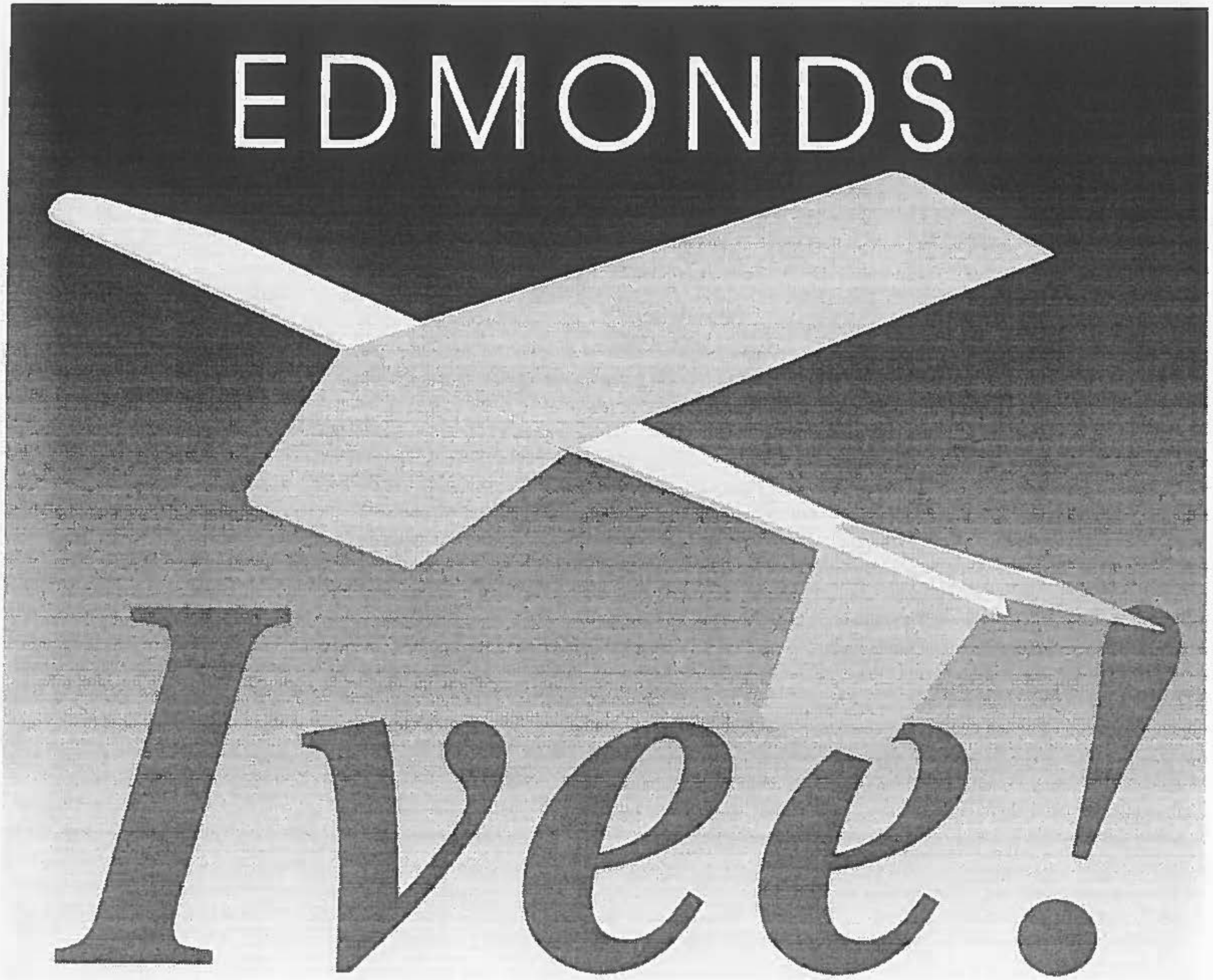

Edmonds
AEROSPACE

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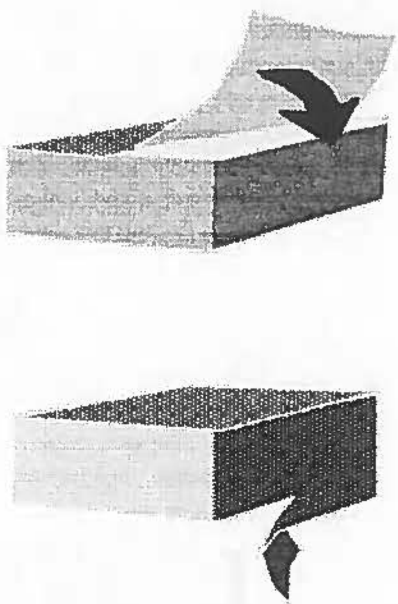
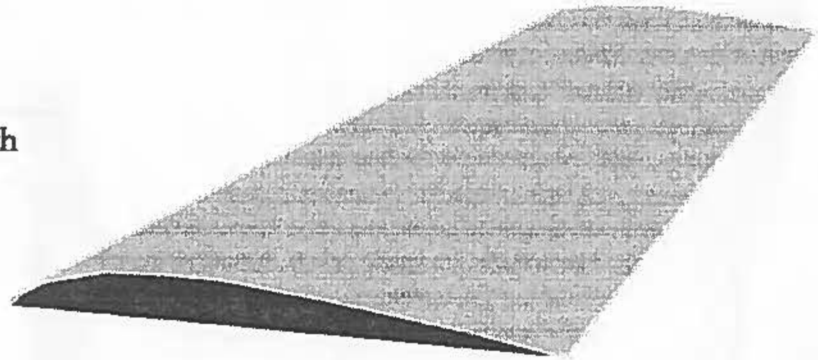
Ivee can make you a champion. I've designed this kit to teach you about building and flying contest-level boost gliders. It is a basic design with no special frills, but if you learn to trim it well, it will give you good, reliable performance in a league with anything else out there. I will leave almost every possible construction option open to you, so by the time you are done, you'll probably feel like you designed it yourself. As you acquire more experience with contest flying, you will develop your own special techniques to give you that edge for regional or national competition.

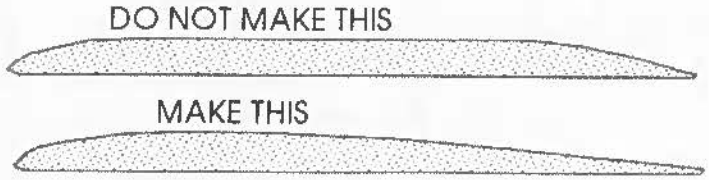


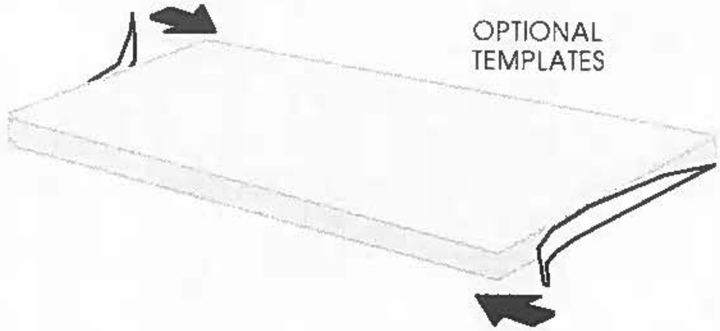
The first thing you'll learn about glider construction is that it all comes down to a sanding block. You can buy pre-made sanding blocks at the store, but you can make a great block by buying some adhesive-backed sandpaper and sticking it to a four or five inch piece of 1X3, 2X4 or other small wood block, tearing the paper along the edges of the block to match the size of the block. You can even glue paper to a block if you can't find the adhesive backed paper. To sand your wings well, you really need at least two grades of sandpaper. You need a sheet of coarse paper to do the actual shaping of the airfoil cross section of the wing, and a sheet of fine to make the surface