

Do not try to make your ornithopter using "household materials". If you want it to fly, you have to build it right.

# FREEBIRD

THE ORIGINAL D.I.Y. ORNITHOPTER!

Wingspan: 16 inches  
Weight: 1/4 ounce

The Ornithopter Zone  
www.ornithopter.org

## Required Materials

### Balsa wood:

- 1/8" square stick
- 3/32" square stick
- 1/8 x 5/16" stick
- 1/8 x 1/2" stick

*Instead of the plastic bead, use a 1/8" long section of the metal tubing.*

- Model aircraft plywood, 1/32" thick
- Steel music wire, 1/32" diameter
- Aluminum (or brass) tubing, 1/16" diameter
- ~~Small plastic bead with 1/32" hole~~
- Insulation stripped from 22 gauge wire
- Model airplane rubber, 1/8" wide by 18" long
- Model airplane tissue (6" x 20" sheet)

## Tools and Glue

- White glue
- Epoxy or CA glue
- Hobby knife (or single edge razor blade)
- Needle-nose cutting pliers
- Straight pin
- Sandpaper
- Ruler
- Solid cardboard to cut on
- Wax paper

**1 Gather Materials.** Your local hobby shop or [sigmfg.com](http://sigmfg.com) should have most of the items listed above. Do not make substitutions, especially with the rubber band. Office-grade replacements will result in an ornithopter that barely flies.

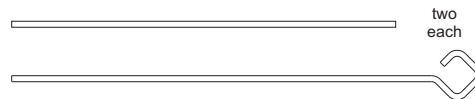
**Prepare the Wood Parts.** Using the hobby knife, with cardboard to protect your work surface, cut balsa to the following sizes:

- 1/8" square stick - two 8" lengths (wing spars)
- 3/32" square stick - two 7" lengths (tail pieces)
- 1/8 x 5/16" stick - one 5" piece (motor stick)
- 1/8 x 1/2" stick - one 1-1/8" piece (strut)

Also cut two strips of aircraft plywood, 3/16 by 2-1/8". You can round the ends with sandpaper. These are the connecting rods.



**2 Wire Parts.** With pliers, cut two 2" lengths of music wire and two 2-3/4" lengths. With the two longer pieces, use the pliers to form a small hook in one end, about 1/4" wide.



**Aluminum Tubing.** Press down with the hobby knife to cut aluminum tubing. Cut three 1/2" lengths. Sand the ends until they are smooth and perpendicular.

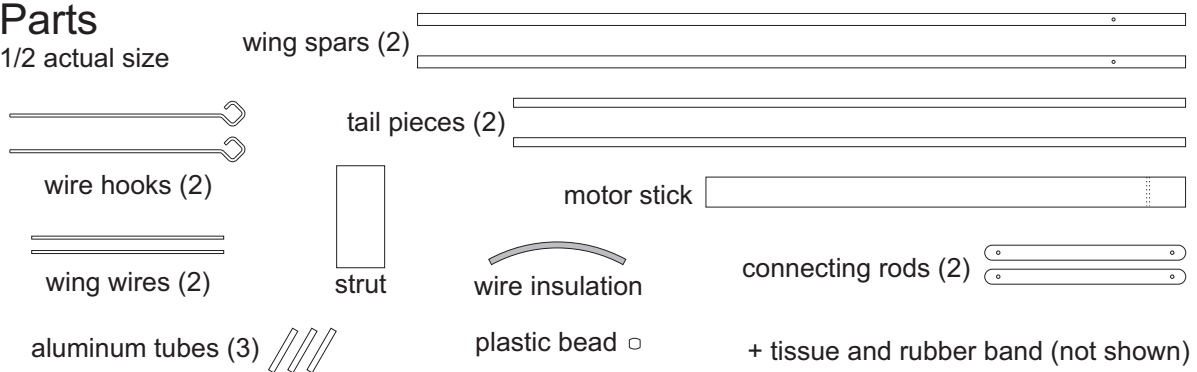


side view, enlarged

Also cut a 1/8" length of tubing to substitute for the plastic bead shown later in the instructions. Smooth off the end of the tube before cutting.

## Parts

1/2 actual size



**3 Drilling Holes.** You can use the sharp end of the wire you cut to drill holes. Work on a flat surface protected with cardboard. The wire is sharp, so don't support the wood with your finger. Keep the wire straight up and down, and twist it between your fingers to make a hole.

Holes should be made 3/4" from one end of each wing spar and 3/8" from one end of the motor stick, as shown above.

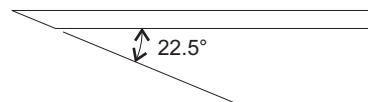
The plywood is much harder than balsa, so make a starter hole first, using a straight pin. Make holes exactly 1-3/4" apart in the connecting rods.

