week 5

Whatever Floats Your Boat

Create a boat that can stay afloat for at least 1 minute while carrying the heaviest load.

Subjects and Skills

- Calculating the buoyancy and density of objects
- Relationship between buoyancy and density; displacement, weight, and density; Archimedes

Materials

- Clay
- Popsicle sticks
- One 2' x 2' sheet of foil per team
- Two corks per team
- One styrofoam plate per team
- Glue
- Golf balls, pennies, marbles, or other weight
- A sink or large container to hold water

Vocabulary

- Hull
- Density
- Buoyancy
- Archimedes
- Displacement

Purpose

This challenge will provide students with an understanding of:

- the relationship between buoyancy and density;
- the application of buoyancy in designing and engineering; and
- the basic concepts of displacement, weight, and density.

Objectives

Students will gain an understanding of:

- the relationships between buoyancy, density, displacement, and the weight of an object;
- Archimedes' principles of buoyancy;
- the development of hulls; and
- how math is applied to calculating the buoyancy and density of objects.

Activity Preparation

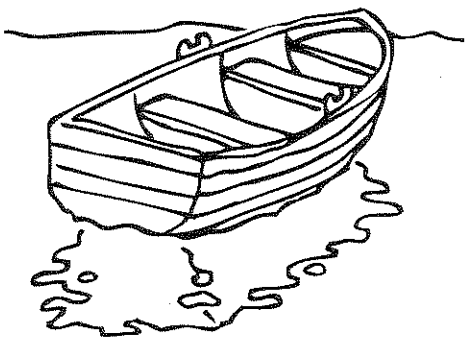
1. Run off activity sheets.
2. Gather materials and place them in two different areas of the room.
3. Bookmark websites to be used in class.
   a. http://www.gamequarium.org/cgi-bin/search/linfo.cgi?id=7898
   b. http://science.discovery.com/videos/what-the-ancients-knew-buoyancy-defined.html
   c. http://www.pbs.org/wgbh/nova/lasalle/buoybasics.html
   d. http://beityaacov2010.wikispaces.com/Archimedes

Activity Procedure

1. Ask questions to foster students' ideas about the buoyancy of objects (e.g., "Why do some objects sink while others float?" "How does a boat with an anchor inside it stay afloat, yet the anchor by itself would quickly sink?").
2. Write the word "displacement" on the board and ask about the definition and its possible relationship to the concept of buoyancy.
3. Watch Bill Nye's video (07:53) on buoyancy at Link a. and a video on displacement called *What the Ancients Knew: Buoyancy Defined* (01:06) at Link b.
4. Discuss the basic principles from the videos. Incorporate information from NOVA's Buoyancy Basics site at Link c.
5. Introduce Archimedes by visiting Archimedes of Syracuse: The Father of Buoyancy at Link d.
6. Distribute the activity sheets. As students work independently, prepare the materials by placing them in two different areas of the room, if you have not already done so. Divide students into teams to complete the team challenge, and assign each team a number.
7. Review the team challenge, and answer any questions students may have. After the competition is over, have students complete the activity sheets.
8. If you wish, assign one of the activities in Extend the Learning With Buoyancy: Activities.

Name: _____ Date: _____

Whatever Floats Your Boat



GOAL

- Make a boat that will stay afloat for at least 1 minute while carrying the most weight.

MATERIALS

- Clay
- Popsicle sticks
- One 2' x 2' sheet of foil per team
- One styrofoam plate per team
- Two corks per team
- Glue
- Golf balls, pennies, marbles, or other weight

TIME TO CREATE

- 20 minutes

INDIVIDUAL ACTIVITY

Read the information on hulls and buoyancy, and then answer the questions.

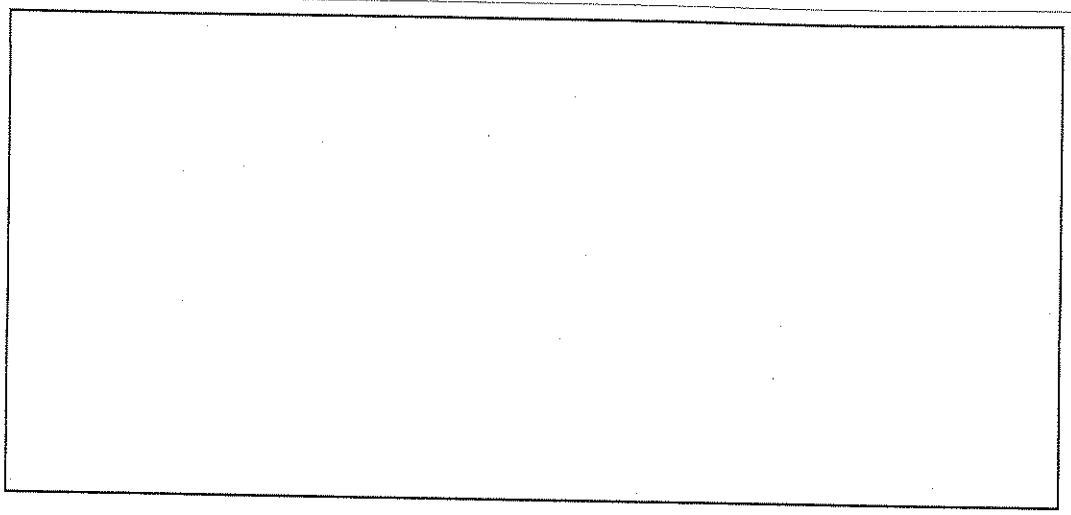
An object designed to float, such as a boat, is based on the scientific elements of buoyancy, displacement, and density. A man by the name of Archimedes was the first to articulate the aspects of buoyancy. His principle explains that an object's ability to float depends on the upward force, or displacement, of the water against the object. Think about this as a boat pushing down on the water as the water is pushing up. The water pushes up harder than the boat pushes down, so the boat is able to float. Archimedes' principle not only applies to buoyancy of ships and other vessels in water, but it also explains the rise of a balloon in the air and the apparent loss of weight of objects underwater.

