



**Build Your Own
Wright Models**



Wright Brothers 1900 Glider

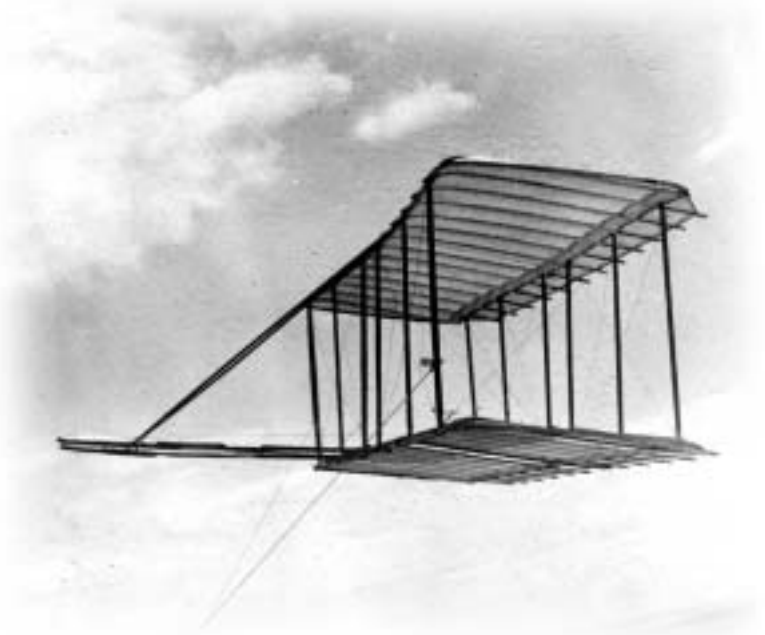
The Wright Brothers' 1900 aircraft was flown repeatedly at Kitty Hawk, North Carolina, during the fall of 1900, mostly as a kite but also as a piloted glider.

The brothers' main concern at this time was to learn how to control the forces on an aircraft. Others who had thought it was more important to fly first and figure out control later had died in crashes. The Wright Brothers used this aircraft to learn the fundamentals of aerodynamics.

The brothers had observed soaring birds twist their wings to change direction and had successfully done the same thing, which they called "wing-warping," in 1899 by twisting the wings of a small kite. In 1900, the brothers decided to test wing-warping on an aircraft that was large enough to carry a person. The pilot could control the roll of the aircraft by using a foot pedal. The pedal was connected to wires that pulled on the wing tips and warped (or twisted) the wing, producing unequal forces on the wings, which would roll the aircraft.

The 1900 aircraft was relatively large: it had a 17-foot wingspan, a 5-foot chord, and 4 feet between the wings. Without the pilot, the 1900 craft weighed about 50 pounds. In 1900, glider pilots usually flew in a vertical position. The Wright Brothers correctly understood that this produced a lot of aerodynamic drag that would slow the glider down. They chose instead to streamline their aircraft by having the pilot lie horizontally on the lower wing. The aircraft had two wings covered by tightly woven sateen fabric, a stabilizer mounted on the front of the aircraft, and no tail.

All aircraft wings have a natural tendency to flip tail over nose because of the pressure distribution around the wing. To prevent their aircraft from flipping, the Wright Brothers attached a horizontal stabilizer (called a "canard," after the French word for "duck") to the front of the aircraft. On later models the shape of the stabilizer was varied by the pilot to provide pitch (up and down) control. But on the 1900 aircraft, they fixed the stabilizer in place and just tested the wing-warping. They found it too confusing at this time to prove both pitch and roll control.



For 3 weeks, the winds were so light that they flew their craft only as a kite, using chain to simulate the weight of a pilot and operating the controls by cable from the ground. On their final day the winds grew strong, so they decided to test the craft as a glider, with Wilbur as pilot. Launching from a dune hill, he made about a dozen glides, some lasting as much as 20 seconds and covering up to 400 feet, longer than a football field! Even though this was the only day of the season with winds strong enough to carry a pilot, the flights showed that wing-warping was a success. Lessons learned on the 1900 aircraft were incorporated into all of the later Wright aircraft.





Wright Brothers 1900 Glider Model Instructions

Designed by

Roger Storm, NASA Glenn Research Center

Materials

- One or two clean Styrofoam meat trays, at least 8.5 inches (21.5 centimeters) by 5.5 inches (14 centimeters), preferably white
- 30 to 35 toothpicks
- Low-temperature glue gun
- Scissors
- Hobby knife, razor utility knife, or single-edge razor blade (adult help here)
- Cardboard or board to cut on
- Ultrafine-tip black marker
- Ruler
- Emery board
- Manila file folder
- Small plastic toy army soldiers, about 2 inches (5 centimeters) tall (optional)

General Instructions

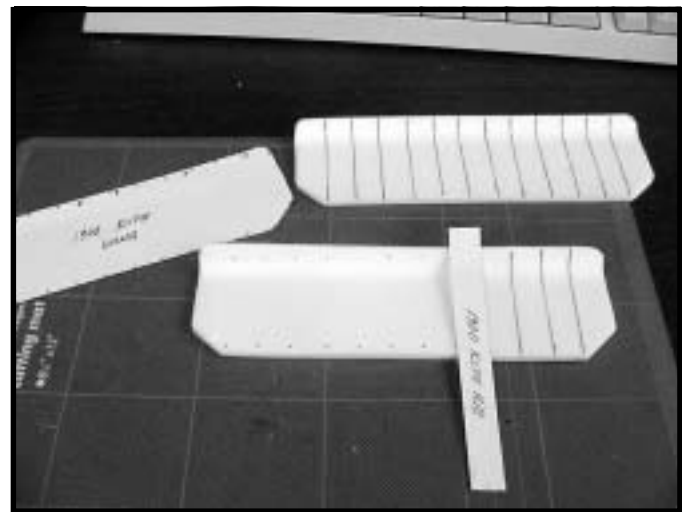
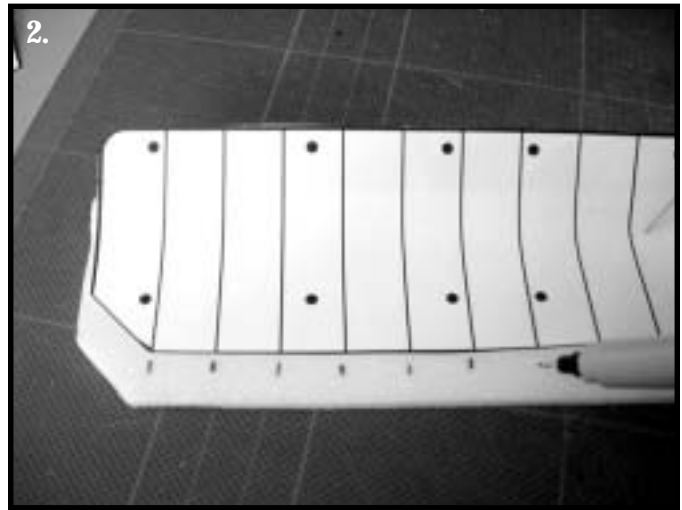
- Use scissors to cut out all three templates on the heavy lines of the 1900 Glider template (found in the back of this book).
- Do all hobby knife or razor blade cutting on the board or cardboard to protect your working surface.
- The finished model is for display only; it is not meant to fly.

Procedure

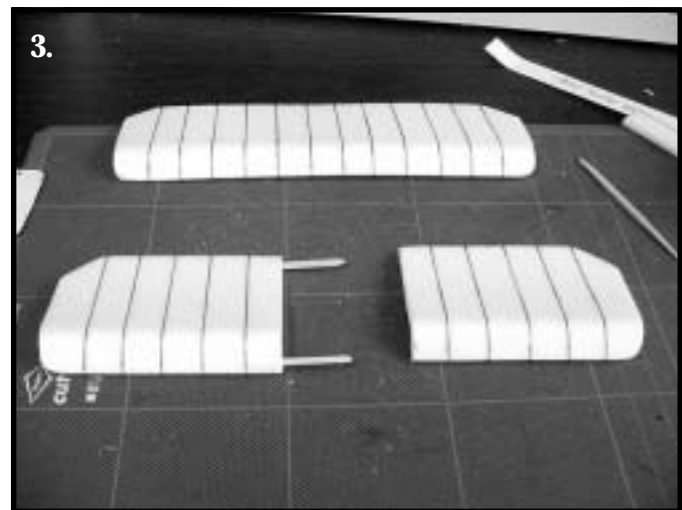
1. Carefully trace the wing and elevator shapes on the inside of the Styrofoam tray as shown. Be sure the front edges of the wings go about two-thirds of the way up the curved sides of the tray. Check the bottom of the tray and avoid any logo found there. You may need two trays. Cut out the wings and elevator with the hobby knife or scissors. Use the emery board to smooth the cut edges and sand off the pen lines.



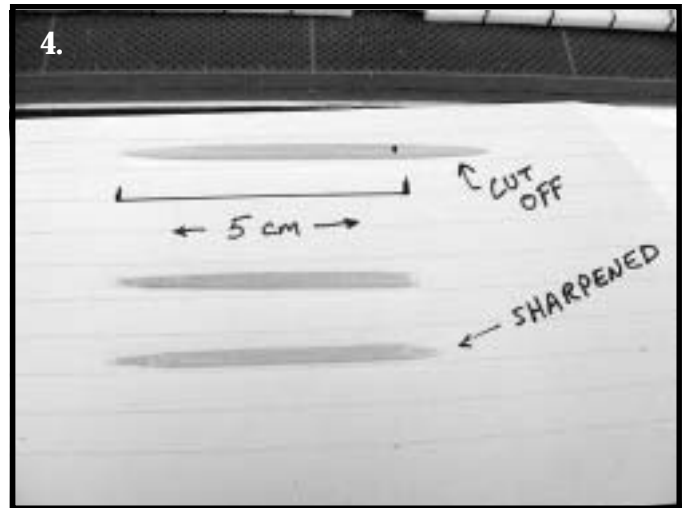
2. Using the templates as a guide, mark the locations of the rib lines on the tops and bottoms of the wing and elevator sections with the ultrafine-tip black marker. Make two sets of marks, one on each edge. Connect the marks to make the rib lines. Make a rib template from a manila folder to draw the rib lines (so the end of the template can be bent to conform to the rounded shape of the Styrofoam).



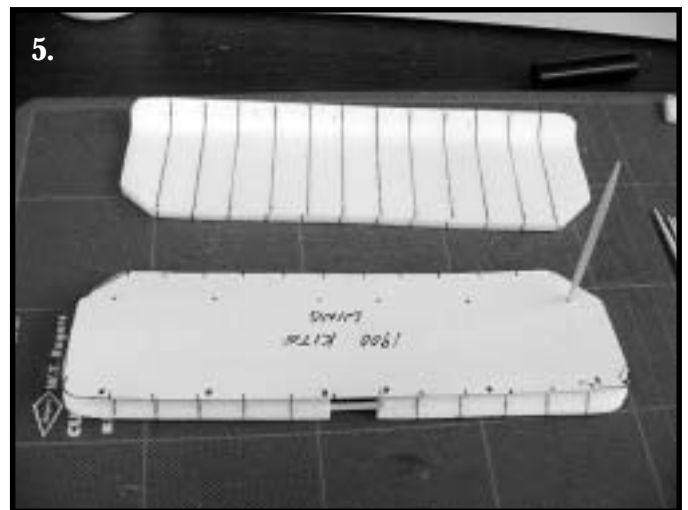
3. Cut out the center of the lower wing only as shown by the dotted lines on that template. Cut a toothpick in half and sharpen the cut ends. Dip the ends in glue and stick them in the cut edges to join the lower wing halves, leaving a .6-inch (1.5-centimeter) gap between the halves. (If the Styrofoam is thin, glue the toothpicks to the underside of the wing instead.)



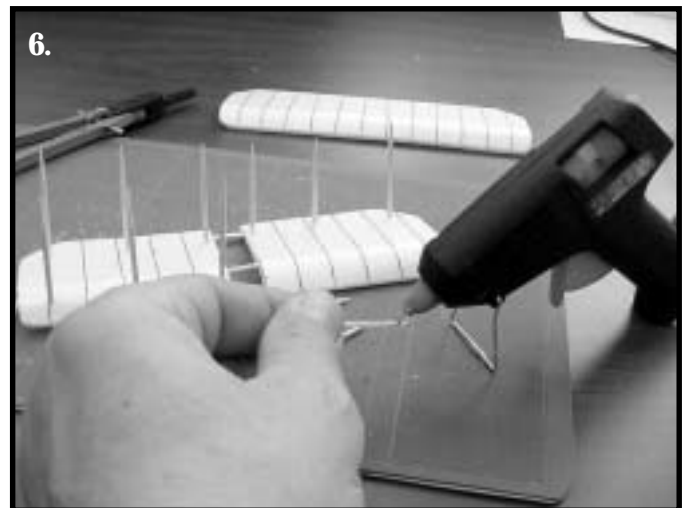
4. Make 12 spars by cutting toothpicks to a 2-inch (5-centimeter) length and sharpening the cut ends.



