STEM On The Go!

Flying Airplane vs Flying Hoopster

Objective:

Students will learn about gravity (weight), lift, thrust and drag as related to the flight of planes.

Grade(s):	8th
Time Allotment:	70-90 minutes
# of Students:	15 groups of two students (30 students max)
STEM Focus:	Science
Topics of Study:	Aerodynamics of flight and design, Forces of gravity, lift, drag and thrust
Author and Date:	Shawn Gardner 2018
Technology Used:	
Associated Industry:	Avcraft Inc., Columbus, NE; Midwest MedAir, Columbus, NE; Army National Guard Unit, Grand Island, NE; Silverhawk Aviation, Lincoln, NE; Duncan Aviation, Lincoln, NE; Offutt Air Force Base, Omaha, NE
Agricultural or Environmental Component:	Uses of payloads delivered by planes or drones to deliver: cargo to rural or disaster areas, medication to people living in rural areas, blood samples to clinics for faster testing in rural areas, defibrillators to heart attack victims, telemedicine kits that would get doctors in touch with victims of natural disasters or terrorist attacks, blood units to surgeons in remote regions of the world, and necessary materials to agricultural crops.
State Fair Moment:	The farthest flight by a paper plane was 226 feet 10 inches (69.14 meters). Show video of world record paper airplane throw (less than a minute) https://www.livescience.com/33741-record-paper-airplane-throw.html
Soft Skills:	Communication, teamwork, problem-solving, interpersonal skills
Optional Online Material and Resources:	https://www.youtube.com/watch?v=5ltjFEei3AI
Lesson Evaluation Form:	https://goo.gl/forms/9PwfHUr2RZaDzrV63

Nebraska Standards

Content (What is taught in each grade level - 2018)

SC 2.1 MATTER. Observe and describe properties of objects and their behavior. Measure objects using standard and non-standard units. Force and Motion - compare relative position and motion of objects.State location and/or motion relative to another object or its surroundings (in front of, behind, between, over, under, faster, slower, forward and backward, up and down). Describe how objects move in many different ways (straight, zigzag, round and round, back and forth, and fast and slow). 2.2.1 ,2.2.1.c ,2.2.2 ,2.2.2.a,2.2.2.b
SC 3: LIFE SCIENCE. Integrate and communicate the information, concepts, principles, processes, theories, and models of the Life Sciences to make connections with the natural and engineered world. (ex: birds and bats were beginning of modern planes).

SC 4: EARTH AND SPACE SCIENCES.
2.4.3.b Observe and describe simple daily changes in weather (how wind affects flight distance).

Grades 3-5 NEBRASKA SCIENCE STANDARDS
SC 2: PHYSICAL SCIENCE: MATTER. Explore and describe physical properties of matter and its changes. Use appropriate metric measurements to describe physical properties. Force and Motion: identify the influence of forces on motion. Describe motion by tracing and measuring an object's position over a period of time (speed). Forces/Newton's 2nd law: Describe changes in motion due to outside forces (push, pull, gravity). Universal Forces: Describe magnetic behavior in terms of attraction and repulsion (gravity).
2.1., 5.2.1, 5.2.1.c, 2.2., 5.2.2, 5.2.2.a, 5.2.2.b, 5.2.2.c

SC 4: EARTH AND SPACE SCIENCES.
4.3. Energy in Earth's Systems
5.4.3 Students will observe and describe the effects of energy changes on Earth.
Energy Sources - Weather and Climate
5.4.3.b Observe, measure, and record changes in weather (temperature, wind direction and speed, precipitation)

State Fair Moment (description of activity): Show video of world record paper airplane throw (less than a minute). World record paper airplane was created by JOHN COLLINS, aircraft designer, and flown by JOE AYOOB, former college quarterback for California. It was constructed from a single sheet of uncut A4 paper.
https://www.livescience.com/33741-record-paper-airplane-throw.html

Materials List -

Container(s) Name(s): Paper Airplane vs Flying Hoopster

Number of Containers: 1

Container Location: STEM On The Go! Trailer

Quantity	Part Description
	Consumables Items
	Paper
	Masking tape
	Scotch tape
	Painter's tape
	3 x 5 inch index cards
	Straws
	Question Sheet
	Recording Sheet
	Non-Consumable Items
1	Lesson Binder
15	Rulers
	Tape measures
	Pencils
	Colored Craft Sticks
5	Calculators
	To be provided by Instructor
	Boxes or hula hoops to use as targets

	Copies of Recording Sheet and Assessment of Learning

Lesson Objective

Students will learn about gravity (weight), lift, thrust and drag as related to the flight of planes.

The same principles are at work in all fliers. Gravity is pulling them down, but,at the same time, air helps hold them up. For something to glide through the air, there must be a balance between the gravity that pulls the glider down and the lift produced as it glides through the air. A design must balance these forces so that the glider moves forward, propelled by the pull of gravity.

Instructions

1. Review key terms: gravity (weight), thrust, lift and drag. Watch video: Show video explaining lift, weight/gravity, thrust and drag (7 minutes) The Aerodynamics of Flight: https://www.youtube.com/watch?v=5ltjFEei3AI
2. Instruct students to get into pairs.
3. Each pair makes one paper airplane and one flying hoopster.
    a. Hoopster: https://www.scientificamerican.com/article/loop-the-loop-with-a-flying-hoopster/
    b. Paper airplane: https://www.diynetwork.com/made-and-remade/learn-it/5-basic-paper-airplanes
4. Each partner practices throwing airplane a few times. Each partner practices throwing the hoopster a few times.
5. Each partner throws paper airplane 2 to 5 times, trying to make it travel as far as possible. Mark where plane landed with craft stick. Measure and record **distance** in feet (to the closest foot).
6. Repeat with the hoopster.
7. Calculate the average distance the airplane flew and record. Calculate the average distance the hoopster flew and record.
8. Each pair throws paper airplane 2 to 5 times, trying to place it inside the target (box or hula hoop). Mark where plane landed with craft stick. Measure and record distance from where plane landed to target (to the closest foot).
9. Repeat with the hoopster.
10. Calculate the average distance the airplane missed the target and record. Calculate the average the distance the hoopster missed the target and record. The smallest average error has the best accuracy.
11. Answer questions located in the Additional Materials section.

Extension of Learning (Optional)

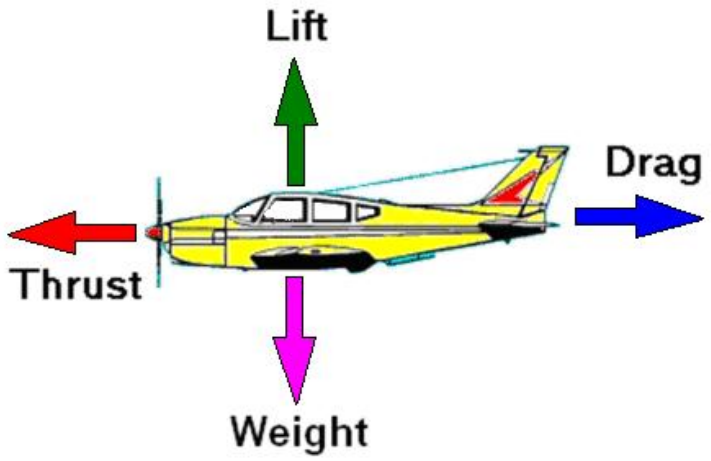
1. **Put a paper clip at the bottom of the small hoop.** What happens when your hoopster has cargo? If you add the same cargo to the paper airplane, does it have a similar effect?
2. Make a **really long hoopster with two straws.** To do this, cut a little slit at the end of one straw and pinch its so it fits inside the other straw, then tape them together. Does it fly farther than the short one?
3. **Make a double hoopster** by using two index cards to create two little hoops side-by-side on one end and two big hoops side-by-side on the other. Do the extra hoops make a difference in how it flies?

