National Aeronautics and Space Administration

3..2..1..Takeoff! *(Complex Version)*

Exploring the forces of flight on a straw paper airplane | Suggested Grades: 5-8

Activity Overview

In this activity, students will construct small paper x-planes and fly them by producing their own thrust, by blowing air through a drinking straw, to examine Newton's Third Law of Motion. Students will design and build a second airplane attempting to improve the design of their plane in order to allow it to fly further.

Steps

1. Review Newton's Third Law of Motion, the forces of flight and how these principles affect aircraft. Discuss the X-59 Quiet SuperSonic Technology (QueSST) aircraft and how NASA designs aircraft.

2. Direct students to the construction technique for making the paper x-plane (refer to images on page 2).

3. Complex X-Plane construction:
   a. Carefully cut out the rectangle and wing shape (page 3). The rectangle will be the fuselage (body) of the plane.
   b. Wrap the rectangle around a pencil length-wise and tape the rectangle so that it forms a tube (Fig.1, page 2). Note: do not tape tube to pencil.
   c. Leave the pencil in place and tape the wing shape onto the fuselage. Ensure the outlined tabs line up with the fuselage (Fig.1, Step 2).
   d. Using the sharpened end of your pencil, twist the top of the fuselage into a nose cone and tape (Fig.1, Step 3).
   e. Measure the length of the paper plane in centimeters from end to end and record in Data Table (page 5).

4. Remove the pencil and replace it with a straw. Blow into the straw to fly your plane! Fly your plane 3 times, record the distance traveled for each flight, and calculate the average distance your plane traveled in the Data Table (page 5).

5. Once completed, the first design will act as your control. Next students will design their own x-plane, but choose one variable to change (for example plane length) with the goal of increasing the distance it travels. Students can simply make adjustments to their first plane or design and build their own design (Design 2) in the space provided on page 3.

6. To finish the activity, have students analyze their data and answer the discussion questions on page 5.

Time: 45 minutes

Materials:

- Paper plane template
- Clear tape
- Scissors
- Ruler
- Meter stick or tape measure
- Pencil
- Drinking straw

NEXT GENERATION SCIENCE STANDARDS

- 3-PS2-2
- 5-PS2-1
- MS-PS2-1
- MS-PS2-2

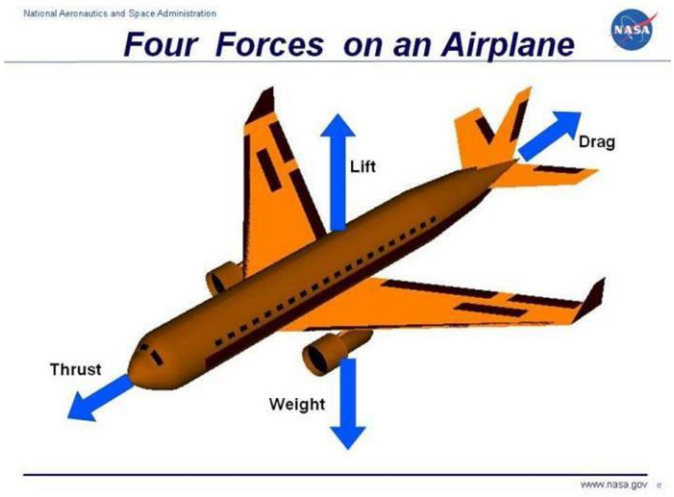
Suggested Lithograph:

Newton's Third Law of Motion

Every action has an equal and opposite reaction. Unlike traditional planes, paper planes do not carry their own fuel. Instead, a sharp puff through the straw momentarily fills the plane tube with "high pressure" air. The tube directs the air back through the opening, producing an action force. The straw planes take-off because of the equal and opposite reaction force (Newton's third law). These two forces are referred to as a force pair. A force pair identifies two interacting objects and describes the direction of the force acting on each object. It is important to note that both forces in the force pair are the same type (e.g. gravitational), are equal in magnitude, and are opposite in direction.

