From one Teacher to Another

As a teacher, have you ever been frustrated by the feeling that your students aren't really internalizing some of the basics of science – the "scientific method", measurement, and other process skills? It seems that we teach these fundamental concepts from early elementary school on up, but the students continue to struggle with them as abstract concepts year after year, no matter what we try. So we've limited our use of workbooks and rote memorization and incorporated more hands-on activities in our classrooms. This was great, but we still have lots of students who aren't fully grasping what the "scientific method" really means and who don't have the process skills that would allow them to begin testing questions of their own. I see a hole in many of the hands-on experiments I've done in my class. We give them a question to test, they create a hypothesis, they follow the rest of the steps and so on, but that is just it – they are following. They follow all the way to the end where they draw a conclusion based on their data and then, "I'm finished!", and they are. They've done something hands on, they've used the steps of the scientific method to complete an experiment, and they've probably even done some measuring, graphing, and maybe a little problem solving. But so what with the conclusion they've drawn? Does it have any kind of value to them? What is this piece of newfound information for? I think we've got to take some of our classroom experiments a bit further. We've got to create in students an intrinsic need for that piece of information so that they conduct the entire process in a more personal and attentive way. If the results of *their* experiment (one they design themselves) is of use to them personally, for some other reason than a grade, I think we are getting somewhere. This is the way it works in real life after all. Someone has an actual problem to solve or challenge to meet and the entire scientific process springs from there. The scientist reviews what others have already learned about the topic. Their question is born from the holes that are left in that body of knowledge. The experiment is not done just for the sake of the experiment but because whatever is learned from the experiment is of value to solving the original problem.

This unit of study attempts to create a drive in students similar to that of a scientist searching for solutions to real life problems. The students are challenged with making a boat that will be the fastest in the class. The activities in this unit facilitate the students 1) discovering/studying relevant background information, 2) developing a question around boat design and speed, and designing an experiment to test it, 3) conducting their experiment in the FlowWorks exhibit at The Children's Museum of Houston, 4) using the information they and their classmates gather from all of their experiments to inform their boat building, and 5) building and racing self-created boats during a "Classroom Regatta."

The student experiments conducted in FlowWorks will be of value to students in that the results will equip them to make faster boats for the regatta. This works to invest students in the scientific process from the very beginning. They now have a need for the answer to their question and the process of getting there becomes so much more organic. Additionally, the students will be more invested in obtaining precise measurements, accurate data, etc.

All of this is built within the context of boats design and speed. It may or may not be vital that students understand how boats work and how to build the fastest boat, but the value in practicing the scientific process under this context is that it facilitates the study of important concepts like density, buoyancy, and resistance/friction. Also, this unit's culminating "race" plays to the competitive nature of early elementary/middle school students. This unit excites students and accomplishes goals that you've set out for them to achieve – to internalize what it is that scientists do and actually practice becoming scientists themselves.

Introduction to the Unit

This unit is written for 5th grade science students but can easily be modified to accommodate the needs of most upper elementary and middle school students. Prior to the FlowWorks visit, students will study concepts related to boat design and prepare for the experiment they will conduct in FlowWorks. After returning from the FlowWorks exhibit, students will analyze the data gathered in FlowWorks and use it to create boats to be raced in the Classroom Regatta.

The pre-visit activities are designed to allow students to discover and explore the properties and principles that allow boats to float. Under that context, students will also be getting real-life experience designing scientific experiments, taking measurements, and analyzing data. After acquiring the necessary background information regarding boats and practicing necessary process skills, students complete the pre-visit activities by setting up the experiment that they'll conduct in FlowWorks regarding boat design and speed. They'll choose a specific question to test, create a hypothesis, and design their experiment (identify independent and dependent variables, decide how to control for others, create data tables, etc).

During their visit to FlowWorks at The Children's Museum of Houston, students will conduct the experiment they designed, collect and record their data, and get a little wet. 

When students return to the classroom, they'll be eager to share their data with one another – each group has tested a different question and in order for individual students to be prepared to create the fastest boat possible, they'll need to rely on the results of their own experiment and also those of their classmates. As students share the results of their experiments they can make conclusions based on that data as well as share concerns about any inconsistent data, experimental error, etc. and discuss how they might answer outstanding questions if necessary.

Based on the information students gather regarding the factors affecting boat speed, groups or pairs of students will use recycled materials brought from home to design and create the fastest boat possible. Of course the success of the student boats is a direct result of the quality of experiment they designed and tested in FlowWorks, the reliability of their data, and the accuracy of their conclusions.

The post-visit activities culminate in a Classroom Regatta. Each group or pair of students will test their boat's speed (using an easy, make-it-yourself "River Raceway"), putting many important process skills to use once again. Make sure to take pictures of this exciting event. Upon receipt of your Classroom Regatta photos, we'll send you family museum passes for the students with the winning boat!

