EXPERIMENT MANUAL

Ultralight Airplanes

THAMES & KOSMOS

Franckh-Kosmos Verlags-GmbH & Co. KG, Pfizerstr. 5-7, 70184 Stuttgart, Germany | +49 (0) 711 2191-0 | www.kosmos.de
Thames & Kosmos, 89 Ship St., Providence, RI, 02903, USA | 1-800-587-2872 | www.thamesandkosmos.com
Thames & Kosmos UK LP, 20 Stone Street, Cranbrook, Kent, TN17 3HE, UK | 01580 713000 | www.thamesandkosmos.co.uk

Safety information

WARNING.
Not suitable for children under 3 years. Choking hazard — small parts may be swallowed or inhaled.
Keep the packaging and instructions as they contain important information.
Do not throw the models toward other people or animals. Make sure people and animals are well out of the potential flight path of the plane.
A parent or other adult should supervise all outdoor experiments with the plane.
Be careful when inserting the wooden dowels into the plastic components. If you put too much force on them, they can warp, splinter, or break. Do not injure yourself!

Extra parts

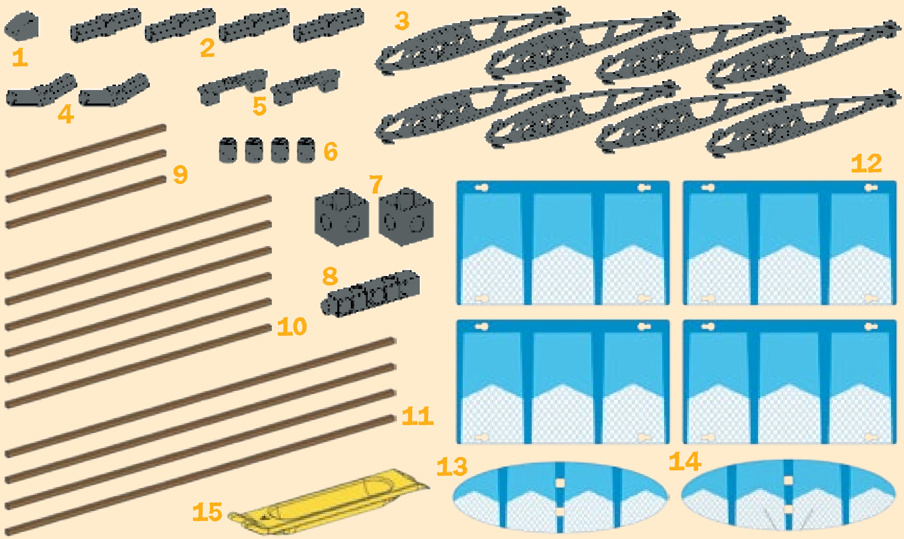
This kit includes extra dowel holder pegs, which you can use to add weight at any point along the central fuselage dowel. Add an extra dowel holder peg near the nose or the tail to fine-tune the glider's center of gravity. You can quickly adjust the counterweight by sliding it backwards and forwards. You can also use the extra dowel holder pegs to connect the bamboo dowels to the plastic components in other Thames & Kosmos kits that have the compatible peg-and-hole connection system.

Working with bamboo dowels and sandpaper

Bamboo is a super strong natural material. The thickness of the bamboo dowels can vary, as the material can be affected by humidity and other factors. When working with the bamboo dowels, you may find that some of them do not slide easily into the airfoil ribs or other plastic connectors. Here are some tips for working with the bamboo dowels to get them to fit.

1. If a bamboo dowel does not slide smoothly into a connector, try the other end of the dowel or a different bamboo dowel.
2. We have included a piece of **sandpaper:** With the sandpaper, you can sand down the bamboo dowel to reduce its thickness. Slide the sandpaper back and forth along the part of the dowel that you want to sand down, and test it often until it fits.
3. We have included extra bamboo dowels in the case that one does not work or in case one breaks, but if you need extra dowels, please contact Thames & Kosmos technical support for replacements.

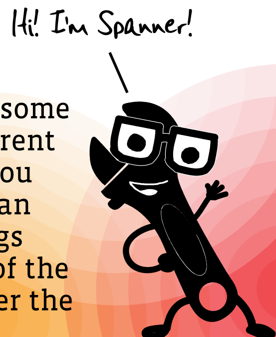
KIT CONTENTS



1	Nose piece (1)
2	Straight connectors (4)
3	Airfoil ribs (8)
4	150-degree connectors (2)
5	Stabilizer connectors (2)
6	Dowel holder pegs (4)
7	Cube pieces (2)
8	5-hole dual rod (1)
9	Bamboo dowel, 90 mm (3) 1
10	Bamboo dowel, 150 mm (6) 2
11	Bamboo dowel, 220 mm (4) 3
12	Wing surface plastic film (4)
13	Vertical stabilizer film (1)
14	Horizontal stabilizer film (1)
15	Part separator tool (1)
	Not shown:
16	Sandpaper piece (1)

YOU WILL ALSO NEED: *A "test flying" area at least 10 meters (about 30 feet) long, preferably with a grassy or smooth surface for a safe landing*

Hey Glider Geeks!



Ready to learn how airplanes work by building awesome flying gliders? With this kit, you can build five different glider models and test them to learn how they fly. You can try all sorts of wing positions and angles. You can even design your own gliders! You'll learn how wings generate lift and how the shape and configuration of the wings affect the plane's flying performance. Spanner the Geeker will be your guide!

PART 1

HOW DO AIRPLANES FLY?

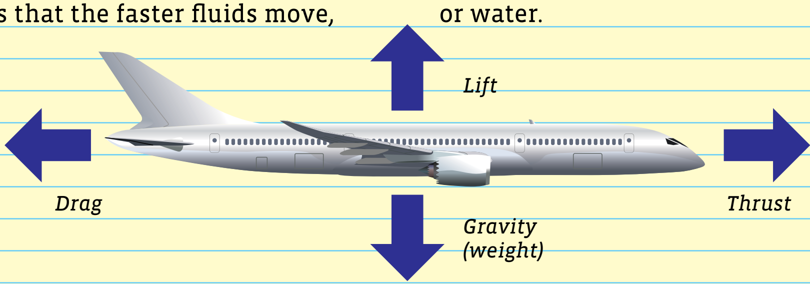
Before you build and fly your first model, let's learn a little about airplanes and how they fly.

Let's start with defining the word **airplane**. Airplanes are heavier-than-air craft lifted by fixed wings and propelled forward by an engine. Aircraft is a more general term for any man-made craft that flies. And gliders, which we will build in this kit, are not powered by an engine.

Next let's consider what planes fly in: **air!** Air is a mixture of gases. The molecules in air are always moving around and they are always being pulled toward Earth by gravity. **Air pressure** is the result of all these moving particles pushing on each other and all the things under and around them.