smooth. Some builders actually progress through a series of several papers while they are building, starting with very coarse and ending with very fine. The most important thing to remember is that, if you only intend to have one sanding block, the coarse paper must go on it. The finer papers used to smooth the surface may be held in your fingers, but even here, a block often offers advantage.

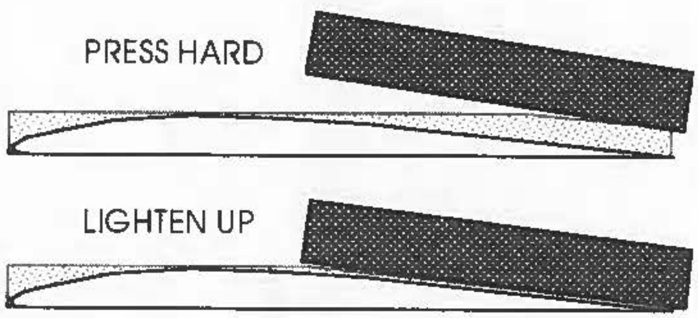
It's a good idea to cut out all the sheet balsa pieces before you do anything else. The wood usage is shown with the paper patterns (on the large sheet included with these instructions), make sure you use the right wood for the right piece. If you can temporarily bond the patterns to the wood, you can cut right through them to make your components. Use the patterns to cut out the wings and tail, and to mark the fuselage stick for tapering. Taper the aft fuselage carefully, making sure the cut is as straight as possible, and that you don't take away more wood than you're supposed to. Use a series of light cuts instead of one heavy one. You may wish to use a straightedge to cut along. The grain directions are important for all the little pieces, so cut them in the orientations shown. Now it's just about time to start sanding, but I want you to do the most important thing right now. TURN ONE WING OVER. I can't tell you how many times I've made two left wings. The sooner you turn one over the better chance of avoiding this. (Don't, by the way, turn BOTH over.) Now, let's turn the page and start sanding

