Unmanned Flight Safety and Operations

Windes, B.Jones

Lesson: 4-9-2020

Learning Target:

Students will learn about motions and forces and how the velocity of air determines the amount of pressure the air is able to exert.

Bell Work:

Let’s pretend that I have a hair dryer and a ping pong ball. If I took the hair dryer and pointed it straight up, turned it on and placed the ping pong ball into the air blowing out, what would happen to the ping pong ball ?

Let’s Get Started:

Watch Video: Bernoulli’s Principle

Newton’s Laws of Motion

To understand how planes fly, you need to know the laws of motion first described by Sir Isaac Newton. Newton was an English physicist, mathematician, astronomer, theologian and natural philosopher. Newton is considered one of the most influential men in all of history. In 1687, Newton published a book titled “Philosophiae Naturalis Principia Mathematica”, also known as the “Principia”. In this book, Newton explained the three laws of motion. Newton’s first and third laws of motion help to explain flight. The **first law** says that “an object at rest remains at rest while an object in motion remains in motion, unless acted upon by an external force.” Newton’s **second law** says that “force is equal to the change in momentum per change in time. For constant mass, force equals mass times acceleration or $F=m \cdot a$.” Newton’s **third law** states that “for every action, there is an equal and opposite reaction.”

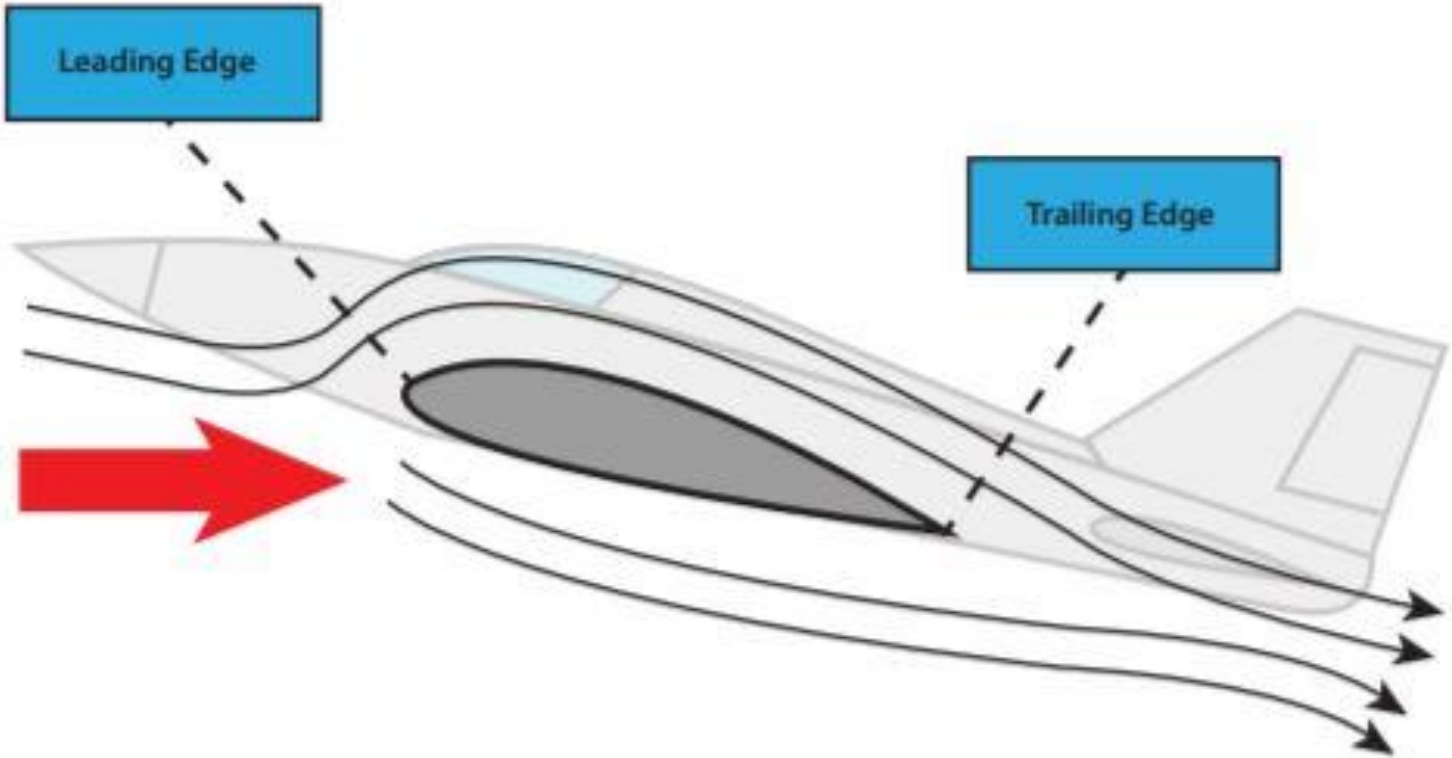
How does Daniel Bernoulli, who is known for the Bernoulli Principle, figure into all of this?

