STEM LAB:
Boats and Buoyancy

TEACHER

LEVEL: All Year Levels | TOPIC: STEM | TIME REQUIREMENT: 45 mins

BACKGROUND

Displacement describes the action of moving something from its place or position. By submerging an object in a container of water and measuring how much water is displaced, you can determine the volume of an object. If a 2 cm diameter marble is dropped into a graduated cylinder, the water level will rise (be displaced) by 4.2 mL. In this case, the volume of the marble is identified as 4.2 mL. When converted into centimetres, the marble's volume is 4.2 cm^3. Buoyancy is an upward force that allows an object immersed in liquid to rise or maintain itself at the surface level. A Greek mathematician, Archimedes is responsible for discovering that the buoyant force on an object is equal to the weight of the liquid the object displaces. An object will float when the weight of the displaced liquid is greater than the weight of the object. An object will sink if the weight of the displaced liquid is less than the weight of the object. These rules apply to boats, and thus for a boat to float, it must be designed to weigh less than the water it displaces.

In this investigation, students compare the buoyancy of a flat piece of aluminium with a square aluminium boat. To increase the weight, they incrementally place 20 cent coins on the centre of the boat. Based on your conclusions from the first activity, they are then tasked with developing their own design challenge and designing a boat to meet it.

METHOD - STUDENT PRACTICAL

Assembling the Prototype

1. Fill the plastic container with water until 75% full. Place the aluminium foil square in the centre of the container so that it floats on top of the water.
2. Place a 20 cent coin in the centre on the foil.
3. Wait 5 seconds, before adding a second coin. Continue adding 20 cent coins until the foil sinks. Allow 5 seconds before adding each coin.
4. Record how many coins the foil was able to support before taking on water in Table 1. The coin that caused the foil to sink should not be counted.
5. Remove the foil and coins from the container and dry thoroughly with a paper towel. Drying the coins and foil is important, as the water covering them will add mass and skew results.
6. To create an aluminium boat, lightly fold the edges of the foil in by 1cm and crease the folds by running your fingers along them.
7. Pinch the corners of the foil together to secure them and create a small lip surrounding the square base.
8. Now that you have your square boat, gently place it in the water container.
9. Place a 20 cent coin in the centre of the boat.
10. Wait 5 seconds and then continue adding 20 cent coins in 5 second intervals until the boat takes on water or sinks. If a coin slips off, simply retrieve the coin, dry it and place in on the boat once again.
11. Record how many coins the foil was able to support before taking on water in Table 1. The coin that caused the foil to sink should not be counted.

MATERIALS

- 1 Plastic container
- 1 Piece of aluminium foil (10 cm × 10 cm)
- 1 Piece of aluminium foil (30 cm × 30 cm)
- Water
- 20 cent coins (10-20)
- Alternatively, you may use other objects with consistent weights; such as beans, metal washers, marbles or small bags of rice. Ensure you measure and record the weight of the masses prior to using them.
- Paper towels
- Scissors
- Any additional materials for students own design

SAFETY PRECAUTIONS

- Wipe up any water spills immediately.
- Take care when using sharp instruments and cutting tools.

Designing your own boat

1. Based on your experience assembling the boat prototype in the above activity, what conclusions can be made on which structures and materials are more effective? Consider how the assembly method can be changed, improved or used to test a hypothesis.
2. Develop a 1 sentence design challenge. For example, design a boat that can withstand the weight of 20 silver coins.
3. Develop a design plan for a boat that fulfils the needs of your design challenge.

    - Describe and draw the boat you will construct. Include annotations.
    - List of the required materials you will need.
    - Describe the building steps you will follow.
    - Describe the method you will use for testing the boat.
    - List the safety measures you will use to ensure no harm comes to yourself or others. List the safety equipment you will use to do this.
    - Design a data table of what you will measure as you conduct your tests.
    - Develop a criteria for success for determining if you met or exceeded your design challenge goals.

4. Based on your design plan, construct the boat.
5. Test your boat and record the results in the data table you created earlier.
6. If necessary, make changes to the design. Record these modifications and determine if these changes had the desired impact.

OBSERVATION AND RESULTS

Assembling the Prototype

	Aluminium Square	Aluminium Square Boat
Number of coins it was able to support.	1-3 20 cent coins (10-30g approx.)	4-6 20 cent coins (40-60g approx.)

Table 1: Assembling the Prototype Results

Designing your own boat

Student results will vary. Some student designs will meet or exceed their design challenge goals. Other designs will fail to meet design expectations. Regardless of the outcome, students should provide a detailed description of how their design performed against the design criteria and an analysis of why they believe their design yielded such results.

INVESTIGATIONS

- Ask students to describe the modifications they made to their boat design. Students should also identify what further modifications they would make to improve the design and describe what impact these changes would have.
- The density (ratio of mass to volume) of water is 100 grams ÷ 100 mL, or 1 g/mL. The density of vegetable oil is 0.91 g/mL. Challenge students to describe how the results would be different if they placed their completed boat model in the sam container filled with vegetable oil instead of water.