National Aeronautics and Space Administration

Fan-tastic Forces

Exploring the forces of flight | Suggested Grades: 3-8

Activity Overview

Visitors will engage in a series of demonstrations focusing on the forces of flight using different materials and shapes to determine which are the most and least susceptible to lift, weight, drag, and thrust.

Steps

1. Optional: watch instructional video prior to starting activity with students. https://youtu.be/422Cgx1NZZk
2. Construct forces of flight objects needed prior to visitor arrival (see page 3).
3. Briefly review the four forces of flight and their importance to an aircraft. It is important to remind visitors that each force is dependent on the opposite force.
4. Explain to visitors that they will be able to witness and demonstrate these four forces using different objects with a fan.
5. For each force of flight ask visitors to select which they think will be most susceptible or least susceptible to each force. Example questions are listed below.
    a. **Lift:** Which wings will be pushed up higher? The wings with more or less surface area?
    b. **Weight**: Which material will need more power to fly and stay in the air?
    c. **Drag**: Which airplane shape will take off (move forward) the easiest?
    d. **Thrust**: Which setting on the fan do you think has the most power.
6. Allow visitors to test each force and determine which was most/least susceptible when the force was applied. (To test: visitors will hold each constructed demonstration in front of the fan, with the demonstration facing towards the fan).
7. At this point you can discuss with visitors how aircraft designs and NASA take into account the four forces of flight.

Connections

- When might you feel the forces of flight? ie. swing, wind
- How many of the forces of flight do you feel from the ground?
- What in your daily life reflects the aerodynamic principles of the four forces of flight?

Time: 5-10 minutes

Materials:

- Fan/Box fan
- Ruler
- Tape
- Straws
- Patterns for 3D shapes
- Paper
- 2 objects of equal size, but different weights (i.e. notecard vs. plastic cutout)

NEXT GENERATION SCIENCE STANDARDS

- 3-PS2-1
- 3-PS2-2
- 5-PS2-1
- MS-PS2-4

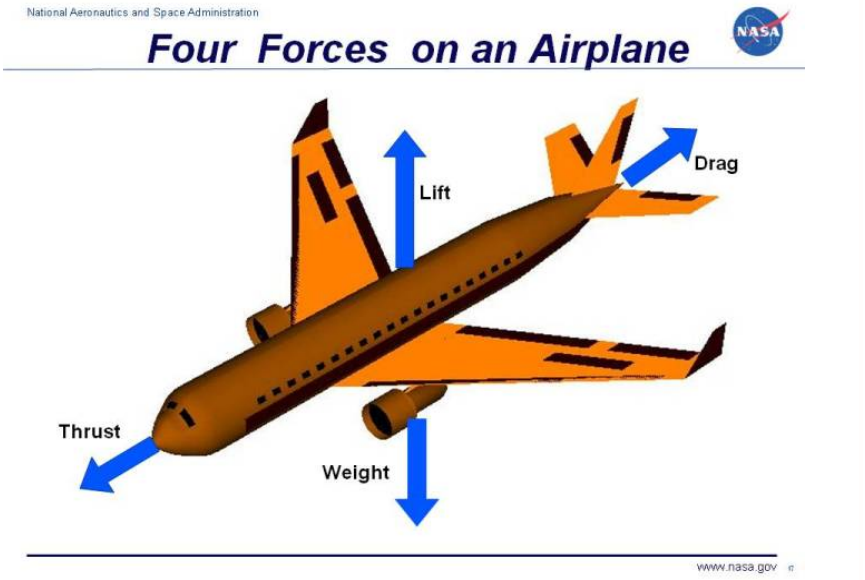
For more information and further activities:

- www.nasa.gov/X59
- www.nasa.gov/stem/nextgenstem/aeronaut-x/
- www.nasa.gov/aeroresearch

Understand How Objects Fly by Learning About the Four Forces of Flight.

When an airplane flies, the wing is designed to provide enough lift to overcome the airplane's weight, while the engine provides enough thrust to overcome drag and move the airplane forward. The thrust from an engine will need to overcome the weight of the airplane to move it forward.

