National Aeronautics and Space Administration

Shape Your Flight

Exploring geometry and its relation to aircraft design | Suggested Grades: 5-9

Activity Overview

Students will build a paper airplane and calculate the triangular area of the wings, then test and calculate the accuracy of their aircraft's flight.

Steps*

1. Explain to students the forces of flight and how these principles are important to understanding how NASA designs new aircraft. Optional: View History of X-Planes video with students.
2. Review how to calculate and measure the area of a triangle with your students. Then, divide the students into groups of 2-4.
3. Have students construct a paper airplane in their groups following the directions provided on page 5.
4. For *Part 1*, students will outline two right triangles within each wing on their paper airplane (Figure 1, page 5).
5. Using **centimeters**, students will take measurements of the triangles' sides outlined in Step 4 and record in the Part 1: Data Table. Using these measurements, calculate the area of each wing and record in the Data Table.
6. Next, for *Part 2*, students will fly their airplanes. A flight line should be marked with masking tape to a distance of 7.5 meters. A take-off point should be clearly marked for students (Figure 2, page 5).
7. Students will launch their airplanes at the same height for each test trial (shoulder level suggested) from the take-off point. Keep in mind the objective of this activity is for the airplane to fly with the greatest accuracy possible (smallest triangular area of flight). Students will sketch all flight triangles on page 4.
8. All following measurements need to be recorded in the Part 2: Data Table using **meters**. Students will first measure the distance between the flight line and the landed paper airplane. See "Side a" in Figure 2. This measurement should be perpendicular to the flight line to ensure a right angle is created.
9. Next, students will measure the distance between the take-off point and the perpendicular point that crossed the flight line (point where right angle is created). See "Side b" in Figure 2.
10. Select an option below to continue the activity in the Part 2: Data Table:
    1. Simple Option: Classify the triangle, measure the sides and calculate the perimeter and area.
    2. Advanced Option: Students will use the Pythagorean Theorem to calculate the measurement of the hypotenuse and then calculate the area.**
11. For test trials 2 and 3 students will repeat steps 7 through 10.
12. Have students compare their results, complete their discussion questions (page 4), and determine their most accurate flight.
13. Review the activity discussion questions as a group.
14. Optional: Repeat this activity allowing students to create their own paper airplane design and compare results. This should lead to a discussion on how the shape of the aircraft affects accuracy of flight.

Time: 45 Minutes

Materials:

- Paper
- Tape
- Metric Ruler
- Pencil
- Tape Measure
- Activity Worksheet
- Calculator

*Large empty space is required for this activity.

NEXT GENERATION SCIENCE STANDARDS

MS-ETS1-3
MS-ETS1-4

COMMON CORE MATH STANDARDS

CCSS.MATH.CONTENT.
6.G.A.1
6.G.A.4
7.G.A.1
7.G.A.2
7.G.A.6
8.G.B.6
8.G.B.7
HSG.MG.A.3

*Certain aspects of activity may need to be adapted to adequately align with student's abilities.
** Calculating the length of the hypotenuse is not necessary to calculate the area of the triangle.

New Wing Design Exponentially Increases Total Aircraft Efficiency

Innovators at NASA's Armstrong Flight Research Center are experimenting with a new wing design that removes adverse yaw and dramatically increases aircraft efficiency by reducing drag. Known as the PRANDTL-D wing, this design addresses integrated bending moments and lift to achieve a 12 percent drag reduction. The approach to handling adverse yaw employs fine wing adjustments rather than an aircraft's vertical tail. The technology has the potential to significantly increase total aircraft efficiency by optimizing overall aircraft configuration through the reduction in size or removal of the vertical tail as well as the reduction of structural weight. Similar improvements have been applied to propellers to achieve significant efficiencies with rotating machinery.

For more information, please visit the following website:
https://technology-afrc.ndc.nasa.gov/featurestory/prandtl-wing-design

New Wing Design Exponentially Increases Total Aircraft Efficiency.
Credits: NASA
Illustration of the X-59 QueSST as

New NASA X-Plane Construction Begins Now

NASA's aeronautical innovators are ready to take things supersonic, but with a quiet twist. For the first time in decades, NASA aeronautics is moving forward with the construction of a piloted X-plane, designed from scratch to fly faster than sound with the latest in quiet supersonic technologies.

The answer to how the X-plane's design makes a quiet sonic boom is in the way its uniquely-shaped hull generates supersonic shockwaves. Shockwaves from a conventional aircraft design coalesce as they expand away from the airplane's nose and tail, resulting in two distinct and thunderous sonic booms.

But the design's shape sends those shockwaves away from the aircraft in a way that prevents them from coming together in two loud booms. Instead, the much weaker shockwaves reach the ground still separated, which will be heard as a quick series of soft thumps – again, if anyone standing outside notices them at all.

It's an idea first theorized during the 1960s and tested by NASA and others during the years since, including flying from 2003-2004 an F-5E Tiger fighter jet modified with a uniquely-shaped nose, which proved the boom-reducing theory was sound.

For more information, please visit the following website:
https://www.nasa.gov/lowboom/new-nasa-x-plane-construction-begins-now

Illustration of the X-59 QueSST as it flies above NASA's Armstrong Flight Research Center in California.
Credits: Lockheed Martin

NASA Selects Three Ideas to Pursue that Could Help Transform Aviation

Like a collection of savvy entrepreneurs gathered to hear new business proposals in a "shark tank," NASA's aeronautical innovators always are looking for the "next best thing."

