# Boat Building Challenge

*Who were the first boat-builders?*

*No one really knows.*

*The oldest known boats are dugout canoes constructed in China and South Korea around 6,000 B.C. But it's possible that the almost-human species* Homo erectus *used some type of boat* ***800,000 years ago!***

*Since* H. erectus *are known to have made tools from bamboo, they may also have made rafts from the same material. But regardless of the materials and who used them, the basic principles that allowed the first boats to float are the same principles that operate on the*

Egyptian tomb painting from 1450 B.C. showing officer with sounding pole. Officer is telling crew to come ahead slow. Engineers with cat-o'-nine-tails assure proper response from the "engines." Courtesy NOAA.

## What You Will Do

**Design a boat hull that is able to float a specified weight. Then, design a way to propel your vessel using wind power**

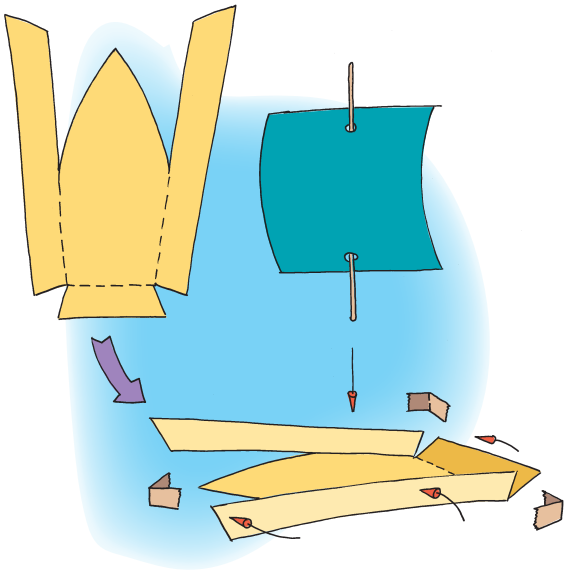
## What You Will Need

- ❒ Sheets of aluminum foil, 12 inches x 12 inches; one sheet for each hull
- ❒ 50 pennies for each hull
- ❒ Plastic or metal tub full of water, at least 24 inches diameter
- ❒ Foam plates
- ❒ Wooden skewers
- ❒ Poster board
- ❒ Hole punch
- ❒ Battery operated fan
- ❒ Masking tape
- ❒ Modeling clay

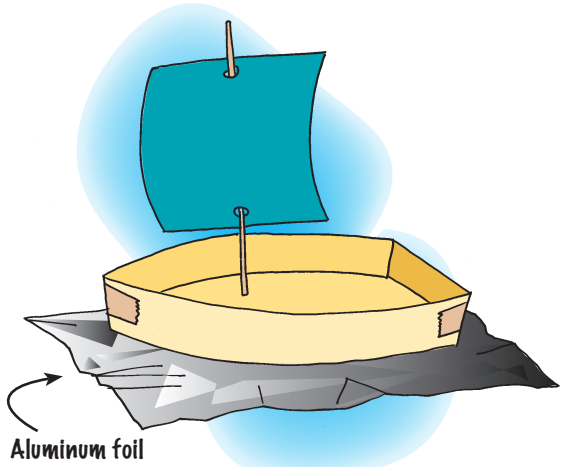
## How to Do It

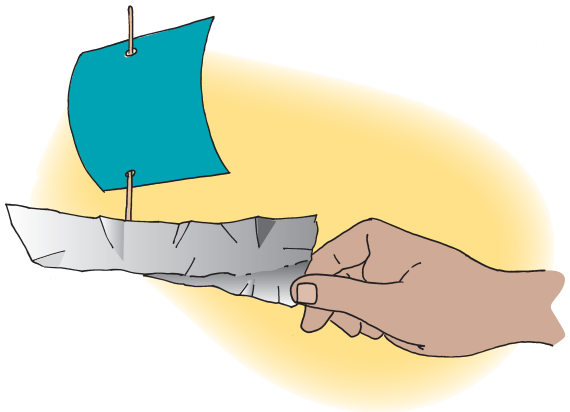
1. Fold a sheet of aluminum foil into a shape that will float in the tub of water and support the weight of ten pennies. Not sure how to do this? Read "What's Happening" for some clues.