Four Forces on an Airplane

A plane flies because of four forces: lift, thrust, drag and weight. As the plane flies through the air, lift holds it up. Thrust from the engine sends it forward. Drag from the air slows it down. Its weight brings the plane back to Earth again. Each force has an opposite force that works against it. Lift works opposite of weight. Thrust works opposite of drag. When the forces are balanced, a plane flies in a level direction.



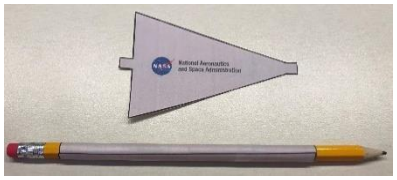
Manufacturing of NASA's X-59 QueSST Begins

NASA and Lockheed Martin have now taken a step closer to a future with faster-than-sound air travel over land.

Lockheed Martin Aeronautics Company of Palmdale, California, recently began manufacturing the first part of NASA's X-59 Quiet SuperSonic Technology (QueSST) aircraft. When completed, NASA will use the X-59 to study how reducing the sonic boom heard from traditional supersonic jets to a quiet sonic "thump" could lead to acceptance of supersonic flight over land.

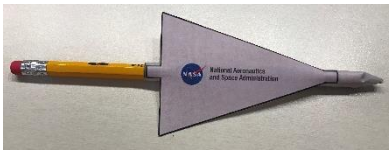
For more information please visit the following website: https://www.nasa.gov/image-feature/langley/manufacturing-of-nasa-s-x-59-quesst-begins

Fig. 1: X-Plane Instructions

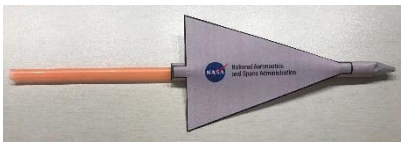


Step 1: Wrap rectangle around pencil lengthwise and tape closed (do not tape to pencil).

Step 2: Tape wing shape to the top of the tube.



Step 3: Twist end of tube into a nose using pencil tip. Secure twisted tip with tape.

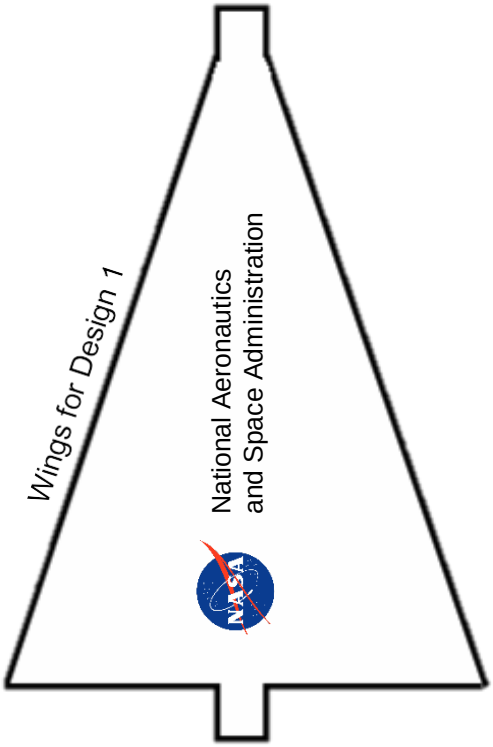


Step 4: Remove pencil and replace with straw.

Other Resources:

- https://www.nasa.gov/stemonstrations-newtons-third-law-rocket-races.html
- https://www.youtube.com/watch?v=9AmGa9Qv8Ec
- https://www.nasa.gov/lowboom/new-nasa-x-plane-construction-begins-now

X-Plane Template



Optional: For Design 2, draw and cut out your own wings and fuselage in the space below.

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Data Table

	Design Details		Distance Traveled (cm)			
	Wing Shape (sketch)	Plane Length (cm)	Trial #1	Trial #2	Trial #3	Average Distance $= \frac{Trial\ 1 + Trial\ 2 + Trial\ 3}{3}$
First Design (Control)						
Second Design						

Discussion Questions:

1. How did your average flight distances compare? Between the two designs, which one flew the furthest?

2. What did you change in your second plane design?

3. Did the changes you made to your airplane increase or decrease the average distance your plane traveled the second time?

4. If you were going to make a third plane what would you do differently? Why?