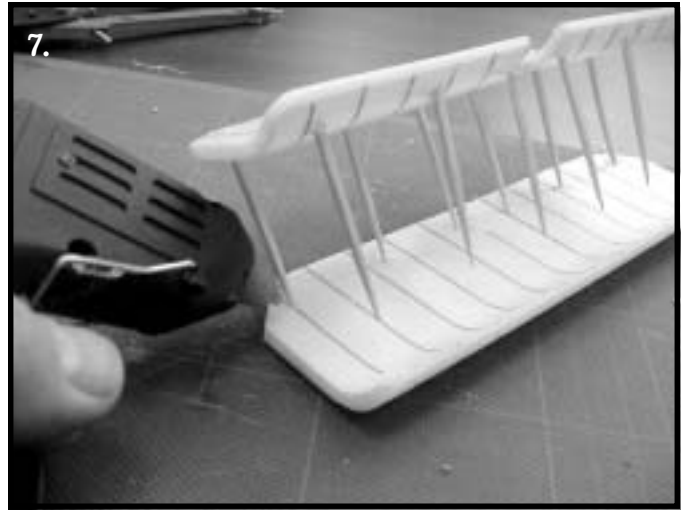
5. Use the wing template and a sharp toothpick to mark the holes for the spars on the top surface of the lower wing and bottom surface of the upper wing. Note that the front edges of the wings curve down. In this picture the upper wing in the back is upside down.



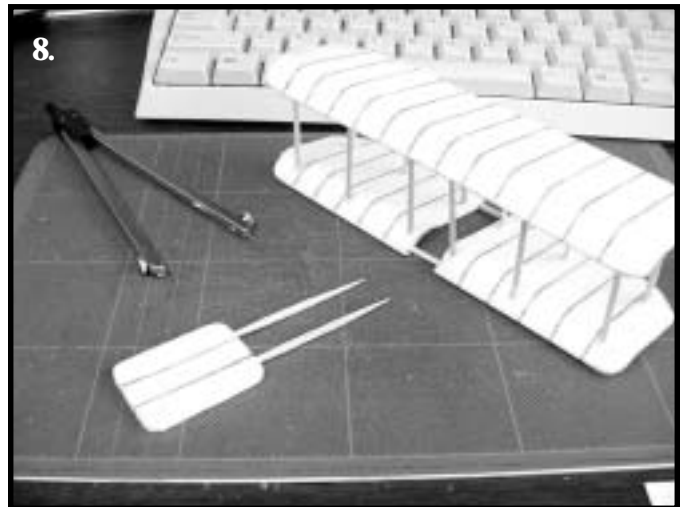
6. Dip toothpicks in glue and insert them in the spar holes now marked in the lower wing. Try not to push them all the way through the wing. Be sure they are standing up as straight as possible.



7. Now, with both the upper and lower wings and wings upside down (the edges should be curving up at this point), insert the back row of spars into the underside of the top wing. Use the marked holes as a general guide, but keep the spars straight and evenly spaced. Put a little glue on each to keep them in place as shown in the picture. Now join the front spars to the top wing, remembering to keep them straight and fasten them with dabs of glue. This takes some effort to get everything in the right place and is easier to do with two people.



8. Stick two toothpicks into the edge of the end of the elevator and add a dab of glue to hold them in place. (If the Styrofoam is thin, glue toothpicks to the underside of the elevator instead.)



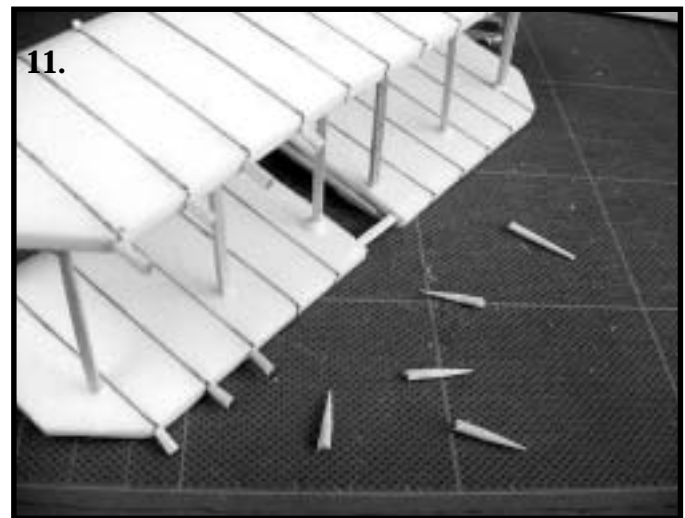
9. Turn the glider over and glue the elevator assembly on either side of the opening in the lower wing as shown.



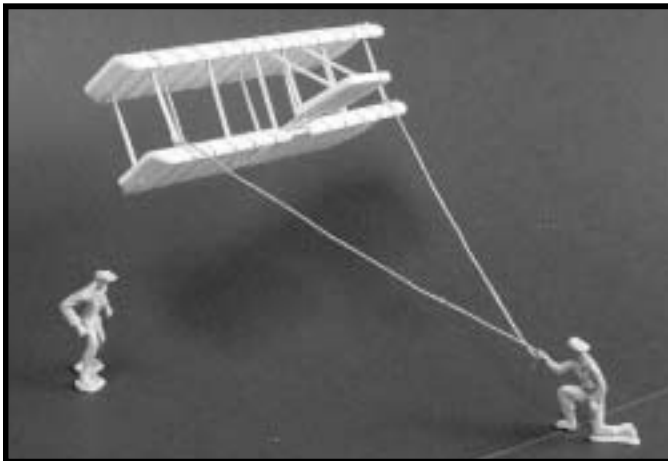
10. Turn the glider over again and insert a toothpick in the center of the left rib line as shown and add a bit of glue. Then insert the other end of the toothpick into the front edge of the upper wing and glue. Add another toothpick in the same way to the right rib line. (If the Styrofoam is thin, glue these to the underside of the upper wing instead.)



11. (Optional) Cut enough .6-inch (1.5-centimeter) toothpick pieces to stick into the back edge of each wing on the lines to simulate the ribs.



12. For display, the kite can be hung on a thread and strings can be added to be held by kneeling plastic toy soldiers. ADULTS: You may add figures by cutting, swapping, and gluing parts of plastic army soldiers. To obtain the desired poses, arms and legs can be removed and some from other soldiers glued in their place. Guns and helmets should be trimmed away using a hobby knife and the figure arms and legs can be shaped, swapped, or repositioned to fit and glued on. Five-minute epoxy works best for this. See steps 12 of the 1901 Glider instructions (pages 52 and 53) for more detailed illustrations.





Wright Brothers 1901 Glider

The 1901 Glider was the second unpowered aircraft built by the brothers. The aircraft was flown repeatedly at Kitty Hawk during 1901 as a piloted glider and as a kite. The Wright Brothers learned more about the fundamentals of aerodynamics using this aircraft, which they began building in 1900.

The 1901 aircraft was larger than the 1900 aircraft, but of the same basic design: it had two wings, no tail, and an elevator-stabilizer mounted in the front of the aircraft. The wingspan was increased from 17.5 to 22 feet, and the chord (front edge of the wing to the back edge) was changed from 5 to 7 feet, increasing the overall wing area from 165 to 290 square feet. The brothers wanted to provide more lift so they could pilot their glider in winds of less velocity. Without the pilot, the 1901 craft weighed about 100 pounds. The pilot would lie on the bottom wing and control the roll of the aircraft with a foot pedal. The pedal was connected to wires that pulled on the wing tips and warped (or twisted) the wing, producing unequal forces on the wings, which would roll the aircraft. On the 1901 aircraft, the pilot could also change the shape of the elevator to control the up or down position of the nose, or pitch, of the aircraft.

The aircraft was flown frequently up to 300 feet in a single glide, but did not perform as well as the brothers had expected. To improve the flying characteristics, they installed additional struts (structural pieces added to provide support and designed to resist pressure in the direction of their lengths) on the lower wing to alter the camber (or curve) of the aircraft wing. The photo to the right shows the aircraft immediately after landing, and you can see the additional struts between the wings at the center.

During their test flights the brothers encountered an effect known as “adverse yaw.” Sometimes when the wings were warped to produce roll, which should have resulted in a curving flight toward the lower wing, the increased drag on the upper wing twisting in the opposite direction caused the air speed to decrease, and the aircraft would turn into the ground.



Wilbur Wright testing his flying position in the 1901 Glider.



While trying to solve these new problems, the Wrights gathered the first real usable and accurate aerodynamic data obtained by experimenting with a wind tunnel. These results would be applied to the 1902 aircraft, which would answer many questions raised by the 1901 aircraft (shown in the photos below) as the brothers progressed toward the successful 1903 Flyer.





Wright Brothers 1901 Glider Model Instructions

Designed by

Roger Storm, NASA Glenn Research Center

Materials

- One or two clean Styrofoam meat trays, at least 9 inches (23 centimeters) by 11 inches (28 centimeters), preferably white
- 30 to 35 toothpicks
- Low-temperature glue gun
- Scissors
- Hobby knife, razor utility knife, or single-edge razor blade (adult help here)
- Cardboard or board to cut on
- Ultrafine-tip black marker
- Ruler
- Emery board
- Manila file folder
- Small plastic toy army soldiers, about 2 inches (5 centimeters) tall (optional)

General Instructions

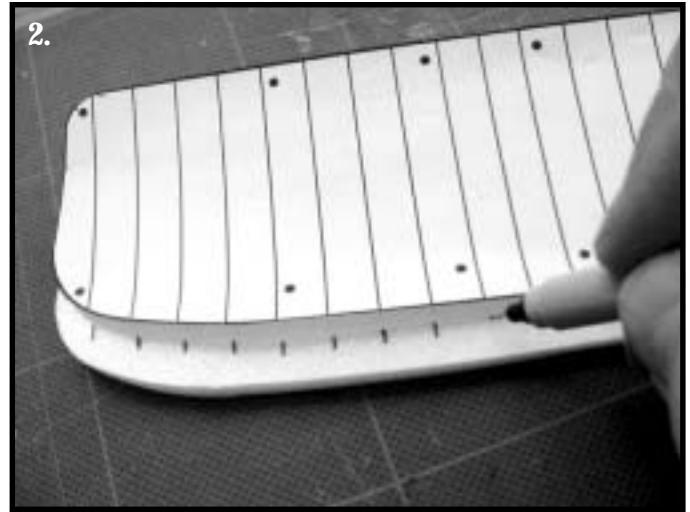
- Use scissors to cut out all three templates on the heavy lines of the 1901 Glider template (found in the back of this book).
- Do all razor knife or razor blade cutting on the board or cardboard to protect your working surface.
- The finished model is for display only; it is not meant to fly.

Procedure

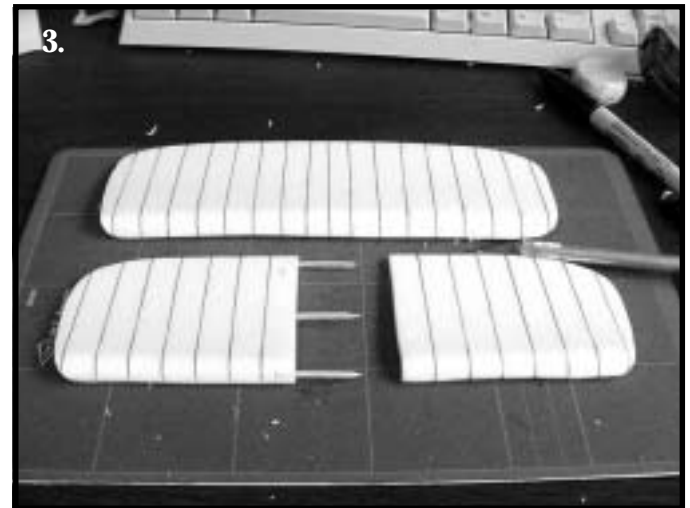
1. Carefully trace the wing and elevator shapes on the inside of the Styrofoam tray as shown. Be sure the front edges of the wings go about two-thirds of the way up the curved sides of the tray. Check the bottom of the tray and avoid any logo found there. You may need two trays. Cut out the wings and elevator with the hobby knife or scissors. Use the emery board to smooth the cut edges and sand off the pen lines.



2. Using the templates as a guide, mark the locations of the rib lines on the tops and bottoms of the wing and elevator sections with the ultrafine-tip black marker. Make two sets of marks, one on each edge. Connect the marks to make the rib lines. Make a rib template from a manila folder to draw the rib lines (so the end of the template can be bent to conform to the rounded shape of the Styrofoam).



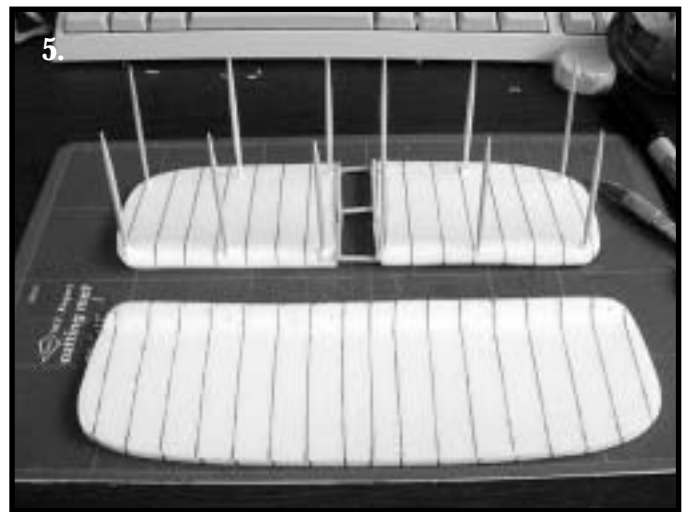
3. Cut out the center of the lower wing (only of the lower wing) as shown by the dotted lines on the template. Cut two toothpicks in half and sharpen the cut ends of three of them. Dip the ends in glue and stick them in the cut edges to join the lower wing halves, leaving a .6-inch (1.5-centimeter) gap between the halves. (If the Styrofoam is thin, glue the toothpicks to the underside of the wing instead.)



