Lesson 3: Rolling Down the River

Boats have always been important to Alabama. For Native Americans, canoes and walking were about the only ways to get around. Boats opened up the Gulf of Mexico for fishing and travel. Even 3,000 years ago, Alabama’s indigenous people traveled hundreds of miles, all the way up along the Ohio River to trade resources like Alabama sea shells for Midwestern copper.

European explorers and pioneers used boats to open up Alabama to French, Spanish, English settlement. Throughout the years, ships were important in military battles fought in Alabama waters. There were races between sailboats on Mobile Bay and paddleboats on Alabama’s rivers.
What about modern times? Can you imagine where bass fishermen and shrimpers would be without boats? The harbor at Mobile sends and welcomes ships from all around the world. And even today, modern barges follow the same routes that Native Americans followed centuries ago – and for the same purpose of doing business.

When it comes to boats and shipping, no job is more important than that of the engineer. Engineers keep the barges and ships running. Engineers design and improve every boat, from the sleek bass boat to the massive ocean-going tanker. Engineers create and maintain the systems of harbors and barge canals that link Alabama to South America, Europe, and the rest of the good old U.S.A.

Lots of boats are sold in Alabama – for work and play. Every year, that means $300 million in new powerboat, boat motor, trailers and accessories. Alabama is 11th in the country for those purchases. There are 16 active boat builders and 63 other companies that make things like boat engines and accessories. About 1,100 people make their living by building boats and the things in them. Alabama also has more than one hundred marinas, clubs, and storage facilities.

Boats are big business in Alabama. Just like building cars, homes, and electronics, creating new and better boat designs is an exciting career opportunity – for you.
Age Level: 9 to 19

Objectives:
- Engage in scientific and engineering practices.
- Learn about engineering / nautical engineering (is an engineering discipline dealing with the design, construction, maintenance and operation of marine vessels and structures).
- Learn about teamwork and working in groups.

Learner Outcomes:
Learner outcomes are the knowledge, skills, and abilities that youth will attain through their experiences. 4-Hi Does Ag lessons will collectively provide young people the opportunity to apply science and engineering practices so they will be able to:
- Design a solution to a real-world problem.
- Design, build and revise simple models or prototypes to represent design solutions.
- Work together to plan and conduct investigations. Data collected from investigations will serve as evidence of meeting criteria or the need for revising designs for further testing. The number of trials is considered.
- Recognize that solutions to a problem are limited or constrained by the available materials and resources.
- Measure success of a design solution by considering desired features (criteria).
- Routinely identify cause-and-effect relationships; use the language of cause and effect to describe a system; test cause-and-effect relationships; and use relationships to describe a system or tool in terms of its components and interactions.
- Generate and compare multiple solutions to a problem based on how well they meet criteria and constraints of the design solution.
- Evaluate competing design solutions using a systematic process to determine how well they meet criteria and constraints of a problem.

*Please note: More information on Criteria & Constraints can be found on pg. 7 of the Lesson Overview.

In these lessons, youth will engage in and get better at many of the Science and Engineering Practices listed in the Next Generation Science Standards. These are listed below.

**Next Generation Science Standards: Scientific and Engineering Practices**
- Ask Questions and Define Problems
- Develop and Use Models
- Plan and Carry Out Investigations
- Analyze and Interpret Data
- Use Mathematics, Information and Computer Technology, Computational Thinking
- Construct Explanations and Design Solutions
- Engage in Argument Based on Evidence
- Obtain, Evaluate, and Communicate Information
NOTE TO FACILITATOR:
CONTINUOUSLY REINFORCE THE CONCEPTS OF THE 4-HI ENGINEERING DESIGN PROCESS (PICTURED BELOW) WHILE YOUTH ARE ENGAGED IN THE ACTIVITY.
Lesson 3 / Part 1: Common Experience

For the Educator:
This part of the lesson introduces youth to important concepts. These concepts need to be understood before they are given their problem and design challenge.

By the end of the activity, the goal is for youth to identify factors that influence whether an object sinks or floats. These might be weight, shape and whether an object contains empty space (which has a very low density). These are properties that are important in building boats.

If an object is solid, it will float if it is less dense than the liquid in which it is immersed. For hollow objects, shape also comes into play. Encourage youth to observe that some objects will sink or float every time (that there is consistency in the way the objects behave). This will help youth devise their own ideas about physical properties and how they can be used to describe and categorize objects.

Time: Whole Experience: 1 hour, 55 minutes
- Experience Broken down into sessions to better meet youth needs:
  - Common Experience: 45 minutes
  - Inquiry Experience: 1 hour, 10 minutes

Suggested Group Size: Teams of 2-3

Materials suggested (estimated at 20 youth):
**There should be enough items that each team has 5 items to test.

- Wood
- Metal
- Plastic
- Aluminum foil,
- Apples & oranges
- Bath toys
- Plastic bottles
- Ping pong balls
- Tennis balls
- Toy blocks
- Toy cars
- Paper
- Bathtub toys
- Plastic forks
- Rubber balls
- Soda-bottle caps
- Pencils & erasers
- Sponges
- Clay balls
- Balloon
- Beach ball
- Popsicle sticks
- Crayons
- Rolling Down the River Data Sheet (1 per team)
- Three to four water stations for testing whether items sink or float and paper towels.

