How Do Ships Float?

National Museum of the United States Navy

In this packet, we will be learning the physics behind why ships stay afloat! On the way we're going to do our own little experiments and activities to test the science that can be done in the classroom or in the home.

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*This packet is intended for elementary schools, to be used in groups of three or fewer and/or individually.

How have ships changed over the years in the United States Navy?

Mankind has been building boats throughout its history. The oldest recovered boat in the world is the Pesse canoe which is thought to have been built between 8200 BC and 7600 BC. Christopher Columbus discovered America commanding three boats called the Nina, the Pinta and the Santa Maria**.** Some of the first settlers in America sailed across the Atlantic on a boat called the Mayflower. These boats had a few things in common. They were built of sturdy wood and powered by sails and wind.

The first ships of the U.S. Navy had a lot in common with those ships too. Originally, the U.S. Navy bought old merchant ships and converted them into warships. In fact George Washington bought a fishing ship out of his own pocket and it became the USS *Hannah*, one of the founding ships of the U.S. Navy.

It soon became clear that the newly independent United States needed a custom made Navy to protect itself. So in 1794, Congress voted to build it's own ships, known as the six frigates. These ships were bigger than the ships of the European navies and could carry more guns. One of these ships, USS *Constitution*, is still in service today.

The USS *Constitution* is the oldest ship still in the U.S. Navy today.

These early ships were still powered by sails, but their hulls had metal plates added to originally protect against worms! These worms would eat the wood of the hull, but when they tried to eat copper, they were poisoned. This is why the USS *Constitution* had copper plating on the hull.

By the 1840s, the Navy adopted new technology such as steam power. Steam powered ships were much faster and more reliable as sail powered ships because they didn't need the wind. Ships could also be built bigger and heavier because steam was more powerful.

It was during the Civil War that both the Confederate and the Union Navies began to develop metal hulls. The Battle of Hampton Roads, between the CSS Virginia and the USS *Monitor* was the first time two metal hulled ships had fought each other. Many of the new inventions used on the USS monitor are still used on warships to this day.

Today, ships are bigger than ever before. One of the biggest type of ship the navy has is an aircraft carrier. These ships work like a floating airport, carrying planes and letting them take off at sea. The first U.S. Navy aircraft carrier was the USS *Langley*.

Aircraft carriers are now so big, traditional steam power that uses coal or gas as its fuel isn't strong enough to push them. The U.S. Navy now uses nuclear power in their biggest aircraft carriers. The USS *Enterprise* (CVN-65) had eight nuclear reactors on board and was almost as long as the empire state building is high.

Today the United States navy has over 450 ships ranging from the nuclear powered aircraft carriers to the sail powered, wooden hulled USS *Constitution* that is still part of the Navy to this day.

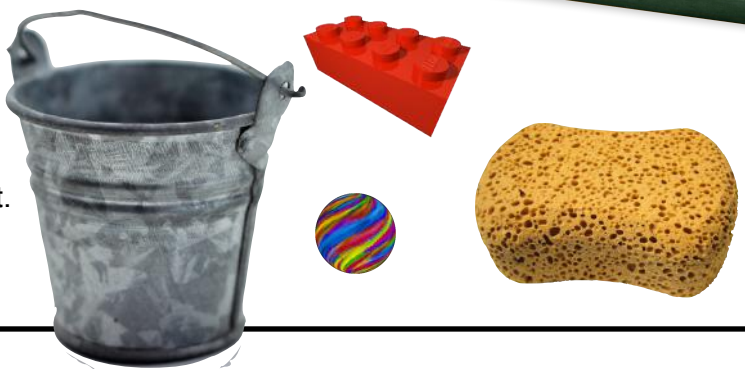
Why do some things float and some things sink?

Have you ever wondered why some things float and some things sink? A marble dropped in a puddle will sink whilst a giant ship on the ocean will float. This doesn't seem to make sense.

Really easy to do at home!

What you'll need:

Fill up a bucket with some cold water. Gather some things from your home and test if they float on the water and if they don't. Try and come up with an idea about why some objects floated and others didn't.

