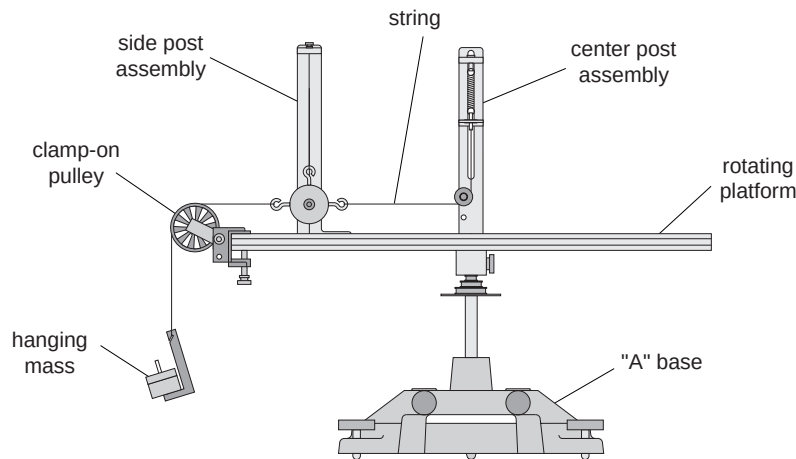


Figure 3.1: Centripetal Force Apparatus

- ② Attach the clamp-on pulley to the end of the track nearer to the hanging object. Attach a string to the hanging object and hang a known mass over the clamp-on pulley. Record this mass in Table 3.1. This establishes the constant centripetal force.
- ③ Select a radius by aligning the line on the side post with any desired position on the measuring tape. While pressing down on the side post to assure that it is vertical, tighten the thumb screw on the side post to secure its position. Record this radius in Table 3.1.
- ④ The object on the side bracket must hang vertically: On the center post, adjust the spring bracket vertically until the string from which the object hangs on the side post is aligned with the vertical line on the side post.
- ⑤ Align the indicator bracket on the center post with the orange indicator.
- ⑥ Remove the mass that is hanging over the pulley and remove the pulley.
- ⑦ Rotate the apparatus, increasing the speed until the orange indicator is centered in the indicator bracket on the center post. This indicates that the string supporting the hanging object is once again vertical and thus the hanging object is at the desired radius.
- ⑧ Maintaining this speed, use a stopwatch to time ten revolutions. Divide the time by ten and record the period in Table 3.1.
- ⑨ Move the side post to a new radius and repeat the procedure. Do this for a total of five radii.

Table 3.1: Varying the Radius

Mass of the object = _____
Mass hanging over the pulley = _____
Slope from graph = _____

Radius	Period (T)	T ²

Analysis

- ① The weight of the mass hanging over the pulley is equal to the centripetal force applied by the spring. Calculate this force by multiplying the mass hung over the pulley by “g” and record this force at the top of Table 3.2.

- ② Calculate the square of the period for each trial and record this in Table 3.1.
- ③ Plot the radius versus the square of the period. This will give a straight line since:

$$r = \left(\frac{F}{4\pi^2 m} \right) T^2$$

- ④ Draw the best-fit line through the data points and measure the slope of the line. Record the slope in Table 3.1.

Table 3.2: Results (varying radius)

- ⑤ Calculate the centripetal force from the slope and record in Table 3.2.
- ⑥ Calculate the percent difference between the two values found for the centripetal force and record in Table 3.2.

Centripetal Force = mg	
Centripetal Force From Slope	
Percent Difference	

Part II: Vary Force (constant radius and mass)

The radius of rotation and the mass of the hanging object will be held constant for this part of the experiment.

