Slow Boat Design

Grade Level:	Total Time Required:
4	4 periods (30 minutes each), approximate

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Lesson Objectives:

In this lesson, students will design and build a boat to move slowly through the water.

Students will be able to:

1. Investigate a transportation system and devices that operate in water and recognize the forces (i.e., lift, drag, friction, thrust and gravity) that affect their motion.
2. Make appropriate measurements to compare the speed of an object in terms of the time required to travel a given distance.
3. Investigate how changes in speed are caused by forces: the greater the force exerted on an object, the greater the change.
4. Define a problem in the context of motion and transportation.
5. Propose a solution to this problem by evaluating, reevaluating and testing the design.
6. Gather evidence about how well the design meets the needs of the problem.
7. Document the design so that it can be easily replicated.
8. Choose and use the appropriate tools to estimate and measure length, mass and temperature in SI units

Indiana Standards:

4.PS.1 Investigate transportation systems and devices that operate on or in land, water, air and space and recognize the forces (lift, drag, friction, thrust and gravity) that affect their motion.

4.PS.2 Investigate the relationship of the speed of an object to the energy of that object.

3-5.E.1 Identify a simple problem with the design of an object that reflects a need or a want. Include criteria for success and constraints on materials, time, or cost.

Next Generation Science Standards:

Discipline Core Ideas

3-5.ETS1-1 Identify a simple problem with the design of an object that reflects a need or a want. Include criteria for success and constraints on materials, time, or cost.

Science/Engineering Practices
1. Asking questions (for science) and defining problems (for engineering)
6. Constructing explanations (for science) and designing solutions (for engineering)
7. Engaging in argument from evidence

Crosscutting Concepts
2. Cause and effect: Mechanism and explanation.

Common Core Mathematics:

4.MD.A.2 Use the four operations to solve word problems involving distances, intervals of time, liquid volumes, masses of objects, and money, including problems involving simple fractions or decimals, and problems that require expressing measurements given in a larger unit in terms of a smaller unit. Represent measurement quantities using diagrams such as number line diagrams that feature a measurement scale.

4.MD.A.3 Apply the area and perimeter formulas for rectangles in real world and mathematical problems.

Common Core English and Language Arts:

SL.4.1 Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on *grade 4 topics and texts*, building on others' ideas and expressing their own clearly.
SL.4.1b Follow agreed-upon rules for discussions and carry out assigned roles.
SL.4.1.c Pose and respond to specific questions to clarify or follow up on information, and make comments that contribute to the discussion and link to the remarks of others.

L.4.6 Acquire and use accurately grade-appropriate general academic and domain-specific words and phrases, including those that signal precise actions, emotions, or states of being (e.g., quizzed, whined, stammered) and that are basic to a particular topic (e.g., *wildlife, conservation,* and *endangered* when discussing animal preservation).

Concepts and Vocabulary

Term	*Defined by a scientist or engineer*	*Defined by a student*
Force	A dynamic influence that changes a body from a state of rest to one of motion or changes its rate of motion.	Pushing
Drag	The phenomenon of resistance to motion through a fluid.	What makes planes go slower
Speed	The rate or a measure of the rate of motion.	How fast something goes
Motion	The process of continual change in the physical position of an object.	Movement

Sources: 1) http://www.thefreedictionary.com

Equipment, Materials, and Tools

Materials		
At least two storage containers, Sterilite 41 quart or similar	Golf Balls	Small foam plates
Toy Boats (1 for each group)	Foam core board	Pieces of cloth
Large paper binder clips	Small plastic cups (note size)	A couple of towels for clean-up
String	Duct tape	Zip ties
Spoons	Lightweight foam	Craft sticks

Tools		
Scissors	Rulers	Stopwatch

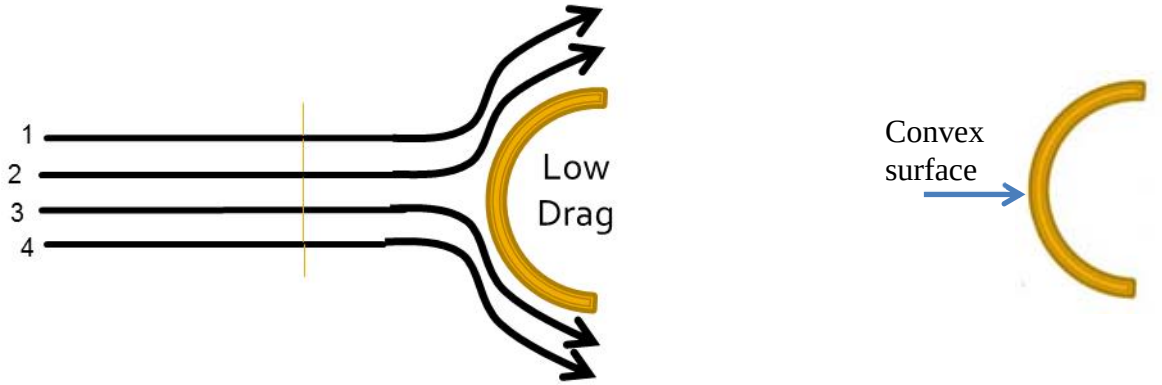
Storage containers:
http://www.target.com/p/sterilite-underbed-storage-box-41-qt/-/A-13796221#prodSlot=medium_1_2&term=sterilite+41+quart