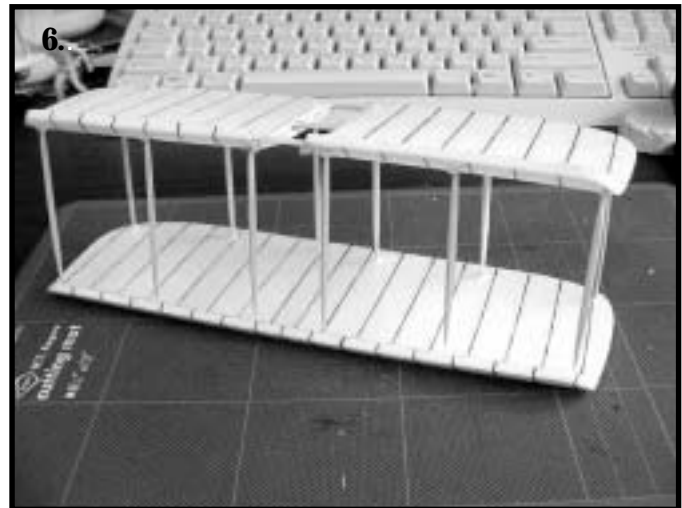
4. Use the wing template and a sharp toothpick to mark the holes for the spars on the top surface of the lower wing and the bottom surface of the upper wing. Note that the front edges of the wings curve down. In this picture the upper wing in the background needs to be turned upside down.



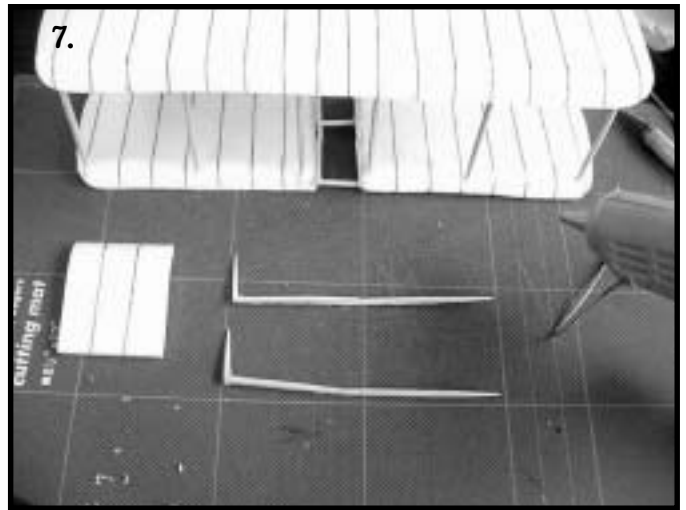
5. Dip toothpicks in glue and insert them in the spar holes now marked in the lower wing. Try not to push them all the way through the wing. Be sure they are standing up as straight as possible. The upper wing in the foreground of this picture is upside down (the curved edge is curving up).



6. Now, with both the upper and lower wings upside down (the edges should be curving up at this point), insert the back row of spars into the underside of the top wing. Use the marked holes as a general guide, but keep the spars straight and evenly spaced. Put a little glue on each to keep them in place as shown in the picture. Now join the front spars to the top wing, remembering to keep them straight, and fasten them with dabs of glue. This takes some effort to get everything in the right place and is easier to do with two people.



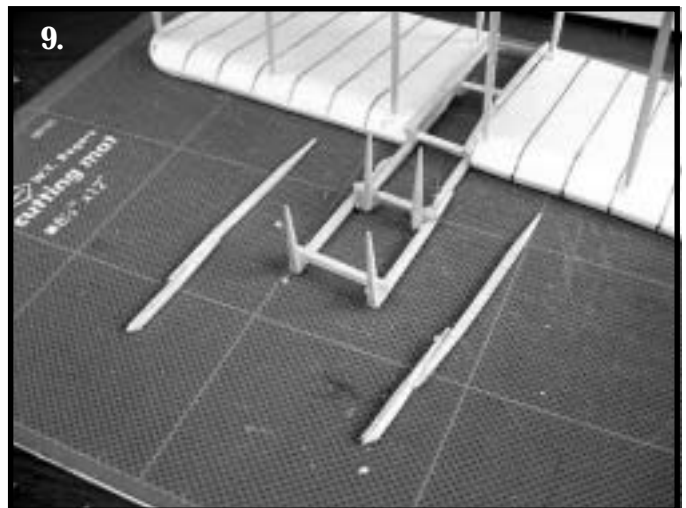
7. To make a skid, join two toothpicks end to end and side by side so the overall length is 4.3 inches (11 centimeters). When the glue is dry, cut them to a length of 3.5 inches (9 centimeters) and then glue the cutoff end back on at a 90-degree angle as shown. Repeat the process for the second skid.



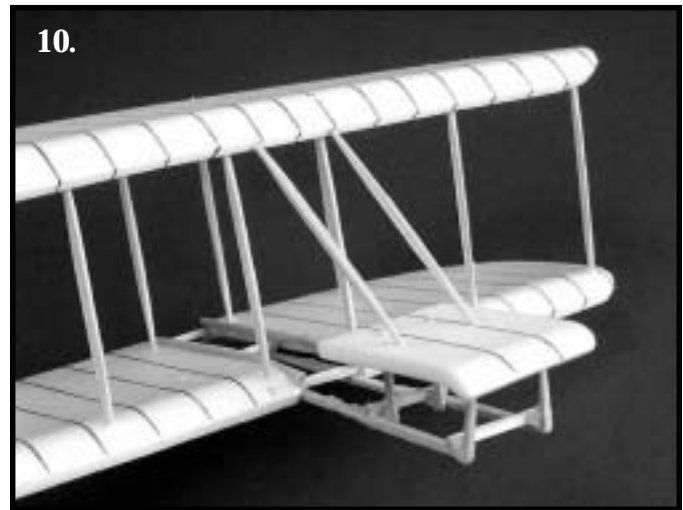
8. Turn the wing assembly upside down and glue the skids on either side of the opening in the lower wing. The skids should overlap the front and middle toothpicks that join the wing halves and should extend out beyond the front (curved edge) of the lower wing.



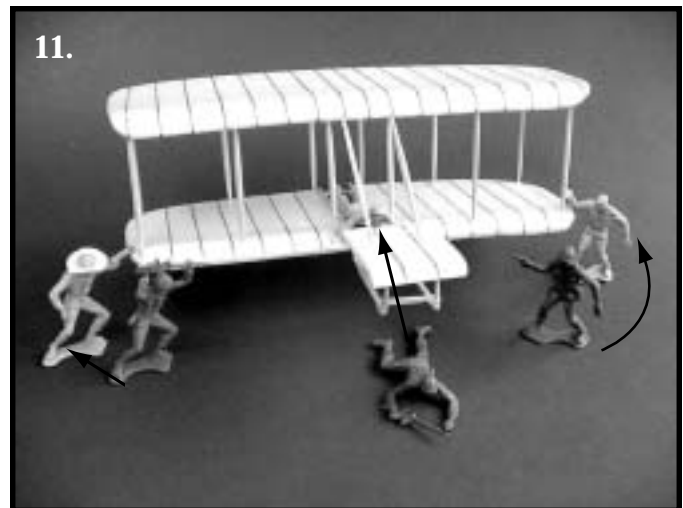
9. Turn the assembly back over so it is right side up, and cut two pieces of the right length to brace between the two skids. Glue one at the end and one at the middle. Cut two more pieces for upright support for the elevator and glue them sticking up at the middle cross brace. Make two braces to go from the upper wing to the elevator by joining two toothpicks end-to-end and trimming them to a length of 2.5 inches (6.5 centimeters).



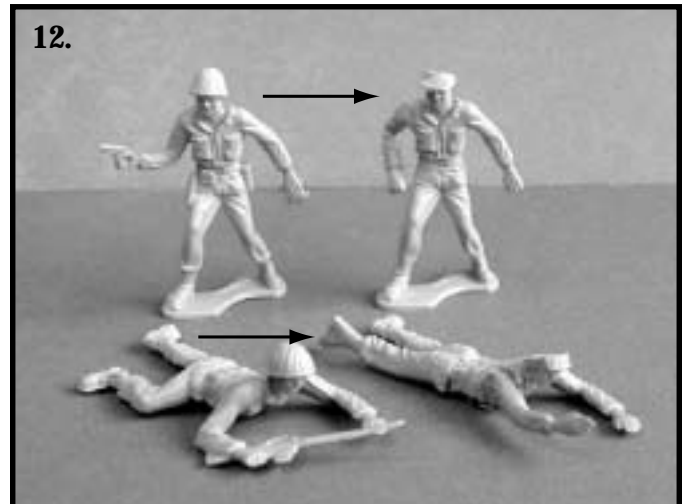
10. Place glue on the ends of the four upright supports and push them into the elevator. Also put glue on both ends of the upper braces and push them first into the center of the top of the elevator along the rib lines, and then into the front edge of the upper wing, as shown. (If the Styrofoam is thin, glue the braces to the underside of the upper wing instead.)

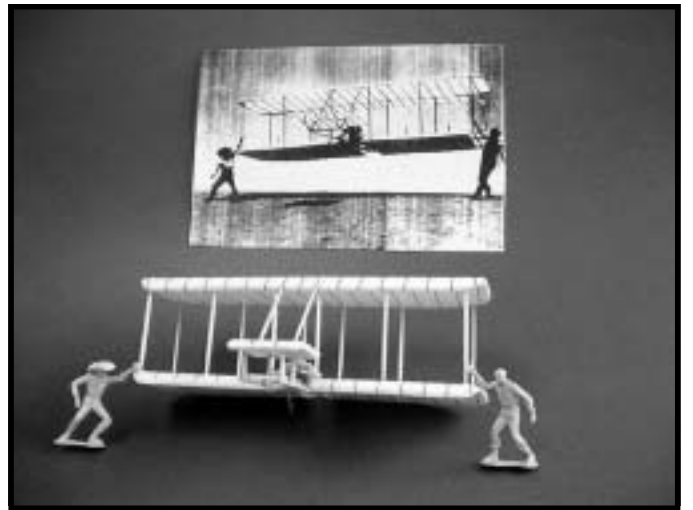
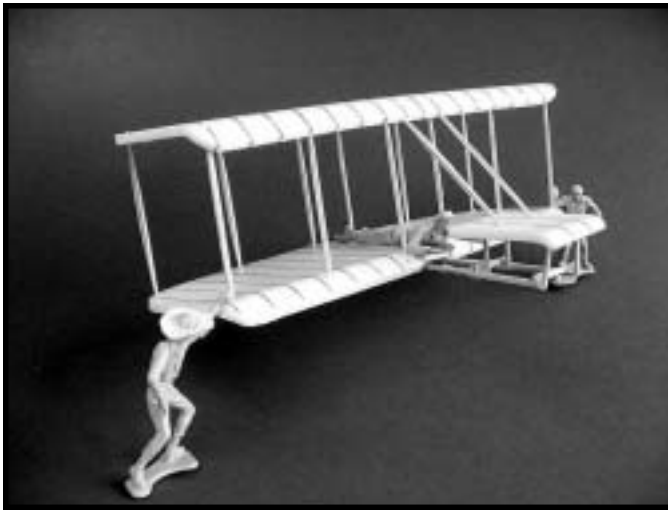


11. (Optional) You can make the figures of Wilbur and Orville Wright by swapping and gluing parts of plastic army soldiers. To obtain the desired poses, arms and legs can be removed and some from other soldiers glued in their place. Guns and helmets should be trimmed away using a hobby knife and the figure arms and legs can be shaped, swapped, or repositioned to fit and glued on. Five-minute epoxy works best for this. The dark soldiers in the photograph are the original shapes and the light soldiers are the final shapes.



12. The original soldiers on the left were transformed into the figures of Wilbur and Orville Wright on the right.







Wright Brothers 1902 Glider

The Wright Brothers' 1902 Glider was their third unpowered aircraft. It was flown repeatedly at Kitty Hawk during 1902 as a kite and as a piloted glider. The brothers used this aircraft to solve some of the problems encountered with the 1901 Glider. They also used it to develop their piloting skills, because this was the first aircraft in the world that had active controls for all three axes: roll, pitch, and yaw.

The 1902 aircraft had two wings and an elevator-stabilizer mounted in the front, like the 1901 aircraft. It had a 32-foot wingspan, a 5-foot chord, and 5 feet between the wings. Without the pilot, it weighed about 120 pounds. As before, the pilot lies on the bottom wing and controls the roll of the aircraft by warping the wing shape. On the 1902 aircraft, however, and on all flyers through 1905, the warping was controlled by a control device called a "hip cradle," instead of the pedals that were used on the 1900 and 1901 aircraft.

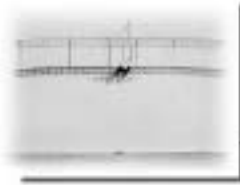
There were other major differences between this aircraft and its predecessors as well. Data from the 1901 wind tunnel experiments showed that a longer, thinner wing gave less drag and a better lift-to-drag (L/D) ratio, so the aspect ratio (ratio of wingspan to wing chord or width) was changed from 3:1 on the 1901 aircraft to 6:1 on the 1902 aircraft. To try to solve the problem of adverse yaw from the 1901 Glider, two 6-foot rudders were added to the rear of the craft.

Test flights went better than in 1901, but occasionally, the glider would spin out of control on recovering from a turn at low speed. Lying awake one night, Orville concluded that the rudder was acting like a vertical wing, in which turning generated an angle of attack, and thus, an unwanted force in the wrong direction. To correct this, a single, movable rudder was attached at the rear and connected to the wing-warping.

