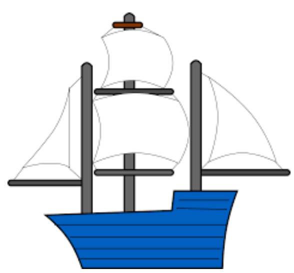
FLOAT YOUR BOAT

Have you ever watched a sailboat glide across the water or wondered how a large ship weighing many tons can stay afloat? It seems like something so heavy would sink as soon as it launched.

In **physics** (the study of matter, motion, energy, and force), an upward force called **buoyancy** explains how an object can float in a **fluid,** like a **liquid** or **gas**. The **buoyant force** equals the weight of the fluid that is displaced. In other words, when a boat sinks, it moves the water under it. The further the boat moves into the water the more upward force is applied by the water. The boat will sink until the weight of the water that is displaced equals the weight of the boat. The following video links explain this in a way that is fun and easy to understand!

Objects that are made of materials less **dense** than water always float. **Density** describes how much space an object or substance takes up (its **volume**) in relation to the amount of matter in that object or substance (its **mass**). Things made of heavier materials, like steel, are denser than water and will sink. So, why is it that large boats made of steel don't sink? The **hull** (the watertight body of a ship or boat) is hollow and contains a lot of air. The combination of the air and metal is less dense than the water, so a large boat can float even though it is heavy.



To stay upright, a boat also needs to have most of its weight toward the bottom, not the top. Sailboats have tall, heavy **masts** (poles that rises vertically from a ship and support the sails). How can they possibly stay balanced? The answer lies in a fin-like structure called the **keel**. **Keels** are found on all kinds of ships: cruise ships, cargo ships and sailboats. Keels have been around a long time. Historical evidence suggests that ancient civilizations, like the Chinese, Greeks and Vikings, understood the importance of adding a keel to their vessels.

The keel sits on the bottom of a boat in the center of the hull. The dual purpose of the keel is to keep the boat going straight without slowing it down, and to keep the boat from being blown sideways. It also adds heavy weight (called **ballast**) to help to keep the boat upright by lowering the center of mass.

Sailboat out of water with the keel visible underneath

Have you ever heard the phrases, **"even keel"** and **"keel over"**? To say that something or someone is on an "even keel" means they are progressing smoothly and steadily. To "keel over" means to collapse due to being tired or ill.

ACTIVITY: Explore sailboats, buoyancy, and how a keel works

Materials:

- container to fill with water (wading pool, bathtub, dish basin)
- three corks
- rubber bands
- waterproof material to make a sail (2 ½" square): wax paper, a piece of nylon fabric, or craft foam are good choices
- toothpick
- 3 - 5 nails or screws
- aluminum foil

Part 1:

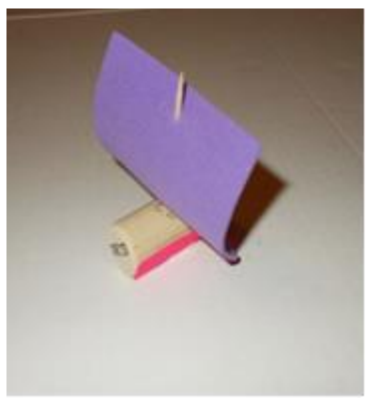
1. Fill your container with water.
2. Use two rubber bands to hold three corks together, side to side.
3. Place a toothpick in the middle cork so that it is **vertical** (straight up and down).

4. Cut a sail about 2.5" X 2.5" and poke the toothpick through the top and bottom ends of the sail near the edges.
5. Place it in the water and blow on the sail from behind.

How did it go?

<u>Part 2:</u>

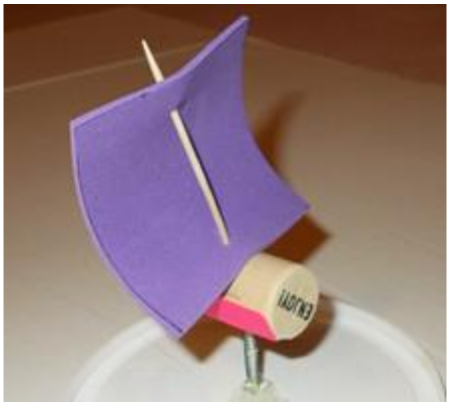
1. Remove the rubber bands and the two end corks.
2. Keep the sail in place, but rotate it 90º.
3. Place it back in the water.

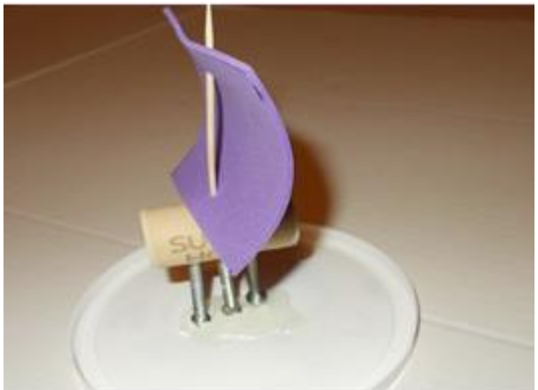


What happened?

<u>Part 3:</u>

1. Add a keel by sticking a nail into the bottom of the boat right below the sail.
2. Place it in the water again.
3. **If that doesn't help, add nails in line with the first one until the boat can float without tipping.**
4. Blow on the sail.





What did you observe?

Part 4:

1. Cut a piece of aluminum foil and wrap it around the nails in the shape of a rectangle. It should look like a fin.
2. Put your boat back in the water and add a breeze.

How did that change things?

Some thoughts about this activity:

⚓ The boat made with three corks was wide and stable. It likely floated well and sailed easily.

⚓ When you removed two of the corks, your boat probably tipped over.

⚓ When you added some weight to the bottom of the boat with the nails or screws, the boat became more stable as the center of mass was lowered.

⚓ Nails or screws alone do not form a fin-shape to push effectively against the water. You may have noticed that your boat did not sail straight.

⚓ Wrapping the nails in foil shaped like a fin provided resistance to the water so the boat was able to move forward.

⚓ The science of **physics** and **hydrodynamics** can explain buoyancy and how a keel works. **Physics** is the study of matter, motion, energy, and force. **Hydrodynamics** studies the forces acting on or exerted by fluids, especially liquids.

ADDITIONAL RESOURCES:

Books available from the Washoe County Library System

Dare the Wind by Tracey E. Fern and Emily Arnold McCully

Does It Sink or Float? by Susan Hughes

Forces and Motion by Kelly Milner Halls

How do Big Ships Float? by Isaac Asimov and Elizabeth Kaplan

Sail! Can You Command a Sea Voyage? by Julia Bruce

Sailing Days: Stories and Poems About Sailors and the Sea compiled by Amy McKay

Submarines by Joanne Mattern

Videos

MITK12 Videos, "How Do Ships Float?" https://youtu.be/pnIlE1xD-yM

Science Channel, "How Do Submarines Dive and Surface?" https://youtu.be/BTis6GioP2g

SciShow Kids, "Why Do Ships Float?" https://www.youtube.com/watch?v=CvWrkxzCiaY

Websites

International Maritime Organization, About Ships https://kids.imo.org/en/about-ships.php

University of Colorado, Boulder, Engineering, Teach Engineering, Lesson: What Floats Your Boat?
https://www.teachengineering.org/lessons/view/duk_float_mary_less