Return Instructions

1. Properly dispose of damaged consumable materials.
2. Return all non-consumable and leftover consumable items from the Materials List to the same container they came from.
3. Initial the Return Checklist located in the front of the Lesson Binder found in the lesson container. Make note if any items have been damaged, are missing, need batteries, etc.
4. Return containers to the trailer.
5. Email Danita Wickens - wickensd@discoverers.org - if you had any issues with the lesson.
6. Fill out the Lesson Evaluation Form: https://goo.gl/forms/9PwfHUr2RZaDzrV63

Additional Material

Key Terms: **gravity, lift, drag and thrust**



Gravity is the force which tries to pull two objects toward each other. Anything which has mass also has a gravitational pull. The more massive an object is, the stronger its gravitational pull is.

Lift is the force that directly opposes the weight of an airplane and holds the airplane in the air. **Lift** is generated by every part of the airplane, but most of the **lift** on a normal airliner is generated by the wings. **Lift** is produced by the motion of the airplane through the air.

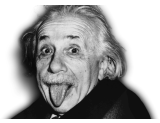
Drag is the sum of all the forces that oppose the motion of the object (in a powered vehicle, **drag** is overcome by **thrust**).

Thrust is the force that propels an object in a given direction, especially when generated by the object itself (by an engine or rocket).

Helpful Teacher Notes:

1. The flying hoopster gets the lift needed to glide from two rings (instead of wings).
2. Normal wings have wing tips - which generate vortices - (Wingtip vortices are circular patterns of rotating air left behind a wing as it generates lift. One wingtip vortex trails from the tip of each wing. Wingtip vortices are sometimes named trailing or lift-induced vortices because they also occur at points other than at the wing tips.). This adds drag, which isn't ideal for an object trying to stay aloft.
3. The lift-providing rings have no wing tips and so they have less drag.
4. The streamlined shape of the "hoopster" also makes it easy to throw accurately.

Partner Names_____



Answer the following questions with your partner.

Assessment of Learning (Formative and/or Summative):

1. How was your throwing technique different for the paper airplane and the flying hoopster? Explain.

2. Which soared farthest on average?

3. Which was most accurate?

4. Are these results what you expected? Why or why not?

5. If you could redesign this experiment by changing something, what would you change? (What could you test that you didn't get to test today?)

Recording Sheet

DISTANCE		
	Airplane Distance in feet	**Hoopster** Distance in feet
Throw 1		
Throw 2		
Throw 3		
Throw 4		
Throw 5		
AVERAGE		
ACCURACY		
	Airplane Distance from target in feet	**Hoopster** Distance from target in feet
Throw 1		
Throw 2		
Throw 3		
Throw 4		
Throw 5		
AVERAGE		

Hoopster Instructions - https://www.scientificamerican.com/article/loop-the-loop-with-a-flying-hoopster/

Key Concepts

Gravity
Thrust
Lift
Drag

Introduction

Paper airplanes are fun to make and fly. Most designs resemble miniature planes—made of folded paper, with wings, stabilizers and sometimes even flaps. These creations look like they are ready to soar. There are some designs, like the one you can try in this activity, however, that look so awkward one might imagine they would not fly at all. Find out if it will really soar!

Background

Although there are many different paper airplane designs, almost all of them have a flat winglike structure, which, like a traditional plane, helps create lift to keep the plane in the air. The plane in this activity, which is reminiscent of Phillip Swift's design entered in *Scientific American*'s International Paper Airplane Competition in 1967, gets the lift needed to glide from two rings, instead of wings. Normal wings have wing tips that generate vortices, adding drag (which isn't ideal for an object trying to stay aloft). The lift-providing rings have no wing tips and so they have less drag. The streamlined shape of the "hoopster" also makes it easy to throw accurately.

Materials

1. Scissors
2. Ruler

3. Pen or pencil (optional, for measuring out paper to cut)
4. 3-x-5-inch index card (or a file folder or some other stiff paper)
5. Piece of printer paper (or similar stiff paper)
6. Clear plastic tape
7. Stiff plastic straw (that does no have a bendy top)
8. Measuring tape (or long string)
9. Open space—indoors or out—where you can throw a paper airplane and measure the distance traveled. A long hallway or large room might work best indoors. Outdoors, try to find a time when and area where it is not too windy.

Preparation

1. Use the ruler (and pen or pencil) to measure one-inch increments along the short side of your index card.
2. Cut a file card the long way into three equal strips, generating three strips that are one inch wide and five inches long. (If you're using stiff paper, use a ruler to make three strips that are one inch wide and five inches long.)
3. Place one piece of tape on the short end of one strip. Curl the paper into a full loop and tape the two short ends together.
4. Place the other two strips end to end, so they overlap a little. Tape them together to make one long strip.
5. Place another piece of tape on one end. Curl the strip into a larger loop and tape the ends together.
6. Place one end of a straw onto the middle of a strip of tape. Place the big loop on top of the straw and fold the tape up the sides of the loop.
7. This part can be a little tricky: Place another strip of tape at the other end of the straw and press the small loop very gently onto the tape.

Move it around until it lines up with the big loop then press the tape down firmly. *Does this look like any aircraft that you have seen before? How well do you think it will glide? Why?*

8. Use the other sheet of paper to construct your favorite standard paper airplane.
9. Get ready to fly your "hoopster"! Hold the hoopster in the middle of the straw, with the small "hoop" in the front. Throw it like a spear. (It may take a little practice to get the throwing technique right). *How did it glide?*
10. Designate a "starting line" from where you can throw both planes.
11. Throw the hoopster. Measure from the starting line to where it landed. *How far did it go?*
12. Repeat this at least two more times. *What is the average or the median distance it traveled? Do you think it will beat the paper airplane?*
13. Practice throwing your standard paper airplane. *How did it glide?*
14. Now stand at your same starting line and throw the standard paper airplane. Measure from the starting line to where it landed. *How far did it travel*?
15. Repeat at least two more times with the standard paper airplane. *What is the average or the median distance it traveled?*
16. *Which paper glider soared farthest? Were their flight patterns different? Did you need to throw them differently?*

Extra: Try changing the dynamics of each plane with an addition. Put a paper clip at the bottom of the small hoop. *What happens when your hoopster has cargo? If you add the same cargo to the standard airplane, does it have a similar effect?*

Make a really long hoopster with two straws. *Does it fly farther than the short one?* To do this, cut a little slit at the end of one straw and pinch it so it fits inside the other straw, then tape them together.

