

Wind Tunnel Testing

Learning Objectives

- Students will learn the four forces of flight.
- Students will explore the basic understanding of aerodynamics and the use of wind tunnels in testing aircraft.

Activity Overview

- Students will use the Engineering Design Process to design, build, and test a model aircraft using a wind tunnel.

Standards Addressed

- **SC.3.E.5.4**– Explore the Law of Gravity by demonstrating that gravity is a force that can be overcome.
- **SC.3.N.1.1** – Raise questions about the natural world, investigate them individually and in teams through free exploration and systematic investigations, and generate appropriate explanations based on those explorations.
- **SC.N.1.2** - Compare the observations made by different groups using the same tools and seek reasons to explain the differences across groups.
- **SC.4.P.12.1** - recognize that an object in motion always changes its position and may change its direction.
- **SC.5.P.13.1** - Identify familiar forces that cause objects to move, such as pushes or pulls, including gravity acting on falling objects.

Materials

Item	Quantity Needed	Notes
Wind Tunnel	1	
Tape	1 roll	
Cardstock	1 ream	
Paperclips	1 box	
Cardboard tubes	8-16	
Craft sticks	1 box	
Aluminum foil	1 roll	
Toothpicks	1 box	
Scissors	2 per group	<i>As needed</i>
Meter stick	1	

Preparation

- Create a testing station by placing the wind tube horizontally. Place the meter stick inside the wind tube to measure how far the models move.
- Create 6 trays with the following: 1 foot tape, 3 sheets of cardstock, 5 paper clips, 5 craft sticks, 2 cardboard tubes, 1 sheet aluminum foil, and 5 toothpicks.

Science Content

What are Wind Tunnels?

Wind tunnels are machines for “flying” aircraft on the ground. They are tube-like structures or passages in which wind is produced, usually by a large fan, to flow over objects such as aircraft, engines, wings, rockets, or models of these objects. A stationary object is placed in the test section of a tunnel and connected to instruments that measure and record air flow around the object and the aerodynamic forces that act upon it. From information gathered in these observations, engineers can determine the behavior of an aircraft or its components at takeoff, while cruising, and during descent and landing. Wind tunnels also help engineers determine the performance of, and eliminate bugs in, new designs of civil and military aircraft without risk to a pilot or costly aircraft. Responses to flight conditions of new materials and shapes for wings, ailerons, tails, fuselages, landing gear, power systems, and engine cowlings can be assessed before these designs are incorporated into aircraft.

Types of Wind Tunnels

According to NASA’s official “Aeronautical Facilities Catalogue”, there are about 42 wind tunnels throughout the United States. Some of these tunnels are designed for the study of wing and fuselage shapes. Other wind tunnels are devoted either to testing propulsion systems or testing at various speeds. Airflow in a wind tunnel is produced and conditioned in several ways to simulate flight at the speeds, altitudes, and temperatures that would be encountered by particular kinds of aircrafts. The speed of air flowing through a tunnel is usually expressed in terms of the speed of sound (760 mph). The ratio between the speed of airflow and the speed of sound is called a Mach number. At Mach 2, for example, the speed of a vehicle is twice the speed of sound (1,520 mph at sea level).

Source: <http://www.nasa.gov>

Facilitation Guide

Engage (10 minutes)

- I. Introduce the activity by discussing with students the four forces of flight:
 - Lift: the upward force that opposes gravity, allowing an aircraft to stay airborne.
 - Drag: the force that opposes the aircraft’s motion through the air, acting in the opposite direction of thrust.
 - Thrust: the forward force that propels the aircraft through the air, typically generated by engines or propellers.
 - Weight: the downward force due to gravity, acting on an aircraft’s mass.

2. Explain to students that different types of aircrafts need to be tested before a manned flight, to ensure safety and efficiency. Scientists typically use wind tunnels to do this. Show the class a few wind tunnel examples on the PowerPoint.
3. Introduce the challenge to the students: design and create a model aircraft that can fit safely and fly within the wind tube.
4. Explain that in order to meet the goals of the challenge, they will need to use the Engineering Design Process. Briefly explain the Engineering Design Process to the students. First they define a **GOAL** for the design and **ASK** questions to establish design criteria. They **IMAGINE** at least two possibilities for design. Then they **PLAN** the design before building. They **CREATE** at least one design solution and test it. Then, they **IMPROVE** the design and test it again.

Activity (30 minutes)

1. Allow students to **ASK** questions so they have a good understanding of the activity and the goals. Questions could include: what materials do we have, how much time do we have to build, how do we test, etc.
2. Once all questions have been answered, have the students briefly close their eyes and **IMAGINE** a possible solution to the problem and how they would meet the goals.
3. Give the students a few minutes to come up with a **PLAN** for their design and to decide which materials they would like to use. When they have a plan, have ONE student from each group come up and grab a tray of materials.
4. Give students about 15 minutes to **CREATE** their design. As groups are working, circulate around the room and ask:
 - How and why did your team choose this design?
 - How do you think it will work?
 - Do you think it will meet the goals? Why do you think so?
5. To test, have each group place their model in the wind tunnel and measure how far the model aircraft traveled using the meter stick.
6. After testing, give groups an additional 7-10 minutes to **IMPROVE** their design before testing again.

Reflect (10 minutes)

1. How is the wind tunnel used to test aircraft? How do you think our model is similar and/or different from real-life wind tunnels?
2. What was successful about your model aircraft?
3. Which of the four forces of flight do you think was the strongest on your aircraft?