Aerodynamics

In this packet, we will be learning the basic physics behind how air balloons, airships, and airplanes fly! We are then going to practice these principles in easy and fun activities that can be done in the classroom or at home.

Contact the Albacore Museum for Field Trip and School Visit Opportunities!

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

Special Thanks to National Museum of the United States Navy for writing content

History of Flight in the United States Navy

In 1910, Captain Washington Irving Chambers, who worked for the Navy's Bureau of Equipment attended an aviation meeting near Baltimore as an official observer. Appreciating the potential value of the airplane in naval warfare, Captain Chambers tried to interest the Wright Brothers, who had successfully flown the first flight in 1903. Wilbur Wright declined to make the attempt. Chambers then approached the Curtiss Company, and they agreed to try flying a plane for the Navy. The necessary arrangements were made by Captain Chambers and on November 14, 1910, the Curtiss representative, Eugene Ely, successfully flew a Curtiss land-plane from a platform rapidly built on the bow of the U. S. S. Birmingham at Hampton Roads, Virginia. The Curtiss Company agreed to instruct several naval officers for free, as no money had yet been permitted by Congress for the development of naval aviation. As a result of Captain Chambers's reports and recommendations on aviation, the first aviation appropriation of $25,000 was included in 1911-12. Two Curtiss planes and one Wright plane were purchased, and in the summer of 1911 the first naval aviation unit was organized and an aviation training camp was established at near Annapolis, Maryland.

By the beginning of the World War I, the US Navy rarely used airplanes. Most countries used hot air balloons and airships (zeppelins) in order to photograph enemy grounds and gain intelligence. Most of the actual planes owned by governments were not for warfare and didn't see the line of battle until the end of the War. Pilots started carrying bricks on board to drop on opposing planes, and some even started carrying guns with them. The French and Germans became well known for their Aces, or talented pilots, like Manfred von Richthofen (Red Baron). Pilots like Richthofen learned to do spins, half-rolls, and climbing turns, among other flying techniques.

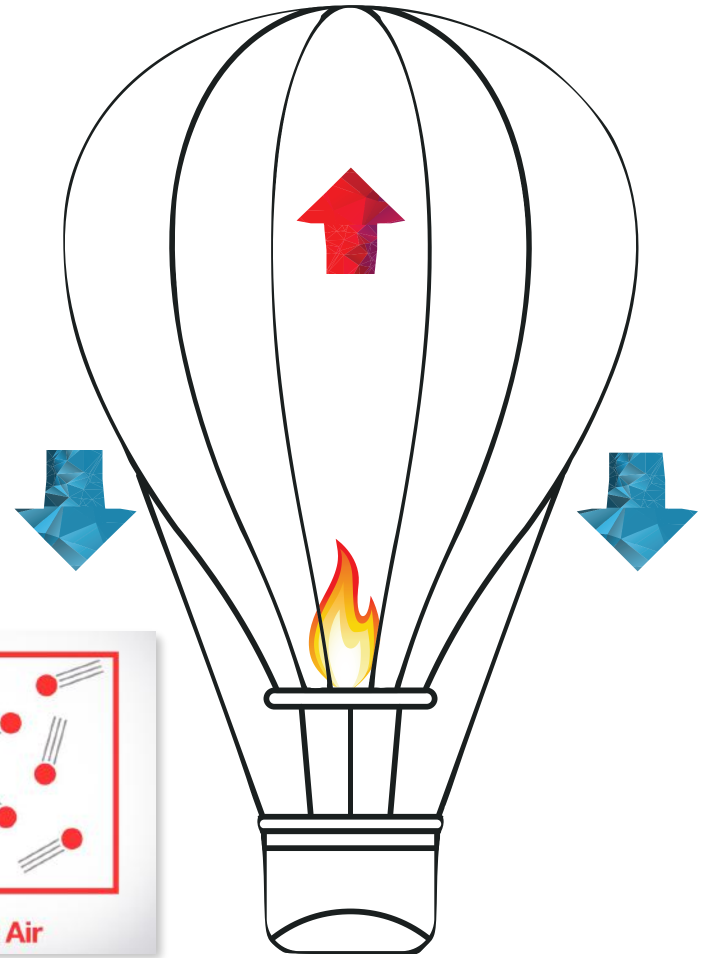
Naval Aviation and the nation's greatest test came with the onset of World War II. After the Japanese attack on Pearl Harbor, 7 December 1941, the United States was thrust into the global conflict and the Navy took the lead in the Pacific War. Naval Aviation was a key component of victory, whether in the great carrier battles with the Imperial Japanese Navy, supporting the island-hopping campaign, or combating U-boats in the Battle of the Atlantic. By 1945, the ranks of Naval Aviation personnel numbered over 430,000 men and women.

