Beginners Guide to Aeronautics

LESSON DESCRIPTION
Students perform a series of simulations to explore the theory and practice of flight

OBJECTIVES
Students will:
- Explore the theory and practice of flight using Web-based and downloadable computer simulation programs for the Beginners Guide to Aeronautics Web site
- Conduct experiments using a simulation
- Apply input variables into a simulation
- Analyze the graphical interpretations of a simulation

NASA SUMMER OF INNOVATION

UNIT
Engineering

GRADE LEVELS
7 – 9

CONNECTION TO CURRICULUM
Science, Mathematics, and Technology

TEACHER PREPARATION TIME
1 hour per computer simulation

LESSON TIME NEEDED
1 hour per computer simulation   *Complexity: Advanced*

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
- Position and motion of objects
- Motions and forces

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

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
- Write and interpret numerical expressions
- Analyze patterns and relationships

ISTE NETS and Performance Indicators for Students
Creativity and Innovation
- Apply existing knowledge to generate new ideas, products, or processes
- Use models and simulations to explore complex systems and issues
- Identify trends and forecast possibilities

Communication and Collaboration
- Interact, collaborate, and publish with peers, experts, or others employing a variety of digital environments and media

- Communicate information and ideas effectively to multiple audiences using a variety of media and formats
- Contribute to project teams to produce original works or solve problems

Research and Information Fluency
- Plan strategies to guide inquiry
- Locate, organize, analyze, evaluate, synthesize, and ethically use information from a variety of sources and media
- Evaluate and select information sources and digital tools based on the appropriateness to specific tasks
- 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
- Use multiple processes and diverse perspectives to explore alternative solutions

Digital Citizenship
- Advocate and practice safe, legal, and responsible use of information and technology
- Exhibit a positive attitude toward using technology that supports collaboration, learning, and productivity
- Demonstrate personal responsibility for lifelong learning
- Exhibit leadership for digital citizenship

Technology Operations and Concepts
- Understand and use technology systems
- Select and use applications effectively and productively
- Troubleshoot systems and applications
- Transfer current knowledge to learning of new technologies

MANAGEMENT
Teachers need familiarization of each simulation before presenting to students. Preload the Web site and/or simulations on student computers.

CONTENT RESEARCH
KEY CONCEPTS

MATERIALS
- Computer lab with teaching computer and projector
- Simulator software installed on individual computers
- Computer lab with Web access to Beginners Guide to Aeronautics Web site below

- **Air Pressure—**The weight or force of air pressing on a surface.
- **Bernoulli Principle—**Daniel Bernoulli explained that when a fluid moves faster, the molecules inside the fluid exert less pressure on the objects around them, or as the speed of a moving fluid increases, the pressure within the fluid decreases. This applies to all fluids, liquids, and gases.
- **Center of Mass—**The point in an object about which the object's weight is centered.
- **Center of Pressure (the other "center")—**The point on the surface of an object about which the object's surface area is centered. One-half of the total air pressure is on one side of the point and half on the other side.
- **Engine—**The part of the aircraft that provides the power for takeoff and landing and sustains flight.
- **Four forces of flight—**Lift, thrust, drag, and weight
  - **Lift** is a force that acts upward against gravity and makes it possible for aircraft to rise in the air.
  - **Thrust** is a forward force that pushes an aircraft through the air.
  - **Drag** is the force of resistance to the motion of a vehicle body as it moves through a fluid such as water or air; drag acts in the opposite direction to thrust.
  - **Weight** is a response of mass to the pull of gravity. It acts downward against lift.
- **Glider—**An aircraft that has no engine and is carried along by air currents.
- **Jet Engine—**A type of air-breathing engine often used on aircraft. The engine draws air in at the front and compresses it and then combines with fuel and ignited. The engine burns the resulting mixture. The

combustion (burning) greatly increases the volume of the gases, which are then exhausted (pushed) out of the rear of the engine. The force of the gases being pushed out of the back thrusts the plane forward.