Make a double hoopster. Use two index cards to create two little hoops side by side on one end and two big hoops side by side on the other. *Do the extra hoops make a difference in how it flies?*

Airplane Instructions -

https://www.diynetwork.com/made-and-remade/learn-it/5-basic-paper-airplanes

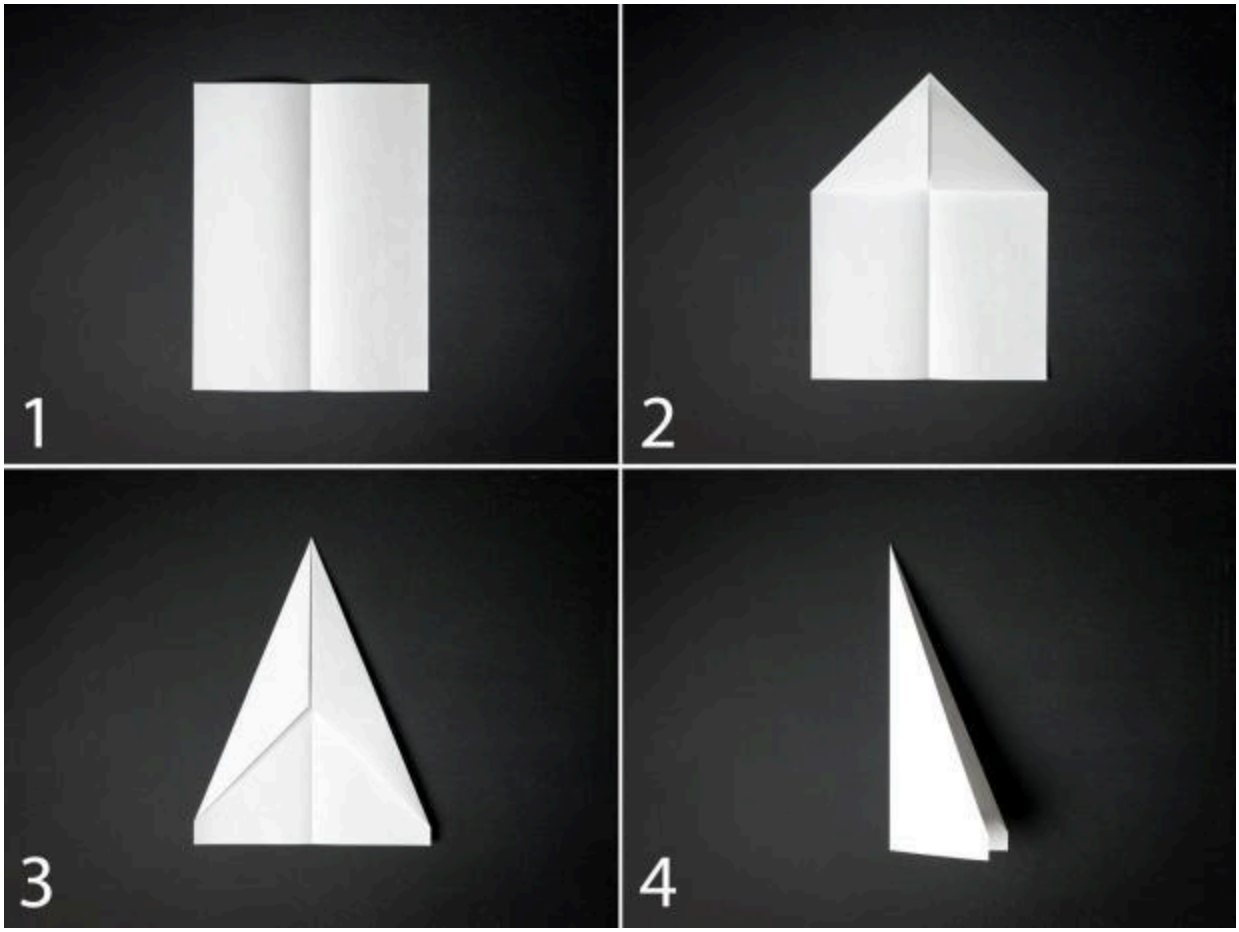
Test your paper folding technique with these paper airplane examples. Whether you are looking for a quick diversion from the grind of adulthood or are teaching a youngster DIY skills, these planes are a great way to add a little levity to your day. The examples below are all beginner or intermediate level. The materials are cheap and only require paper, a pair of scissors, a ruler, and some double stick tape (optional) to complete.

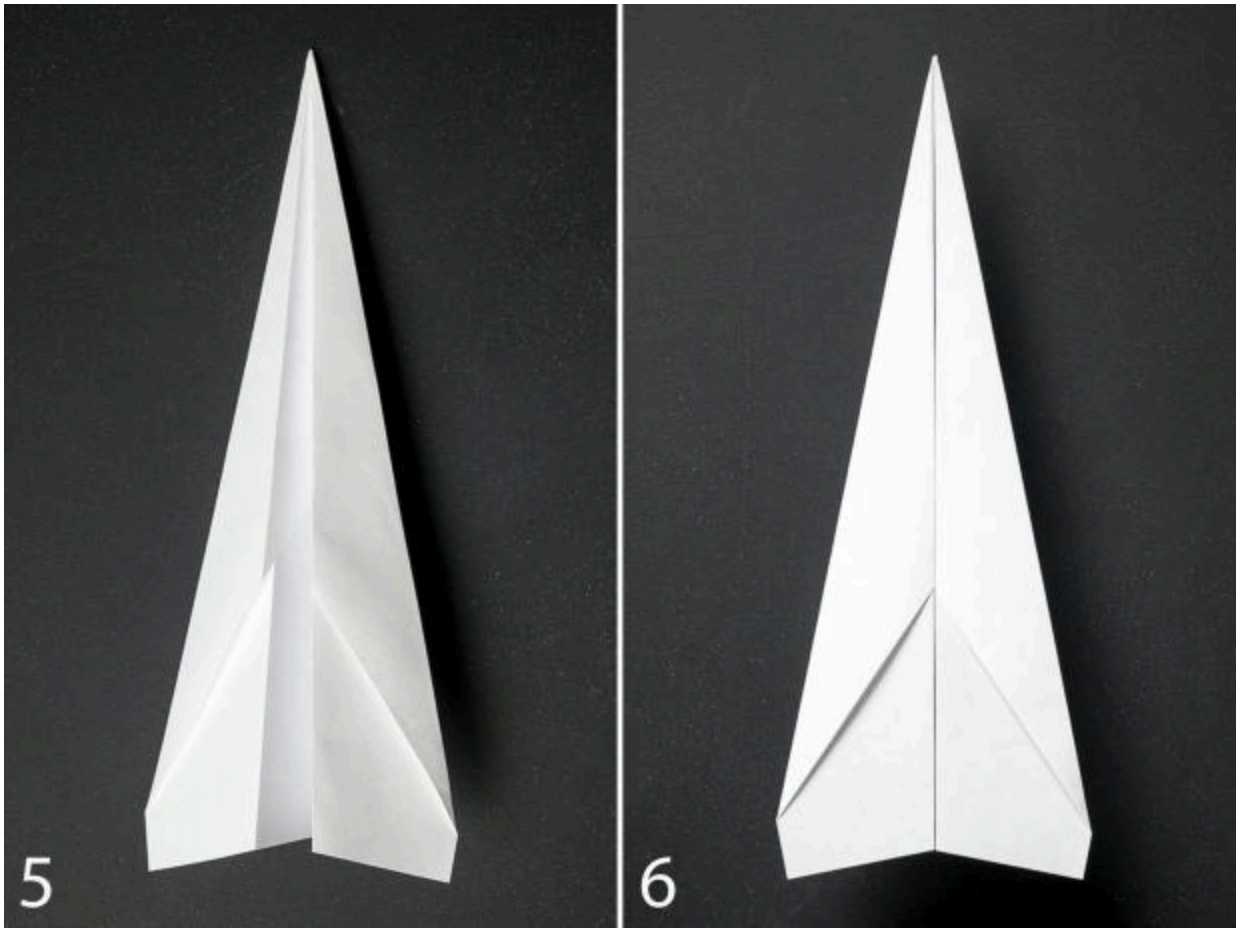
Sam Henderson

For best results use a flat, thin-edged ruler. Make good creases along each edge. Adding double stick tape to the inside of the body keeps the wings from separating in flight.