Today, the United States Navy operates over 3,700 airplanes which are used for anything from transportation to surveillance. Now, let's learn how these aircrafts fly!

Guiding Question:

How would the US Navy use airships and hot air balloons today?

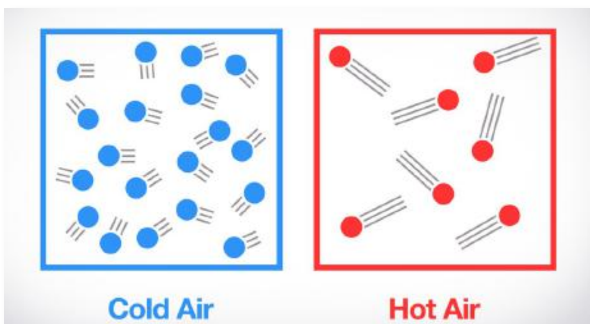
Hot Air Balloons



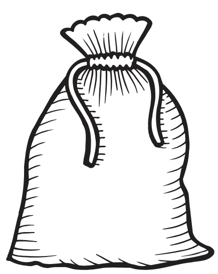
How do they work?

There are two types of aircrafts: lighter than air and heavier than air. A hot air balloon is a “lighter than air” aircraft, meaning, the balloon is **buoyant** in the air. The balloon itself is heavier than air, but with heat and helium, we can make these object fly.

When hot, the molecules in air speed up, making them move around faster. This makes for fewer molecules in the given space, thus making it lighter than the surrounding area. By heating the inside of the hot air balloon with a flame, molecules escape the balloon through the bottom. We heat up the molecules and make the inside lighter than the outside.

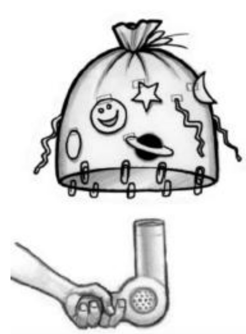


Let’s Test it Out!



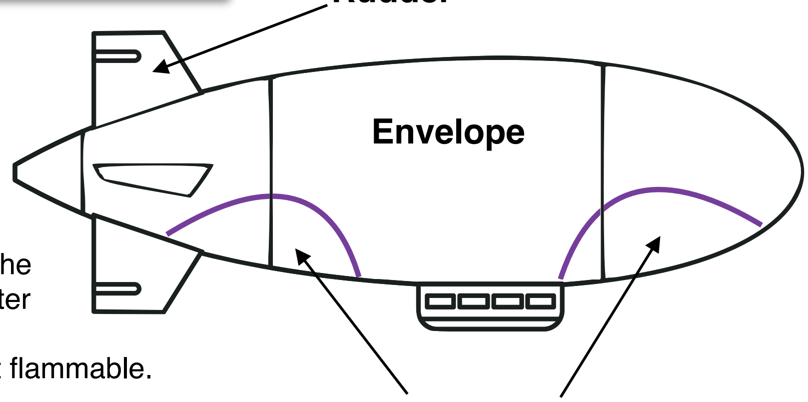
What you’ll need:
- 5 gallon or kitchen trash bag
- paperclips (for weight)
- Sticker or paper to decorate your balloon
- 1 hair dryer
- String

1. Find a partner or group to work with.
2. Tie the end of your trash bag with the opening in the bottom.
3. Decorate your bag as you wish, using light materials like stickers and paper.
4. Pierce the bottom of your bag (the open end) with paperclips for weight if you like.
5. With permission from a parent or adult, one person will hold the bag up while another blows hot air under the balloon.
6. Feel the tension from the balloon wanting to lift up into the air. Now, carefully let go and watch your balloon lift up!



