Big River Journey Classroom Activity: Boats

Build an Aluminum Foil Boat

Objective

Design a boat that will float and hold many pennies; evaluate the design.

Science Concept: buoyancy

A fluid exerts an upward force on objects less dense than itself. An object floats if water's density is greater than the object. By enclosing air, which is much lighter than water, even steel boats can float. Without buoyancy, river and sea transportation, exploration and commerce would not have been possible.

Materials:

- sheets of aluminum foil, approximately 12" x 6" (keep the size uniform) tubs of water
- pennies, up to 100 per tub bowls for pennies
- tsp bleach per tub paper or cloth towels
- buckets for used foil and hand towels.

Prep

Fill tubs with 3"- 4" of water. Add 1 tsp of bleach to each tub. Cut foil into uniform sizes sheets. Put pennies in bowls. Provide towels to mop up spills.

Directions to students

1. Shape a piece of aluminum foil into a boat shape.
2. Float the foil on water.
3. Add pennies until the boat sinks.
4. Count the number of pennies the boat held.
5. With a new sheet of foil, redesign the boat hull and repeat test.
6. Record the number of pennies held and student's name on the board.

Questions for students:

1. What can you say about your hull design?
2. What is the equivalent "boat" to your design? Canoe, barge
3. How does the placement of pennies affect the number the boat holds?
4. What kinds of boats are used on the Mississippi River to haul cargo? Why? What advantages do barges have over deep hull boats?

Note to teacher

Give students the opportunity to be as creative as possible with the hull shape. Make no suggestions, unless to show how to fold up one side to make an edge. The best designs are flat barges with small sides. The placement of pennies also makes a difference in the number held. The record for one sheet of 8" x 12" foil is around 280 pennies. Recycle the foil along with your pop cans.

Science Museum of Minnesota, 2001

Science Museum of Minnesota

How Does a Steel Boat Float?

By Captain Jim Kosmo

Vice President, Padelford Packet Boat Co., Inc.

We all know that many objects actually will float on water, but a piece of steel will quickly sink to the bottom; so, why does a 250 ton steel riverboat such as the Harriet Bishop float? Well, actually it is the same reason that wood, styrofoam or other items float – AIR.

Most any material can be made to float if you can enclose enough air in a watertight space. Wood and other materials that float naturally will be seen to have many tiny watertight pockets of air inside them when viewed under a microscope.

To make a piece of steel (or aluminum foil) float you first must form it into a watertight shape that encloses air. The larger the watertight space the better your steel vessel will float.

Once you have mastered this step you are well on your way to building a boat. At this point you will begin to realize that a good riverboat captain better have a good background in mathematics.

Mathematics is critical in determining the safety of the vessel and how much weight it can handle. Math also is required for plotting your course, but that is another lesson.

Before leaving the dock, a good captain must determine the "displacement" of the vessel. Displacement means how much water does the vessel push out of place, or displace. The weight of the water displaced will equal the weight of the boat. So you can find out how much your vessel weighs if you determine how much water it displaces when it settles into the water – i.e., measure how much of the vessel is under water. For example, if your vessel is 30 feet wide, 80 feet long and 4 feet deep in the water, the area of displacement is 30'x 80'x 4' = 9,600 cubic feet. One cubic foot of water weighs 62.4 lbs, thus your vessel weighs 9,600 x 62.4 = 599,040 lbs or 299.5 tons.

Using this method you also can determine how many one cent coins can be loaded into your aluminum foil vessel under ideal conditions. Obviously, you will want to convert the figures to inches and ounces. If you have some truly enthusiastic students who want to do the calculations for extra credit you could give them the weight of water for a cubic foot (62.4 lbs.) and see if they can figure out how to get the weight of a cubic inch. If they need some help, tell them there are 998.4 ounces (62.4 lbs. x 16 oz.) in a cubic foot of water and 1,728 cubic inches (12 x 12 x 12). Thus, a cubic inch of water weighs .578 oz. (998.4 oz. / 1,728 cu. in. = .578).

The other figure you need is the weight of a Lincoln cent coin -- .11 ounces.

If the students still need assistance tell them to measure the watertight area that is created inside the aluminum foil vessel they have created. For example, if you have a 6" x 12" piece of foil and fold it in a square shape with 1" high sides you end up with a vessel that is approximately 4" wide x 10" long x 1" deep. In a perfect world the foil vessel would stay afloat until the weight of the vessel and its load equals the weight of the water that is displaced: 4" x 10" x 1" = 40 cubic inches x .578 oz. (the weight of one cubic inch of water) = 23.12 oz. If you divide this displacement weight of 23.12 oz. by the weight of a penny (.11 oz.) you discover that under absolutely perfect conditions the maximum number of pennies you could load before your vessel sinks is 210. In actual practice it would be virtually impossible to do this because you most likely would not be able to distribute the load perfectly. Real vessels are required to have a substantial margin for error.

Padelford Packet Boat Co., 2000