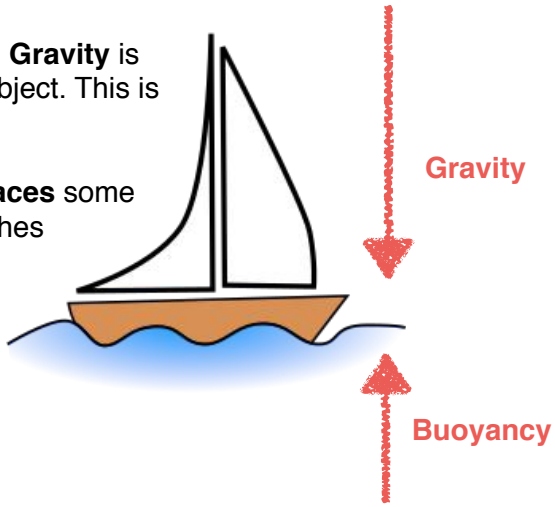


So why do some thing float and why do some things sink?

When an object is placed in the water two forces are affecting it. **Gravity** is pulling the object down but the water pushes back against the object. This is called **buoyancy.**

Buoyancy is created when we put something in water. It **displaces** some water, meaning the water has to go somewhere else, which pushes back against the object.

If gravity pushes an object down more than buoyancy can push it up, then it sinks. On the other hand, if buoyancy is stronger than gravity it floats.



Displacement in Action

What you'll need:

1 Bowl full of water
1 Plate
Coins of different sizes from smallest to biggest

What to do:

1. Get a bowl and fill it to the brim with water.
2. Place the bowl gently on the plate.
3. Get your coins and line them up in order from biggest to smallest.
4. Begin the test by dropping the smallest coins into the bowl from a low height, then carry on until you are dropping the biggest coins. What does the water do? Does it spill over the top of the bowl?

When the coins in the water cause the water to flow over the bowl, that is displacement in action.

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How can buoyancy be stronger than gravity?

A ball of clay will sink to the ground, but a ball of clay shaped to look like a boat will float. If they weigh the same and are made from the same things, it must be the shape that makes the difference.

Let's Test it Out

What you'll need:

1 bucket
1 adult to help you fill the bucket up with water
2 bits of clay around the same size

What to do:

1. Roll one bit of clay into a ball.
2. Make the other bit of clay into a boat.
3. Drop the ball of clay into the water. Note if it floats or sinks.
4. Now, put your clay boat into the water. See if it stays afloat.

The ball of clay sinks but the clay shaped into a boat should float.

So why does the shape make such a difference?

It has to do with something called **density.**

The more weight that is packed into a smaller space, the more dance that object is. A small ball of metal is heavier than a loaf of bread, so the ball of metal is more dense.

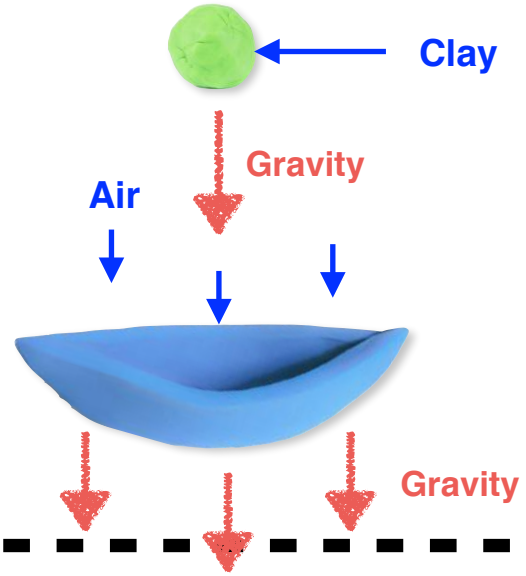
What does this have to do with floating?

Well just like the object has its own density, so does water. When we drop a ball of clay into a bucket of water, all of its weight presses down on one point. The water pushes back, but it doesn't have enough force to keep the dense ball afloat. The ball is more dense than the water so it sinks.

This changes when the ball of clay changes shape. When the clay is in a shape of the boat, the weight is spread out more so it is less dense. There is also room for air inside the boat.

So with both the shape of the boat and the air inside means that the clay does not press hard enough down on one place in the water to beat the force of buoyancy.

Because the buoyancy is greater than the force of gravity, the clay boat floats.



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How do we design ships to float?

Did you know?
USS Zumwalt weighs almost 16,000 tons.

Designing a ship, especially a big and heavy one, can be quite complicated. A ship designer needs to make sure that the ship is never more dense than the water to make sure it floats.