At this stage, all parts should look like the drawing at the top of the page.

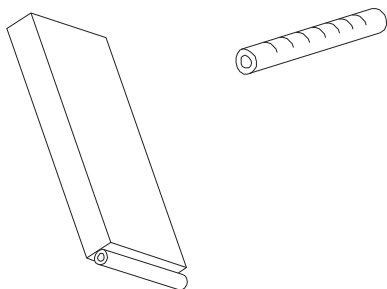
**5 Wing and Tail Tissue.** On the next page, you will find outlines for the wings and tail. Trace the outlines onto the tissue paper, arranging them as shown here. Flip the tissue over so you can trace both wing halves. Cut out the wings, both in one piece, and cut out the tail. Save the leftover tissue.



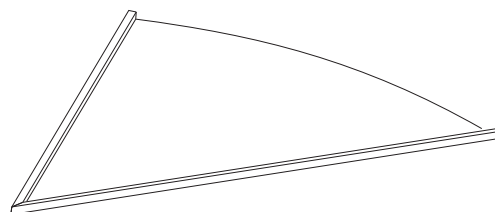
**6 Tail Pieces.** Cut a 22.5° angle at the end of each tail piece. Use the drawing to make this cut accurately.



**4 Crank Bearing.** Glue the metal tube to one end of the balsa wood strut using epoxy or CA glue. Optionally, you can file some grooves first to improve the bond strength. This doesn't seem to be necessary, though.



**7 Tail Assembly.** On wax paper, apply glue to the bevel end of each tail piece. Spread a thin layer of glue along the length of each tail piece and glue them onto the tail tissue, joined at the bevel.