Now perfected, the glider worked beautifully, keeping the nose of the aircraft pointed into the curved flight path. On the 1902 aircraft, the pilot could also change the angle of the elevator to control the up and down position, or pitch, of the nose of the aircraft. For the first time in history, a craft could be controlled in three dimensions. With this new aircraft, the brothers completed gliding flights of over 650 feet.

At the end of 1902, all that remained for the first successful airplane was the development of the propulsion system. During the following winter and spring, the brothers built their own small engine from scratch and perfected their own propeller design for the 1903 flyer.





Wright Brothers 1902 Glider Model Instructions

Designed by

Roger Storm, NASA Glenn Research Center

Materials

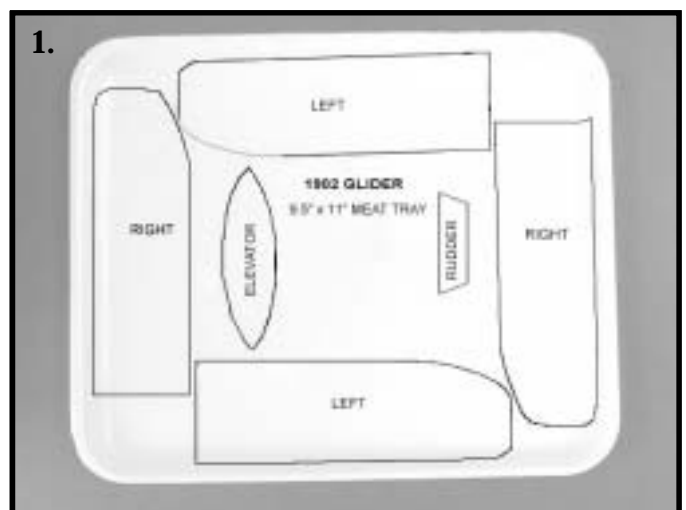
- One or two clean Styrofoam meat trays, at least 9 inches (23 centimeters) by 11 inches (28 centimeters), preferably white
- 30 to 35 toothpicks
- Low-temperature glue gun
- Scissors
- Hobby knife, razor utility knife, or single-edge razor blade (adult help here)
- Cardboard or board to cut on
- Ultrafine-tip black marker
- Ruler
- Emery board
- Manila file folder
- Small plastic toy army soldiers, about 2 inches (5 centimeters) tall (optional)

General Instructions

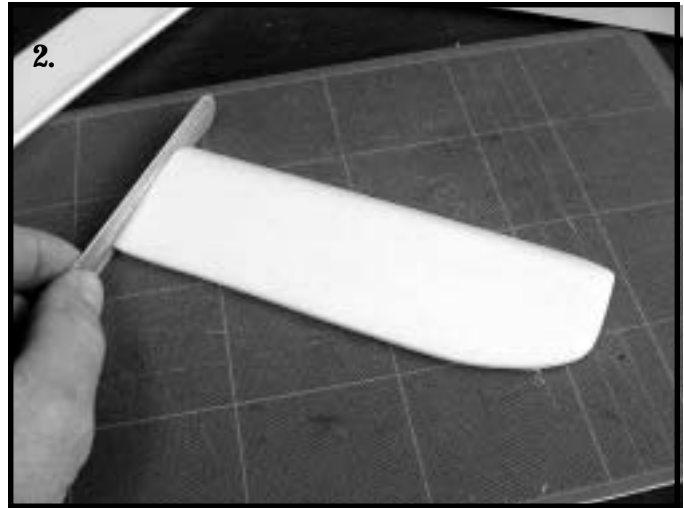
- Use scissors to cut out all three templates on the heavy lines of the 1902 Glider template (found in the back of this book).
- Do all hobby knife or razor blade cutting on the board or cardboard to protect your working surface.
- The finished model is for display only; it is not meant to fly.

Procedure

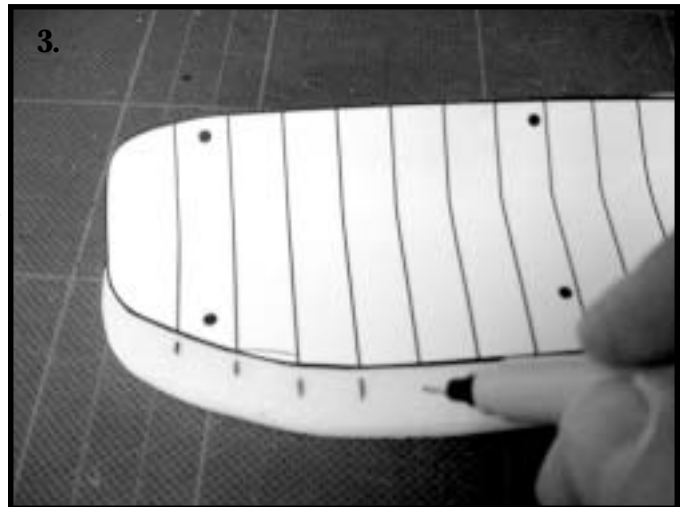
1. Carefully trace the wing and elevator shapes on the inside of the Styrofoam tray as shown. Be sure the front edges of the wings go about two-thirds of the way up the curved sides of the tray. Check the bottom of the tray and avoid any logo found there. You may need two trays. Cut out the wings and elevator with the hobby knife or scissors.



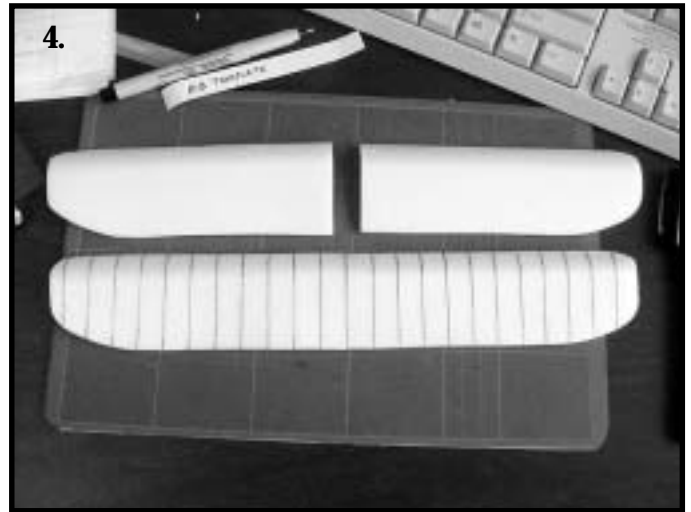
2. Use the emery board to smooth the edges and sand off the pen lines. Make sure that the two halves of the upper wing are flat where they will be joined, as shown at the right.



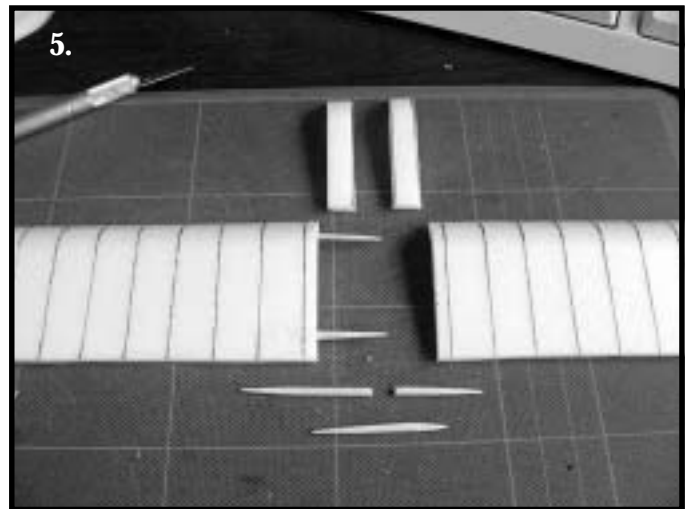
3. Using the templates as a guide, mark the locations of the rib lines on the tops and bottoms of the wing and elevator sections with the ultrafine-tip black marker. Make two sets of marks, one on each edge. Connect the marks to make the rib lines. Make a rib template from a manila folder to draw the rib lines (so the end of the template can be bent to conform to the rounded shape of the Styrofoam).



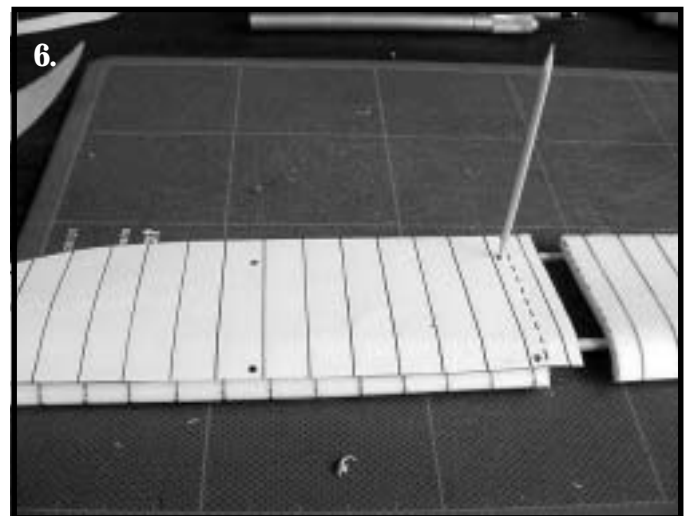
4. Place glue on the flat edge of the upper wing halves and join them as shown.



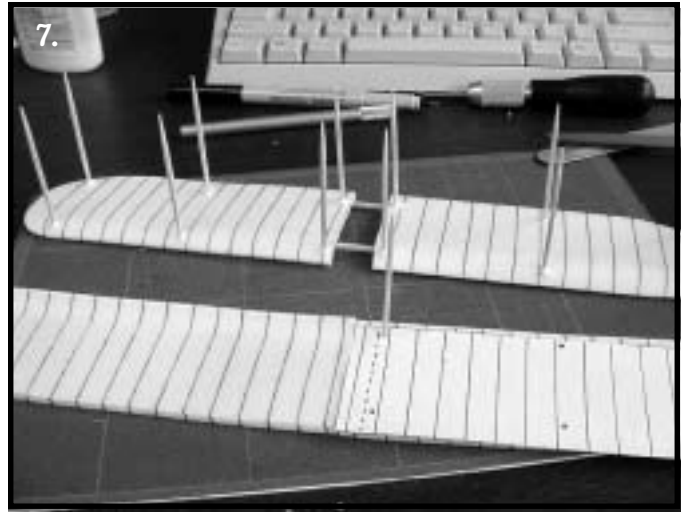
5. Cut off the parts of the lower left and right wing only as shown by the dotted line on the template. Cut a toothpick in half and sharpen the cut ends. Dip the ends in glue and stick them in the cut edges to join the lower wing halves, leaving a .6-inch (1.5-centimeter) gap between the halves. (If the Styrofoam is thin, glue the toothpicks to the underside of the wing instead.)



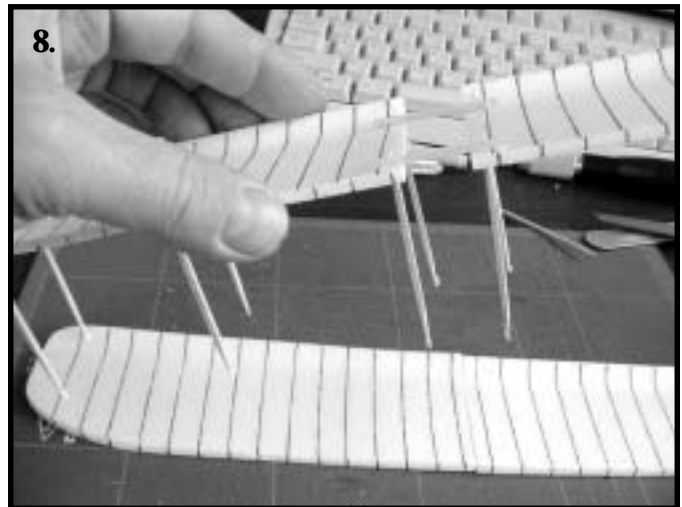
6. Use the wing template and a sharp toothpick to mark the holes for the spars on the top surface of the lower wing (the front edge should curve down as shown) and the bottom surface of the upper wing.



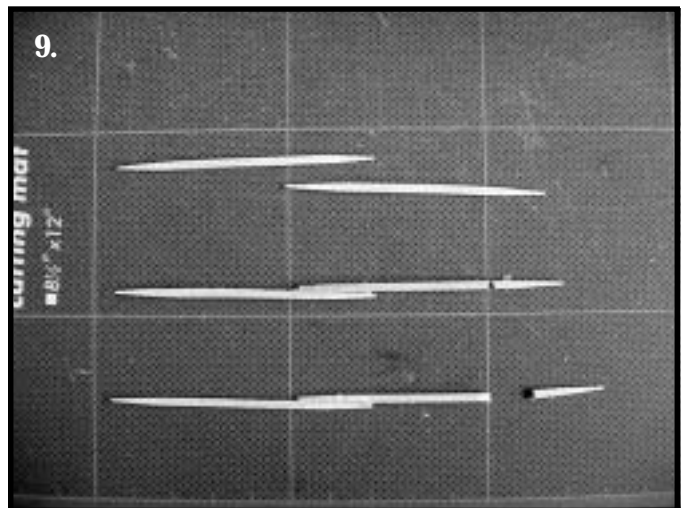
7. Dip toothpicks in glue and insert them in the spar holes now marked in the lower wing. Try not to push them all the way through the wing. Be sure they are standing up as straight as possible.