The boat's hull—the body or frame of a boat—needs to be lighter than the amount of water that the boat is pushing away, or displacing. The very first hull is thought to have been created during the Stone Age, and was designed by hollowing out a tree trunk.

For an object to float, both weight and volume must be considered; the relative density, or weight per unit of volume, of the body compared to the fluid determines the buoyant force. The materials used to create a boat's hull must have a mass that, when divided by its volume, will provide a density of the boat equal to the amount of water displaced. When using steel, hulls are designed to trap air in order to lower the density ratio.

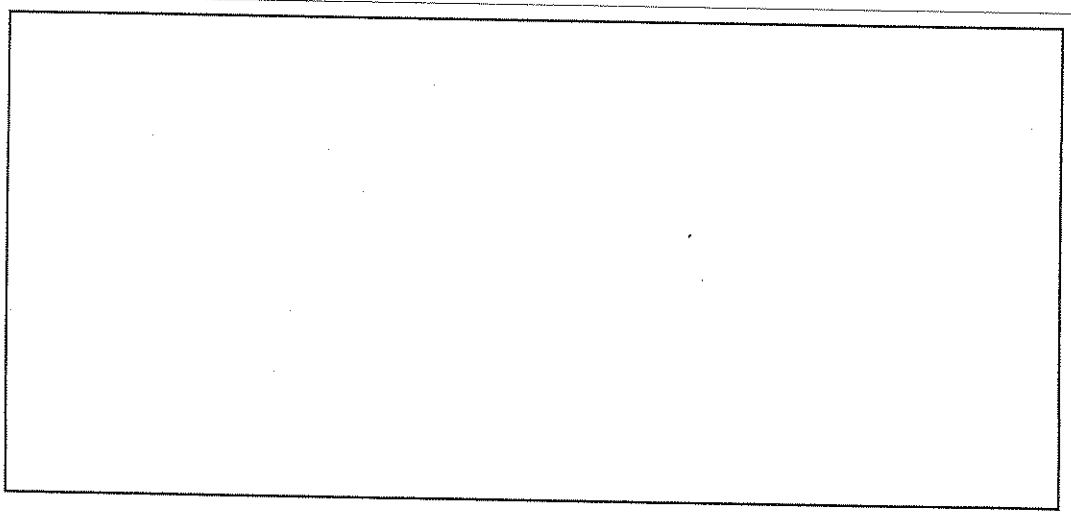
Hulls can be tapered, flat-bottomed, rounded, cathedral, or tunnel. Tapered hulls, like those seen in canoes, allow water to flow around the front, so that a boat can easily move through water. Draw a sketch of a tapered hull on the next page.

SKETCH OF TAPERED HULL



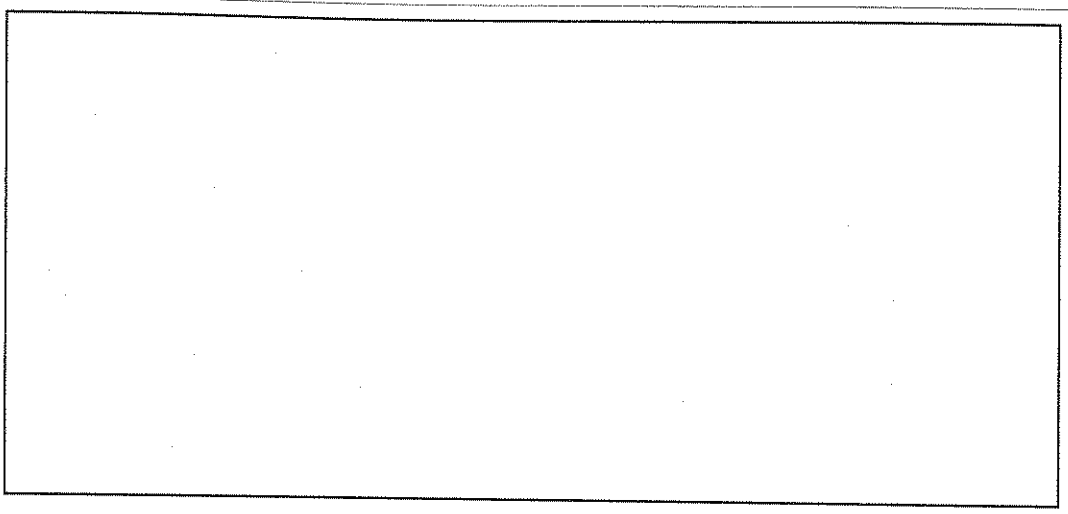
Flat-bottomed hulls, commonly used to transport loads, are good for moving around in shallow water. They require careful balancing of cargo and passengers to prevent capsizing. Draw a sketch of a flat-bottomed hull.