Air behaves like a **fluid** and obeys the physical laws of fluids. The most important principle of fluids to understand in order to understand how airplanes fly is that the faster fluids move, the lower their pressure. This is called **Bernoulli's principle** after the scientist who came up with it. Airplane **wings** are designed to take advantage of Bernoulli's principle to lift a plane upward.

There are four forces that act on a flying airplane. You can think of a **force** as just a push or a pull. The four forces are **lift**, **gravity**, **thrust**, and **drag**. Lift pushes the airplane upward and is caused by the air flowing over the wings. Lift is always perpendicular to the direction of the airflow. Lift counteracts gravity, which is a force that pulls objects together. In this case, the massive Earth pulls the plane toward it. Thrust is the force that moves the plane forward through the air, so the air can flow over the wings, which creates the lift. The propeller or jet engine generates the thrust. Drag is the force of resistance on an object moving through a fluid, such as air or water.

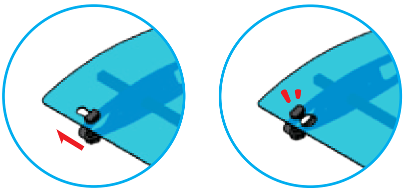


Assembling wing design A

You will need wing design A for all five of the models in this kit.

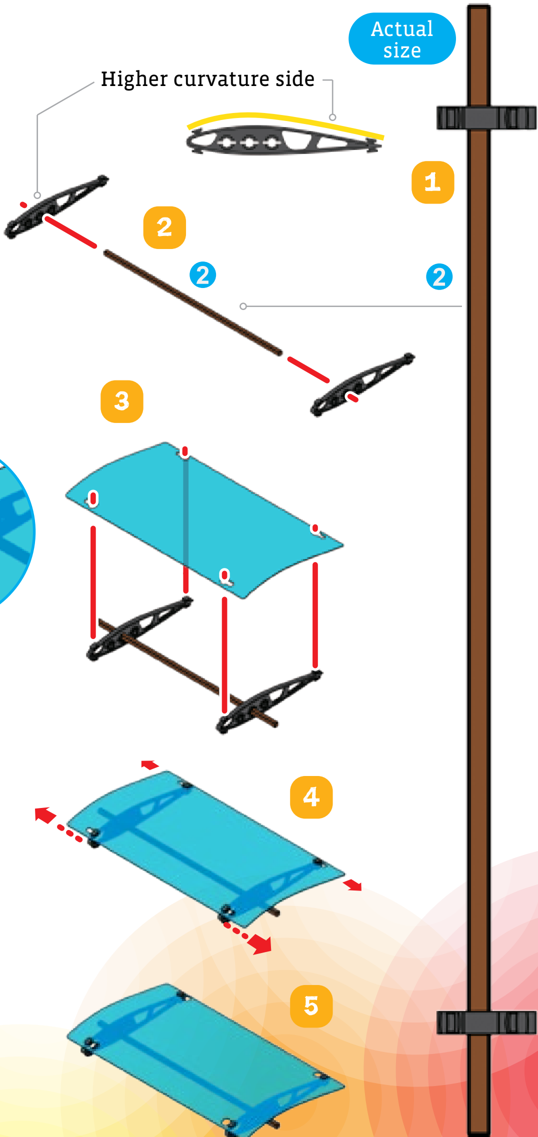
Here's how:

1. Start with one of the wooden dowels of length 2.
2. Slide the airfoil ribs onto each side of the dowel. Use the actual size guide to position them in the correct spots.
3. Attach the wing surface to the airfoil rib by fitting the holes over the small tabs on the airfoil rib.



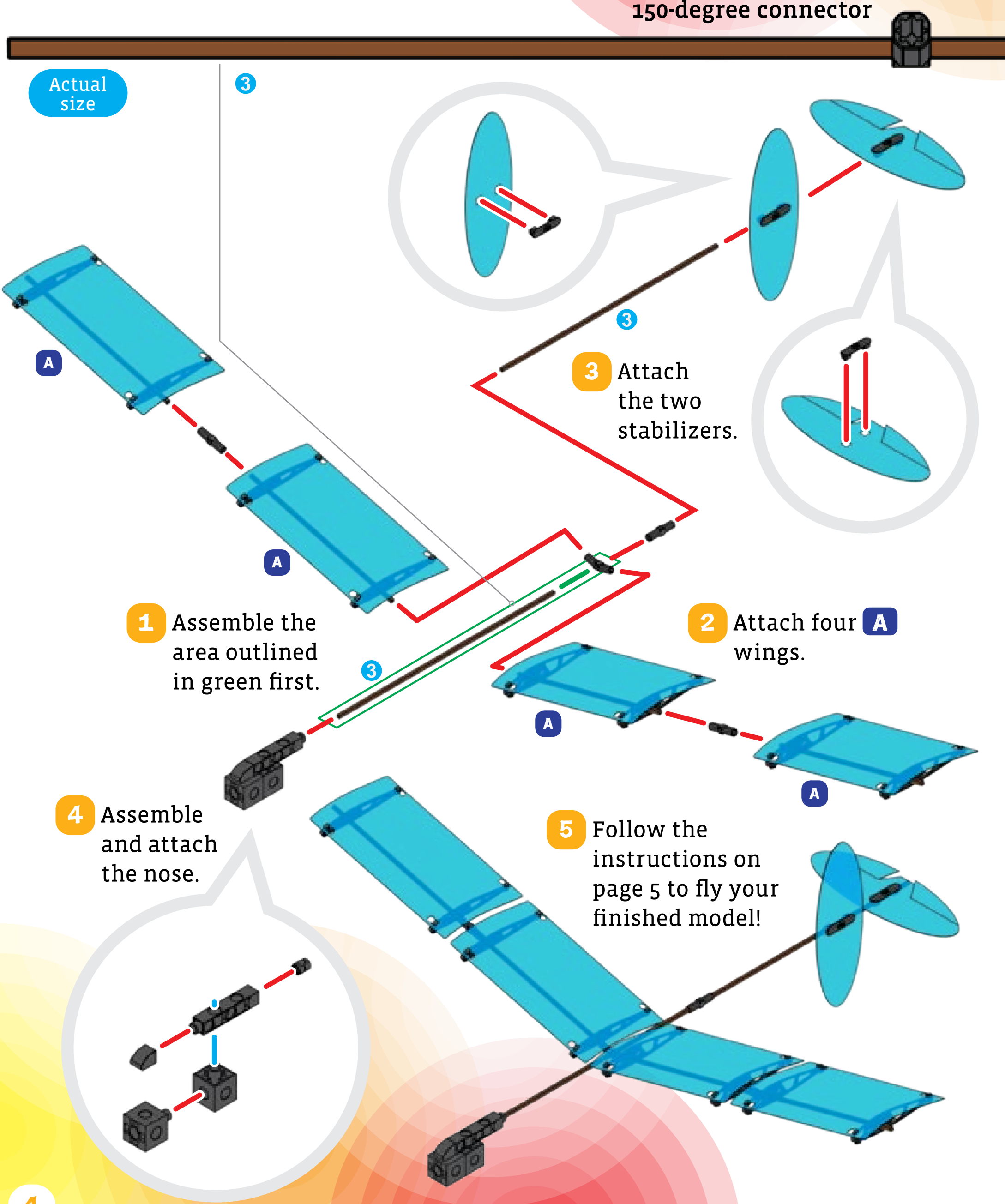
4. Slide the airfoil ribs away from each other to lock the wing surface onto the tabs and to stretch the wing surface taut.
5. The wing is done! You will need to make two or four of these wings for each model.