Increasing the weight of an airplane affects the amount of lift needed. In turn, a larger wing would provide more lift, but that would increase the amount of drag and therefore increase the amount of thrust needed. The forces of flight are interconnected, and a change in one affects the others.



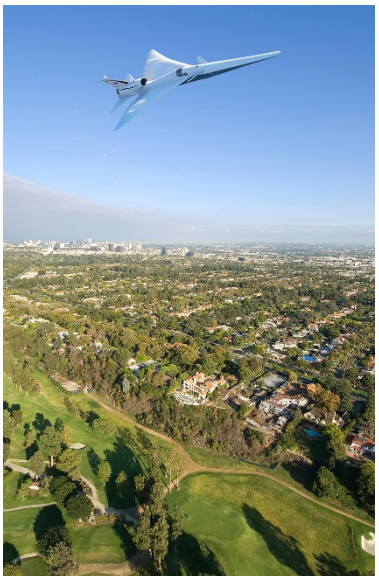
NASA Prepares to Go Public with Quiet Supersonic Tech

With the X-59 you're still going to have multiple shockwaves because of the wings on the aircraft that create lift and the volume of the plane. But the airplane's shape is carefully tailored such that those shockwaves do not combine," said Ed Haering, a NASA aerospace engineer at Armstrong.

"Instead of getting a loud boom-boom, you're going to get at least two quiet thump-thump sounds, if you even hear them at all," Haering said.

For more information please visit the following website:
https://www.nasa.gov/aero/nasa-prepares-to-go-public-with-quiet-supersonic-tech

An artist's concept of the low-boom flight demonstrator outside the Lockheed Martin Aeronautics Company's Skunk Works hangar in Palmdale, California.
Credits: Lockheed Martin



Aeronautical innovations are part of a government-industry partnership to collect data that could make supersonic flight over land possible, dramatically reducing travel time in the United States.
Credits: NASA

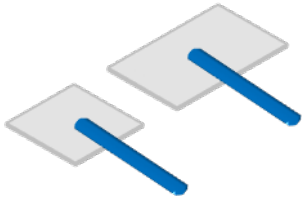
Suggested Lithograph:

For videos relating to sound and the X-59, please visit:
https://www.youtube.com/playlist?list=PLTUZypZ67cdvZ3TbQbDiqLdOkrCswmkUZ

How to construct demonstrations:

Lift:

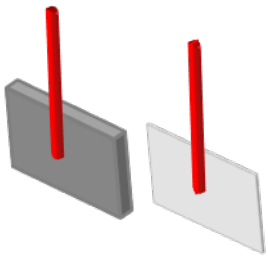
1. Cut one notecard in half hamburger style.
2. Securely attach a straw to the back of one full size notecard and a separate straw to the notecard just cut in half.
    a. For decoration, pictures of planes or different styles of wings can be glued to the front of the cards.



Lift: example of constructed lift demonstration with 2 notecards of different sizes.

Weight:

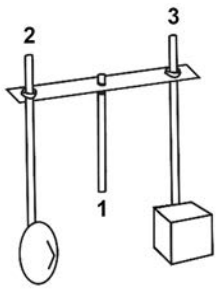
1. Construct or select 2 objects of equal size (equal surface area), but of different weights.
2. Securely attach objects to separate straws for visitor handles.



Weight: example of constructed weight demonstration with notecard and plastic.

Drag:

1. On straw one, wrap a piece of tape about one inch below the top of the straw. Make sure the tape is evenly wrapped and forms a level surface. Set this straw aside until step 5.
2. Using the shapes on page 5-7, construct both a tetrahedron and a cube.
3. Attach the pyramid and cube shapes to the bottom of straws two and three using tape.
4. Place the ruler over straws two and three in the holes on the outer sides of the ruler and attach each straw securely with tape.
5. Using the taped straw from step 1, place it through the center hole in the ruler. When holding this straw, the ruler should be balanced on top of the tape with the shapes equal distances apart (the ruler should be able to rotate on top of the straw like a helicopter propeller).