Using this Unit

Pre-Visit Activities

The pre-visit activities vary as far as where they might fit in your lesson cycle, time duration, etc. All can be adapted, condensed or expanded to meet the needs of you and your students, but for organizational and convenience purposes they are identified here as LEAD-IN (springboard) activities or as PRACTICE activities and estimated time durations are given.

For the most in-depth application of this unit, you and your students should complete all of the pre-visit activities, as each of them adds an important layer to student understanding of either properties/principles behind boat design or scientific inquiry and process skills. If it is not possible for your students to engage in every single activity, hopefully you will be able to choose one or two activities from both Cluster #1 and #2. Although the activities in Clusters #1 and #2 are meant to build on top of one another, they can also be done independent of one another and a specific order is not entirely necessary. Cluster #3 is an exception. In order for students to be prepared for their guided tour of FlowWorks, during which they will be conducting their own experiment, they must have already developed their question and designed their experiment, meaning that **it is absolutely necessary that students complete Cluster #3 in its entirety before their FlowWorks guided tour**.

Materials for FlowWorks

As part of the Cluster #3 activities, students will be developing their question to test, designing the experiment, identifying independent and dependent variables, writing the experimental procedure, deciding how to control for variables, setting up data tables, etc. The beautiful part of this is that the experiment that your students will be conducting in FlowWorks is their own creation, which promotes an internalization of the scientific process and associated skills. It also means that **students must bring their Cluster #3 work with them to the FlowWorks guided tour or they will not have an experiment to conduct**.

Post-Visit Activities

The post-visit activities are an opportunity for students to not only analyze and draw conclusions based on the results of their FlowWorks experiments, but also to use what they've learned for a purpose – the better their experiments, the more well-informed they'll be about the factors effecting boat design, and ultimately, the faster their boat will be in the Classroom Regatta. We strongly suggest that your class not only participate in the post-visit activities (basically analyzing data from the students' experiments and drawing conclusions, creating boats, and racing (testing) the boats) but that you kick off this entire unit by talking about this exciting, culminating event. Using the challenge of making the fastest possible boat as a motivating factor for this entire unit actually models the scientific process as it most often occurs in real life and will give the pre-visit activities and the FlowWorks student experiments all the more relevance and purpose. Remember to send in pictures of your Classroom Regatta and we'll send family museum passes to the students with the fastest boat!

Children's Museum of Houston

Pre/Post Classroom Activities

Pre-Visit Activities

Cluster #1: The properties of boats and what makes them float

Sink or Float (Density)

Clay Float (Buoyancy, Archimedes Principle)

Boat Diagram

Origami Boat

Cluster #2: Experimental inquiry, measuring speed, and exploring boat design

I Have a Need for Speed (equations)

A Day at the Racetrack

Mealworm Marathon

Exploring Streamlining

Cluster #3: Setting up an experiment for the visit to FlowWorks

Developing a Question

Designing the Experiment

Pre-Visit Activities Cluster #1

After engaging in this cluster of activities:
Students will be able to explain buoyancy and other phenomenon that allow boats to float as well as identify the basic parts of a boat.

Associated 5th grade science TEKS:
5.7D: Observe and measure characteristic properties of substances that remain constant such as boiling points and melting points
5.2B: Collect information – observe and measure
5.2C: Analyze and interpret information to construct explanations from evidence
5.2D: Communicate valid conclusions
5.3A: Analyze, review, and critique scientific explanations
5.3C: Represent the natural world using models and identify their limitations
5.4A: Collect and analyze information using tools including calculators, microscopes, cameras, sound recorders, computers, hand lenses, rulers, thermometers, compasses, balances, hot plates, meter sticks, timing devices, magnets, collecting nets, and safety goggles.

Key Words:
Density, mass, volume, buoyancy, Archimedes Principal, bow, stern, hull, keel

Key Concepts/Teacher Notes:
Density

- Density is defined as the measurement of how much mass of a substance is contained in a given volume
- d=mass/volume
- Materials float if they are less dense than water and they sink if they are denser than water. Water has a density of 1.0. Wood (oak, for example)

floats in water because its density is 0.68. Gold sinks in water because its density is 19.32.

Buoyancy

- Buoyancy is defined as the ability to float.
- Buoyancy is the result of the upward force a fluid exerts on an object.
- An object that floats in water can be described as positively buoyant because the buoyant force of the fluid is greater than the weight of the object. An object that sinks in water can be described as negatively buoyant because the buoyant force of the water is less than the weight of the object. An object that neither sinks nor floats, but remains suspended in water can be described as neutrally buoyant.
- Buoyancy floats our boats!

Archimedes Principle

- Around 1500 A.D. a famous mathematician named Archimedes made a startling discovery in the bathtub! He noticed that as he would lower himself into the tub the water level rose and it would fall again when he lifted himself out. This real-life discovery became known as Archimedes Principle.
- Archimedes Principle states that the buoyant force on a submerged object is equal to the weight of the fluid that is displaced by the object.
- In order for an object to float, it must displace enough water to equal its weight, before it is fully submerged. An object will float if it weighs less than the amount of water it displaces. It will sink if it weighs more than the water it displaces. Differently shaped objects displace water differently, even if they are of the same material and have equal weight. This explains why huge steel ships float even though a ball of steel sinks.

