

PSI:

PHYSICAL SCIENCE INVESTIGATION



Teacher's Lesson Description

Title	Wheeling Around
Brief Description of the Videos	In these videos, a solid disk-shaped object and a hollow ring of equal mass are released together at the top of an inclined plane. The disc arrives at the bottom of the plane first since its moment of inertia ($1/2 mr$) is half that of the ring (mr). Student experiments with soup cans with broth and with thicker veggies are also shown to test these same phenomena.
Time Needed	The video segments can be shown and discussed in one 45 minute class period. The student experiments with soup cans can be completed in a second 45 minute period.
Ohio Science Benchmarks Addressed in This Activity	Grades 6-8 PS Benchmark B, Grades 6-8 SI Benchmark A, Grades 6-8 SW Benchmark A
Ohio Grade Level Indicators Addressed in This Activity	Grade 8 PS Indicators 1, 2, 3 ; Grade 7 SI Indicators 1, 2, 3; Grade 8 SW Indicator 1
Concepts Developed	Inertia, Angular Momentum, Moment of Inertia, Rotational kinetic energy is equal to k times the translational kinetic energy.
Lesson Rationale	The concept of inertia is fundamental to understanding Newton's 1st law. Practical applications of the interplay of inertia and rotational vs. translational kinetic energy will help student to understand the complexities of Newton's Laws and how they can impact mechanical design. For example, the amount of force it takes to push a playground merry-go-round if your friends are on the outside verses to the amount of energy needed to start it to go round if they are concentrated in the middle of the ride. People at the edge travel faster than people in the center, so they have greater rotational energy (and require more energy to accelerate).

Background Knowledge for Teachers	The main idea in the Hub and Rim (angular momentum) experiment is that a circular object rolls depending upon its mass, it's radius (diameter), the force exerted to get it to roll (in this case gravitational constant), and the distribution of the mass around the center of the circular object (rim vs. hub, thick condensed soup vs. “sloshy” liquids/vegetables wanting to settle to the bottom, etc. Teachers need to understand Newton’s First Law (Law of Inertia.) It would help to explain the difference between Rotational Kinetic Energy (the energy needed to keep a circular object rotating or not rotating,) and Transitional Kinetic Energy (the energy needed to get a circular object to start rolling or to stop rolling once it is started.) The <i>Moment of Inertia</i> is the name given to rotational inertia, the rotational analog of mass for linear motion. This is important in this experiment since the moment of inertia ($1/2 mr^2$) for the disc is half that of the ring (mr^2). This means the ring will need more force or energy to start its rotation.
Classroom Procedures	The teachers will start the demo by showing the first part of the video. This poses the question about which object will roll to the bottom of an incline first. The experiment is halted for discussion. Next the video is shown of the solid object reaching the bottom first. Discussion follows. The experiment is repeated so classroom discussion can be analyzed. The next step is to have the students experiment with the concept by “racing” soup cans down an incline. The soup cans should have just broth and also liquid with other things (veggies, noodles, etc.) The broth is uniform density and the “veggie soup” will have particles and noodles near the outside of the can. The broth is more like the solid disk and the “veggie soup” is more like the rim. The students will predict the winner of the race. They will speculate on what causes the difference in the speed of the soup cans. The broth should reach the bottom first, just as the solid disc did. Following the race the students can discuss their results.
Materials Needed	For each team--A flat board that is at least 10” wide and 4 or 5 feet long. Two cans of soup, one that is only broth and one that has veggies or noodles in it. A stopwatch can be used but is not necessary.
Science Connections	Inertia, Angular Momentum, Moment of Inertia, Rotational kinetic energy is equal to k times the translational kinetic energy. The rotation of various objects like bike wheels, car tires, and various rides can be better understood.
Additional Web Resources	Explore Learning Gizmo that shows the experiment. http://www.explorelearning.com/index.cfm?method=cResource.dspView&ResourceID=587 Physics Lab on-line. This resource gives the complex mathematics involved in the rim and hub experiment theory. http://dev.physicslab.org/Document.aspx?doctype=3&filename=RotaryMotion_RotationalDynamicsRollingSpheres.xml

Hyperphysics is a web resource that shows various diagrams and the formulas that control the movement of the hub and the rim.

<http://hyperphysics.phy-astr.gsu.edu/hbase/icyl.html#icyl2>

Make your own experiment using these resources from the Exploratorium.

http://www.exploratorium.edu/snacks/downhill_race/index.html

Why do those soup cans roll the way they do?

http://dev.physicslab.org/Document.aspx?doctype=5&filename=Compilations_NextTime_RollingCans.xml

Ohio Science Standards Abbreviations:

ES – Earth/Space Science

SI – Scientific Inquiry

LS – Life Sciences

ST – Science and Technology

PS – Physical Sciences

SW – Scientific Ways of Knowing