Let's look at a clay boat, for example. Clay moulded into a boat shape may float on the water. However, if we add more weight to that boat, the boat will become too heavy and sink. It will become more dense than the water. Ship designers have to be very careful about how they load their boats.

Let's Test it Out

What you'll need:

- **1 bucket**
- **1 adult to help you fill the bucket up with water**
- **2 bits of clay around the same size**

What to do:

1. Make one bit of clay into a boat shape.
2. Take the other bit of clay and make small clay balls.
3. Get your clay boat to float
4. Now, load the small balls onto the boat to see if it stays afloat to not

Challenge your friends to see who can make the clay boat that call hold the most clay balls!

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How do we prevent ships from sinking?

There are many things ship designers need to think about when building a ship. The big one is that they need to make the ship safe. This means that the ship has to stay afloat. One of the ways they do this is by making sure a ship is never more dense than the water. Another way is by making sure the ship is **watertight.**

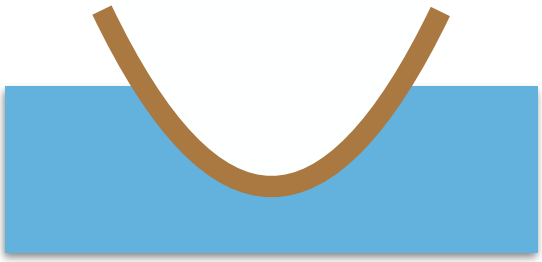
If water gets into a ship, it will make the ship more dense and it will sink. So ship designers need to make sure that doesn't happen by making sure the ship is as watertight as possible.

Over the years, ship builders have learned new tricks and techniques to keep watertight.

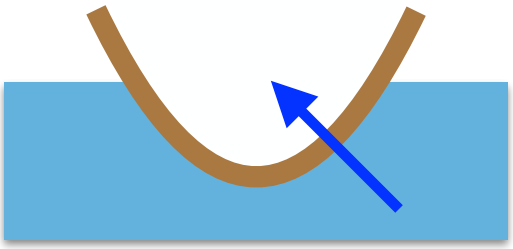
Did you know?

The Titanic sunk because more water got inside the ship, making it more dense than the water.

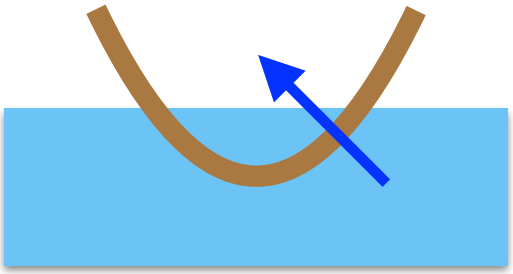
How a ship can sink:



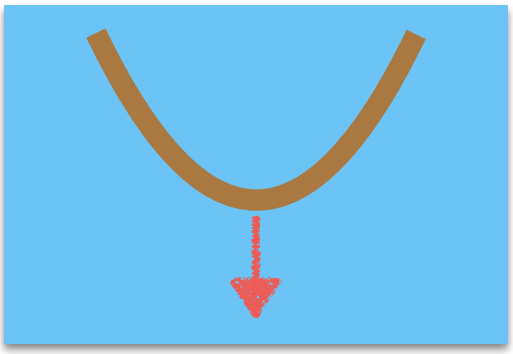
If a ship is watertight, water remains on the outside of the ship whilst air is on the inside. That means the water remains more dense than the ship.



However, sometimes water can get inside the ship. This means the ship is no longer watertight.



If water gets inside the ship, it fills it up. This means the boat gets more dense and more dense.



As more water gets in, it gets more dense and more dense. If the ship becomes more dense that the sea, it sinks.

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How do we make ships watertight?