Basic Parts of a Boat

- The bow is the front of the boat.
- The stern is the back of the boat.
- The hull is the body of the boat.
- The keel is called the "backbone" of the boat. It runs along the bottom of the boat from front to back.

Students will engage in the following hands on activities:

Cluster #1, Activity #1 – Will it sink or float?
Cluster #1, Activity #2 - Clay Float: Exploring Archimedes' Principle
Cluster #1, Activity #3 - Boat Lingo Diagram
Cluster #1, Activity #4 - Origami Boat

Cluster #1, Activity #1 – Will it sink or float?

LEAD-IN activity, 20 minutes estimated duration

Materials: A large, clear container that holds at least 2 gallons of water (e.g. glass aquarium), water, and a variety of the materials listed below or other readily available materials that will sink or float.

Possible Materials	**Expected Outcome/Information**	**Where can I find it?**
Plastic teaspoon	Floats	School/home
Metal teaspoon	Sinks	School/home
Large wooden mixing spoon	Floats	School/home
Rock	Sinks	School/home
Pumice Rock	Floats (this is an igneous rock formed from cooling lava and is filled with lots of holes where there were once air pockets)	Sold as foot scrub Available at most Wal-Mart or other retailers for a few dollars Giant sized samples available at www.teachersource.com for $14.95-$19.95
Twig	Floats	School/home
Wooden craft/popsicle stick	Floats	School/home
Pencil	Floats	School/home
Ironwood (leadwood)	Sinks (the wood from this tree is exceptionally dense and therefore sinks in water)	Samples available at www.teachersource.com for $10.95
Plastic bottle (empty)	Float	School/home
Plastic bottle (filled with water)	Suspends in the fluid (density of the water inside and outside the bottle are both 1.0, therefore the bottle of water neither sinks nor floats)	School/home
12 oz can of Diet Coke	Floats (has less density than regular Coke)	School/home
12 oz can of regular Coke	Sinks (has greater density than Diet Coke)	School/home
Tennis ball	Floats	School/home
Golf ball	Sinks	School/home
Apple	Floats	School/home
Uncooked hot dog	Sinks (hot dogs float after boiling because they expand in the heat, causing them to become less dense and they absorb water and air which are also less dense)	School/home
Whole orange	Floats (The peel of the orange is very spongy and contains lots of trapped air so when the peel is on, the overall orange is less dense than water)	School/home
Peeled orange	Sinks (The fruit of the orange is more dense than water, so without the peel, the orange sinks)	School/home
Crayon	Sinks	School/home
Coin	Sinks	School/home
Key	Sinks	School/home
Latex Balloon filled with air	Floats (the air inside the balloon is much less dense than water)	School/home

Before dropping each object in the water, have students predict whether it will sink, float, or remain suspended in the water. Have students test each object and place them in three separate piles accordingly. Examine each pile and make observations about objects that float, sink, or suspend in water. Probe the students as to why they think some objects floated and others sank. Briefly review the concept of density (how much mass of a substance is contained in a given volume) and remind the students that water has a density of 1.0. Given this information and the observations from this demonstration, ask the students what they might be able to conclude about the densities of the objects in each pile. Use this experience as a springboard into a further discussion of the property of density.

Cluster #1, Activity #2 - Clay Float: Exploring Archimedes' Principle
PRACTICE Activity, 30 minutes estimated duration
Materials: Each group of students will need one small plastic container (bottom half of 2-liter soda bottle), modeling clay, masking tape, ruler, balance, small weights (e.g. washers), paper and pencil for recording data in a science journal or notebook

After an introduction to Archimedes' Principle, students will be ready to explore the phenomenon through this activity.

1. Fill the clear plastic container with water.
2. Attach a piece of masking tape to the container lengthwise, running from the top of the container to the bottom. Mark the starting water level on the tape.
3. Using modeling clay and a balance, create two balls of equal mass.
4. Drop the first ball into the water. Observe and record whether it sinks or floats. Mark the resulting water level on the masking tape and use a ruler to measure the total change in water level. Record this measurement.
5. Remove the clay ball and place it aside.
6. Take the second clay ball and think about how you might shape it so that it will float. Shape the clay accordingly and place it in the water.
7. Observe and record whether the clay sinks or floats. Mark the resulting water level on the masking tape. Measure and record the total change in water level.
8. Remember that the two pieces of clay are of equal mass. Why did one shape sink and the other float?
9. How did the shape of the clay effect the change in water level?
10. How does this demonstration relate to Archimedes' Principle?

Extension: Add weights to the boat shaped clay, one at a time. See how many weights your "boat" can hold before it sinks. Describe what you observe using Archimedes' Principle.