Airships

How do they work?



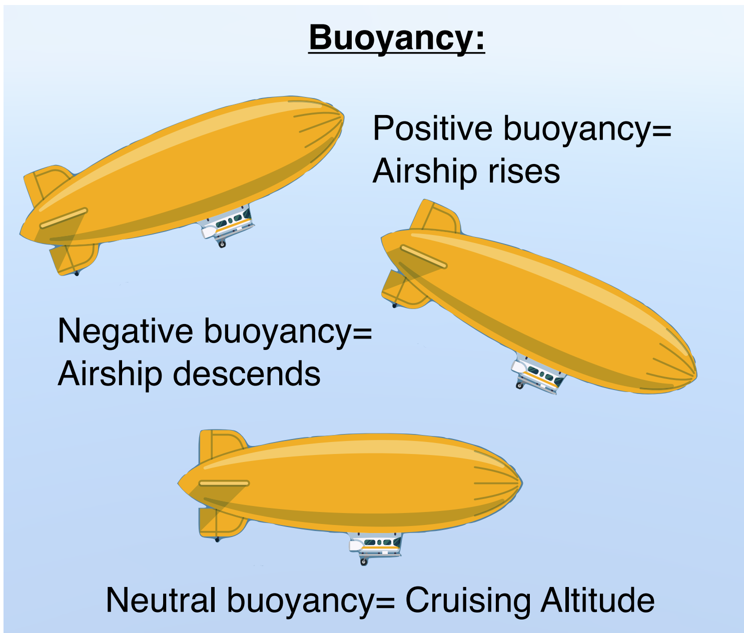
Just like the hot air balloon, airships are "lighter than air" aircrafts. Instead of using heat, airships mainly use lighter gases to lift them up in the air. Helium is used today, just like birthday balloons. In the past, we used hydrogen, which is also lighter than air. Hydrogen, however, is very flammable and can explode. Helium is not flammable.

Unlike hot air balloons, we can steer and control airships. How do we do that? **Rudders** on the back of the airship help with steering and the **ballonets** inside the airship control the altitude or buoyancy. Let's look into how we do that.

Where do you think people sit?

Ballonets are small pockets inside the main envelope of the airship. Air can be pumped in or out of them with ease, and we fill them with regular air we breathe everyday. This air is heavier than helium, which makes up the envelope. By adding more regular air, the airship becomes heavier and lowers its **altitude**. Sucking the regular, heavier air out of the ballonnets allows the envelope to fill with helium, making it lighter and able to increase altitude.

In the graphic to the right, draw the ballonets inside the envelope. Remember that a bigger ballonet is heavier. Look to the graphic above as a reference.



Hindenburg

Earlier, we read about how we used to use hydrogen in the envelope, but we use helium now. This all changed on May 6, 1937, when an airship called the *Hindenburg* exploded. A lot of people were hurt or even died. While helium is a little heavier than hydrogen, we do not want any more accidents.

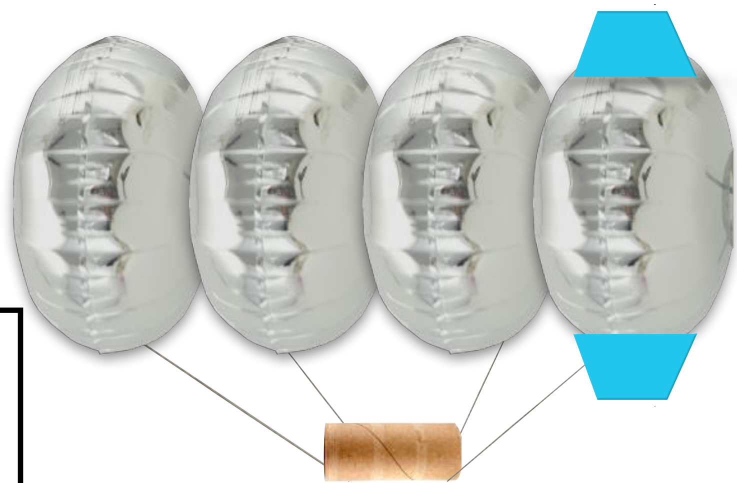
Guiding Question:

How could submarines use this technology?

Airships

Let's Test it Out!

You can make your own airship with helium-filled mylar balloons. You can use string and molding clay to tether your balloons to a surface to prevent your balloon from flying away.



What you'll need:

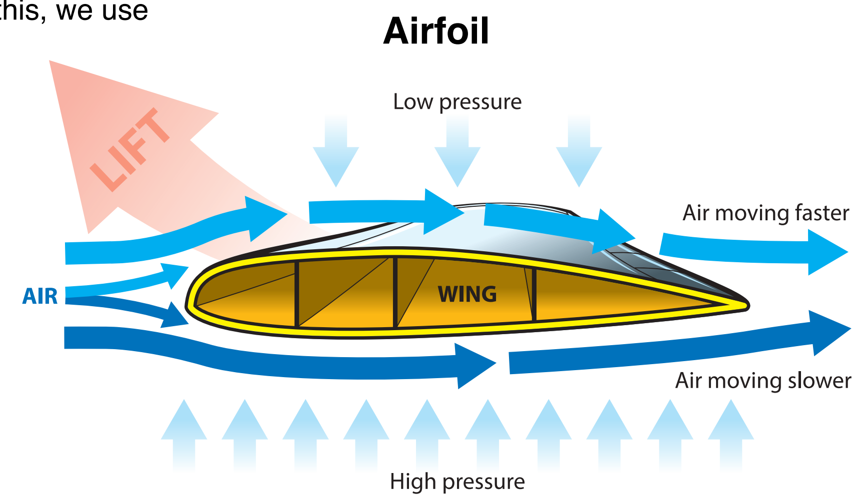
- 4 mylar-helium balloons
- 2 regular (non-helium) balloons
- 1 toilet paper roll
- string
- molding clay
- construction paper
- scissors
- classroom glue

1. Cut 4 tail fins (trapezoids) from the construction paper. See the blue fins in the image as an example.
2. Cut eight pieces of string into equal lengths. Weight each string with a piece of modeling clay to either side of the balloons to balance your airship.
3. Make your airship by gluing the mylar balloons together. Tether them down with string and modeling clay to help.
4. Glue the tail fins (rudders) to the airship, as seen in the example, There should be 4 total, at 12:00, 3:00, 6:00, and 9:00.
5. Untether your balloons from the surface, and watch your airship rise! It is smart to keep a string attached to it like a kite, so you don't lose it!
6. To test out the weight of air against helium, attach the regular balloons to the front or back and see how it tilts (buoyancy).

The US Navy had several airships, especially in the 1930's. One example is the USS Macon, an airship built and operated for scouting and served as a "flying aircraft carrier", capable of fitting eight aircraft that could be released mid-air! It was in service for less than two years. In 1935, the Macon was damaged in a storm and lost off California's Big Sur coast.

Airplanes/Jets

Unlike the hot air balloon or airship, airplanes are "heavier than air" crafts. Because of this, we use physics, not weight, to get our airplanes in the air. This can get a little complicated, but let's learn about lift!

