Foil Boats

5, 10, 15, 20, 25… How many pennies can your foil boat hold? Explore density and buoyancy with different aluminum foil shapes to complete this engineering design challenge!

TEKS:

SCI 3.5 A: The student is expected to measure, test, and record physical properties of matter, including temperature, mass, magnetism, and the ability to sink or float.
SCI 4.5 A: The student is expected to measure, compare, and contrast physical properties of matter, including mass, volume, states (solid, liquid, gas), temperature, magnetism, and the ability to sink or float.
SCI 5.5 A: The student is expected to classify matter based on measurable, testable, and observable physical properties, including mass, magnetism, physical state (solid, liquid, and gas), relative density (sinking and floating using water as a reference point), solubility in water, and the ability to conduct or insulate thermal energy or electric energy.

Materials:

- Aluminum foil
- Bin or bowl (filled with water)
- Paper
- Pencil
- Pennies (or other coins, washers, or similar objects)
- Ruler
- Scissors

How To:

1. Cut two 6x6-inch squares of aluminum foil.
2. Gently place one square of aluminum foil into the bin or bowl of water. Does it sink or float? Remember, when an object sits on top of water it's floating, and when an object goes below the water's surface it's sinking.
3. Next, take the second square of aluminum foil and squeeze it into a ball shape. Gently place this foil ball into the bin or bowl of water. Does it sink or float?

The two foil shapes that you dropped into the water were made up of the exact same amount of aluminum foil, so why did one sink and one float? It has to do with something called density. Density is equal to an object's mass, or the amount of matter something contains, divided by an object's volume, or the amount of space an object takes up.

Density = Mass ÷ Volume

Objects with high density tend to sink, while objects with low density tend to float. Both sheets of aluminum foil had the same mass because they were each made up of a 6x6-inch square of foil. However, you changed the pieces of foil to have different volumes. The foil ball took up less space and had a lower volume than the sheet of foil. This means that the foil ball's density was higher than the foil sheet's density, which caused the foil ball to sink but the foil sheet to float.

The rest of this activity is an engineering design challenge! Use aluminum foil, your knowledge about density, and the steps outlined below to design, create, and test a foil boat that holds as many pennies as possible.

Engineering Design Process:

1. Define – What problem are you trying to solve? What are you trying to accomplish?
2. Brainstorm – Write down and share every idea that you have. There are no wrong answers and lots of possible solutions! Think about the materials you have and the different ways you can use them to solve the problem.
3. Prototype – Create and build your design.
4. Test – Experiment with and evaluate your prototype. Does your prototype solve the problem?
5. Redesign – Think of ways to improve your prototype. Redesign as needed.
6. Share – Share your solution!

Design considerations and tips:

- Boats come in all shapes and sizes! Think of small canoes and kayaks, or giant sailboats and ocean liners. Model a foil boat after your favorite type of ship and see how it holds up.
- Try and find the best spot to place pennies on the boat. Can you add the most pennies if you stack them all directly in the center of the boat? Or, does it work best to spread them out over the entire surface?
- Read the STEM Connection below. How can you modify your design to increase the amount of water your boat displaces while keeping its weight as light as possible?

STEM Explanation:

Why do pebbles sink but gigantic ships float? When an object is placed in water, it pushes some water out of the way—or displaces it—to make room for itself. Then, there are two forces acting on this object: the force of gravity pulling the object down, and the buoyant force of water pushing the object up. The downward force is equal to the weight, or mass x gravity, of the object, while the upward force is equal to the weight of the water that the object pushes out of its way. If the downward force is less than the upward force, the object will float!

This is why pebbles sink, but giant ships float. A pebble weighs more than the *tiny* amount of water that it displaces, so it sinks. In other words, a pebble is denser than water. However, a giant ship weighs less than the *huge* amount of water that it displaces, so it floats! A giant ship is less dense than water. This is also why your foil boat floats. You folded your foil into a shape that has a high volume which displaces a lot of water. This makes the weight of your boat's aluminum foil much less than the weight of the water it displaces. However, if you add too many pennies, the boat ends up weighing more than the displaced water, which causes it to sink. When marine engineers construct boats and other water vessels, they use the density equation (density equals mass divided by volume) to determine if the object will be denser than water (and sink) or less dense than water (and float).

Career Connection:

Marine engineers research, create, and construct new boats, ships, and marine transport parts. A marine engineer might create blueprints or drawings, design engines, test prototypes, or even supervise the construction of full-size ships.

Resources:

https://www.dkfindout.com/us/history/ancient-egypt/ancient-egyptian-boats/
https://www.discovere.org/sites/default/files/Foil%20Boats_082616.pdf
https://www.sciencebuddies.org/stem-activities/aluminum-foil-boats-float#instructions
https://www.ducksters.com/history/ancient_egypt/boats_and_transportation.php