The Dart

The most basic version. A simple standard that everyone should know how to make.

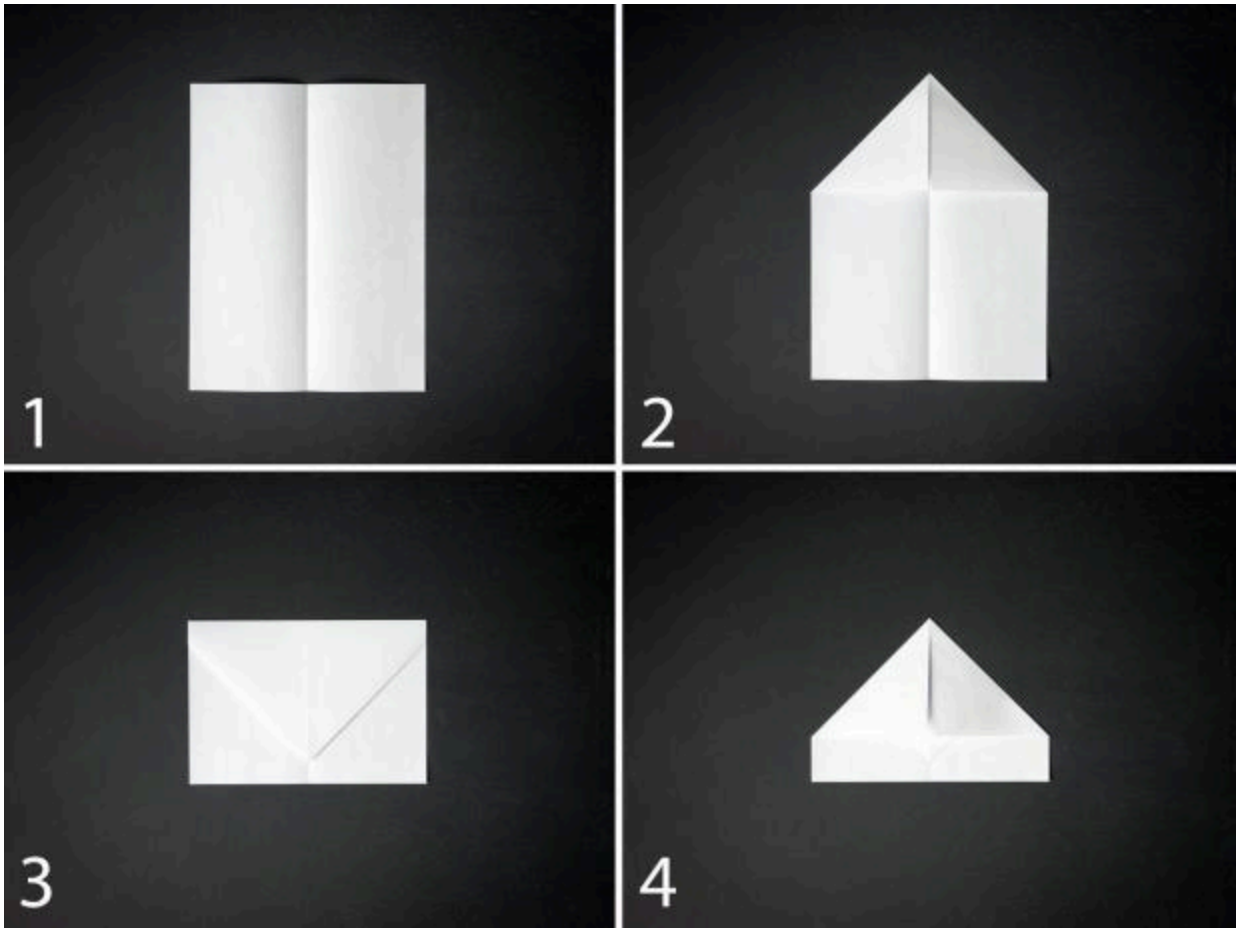




1. *Fold the paper in half vertically.*
2. *Unfold the paper and fold each of the top corners into the center line.*
3. *Fold the top edges into the center line.*
4. *Fold the plane in half toward you.*
5. *Fold the wings down, matching the top edges up with the bottom edge of the body.*
6. *Add double stick tape to the inside of the body. The finished plane should look like this.*

