J. Real Wing: Taper, Sweepback, & Stall Patterns

Content Area:	**Science**
Course(s):	**CAD Architect**
Time Period:	**Marking Period 1**
Length:	**1**
Status:	**Not 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-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.
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.

Enduring Understandings

Students will come to understand:

1. Due to the spanwise flow of air over a wing, the lift produced by a wing decreases with distance from the wing root to the wing tip in an elliptical fashion.
2. Elliptical wing planforms are the most aerodynamically efficient yet most costly to physically build, thus tapered wings serve as a much more practical compromise of aerodynamics and economics.
3. Increasing taper increaseses the likelihood of tip stalling and subsequent spin characteristics of an aircraft, resulting in the need for aerodynamic tailoring in the form of stall strips or washout angles.
4. Sweepback increases the tip stalling characteristics and spanwise flow, often regulated with wing fences.

5. Sweepback provides little advantage to subsonic aircraft; however at transonic to supersonic speeds, sweepback is required and must be dealt with at the low speed end of the flight envelope.

Essential Questions

The following questions will guide student inquiry:

- What aspects of wing design pit aerodynamic requirements against economic realities and how do aerospace engineer's compromise?
- How do aerospace engineers deal with the conflicting aerodynamic requirements of high speed and low speed flight in the same aircraft design?
- How can qualitative research techniques provide insight into the operation of actual aircraft wings?

Knowledge and Skills

Unit Content:

The previous two units explored the operation of a wing from a three-dimensional perspective that takes into account the wing's planform and the induced drag associated with this planform. The previous unit explored one component of a wing's planform: aspect ratio. This unit explore the final two components of a wing's planform, namely taper and sweepback. The unit considers how a wing's taper and a wing's sweepback affect the three dimensional flow characteristics and induced drag.

- Effect of Taper on lift distribution and induced drag (2 days)
- Stall Patterns on real wings and the influence of taper on stall patterns (2 days)
- Effect of Sweepback on stall patterns (2 days)

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

While previous units emphasized accurate quantitative measurements of pressures, temperatures, etc. to quantify flow characteristics and draw conclusions about the operation of airfoils and wings, many qualitative aspects of wing operation can be measured using tufts of string mounted to the wing surface. Watching and photographing the behavior of the tufts of string provide qualitative insight into the flow patterns surrounding a wing.

- Using Tuft Photographs to visualize three dimensional flow patterns over wing surfaces.

Resources

Textbook(s):

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

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