Place all materials on a communal table. After teams have been given their task, teams can come and select what materials they would like to work with.
**Say:**

Think about it: a balloon full of air and a balloon full of water take up the same amount of space (or have the same volume). The balloon full of air weighs less because air has less density (Density has two parts: (1) how heavy the atoms/molecules themselves are, and (2) how closely they are packed together) – the balloon’s building blocks of atoms and molecules are not packed together as tightly as water’s building blocks.

Which would be heavier, a shoe box full of Gummi Bears or a shoebox full of rocks? Which takes up the most space? The lighter Gummi Bears take up the same space as the heavier rocks! That means that the rocks are denser (their molecules are heavier and they are more closely packed together) than the candy, although they have the same volume.

**Ask these questions and allow responses:**
- What does it mean to float? (Stay on top of the water.)
- What does it mean to sink? (Sink or drop to the bottom of a container of water.)
- Can people float? What other objects can you think of that can float?
- What objects can you think of that sink? Why do you think objects sink or float?
- What is something that can cause an object to sink or float? What is it? (The most common answer is weight.)
- What are light things that sink? (marbles)
- What are heavy things that float? (speedboat)
- Name some objects that have empty space inside. (pumpkin, basketball, ping-pong ball) All of these objects float because they have empty space containing air.
- Name some objects that no empty space inside. (marble, paperclip, bowling ball) All of these objects sink because they have no empty space.

**Instruct Youth:**

As a team, youth are to test five objects to see if they sink or float and record what you discover on your data sheet. For each object, try and identify why it sinks or floats.
- Break youth into teams:
- Distribute Data Sheets
- Review data sheet instructions
- Allow youth to test objects
- Whole Group Discussion on data sheet outcomes

**Whole Group Discussion:**
- Based upon your tests, what are some things that influence whether an object sinks or floats?
- How does weight influence floating or sinking?
- A big ship is made of metal, why would it float, but a metal fork won’t float?
- So, how does shape influence floating?
- Why would a marble sink, but an apple float? (Think about density: how solid or compact an object is – how tight its molecules are packed.)
Lesson 3 / Part 2: Inquiry

Time:
- Total Inquiry Experience: 1 hour, 10 minutes
  - Schedule:
    - Planning: 30 minutes
    - Construct & Test: 15 minutes
    - Revise & Test: 15 minutes
    - Evaluation: 10 minutes

Suggested Group Size: Teams of two or three

Materials suggested (estimated at 20 youth):
- Beans: 6 cups
- Measuring cups: 1 set to share
- Sponges: 3
- Foam board (pre-cut): 1 piece
- Fan (to make boats move): 1
- Popsicle sticks: 1 bag
- Straws: 1 box
- Paper assortment: 50 sheets
- Fabric scraps: whatever is available
- Styrofoam plates and cups: 15-20 each
- Wire: 1 roll
- Wire cutters: 1 to share
- Ping Pong Balls: 6
- Aluminum foil: 1 sheet
- Glue: 1 stick per team
- Tape: Several rolls
- Scissors: 1 per team
- Clay: 1 box
- Plastic bags: 1 box
- Rubber bands: 1 box
- Paper towels and/or towels: can be messy!
- Plastic tub and/or bins for multiple water stations
- Planning Sheet: 1 per youth
- Construct - Test - Improve - Test - Evaluate Worksheet: 1 per team
- Measure Your Success Worksheet: 1 per youth

Place all materials on a communal table. After teams have been given their Engineering Design Challenge, they can come and select what materials they would like to work with.

Teacher's Tip:
If you pre-measure beans into cups it saves time and you end up with fewer beans on the floor.
Alabama has thousands of miles of waterways. These rivers and streams are important for many reasons: to support wildlife, recreation, and to move river barges.

**4-Hinnovators, your team’s challenge is:**

The transportation of farm products such as corn and soybeans can be a challenge to Alabama farmers. It must be quickly and efficiently moved to factories for processing or to coastal ports for overseas exporting. Barge transportation can be the most efficient, economical, and environmentally friendly way to transport goods. You can watch barges travel the Tombigbee River in Alabama. Your challenge is to design and build a boat that can transport \( \frac{3}{4} \) cup of beans across a water source and keeps those beans dry. Will you help?
Instruct Youth:

- Explain that youth must work as a team to design a boat prototype that transport ¼ cup of beans without sinking.
- Distribute Planning Worksheet.
- Restate the problem.
- Identify criteria (will not sink with ¼ cup of beans & stay dry).
- Identify constraints (must use available resources).
- Brainstorm possible solutions.
- Individually, sketch out 2 or 3 possible boat designs with labels.
- As a team identify the pros and cons of each team member’s design.
- Choose the best design or best components from the design sketches to build the team’s prototype.
- Identify materials needed to build the prototype.

Distribute the **Construct•Test•Improve•Test•Evaluate Worksheet.**

- Teams construct their prototype from their plans.
- Teams may need to rethink their design, modify as they go along or start over.
- Teams may test their boat two times.
- Teams improve prototypes.
- Teams perform their final test.
- Teams will present and discuss their experience as a group.

Whole Group Discussion:

- Why did your boat float? Or Why did your boat not float?
- What did you do to keep your beans dry?
- Among all the teams, what worked best and why?
- How did you change your design as you were working on it?
- If you had to do it all over again, how would your design change?
- How do you think working as a group helped you to complete this project?
- What parts of the engineering design process did you use?
- Do you think engineers have fun taking on challenges like this?

Success should be evaluated in a variety of ways, not just whether the youth met the goal.

Distribute the **Measure Your Success Worksheet.**

The focus of this measurement tool is on youth determining for themselves what they have learned.