Drag: constructed drag demonstration

Thrust:

1. Adjust the setting on the fan from low to high.

Activity Extension:

1. Construct paper airplanes with straws through the middle as handles and allow students to hold them in front of the fan. Ask students to explain the four forces of flight enacting on the plane.
2. Ask students to use what they learned to design and create their own aerodynamic airplane.

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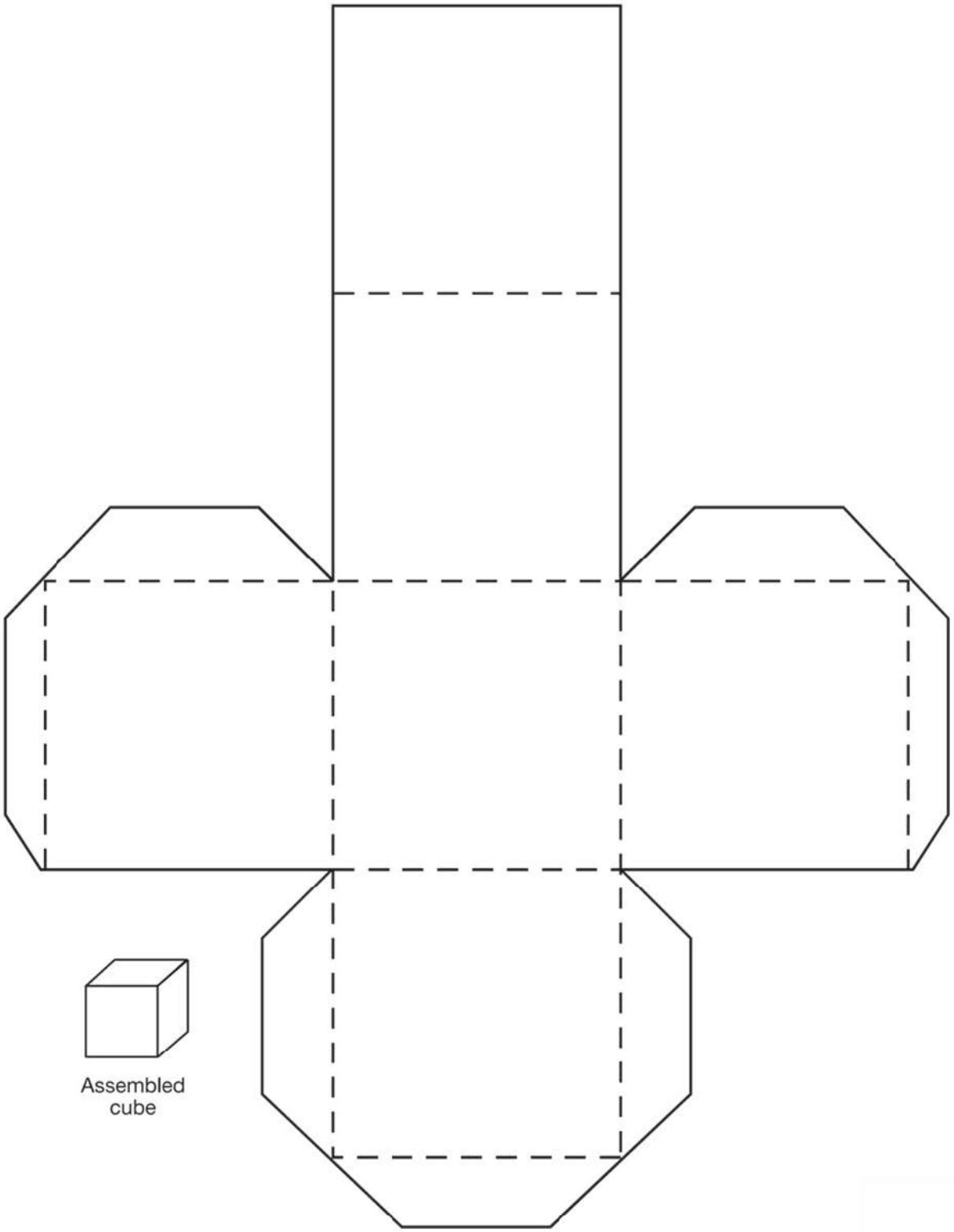
Assembled
cube