The Steath

This one is built for distance, plus it just looks cool.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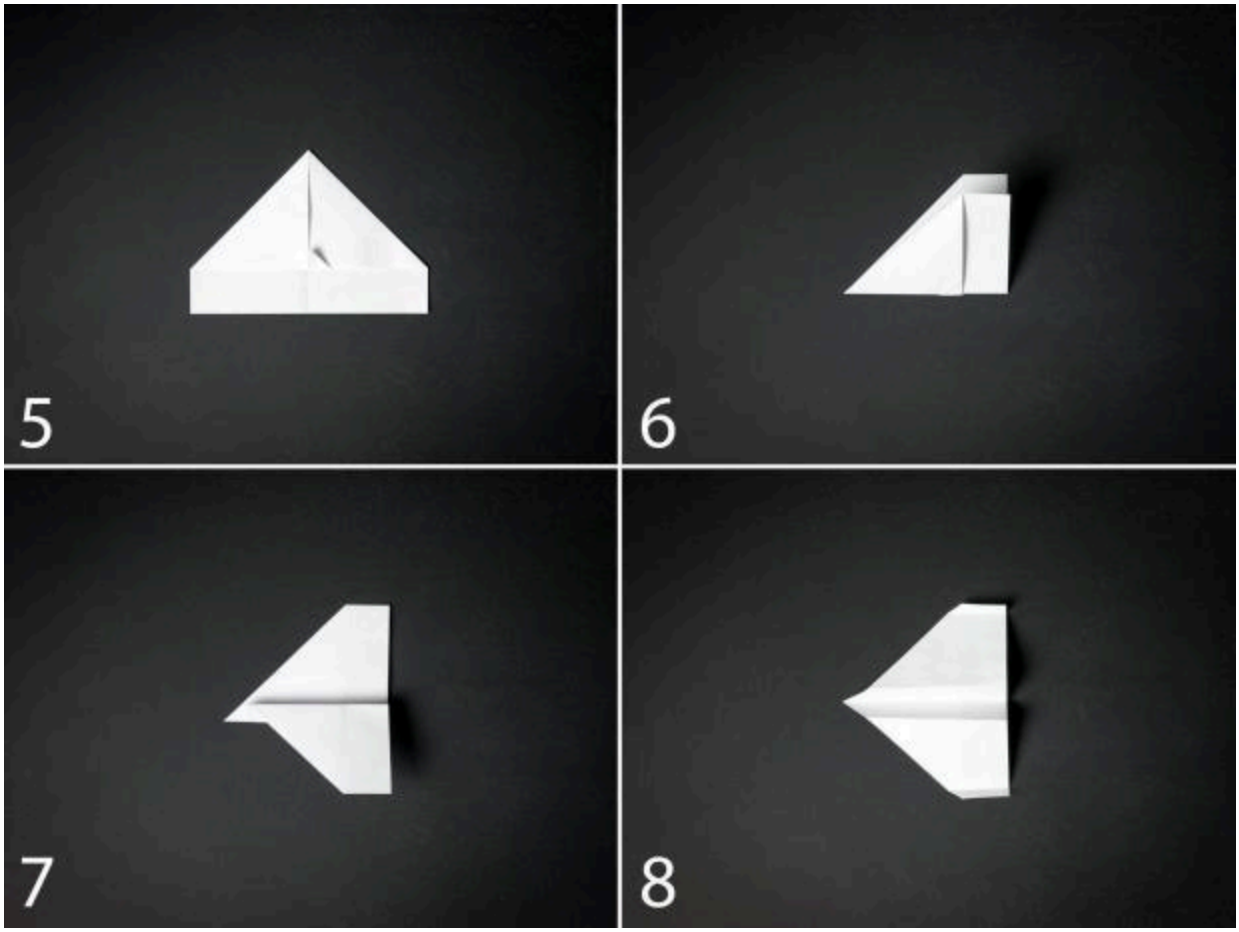