TIP!
If the airfoil ribs are hard to slide onto the dowels, use a little force. It's a tight fit by design. Don't force it so much that the dowel snaps. Press the end of the dowel onto the tabletop and slide the airfoil down with both hands. If it is still too tight, use some sandpaper: See the tip on the inside front cover.



Model 1: Straight wing glider

Assemble four A wings from page 3 first. Then follow the diagrams below to assemble the glider.



PART 2 TAKING IT TO THE SKIES

How to launch and test the gliders

After you have built a model, follow these instructions to fly it.

Here's how:

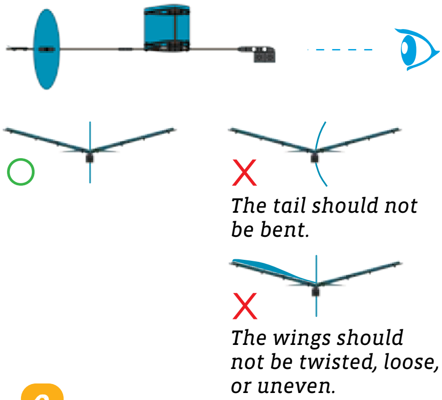
1 Inspect the model. Look at the model head on. Make sure all components are securely assembled, nothing is twisting, and the two sides are perfectly symmetrical.

2 Take the model to an open space with a 10-meter-long "test flying" area. Grass or smooth flooring is preferable to keep your model safest upon landing.

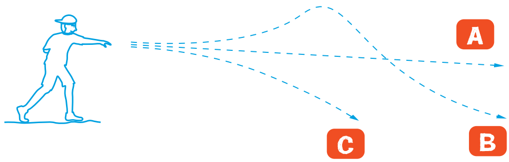
3 Hold the model by the middle fuselage dowel. Throw it forward with a smooth flick of the wrist. **A** If the model flies straight forward on the first try, you don't need to adjust it. **B** If the model flies up and then falls down, it is too light in the front: move the main wing toward the tail. **C** If the model flies downward too fast, it is too heavy in the front: move the wing toward the nose.

4 Make adjustments until you get it to fly nicely!

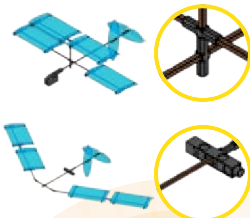
1



2



3

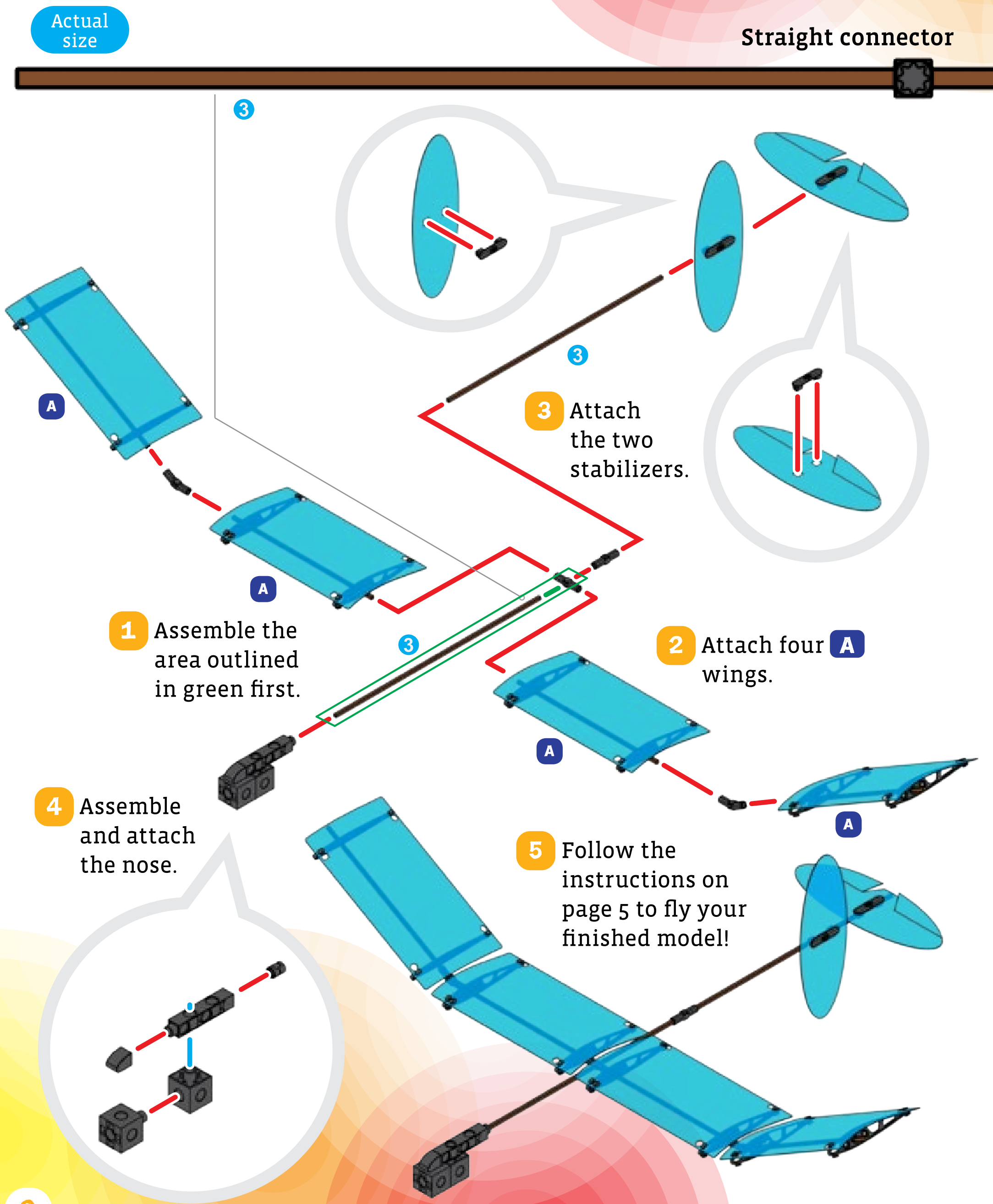


Adjust the location of the main wing along the body.