2. Use another sheet of aluminum foil, pieces of foam plate, wooden skewers, and poster board to make a boat that will use sail power to carry ten pennies across the tub of water. The drawing below shows one way to cut and fold a piece of poster board to make a three-dimensional boat.



- Use masking tape at the corners of the bow (front of the boat) and stern (rear of the boat).
- Cut a sail out of poster board, and use the punch to make holes for the mast (wooden skewer).
- Use masking tape and/or modeling clay to help hold the mast onto the hull.
- To waterproof your boat, place it on top of a piece of aluminum foil, then fold the foil up and over the sides of the boat as shown below.



- Make a keel by pinching the aluminum foil to form a ridge that runs from front to back along the middle of the bottom of the boat. (See illustration below left.)

3. Now let's go for a sail! Place ten pennies in the boat, float the boat in a container of water, and use the fan as a source of wind to sail your vessel around the container.

Note: The pennies perform an essential function for sailing vessels: they provide weight in the hull, called "ballast," that keeps the boat from turning over when the wind presses against the sails.

## Want to Do More?

Have a contest to see who can build a hull that will carry the most "cargo" (the greatest number of pennies), starting with the same materials. You can modify the contest to see whose can build the fastest sailing boat. You may want to experiment to find out whether it is better to use one large sail or several small sails to increase sailing speed, and whether triangular shaped sails or square sails give the best performance.

## What's Happening?

Water tends to maintain a level surface. When you put an object into water, gravity pulls the object down and displaces some of the water,

which means some of the water is pushed aside. Now the surface of the water is no longer level. Gravity pulls the displaced water down, and causes an upward force on the object. This upward force is equal to the weight of the water that the object displaces, and is called buoyancy. Buoyancy depends upon the volume of liquid displaced as well as the density of the liquid. Density is the mass of a certain volume of liquid, usually stated as grams per milliliter. This is why it is easier to float in the ocean than in fresh water. Seawater is more dense than fresh water, so your buoyancy is greater in the ocean.

The amount of fluid that an object displaces depends upon the volume of the object: more volume means more fluid displaced, which means more buoyancy. Increasing the volume of an object also increases its surface area, which in turn increases the effect of friction as the object moves through the fluid. Boat designers have to consider buoyancy as well as friction when deciding on the shape of a boat's hull. A boat designed for speed must have enough displacement to stay afloat, but surface area has to be minimized to decrease the effects of friction. On the other hand, an object designed to carry a heavy weight, such as a cargo ship, must be designed with greater displacement, as well as greater power to overcome the effects of increased friction.

Boat hulls are designed to displace a volume of water that weighs more than the boat and its cargo. If the force of displaced water pushing on the hull is greater than the force of gravity pulling the boat down, then the boat floats! But if you could take a sea-worthy boat hull, break it down, and bundle the pieces together, the bundle will sink. Why? Because there is no longer sufficient water displacement to counteract the force of gravity on the pieces of the hull.

Visit *http://www.sedl.org/scimath/compass/v02n03/boat.html* and *http://www.thirteen.org/edonline/nttidb/lessons/jx/buoyjx.html* for more boat building challenge ideas.

Portrait of Archimedes, by Domenico Fetti, about 1620

## The Archimedes Principle

The idea of buoyancy was summed up by a Greek mathematician named Archimedes: any object, wholly or partly immersed in a fluid, is buoyed up by a force equal to the weight of the fluid displaced by the object. Today, this definition is called the Archimedes Principle.

Archimedes is considered one of the three greatest mathematicians of all time. The other two are Newton and Gauss. Archimedes was born in 287 B.C., in Syracuse, Greece. He was a master at mathematics and spent most of his time thinking about new problems to solve.

Many of these problems came from Hiero, the king of Syracuse. Archimedes came up with his famous principle while trying to solve this problem.

The king ordered a gold crown and gave the goldsmith the exact amount of metal to make it. When Hiero received it, the crown had the correct weight but the king suspected that some silver had been substituted for the gold. He did not know how to prove it, so he asked Archimedes for help.

One day while thinking this over, Archimedes went for a bath and water overflowed the tub. He recognized that there was a relationship between the amount of water that overflowed the tub and the amount of his body that was submerged. This observation gave him the means to solve the problem. He was so excited that he ran naked through the streets of Syracuse shouting "I have found it!". The goldsmith was brought to justice and Archimedes never took another bath…(just kidding!).