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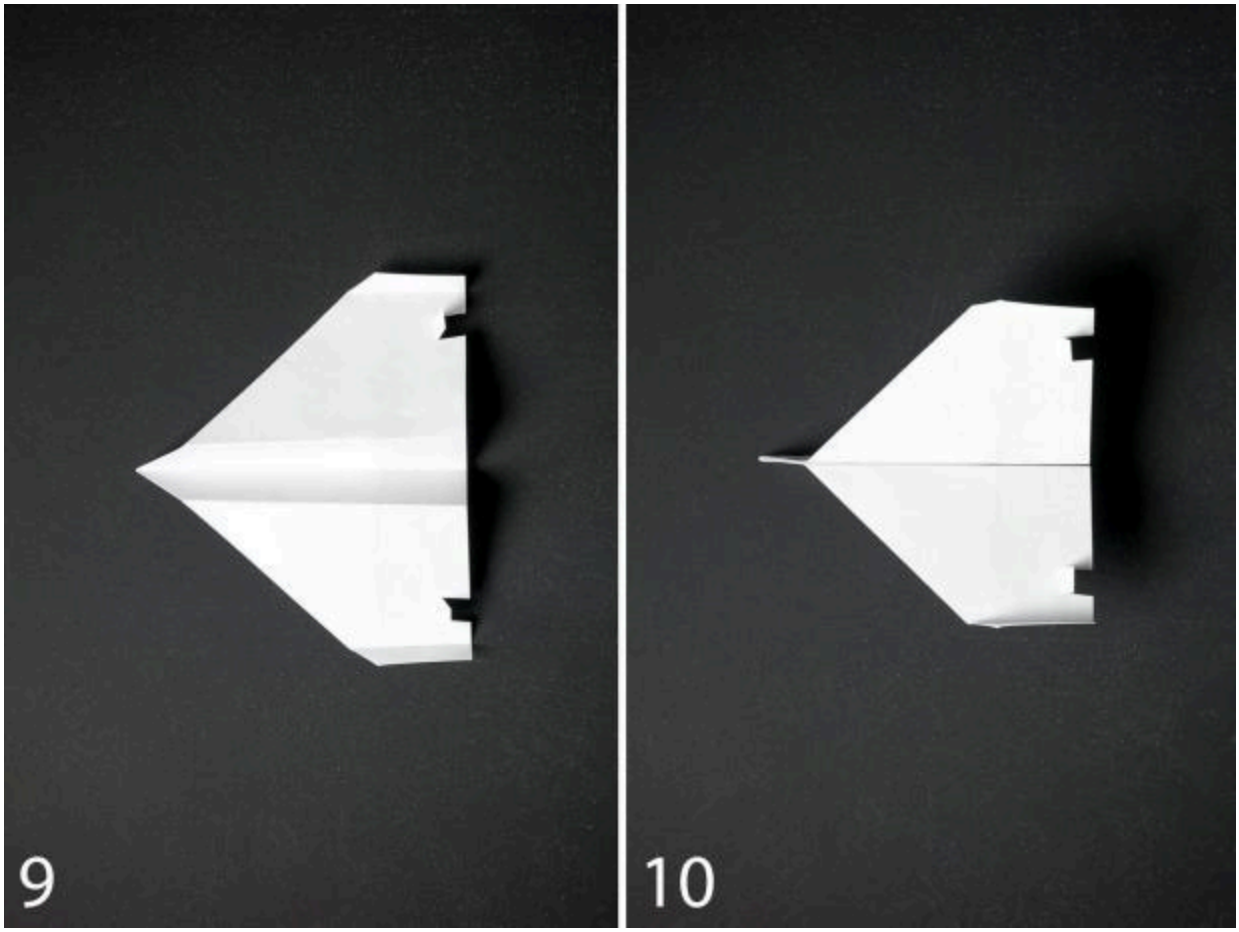
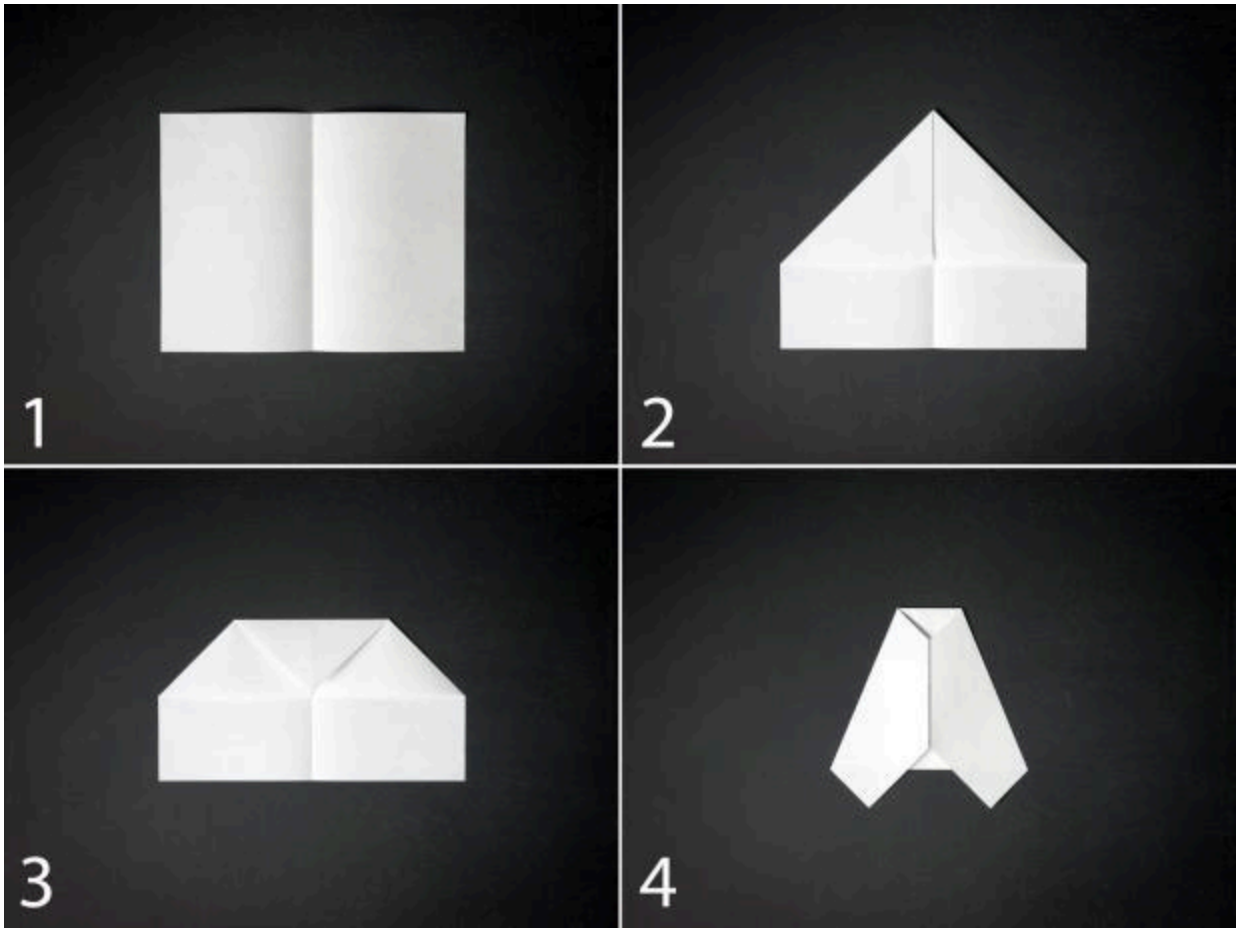
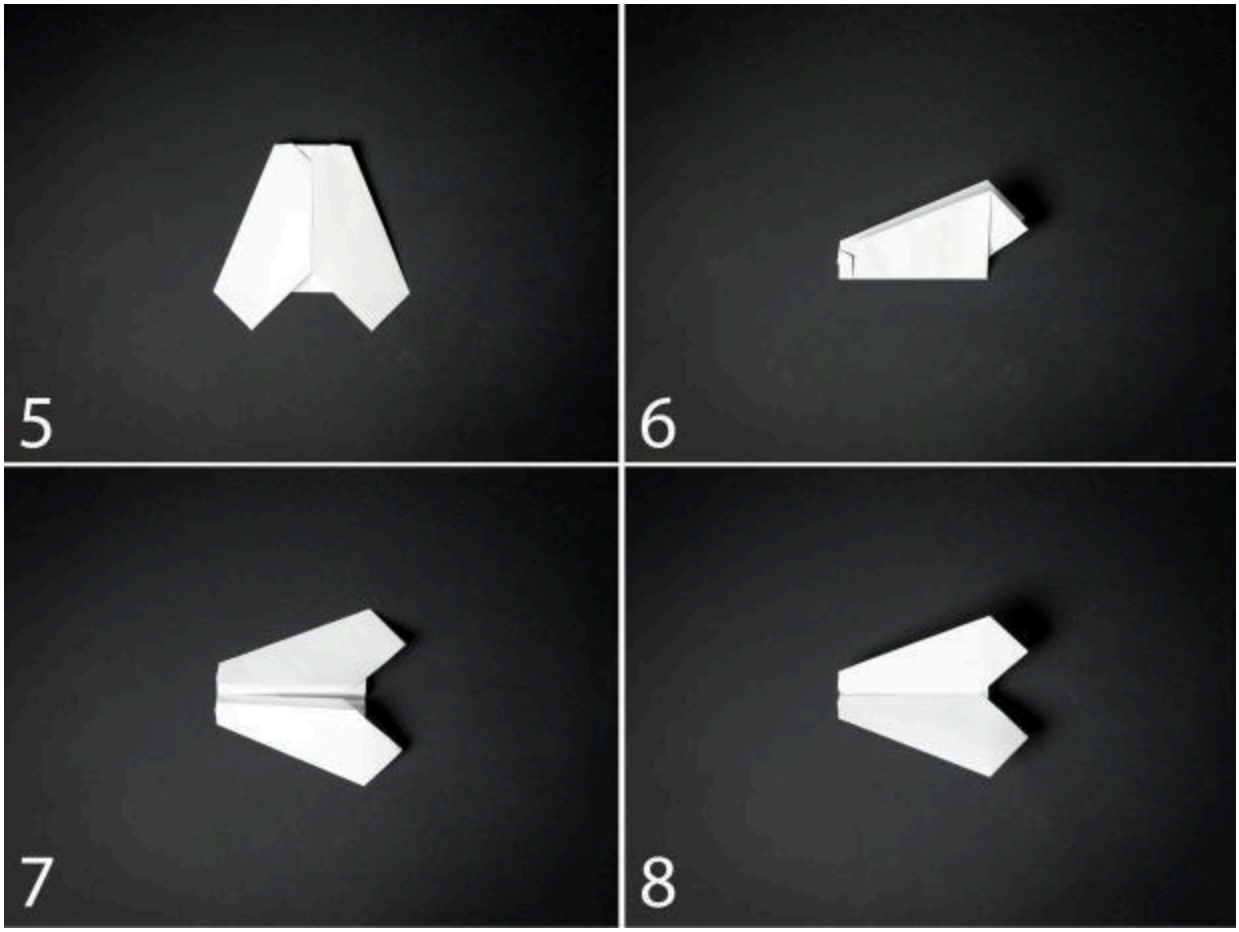