Adjust the tail angle.

Model 2: Bent wing glider

Assemble four A wings from page 3 first. Then follow the diagrams below to assemble the glider.



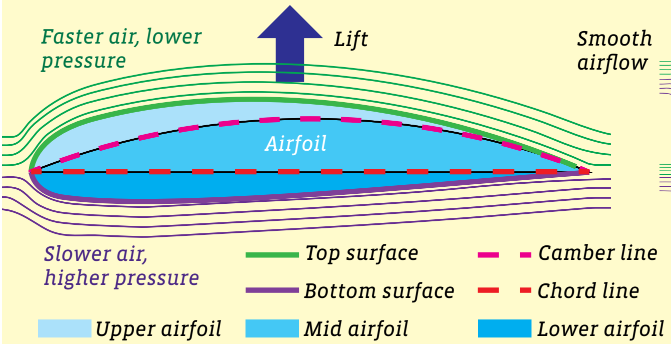
GEEK OUT!

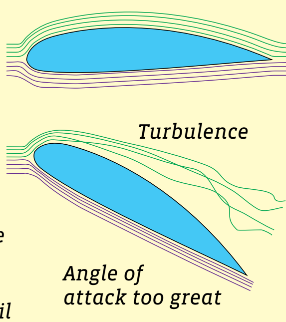
HOW DO WINGS LIFT AIRPLANES?

The Ancient Chinese made kites with curved surfaces because they observed that these kites flew better than kites with flat surfaces. In the 18th and 19th centuries, the English engineer **George Cayley** and the German engineer **Otto Lilienthal** experimented with curved wing surfaces and proved the same thing: Wings have **cambers**, or curved top surfaces, to produce lift. The bottom surface must remain flat or less curved. This shape is called an **airfoil**.

The air flowing over the curved top surface of a wing has to travel farther than the air flowing under the surface. After all, the shortest distance between two points is a straight line. The same number of air molecules flowing over a greater distance results in faster moving air and thus a lower air pressure above the wing. You already learned that Bernoulli's principle states that air pressure decreases as its speed increases. Because the air pressure is higher under the wing, it pushes the wing upward. The low pressure above can't push as hard downward as the higher pressure below can push upward.

Wings also create lift in another way. As the wing moves through the air, its lower surface hits air particles, which push back on it, generating additional upward force. The greater the **angle of attack**, or the angle of the wing relative to the air flow, the greater the lift. But only to a point, because if the wing's angle is too great, turbulence forms at the back of the wing. This turbulence disrupts the smooth flow of air, causing the plane to lose its lift and stall!

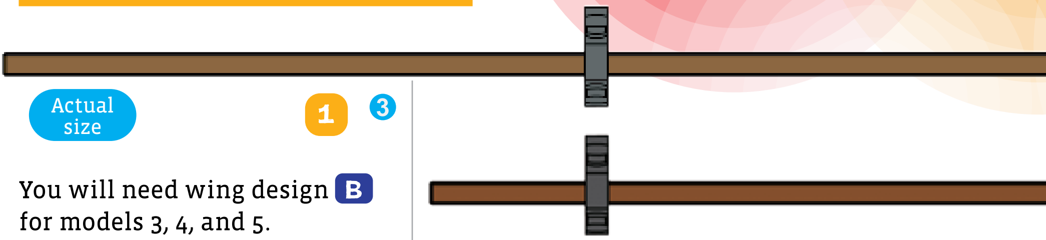




Assembling wing design B

B

Actual size



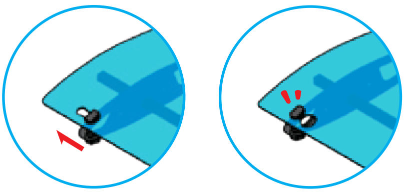
You will need wing design B for models 3, 4, and 5.

Here’s how:

1. Start with one of the wooden dowels of length 3.

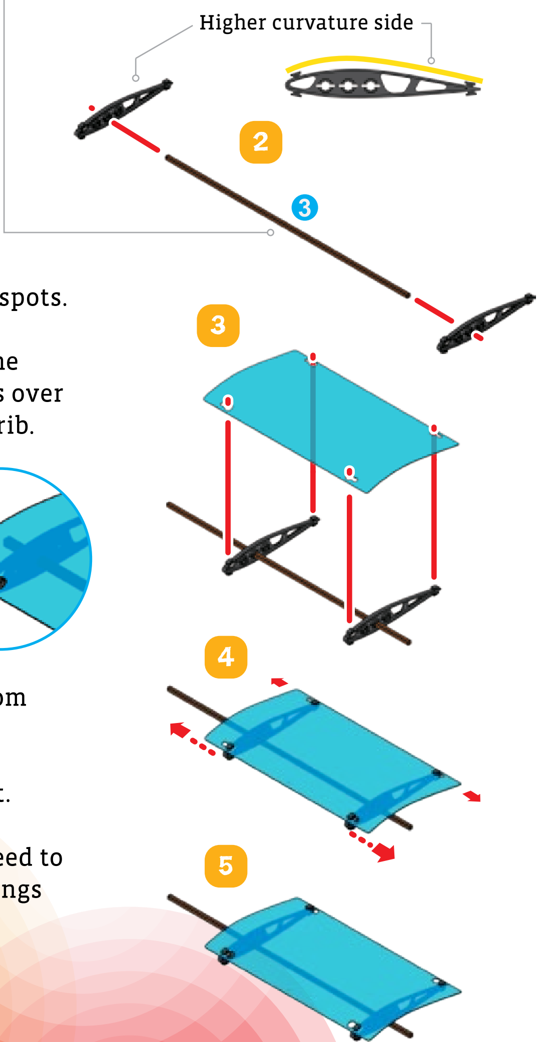
2. Slide the airfoil ribs onto each side of the dowel. Use the actual size guide to position them in the correct spots.

3. Attach the wing surface to the airfoil rib by fitting the holes over the small tabs on the airfoil rib.



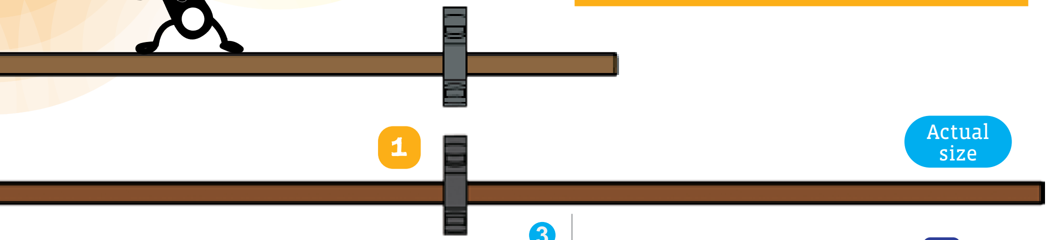
4. Slide the airfoil ribs away from each other to lock the wing surface onto the tabs and to stretch the wing surface taut.