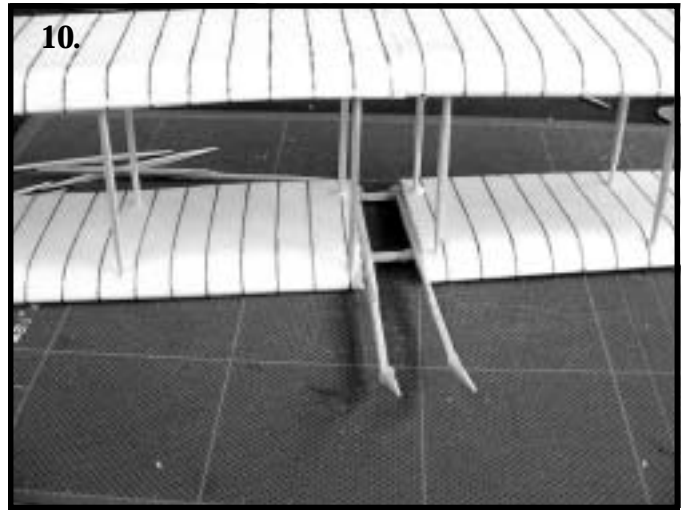
8. Now, with both the upper and lower wings upside down (the edges should be curving up at this point), insert the back row of spars into the underside of the top wing. Use the marked holes as a general guide, but keep the spars straight and evenly spaced. Put a little glue on each to keep them in place as shown in the picture. Now join the front spars to the top wing, remembering to keep them straight and fasten them with dabs of glue. This takes some effort to get everything in the right place and is easier to do with two people.



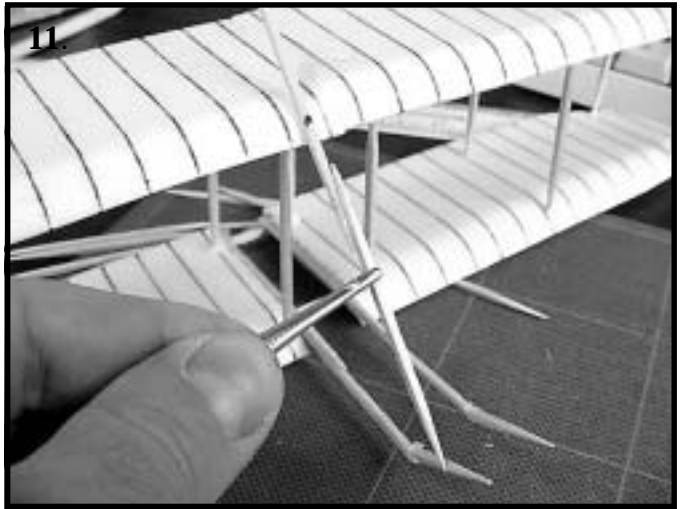
9. To make each of the two skids join two toothpicks end to end. When the glue is dry, trim them to a length of 3 inches (7.5 centimeters) and then glue the cutoff end back on at a 30-degree angle.



10. Glue the skids on either side of the opening in the lower wing so that the tips point upward. They should project out from the downward curving front surface.



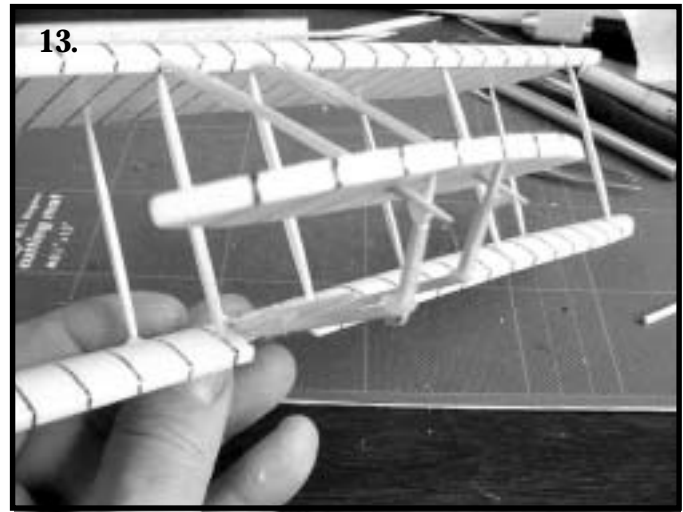
11. Cut a piece to brace across the skids and glue it at the 30-degree joint. Make two braces to go from the upper wing to the elevator by joining two toothpicks end to end and side by side to form a longer toothpick, and then mark them to the correct length by holding them between the upper wing and the skid, as shown. Allow enough to stick into the upper wing, cut off the excess, and then sharpen the cut end. (If the Styrofoam is thin, do not sharpen the cut end.)



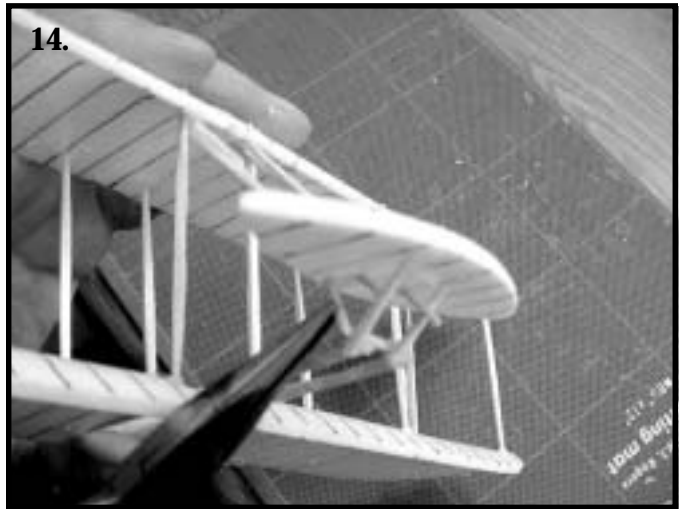
12. Push the ends of the uprights through the center of the elevator at an angle back toward the wing. Put glue on the top end of the upper braces and push them into the edge of the upper wing. (If the Styrofoam is thin, glue the ends of the uprights underneath the front edge of the upper wing.)



13. Now glue the lower end of the brace that sticks through the elevator to the upturned part of the skid in a way that makes the elevator level. Add a crossbar across the skids at the joint where the skids turn up at the 30-degree angle.



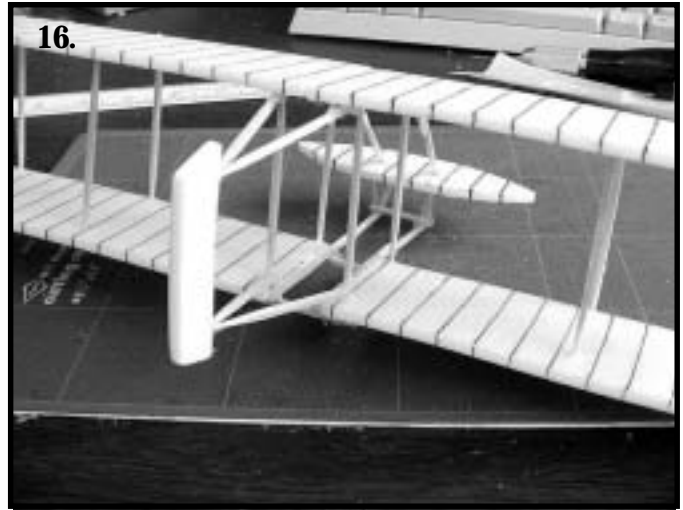
14. Cut two small pieces of toothpick long enough to go from the 30-degree joint to the rear of the underside of the elevator, and glue them in place. You may need to use tweezers or long-nosed pliers.



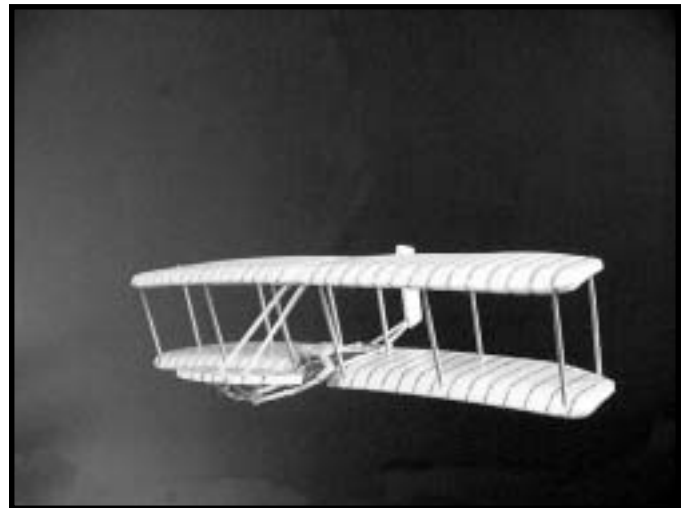
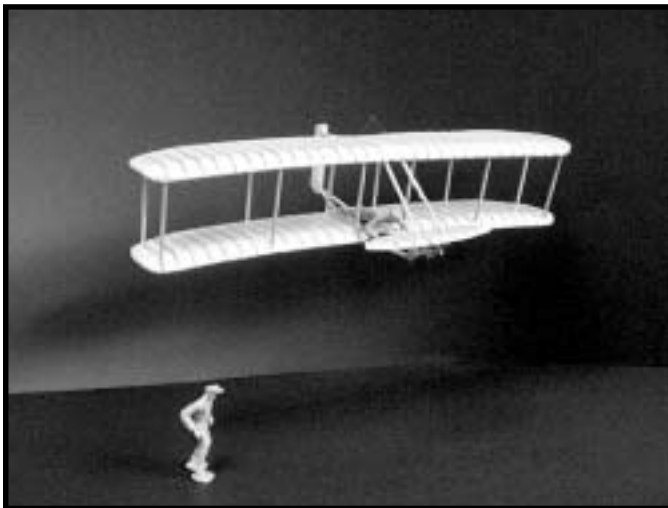
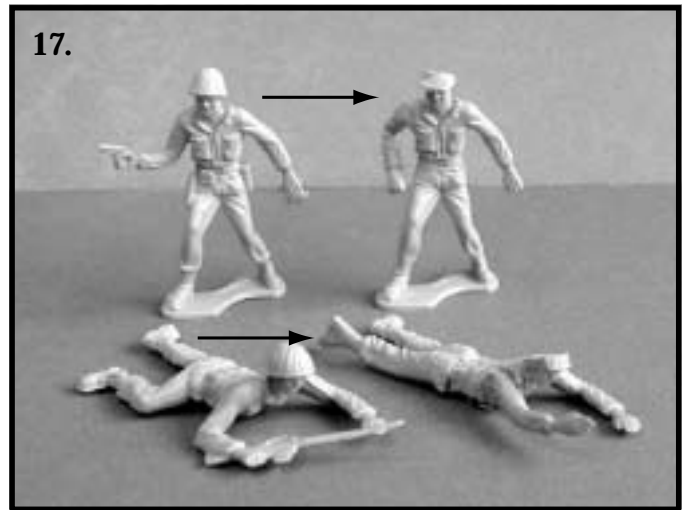
15. To attach the rudder, cut four toothpicks into 2-inch (5.5-centimeter) lengths, and stick the sharp ends into the long edge of the rudder, two on the top and two on the bottom so they form a "V" shape, as shown. The distance between the two legs of the V should be 3/4 inch (1.8 centimeters). Turn the glider over and glue the top two braces to the underside of the upper wing.



16. Turn the glider right side up and glue the bottom two rudder braces to either side of the opening in the lower wing. This finishes the glider.



17. (Optional) You can make the figures of Wilbur and Orville Wright by swapping and gluing parts of plastic army soldiers. To obtain the desired poses, arms and legs can be removed and some from other soldiers glued in their place. Guns and helmets should be trimmed away using a hobby knife and the figure arms and legs can be shaped, swapped, or repositioned to fit and glued on. Five-minute epoxy works best for this. The picture to the right shows how to make a pilot lay on the wing. The original soldiers on the left were transformed into the figures of Wilbur and Orville Wright on the right.





Wright Brothers 1903 Flyer

The Wright Brothers' 1903 aircraft was the first heavier-than-air, self-propelled, maneuverable, piloted aircraft. It was, in short, the first airplane.

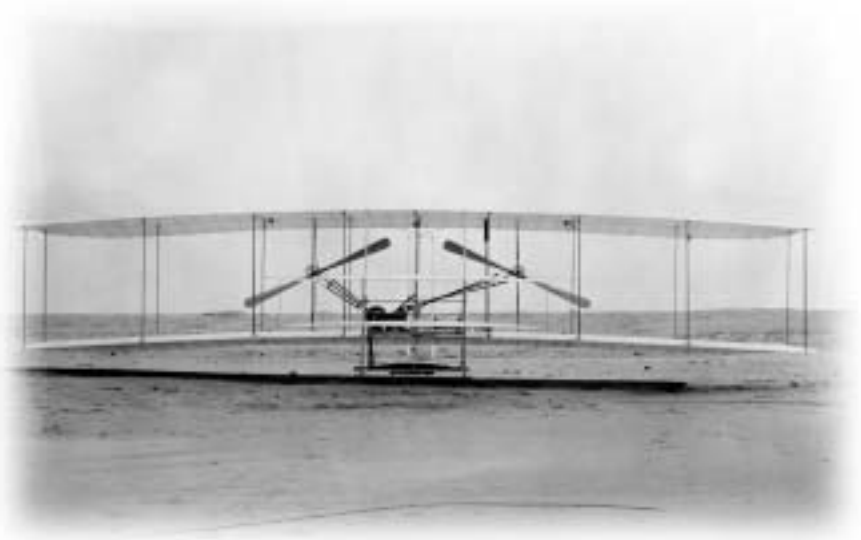
The forces acting on this aircraft were identical to the forces that act on any modern aircraft. The various parts of the aircraft were designed and perfected by 3 years of flight testing of unpowered kites and gliders and from wind tunnel testing. The Wrights used a moving elevator at the front of the aircraft to control pitch (an up or down movement of the nose). From the glider flights of 1901, the brothers identified the need for a rudder at the rear of the aircraft to control yaw (a side-to-side movement of the nose) and to allow coordinated turns. Control of roll (an up-and-down movement of the wing tips) was provided by wing-warping, which meant twisting the wing tips to increase or decrease lift on the outer sections of the wing.