1. *Fold the paper in half vertically.*
2. *Unfold the paper and fold each of the top corners into the center line.*
3. *Fold the peak toward you and 3/4” from the bottom of the paper.*
4. *Fold both top corners into the center line.*
5. *Fold the remaining tip over the two flaps at the center line to lock them in place.*
6. *Fold the plane in half away from you.*
7. *Fold the wings down 1” from the bottom of the plane.*
8. *Fold up the sides of each wing 1/2” tall.*
9. *Cut two small slits at the back of each wing. Fold up the tabs.*
10. *Add double stick tape to the inside of the body. The finished plane should look like this.*

The Bumble

Built correctly, this bee-like beauty stays in the air for a long time.

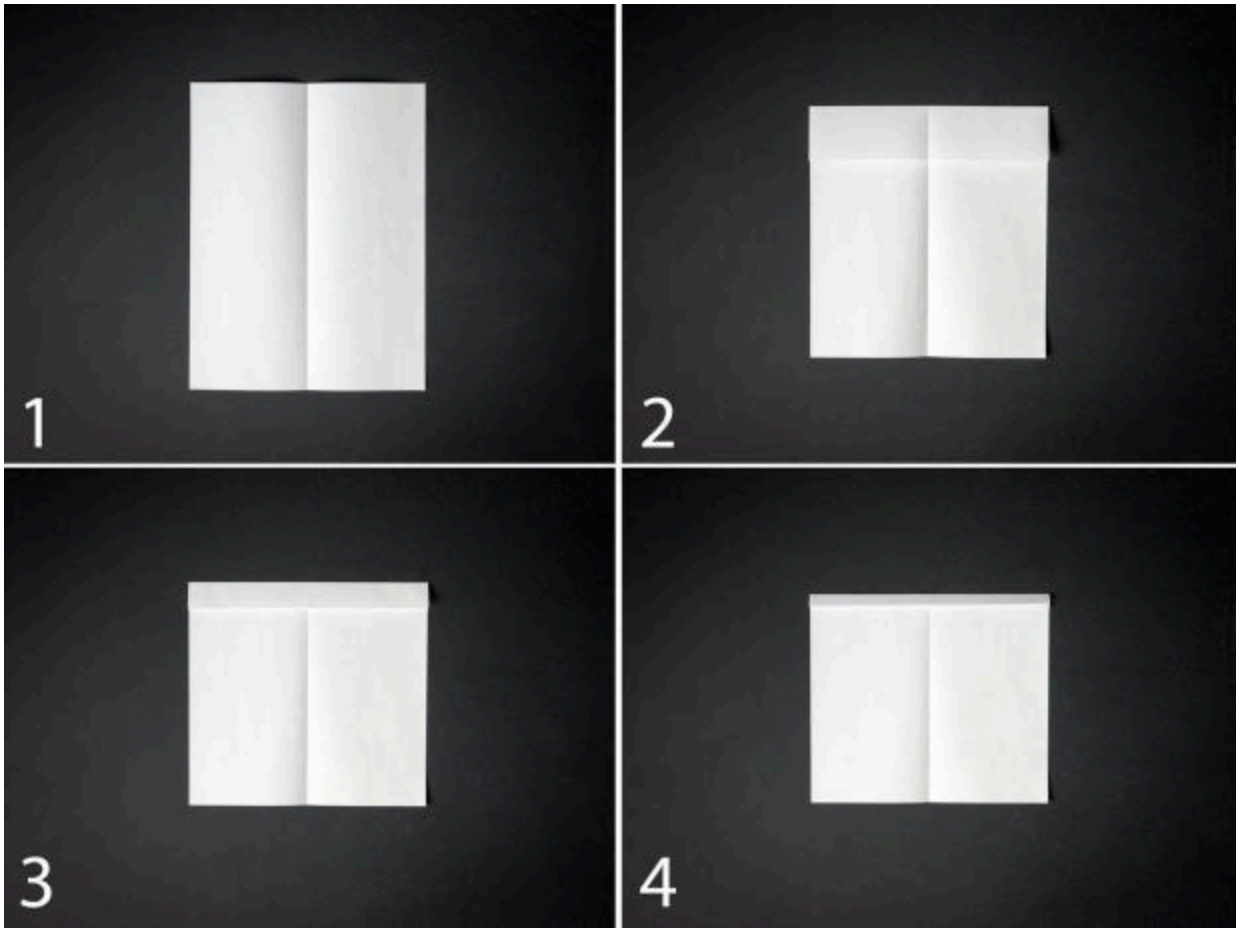


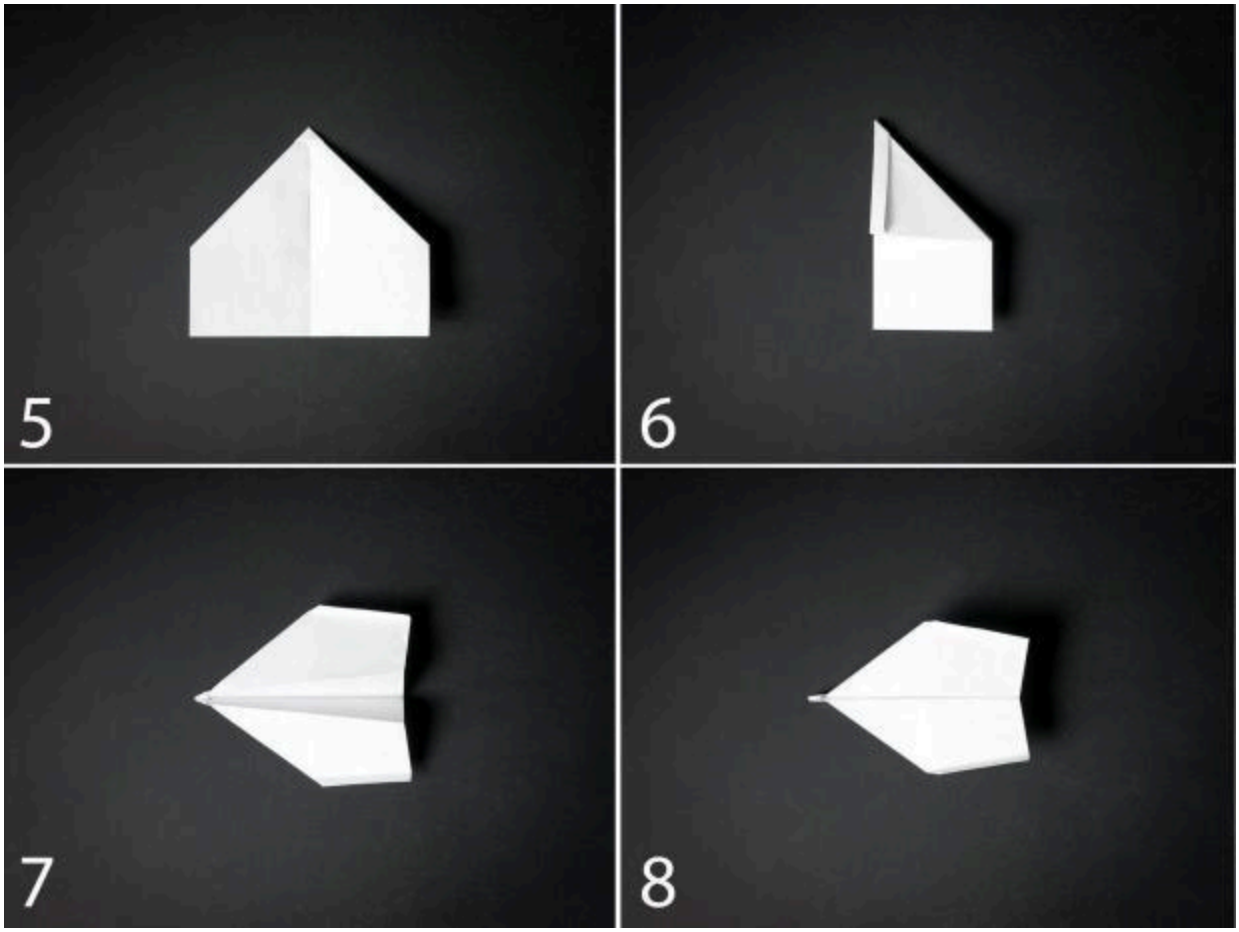


1. *Fold the paper in half horizontally.*
2. *Unfold the paper and fold each of the top corners into the center line.*
3. *Fold the peak down to meet the edge of the previous fold.*
4. *Fold the upper sides into the center line.*
5. *Fold the top edge 1/2” away from you.*
6. *Fold the plane in half towards you.*
7. *Fold the wings down 1/2” from the bottom of the plane.*
8. *Add double stick tape to the inside of the body. The finished plane should look like this.*

The Hunter

Count on speed and distance from this sleek plane.