Activity #3 - Boat Lingo Diagram
LEAD IN activity, 5 minutes estimated duration
Materials: Blackline Master A.

Students will identify and label four basic parts of a boat (see Key Concepts/Teacher Notes). This terminology will be used as students conduct experiments on factors effecting boat speed as well as when they design their own boats.

Activity #4 - Origami Boat
PRACTICE activity, 45 minutes estimated duration
Materials: Origami paper, recycled cardboard (cut to roughly standard notebook paper size), extra cardboard, glue, paper, writing materials

Students will:
1. Create an origami boat using the following website as a guide: http://www.origami-instructions.com/easy-origami-boat.html
2. Glue the origami boat to the sheet of cardboard
3. Attach signs, arrows, etc to make a 3-D diagram of a boat, with the four basic parts labeled
4. Take the diagram to another classroom and use it to teach a buddy about the four basic parts of a boat

Children's Museum of Houston

Pre/Post Classroom Activities

Pre-Visit Activities Cluster #2

After engaging in this cluster of activities:
Students will measure, calculate, and graph the speed of given objects, conduct speed related experiments using the scientific method, and explore the concept of streamlining and how it affects boat speed.

Associated 5th grade science TEKS:
5.1A: Demonstrate safe practices during field and laboratory investigations
5.2A: Plan and implement investigations, formulate hypotheses, use equipment and technology.
5.2B: Collect information – observe and measure
5.2C: Analyze and interpret information to construct explanations from evidence
5.2D: Communicate valid conclusions
5.3A: Analyze, review, and critique scientific explanations
5.3C: Represent the natural world using models and identify their limitations
5.4A: Collect and analyze information using tools including calculators, microscopes, cameras, sound recorders, computers, hand lenses, rulers, thermometers, compasses, balances, hot plates, meter sticks, timing devices, magnets, collecting nets, and safety goggles.
5.4B: Demonstrate that repeated investigations may increase the reliability of results.

Key Words:
Hypothesis, independent variable, dependent variable, controls, speed, streamlining

Key Concepts/Teacher Notes:

Hypothesis

- An educated prediction

Independent variable

- The thing that the scientist changes in an experiment

Dependent variable

- The thing that changes as a result of the independent variable

Controls

- Things that the scientist must keep constant in order to isolate the effects of only the independent variable

Speed

- Speed = distance ÷ time

Streamlining

- Streamlining is modifying the shape and/or texture of an object to its air or water resistance.
- Streamlined objects can move more quickly through air and water and require less energy to do so than objects that are not streamlined.
- Although rectangular boats or planes could carry more cargo and passengers, boats and planes are shaped in a streamlined design because they travel faster and require less fuel.
- In addition to shape, texture is an important part of streamlining. Boats and planes are made of smooth materials to help reduce resistance. Many airlines wash planes between each flight so as to eliminate air resistance caused by dirt and save on fuel.

Students will engage in the following hands on activities:

Cluster #2, Activity #1 – I Have a Need for Speed (equations)
Cluster #2, Activity #2 – A Day at the Racetrack
Cluster #2, Activity #3 – Mealworm Marathon
Cluster #2, Activity #4 – Exploring Streamlining

Cluster #2, Activity #1 – I Have a Need for Speed (equations)
PRACTICE activity, 20 minutes estimated duration
Materials: Blackline Master B

Students will review the equation for speed and how it is used. They will utilize the equation to solve for speed in a number of story problems.

Cluster #2, Activity #2 – A Day at the Racetrack
PRACTICE activity, 45 minutes estimated duration
Materials: Blackline Master C

Students will conduct an experiment in which they measure the speed of cars rolling down tracks with various inclines to determine which incline produces the highest speed.

* Encourage students to measure time using the second hand on a clock or watch instead of using a stopwatch. In the FlowWorks exhibit, students will be measuring time using a lap clock that continuously loops from 0-60 seconds.

Cluster #2, Activity #3 – Mealworm Marathon
PRACTICE activity, 45 minutes estimated duration
Materials: Blackline Master D

Students will conduct an experiment in which they measure, graph, and calculate the speed of a mealworm.

*If your district has a science center, it's likely that you'll be able to order mealworms from there. Otherwise, packages of mealworms are available at most pet supply stores for a few dollars.
*Prior to beginning this experiment with your class, take the carton of mealworms out of the refrigerator and allow them to warm to roughly room temperature. Cold mealworms are slow mealworms and make for a boring speed graph.
* No mealworms were harmed in the making of this experiment.
* Encourage students to measure time using the second hand on a clock or watch instead of using a stopwatch. In the FlowWorks exhibit, students will be measuring time using a lap clock that continuously loops from 0-60 seconds.

Cluster #2, Activity #4 – Exploring Streamlining
PRACTICE activity, 45 minutes estimated duration
Materials: Blackline Master E, materials for "River Raceway" (see below), one squeeze-bottle empty plastic ketchup bottle (stands on its cap), one regular-shaped empty plastic ketchup bottle

Students will conduct an experiment in which they observe the effects of streamlining and determine which "boat" shape travels at the highest speed.