The brothers began large-scale testing of their ideas with a combination kite and glider in 1900. The ideas tested on this aircraft were further refined on the glider of 1901, verified by the Wrights' wind tunnel data, and finally confirmed on the very successful 1902 Glider.

The 1903 aircraft (shown below) was similar to the 1902 craft, but now with a longer 40-foot wingspan, a 6-foot chord, 5 feet between the wings, and twin rudders and elevators. The biggest difference between the 1902 and 1903 aircraft was the addition of the propulsion system. The 1903 aircraft used twin pusher propellers located behind the wings. They were made to rotate in opposite directions, so that the rotational forces would cancel each other out. The Wright Brothers used gasoline to turn the propellers. Since no one could provide them with a lightweight motor of adequate horsepower, they built their own 4-cylinder, 12-horsepower motor. To put this into perspective, the motor of a modern lawn mower can easily achieve 6 horsepower.

The motor was placed on the lower wing next to the pilot and connected to the propellers with bicycle chains. A small gasoline tank was mounted on one of the wing struts. With the pilot and motor, the 1903 craft weighed a little over 700 pounds. This aircraft was first successfully flown on December 17, 1903, at Kitty Hawk, NC, on four flights from about 100 to over 800 feet.

Each of the four flights was marked by an instability in pitch; the nose, and consequently the entire aircraft, would slowly bounce up and down. On the last flight, hard contact with the ground broke the front elevator support, damaged the engine, and ended the season's flying. The brothers were encouraged, but realized that there was still more work to do before a truly operational aircraft could be developed. They continued to perfect their design through 1904 and 1905.





Wright Brothers 1903 Flyer Model Instructions

Designed by

Roger Storm, NASA Glenn Research Center

Materials

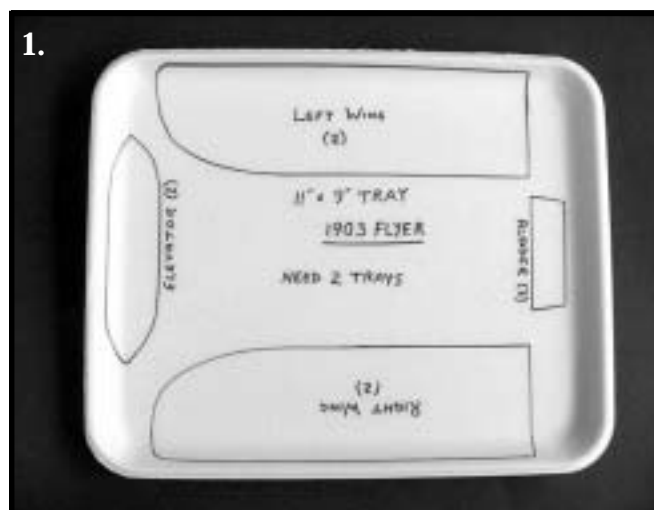
- Two to three clean Styrofoam meat trays, at least 9 inches (23 centimeters) by 11 inches (28 centimeters), preferably white
- 40 to 50 toothpicks
- 30-inch piece of 1/8- by 1/8-inch (.3 centimeter) piece of balsa wood
- Two craft sticks or wooden ice cream sticks
- Low-temperature glue gun
- Scissors
- Hobby knife, razor utility knife, or single-edge razor blade (adult help here)
- Cardboard or board to cut on
- Ultrafine-tip black marker
- Ruler
- Emery board
- Manila file folder
- Clear plastic sheet, such as a transparency sheet for an overhead projector
- Small plastic toy army soldiers, about 2 inches (5 centimeters) tall (optional)

General Instructions

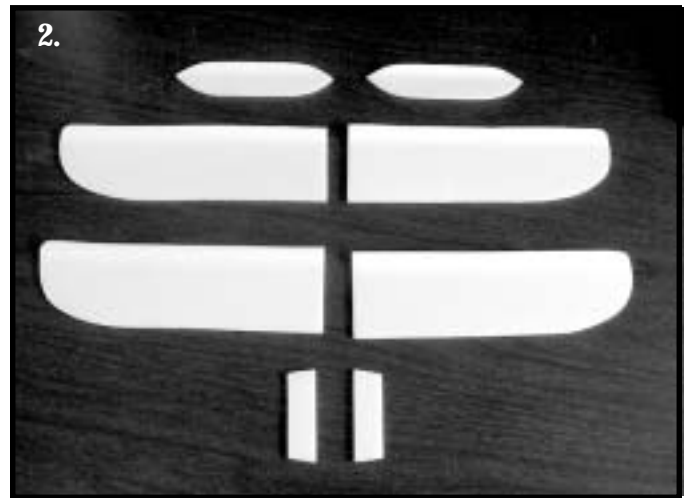
- Use scissors to cut out all three templates on the heavy lines of the 1903 Flyer template (found in the back of this book).
- Do all hobby knife or razor blade cutting on the board or cardboard to protect your working surface.
- The finished model is for display only; it is not meant to fly.

Procedure

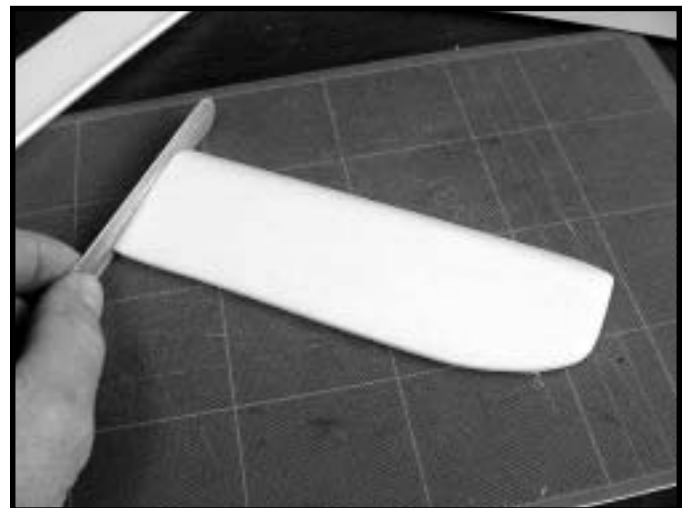
1. Carefully trace the wing and elevator shapes on the inside of the two Styrofoam trays as shown. Be sure the front edges of the wings go about two-thirds of the way up the curved sides of the tray. Check the bottom of the tray and avoid any logo found there. Cut out the wings and elevator with the hobby knife or scissors. Use the emery board to smooth the cut edges and sand off the pen lines.



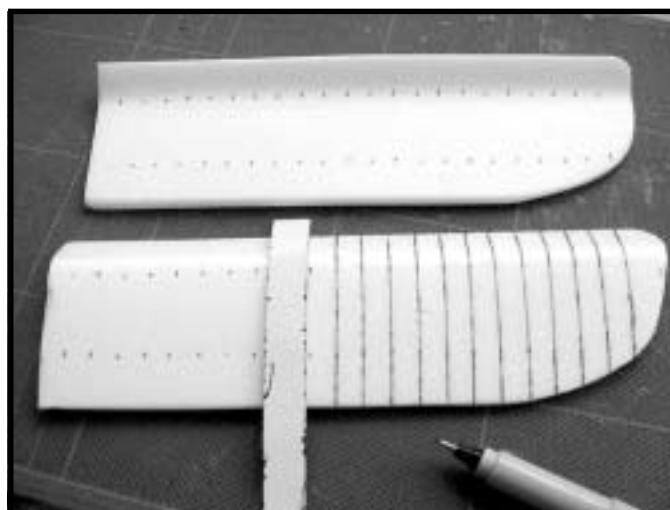
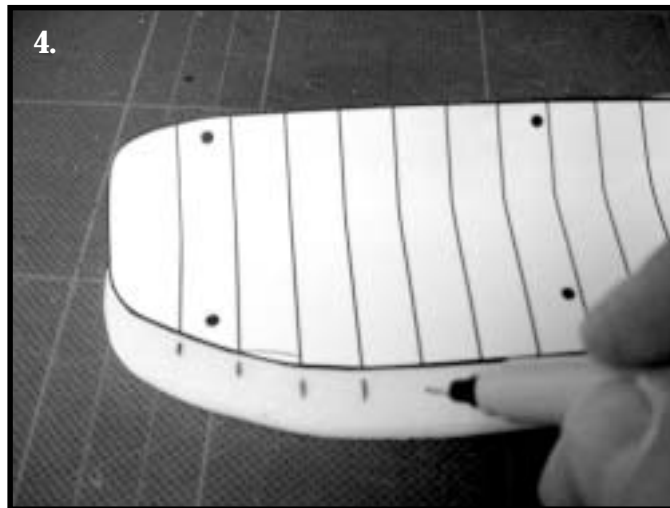
2. When finished you should have these parts, as shown.



3. Using the emery board, make sure that the two halves of the upper and lower wings are flat where they will be joined, as shown at the lower right.



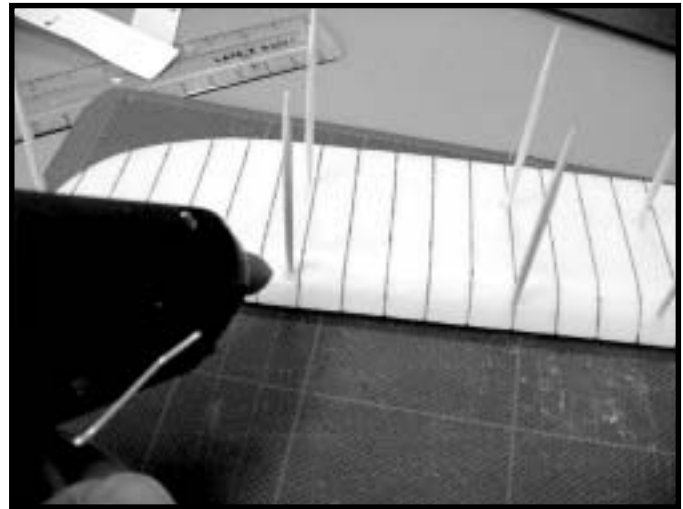
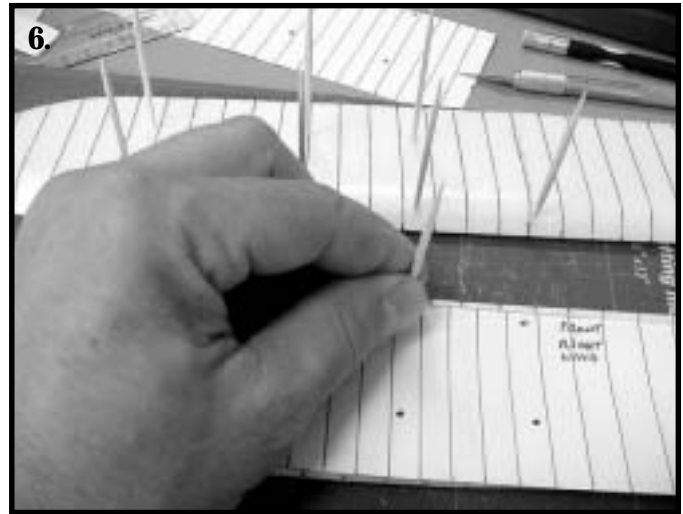
4. Using the templates as a guide, mark the locations of the rib lines on the tops and bottoms of the wind and elevator sections with the ultra-fine tip black marker. Make two sets of marks, one on each edge. Connect the marks to make the rib lines. Make a rib template from a manila folder to draw the rib lines (so the end of the template can be bent to conform to the rounded shape of the Styrofoam).



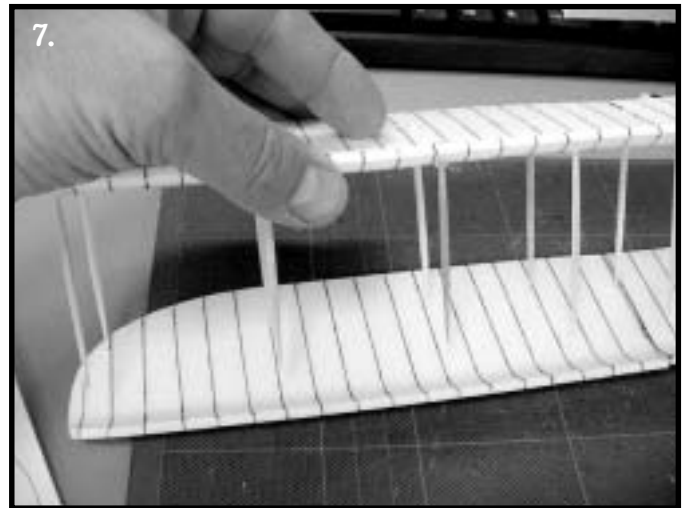
5. Place glue on the flat edge of the upper and lower wing halves and join each wing as shown.