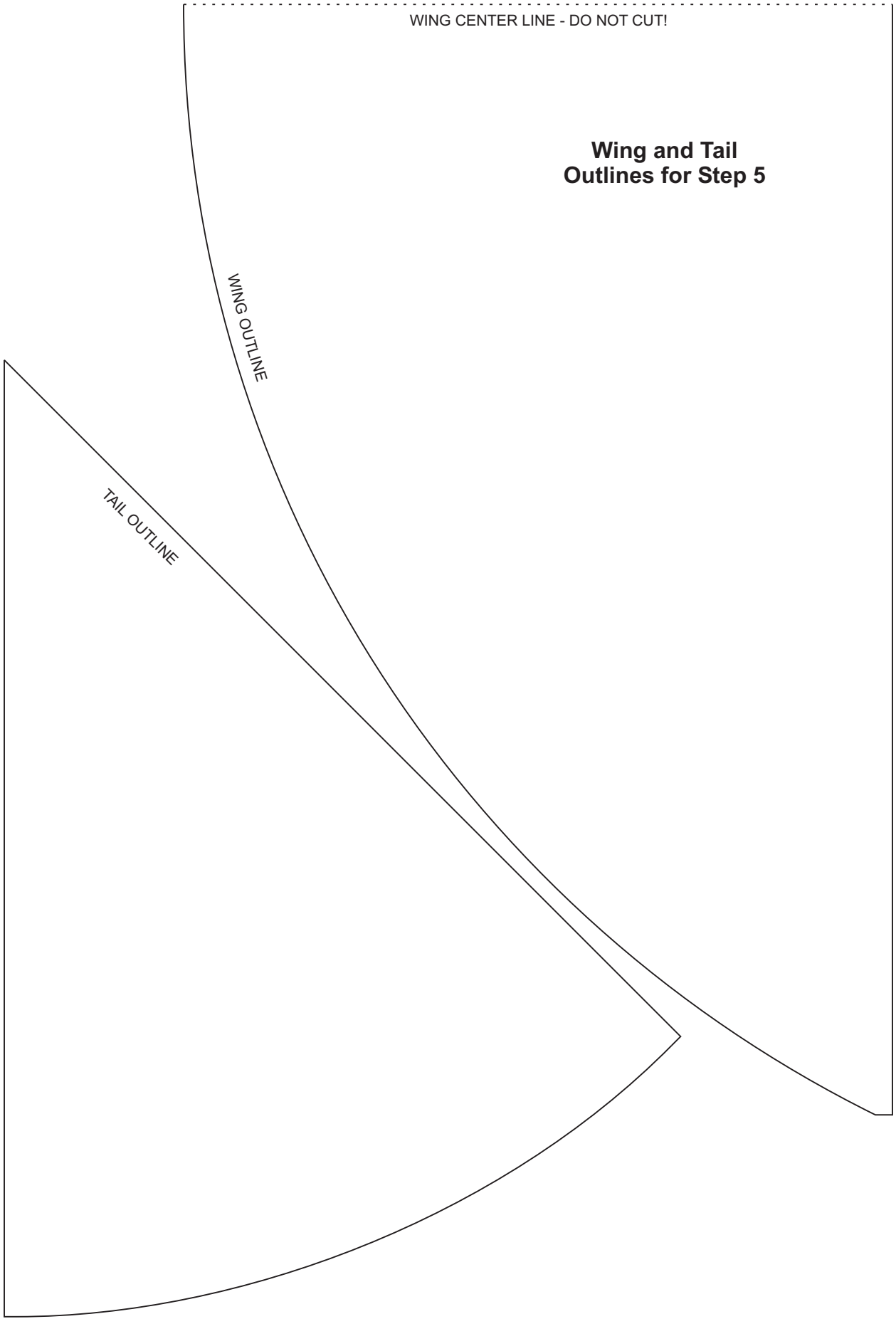


WING CENTER LINE - DO NOT CUT!

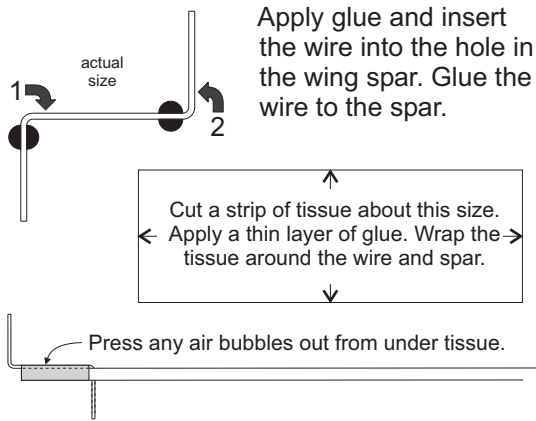
**Wing and Tail  
Outlines for Step 5**

WING OUTLINE

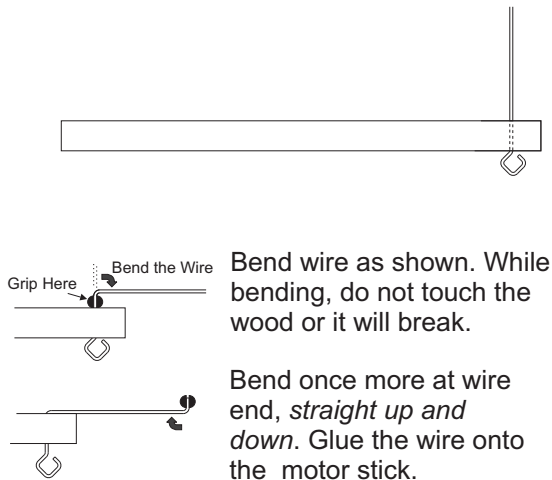
TAIL OUTLINE



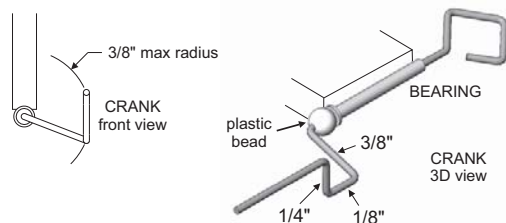
- 8 Wing Spars.** Using pliers, bend the wing wires precisely as shown below. Grip with pliers where indicated (●). Try for sharp 90° bends, and make sure the part will lay flat after bending.



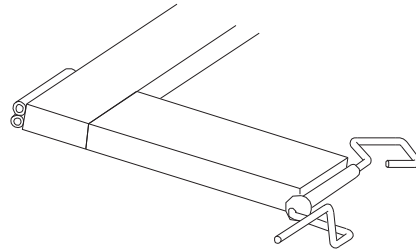
- 9 Wire Hook.** Apply glue, then insert a wire hook through the hole in the motor stick. The hook opening should be on the right.



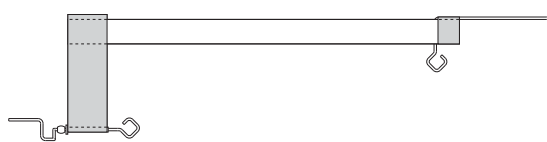
- 10 Crank Wire.** Slide the other hook wire through the crank bearing tube. Put the plastic bead on the wire, and then bend the wire as shown.



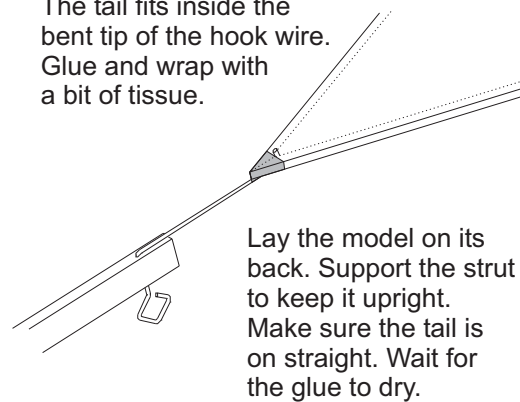
- 11 Body Assembly.** Glue together the wing hinge tubes, strut, and motor stick as shown. Lay flat on wax paper until dry.