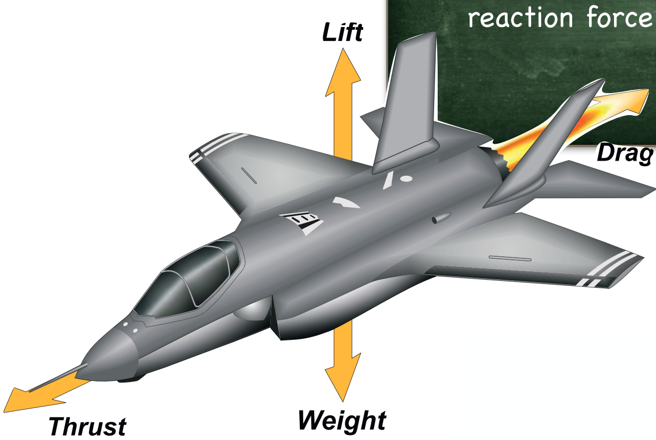


The shape and speed are the most important factor when you're getting a plane to fly. The shape of the wing, known as an **airfoil**, makes the air pressure very low on top of the wing and high below it. We use high speeds to change the air pressure. When the plane speeds up for takeoff, these speeds create lower air pressure (fewer molecules) above the wing. This creates **lift**. The curve on top of the airfoil creates this change in pressure, mixed with speed. The molecules passing over the wing have farther to go because of this curve. This causes the air to speed up above the wing, spreading the molecules out and lowering the air pressure. The air below the airfoil remains the same, so the higher pressure is pushing up on it, helping with lift.

We just learned about how we create lift in an airplane, but three other factors play a important role in flying. The airfoil lifts the plane in the air, and once up, **thrust** will push the aircraft forward. We need energy from an engine to create thrust. However, when we thrust something forward in the air, the air pushes back, or resists, the plane. This resistant force is called **drag**. If or when an airplane slows down, the **weight,** or gravity, and drag will take over. This will lower the altitude of the place, which we use for landing.

Let's look at Isaac Newton's Laws of Motion. How do they apply?

- Second Law of Motion, acceleration is produced when a force acts on a mass. The greater the mass, the greater the amount of force required.
- The Third Law of Motion states that for every force, there is a reaction force that is equal in size, but opposite in direction. Therefore, whenever one object pushes another object, it gets pushed in the opposite direction equally as hard.