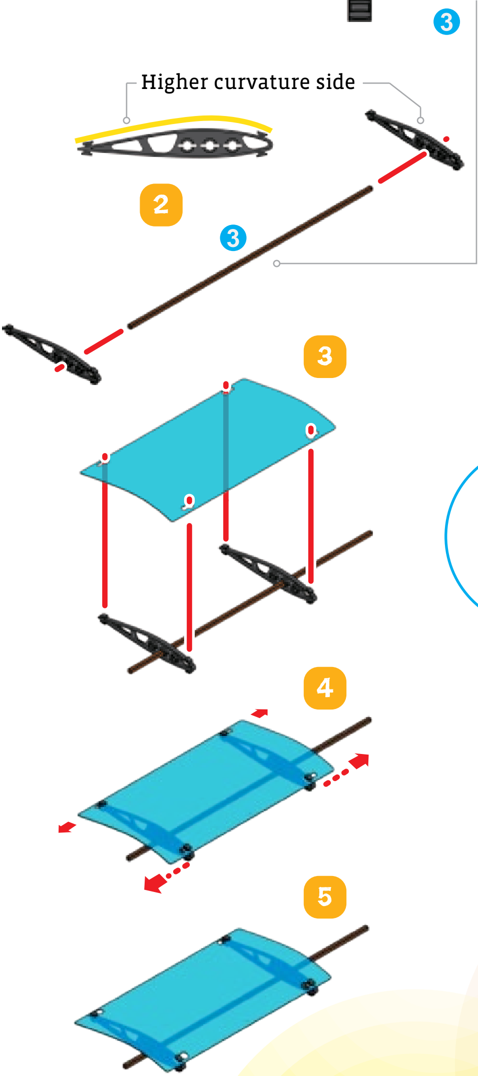
5. The wing is done! You will need to make two or four of these wings for each model.



Assembling wing design C

C

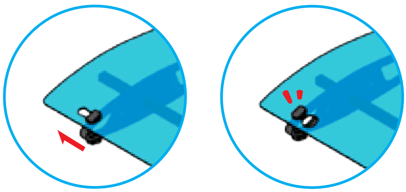




You will need wing design C for models 3, 4, and 5.

Here's how:

1. Start with one of the wooden dowels of length 3.
2. Slide the airfoil ribs onto each side of the dowel. Use the actual size guide to position them in the correct spots.

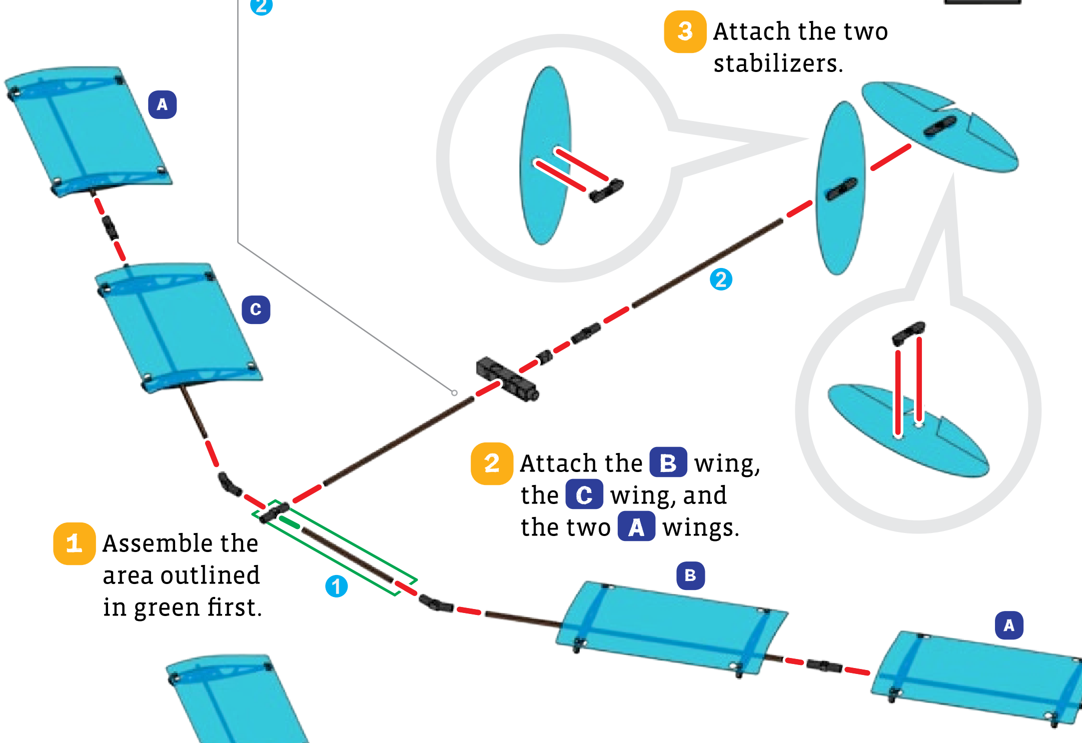


3. Attach the wing surface to the airfoil rib by fitting the holes over the small tabs on the airfoil rib.
4. Slide the airfoil ribs away from each other to lock the wing surface onto the tabs and to stretch the wing surface taut.
5. The wing is done! You will need to make two or four of these wings for each model.

Model 3: Sweepback wing glider

Assemble two **A** wings from page 3, a **B** wing from page 8, and a **C** wing from page 9 first. Then follow the diagrams below to assemble the glider.

Actual size



1 Assemble the area outlined in green first.

2 Attach the **B** wing, the **C** wing, and the two **A** wings.

3 Attach the two stabilizers.

4 Follow the instructions on page 5 to fly your finished model!

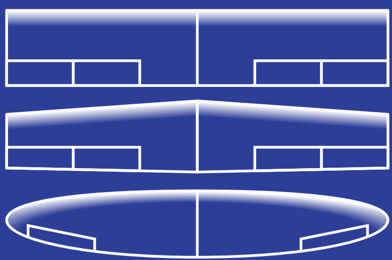
This model doesn't have a nose piece… how does that affect its flying?

GEEK OUT!

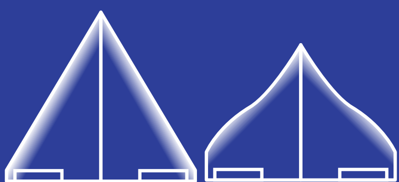
ALL ABOUT WING DESIGN

The effectiveness of a wing depends on many factors including its shape, area, the shape of its airfoil, its angle of attack, special features (like spoilers, flaps, slats, ailerons), the speed of the plane, the weight of the plane, and the density of the air (the altitude of the plane). Here are five wing designs.