*This activity involves the use of the "River Raceway" which your class will use again when you test the speed of the student created boats during the "Classroom Regatta." Initial assembly of the River Raceway is simple but will have to be done outside of class time and may take approximately 45 minutes (see below for required materials). Remember, you and your students will be able to use the River Raceway for this activity, for the culminating Classroom Regatta, and you may even find other uses for it in the future. See below for easy assembly instructions.
*Activities involving the River Raceway must be done outside.
*Encourage students to measure time using the second hand on a clock or watch instead of using a stopwatch. In the FlowWorks exhibit, students will be measuring time using a lap clock that continuously loops from 0-60 seconds.

Assembling the River Raceway
1. Purchase a 41 quart clear Sterilite container (34 ¾" x 16 ½" x 6"). These are available at Wal-Mart and other retailers.
2. Place the end of a garden hose and trace the outline onto the outside of the container, centered in the bottom third of on of the shorter sides.
3. Use a drill to remove the plastic inside the traced circle.
4. Measure 18 cm away from the side with the hole and use colored tape to mark this spot on both sides of the container. This marks the starting line.
4. Insert the hose into the hole and so that the end of the hose is flush with the inside of the container.
5. Place a brick or piece of wood (approximately 2 inches high) under the hose side of the container so as to create a decline.
6. Turn the water on and allow for the container to fill. The stream of water coming from the hose should be flowing below the surface of the water. Keep the hose running for the duration of the experiment and allow the water to run over the end opposite of the hose.

Using the River Raceway

- The entire container is 78 cm long and the starting line is at 18 cm (see above). This means that all boats (or any object to be tested on the River Raceway) must be less than 18 cm long so that they can fit behind the starting line.
- Aside from the area behind the starting line, there are 60 cm of "raceway" space. Measure the speed of boats in cm/second.

Pre-Visit Activities Cluster #3

After engaging in this cluster of activities:
Students will prepare for their visit to the FlowWorks exhibit at The Children's Museum of Houston by designing the experiment they will conduct.

Associated 5th grade science TEKS:
5.2A: Plan and implement investigations, formulate hypotheses, use equipment and technology.
5.3A: Analyze, review, and critique scientific explanations

Key Words:
Hypothesis, independent variable, dependent variable, controls, speed

Key Concepts/Teacher Notes:
In the FlowWorks exhibit:

- Students will be making and calculating the speed of boats to answer their questions about boat design and speed. Boats are assembled in FlowWorks from a variety of pre-made pieces that easily snap together. There will be two different bow shapes to test, three different stern pieces to test, and students can either connect the bow directly to the stern (for the shortest possible hull) or use any number of separate hull pieces (to increase the length of the hull).
- A digital lap clock will be present where students race their boat, continuously looping from 0-60 seconds. If you've encouraged students to time the previous experiments using the second hand of a clock instead of a stopwatch they should be prepared for how to use this clock and record accurate data.
- The distance of the boat race in FlowWorks is 6 meters.

Students will engage in the following hands on activities:
Cluster #3, Activity #1 – Developing a Question
Cluster #3, Activity #2 – Designing Your FlowWorks Experiment

Cluster #3, Activity #1 – Developing a Question
PRACTICE activity, 30 minutes estimated duration
Materials: Paper and pencil for students to write down the specific question that they will be investigating at the FlowWorks exhibit (you should also keep a record of which students are responsible for which questions)

In the FlowWorks exhibit, there are three possible factors to test as they related to boat speed: bow shape, stern shape, and number of hull pieces (length of hull). Students will need to information on each of these factors to inform the boat building they do back in the classroom, but this would be too many experiments for one pair or group to test during their FlowWorks visit. For that reason, your class needs to break into groups and then decide how to choose or assign a specific question for each group to answer so that all questions are covered. Once you return back to the classroom and share results everyone will have the information they need to completely design their boat. It's possible to have more than one group investigate a particular question. This will increase the reliability of the data and may also initiate interesting discussions about reliability and experimental error.

Possible questions for your class to investigate: (You may give these to the students or have them arrive at them on their own)

1. Which bow piece results in the fastest speed?
2. Which stern piece results in the fastest speed?
3. Is the speed greater when the bow and stern are attached directly together (shortest possible hull size) or when one hull piece is added to the boat (longer hull).
4. How is speed affected by increasing the length of the hull beyond one hull piece?

Cluster #3, Activity #2 – Designing Your FlowWorks Experiment
PRACTICE activity, 45 minutes estimated duration
Materials: Blackline Master F
Students must bring their completed Blackline Master F with them to FlowWorks to be able to participate.

