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UNIT 2 | SECTION D | LESSON 2 | PRESENTATION

BUILD AND TEST A WIND TUNNEL

LEARNING OBJECTIVES

By the end of this lesson, students will be able to:

- Describe the scientific process the Wright Brothers used to solve the power, control, and lift problems they encountered.
- Differentiate between airfoil designs and identify their strengths and weaknesses.
- Analyze data from wind tunnel tests to determine which airfoil designs created the greatest lift.
- Synthesize the results of the wind tunnel test.

WARM-UP

Watch a video of Boeing's 737 MAX winglets in a wind tunnel.

VIDEO

Write 2-3 sentence answers for each of the following questions:

Why are wind tunnels used to design aircraft?

What are wind tunnels used to measure?

What other industries besides aviation use wind tunnels to test designs?

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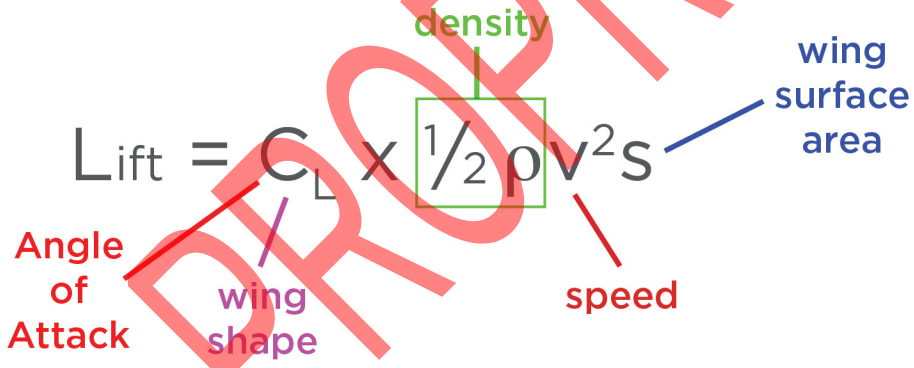
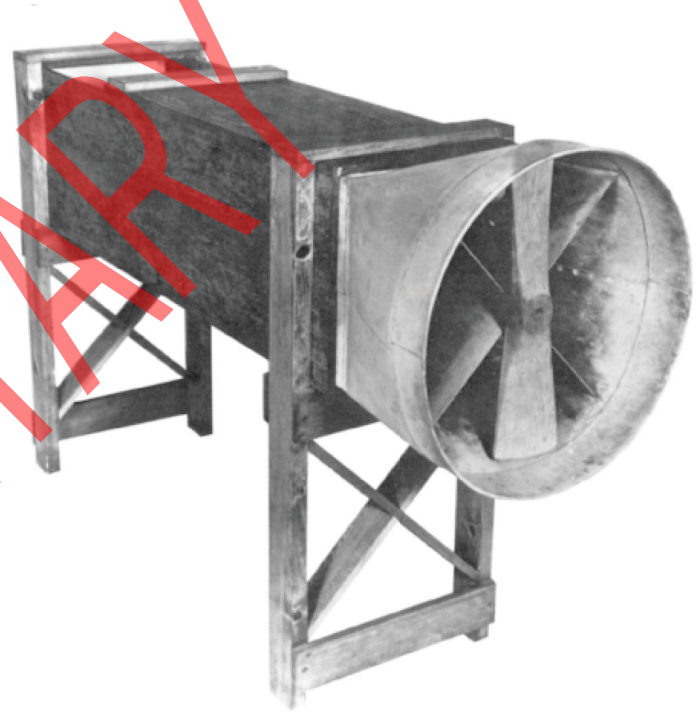
CHECKING THE DATA

- In their quest to build the flyer, the Wright brothers had been using the aerodynamic data of Otto Lilienthal and other early glider pioneers.
- The brothers realized their gliders were only producing a fraction of the lift predicted by Otto Lilienthal's previous experiments.
- They decided it was time to do their own aerodynamic research.



FIRST WIND TUNNEL



- **In order to improve on their designs, the Wright brothers built a wind tunnel and were the first to use a series of engineering practices to test, analyze, and improve their airfoil designs.**
  - manages airflow around stationary object
  - helps control variables that may impact results of testing
- **The wind tunnel consisted of a simple wooden box with a square glass window on top for viewing during testing. A fan, belted to a one-horsepower engine, provided airflow of about 30 miles per hour.**

BUILD YOUR OWN WIND TUNNEL!

