Required Materials

Balsa wood:
- 1/8" square stick
- 3/32" square stick
- 1/8 x 5/16" stick
- 1/8 x 1/2" stick
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
Razor blade or hobby knife
Small hacksaw or hobby saw
Needle-nose cutting pliers
Straight pin
Sandpaper
Ruler
Wire stripper
Solid cardboard to cut on
Wax paper

Gather Materials. Your local hobby shop 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 razor blade, 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.

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 razor blade to cut aluminum tubing. Cut three 1/2" lengths. Sand the ends until they are smooth and perpendicular.

Did you know?
You can build this model from a kit, saving time and money. Special parts make it easier to build. To find out more, visit www.birdkit.com.
Drilling Holes. Use the sharp end of the wire you cut to drill holes. Work on a protected, flat surface. The wire is sharp, so don't support the wood with your finger! Keep the wire straight up and down. Twist it between your fingers to slowly 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.

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

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

Crank Bearing. Using a hobby saw or small hack saw, file grooves across one side of one of the aluminum tubes, but not all the way through the tube wall. Glue the tube to one end of the balsa wood strut using epoxy or CA.

Ornithopter Zone kits such as Phoenix avoid this step, because the bearing tube has a flange, which helps hold it in place. The kits also have pre-cut tubing.

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.

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

Tail Assembly. 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 end.
Wing and Tail
Outlines for Step 5
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.

Apply glue and insert the wire into the hole in the wing spar. Glue the wire to the spar.

Cut a strip of tissue about this size. Apply a thin layer of glue. Wrap the tissue around the wire and spar.

Press any air bubbles out from under tissue.

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.

Bend wire as shown. While bending, do not touch the wood or it will break.

Bend once more at wire end, straight up and down. Glue the wire onto the motor stick.

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.

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.

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.

Lay the model on its back. Support the strut to keep it upright. Make sure the tail is on straight. Wait for the glue to dry.
**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.

**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.

**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. Make sure the wing wires are not able to slide forward.

**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.

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

First, **bend the tail wire up slightly**, just a few degrees. Do not touch or hold any wooden parts 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 and exposure to light shorten the life of the rubber band.

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. Adjust weight as needed. (Winding the opposite way 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 also cause a nose dive or stall.

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