Once students have decided what question they will be responsible for investigating, it is time for them to design their experiments. Blackline Master F should be used as a guide to help ensure that students plan appropriately. Based on what they have learned so far, students should form a hypothesis for their question. Students need to identify their independent and dependent variables as well as decide how they will control for other variables. They need to set up a data table to record their data (time to finish line), remembering to plan for several trials. Students will need to describe their procedure. Ensure that they plan to find an average time to the finish line (6 meters from starting line) and then calculate the average speed (6 meters ÷ average time) for each condition in their experiment. An example data table set-up might look like this:

	Time (seconds) Trial 1	Time (seconds) Trial 2	Time (seconds) Trial 3	Average time (Trial 1+2+3) ÷ 3	**Speed** **6 m ÷ Ave. time**
Condition #1 **Curved bow**					
Condition #2 **Pointed bow**					

Post-Visit Activities

Reporting/Analyzing Data and Drawing Conclusions
Student Boat Building
Classroom Regatta
Final Discussion

Post-Visit Activities

After engaging in this cluster of activities:
Students will prepare for their visit to the FlowWorks exhibit at The Children's Museum of Houston by designing the experiment they will conduct.

Associated 5th grade science TEKS:
5.7D: Observe and measure characteristic properties of substances that remain constant such as boiling points and melting points
5.1A: Demonstrate safe practices during field and laboratory investigations
5.2A: Plan and implement investigations, formulate hypotheses, use equipment and technology.
5.2B: Collect information – observe and measure
5.2C: Analyze and interpret information to construct explanations from evidence
5.2D: Communicate valid conclusions
5.3A: Analyze, review, and critique scientific explanations
5.3C: Represent the natural world using models and identify their limitations
5.4A: Collect and analyze information using tools including calculators, microscopes, cameras, sound recorders, computers, hand lenses, rulers, thermometers, compasses, balances, hot plates, meter sticks, timing devices, magnets, collecting nets, and safety goggles.
5.4B: Demonstrate that repeated investigations may increase the reliability of results.

Key Words:
Hypothesis, independent variable, dependent variable, controls, speed, density, buoyancy

Key Concepts/Teacher Notes:
In the FlowWorks exhibit:

- Students will be making and calculating the speed of boats to answer their questions about boat design and speed. Boats are assembled in FlowWorks from a variety of pre-made pieces that easily snap together. There will be two different bow shapes to test, three different stern pieces to test, and students can either connect the bow directly to the stern (for the shortest possible hull) or use any number of separate hull pieces (to increase the length of the hull).
- A digital lap clock will be present where students race their boat, continuously looping from 0-60 seconds. If you've encouraged students to

time the previous experiments using the second hand of a clock instead of a stopwatch they should be prepared for how to use this clock and record accurate data.

- The distance of the boat race in FlowWorks is 6 meters.

Students will engage in the following activities:
Post-Visit Activity #1 – Reporting/Analyzing Data and Drawing Conclusions
Post-Visit Activity #2 – Student Boat Building
Post-Visit Activity #3 - Classroom Regatta
Post-Visit Activity #4 - Final Discussion

Post-Visit Activity #1 – Reporting/Analyzing Data and Drawing Conclusions
PRACTICE activity, 45 minutes estimated duration
Materials: Blackline Master F, complete with student data from FlowWorks experiments

1. Have each group present the data and results from their FlowWorks experiment.
2. Compare results from groups that tested the same question and address any inconsistencies if necessary.
3. Guide the students to draw conclusions about each factor affecting boat speed and what works to make the fastest boat.

Post-Visit Activity #2 – Student Boat Building
PRACTICE activity, 60 minutes estimated duration
Materials for boat building: tape, glue, thumb tacks, craft sticks, aluminum foil, yarn, string, and a variety of recycled materials that students can bring from home (see a list below)

Possible recycled materials for boat building: Plastic bottles, margarine and other plastic containers, milk jugs, egg cartons, juice cartons, ice cream containers, etc. Be sure to remind students that they are not to bring glass, sharp metal, or any other possibly dangerous or hazardous material.

As students plan and build their boats, frequently refer back to the results of their FlowWorks experiments and encourage them to use the conclusions they drew to guide their boat design. Remind the students that the goal is to build the fastest boat in the class.

Post-Visit Activity #3 – Classroom Regatta
PRACTICE activity, 90 minutes estimated duration
Materials: Blackline Master G, the homemade "River Raceway" (see *Assembling the River Raceway* and *Using the River Raceway* on page 13), student created boats

Once the students have constructed their boats, its time for the Classroom Regatta! To determine which boat is the fastest in the class, test each boat using the "River Raceway" (see above). Have students record the results of the Classroom Regatta on Blackline Master G so that they can calculate the speed of each boat and determine the winner!

*Remember to send in pictures of your Classroom Regatta and we'll send family museum passes to the students with the fastest boat!