- 12 Body Assembly, Continued.** Reinforce the body glue joints as you did with the wing spars. Use four layers of tissue cut to size.

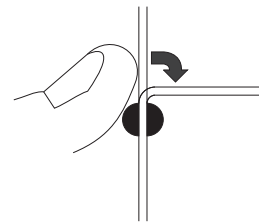


- 13 Tail Placement.** The tail fits inside the bent tip of the hook wire. Glue and wrap with a bit of tissue.

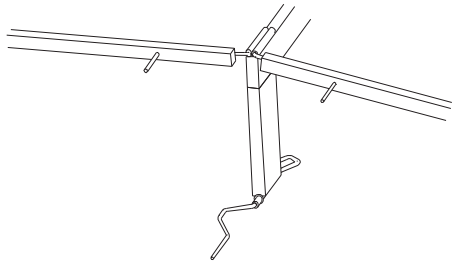


**To bend wire:** Position the pliers 1/32" from where you want the bend. Squeeze the pliers tightly while bending.

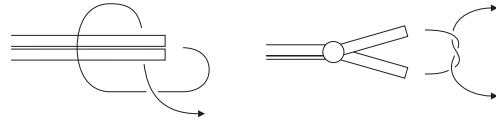
Pliers with grooves across them work much better for holding the wire.



- 14 Wing Installation.** Scrape any excess glue from the wing wires. When the tail is dry, pick up the model and gently insert the wing wires into the wing hinge tubes.

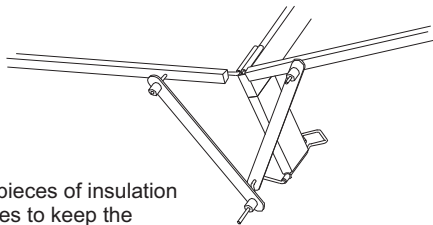


- 17 Rubber Band.** Hold together the ends of the rubber. Tie a knot as shown, forming a large rubber band. Then tie the free ends together to secure. Do not install the rubber band on the model until all glue is completely dry. Then, *double the rubber band* and hook it onto the motor hooks, with the knot in the back.



**Flapping Mechanism.** Slide a connecting rod onto the crank wire. Wiggle it past the first two bends in the wire. Fit the other end onto the wing wire for the bird's left wing. Then install the other connecting rod on the outer part of the crank and the right wing.

**15**



Twist short pieces of insulation onto the wires to keep the connecting rods in place. Watch out for sharp wire ends, and support the wires from behind so they don't bend.

*Wings must be 90 degrees from body!*

**18**

**Before You Fly!** Your Freebird will not fly until you make these adjustments.

First, **bend the tail wire up slightly**, about five degrees. Do not touch or use any wooden parts for leverage when you do this or they will break.

For test flights, turn the crank about 50 times to wind up the rubber band. After adjustments, you can wind up to 120 turns dry, or 220 with lubrication. Dry operation shortens the life of the rubber band. Vegetable oil will work.

Launch with a smooth horizontal motion, with the body inclined 20° from horizontal. Do not *throw*.

**Sharp turn followed by crash:**

Add weight to the wingtip on the *outside* of the turn. You can use a straight pin for this. Adjust weight as needed. Winding the opposite direction may also solve this problem.

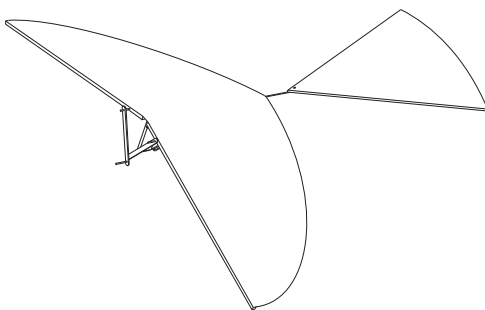
**Nose dive:** Bend the tail up slightly.

**Stall** (slowing almost to a stop and then losing height): Reduce the tail angle slightly.

Errors in the strut length or the hole spacing of the connecting rods can cause a nose dive or stall.

With proper adjustments, the Freebird will fly in a large circle for up to 30 seconds (dry motor) or up to one minute with lubrication.

**16**



**Wing Tissue.** Throughout this step, hold the wings in the "down" position, and be sure the wing wires stay all the way back in their tubes. Spread a thin layer of glue on the top of each wing spar and attach the straight leading edge of the wing tissue there. Allow the tissue to center itself naturally as you glue it to the top of the motor stick.