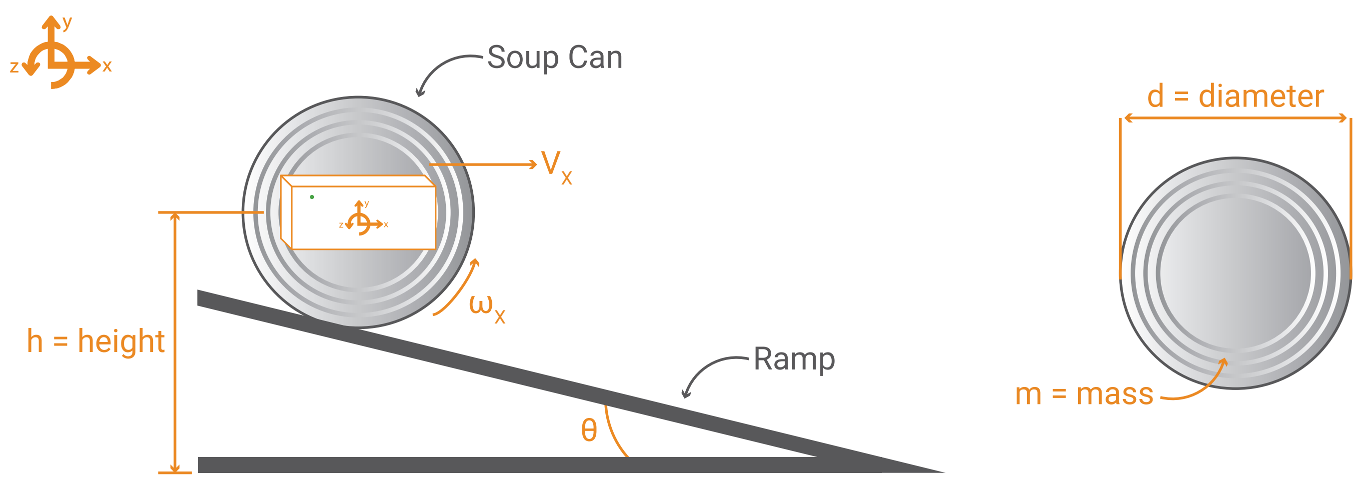
Soup Can Race

Exploration

When two cans of different geometries are released from rest at the same time at the top of an inclined plane the results of the race may not be what you predict. The moment of inertia of each soup can will affect whether it reaches the end of the inclined plane first.



Materials

- PocketLab (use two if available)
- Inclined ramp (piece of acrylic or thick cardboard)
- Can of thin soup, such as chicken broth
- Can of thick soup, such as cream of mushroom
- Can of sand (or any other material on hand)
- Empty can or hoop

Objective

In this experiment, students will:

1. Determine the order in which each can will reach the bottom of the ramp first and explain why in terms of the energy in the system and the moment of inertia in each can.

Method

1. Race the cans in pairs--winners move to next round.
2. Attach a PocketLab to the side of the two cans (example: chicken broth versus cream of mushroom--each can has a PocketLab attached).
3. Construct a ramp by placing a small object under the piece of acrylic or thick cardboard.
4. Release the cans at the same time.
5. Record the angular velocity with PocketLab and note which can crosses the finish line first.
6. Replace the slower can with a can that has not been tested yet.
7. Repeat Steps 4 – 6 until all cans have been tested and results have been recorded.

Predictions

- Measure or estimate the mass of each can – how will this affect the angular velocity?
- Think about the basic energy equation for this system. There is potential energy with the can at the top of the ramp. This will change to translational kinetic energy and rotational kinetic energy. How will this affect which can reaches the finish line first?
- Calculate the moment of inertia for the different cans. Use your calculations to predict which can will come in first and which will come in last. Explain your prediction.

Rotational Kinect Energy

$$mgh = 1/2 I\omega^2 + 1/2 mv^2$$

Potencial Energy

Translational Kinect Energy

Moment ofInertia of a solid Cylinder

$$I = 1/2mr^2$$

Moment of Inertia of a Hoop

$$I = mr^2$$

Data Analysis and Observations

- As the mass of the cans increased, what did the angular velocity do? Rank the cans in order of greatest angular velocity to least angular velocity.
- Which can was the fastest down the ramp? Which was the slowest?
- Did the solid cylinder or hoop rotate faster? Did this match your predictions?

Conclusions

- How does the mass of the can affect the angular velocity? How does the mass of the can affect the moment of inertia? How does the moment of inertia affect the angular velocity? Explain how the mass, moment of inertia, and angular velocity are all related. Use the equations to support your answer.
- Using the energy balance equation for the system, explain why the moment of inertia, I, would have an effect on the translational kinetic energy of a hoop versus a solid cylinder? How would this affect which can arrives at the bottom of the ramp first?

WATCH THE VIDEO

Soup Can Race

TEACHER GUIDE

Make sure to use cans that have very different densities. To fill a can with sand, make a small hole in a can of chicken broth and drain the can. Then fill sand in the can through the small hole. Seal the hole with cardboard and tape or whatever you have available. A jar filled with sand versus an empty jar would also highlight the relationship in this experiment, but the jars could only be compared to each other, not the cans of soup. An empty soup can, a soup can filled with sand, a can of chicken broth, and a can of cream of mushroom work the best. Use a ruler as a starting block to ensure there is not an accidental extra push when the cans are released and to control their starting points.

The hoop should show the slowest angular velocity and should finish last in all the races. The can of chicken broth should finish first in all the races. The can of cream of mushroom should finish second. The cans that are filled which have more mass are also more dense and will have a higher moment of inertia. Have students compare the chicken broth and the cream of mushroom to highlight the difference. The amount of rotational energy is related to the distribution of the mass around the center of rotation. The cream of mushroom (greater density around the center) requires more energy to roll at the same rate as the chicken broth (lower density around the center). Moment of inertia is a measurement of an object's resistance to rotating about an axis and is related to the distribution of the mass relative to the axis of rotation. The cream of mushroom has a greater moment of inertia than the chicken broth and therefore requires more energy to reach the same velocity. This same principle does not apply to the hoop however. The empty can has a different formula for its moment of inertia. Push students to connect the hoop finishing last to the given equations.