Post-Visit Activity #4 – Final Discussion
PRACTICE activity, 30 minutes estimated duration
Materials: student brains

After the students have "raced" their boats in the Classroom Regatta, calculated the speed of each boat, and determined a winner, they are ready to have one last discussion about this unit. See below for some possible questions to discuss:

1. Are the results of our Classroom Regatta consistent with what we might have expected, given the conclusions we drew from our FlowWorks experiments? Why or why not?
2. What new questions do we have a this point? If we wanted to conduct additional experiments to test these new/outstanding questions, how might we do so?
3. What, if any, limitations do we face when using models of boats instead of actual boats? (e.g. differences in material, weight of boat, lack of steering capability, method of propulsion)
4. How can we use density, buoyancy, and Archimedes' principle to explain what we observed during our FlowWorks experiments as well as the outcome of our Classroom Regatta?

Children's Museum of Houston

Pre/Post Classroom Activities

A Day at the Racetrack

QUESTION:

Which angle will cause the car to roll at the fastest speed?

Independent Variable: ______________________________________

Dependent Variable: ______________________________________

Variables to control for: ____________________________________

HYPOTHESIS:

____

____

PROCEDURE:

1. Obtain a flat board (about 1.5 meters long) to make a ramp. Use masking tape on one side of the board to mark a starting line.
2. Use masking tape to mark a finish line on the floor, about 2 meters beyond the ramp.
2. Place one science textbook under one sight to produce a slight incline (the end with the starting line should be higher).
3. Hold the toy car so that the front wheels are just behind the starting line. On the word "Go" you should release the car and your partner should start timing.
4. Watch the racecar as it speeds toward the finish line. When the front wheels cross the finish line, say "stop" to signal your partner to stop timing.
5. Record the time in the data sheet and repeat the process twice more for trials 2 and 3.
6. Repeat steps 3-5, this time with two books under the ramp.
7. Repeat steps 3-5, this time with three books under the ramp.

Blackline Master C

RECORD THE DATA:

	Time (seconds) Trial 1	Time (seconds) Trial 2	Time (seconds) Trial 3	Average time (seconds) (Trial 1+2+3) ÷ 3	**Speed** **Distance (meters) ÷ Average time (seconds)**
1 book					
2 books					
3 books					

* For your speed calculations, make sure you have an accurate measurement of the track, from the starting line to the finish line.

DRAW A CONCLUSION:

____

____

Blackline Master C

Children's Museum of Houston

Pre/Post Classroom Activities

Boat Lingo

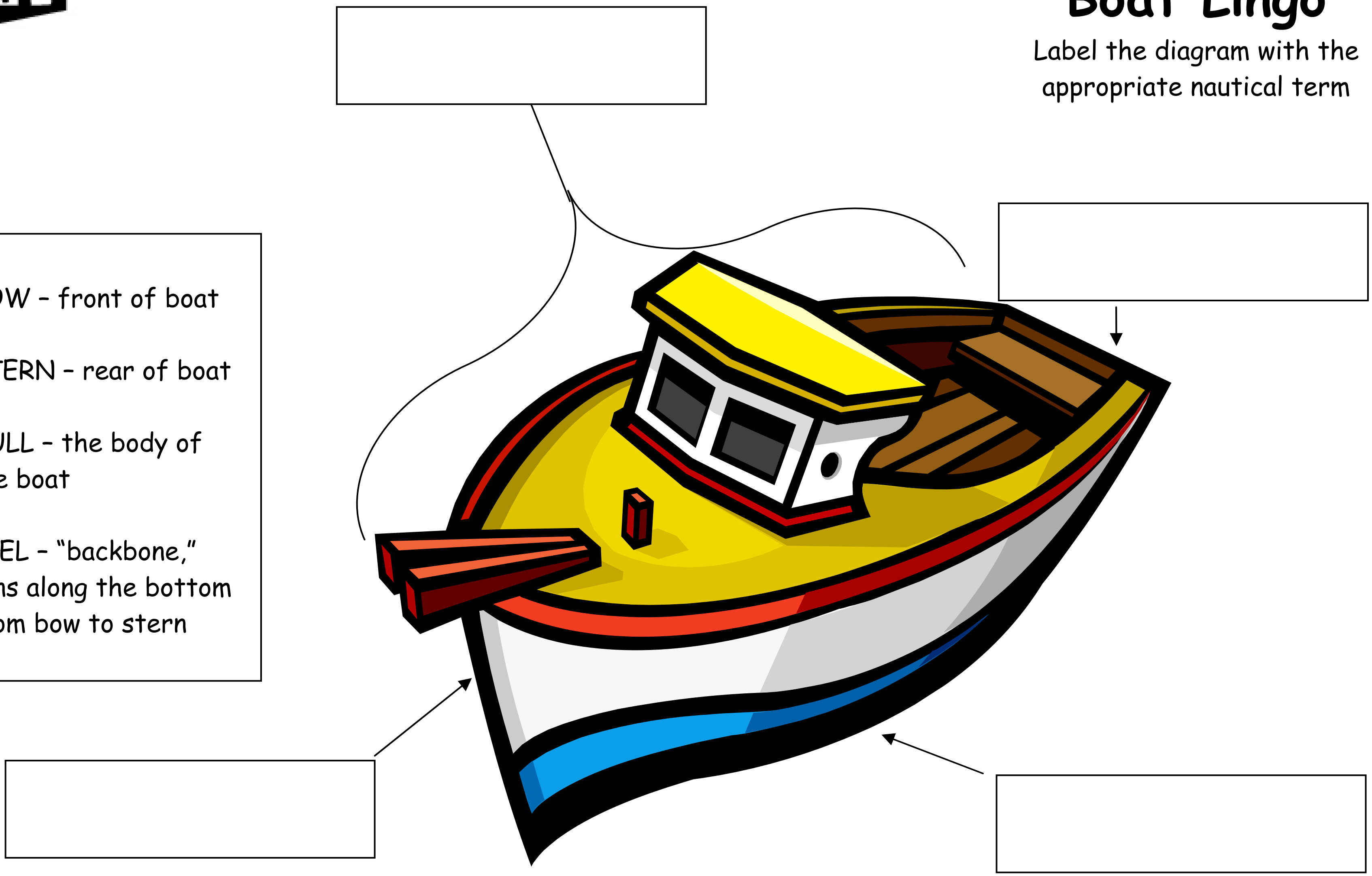
Label the diagram with the appropriate nautical term

