The STUDIO Name: _____

Foil Penny Boat Challenge

Materials:

- Aluminum foil
- Scrap paper
- Ruler
- Pennies
- Rag
- Water
- Dishpan
- Measuring cup
- Rice

---

1. As a group draw out some boat plans. Choose one plan to execute.
2. Fold your aluminum square into a boat shape.
3. carefully fill each hull with dry rice so that the rice is level with the top of the hull. Being careful not to damage the hull, transfer the dry rice into a measuring cup. What is the volume of each hull using the rice?
4. Fill the bucket, tub, sink, or dishpan with some water.
5. Take the boat hull and carefully float it in the container of water.
6. Gently add one penny at a time. To prevent the hull from tipping, carefully balance the load as you add pennies (left to right, front to back — or port to starboard, fore to aft, if you are feeling nautical).
7. Keep adding pennies until the hull finally sinks.
8. Carefully take out the sunken hull and place it and the pennies on a rag or paper towels. Dump any excess water back into the container.
9. Count how many pennies the hull could support before sinking (i.e., the penny that sank the hull does not count).
10. Convert the number of pennies each hull could support to grams. To do this, multiply the number of pennies by 2.5 grams (the weight of a single penny). How many grams could each hull support?
11. For each hull, divide the number of grams it could support by its volume in cubic centimeters. This roughly gives you the hull's density.

How many pennies did your group use (the penny that sank the boat doesn't count)?_____

What was the volume of your boat (from the measured rice)?_____ML or CM^3

What was the density of each hull right before sinking? How do you think this relates to the density of water?_____

What Happened?

When you first put one of the boat hulls on the water, it should have floated because its total density (or mass per unit of volume) was less than the density of water. As you added pennies to the hull, its density increased and the hull floated lower. Eventually, when enough pennies were added, the hull's density roughly equaled the density of water. This happens right before the penny is added that sinks the hull. The hull sinks because its density has finally become greater than the density of water. Consequently, the density of the hull right before sinking should roughly equal the density of water, which is 1 gram per cubic centimeter. Even though the larger hull supports more weight, the larger hull also has a larger volume, and both hulls should roughly have a density of 1 gram per cubic centimeter right before sinking. (Your densities may not have been exactly this, but may have ranged between 0.7 to 1.3 grams per cubic centimeter. Sources of error that you could try to get rid of to give you an answer closer to the actual density of water include more accurately calculating the volume of each hull, using something smaller than pennies, and including the hull's weight in your calculations.)

Digging Deeper

What determines whether an object floats or sinks? It is the density (mass per unit volume) of the object compared to the density of the liquid it is in. If the object is denser than the fluid, the object will sink. If the object is less dense than the fluid, the object will float.

With a steel-hulled ship, it is the shape of the ship's hull that matters. On an empty ship with a steel hull enclosing a volume of air, the ship's density is equal to the sum of the mass of the steel hull and the mass of the enclosed air, all divided by the hull's volume. The ship floats because its density is less than the density of water. But when cargo or other weight is added to the ship, its density now becomes the sum of the mass of the steel hull, enclosed air, *and* the cargo, all divided by the hull's volume. If too much weight is added, the density of the ship becomes greater than the density of water, and the ship sinks. Extra cargo would need to be thrown overboard in a hurry or it is time to abandon ship!

Video:
https://www.sciencebuddies.org/stem-activities/aluminum-foil-boats-float