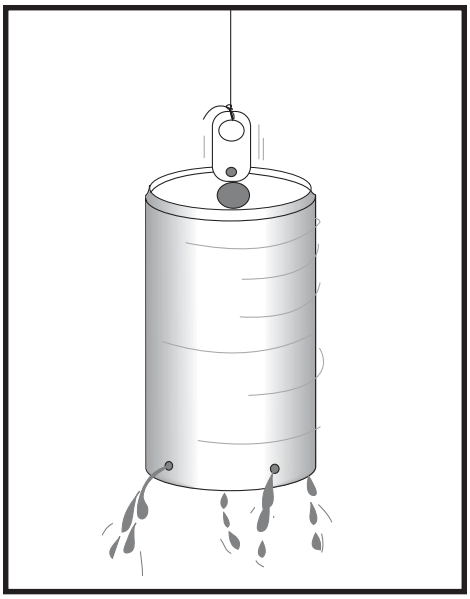


Educator Information

Pop Can Hero Engine

Objectives:

- To demonstrate Newton's Third Law of Motion by using the force of falling water to cause a soda pop can to spin.
- To experiment with different ways of increasing the spin of the can.

Description:

A soft drink can suspended by a string spins by the force created when water streams out of slanted holes near the can's bottom.

Science Standards:

Science as Inquiry
Physical Science - Position and motion of objects
Unifying Concepts and Processes - Change, constancy, and measurement
Science and Technology - Understanding about science and technology

Science Process Skills:

Observing
Communicating
Measuring
Collecting Data
Inferring
Predicting
Making Models
Interpreting Data
Making Graphs
Hypothesizing
Controlling Variables
Defining Operationally
Investigating

Mathematics Standards:

Computation and Estimation
Whole Number Computation
Measurement
Statistics
Probability

Management:

This activity works well with small groups of two or three students. Allow approximately 40 to 45 minutes to complete. The activity is divided into two parts. In part one the learners construct the engine and test it. Part two focuses on variables that affect the action of the engine. The experiment stresses prediction, data collection, and analysis of results. ★Be sure to recycle the soda pop cans at the end of the activity.

Part One

Materials and Tools:

- Empty soda pop can with the opener lever still attached - one per group of students
- Common nail - one per group of students
- Nylon fishing line (light weight)
- Bucket or tub of water - several for entire class
- Paper towels for cleanup
- Meter stick
- Scissors to cut fishing line

Background Information:

Hero of Alexandria invented the Hero engine in the first century B.C. His engine operated because of the propulsive force generated by escaping steam. A boiler produced steam that escaped to the outside through L-shaped tubes bent pinwheel fashion. The steam's escape produced an action-reaction force that caused the sphere to spin in the opposite direction. Hero's engine is an excellent demonstration of Newton's Third Law of

Motion (See page 5 for more information about Hero's Engine and pages 15-16 for details about Newton's Third Law of Motion.). This activity substitutes the action force produced by falling water for the steam in Hero's Engine.

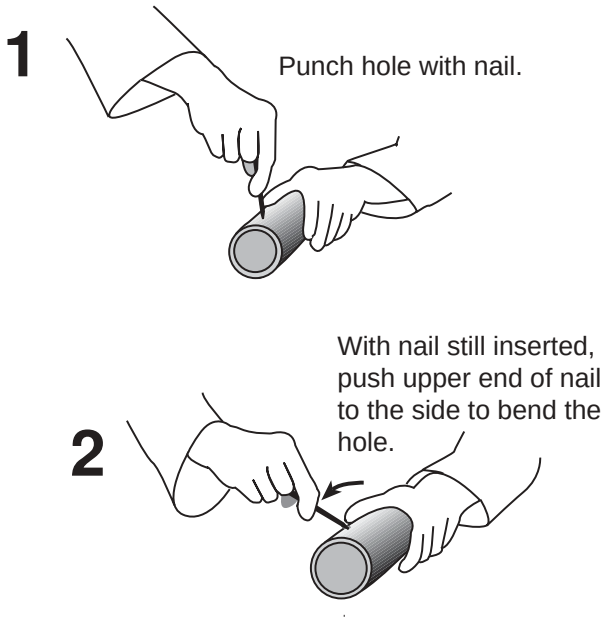
Part One:
Making a Soda Pop Can Hero Engine:

1. Distribute student pages and one soda pop can and one medium-size common nail to each group. Tell the students that you will demonstrate the procedure for making the Hero engine.
2. Lay the can on its side and use the nail to punch a single hole near its bottom. Before removing the nail, push the nail to one side to bend the metal, making the hole slant in that direction.
3. Remove the nail and rotate the can approximately 90 degrees. Make a second hole like the first one. Repeat this procedure two more times to produce four equally spaced holes around the bottom of the can. All four holes should slant in the same direction going around the can.
4. Bend the can's opener lever straight up and tie a 40-50 centimeter length of fishing line to it. The soda pop can Hero engine is complete.

Running the Engine:
1. Dip the can in the water tub until it fills with water. Ask the students to predict what will happen when you pull the can out by the fishing line.
2. Have each group try out their Hero engine.

Discussion:
1. Why did the cans begin spinning when water poured out of the holes?
2. What was the action? What was the reaction?
3. Did all cans spin equally well? Why or why not?

How To Bend The Holes



Part Two:
Experimenting with Soda Pop Can Hero Engines
1. Tell the students they are going to do an experiment to find out if there is any relationship between the size of the holes punched in the Hero Engine and how many times it rotates. Ask students to predict what they think might happen to the rotation of the Hero engine if they punched larger or smaller holes in the cans. Discuss possible hypotheses for the experiment.

Part Two

Materials and Tools:

- Student Work Sheets
- Hero Engines from part one
- Empty soda pop can with the opener lever still attached (three per group of students)
- Common nails - Two different diameter shafts (one each per group)
- Nylon fishing line (light weight)
- Bucket or tub of water - Several for entire class
- Paper towels for cleanup
- Meter stick
- Large round colored gum labels or marker pens
- Scissors to cut fishing line

2. Provide each group with the materials listed for Part Two. The nails should have different diameter shafts from the one used to make the first engine. Identify these nails as small (S) and large (L). Older students can measure the diameters of the holes in millimeters. Since there will be individual variations, record the average hole diameter. Have the groups make two additional engines exactly like the first, except that the holes will be different sizes.
3. Discuss how to count the times the engines rotate. To aid in counting the number of rotations, stick a brightly-colored round gum label or some other marker on the can. Tell them to practice counting the rotations of the cans several times to become consistent in their measurements before running the actual experiment.
4. Have the students write their answers for each of three tests they will conduct on the can diagrams on the Student Pages. (Test One employs the can created in Part One.) Students should not predict results for the second and third cans until they have finished the previous tests.
5. Discuss the results of each group's experiment. Did the results confirm the experiment hypothesis?
6. Ask the students to propose other ways of changing the can's rotation (Make holes at different distances above the bottom of the can, slant holes in different directions or not slanted at all, etc.) Be sure they compare the fourth Hero Engine they make with the engine previously made that has the same size holes.

Discussion:

1. Compare the way rockets in space change the directions they are facing in space with the way Hero Engines work.
2. How can you get a Hero Engine to turn in the opposite direction?
3. Can you think of any way to put Hero Engines to practical use?
4. In what ways are Hero Engines similar to rockets? In what ways are they different?

Assessment:

Conduct a class discussion where students share their findings about Newton's Laws of Motion. Collect and review completed Student Pages.

Extensions:

- Compare a rotary lawn sprinkler to Hero's Engine.
- Research Hero and his engine. Was the engine put to any use?
- Build a steam-powered Hero engine - See instructions below.