BOW – front of boat

STERN – rear of boat

HULL – the body of the boat

KEEL – "backbone," runs along the bottom from bow to stern



Blackline Master A

Exploring Streamlining

QUESTION:

Which shape will have the fastest speed down the "River Raceway"?

Independent Variable: ____

Dependent Variable: ____

Variables to control for: ______________________________________

HYPOTHESIS:

____

____

PROCEDURE:

1. Ensure that the "River Raceway" is operating properly. The hose should be flush with the inside of the container. The hose side of the Raceway should be elevated about 2 inches off the ground. The water should be on and the stream should be well below the surface of the water. Excess water should be running off the "finish line" side and into the grass.
2. Place the first bottle just behind the finish line.
3. When a partner begins timing, let the go of the bottle and allow it to be propelled by the stream of water.
4. Yell "finish" when the bottle reaches the opposite end of the container – this should signal your partner to stop timing.
5. Record the time in your data sheet. Repeat twice more for trials 2 and 3.
6. Repeat steps 2-5 for the second bottle.

RECORD THE DATA:

	Time (seconds) Trial 1	Time (seconds) Trial 2	Time (seconds) Trial 3	Average time (seconds) (Trial 1+2+3) ÷ 3	**Speed** **60 cm ÷ Average time (seconds)**
Squeeze bottle					
Regular bottle					

* For your speed calculations, note that the distance from the starting line to the end of the container is 60 cm.

DRAW A CONCLUSION:

____

____

How does this experiment relate to the concept of streamlining?

Describe real-life applications of streamlining.

I Have a Need for Speed (equations)

Speed = Distance ÷ Time

For example, if a horse gallops 21 meters in 3 seconds:

Speed = 21 meters ÷ 3 seconds
Speed = 7 meters/second

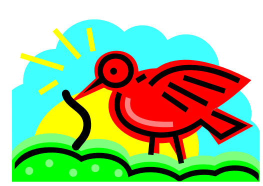
Answer the following problems by calculating the speed. Remember to include units in your answers.

1. What is the speed of a football moving 30 yards in 2 seconds?

2. What is your speed on a bike if you go 5 miles in 15 minutes?

3. Jessica lives 1 mile away from school and it takes her 16 minutes to walk home. Victor lives 2 miles away from school and it takes him 30 minutes to walk home. Who walks home at the faster speed?

4. A caterpillar crawled 20 centimeters in 5 minutes. It stopped to munch on a leaf and then was eaten by a bird. What was his speed before becoming lunch?



Mealworm Marathon

Procedure:

1. Tape a piece of white printer paper to your table.
2. Use two create a lane in which your mealworm can crawl (this will keep him traveling in a straight line).
3. Draw a starting line on your paper.
4. Place the mealworm headfirst behind the starting line.
5. Begin timing. Draw and label a line on the paper (at the head of the mealworm) after 10 seconds. DO NOT STOP TIMING – KEEP GOING!
6. Draw and label another line on the paper (at the head of the mealworm) at the end of 20 seconds. DO NOT STOP TIMING – KEEP GOING!
7. Continue to draw lines after each 10 second interval until you reach 2 minutes (or until your mealworm reaches the end of the lane).
8. Carefully put your mealworm back into the container.
9. Measure the distance between the starting point and the first line, and then every interval that follows. Record these distances (in cm) in the data chart.

Data:

DATA	
Time (s)	Distance (cm)
10	
20	
30	
40	
50	
60	
70	
80	
90	
100	
110	
120	

Create a line graph:

Calculate:

Calculate your mealworm's speed:

Blackline Master D