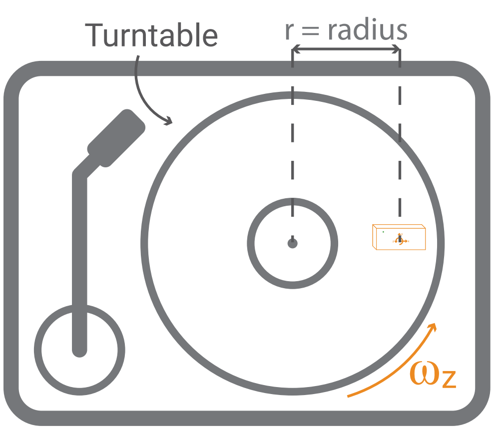
Friction on a Turntable

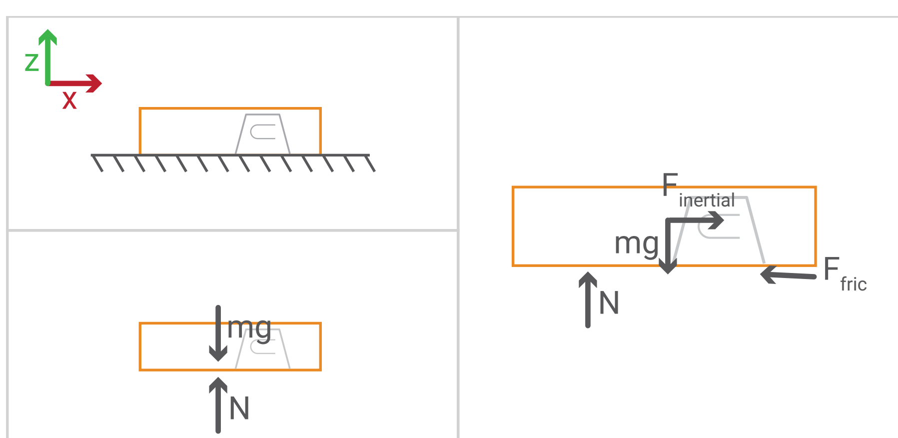
Exploration

An inertial force arises from the rotation of the object and the object mass (sometimes called the centrifugal force, not to be confused with centripetal force). If the inertial force is greater than the force of friction, the object will slide off of the rotating turntable (following Newton's First Law of Motion). The parameters that cause the inertial force to be greater than the force of friction depend on many variables.

Materials

- Turntable (or Lazy Susan or Frisbee)
- Different types of material (duct tape, sandpaper, cotton fabric, etc.) to put on the turntable in order to test the effects of friction
- Ruler or measuring tape
- PocketLab





Objective

In this experiment, student will:

1. Use a turntable (or Lazy Susan or Frisbee) to investigate how the radius of the PocketLab from the center, the angular velocity of the PocketLab, and the type of material the PocketLab is on, affects whether the object can stay on the turntable.
2. Explain how and why those different variables affect whether the PocketLab stays on the turntable.

Method

1. Place the PocketLab on the turntable so the radius is roughly half the distance from the center to the edge of the turntable. Measure the radius and record it.
2. Rotate the turntable slowly then gradually increase the angular velocity. Use the PocketLab's angular velocity graph to monitor.
3. Continue to increase angular velocity until the PocketLab flings off the edge. Record the exact angular velocity that this occurred.
4. Change the radius by moving the PocketLab to different locations on the turntable. Repeat steps 2 and 3. Make sure to try radii that are close to the center and close to the outside of the turntable.
5. Place the PocketLab back to the original radius position. Keep the radius constant. Test the different materials by taping them to the turntable underneath PocketLab and repeating steps 2 and 3.

Predictions

- Predict the angular velocity required to fling PocketLab off the turntable. Explain your answer.
- How will the radius affect the angular velocity required to fling PocketLab off the turntable? Explain your prediction.
- Rank the materials in order of what you predict will require the greatest angular velocity to the least angular velocity to fling PocketLab off the turntable. Explain your prediction.

Data Analysis and Observations

- What was the angular velocity required to fling the PocketLab off the turntable when the PocketLab was in its original position? Was it close to your prediction?
- How did changing the radius affect the angular velocity required to fling the PocketLab off the turntable?
- Rank the materials in order of greatest angular velocity to least angular velocity required to fling the PocketLab off the turntable.

Conclusions

- Explain why the PocketLab is able to stay on the turntable at lower angular velocities, but will fling off after it reaches a higher angular velocity. Use your knowledge of inertia to support your answer.
- Explain why the radius affects the angular velocity required to fling the PocketLab off the turntable. Use your knowledge of inertia to support your answer.
- Explain why the angular velocity required to fling the PocketLab off the turntable changes depending on the material the PocketLab is on. Use your knowledge of inertia force and the coefficient of friction to explain your answer.

WATCH THE VIDEO

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TEACHER GUIDE

A turntable is not required for this lab. A Lazy Susan, Frisbee, or anything else that the PocketLab can rest on while it spins freely will work. The key relationship for students to grasp is between the radius and angular velocity. If three PocketLabs were all placed at different radii on the same turntable, they would fling off at different times even though their angular velocity would all be the same. Students will see this concept when the PocketLab flings off at lower angular velocities when the radius is greater but will require greater angular velocities to fling off when the radius is smaller.

Push students to think about whether the radius of a rotating object from the spinning axis will affect its angular velocity. The answer is no. The angular velocity is not dependent upon the radius. If a turntable is rotating 1,000° per second, it doesn't matter whether the PocketLab is placed closer to the center or closer to the outer edge, it is still rotating at 1,000° per second. However, the PocketLab will experience a greater linear velocity when the radius is greater. This is because the PocketLab has to move across a greater distance/arc in the same amount of time to cover the same degrees of rotation as if it were closer to the center.

In the experiment, the PocketLab will experience greater linear velocities near the outside of the turntable, causing it to break the centripetal force (caused by the frictional force between the PocketLab and the turntable) at a lower angular velocities. Closer to the center, the PocketLab will experience lower linear velocities as it rotates, causing it to stand greater and greater angular velocities without breaking the centripetal force holding it in place. Students may see the connection when thinking of a merry-go-round. It is much harder to stay on the merry-go-round closer to the outside than the inside even though one would be experiencing the same angular velocity at both positions.

For the second part of the lab, students should find that the smoother the material, the less frictional force there is holding the PocketLab to the turntable. This means the angular velocity needed to break the centripetal force keeping the PocketLab moving in a circle will be much less.