D. Airfoils: Generation of Lift

Content Area: **Science**
Course(s): **CAD Architect**
Time Period: **Marking Period 1**
Length: **1**
Status: **Published**

Assessment

"Do Now" Activities

"Exit Ticket" Activities

Practice Problem Worksheets

Quizzes

Standards

SCI.9-12.HS-ETS1-2	Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.
SCI.9-12.HS-ETS1-3	Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.
SCI.9-12.HS-ETS1-4	Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.
SCI.9-12.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.
SCI.9-12.HS-PS3-1	Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known.

Enduring Understandings

Students will come to understand:

1. The limiting assumptions that simplify the study of airfoil sections (namely that the fluid flow is invisid and incompressible).
2. Aerodynamic forces can be normalized to non-dimensional coefficients by dividing out a characteristic area and dynamic pressure.
3. Aerodynamic coefficients vary based on the geometry of the airfoil and the angle of attack with the oncoming fluid.
4. Plots of aerodynamic coefficients vs. angle of attack help predict flight characteristics of an aircraft.
5. All airfoils have a limiting angle of attack above which air no longer flows smoothly over the shape of

the airfoil, known as a stall.

Essential Questions

The following questions will guide student inquiry:

- What factors affect the force of lift generated when fluids in motion interact with objects in the flow?
- How does the shape of a body in motion relative to a fluid affect the force of lift acting on that body?
- How do aircraft wings vary in design to meet different design parameters while adhering to the same physical laws of fluid dynamics?

Knowledge and Skills

Unit Content:

An airfoil is the foundational shape that gives a wing the ability to create lift, and an understanding of airfoils is fundamental to the design of any aircraft or flying machine. This is the first of four units that discuss in detail the different operational and design aspects of airfoils. This unit explains how airfoils work, defines terminology associated with their geometry, and describes how dimensionless coefficients can be derived to quantify the aerodynamic qualities of an airfoil. Once these fundamental concepts are understood, the until will focus on lift generated by an airfoil. There are two key geometric characteristics of airfoils: (1) camber (or net curvature), and (2) thickness. This unit will conclude with the effect these two properties on the lifting characteristics of a given airfoil.

- Streamlines, Circulation, and Pressure Distribution
- The Generation of Aerodynamic Lifting Forces (1 day)
- Simplifying assumptions: Inviscid and Incompressible flow
- Airfoil Terminology and Definitions (1 day)
- Dimensionless Physical Coefficients (1 day)
- The Basic Lift Equation, Its Graphical Representation & Its Interpretation (4 days)
- The Aerodynamic Stall (2 days)
- How Airfoil Geometry Affects Lift (the role of thickness and camber) (2 days)

Science, Technology, Engineering, Mathematics, and Aerospace Skills:

Airfoil geometry was standardized by the NACA, the forerunner to NASA, in the 1920s and 30s. The system for defining airfoil geometry facilitates both aerodynamic research and wing construction. Students will learn to interpret the NACA 4 and 5 digit airfoil system and use the system to build airfoils for wind tunnel testing.

- Plotting airfoils and using MS Excel to facilitate plotting
- Wind tunnel testing of airfoils for lift vs. angle of attack

Resources

Textbook(s):

Hurt, H. H. (1965). *Aerodynamics for Naval aviators*. Washington, DC: Federal Aviation Administration.

Smith, H. C. (1992). *The illustrated guide to aerodynamics* (2nd ed.). Blue Ridge Summit, PA: McGraw-Hill, Inc.

Cessna Aircraft Company. (1977). *Pilots operating handbook: Cessna 172*. Wichita, KS: Cessna Aircraft Company.

Federal Aviation Administration. (2013). *The pilots handbook of aeronautical knowledge*. Washington, DC: Author.

Lab Equipment:

Pasco Low Speed Wind Tunnel

Balsa tools to create airfoil sections

Foam cutter and foam cutting tools to create airfoil sections

Balsa gliders

Video Camera/digital camera

Computer Software:

Microsoft Excel

Foilsim

NASA Site