Bernoulli based his work off of Newton. Bernoulli was a Dutch-born scientist who studied in Italy and later lived in Switzerland. Bernoulli was born into a family of mathematicians. His father, Johann, was one of the first developers of calculus. Johann Bernoulli wanted great things for his son Daniel but was also jealous of his son's success. Johann wanted Daniel to study business and medicine, which he did. It was mathematics that really grabbed Daniel's interest. Despite his son's best efforts, Johann never acknowledged his Daniel's achievements and even tried to take credit for some of his son's ideas.

In 1738, Bernoulli published his book “Hydrodynamica”, which was a study in fluid dynamics. Air, just like water, is a fluid, but, unlike water, which is a liquid, air is a gas. Air is considered a fluid because it flows and can take on different shapes. Bernoulli said in “Hydrodynamica” that as a fluid moves faster, it produces less pressure, and slower moving fluids produce greater pressure.

So if we understand the forces at work on an plane and what principles guide these forces, we can explain how lift is generated for an plane. It takes a force, or thrust, to get the airplane moving. That’s Newton’s first law. This law states that an object at rest remains at rest while an object in motion remains in motion, unless acted upon by an external force.

Because of the shape of a plane's wing, which is called an airfoil, the air into which the plane flies is split at the wing's front edge, passing above and below the wing at different speeds so that the air will reach the back of the wing at the same time. The wing's top surface is curved so that the air going over the top of the wing speeds up and stretches out, which then decreases the air pressure over the wing. The air flowing under the wing moves in a more straight line, so its speed and pressure remain roughly the same. Because high pressure always moves toward low pressure, the air below the wing pushes up toward the air above the wing. The wing, which is between the two forces of air, is then "lifted" by the force of the air perpendicular to the wing. The faster an airplane moves, the more lift it generates. When the lift is greater than the gravity, the plane is able to fly, and because of thrust, the plane is able to move forward in flight. So according to Newton's third law of motion, the action of the wings moving through the air creates lift.


Leading Edge
Trailing Edge

EXPERIMENT #1 Paper Tent

Materials:

- One 3 ½” x 4” piece of paper
- One straight straw

Instructions for the experiment:

1. Fold the paper in half to make a paper tent.
2. Place the paper tent on a flat surface such as a table.
3. Put the straw about 2 inches away from tent so that you will be able to blow a steady stream of air across the surface of the table and through the tent.
4. Watch what happens.
5. Now, blow harder and watch what happens.

What We Hope Happens:

When this is done correctly, the sides of the tent will pull towards each other. The reason for this is that the faster moving air under the tent creates a lower pressure compared to the air over the tent, and as a result, the tent will bend toward the table because, according to the Bernoulli Principle, higher pressure air pushes toward lower pressure air.

Did Something Go wrong:

If the this does not work as like we had hoped, you might have the end of your straw too close to or too far away from the tent or you might not have blown hard enough.