O. High Speed Flight

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-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 learn:

1. Since sound is a pressure propagation that travels through air, as an aircraft approaches the speed of sound, it approaches the speed of the pressure propagations and creates shock waves that drastically changing the dynamics of the fluid flow.
2. The design requirements to sustain controlled transonic and supersonic flight are drastically different than the requirements for subsonic flight, posing unique engineering challenges.
3. When conventional subsonic aircraft approach the speed of sound, such as in a dive, the onset of the effects compressibility lead to dangerous control problems.
4. When a subsonic airfoil operates in the transonic flight regime, a normal shock wave forms and the resulting pressure gradient stalls the airfoil.

Essential Questions

The following questions will guide student inquiry:

- What is the relationship between the velocity of a flying machine and the compressible nature of the air around the machine?
- How do the requirements for high speed flight contradict the requirements for low speed flight and how do engineers reconcile these contradictions in practical design?
- What happens to a conventional subsonic aircraft as it approaches the speed of sound?

Knowledge and Skills

Unit Content:

High speed flight refers to flight approaching the speed of sound. Flight at speeds where air exceeds the speed of sound around some portions of the airplane while remaining below the speed of sound in others is known as transonic flight. Aircraft operating in the transonic realm an beyond require special aerodynamic considerations, including very sharp, streamlined surfaces, swept wings, and fuselages designed around the area rule. Many of these demands run counter to good design practice for subsonic flight. In high speed flight the air can no longer be considered incompressible and the effects of compressibility and shock waves must be considered. This unit will explore these design contradictions and how aerospace engineers compromise to make successful high speed aircraft.

- The Speed of Sound
- Mach Number
- Shock Waves
- Critical Mach Number
- Airfoils in Transonic Flight
- Wave Drag
- Swept Wings at High Speed
- Control Problems
- Area Rule

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

The unit will close with a look at compressible fluid mechanics, the study of fluid flow at transonic and supersonic velocities. Emphasis will be placed on the fact that compressible fluid mechanics is goverened by both the laws of fluid mechanics and thermodynamics, combining all of the material discussed in this course.

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