- **Newton's Laws of Motion—**The laws relate force and direction to all forms of motion.
  - o **Newton's First Law—**Objects at rest remain at rest and objects in motion remain in motion in a straight line unless acted upon by an unbalanced force.
  - o **Newton's Second Law—**The second law relates force, acceleration, and mass. Force equals mass times acceleration.
  - o **Newton's Third Law—**For every action, there is an equal and opposite reaction.
- **Parts of an Airplane:**
  - o **Fuselage—**Long narrow part of the aircraft going down the center that contains the main systems of the plane and space for the cockpit, passengers, and cargo, and to which the wings and tail are attached.
    - **Cockpit—**Control center where the pilot, instrumentation, and navigational aids used in flying are located.
    - **Engine—**Part of the airplane that provides the power (thrust) for sustaining flight and for takeoff and landing.
    - **Landing Gear—**Wheels, floats, or skis of an aircraft.
  - o **Wings—**Long areas of the plane extending from the fuselage that produce lift as the plane moves through the air ailerons, which are surfaces on the outer trailing edge of the wing that move up and down to roll the plane and bank the wings into a turn.
    - **Flaps—**Part of the trailing edge of the wing that is lowered to increase lift and also to slow down the aircraft for landing by increasing drag.
  - o **Tail**—Also called the empennage; the rear part of an aircraft, including the horizontal and vertical stabilizers, elevators, and rudder.
    - **Vertical Stabilizer—**Vertical wing-like part of an aircraft's tail assembly that is fixed and to which the rudder is hinged.
    - **Rudder—**Vertical part usually hinged to the vertical stabilizer and used to move the aircraft left or right (yaw).
    - **Horizontal Stabilizer—**Horizontal wing-like part of an aircraft's tail assembly that is fixed and to which the elevator is hinged.
    - **Elevator—**Surface on the horizontal part of the tail section that moves up or down to control the up and down motion (pitch) of the plane.
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- **Pitch—**Act of moving the nose of a plane up or down, controlled by the elevators.
- **Roll—**Act of banking a plane left or right, controlled by the ailerons.
- **Wind Tunnel—**Machine that can simulate the movement of air around an aircraft in flight.
- **Yaw—**Act of turning an aircraft to the left or right, controlled by the rudder.

LESSON ACTIVITIES
The Beginner's Guide to Aeronautics Homepage
http://www.grc.nasa.gov/WWW/K-12/airplane/index.html
- **FoilSim III Simulator** program
  - o With this software you can investigate how an aircraft wing produces lift and drag by changing the values of different factors that affect lift and the factors that affect drag.
- **AtmosModeler Simulator** program
  - o With this software you can investigate changes in the atmosphere and its effects on aerodynamic variables.
- **Interactive Sound Waves Simulator** program
  - o With this software you can investigate how sound waves travel through the air.
- **EngineSim Simulator** program
  - o With this software you can investigate how a jet (or turbine) engine produces thrust by interactively changing the values of different engine parameters.
- **Wright 1901 Wind Tunnel Simulator** program
  - o With this software you can investigate exactly the same way that the Wright Brothers' 1901 wind tunnel worked.

- **TunnelSys Simulator** program
  - o With this software you can investigate the design, testing, and post-processing of a wing model in a wind tunnel.

Aerodynamics of Baseball

- **Hit Modeler Simulator** program
  - o With this software, you can study how far a baseball will travel after it is hit by a bat by changing the values of the factors that affect the aerodynamic forces on the ball. These are the same forces that generate the drag of an aircraft wing.

- **Curveball Simulator** program
  - o With this software you can study how a big league pitcher throws a curveball by changing the values of the factors that affect the aerodynamic forces on the ball. Values include the pitch speed, wind, and weather conditions. These are the same forces that generate the lift of an aircraft wing.

Aerodynamics of Soccer

- **Soccer NASA Simulator** program
  - o With this software you can study how a soccer player "bends" the ball and makes it curve through the air by changing the values of the factors that affect the aerodynamic forces on the ball. Factors include the speed of the kick, the direction and angle, and the weather conditions. These are the same factors that affect the lift and drag on an aircraft wing.

ADDITIONAL RESOURCES
Aeronautics Educators Guide
http://www.nasa.gov/audience/foreducators/topnav/materials/listbytype/Aeronautics.html
- Aeronautical lesson plans containing experiments

The Courage to Soar Educator Guide
http://www.nasa.gov/audience/foreducators/topnav/materials/listbytype/The_Courage_to_Soar.html
- Aeronautical lesson plans containing vocabulary lists, student texts, diagrams, experiments, and student data sheets

The Beginner's Guide to Aeronautics Homepage
http://www.grc.nasa.gov/WWW/K-12/airplane/index.html
- Aeronautical activities, interactive activities, interactive simulator, and animated movies

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
- Aeronautical lesson plans containing experiments

DISCUSSION QUESTIONS
What is a Web-based computer simulation program? *With a Web-based computer simulation version, you have to be connected to the Internet. Input is provided by user inputs on a variety of variables, interactively changing the independent variables for different parameters. Output is provided by a variety of plots, performance graphs, and text fields. Different versions require different levels of knowledge, experience with computer simulation packages, and familiarity with computer technology.*
What is a downloaded computer simulation program*? With a downloaded version, you can run the program offline and do not have to be connected to the Internet.*
Why is the Web-based computer program considered to be a simulation? *A Web-based or software computer program is similar to reality.*

ASSESSMENT ACTIVITIES
Provide independent variables for a simulation that students will run and instruct them to interpret results graphs.

ENRICHMENT

Smart Skies—Line Up With Math

http://smartskies.nasa.gov/lineup/

- Interactive computer-based Air Traffic Control Simulator
- Six Problems sets, teacher guides, and students work books