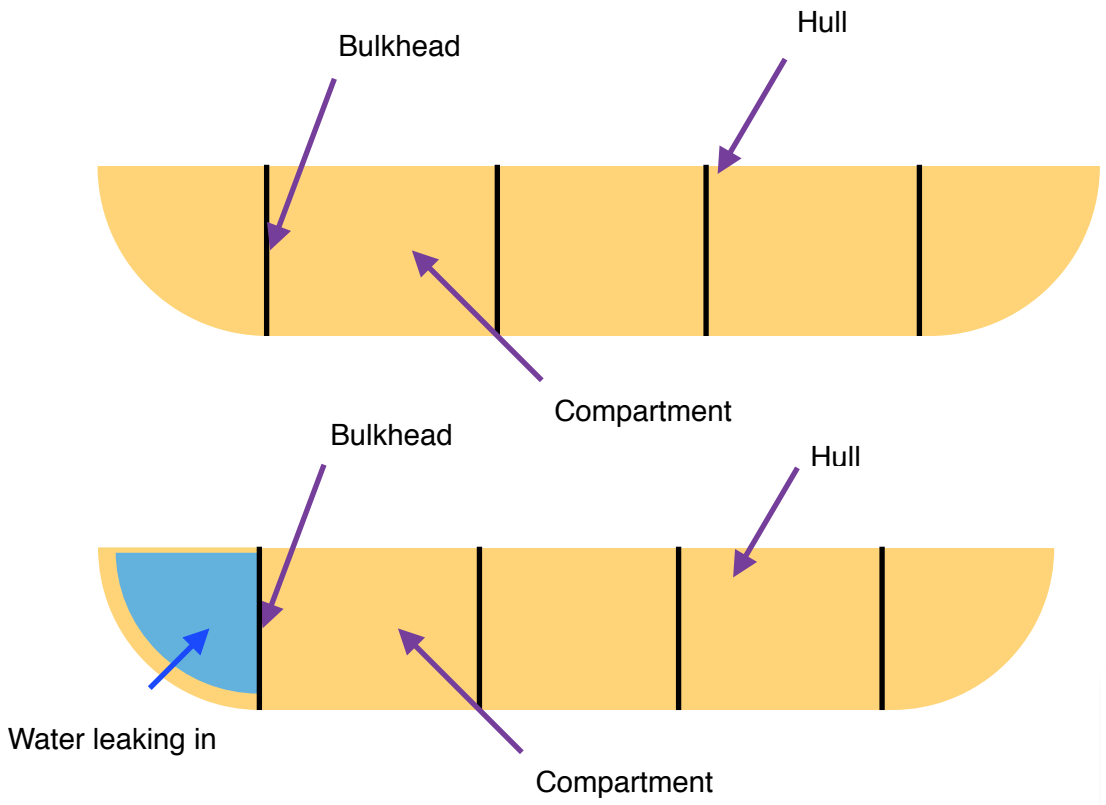
There are many different parts of a ship and they all are designed to help keep the ship afloat.

The main part of the ship that goes underwater is the **hull.** The hull is usually made of a very strong metal like steel so that it is difficult for something to make a hole in it and let water in.

Steel hulls do make a ship more heavy, but luckily the hull has a lot of air inside it which means that it is less dense than the water. The hull is also quite big, to the water pushes against it more which means that it is more buoyant.

Even though steel is quite tough, sometimes things still manage to make a hole in a ship's hull. That's why most big ships have something called **compartments.** These are sections of the ship's hull divides by special watertight walls called **bulkheads.** This means that if part of the hull does start leaking in water, the crew of a ship can close off that compartment to stop the water spreading. The rest of the hull will still have enough air in it to mean the ship is not more dense than the water and won't sink.

How do compartments and bulkheads work?



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Vocabulary

Gravity: The force that pulls everything towards the Earth and gives everything weight
Displace: To move from its place
Buoyancy: The upwards push of the water on an object
Density: How tight an object's weight is packed into a space.
Compartments: Closed off areas of a ship that are watertight to stop water from spreading.
Hull: The part of the ship that sits in the water that the rest of the ship can be built on.
Bulkheads: The strong walls that separate compartments in a ship.
Watertight: To stop water from getting inside the ship.

Fill in the following sentences with the vocabulary words you just learned.
Use context clues to help:

When we put an object in the water, it _____ the water. The force of this pushes back against the water and is called _____. _____ is the force that pushes the object down into the water. When the force pushing against the object in the water is greater than the force pushing it down, the object floats. An object will float if its _____ is less than the water, which means there is less weight packed into the space. Ship designers can make sure their boat floats by keeping it _____ so water cant get in and make it heavier. One of the ways they do this is by making the main body of the ship called the _____ out of strong metal. Ship builders can also separate the hull into different sections called _____. These sections are separated by _____, the strong walls that stop water from getting from one part of the ship to another.