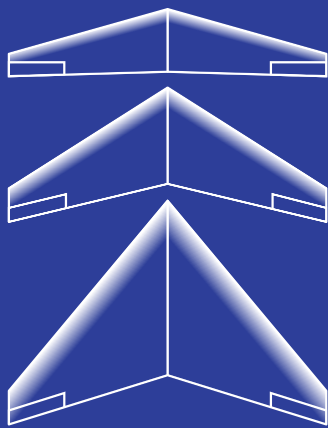
1. **Straight wings** are stable, good for low-speed and smooth flying, inexpensive, and lightweight. However, they create a lot of drag.



2. **Delta wings** come in two types: A simple delta wing is a triangle with straight edges. A complex delta wing is a triangle with curved edges. They are used in very high-speed jets, like the supersonic transport Concorde.



3. **Sweepback wings** are used for most high-speed aircraft. They create less drag but are less stable at low speeds. The wings on commercial jets have a lower sweep than those on high-speed fighters.

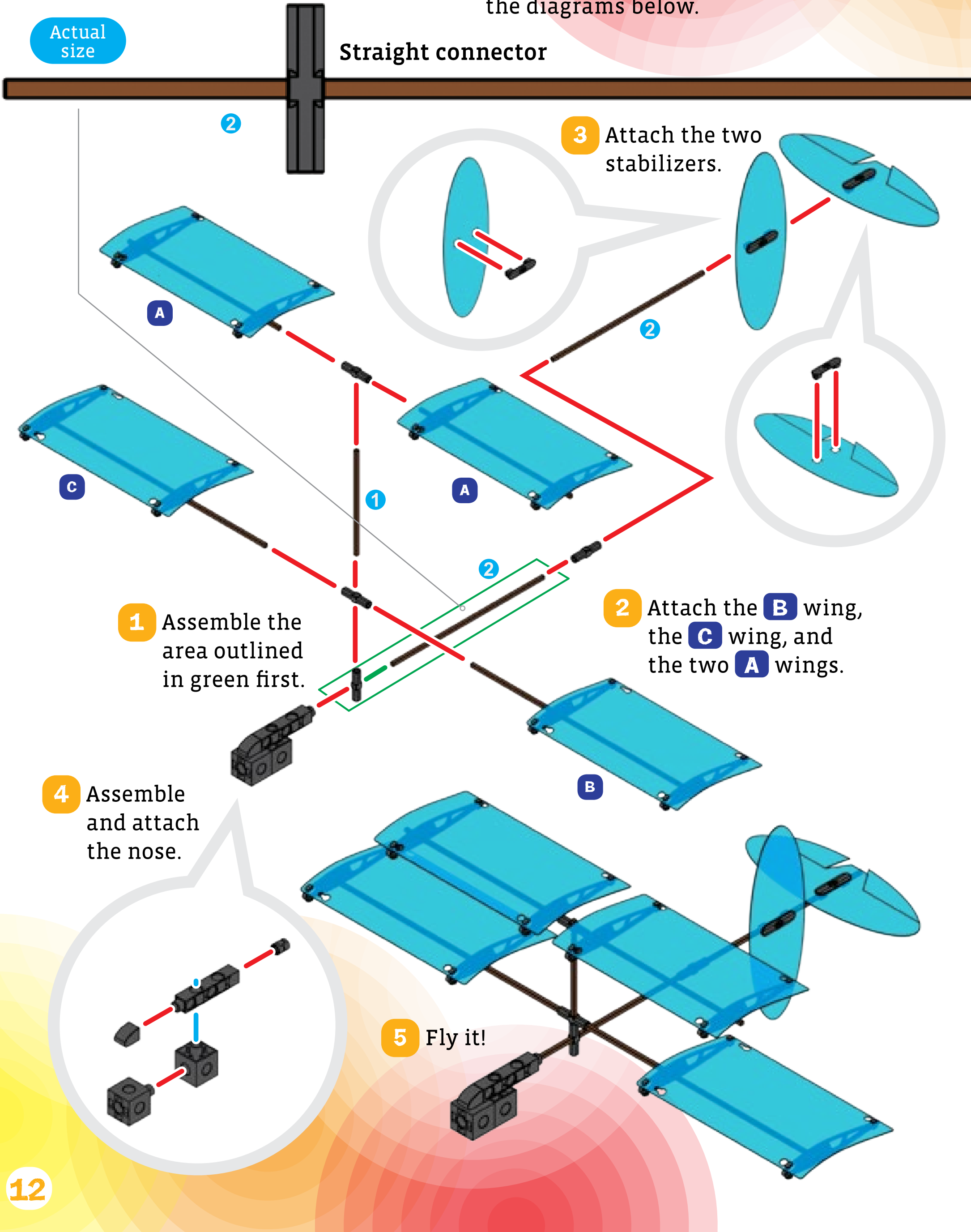


4. **Forward-sweep wings** are very experimental, very unstable, and not used in mass produced airplanes.

5. **Swing-wings** are wings that swing backward from a straight wing at low speed to a sweepback wing at high speed. They take advantage of the benefits of both types of wings.

Model 4:
Biplane glider

Assemble two A wings from page 3, a B wing from page 8, and a C wing from page 9 first. Then follow the diagrams below.



1 Assemble the area outlined in green first.

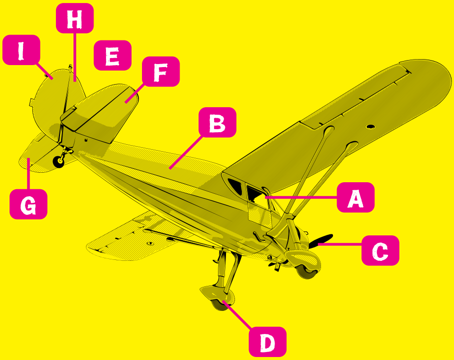
2 Attach the B wing, the C wing, and the two A wings.

3 Attach the two stabilizers.

4 Assemble and attach the nose.

5 Fly it!

GEEK OUT!