You and your classmates are going to build your own wind tunnel.

Later in the lesson you will also build your own airfoils to test in the tunnel.

Be sure to construct the wind tunnel correctly so that the airfoil testing is possible.

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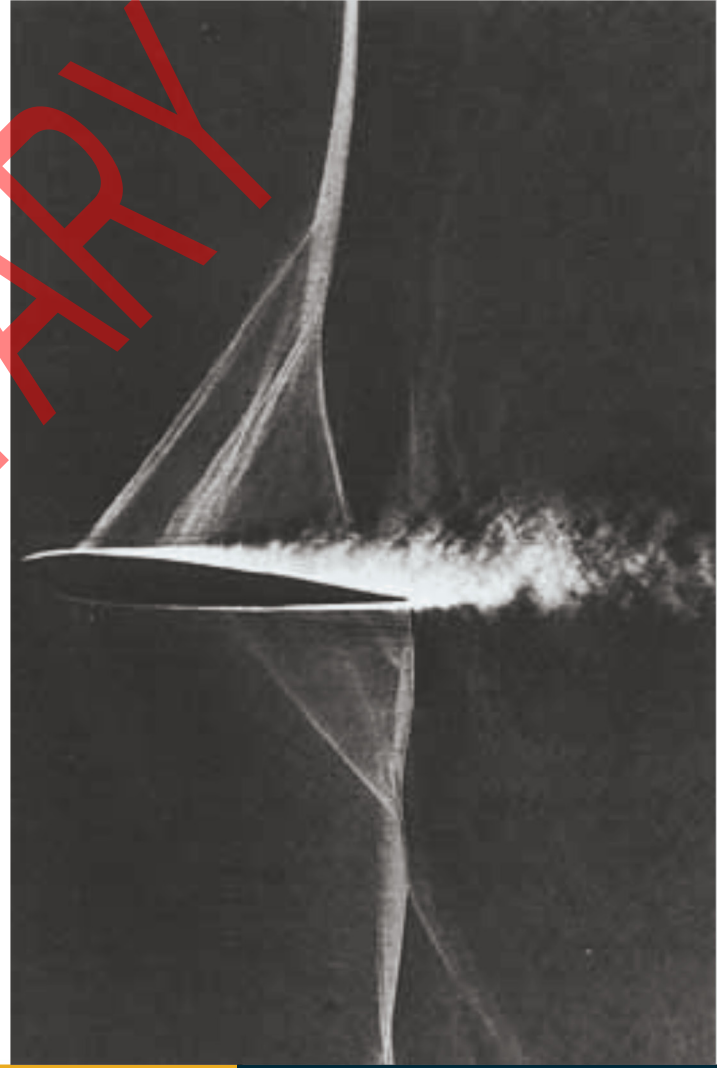
WHAT IS AN AIRFOIL?

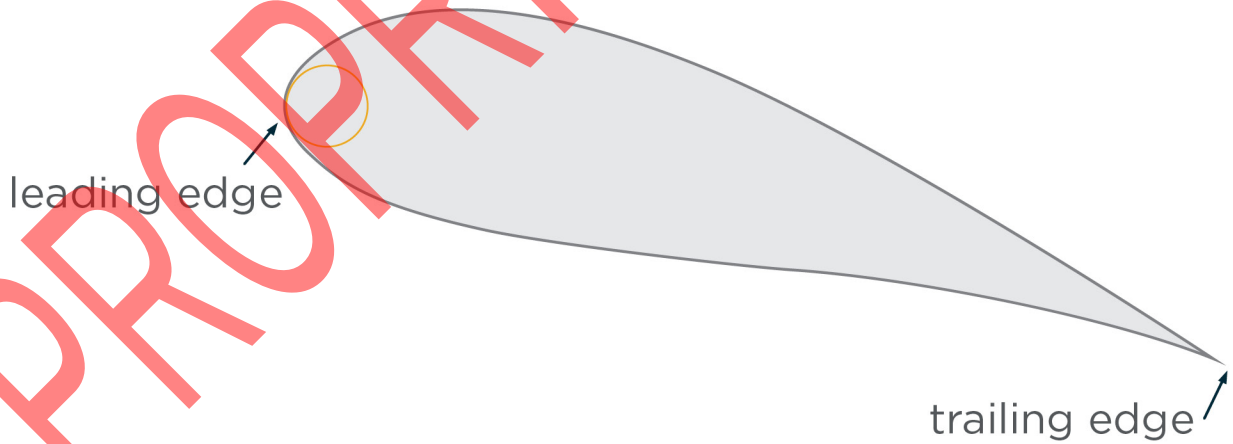
- A wing shape that when moved through a fluid (air) produces an aerodynamic force
- Airfoils are used as the basic form of the wings, fins, and horizontal stabilizers of most aircraft



