

Aerodynamics in the classroom Curriculum Unit: Lesson 2

“Streaming Across Airfoil Shapes”

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Suggested Time: 50 minutes

Grade Level: High School

NGSS Standards

- **HS-PS2-1.** Analyze data to support the claim that Newton’s second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration.
- **HS-PS2-2.** Use mathematical representations to support the claim that the total momentum of a system of objects is conserved when there is no net force on the system.

Science and Engineering Practices

- Planning and Carrying out Investigations
- Analyzing and Interpreting Data
- Constructing Explanations and Designing Solutions

Lesson Overview

In this lesson students will be introduced to the idea behind using airfoil shapes to generate lift and the parameters that define an airfoil shape. Students will learn some of the terminologies related to flight and test the process using simple prototype of an airfoil shape. Students will use their data literacy skills to describe the effect of changing the angle of attack on the performance of the airfoil shape.

Vocabulary

- Airfoil
- Angle of attack
- Lift
- Drag
- Camber
- Chord

- Leading edge
- Trailing edge

Objectives and Learning Outcomes

- Students will define how an airfoil shape looks like.
- Students classify and show the different shapes of an airfoil.
- Students will illustrate the meaning of lift and drag forces.
- Students will construct a simple paper airfoil shape and test it.
- Students will discover and analyze the effect of changing the angle of attack on the airfoil.

Required Project Materials

- A4 and A3 paper sheets
- Tape
- Ruler
- Scissors
- straws
- Marker
- string
- Hair drier
- Computer with internet access
- Angle of attack STEAM Journal

Multimedia Resources

“The basics of Airfoils” <https://www.youtube.com/watch?v=7Lb7nx3Jv20&t=37s>

“What is an angle of attack?” <https://www.youtube.com/watch?v=t0tCRq2JedY>

“Airfoil dimensions” <https://www.grc.nasa.gov/www/k-12/airplane/geom.html>

“NASA Airfoil Simulator” <https://www.grc.nasa.gov/www/k-12/airplane/foil3.html>

Optional Multimedia resources

“NACA Airfoil Series” <https://www.nasa.gov/image-feature/langley/100/naca-airfoils>

“History of Airfoil Design” <https://www.century-of-flight.net/history-of-the-airfoil/>

Before the lesson/Background information

Students should have gained a knowledge from the previous lesson about the forces of flight and parts of an airplane as well as other concepts like gravity and pressure.

Lesson Plan

Engage (Estimated time: 5 minutes)

- Use the video link in the Multimedia resources section labelled as “The basics of airfoil” to engage the students of how airfoil shape look like.
- By the end of the video ask the students about the different parameters that define how an airfoil shape looks like. Invite a student to draw the shape of an airfoil on the board and label the different parameters (show the students the image in the link labelled as “Airfoil dimensions” in the multimedia resources)

Explore (Estimated time: 20 minutes)

- Ask the students to **work in groups** in order to use the materials listed in the required project material section to create a simple wing shape with an airfoil cross-section. Students will need to use ruler to divide the paper sheet into half and label the midpoint of the wing. Students are also supposed to use straw to hold the wing along the midpoint using a string. The teacher will be passing by the groups of students to scaffold and give further instruction to help them.
- Next, students are supposed to use hair drier in order to direct air towards their model and record their observations.
- In group discussions, students are supposed to discuss their observation and try to define the meaning of lift and drag forces produced on the surface of the wing.



Figure 1: Example of student outcome in the explore step

Explain (Estimated time: 10 minutes)

- The teacher is now going to explain and clarify the results of the experiment that the students did in the exploration step **by defining the meaning and reason of lift and drag forces** on the surface of the wing.
- The teacher is going to explain the meaning of the angle of attack referring that this could be represented in the experiment by the orientation of the hair drier with respect to the horizontal line.

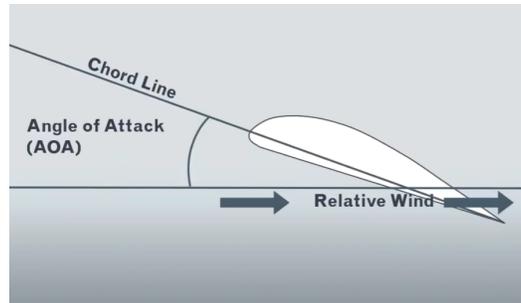


Figure 2: Angle of attack

Elaborate and Evaluate (Estimated time: 15 minutes)

- Students will use the airfoil simulator using the link in the multimedia resources labelled as “NASA airfoil simulator” in order to investigate the effect of increasing the angle of attack on the amount of lift produced for a certain airfoil shape and certain flight conditions.
- Students will use a graph paper in the STEAM Journal to graph the produced lift coefficient vs the angle of attack and reflect on their observations.

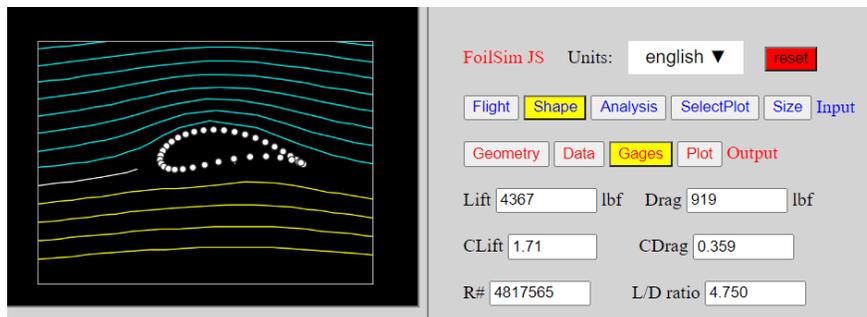


Figure 3: NASA Airfoil Simulator Result

*Assessment

Formative: students will be assessed based on the group work and discussions in the exploration step

Summative: Students will receive grades based on their answers in the STEAM Journal

*Homework

Students will write an essay of maximum 500 words about the history of airfoil design