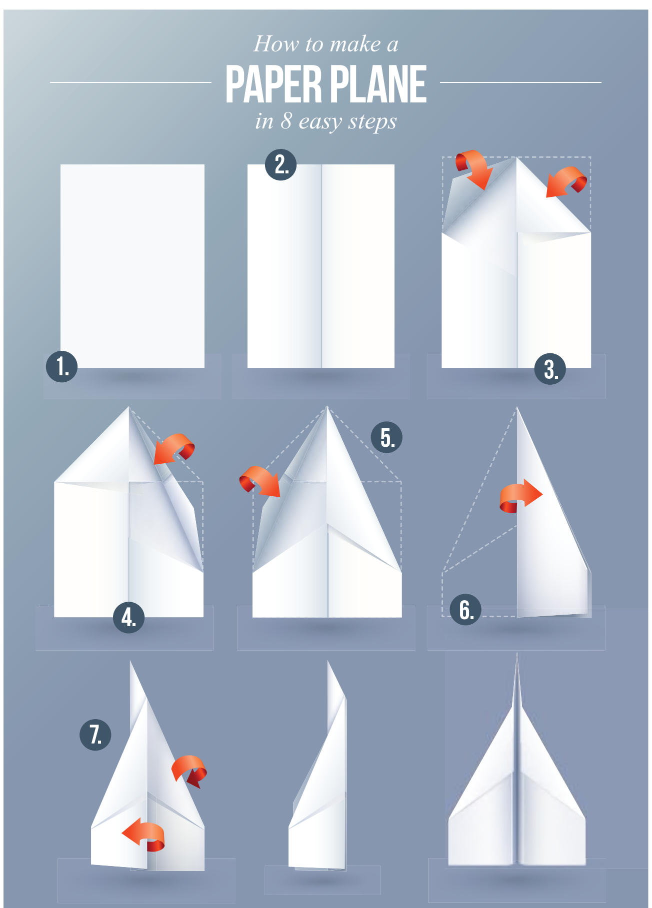
Airplanes/Jets

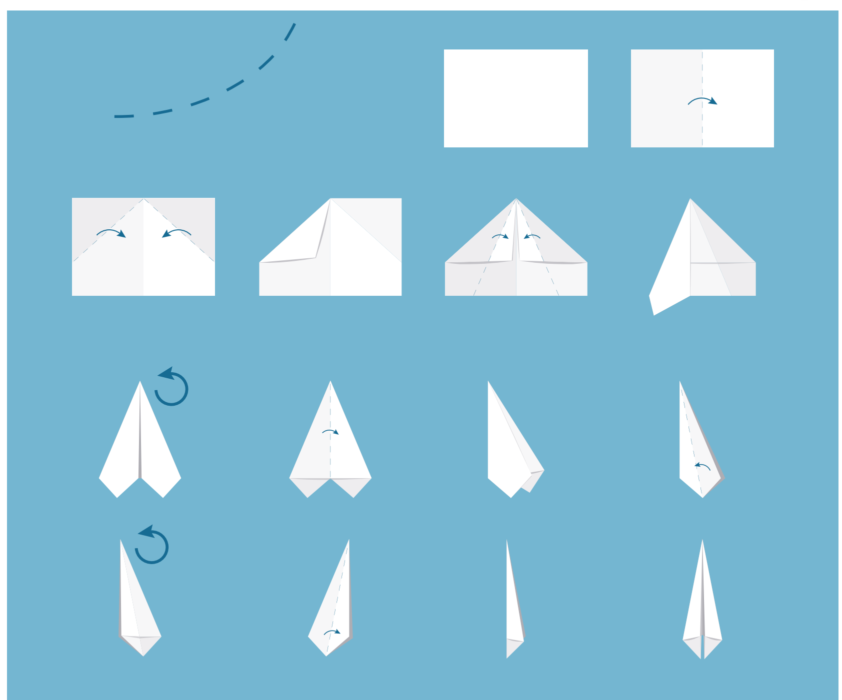
Let's Test it Out!

First, we are going to quickly test how an airfoil works! This is super easy. Cut a 1 inch slip from a regular sheet of paper. Hold the end of the slip under your bottom lip, and blow out with your lips tight like hen whistling. What happens? Why do you think this happened? Use the vocabulary we learned on the last page to help explain.

Let's make paper airplanes!

Now we get to the fun part! Using different types of paper, different sizes, and even some weights, we re going to test the 4 forces (lift, gravity, thrust, and drag) to see how far we can fly a paper airplane. I have some examples of patterns you can use below, but remember, you are not limited by the size, look, or weight of your plane. Keep track of all the planes your make on the next page and record how far each one travels. What do you think helped your plane fly longer? What held it back? Use the vocabulary words we have learned today to describe each attempt.





Landscape

Portrait

Paper Airplane Trials

Airplane Name	Unique Factor Used	Distance (inches)	Type of force tested (you can use more than one)
Sgt. Pepper	Added a weight (penny) to the front	140	Drag, Gravity

Vocabulary

Altitude: the height of an object or point in relation to sea level or ground level

Airfoil: a structure with a curved top designed to give the most lift to drag in flight, used as the basic form of the wings

Ballonet: a separate gas- or air-filled compartment within the main envelope of a balloon or airship

Buoyant: able or apt to stay afloat or rise to the top of a liquid or gas

Drag: the pulling force applied by air or other fluid surrounding a moving object.

Lift: an upward force that counteracts the force of gravity

Rudder: a flat piece, usually of wood, metal, or plastic, hinged vertically near the stern of a boat or ship for steering

Thrust: the sudden force or push in a specified direction

Weight: the force exerted on the mass of a body by a gravitational field

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

Airships use _____________ to steer and_____________ to direct a negative or positive ______________, controlling its height or _____________. Airplanes, on the other hand, require the shape of the ____________. These wings use lower air pressure above it to create _________. The engine creates _____________, preventing _____________. All this helps planes fly, regardless of their _______________.