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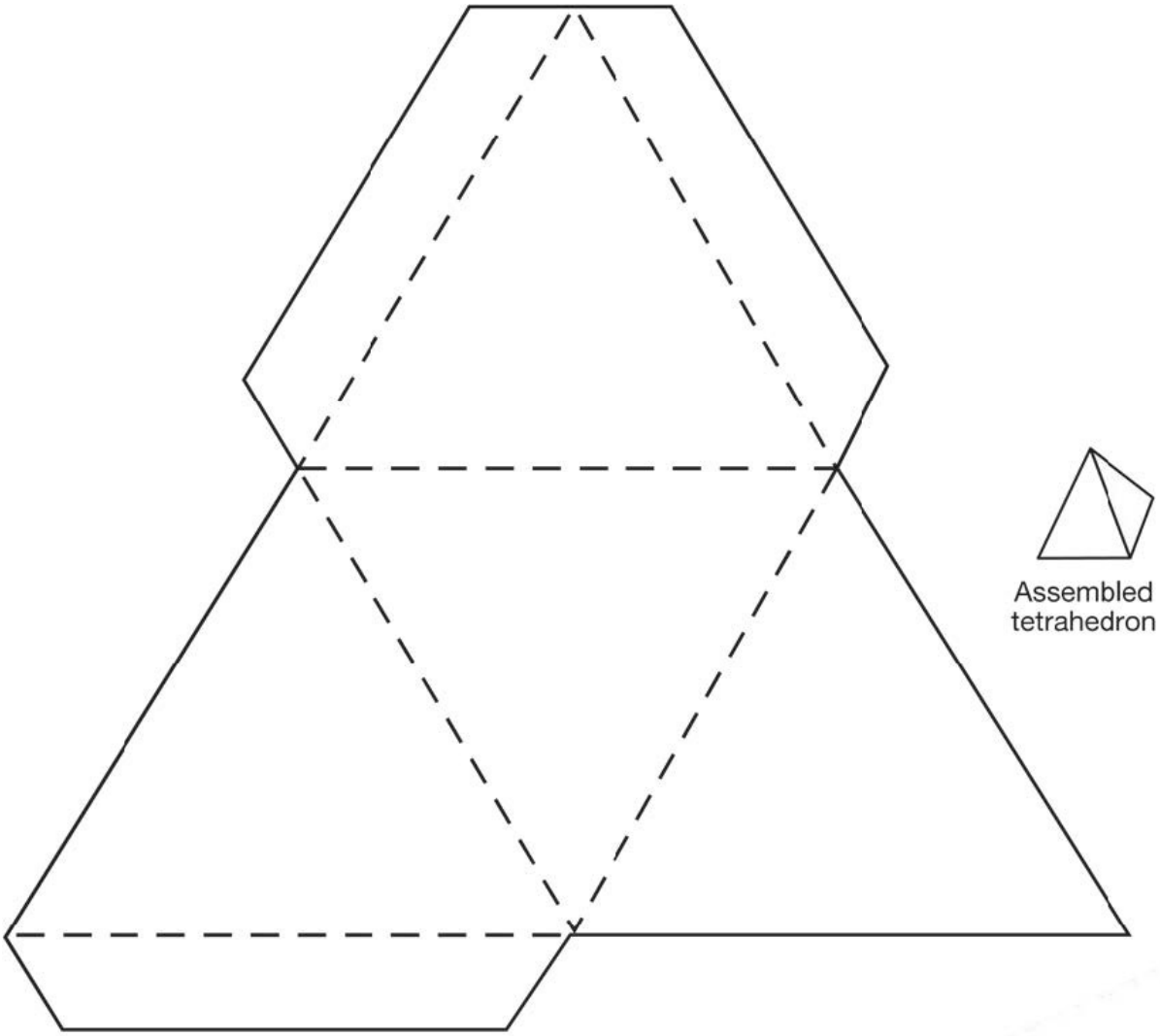

Assembled
tetrahedron