Future aircraft designs may look much differently than today's familiar configuration. The wings and tail, for example, might be seamlessly blended with the main hull in one continuous line. These exotic designs – which could reduce fuel use, emissions and noise – will be easier to build using composite materials, which theoretically can be manufactured in any shape.

For more information, please visit the following website:
https://www.nasa.gov/aero/nasa-selects-three-ideas-to-pursue-that-could-transform-aviation

Future aircraft may feature unusual looks made possible through the use of composite structures. Bonding composite parts together in a more efficient manner is one of the ideas selected for study by the Convergent Aeronautics Solutions project.
Credits: NASA

Shape Your Flight

Paper Airplane Worksheet

Part 1: Data Table

Airplane	Triangle	Side a	Side b	Side c	Area (Area = ½·base·height)
Wing 1	Triangle 1	_____cm	_____cm	_____cm	_____cm²
Wing 1	Triangle 2	_____cm	_____cm	_____cm	_____cm²
Total	(Triangle 1 Area + Triangle 2 Area)	X	X	X	_____cm²
Wing 2	Triangle 1	_____cm	_____cm	_____cm	_____cm²
Wing 2	Triangle 2	_____cm	_____cm	_____cm	_____cm²
Total	(Triangle 1 Area + Triangle 2 Area)	X	X	X	_____cm²

Part 2: Data Table

	Trial 1	**Trial 2**	**Trial 3**
Classification of Triangle			
Side a	_____m	_____m	_____m
Side b	_____m	_____m	_____m
Side c Measure or Calculate *Pythagorean Theorem* ($a^2 + b^2 = c^2$)	_____m	_____m	_____m
Perimeter of Flight Triangle (*Perimeter* $= a + b + c$)	_____m	_____m	_____m
Flight Triangle (*Area* $= \frac{\text{base + height}}{2}$)	_____m²	_____m²	_____m²

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Paper Airplane Worksheet

Flight Triangle Sketches

Trial 1

Trial 2

Trial 3

Discussion Questions

1. How can geometry be important when designing aircraft? Determining flight path accuracy?

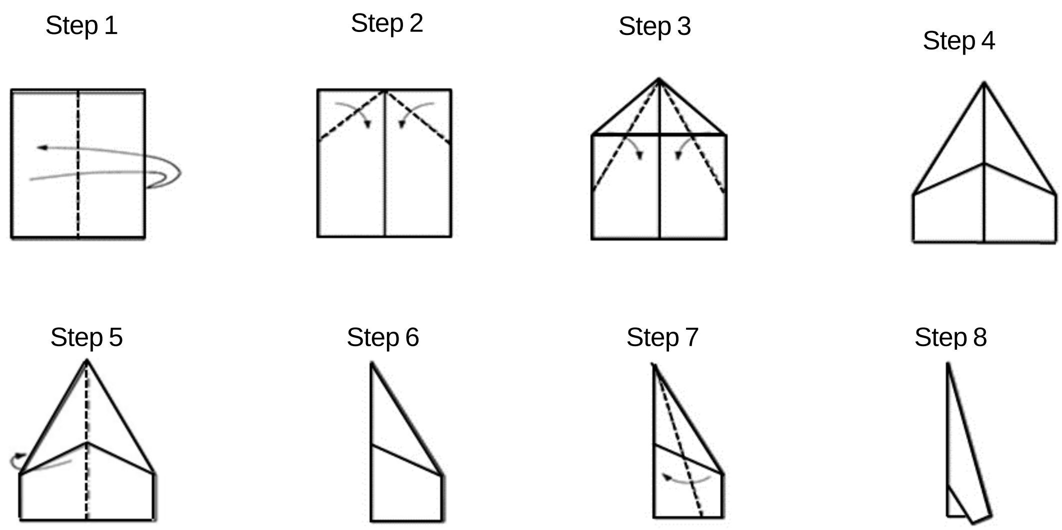
2. How could altering the size or shape of the wing design affect the flight path?

3. Compare your flight triangles. Which trial was the most accurate and why (i.e., which had the smallest triangular area of flight)?

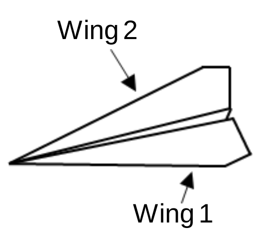
Shape Your Flight

Paper Airplane Diagrams

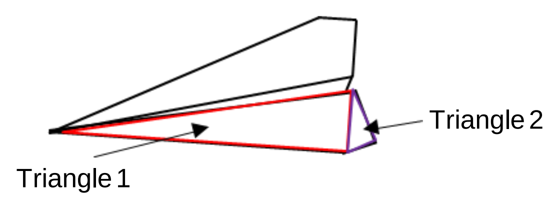
Paper Airplane Folding Instructions



Finished Airplane



Finished Airplane with outlined triangles (**Figure 1**)



Wing 1 Total Area = Triangle 1 area + Triangle 2 area

(Repeat process for Wing 2)

Flight Line Setup and Calculations (**Figure 2**)