

## Physics Lab 7: Round and Round

**Goals:** Improve communication skills; Improve ability to make, describe, and record observations; Gain exposure to and experience with a wide variety of rotational phenomena; Have fun with physics phenomena.

**Equipment:** Varies depending on station. Include rough sketches of each experimental set-up in your lab notebook.

**Groups & Lab Notebook:** Work as a whole class, with individual students invited to take turns to participate in particular stations. Record activity and qualitative observations. Update Table of Contents. General Lab Notes guidelines apply. See earlier lab handouts for details. Recall that for math and physics labs, your notebook should reflect your learning and your engagement, and should serve as a stand-alone representation of what you did and what you learned.

### **Announcement: Bring your notes from this lab with you to Wednesday's class**

#### **Part 0: Getting Started**

Today's activities will be a combination of discussion and demonstration. For each station, note as appropriate the equipment (including a rough sketch), the activity, and qualitative observations. What you will observe/experience in these activities set the stage for the physics we are about to study.

#### **Station I: Mass (Distribution) Matters**

Confirm that the rods are essentially the same mass by picking them up and moving them in **straight lines**. What do you notice? Why is this evidence that they are the same mass? Next, hold each rod in its middle, and **twist** it back and forth. What do you notice?

#### **Station II: Ramp and Roll**

The two disks are the same mass and have the same radius: one disk has more of its mass concentrated near its center while the other disk has more mass concentrated near its edge (rim). Release both disks from rest from the same height on the ramp, so that they have a "race" to reach the bottom. Which configuration wins, or do they tie?

#### **Station III: Spin and Fall**

The masses on the horizontal rod can be moved closer to the axis or further from the axis. As the hanging mass falls, the string rotates the pulleys without slipping and the horizontal rod rotates. In which case will the hanging mass fall fastest: with the masses closer to the axis or further from the axis? Note: we'll collect data using the Rotary Motion Sensor for later analysis.



**PAUSE: take notes, ask questions, catch breath**

#### **Station IV: Wheel Walk**

- Hold the bicycle wheel (not spinning) in your hands in front of you (like you are a zombie holding a bicycle wheel). Orient the wheel so that it is vertical. Walk forward. While walking, turn right. While walking, turn left.
- Now, spin the wheel as fast as you can. Repeat your previous motion: walk forward; then, while walking, turn right; then, while walking, turn left. What do you feel? What do you observe?

#### **Station V: What the Wheel?**

Hang the wheel from the ceiling. Hold the wheel so that it is vertical, then let it go. What happens? Now, hold the wheel so that it is vertical and spin it very fast. Now let it go: what happens?

#### **Station VI: Ho-Ho-Hoberman Sphere**

- With the Hoberman sphere fully expanded and not rotating at all, pull down on the central string to see it collapse. What direction is the string pulling? Can this twist the sphere? Pay attention to the force required to pull the string.
- Now, release the string to expand the sphere. Give it a little bit of spin about its central axis, and pull the string again. What do you observe about the motion of the sphere? What do you observe about the force required to pull the string (compared to the previous case when the sphere wasn't spinning)?

**PAUSE: take notes, ask questions, catch breath**

### Station VII: Sit and Spin

- (You'll need a spotter to assist you). Sit on the stool with your arms close to your body and your legs close to the chair (optional: hold a weight in each hand, close to your body). Make sure that when you extend your arms and legs that you won't hit anything. Bring your arms and legs close in again. You will be gently spun. You should be spinning freely. Extend your arms and legs out. What happens? Bring your arms and legs back in. What happens?
- If you are feeling adventurous, you can repeat this activity, starting with a faster initial spin.
- If you are feeling REALLY adventurous, you can start with your arms and legs extended for the initial spin, and then bring your arms and legs in – but please be very careful and make sure your partner is ready to spot you!

### Station VIII: Wheel Sit and Spin

- Sit on the stool with your feet firmly planted on the ground. A colleague should get the bicycle wheel spinning as fast as they can, then hand it to you (with your feet still on the ground). You should hold the wheel so that is oriented horizontally, spinning clockwise as viewed from above. Now, lift your feet off the ground. You should be stationary. Next, flip the wheel so that now it is spinning counterclockwise as viewed from above. What happens? (note: a similar version to this is shown at [http://serc.carleton.edu/dmvideos/players/bicycle\\_wheel\\_g.html](http://serc.carleton.edu/dmvideos/players/bicycle_wheel_g.html) which you can view later on your own; you can press the Play button or just click on the movie.)
- Next: flip the wheel back so that it is again spinning clockwise as viewed from above. What happens?
- If needed, have your colleague spin the wheel back up to speed. Put your feet back on the ground so that you are stationary. Again, lift your feet off the ground. You should be stationary. As before, hold the wheel horizontally, spinning clockwise as viewed from above. This time, bring the wheel in contact with the seat of the stool or with your pants (but not bare skin) so that the friction brings the wheel to a stop. What happens?

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### Station IX: When Wheels Collide - Video

A horizontally oriented disk rotates about its central axis. Another horizontally oriented disk (not rotating) is dropped from above to land directly on the rotating disk.

- Watch the video available at [http://serc.carleton.edu/dmvideos/players/disk\\_disk\\_colli.html](http://serc.carleton.edu/dmvideos/players/disk_disk_colli.html). What happens?
- Collect enough data so that you can determine the angular speed of the bottom disk before the collision (convert to rad/s) and the two disks after the collision (again convert to rad/s). Also record the mass and radius of each disk.

### Station X: Linear and Rotational - Collision Videos

- Watch the video at [http://serc.carleton.edu/sp/library/dmvideos/videos/dart\\_pendulum.html](http://serc.carleton.edu/sp/library/dmvideos/videos/dart_pendulum.html). Pay attention to the motion before and after the collision, and pay attention to linear motion and rotational motion. No need to collect quantitative data – just note your observations.
- Watch the video at [http://serc.carleton.edu/dmvideos/players/marble\\_collides.html](http://serc.carleton.edu/dmvideos/players/marble_collides.html). Pay attention to the motion before and after the collision. It's easy to treat the marble as a point particle. It's harder to treat the wooden block as a point particle, but the yellow dots that mark the block's center of mass can be used to represent the block as a point particle. Observe the center of mass of the block after the collision, and observe the motion of the block about its center of mass after the collision. No need to collect quantitative data – just note your observations.
- Watch the series of videos at [http://s3-us-west-2.amazonaws.com/dmvideos.org/players/lin\\_rot/lin\\_rot.html](http://s3-us-west-2.amazonaws.com/dmvideos.org/players/lin_rot/lin_rot.html); you will have to use the Play button as I don't think clicking on the movie works. Note that you can select a target to be either a can or a block. Note that you can select a Location 1 through 7, which gives videos that adjust the location of the collision with respect to the object's center of mass (Locations 1 and 7 are far from the center of mass, Location 3 is close to the center of mass). Watch the video for each location, paying attention to the linear and/or (amount of) rotational motion after the collision in each case. No need to collect quantitative data – just note your observations.

### Analysis & Extensions

- Consider the scenario in Station II, but instead of solid disks, say you had cans of soup. The cans are the same shape and same mass, but one can has a thick soup in it (potato chowder) and the other has a thin soup (chicken soup). Which wins the race?
- Look at the data collected for Station IX. Is this consistent with conservation of angular momentum?
- Look at the data collected for Station III. Try to determine the rotational inertia of the rotating element for either case. The relevant diameter of the 3-axis pulley is 29 mm.