Steam-Powered Hero Engine

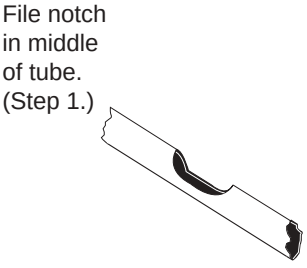
A steam powered Hero engine can be manufactured from a copper toilet tank float and some copper tubing. Because this version of the Hero engine involves steam, it is best to use it as a demonstration only.

Teacher Model

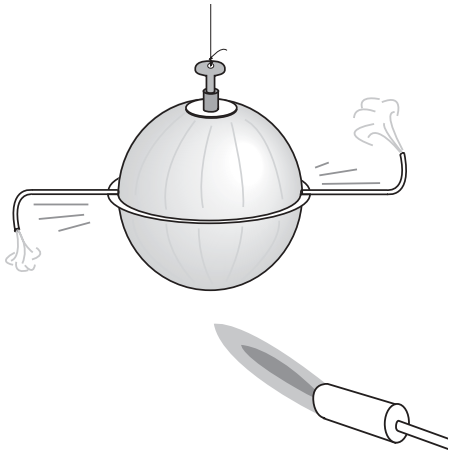
Materials and Tools:

- Copper toilet tank float (available from some hardware or plumbing supply stores)
- Thumb screw, 1/4 inch
- Brass tube, 3/16 I.D., 12 in. (from hobby shops)
- Solder
- Fishing line
- Ice pick or drill
- Metal file
- Propane torch

1. File the middle of the brass tube to produce a notch. Do not file the tube in half.



2. Using the ice pick or drill, bore two small holes on opposite sides of the float at its middle. The holes should be just large enough to pass the tube straight through the float.
3. With the tube positioned so that equal lengths protrude through the float, heat the contact points of the float and tube with the propane torch. Touch the end of the solder to the heated area so that it melts and seals both joints.
4. Drill a water access hole through the threaded connector at the top of the float.
5. Using the torch again, heat the protruding tubes about three centimeters from each end. With pliers, carefully bend the tube tips in opposite directions. Bend the tubes slowly so they do not crimp.
6. Drill a small hole through the flat part of the thumb screw for attaching the fish line and swivel. Twist the thumb screw into the threaded connector of the float in step 4 and attach the line and swivel.



Finished Steam-Powered Hero Engine

Procedure:
Using the Steam-Powered Hero Engine

1. Place a small amount of water (about 10 to 20 ml) into the float. The precise amount is not important. The float can be filled through the top if you drilled an access hole or through the tubes by partially immersing the engine in a bowl of water with one tube submerged and the other out of the water.
2. Suspend the engine and heat its bottom with the torch. In a minute or two, the engine should begin spinning. ★Be careful not to operate the engine too long because it may not be balanced well and could wobble violently. If it begins to wobble, remove the heat.

Caution: Wear eye protection when demonstrating the engine. Be sure to confirm that the tubes are not obstructed in any way before heating. Test them by blowing through one like a straw. If air flows out the other tube, the engine is safe to use.

Pop Can Hero Engine

Names of Team Members:

_____ _____

_____

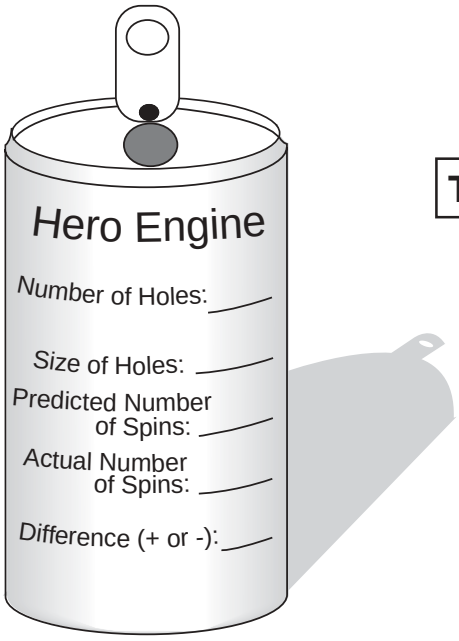
Design an experiment that will test the effect that the size of the holes has on the number of spins the can makes. What is your experiment hypothesis?

