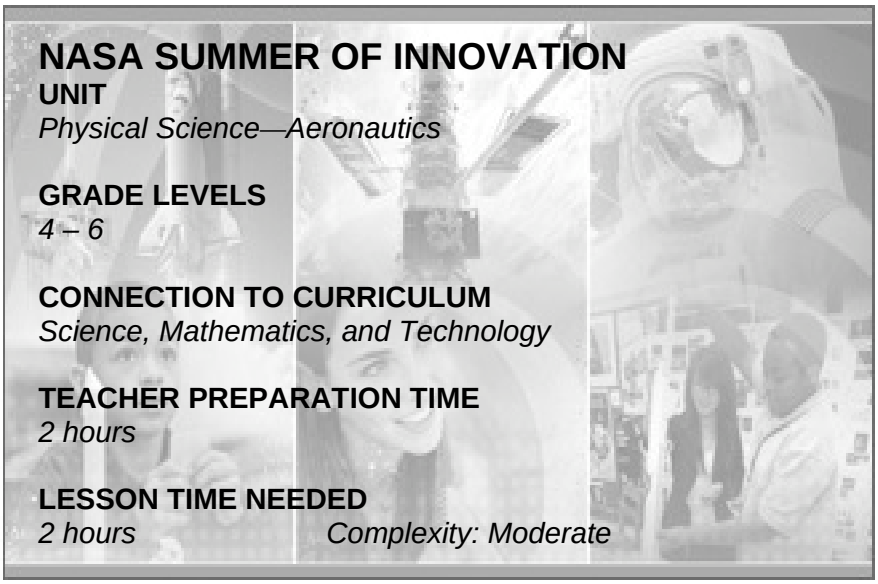
Air Foils

LESSON THEME
To learn how an airfoil creates lift

OBJECTIVES
Students will
- Investigate how an airfoil creates lift
- Design an airfoil
- Construct a model of an airfoil from materials provided
- Observe how their airfoil operates using a fan to provide



NASA SUMMER OF INNOVATION
UNIT
Physical Science—Aeronautics

GRADE LEVELS
4 – 6

CONNECTION TO CURRICULUM
Science, Mathematics, and Technology

TEACHER PREPARATION TIME
2 hours

LESSON TIME NEEDED
2 hours *Complexity: Moderate*

NATIONAL STANDARDS

National Science Education Standards (NSTA)
Science as Inquiry
- Understanding of scientific concepts
- An appreciation of "how we know" what we know in science
- Understanding of the nature of science
- Skills necessary to become independent inquirers about the natural world
- The dispositions to use the skills, abilities, and attitudes associated with science

Physical Science Standards
- Properties and changes of properties in matter
- Motions and forces
- Transfer of energy

Science and Technology Standards
- Abilities of technological design
- Understanding about science and technology

History and Nature of Science Standards
- Science as a human endeavor

Common Core State Standards for Mathematics (NCTM)
Operations and Algebraic Thinking
- Use the four operations with whole numbers to solve problems
- Generate and analyze patterns

Operations and Algebraic Thinking
- Analyze patterns and relationships
- Write and interpret numerical expressions

ISTE NETS Performance Indicators for Students (ISTE)
Creativity and Innovation
- Create original works as a means of personal or group expression
- Use models and simulations to explore complex systems and issues

Communication and Collaboration
Contribute to project teams to produce original works or solve problems

Research and Information Fluency
- Plan strategies to guide inquiry
- Process data and report results

Critical Thinking, Problem Solving, and Decision Making
- Identify and define authentic problems and significant questions for investigation
- Plan and manage activities to develop a solution or complete a project
- Collect and analyze data to identify solutions and/or make informed decisions

Technology Operations and Concepts
- Understand and use technology systems
- Select and use applications effectively and productively
- Troubleshoot systems and applications

MANAGEMENT

- For best results, build and use a wind tunnel and a simple anemometer device—to measure wind speed in m/s units. Fan design generates turbulent airflow. Fan speed is an independent variable (low, medium, and high). Build more than one airfoil, with curvature on upper surface in multiple increments. Angle of attack can be in multiple degree increments (0, 15, 30, 45, 60, 75, and 90 degrees).
- Create a data sheet that lists independent variables and the dependent variables and also contains a table for data collection. Compute the range, mean, and median distances of each airfoil test, and use a graph for plotting averaged numerical data (line graph).

CONTENT RESEARCH

Key Concepts:

Airfoil: An aerodynamic surface shaped used for testing the reaction from the air through which it moves. All the surfaces of an airplane can be shaped as an airfoil. This includes fuselage, wing, rudder, aileron, propeller blade, and helicopter rotor blade.

Angle of attack: An engineering term that describes the angle of an aircraft's body and wings relative to its actual flight path. The angle of attack varies during flight.

Angle of incidence: While angle of attack varies during flight, angle of incidence is fixed with the design of the aircraft. Airfoils are generally attached to the aircraft at a small angle in relation to its longitudinal axis.

Bernoulli's Principle: Lift is generated by a pressure difference across the wing.

Newton's Third Law of Motion: Lift is the reaction force on a body caused by deflecting a flow of gas.

MATERIALS
- Protractor
- Desk fan
- Wooden block (length of protractor)
- 50 cm stiff wire
- Bead
- Scissors
- Glue
- Tape
- Six 10-cm pieces of yarn
- Thin cardboard 11 by 31 cm
- Small nail
- Hammer
- Drill (optional)
- Science journal

LESSON ACTIVITIES

Construct an airfoil and test different angles of attack.

The NASA "Why" Files: The Case of the Challenging Flight
Program 4 in the 2000–2001 Series
http://scifiles.larc.nasa.gov/docs/guides/guide4_00.pdf (pg. 21)

ADDITIONAL RESOURCES

The Courage to Soar Educator Guide
http://www.nasa.gov/audience/foreducators/topnav/materials/listbytype/The_Courage_to_Soar.html (pp.174)
- Activity Eight—The Four Forces of Flight
  - Lesson 17—It Lifts Me Up—The Force of Lift

Airfoil on a String
http://www.grc.nasa.gov/WWW/K-12/airplane/index.html
Interactive FoilSim III Interactive Simulator
http://www.grc.nasa.gov/WWW/K-12/airplane/foil3.html

DISCUSSION QUESTIONS

- Conduct a class discussion where students share their findings about how an airfoil works. *Answers will vary.*
- Describe an airfoil. *It is an aerodynamic surface shaped used for testing the reaction from the air through which it moves.*
- Take a blank sheet of paper and diagram an airfoil cross section. Draw arrows to show the airflow above and below the airfoil. *See diagram in activity.*

ASSESSMENT ACTIVITIES

Experimentally determine:

- What happened to the airfoil at a 40-degree angle? *The airfoil at a 40-degree angle moved up the wire.*
- What happened to the airfoil at a 70-degree angle? *The airfoil at a 70-degree angle moved up the wire more than it did at the 40-degree angle, and it moved more quickly.*
- Explain why there was a difference. *The size of the lift force increases with the angle of the airfoil to the wind.*
- What happened when you flipped the airfoil over? Explain. *When the airfoil is flipped over, the air forces it to the ground because the curved surface of the wing was not on top.*
- What conclusions can you draw from this experiment about the angle of a wing? *From this experiment you can conclude that a wing needs to have the curved surface on top, and it needs to have an upward angle for the best lift.*

ENRICHMENT

- Experiment with various other angles of attack.
- Create other airfoils curvature surfaces to place on wire.