- ① Weigh the object and record its mass in Table 3.3. Hang the object from the side post and connect the string from the spring to the object. The string must pass under the pulley on the center post.
- ② Attach the clamp-on pulley to the end of the track nearer to the hanging object. Attach a string to the hanging object and hang a known mass over the clamp-on pulley. Record this mass in Table 3.3. This determines the centripetal force.
- ③ Select a radius by aligning the line on the side post with any desired position on the measuring tape. While pressing down on the side post to assure that it is vertical, tighten the thumb screw on the side post to secure its position. Record this radius in Table 3.3.
- ④ The object on the side bracket must hang vertically: On the center post, adjust the spring bracket vertically until the string from which the object hangs on the side post is aligned with the vertical line on the side post.
- ⑤ Align the indicator bracket on the center post with the orange indicator.
- ⑥ Remove the mass that is hanging over the pulley and remove the pulley.
- ⑦ Rotate the apparatus, increasing the speed until the orange indicator is centered in the indicator bracket on the center post. This indicates that the string supporting the hanging object is once again vertical and thus the hanging object is at the desired radius.
- ⑧ Maintaining this speed, use a stopwatch to time ten revolutions. Divide the time by ten and record the period in Table 3.3.
- ⑨ To vary the centripetal force, clamp the pulley to the track again and hang a different mass over the pulley. Keep the radius constant and repeat the procedure from Step #4. Do this for a total of five different forces.

Table 3.3: Varying the Centripetal Force

Mass of the object = _____

Radius = _____

Slope from graph = _____

Mass Over Pulley	Centripetal Force = mg	Period (T)	$\frac{1}{T^2}$

Analysis

- ① The weight of the mass hanging over the pulley is equal to the centripetal force applied by the spring. Calculate this force for each trial by multiplying the mass hung over the pulley by “g” and record the results in Table 3.3.
- ② Calculate the inverse of the square of the period for each trial and record this in Table 3.3.
- ③ Plot the centripetal force versus the inverse square of the period. This will give a straight line since:

$$F = \frac{4\pi^2 mr}{T^2}$$

- ④ Draw the best-fit line through the data points and measure the slope of the line. Record the slope in Table 3.3.
- ⑤ Calculate the mass of the object from the slope and record in Table 3.4.
- ⑥ Calculate the percent difference between the two values found for the mass of the object and record in Table 3.4.

Table 3.4: Results (varying the centripetal force)

Mass of Object (from scale)	
Mass of Object (from slope)	
Percent Difference	

Part III: Vary Mass (constant radius and force)

The centripetal force and the radius of rotation will be held constant for this part of the experiment.

- ① Weigh the object with the additional side masses in place. Record its mass in Table 3.5. Hang the object from the side post and connect the string from the spring to the object. The string must pass under the pulley on the center post.
- ② Attach the clamp-on pulley to the end of the track nearer to the hanging object. Attach a string to the hanging object and hang a known mass over the clamp-on pulley. Record this mass in Table 3.5. This establishes the constant centripetal force.
- ③ Select a radius by aligning the line on the side post with any desired position on the measuring tape. While pressing down on the side post to assure that it is vertical, tighten the thumb screw on the side post to secure its position. Record this radius in Table 3.5.

- ④ The object on the side bracket must hang vertically: On the center post, adjust the spring bracket vertically until the string from which the object hangs on the side post is aligned with the vertical line on the side post.
- ⑤ Align the indicator bracket on the center post with the orange indicator.
- ⑥ Remove the mass that is hanging over the pulley and remove the pulley.
- ⑦ Rotate the apparatus, increasing the speed until the orange indicator is centered in the indicator bracket on the center post. This indicates that the string supporting the hanging object is once again vertical and thus the hanging object is at the desired radius.
- ⑧ Maintaining this speed, use a stopwatch to time ten revolutions. Divide the time by ten and record the period in Table 3.5.
- ⑨ Vary the mass of the object by removing the side masses. Keep the radius constant and measure the new period. Weigh the object again and record the mass and period in Table 3.5.

Table 3.5: Varying the Mass of the Object

Mass hanging over pulley = _____

Centripetal Force = mg = _____

Radius = _____

Mass of Object	Period (T)	Calculated Centripetal Force	% Difference

Analysis

- ① The weight of the mass hanging over the pulley is equal to the centripetal force applied by the spring. Calculate this force by multiplying the mass hung over the pulley by “g” and record the result at the top of Table 3.5.
- ② Calculate the centripetal force for each trial using:

$$F = \frac{4\pi^2 mr}{T^2}$$

and record this in Table 3.5.

- ③ Calculate the percent difference between the calculated centripetal force for each trial and mg . Record in Table 3.5.

Questions

- ① When the radius is increased, does the period of rotation increase or decrease?
- ② When the radius and the mass of the rotating object are held constant, does increasing the period increase or decrease the centripetal force?
- ③ As the mass of the object is increased, does the centripetal force increase or decrease?