_____

_____

Mark each can to help you count the spins.
Test each Hero Engine and record your data on the cans below.

Test Number 1



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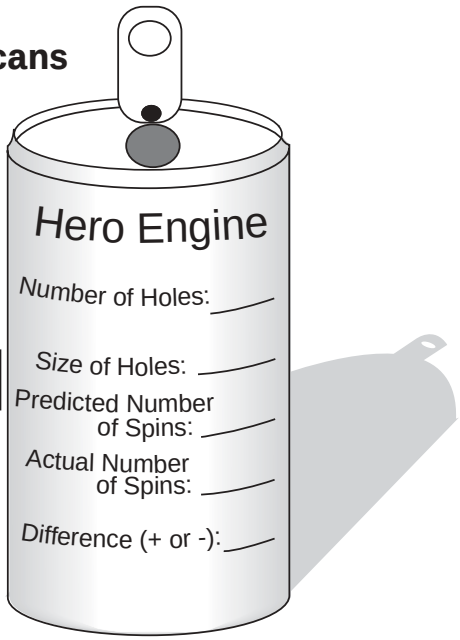
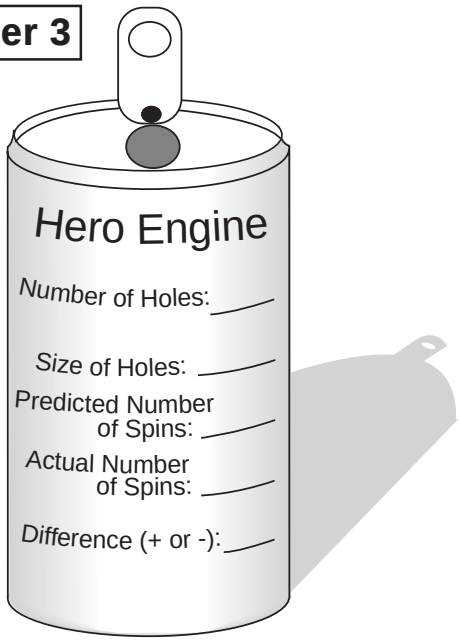


Test Number 3



Based on your results, was your hypothesis correct?

_____

Why?

_____

_____

_____

Design a new Hero Engine experiment. Remember, change only one variable in your experiment.

What is your experiment hypothesis? _____

_____

_____

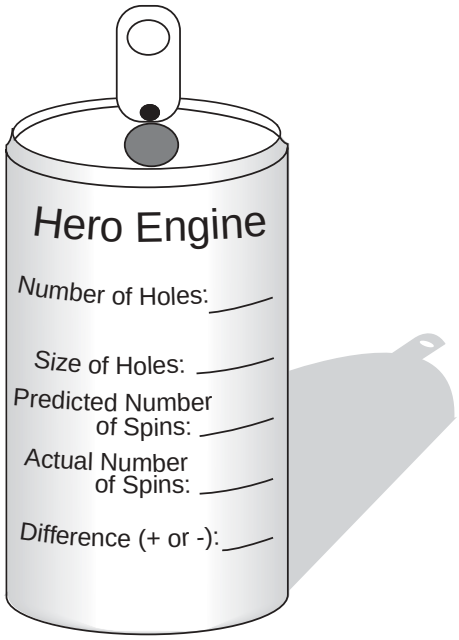
Compare this engine with the engine from your first experiment that has the same size holes.

Based on your results, was your hypothesis correct? _____

Why? _____

_____

_____



Describe what you learned about Newton's Laws of Motion by building and testing your Hero Engines.

_____

_____

_____

Share your findings with other members of your class.