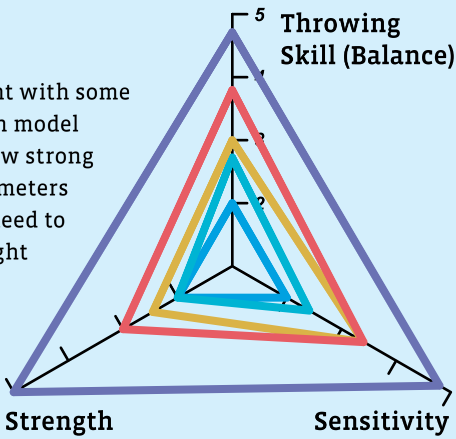


AIRPLANE PARTS

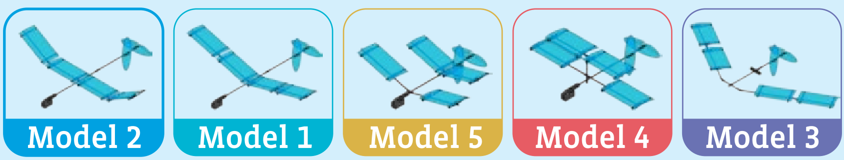
The **cockpit** A is where the pilot sits. The **fuselage** B is the plane's main body tube. The **propellers** C or **jet engines** pull the plane through the air. The **landing gear** D are the wheels that the plane takes off and lands on. The **tail section** E at the back is made up of the **horizontal stabilizer** F, which has **elevator flaps** G attached, and the **vertical stabilizer** H, which has a **rudder** I. The stabilizers keep the plane flying straight and smooth, because if the tail tries to swing in any direction, the airflow pushes back on the stabilizers. The flaps and rudders help control the airplane up and down or side to side.

Flying Performance

It is easier to achieve a smooth, long flight with some models than with other models. Test each model and rate it according to three criteria: How strong do you have to throw it to get it to fly 10 meters (strength), how steady does your throw need to be to result in a balanced and smooth flight (throwing skill), and how sensitive is the model to imperfections in its assembly (sensitivity). Plot it on a graph like this. The bigger the triangle, the harder it is to fly the model.

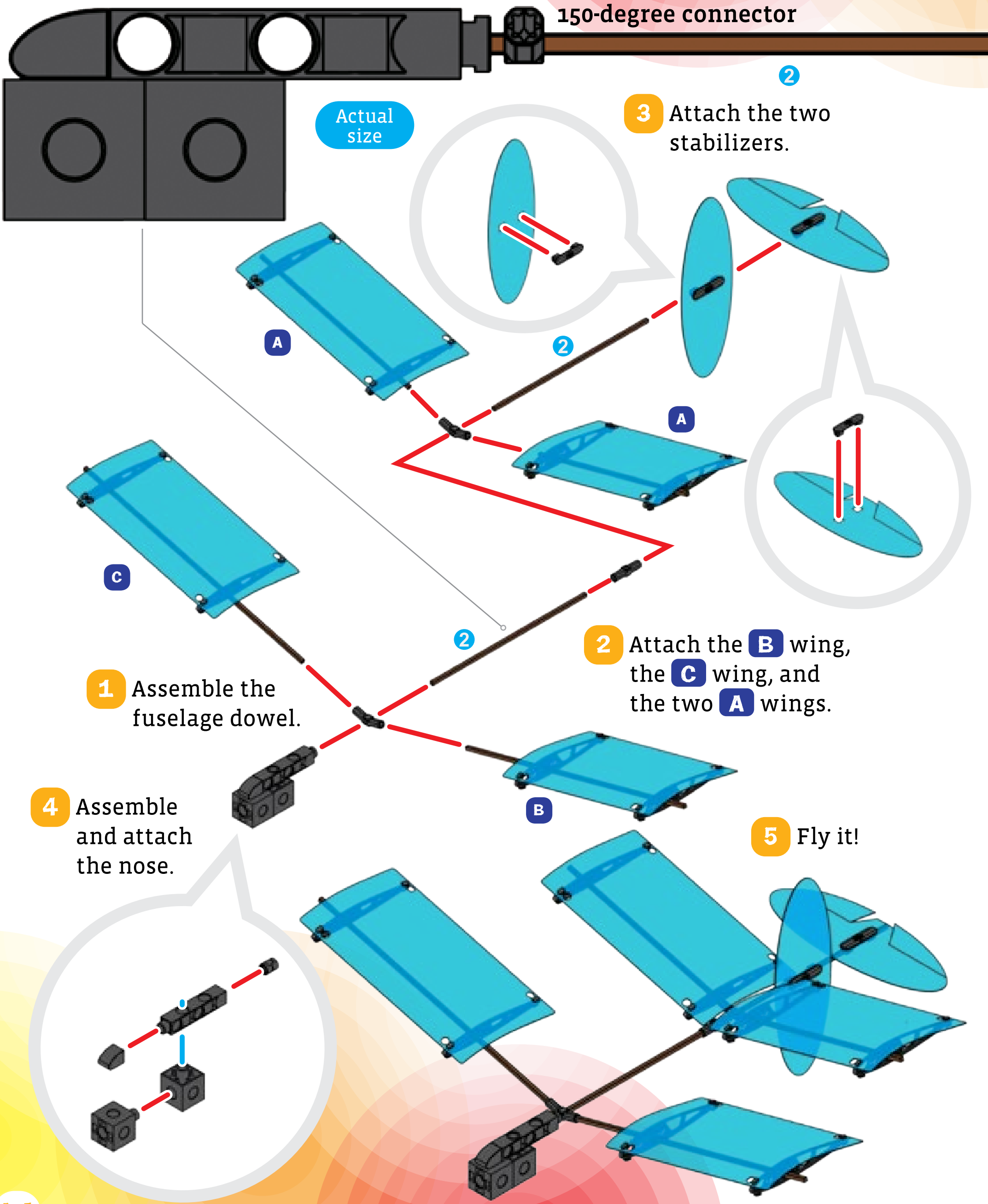


Easy ------------------ Medium --- Challenging



Model 5: Dual wing glider

Assemble two A wings from page 3, a B wing from page 8, and a C wing from page 9 first.



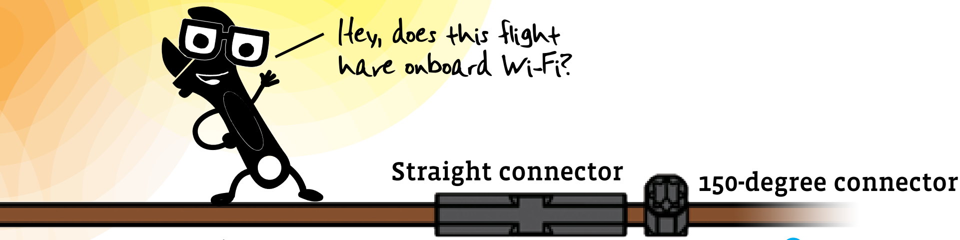
1 Assemble the fuselage dowel.

2 Attach the B wing, the C wing, and the two A wings.

3 Attach the two stabilizers.

4 Assemble and attach the nose.

5 Fly it!

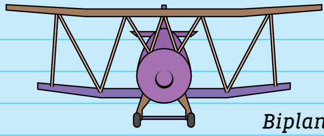


GEEK OUT!

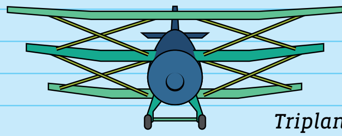
WINGS GALORE: MULTIPLANES

Airplanes have been designed with many numbers of wings. Each wing is actually called a **plane**. **Monoplanes** have one wing plane. **Biplanes** have two wing planes stacked vertically; **triplanes** have three; **quadruplanes** have four; and airplanes have even been designed with as many as 200 planes! **Tandem winged** planes have two wing planes, but they are positioned horizontally, not vertically.

