

Rotating Chair

ME-6856

Introduction

The Rotating Chair is designed to help students learn the basics of rotational motion and inertia by experiencing motion themselves. The Rotating Chair features a stool that can be placed on the platform for rotational studies, with the student sitting on top. In addition, the stool can be removed, allowing students to sit directly on the platform.

A photogate can be used to measure the position, velocity, and acceleration of the Rotating Chair in rotational units.

CAUTION: Always remove any objects that might interfere with the rotation of the stool. Placing objects underneath the platform could damage the platform or cause injury.

Components

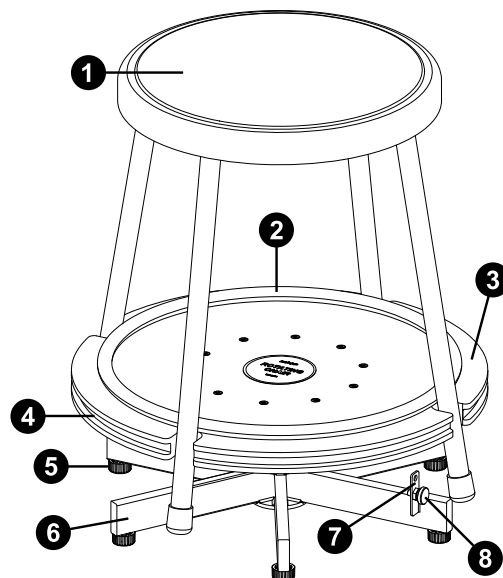
Included components:

- Stool
- Rotating Platform with Photogate Support

Recommended equipment:

- Any of the following photogate setups:
 - Wireless Smart Gate (PS-3225)
 - Smart Gate (PS-2180) with PASPORT interface
 - Photogate Head (ME-9498A) with PASCO digital interface or Smart Timer (ME-8930)
- Bicycle Gyroscope (ME-6837)
- Large Slotted Mass Set (ME-7566)
- PASPORT Force Sensor (PS-2104) or Wireless Force Acceleration Sensor (PS-3202)
- Rope or cord
- PASCO Capstone or SPARKvue data collection software

Features



- 1 Stool
- 2 Foot rung
- 3 Rotating platform
- 4 Groove
- 5 Leveling foot
- 6 Base
- 7 Photogate support
- 8 Thumbscrew

About the apparatus

- The base includes a photogate support with a $\frac{1}{4}$ -20 thumbscrew for attaching a photogate to the base. The thumbscrew can be stored in a threaded hole on the photogate support when not in use.
- The rotating platform has ten evenly-spaced "flags" (spokes) on its underside. These "flags" will interrupt the invisible infrared photogate beam as the chair turns, as shown in Figure 1.

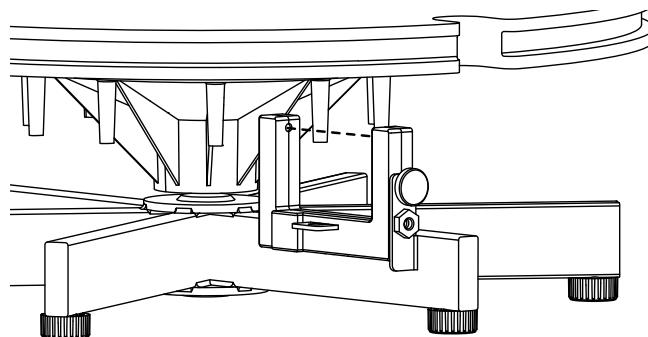


Figure 1

- The radius of the rotating platform is 23 cm (0.23 m). The overall height of the rotating chair is approximately 52 cm (0.52 m).
- The groove on the perimeter of the rotating platform allows the rotating chair to be accelerated by pulling a cord wrapped around the groove.
- The spindle of the rotating platform rotates inside two 20 mm low friction ball bearings.
- The legs of the stool are capped by rubber tips at the ends. These rubber feet can be rotated to level the base and rotating platform.

Basic operation

Rotate on the stool

By placing the included stool onto the platform, students can investigate the basics of rotational motion.

1. Use the leveling feet to level the base and platform.
2. Hold the stool above the platform.
3. Fit each leg of the stool into one of the notches on the edge of the platform.

 **NOTE:** The bottom of each stool leg has a minimum of about 5 cm (~2 in.) clearance from the ground. Remove any objects that might interfere with the operation of the stool. For best results, keep the chair on a hard floor.

4. To rotate, place your feet onto the foot rung or extend them out from the stool. Allowing your feet to rest on the floor will create friction that slows the chair's rotation.

Accelerate the chair with a rope or cord

The rotating chair can be accelerated with the push of a hand or the use of a rope or cord. A rope or cord has the advantage of providing a force at a known distance from the axis of rotation (lever arm). This is particularly helpful when using the equation $\tau = I\alpha$ to investigate torque and rotational motion. For best results, use a rope or cord with minimal stretch.

1. Slip one end of the rope or cord between the foot rung and the platform, then wind the desired length of the rope in the groove, as shown in Figure 2.