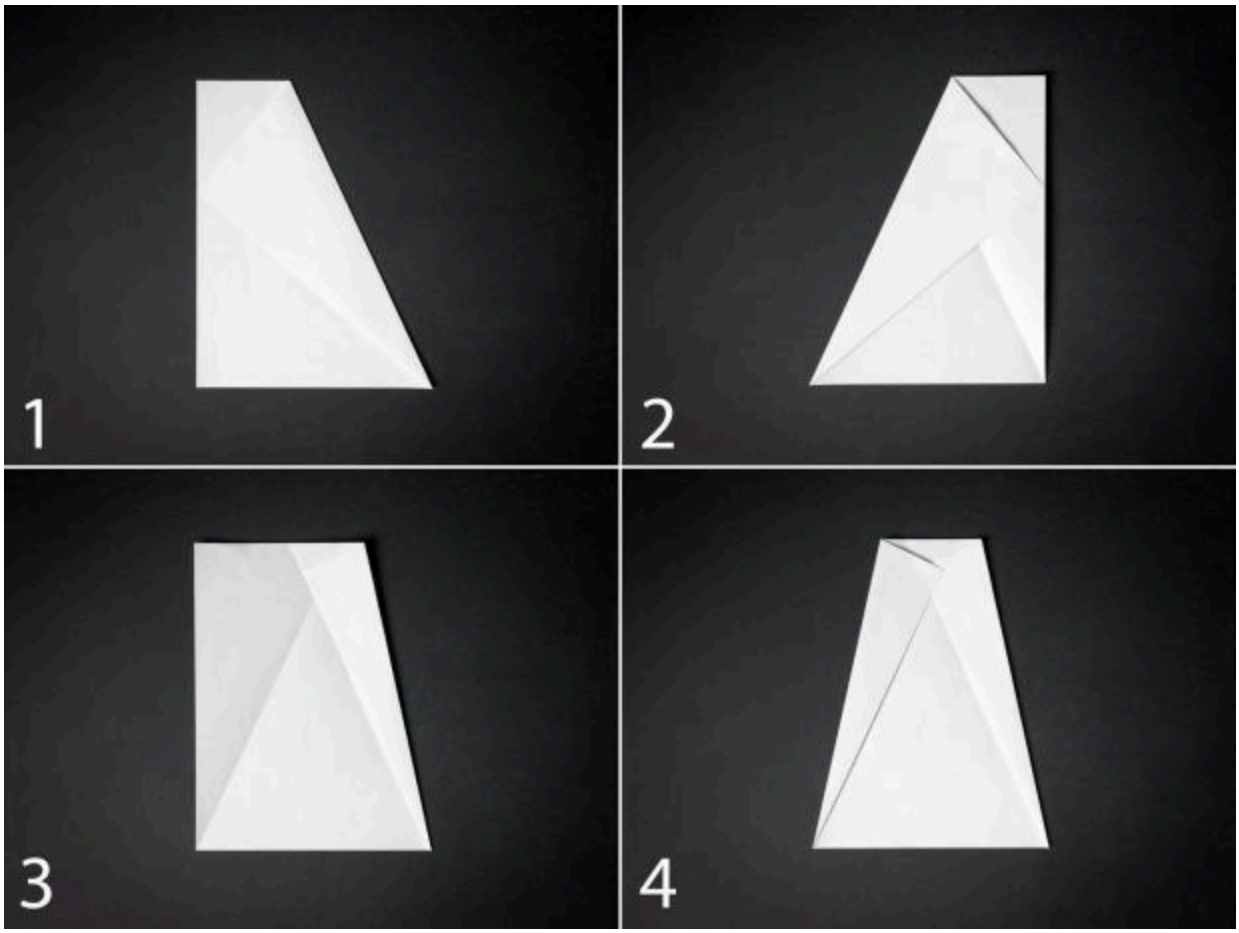


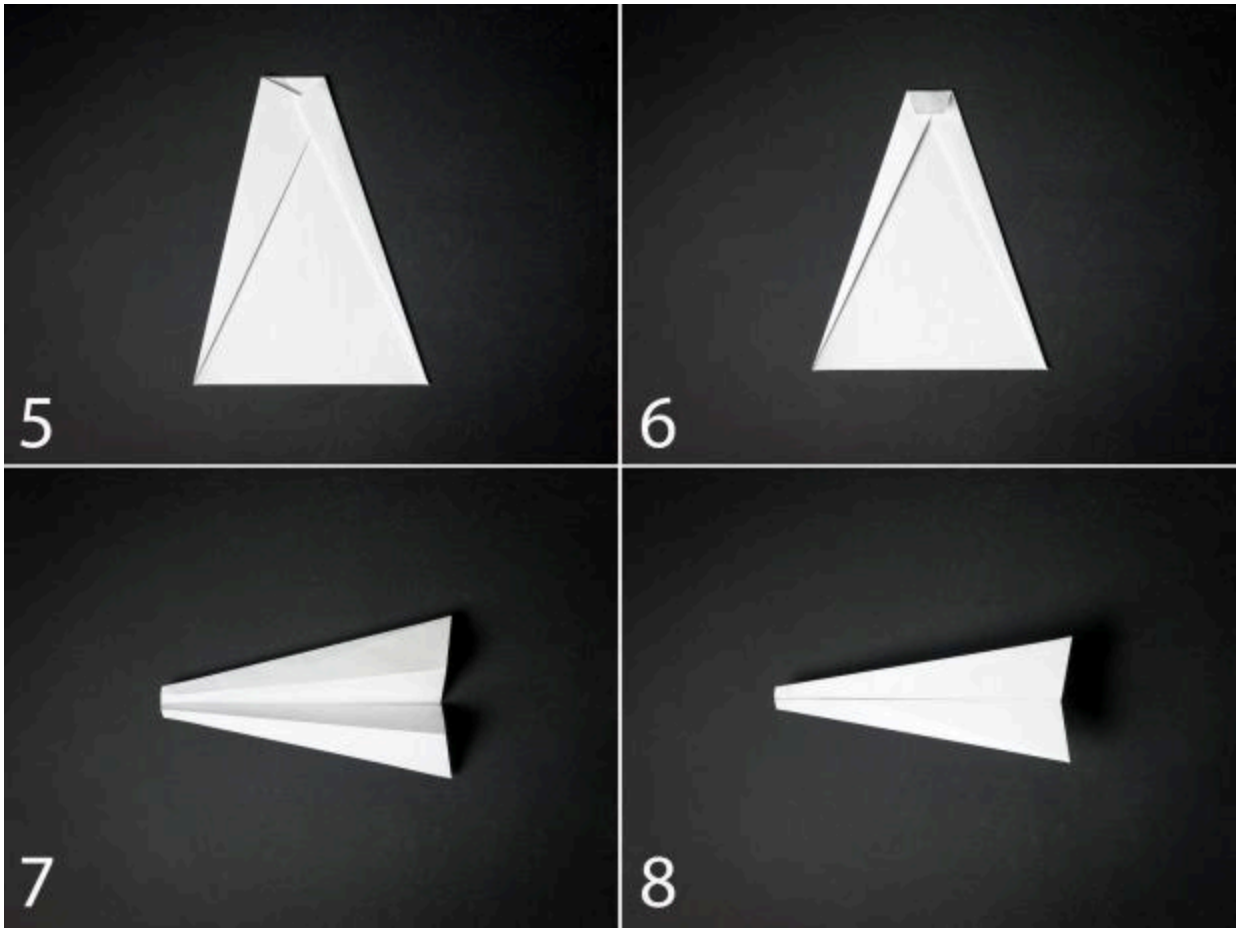
1. *Fold the paper in half vertically.*
2. *Unfold the paper and fold the top edge down 2”.*
3. *Fold the top edge down again to meet the bottom of the previous fold.*
4. *Fold the top edge down one more time to meet the bottom of the previous fold.*
5. *Fold the top edges down and away from you to the center line on the back of the paper.*
6. *Fold the plane in half towards you.*
7. *Starting at the top of the thick nose of the plane, fold the wings down 1/2” in the front and slightly angled to 1 1/2” in the back. Fold up the edges of the wings 1/2”.*

8. *Add double stick tape to the inside of the body. The finished plane should look like this.*

The Bullnose

This plane is deceptively fast and stays aloft for quite a distance.





1. *Fold the top right corner over to the left side, making a fold from the top of the paper to the bottom right corner.*
2. *Unfold the paper and repeat for the left corner.*
3. *Unfold the paper again and fold the top right corner over to meet the crease made from the first fold.*
4. *Fold the left corner over to meet the crease from the second fold.*
5. *Fold the top right edge over to meet the edge of the fold from step 3. Repeat for the other side.*
6. *Fold the top edge down and towards you to meet the point where the right and left layers cross.*
7. *Fold the plane in half away from you. Staring at the nose, fold the wings down at a slight angle, 1/2” in the front to about 2” in the back.*

8. *Add double stick tape to the inside of the body.*