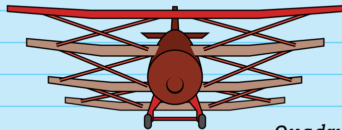
The benefit of adding more wing planes is that each plane adds to the total lift. However, each plane also adds to the weight and drag, and each plane interferes with the other planes. As planes got faster and faster, the monoplane design was favored.



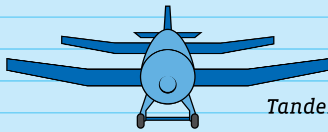
Biplane



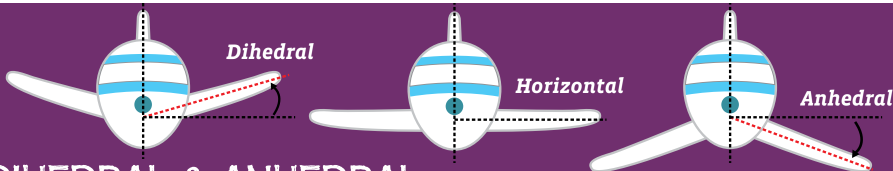
Triplane



Quadruplane



Tandem wing



DIHEDRAL & ANHEDRAL

The angle of the wing relative to the horizontal is called the **dihedral** (if it's above the horizontal) or the **anhedral** (if it's below the horizontal). By angling the wings in this way, the airplane's stability against rolling sideways improves tremendously.

GEEK OUT!

AIRPLANES VS. GLIDERS

... a HIGH-stakes competition!

In this kit, you built models that most closely resemble gliders called **sailplanes**, which look somewhat like airplanes with rigid wings but without engines. Sailplanes are not to be confused with **hang gliders**, which have a fabric wing on a frame that holds a person, or **paragliders**, which look like parachutes with a fabric wing from which a person hangs.

For a glider to fly, it needs lift. Lift happens only when air flows around the wings. This air flow only occurs when the glider glides slowly downward at a certain angle of descent. So it is always losing height in the air stream. If it is flying in the updraft of a mountainside or in a rising stream of warm air (a **thermal**), it can gain height relative to the ground, but relative to the updraft it is still dropping. It can neither start nor rise under its own power, which only airplanes with engines can do.

A pair of wings cannot fly on their own. They would go into a tailspin and plummet. To stay stable in the air stream, a normal airplane needs a **horizontal tail fin**, which holds the pair of wings at the correct angle in the air stream and stabilizes them toward the top and bottom. And for directional stability, it needs a **vertical tail fin**, which, together with the fuselage surfaces, keeps it on course. To prevent the airplane from swinging from side to side, the wings are usually arranged in a flat "V" shape, with a **dihedral angle**, which improves lateral stability.

The tail components only work if they are far enough toward the rear. That makes the airplane heavy in that area, so counterweight has to be mounted toward the nose of the airplane, such as the **cockpit**.

Sailplane

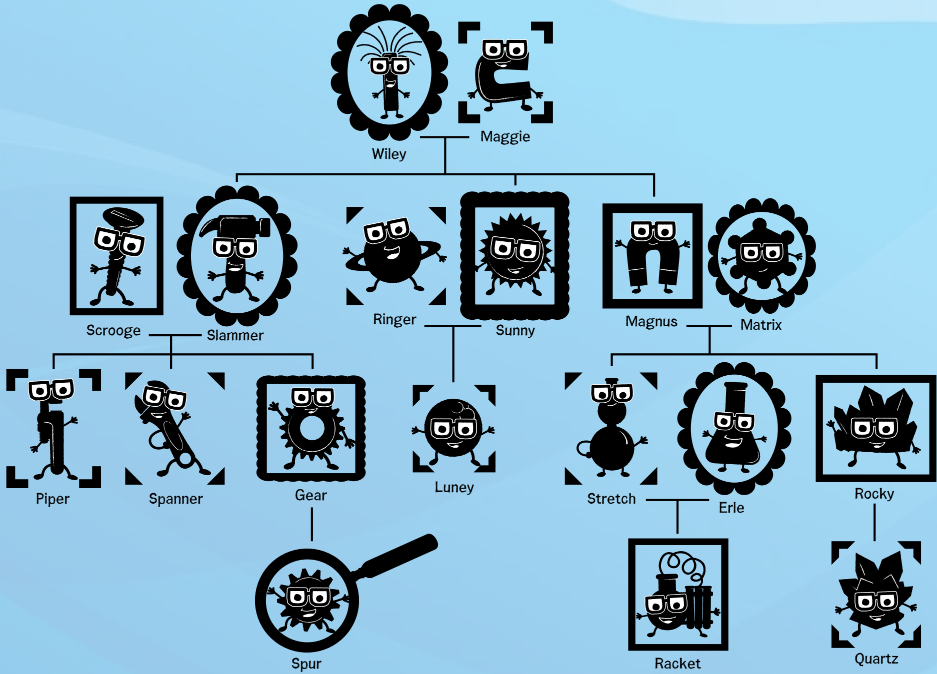
Hang glider

Paraglider

Kosmos Quality and Safety

More than one hundred years of expertise in publishing science experiment kits stand behind every product that bears the Kosmos name. Kosmos experiment kits are designed by an experienced team of specialists and tested with the utmost care during development and production. With regard to product safety, these experiment kits follow European and US safety standards, as well as our own refined proprietary safety guidelines. By working closely with our manufacturing partners and safety testing labs, we are able to control all stages of production. While the majority of our products are made in Germany, all of our products, regardless of origin, follow the same rigid quality standards.

MEET THE GEEKERS!



Concept: Genius Toy Taiwan Co. Ltd.
Technical product development and project management: Genius Toy Taiwan Co. Ltd., Stefanie Bernhart, Sebastian Martin, Dr. Petra Müller
Text: Ted McGuire
Original manual layout: Ted McGuire, Dan Freitas

Manual illustrations and photos: iStock p. 2, p. 13 top, p. 16 bottom
All other illustrations by Genius Toy Taiwan Co. Ltd., and Dan Freitas, Ashley Greenleaf, and Ted McGuire of Thames & Kosmos
Packaging artwork and photos: Genius Toy Taiwan Co. Ltd., Dan Freitas

Distributed in North America by Thames & Kosmos, LLC. Providence, RI 02903
Phone: 800-587-2872; Email: support@thamesandkosmos.com

Distributed in United Kingdom by Thames & Kosmos UK LP. Cranbrook, Kent TN17 3HE
Phone: 01580 713000; Web: www.thamesandkosmos.co.uk

We reserve the right to make technical changes.
Printed in Taiwan / Imprimé en Taïwan

550014-03-140122