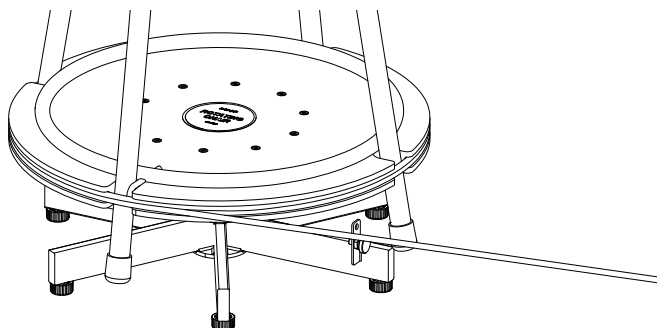


Figure 2

2. Pull the rope or cord at an angle *tangent* to the platform, causing the chair to rotate.
3. When you are finished applying torque to the platform, pull the rope or cord free of the platform.

One easy way to measure the force exerted on the platform is to tie the free end of the rope or cord to a force sensor and apply the torque by pulling on the sensor, as shown in Figure 3. As per the previous instructions, make sure to pull tangent to the platform.

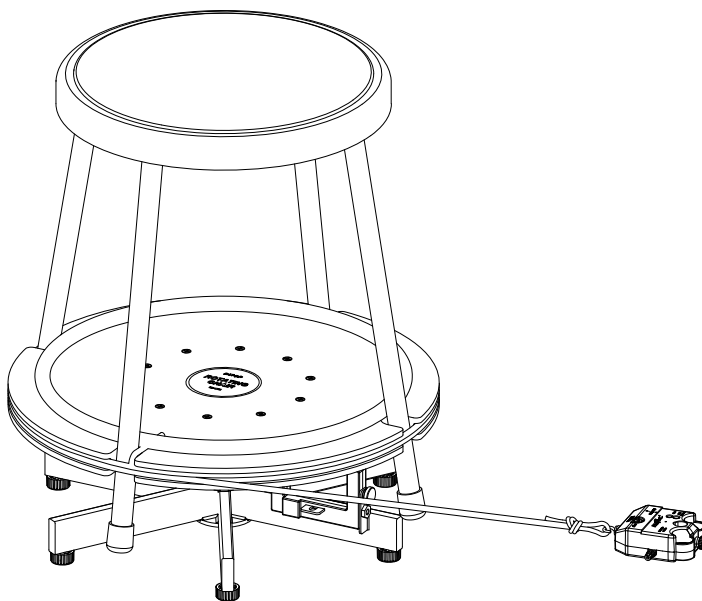


Figure 3

Attach a photogate to measure motion

A photogate can be attached to the bottom platform and used with the built-in "flags" (spokes) to create a smart pulley. To set up such an experiment:

1. Use the included thumbscrew to attach the photogate to the photogate support on one leg of the base, as shown in Figure 1.

 **IMPORTANT:** Make sure to tape the photogate cord to the floor to avoid interference with the stool. Failure to do this may result in damage to the stool or the cord.

2. Connect the photogate to a PASCO interface or a Smart Timer. If using an interface (or a Wireless Smart Gate, which does not require an interface), connect the photogate to SPARKvue or PASCO Capstone.
3. Configure the photogate with the appropriate photogate timer based on which interface you are using:
 - **SPARKvue:** Smart Pulley (Rotational)
 - **PASCO Capstone:** Photogate with Pulley
 - **Smart Timer:** Angular Pulley
4. If using SPARKvue or Capstone, make sure the **Spoke Angle** parameter is set to 36°. (The Spoke Arc Length parameter in Capstone can be ignored, as it is not used for rotational measurements.)

Students can now measure position, velocity, and acceleration of the rotating chair and its rider from rotational frames of reference. For more information on digital setup, see the procedures for your experiment and the SPARKvue or PASCO Capstone online help.

Suggested experiments

Moment of inertia experiments

Students can both qualitatively and quantitatively investigate the moment of inertia with the Rotating Chair.

1. Ask a student to sit on the stool of the Rotating Chair with masses in each hand.

 **CAUTION:** To avoid risk of injury, make sure the student holds on tightly to the masses.

2. Have the student sitting on the stool (hereafter called the rider) extend their arms outward.
3. Have another student or lab partner rotate the rider.
4. After the rider has gained speed, ask them to pull the masses in towards their chest. Qualitatively, the rider and observers will notice the increase in rotational speed as the masses are pulled toward the center axis of rotation.
5. Use a photogate mounted on the photogate support (see Figure 1) to provide quantitative measurements of position, velocity, and acceleration with the masses at both distances.

Using the expression $\tau = I\alpha$, students can calculate the angular acceleration that results when the masses are moved inward and relate this value to a decrease in the system's moment of inertia.

Torque experiments

By applying different torques to the platform and using the photogate to measure the angular acceleration, students can produce a graph to help them discover the moment of inertia of the system.

1. Attach a photogate head to the photogate support on the base of the rotating chair, as shown in Figure 1.
2. Wrap a rope or cord around the groove of the rotating chair platform, then attach a force sensor to the rope or cord, as shown in Figure 3.
3. Ask one student to sit on the stool, then have another student pull on the cord to accelerate the rider. Make sure the student pulls the cord *tangent* to the platform.
4. Repeat Step 3 two more times, increasing the amount of force (torque) in each case.

A plot of the torque versus angular acceleration for this experiment should produce a slope equal to the moment of inertia of the system. You can then repeat the experiment with a different distribution of mass in the system (such as having the student tuck in their arms during rotation in the first experiment and having their arms extended in the second experiment) to observe how such changes influence the results.

Technical support

Need more help? Our knowledgeable and friendly Technical Support staff is ready to answer your questions or walk you through any issues.

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