**Buoyant Boats**

**WHAT YOU NEED**

* [Buoyant Boats](http://sciencenetlinks.com/student-teacher-sheets/buoyant-boats/)
**STUDENT ACTIVITY SHEET**

**MATERIALS**

* Several objects that float, and several that sink (e.g., blocks of wood, pieces of plastic, coins, washers)
* Beakers (or other containers) of water
* Materials to build a Cartesian Diver (empty soda bottle, dropper/pipette)
* Clay
* Aluminum foil
* Craft (popsicle) sticks
* Toothpicks
* Straws
* Tape
* Glue
* Small masses (e.g., coins, washers, nails, beans)
* Scales/balances
* Several sinks or containers for water
* Rulers

**PURPOSE**

To design and construct a boat that takes into account factors such as buoyancy, the properties of materials, and design constraints.

**CONTEXT**

In this lesson, students will design and construct a boat out of aluminum foil and a few other simple materials. The boats will then be tested by floating them in a pool or sink of water, and then adding mass until they sink. While students may not be able to articulate it, they will intuitively begin to understand the scientific laws required for the design of the boat, i.e. buoyancy and Archimedes Principle. They will also explore the shapes of boats and construction techniques that may work for the boats.

"Research suggests that some high-school students believe that scientists and engineers are more capable of making decisions about public issues related to science and technology than the general public." (*Benchmarks for Science Literacy*, [p. 335](http://www.project2061.org/tools/benchol/ch15/findings.htm#Ch3).) Experience with designing solutions will help students to feel more comfortable making decisions related to technology. This lesson builds on the idea that "there is no perfect design. Designs that are best in one respect may be inferior in other ways." (*Benchmarks for Science Literacy*, [p. 55](http://www.project2061.org/tools/benchol/ch3/ch3.htm#IssuesInTechnology_3_5).)

The introductory essay for the 3-5 Structure of Matter benchmark states, "Objects and materials can be described by more sophisticated properties—conduction of heat and electricity, buoyancy, response to magnets, solubility, and transparency." The motivational activity for this lesson addresses that statement. Although not the major focus of the lesson, students should have a basic understanding of the concept of buoyancy as a prerequisite for completing this lesson. For that reason, this lesson should follow some instruction on buoyancy. Additional activities may also be helpful to reinforce the concept after completing these activities. (See the Extensions for some suggestions.)

**MOTIVATION**

**Will it sink or float?**
To do this introduction, gather several objects that sink and several that float for each group of students. Recommended materials include blocks of wood, pieces of plastic, coins, and washers.

Break the class into small groups and distribute the objects and a beaker of water. Have each group predict which of the objects will float and which will sink. Then have them place each object in water to test their predictions. The students should then describe the properties of the objects that sink and the properties of the objects that float. Lead students to describe the buoyancy of each object.

Next, show students a "Cartesian Diver." To build one, you simply need an empty soda bottle (remove the label) and a dropper or pipette. Fill the soda bottle to the top with water. Draw water into the dropper until it is about half full and place it in the soda bottle. The dropper should float. (If it sinks, you need to remove some of the water from the dropper.) Put the cap on the bottle. When you squeeze the bottle, the dropper should sink. (If it does not sink, you need to add a little more water to the inside of the dropper.) The dropper sinks when the bottle is squeezed because the pressure exerted on the bottle is transferred through the water and compresses the bulb of the dropper. This draws more water inside the dropper and increases its mass (and therefore its density). When the pressure is released, the water is forced out of the dropper and it floats again.

Have students try to figure out why the Cartesion Diver floats and sinks. Be sure to lead the explanation to the change in buoyant force on the dropper. The dropper displaces a fixed amount of water; therefore, the buoyant force is fixed. When water is added to the dropper, it weighs more than the buoyant force and sinks. When water is removed, it weighs less then the buoyant force and floats.

**DEVELOPMENT**

Begin by explaining to the students that they will compete in a boat-building competition. The goal is to build an aluminum foil boat that will support the most weight. But, in order to build the boats, they must use and understand the scientific law of buoyancy.

Buoyant force is the upward force that keeps things afloat. The buoyant force is equal to the weight of the water the boat displaces. To review buoyancy, have the students explore [Buoyancy Basics](http://www.pbs.org/wgbh/nova/lasalle/buoybasics.html), on the NOVA Online website. Discuss the diagrams and make sure students understand that the weight of water displaced equals the weight of the wood.

Once students understand the scientific principle of buoyancy, they must consider some engineering principles that will be taken into account when designing their boats. For upper-elementary students, these will be simple principles like overall dimensions and shape. You could have students experiment with a piece of clay, molding it to determine shapes that will float the longest. Students should start to formulate their own ideas of density, although specific terminology is too sophisticated for this grade level. For example, students should realize that the clay (and heavy things, in general) will sink unless shaped a certain way (e.g., like a boat). They should also begin to understand that the reason for this is the 'empty space' in the shape.

The final considerations are the properties of the materials and the design techniques that might be used. Give each team of boat builders a small piece of aluminum foil (a 10-inch square will be enough), two toothpicks, a craft stick, a straw, some glue, and some tape. Give students ample time to experiment with those materials and have them answer these questions:

* What happens to the aluminum foil if it is repeatedly folded?
* Will the glue and/or tape stick to the foil?
* How can the toothpick and craft sticks be used to support the foil in the water?

Now, distribute the student page [Buoyant Boats](http://sciencenetlinks.com/student-teacher-sheets/buoyant-boats/) and the materials listed on that page. Make sure the students understand that they only get one piece of aluminum foil to build the boat. If it tears or gets a hole, they must find a way to repair it. The rationale for getting only one piece of foil is to reinforce the idea that there are limitations to the materials they are using, and that not all attempts will be successful given the constraints for those materials. It will take the students one to two 45-minute periods to build the boats. Once they are constructed, they are ready to be sunk.

For the competition, each boat should be floated in a pool or sink. (If you do this in a pool, you will need some volunteers to retrieve the sunken boats from the bottom. Be sure that your volunteers move gently in the pool. Waves will wreak havoc on other boats.) Each team should slowly and carefully add masses to their boats until they sink. The last mass added, the one that finally puts the boat under, should be removed, and the rest of the mass totaled. The boat that held the most mass is the winner.

**ASSESSMENT**

Evaluation of the project should be based on the design of the boat. How well did students' designs reflect what they learned about the scientific law (buoyancy), engineering principles, properties of materials, and construction techniques? The analysis questions on the student page can also be used as part of the overall evaluation.

**EXTENSIONS**

You can extend the ideas in this lesson by using the Science NetLinks lesson,[Engineering Solutions](http://sciencenetlinks.com/lessons/engineering-solutions/), which has students explore the side effects of technology, and design, implement, and evaluate solutions related to the problem of waste disposal.

[How Life Jackets Work: Buoyancy](http://adventure.howstuffworks.com/outdoor-activities/water-sports/life-jacket1.htm) provides more information about buoyancy in the context of using life jackets.

Source: http://sciencenetlinks.com/lessons/buoyant-boats/