Low and High Drag

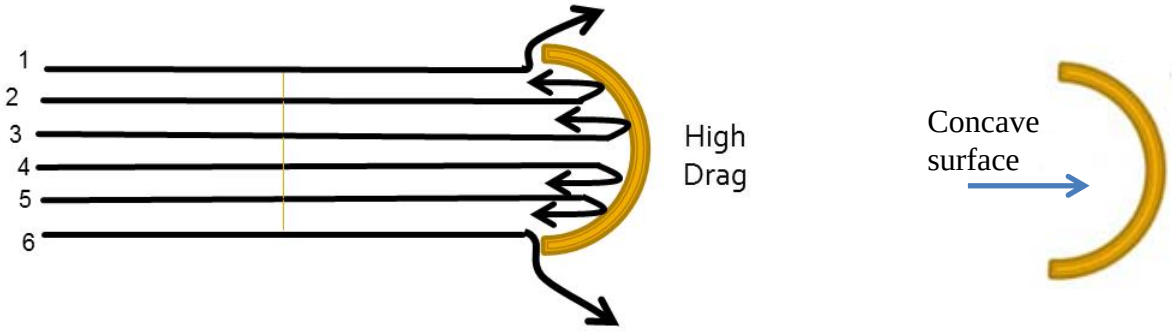
Drag may be influenced by the density of the gas or liquid the object is moving through (i.e. how "thick" the air or liquid is) and the shape/surface area of the object….."

So how can we know if something has low or high drag?

Low Drag: Rounded Shapes (e.g., sports car, high speed train, airplanes, etc.)



High Drag: Concave/Cone shapes (e.g., parachutes, kites, umbrellas, etc.)



Engineering Design

Synopsis of the Design Activity:

Problem:	A fish caught on a fishing line is pulling the boat through the water too fast.
Goal:	Reduce the speed of the boat.
Who is the client:	Fourth graders trying to slow down a boat
End-User:	A boat manufacturing company; anyone fishing in a boat
What is the design:	Design attachments for a boat to make it move slower through the water.
Criteria:	• Increase the drag on the boat. • Maximum width and height design dimensions.
Constraints:	• The maximum depth design dimension. The boat may not touch the bottom of the test tank. • Only the materials provided may be used. • Time.

Lesson Plan #1
Guiding Question - Can you feel the power of the drag force through air?

Time: One 30 minute class session

Procedure:

"FEEL THE POWER OF THE FORCE"

1. Obtain a piece of cardboard or foam core, approximately 2' x 2'.

2. Go to a gym or other open area and have the students run with the cardboard. Make sure the cardboard is not too big that it obstructs their vision. Have them run with the cardboard with the cardboard face perpendicular to the ground.

3. Ask the students if they feel a force pushing back as they run with the piece of cardboard.

4. Are there other times you have felt this type of force? (e.g., an umbrella in wind, walking in water, riding a bike, etc.)

5. The force they are feeling from the cardboard is termed a "drag" force. Movement of an object through a gas or liquid can create a drag force.

Lesson Plan #2
Guiding Question - Can you feel the power of the drag force through water?

Time: One 30 minute class session

Procedure:

1. Set-up the tank with water as shown below in Figures 1 and 2.

2. A hollow ball cut in half can be used to represent low and high drag.

3. Hook each one to a string that overlaps the counter. The string should have a small weight attached to it (approximately 1.5 to 2 ounces).

4. Let go and allow each one to be pulled through the water simultaneously.

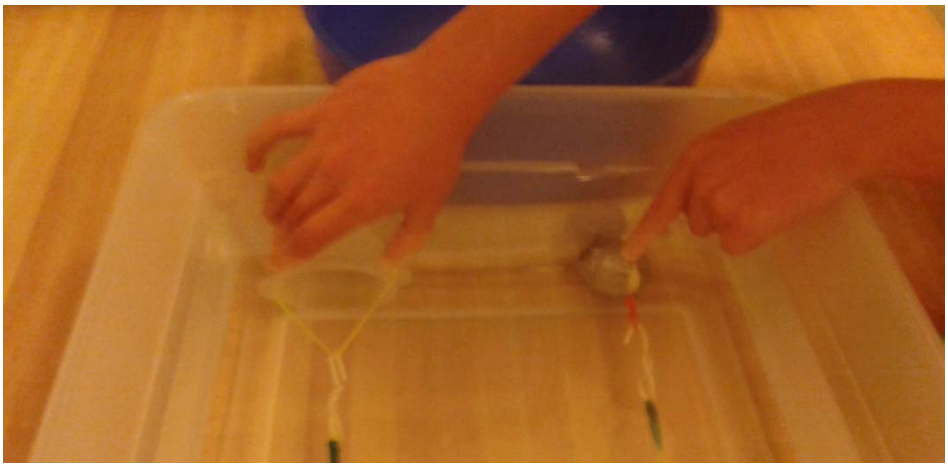


Figure 1. Testing Drag Force on Objects

Figure 2. Test Set-Up for Drag Science Inquiry

Lesson Plan #3
Design Challenge – How slow can you go?