Source: NASA.gov

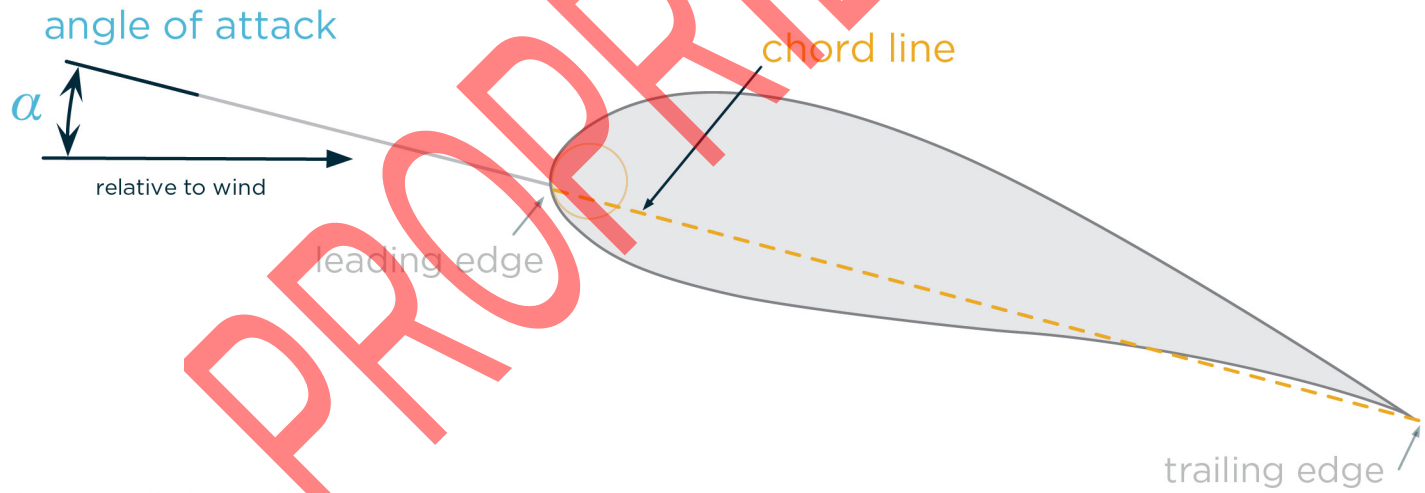
AIRFOIL TERMINOLOGY

- **Leading Edge –** first place air makes contact with the airfoil
- **Trailing Edge –** last place air makes contact with the airfoil