SKETCH OF FLAT-BOTTOMED HULL



Rounded hulls glide through the water. They typically have a keel—a V-shaped extension of the hull along the centerline on the bottom—to prevent the boat from rolling too much. Draw a sketch of a rounded hull on the next page.

SKETCH OF ROUNDED HULL



1. Define density. _____

_____

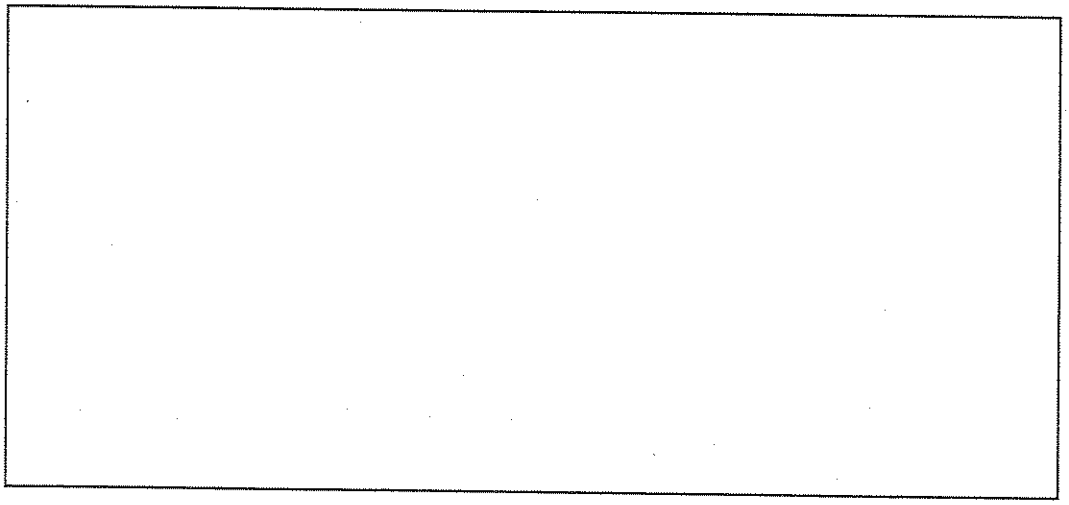
2. Define buoyancy. _____

_____

3. Define displacement. _____

_____

4. Draw the boat design you think will work best for today's challenge.



5. Why did you select that particular design? _____

_____

_____

6. What materials will be most helpful with the buoyancy of your boat?

_____

_____

Remember, if the boat's body is denser than the fluid it is in, it will sink. In calculating the buoyant force on a body, you must also consider the shape and position of the body. A steel rowboat placed on its front end into the water will sink, because the density of steel is much greater than that of water. However, in its normal position, the volume of the boat includes all of the air inside it, so its average density is then less than that of water, and it will float as a result.

TEAM CHALLENGE

Participants will work together in teams of two or three for a total of 20 minutes to design and build a boat using the materials provided that will float in a tub of water. The object is to build a boat that will hold as much weight as possible without sinking or spilling its contents. Your boat must stay afloat for at least 1 minute.

The teacher will select groups and assign group numbers. Once teams have been selected, the teacher will begin the time. You will have exactly 20 minutes to get your supplies and make your team's boat. If your team continues to work after the time is up, you may be disqualified.

Start Time _____:_____ + 20 Minutes = _____:_____ End Time

After the team challenge, answer the following questions.

1. How many golf balls was your boat able to hold? _____ How many marbles? _____ How many pennies? _____
2. What aspects of the various boat designs seemed to make them successful?

_____

_____

_____

3. What designs didn't seem to work well? _____

_____

_____

4. What is it about these designs that made them less successful? _____

5. How would you improve upon your boat design if you were able to rebuild for another challenge? _____

EXTEND THE LEARNING WITH BUOYANCY: ACTIVITIES

1. **Advanced applications.** Visit http://www.pbs.org/wgbh/nova/teachers/activities/3319_alicia.html to learn about negative, positive, and neutral buoyancy. Make a list of real-world applications for this information.
2. **Make your own submarine.** Follow the instructions below to make your own submarine. Once you've finished, write a paragraph explaining why this experiment works and what its real-world applications are.
   - Use a plastic bottle, a cap from a ballpoint pen, and modeling clay.
   - Make the submarine by putting clay on the end of pen cap (the part that points toward the nib).
   - Fill the bottle with water.
   - Put the submarine in the water.
   - Screw the bottle cap onto the bottle.
   - Squeeze the bottle and watch the submarine rise and fall.