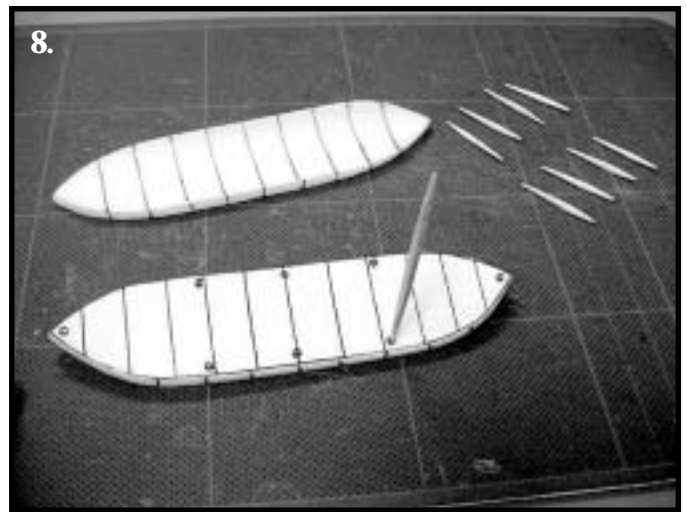
6. Use the wing template and a sharp toothpick to mark the holes for the spars on the top surface of the lower wing. Note that the front edges of the wings curve down. Dip toothpicks into glue and set them upright in the lower wing. Try not to push them all the way through the wing. Be sure they are straight and let them dry.



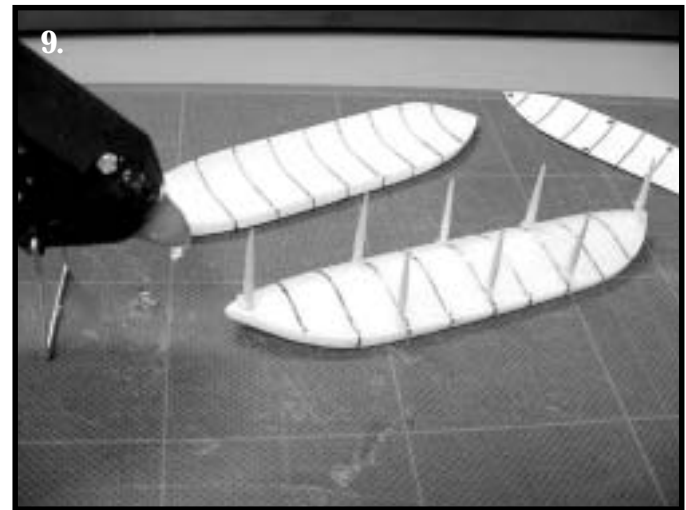
7. Now turn the lower wing upside down and insert the spars into the underside of the upper wing, doing the back row (away from the curved edge) first. Be sure each is vertical and add a little glue to hold each in place. Now tip the wing forward and insert the front row of spars, working from one end to the other. Again, try not to push them all the way through the wing. It takes some effort to get each in the right place and vertical. Add a dab of glue at the top of each spar to help secure it to the upper wing.



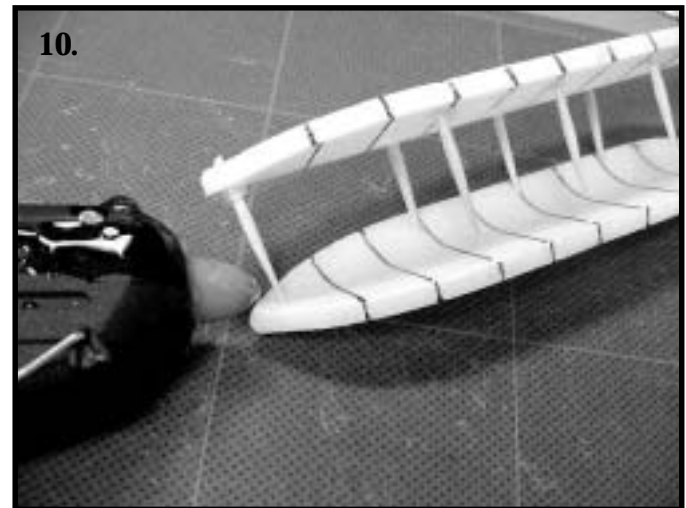
8. For spars for the elevator, cut eight toothpick sections, each 1 inch (2.5 centimeters) in length, and sharpen the cut ends. Mark the locations for these spars on the upper surface of the lower elevator using the template, just as you did with the wings.



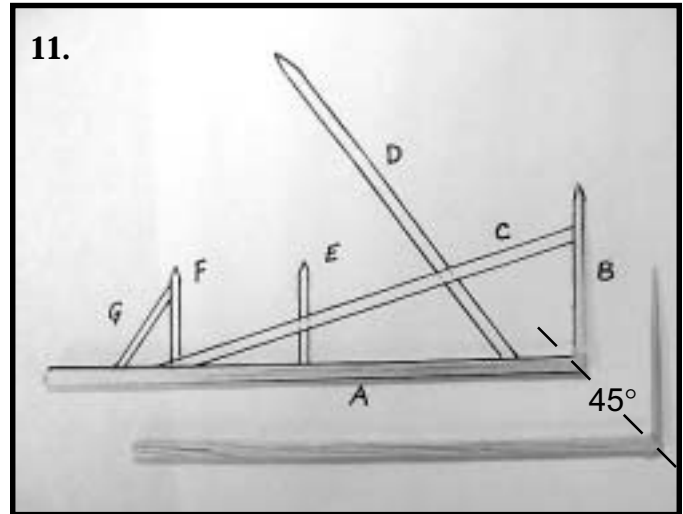
9. Set the eight short spars into the top surface of the lower elevator and add a bit of glue to each at the base, as shown.



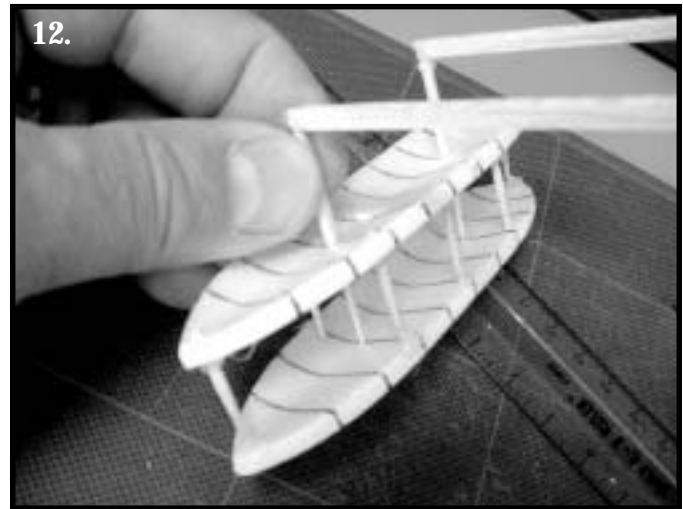
10. Turn the lower elevator assembly over and insert the spars into the underside of the upper elevator, doing the back row first and then the front, trying not to go all the way through the Styrofoam. Anchor with glue.



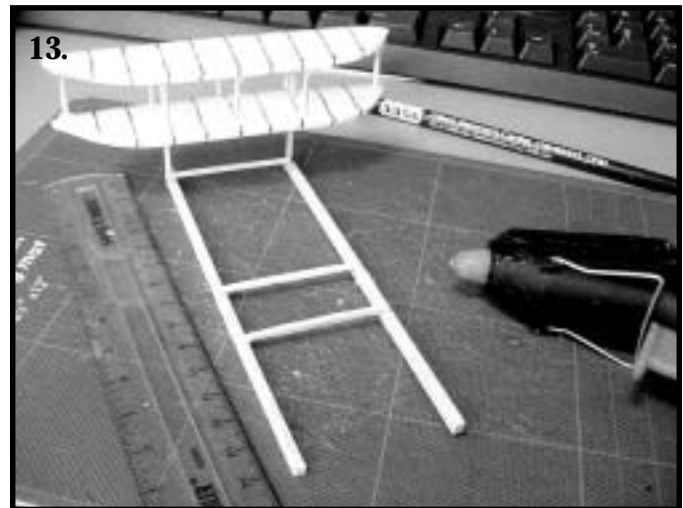
11. Cut a 5.5-inch (14-centimeter) piece of the balsa wood for section A of the skid (from the skid template) and lay it on the template. Cut the right end to form a 45-degree angle at the very end. Cut a toothpick for section B to a length of 1.8 inches (4.5 centimeters), also cutting the end of it at a 45-degree angle. Glue the 45-degree ends of the toothpick and the balsa wood piece together to form a 90-degree angle, as shown. Make a second skid by repeating the process.



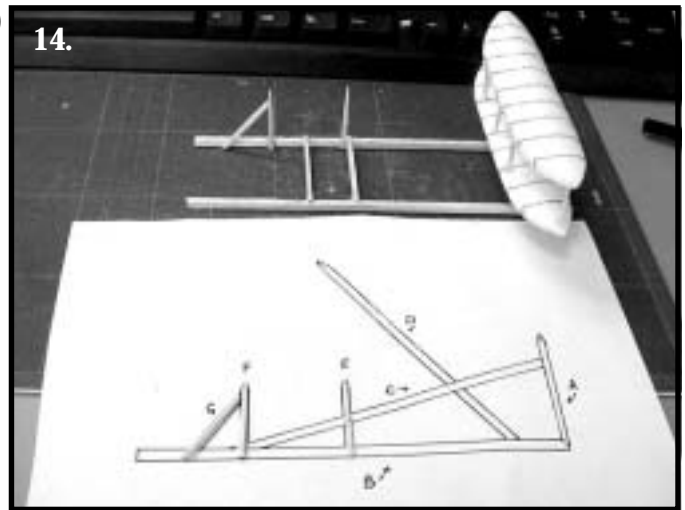
12. Turn the elevator assembly over and poke two holes through the lower elevator, midway between the front and rear spars of each of the spar pairs that are next to the center pair of spars (near the third rib mark from either end). Push the top of the skid assembly through the hole just made, add a bit of glue, and then stick the skid into the upper elevator. Repeat with the second skid as shown.



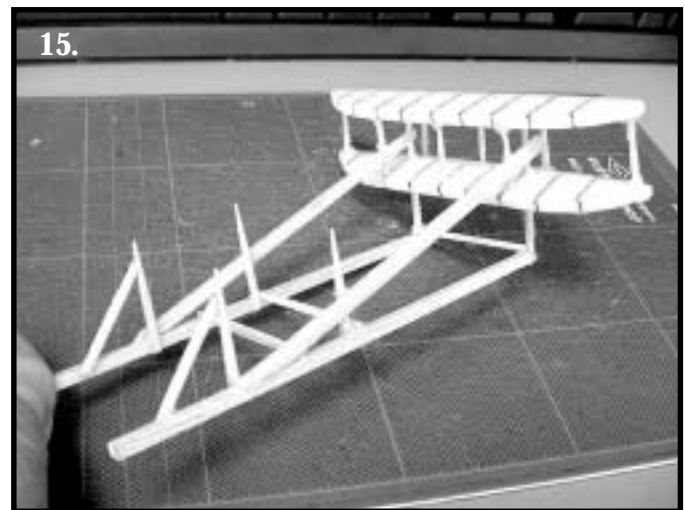
13. Cut the pointed ends off of three toothpicks so that they are 1.8 inches (4.5 centimeters) in length and place them as cross-braces across the skids as shown, one at the right angle of the skid, one at 2.8 inches (7 centimeters) from the right angle, and one at 3.5 inches (9 centimeters).



14. Cut two toothpicks to a 1.2-inch (3-centimeter) length. Glue them to the skid as shown on the template at points E and F, pointed ends up. Now measure and cut another toothpick as the rear brace (section G) and glue it in place. Repeat for the second skid.



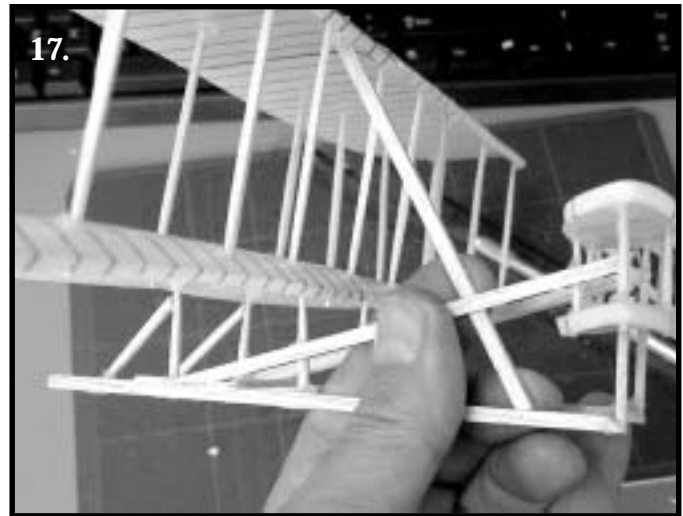
15. Now cut two balsa braces (section C) to go from the rear skid support up to the elevator support. Glue them in place as shown.



