C. Fluid Dynamics & Airspeed Measurement

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-PS3-2	Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motion of particles (objects) and energy associated with the relative position of particles (objects).
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. The law of conservation of mass relates the velocity of an incompressible flow to the constraining geometry of the system via the continuity equation.
2. The law of conservation of energy relates the velocity of an incompressible flow to pressure via Bernoulli's equation.
3. The continuity equation and Bernoulli's equation together relate the properties of a fluid in motion and provide convenient ways to measure fluid velocity.

Essential Questions

The following questions will guide student inquiry:

- How do the laws of conservation of mass and energy explain the behavior of fluids interacting with masses?
- How can measurements of pressure lead to the ability to quantify velocity?
- How can the geometry of a tube be varied to create a source of vacuum?

Knowledge and Skills

Unit Content:

This unit on fluid dynamics builds off the previous unit regarding fluid statics and introduces some of the phenomena associated with fluids in motion. In fact, the remainder of the course is the application of fluid dynamics to the design of aerodynamic surfaces that sustain aerospace vehicles in stable flight. This unit applies the law of conservation of mass (first introduced in chemistry) to fluids to derive the continuity equation. Similarly, the unit applies the law of conservation of energy (ubiquitous in science, but mathematically treated in physics) to fluid flow to derive Bernoulli's equation. Along the way, the unit will define means of visualizing fluid flow.

- Fluids in Motion and Streamlines
- The Equation of Continuity (2 days)
- Bernoulli’s Equation (4 days)

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

Bernoulli's equation relates pressures with fluid velocity. As a result, it provides a practical means of measuring the velocity of an airflow. From a research perspective, this explains how to measure flow velocity in wind tunnels. In practical aircraft, Bernoulli's equation explains how the airspeed indicator and pitot/static system functions.

- Aerospace Application: Airspeed Measurement (stagnation pressure, measurement of dynamic pressure, pitot and static sources)
- Airspeed Systems (actual aircraft systems including aircraft flight manual examples, wind tunnel systems) (1-2 days)
- Types of Airspeed (indicated airspeed, calibrated airspeed, equivalent airspeed, true airspeed) (1 day)
- Venturi Tubes as vacuum sources to drive aircraft gyroscopic instruments

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:

Cutaway and Stock Aircraft Airspeed Indicators from actual aicraft

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

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