Time: One 30 minute class session

Procedure:

1. Distribute the design challenge.

   Ask: *What is the goal?*
   Who is the user or client?
   What is the problem?
   What are the constraints?
   What materials will you use?

Constraints:

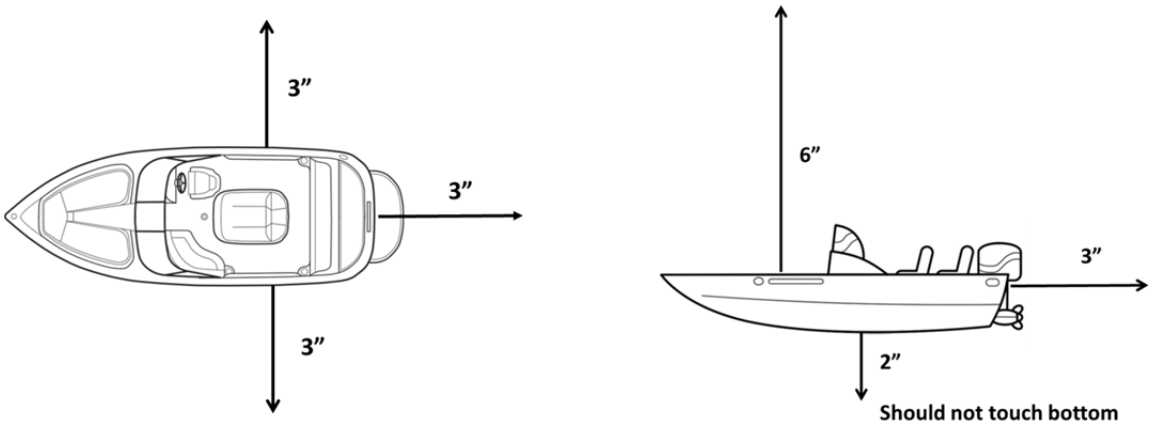


Figure 4. Constraints

2. Instruct students to develop his/her individual plan in his/her design notebooks. Encourage students to label their sketches, include dimensions, and list the materials they will use.

3. Instruct students to work in small teams to share their plans. Next, instruct students to decide on one plan or design and to select a representative from the team to share his/her plan to the teacher for his/her approval.

4. Once teams have teacher approval they may construct their design to slow the boat.

Lesson Plan #4
Guiding Question – Testing your design.

Time: One 30 minute class session

Procedure:

1. Set-up the tank with water as shown in Figures 1 and 2 of Lesson Plan #2.

2. Test an unmodified boat and record the time. Teams will use this time to compare how well their boat performed.

3. Each team will test their boat twice. Record the time for each trial. Students will then calculate the average time and average speed of their boat.

Team #	Trial 1 (seconds)	Trial 2 (seconds)	Average Time (seconds)	Average Speed (inches/second)
1				
2				

Toy boat race

Assessment

The following are possible sources of formative and summative assessment:

- Design notebooks (individual) – Note how students identify and clearly label their drawings; Identify the types of science vocabulary students use in their notebooks (tally the number of times each concept is used); Note how students record data from testing their prototypes and how well they explain their results (patterns in the data)
- Presentation of design to class by the team. Provide positive design attributes, how design criteria where met, and possible redesigns.

- Participation (group) – Note level of engagement; questions students asked; how well they worked in a group; how well each team met the goals of the task
- Other (individual and/or group) – Create a short pre and posttest that highlights key science vocabulary terms; Present a new situation or new problem on the same theme
- See Lesson Extension

Lesson Extensions and Resources

Activity Extensions:

1) Mini Economy

	Price
Foam core board	$2
Small plastic cup	$10
Duct tape (per 2' strip)	$0.25
Lightweight foam	$0.50
Small foam plates	$1
Pieces of cloth	$1
Zip ties	$0.50
Craft sticks	$0.10
Spoons	$0.10

Note: The cups should be expensive so they do not use too many.

2) As an optional activity to better understand how a fluid moves around an object, the students could flow water around an object under a sink with either the faucet or a cup of water. For example, a golf ball could be put under the water stream to show how the fluid moves over the ball. The students could draw the pattern for this and other shapes on a piece of paper to better understand the concepts of fluid flow around an object.

Design Activity

Student Resource

How Slow Can You Go!

Two fourth graders went fishing in a small boat. One of them hooked a fish that was so big that it pulled the boat through the water. This made it very hard to reel in the fish. The fourth graders decided that they need to find a way to slow down the boat the next time they go fishing so that they do not have the same problem.

They would like you to help them design a boat that moves slowly through the water. You will be provided a plastic boat, to use as a prototype, which you can modify to make it move slowly through the water using the materials provided.

Constraints: