E. Airfoils: Generation of Drag

Content Area: **Science**
Course(s):
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. Unlike the coefficient of lift, which arrives at a maximum before rapidly decreasing with angle of attack, the coefficient of drag increases with increasing angle of attack.
2. The angle of attack of an airfoil that corresponds to the maximum lift over drag ratio (L/Dmax) is of serious interest to the pilot and aeronautical engineering due to its influence on aircraft performance.
    1. L/Dmax corresponds to the angle of attack that results in the maximum endurance of a jet aircraft
    2. L/Dmax corresponds to the angle of attack that results in the maximum range of a propeller driven aircraft

    3. L/Dmax corresponds to the angle of attack for maximum angle of climb for jet aircraft
    4. L/Dmax corresponds to the angle of attack that maximizes glide range for all aircraft.
3. An aircraft's gross weight does not affect the lift to drag ratio.

Essential Questions

The following questions will guide student inquiry:

- What factors affect the force of drag 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 drag acting on that body?
- How can the lift to drag ratio of an aircraft be independent of an aircraft's weight?
- How does an aircraft's maximum lift to drag ratio affect the safety of an aircraft in an emergency engine-out situation?

Knowledge and Skills

Unit Content:

This is the second of four units that discuss in detail the different operational and design aspects of airfoils. This unit builds upon the foundation laid in the previous unit by developing airfoil drag characteristics. The drag created by an airfoil is known as "profile drag". Just as with lift, students will define the coefficient of drag for an airfoil, plot the coefficient of drag against angle of attack, and relate the coefficient of drag to the two geometric characteristics of an airfoil section (the camber and thickness). Finally, neither drag nor lift alone define an appropriate airfoil for a given application. Rather, the ratio of lift over drag defines the overall effectiveness of an airfoil. The unit will conclude with plots of lift vs. drag for airfoils as a way of comparing one airfoil to another.

- The Basic Drag Equation, Its Graphical Representation & It’s Interpretation (1 day)
- The Lift-Drag Ratio (L/D) and plots of L/D (2 days)
- How Airfoil Geometry Affects Drag (the role of thickness and camber) (1 day)

Science, Technology, Engineering, Mathematics, and/or Aerospace Skill(s):

Students will learn how to find academic papers using Google Scholar and learn how to use these papers to identify current and past research trends.

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