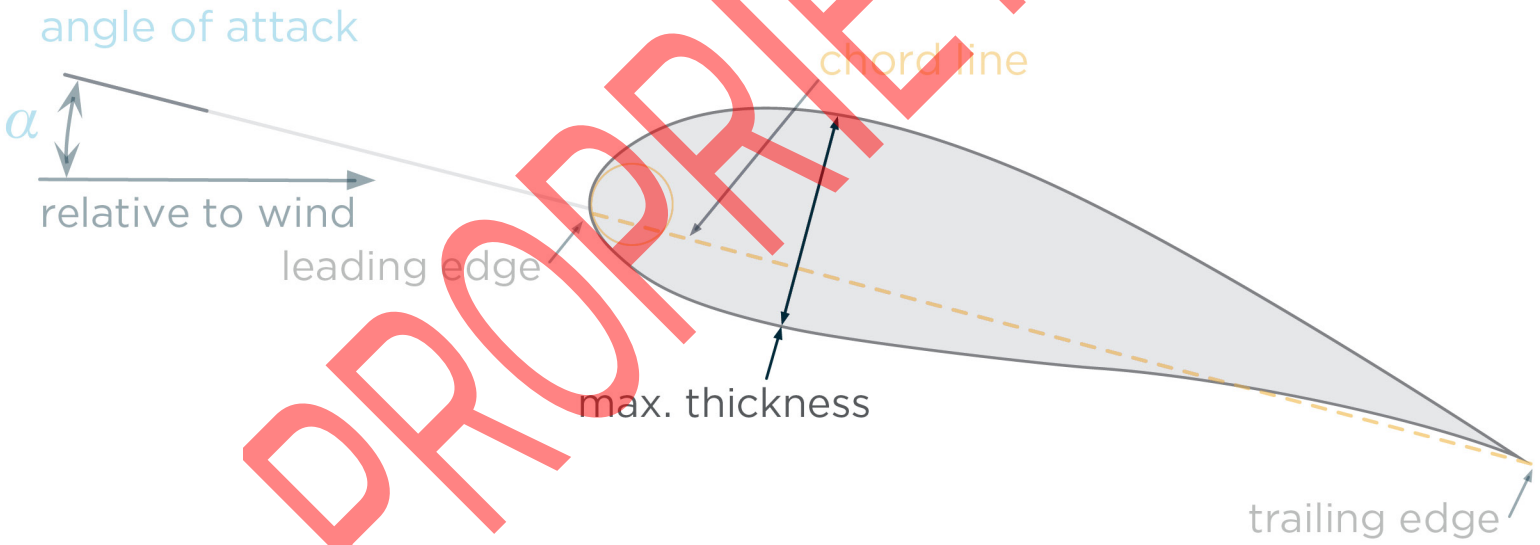
AIRFOIL TERMINOLOGY

- **Chord –** straight line that connects the leading edge to the trailing edge.
- **Angle of Attack –** angle between the chord line and the relative wind flow. If the leading edge of the airfoil is higher than the trailing edge, then the airfoil has a positive angle attack



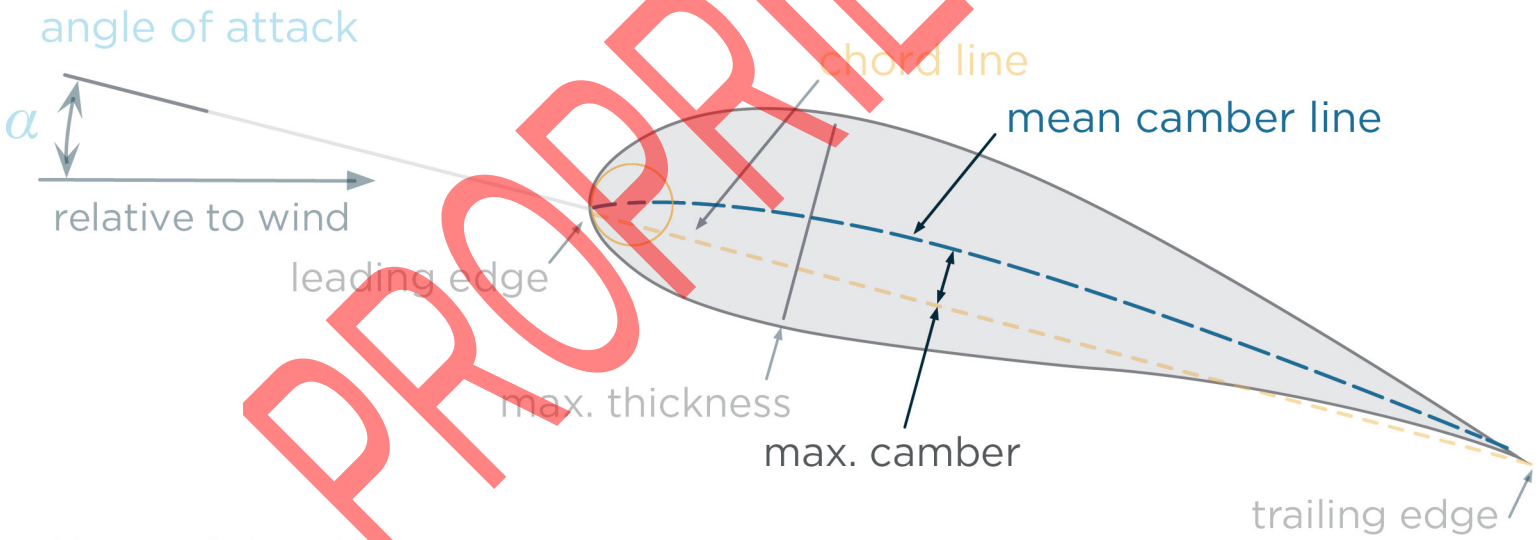
AIRFOIL TERMINOLOGY

Thickness – maximum distance between the upper and lower wing surfaces



AIRFOIL CURVATURE

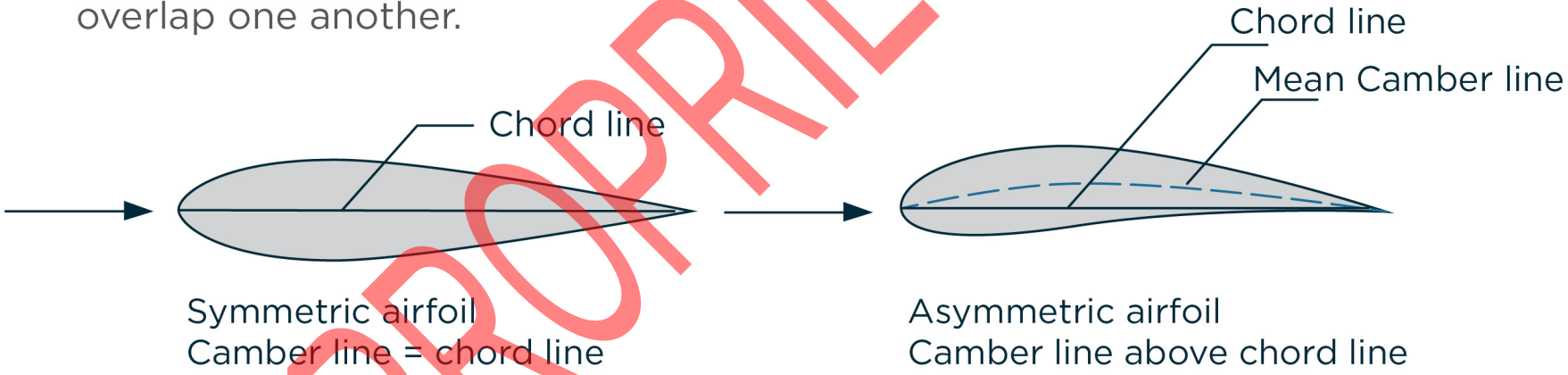
- **Camber –** the curve of the wing
  - The mean camber is a line drawn between the leading and trailing edge so that the distance between the upper and lower surfaces is equal
- **Max Camber –** measured where there is maximum distance between the chord line and the mean camber line



AIRFOIL SHAPES

Symmetrical Airfoil – the upper and lower surfaces of the airfoil are identical. The chord line and the mean camber line directly overlap one another.

Asymmetrical Airfoil – the upper surface is more curved. The mean camber line is above the chord line.



CLASS DISCUSSION

ASYMMETRICAL OR CAMBERED AIRFOILS GENERALLY PRODUCE MORE LIFT. BUT WHAT KIND OF AIRPLANE WOULD BENEFIT FROM A SYMMETRICAL WING?

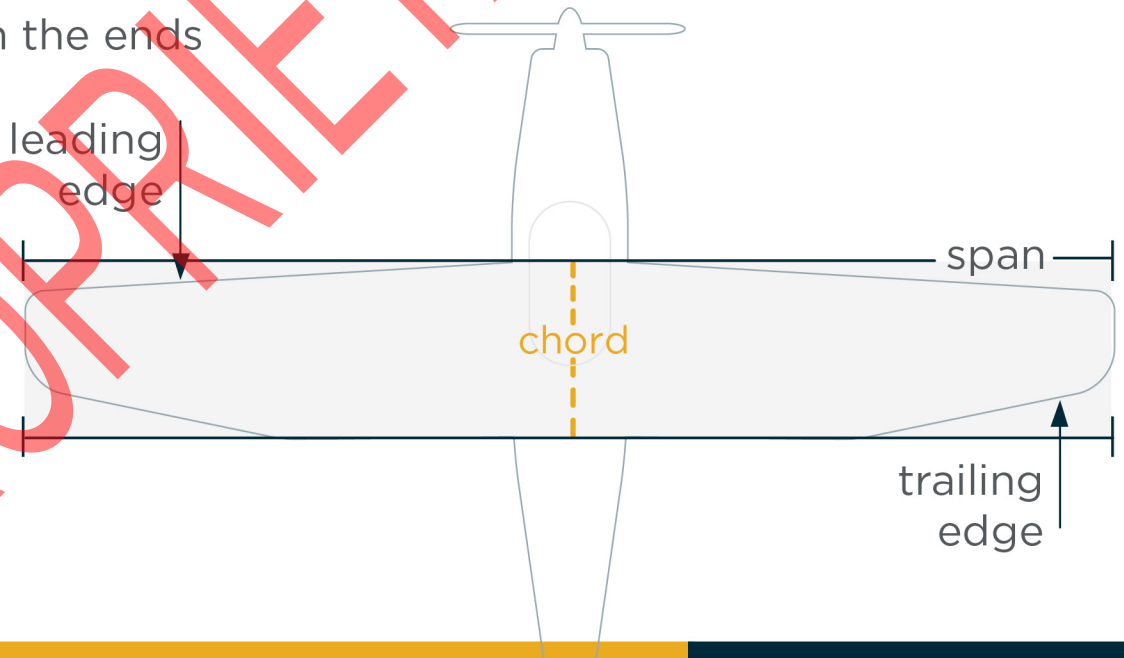
Source: Kevin M. McCarthy / Shutterstock.com

AIRFOIL TERMINOLOGY

Planform – the shape of the airfoil when viewing from above

Chord – the length from the trailing edge to the leading edge

Span – the length between the ends of the wingtips



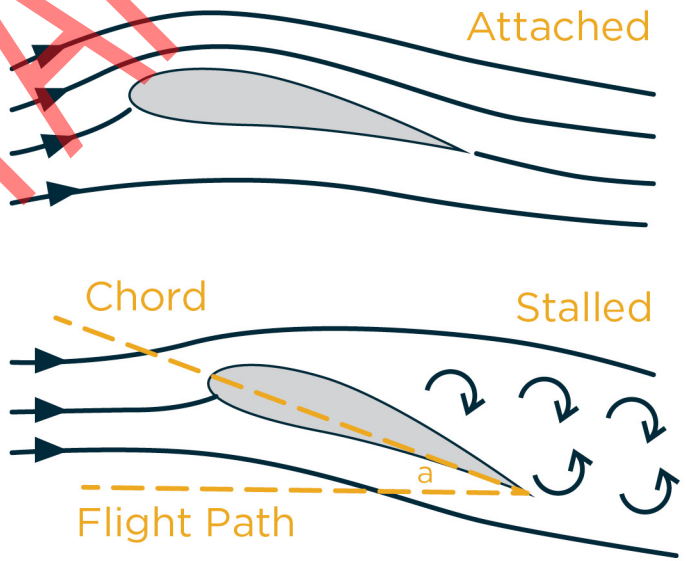
WHAT THE WRIGHT BROTHERS LEARNED

- **By testing more than 200 airfoils, the brothers learned very important factors that influence lift.**
  - Curved surfaces produce more lift than flat surfaces.
  - Curved surfaces also produce more drag; they learned that a curved surface with a small camber was ideal for maximizing lift.
  - Airfoils with the curve closer to the leading edge produce more lift.
  - Airfoils that are thin and long create more lift.
  - Cambered airfoils will create lift at zero angle of attack.

HOW DOES ANGLE OF ATTACK AFFECT LIFT?

- **Lift is directly affected by angle of attack.**
  - As the angle of attack increases, so too does the lift produced by the airfoil.
  - This is true until the critical angle of attack is reached.

- **At the critical angle of attack, the boundary layer of air separates from the airfoil and creates drag.**
  - This is called an "aerodynamic stall".



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BUILD YOUR OWN AIRFOILS

- **Working in small groups, you will build two airfoils of a predetermined span and chord.**
  - One symmetrical airfoil
  - One asymmetrical airfoil
- **Then you will test your airfoils to determine which produces more lift.**
  - If time allows, you can use engineering practices to design and test your own airfoil design.

FORMATIVE ASSESSMENT

In groups of two to three students, explain which type of aircraft would be better suited for:

- **symmetrical airfoil**
- **asymmetrical airfoil**

Submit a short summary for each type of airfoil.

SUMMATIVE ASSESSMENT

An important aspect of engineering design is presenting findings.

In your small groups, prepare a five minute presentation to include the following regarding your airfoil tests:

- **Performance of your airfoils**
- **Limitations encountered**
- **Errors made**
- **Ideas for improving the design of your airfoils**
- **Ideas for improving the testing methods**

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