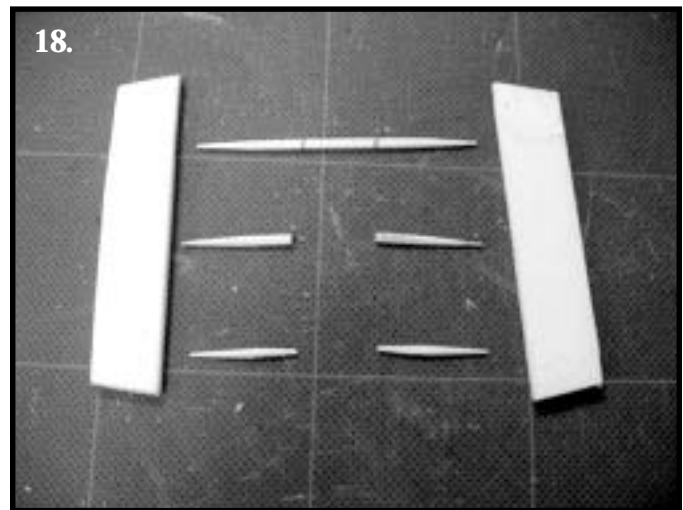
16. Turn the wing assembly over and press the skid assembly into the center of the lower wing as shown. Be sure the elevator projects out from the curved edge of the wing. Try to keep the toothpicks from going through the Styrofoam. Add some glue to each support.



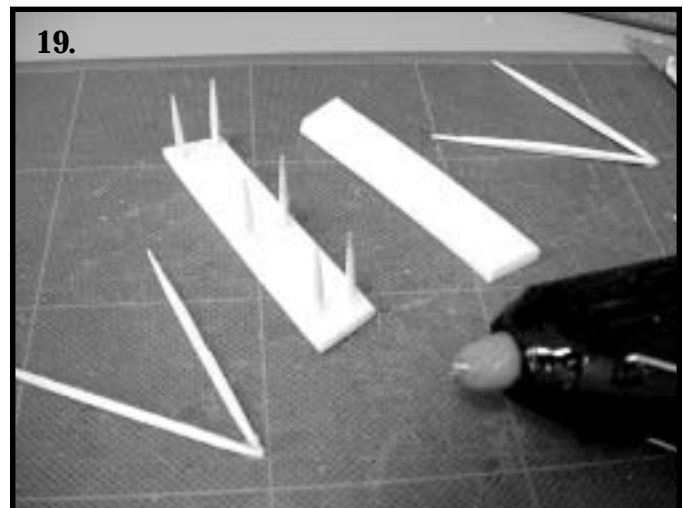
17. Cut two 4-inch (10-centimeter) pieces of balsa for section D and sharpen one end of each. Glue one end under the leading edge of the upper wing between the center and next-to-center spar, and then glue the other end to the bottom skid. Repeat on the other side of the skid.



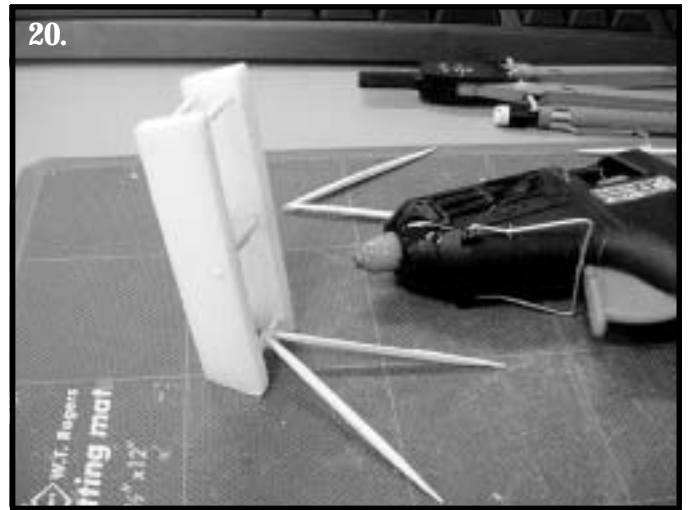
18. Six .8-inch (2-centimeter) rudder braces are needed. Cut them from three toothpicks as shown and sharpen the cut ends.



19. Dip the braces in glue, insert them into the rudder as shown here, and then turn the assembly over and insert the braces into the other rudder. Add more glue for support. To attach the rudder to the flyer, make two sets of V-shaped braces by gluing together two toothpicks as shown. The distance between the two legs of the V should be 1.5 inches (3.8 centimeters).



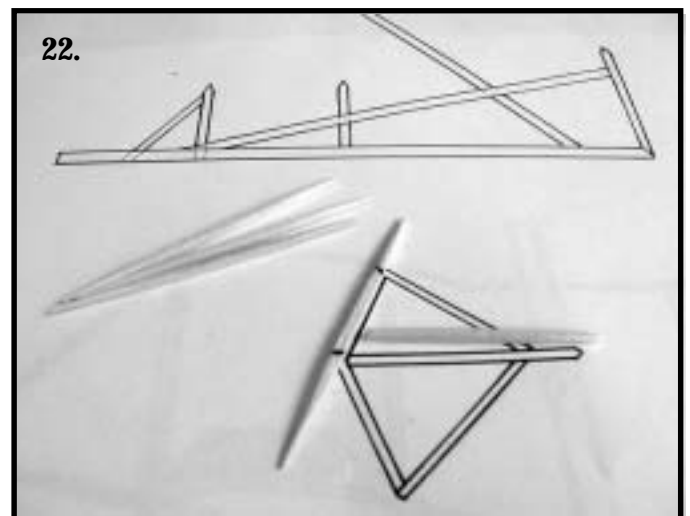
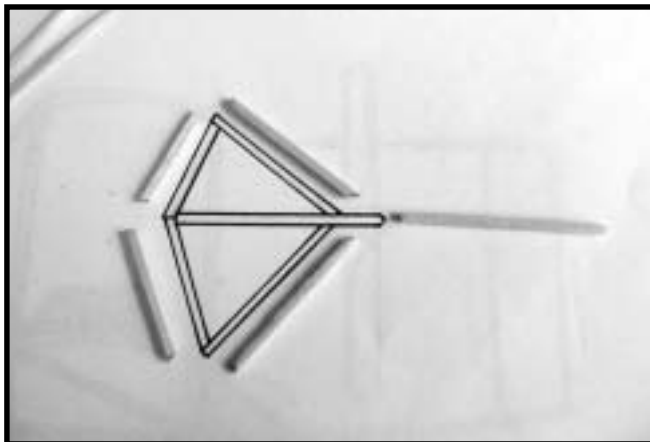
20. Glue the V-shaped braces to the rudders as shown. Once the glue is set, turn the rudder assembly over and glue on the other brace.



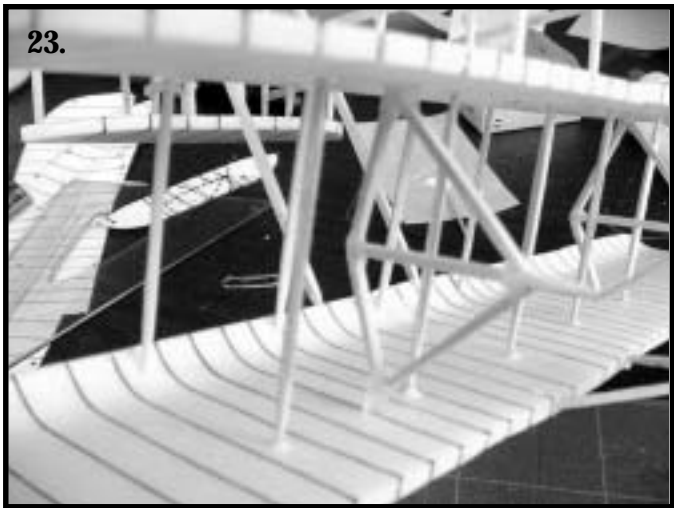
21. Stick the upper brace ends into the rear edge of the upper wing as shown and add a spot of glue. (If the wing is thin, glue the brace under the wing.) Now glue the ends of the lower brace to the rear of the skid so that the rudder is vertical.



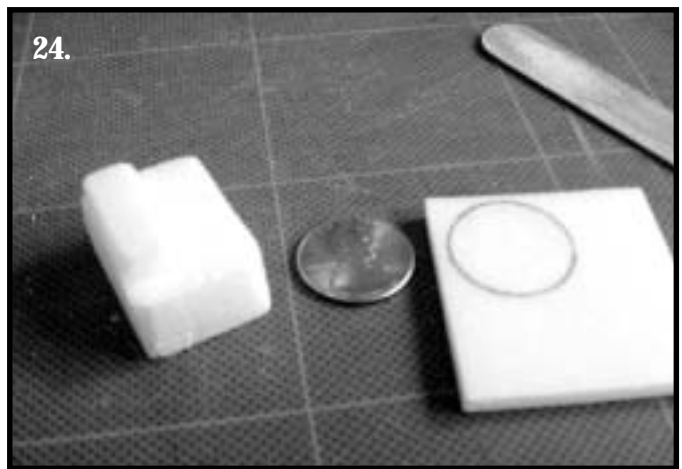
22. To make the propeller supports, use the template to mark and cut five toothpicks for each. Try to keep the assembly flat as it is glued.



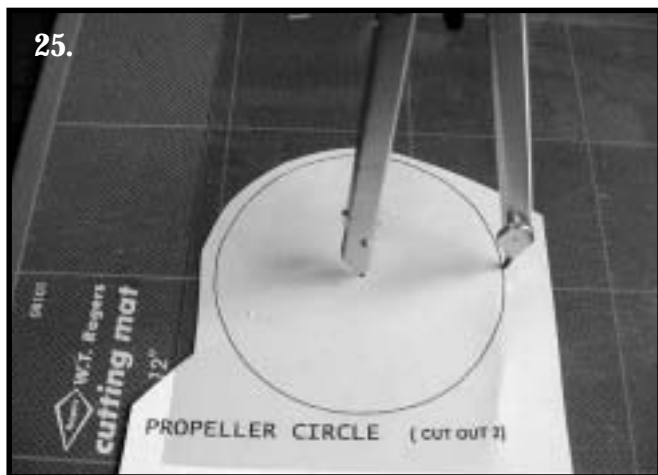
23. When dry, glue each propeller support to the lower wing 2.2 inches (5.5 centimeters) from the center, in line with the back struts. Turn the flyer over and glue to the top wing so that the support is vertical. Extra glue may be added to fill in any gap.

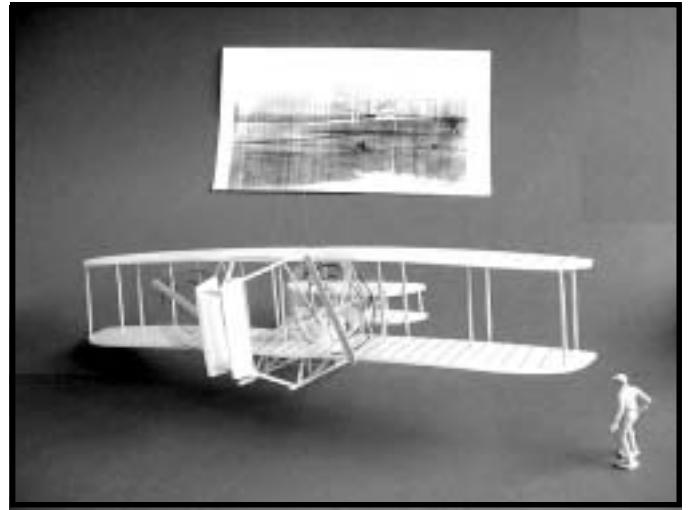
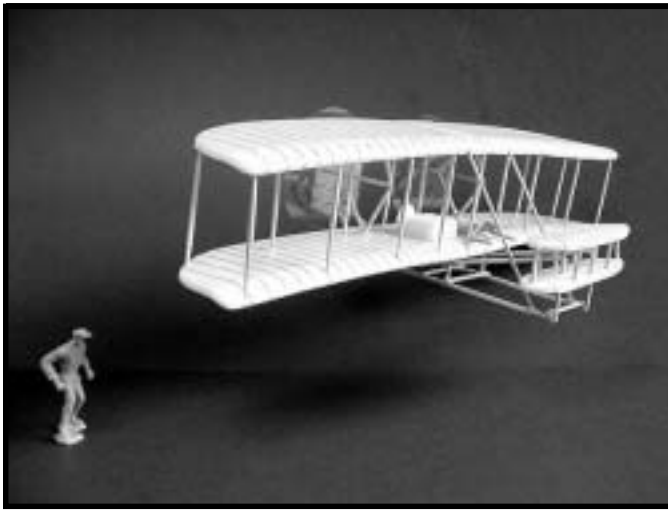


24. Simulate the small engine by gluing two .8- by 1.2-inch (2- by 3-centimeter) pieces of Styrofoam together and then adding a .4- by 1.2-inch (1- by 3-centimeter) piece on top. Trace and cut a circle with a penny or dime, cut out, and then glue on the end of the engine. Glue the engine onto the lower wing just to the right of center.



25. To simulate a turning propeller, trace and cut two 2.8-inch (7.2-centimeter) circles out of stiff clear plastic, such as a piece of a blank transparency sheet for an overhead projector. Draw pieces of smaller circles on the plastic circle with the black marker. Make a small hole in the very center of each circle with a toothpick. Make a propeller blade from a thin craft stick or wooden ice cream stick by cutting a piece the diameter of the plastic circle, rounding the cut edge, and poking a hole in the center. Mount the plastic circle and then the propeller blade on the end of the propeller support and add glue. Make another propeller sheet and blade for the other side.





26. (Optional) You can make the figures of Wilbur and Orville Wright by swapping and gluing parts of plastic army soldiers. To obtain the desired poses, arms and legs can be removed and some from other soldiers glued in their place. Guns and helmets should be trimmed away using a hobby knife and the figure arms and legs can be shaped, swapped, or repositioned to fit and glued on. Five-minute epoxy works best for this. The picture to the right shows how to make a pilot to lay on the wing. The original soldiers on the left were transformed into the figures of Wilbur and Orville Wright on the right.