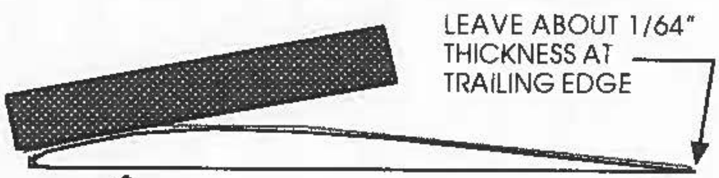
After all these years, we still haven't come up with a better way to produce an airfoiled glider wing than to take out a sanding block and have at it. For those new to gliders, an airfoil is a shape designed to produce aerodynamic lift without producing very much drag. It is the shape you would see if you cut vertically through the wing of an aircraft parallel to the fuselage. Let me try and give you a sense of what we are trying to do. It is not necessary to match some precise contour from a textbook, indeed flying qualities have a lot less to do with airfoil selection than some might have you believe. Good trimming is what makes models fly well, and one tiny trimming adjustment will usually enhance performance more than a year in the wind tunnel developing a new airfoil section.

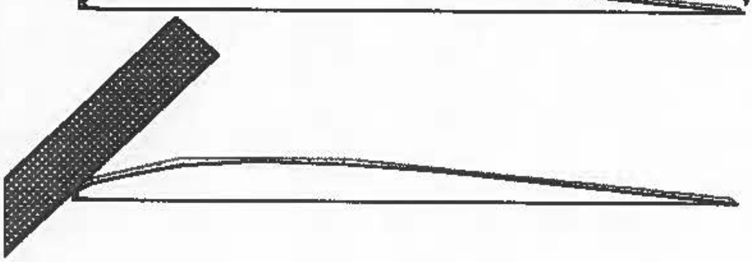










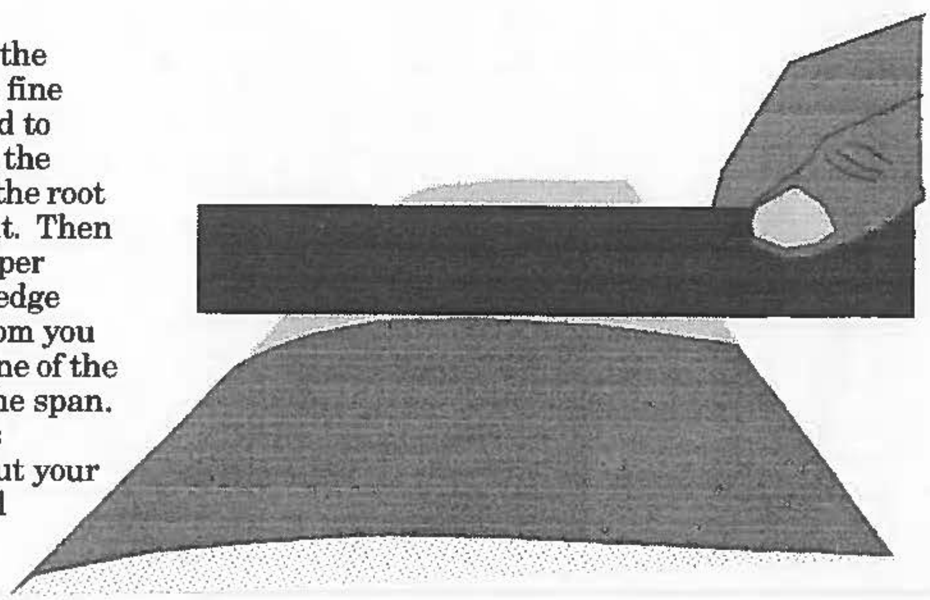


The most important thing is to have a smooth, gentle taper of the upper surface down to the trailing edge. It must not be a sudden, abrupt taper over the last half inch. If you get this part right, there isn't too much else you can do to mess up the wing. Even if you left the leading edge blunt, it might glide reasonably well.

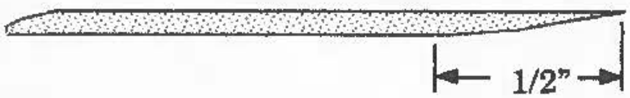
If you want, you may cut out the recommended airfoil templates from the pattern sheet and stick them (not permanently) to the root and tip of each wing, or you may sand "by eye". Put the wing right at the edge of your table and begin making long strokes parallel to the wood grain with the sanding block. The harder you press, the more wood you will remove with each stroke, so you might want to press hard at first, then lighten up as you approach the outline that you want. Now, be careful when the trailing edge starts to get thin. Even though theoretically you might want it to taper down to zero thickness, don't try to actually do that, or you may end up with a ragged trailing edge, or one that is prone to flutter on boost. Leave about 1/64" of thickness at the trailing edge, judged by eye.

The leading edge contour is a matter of personal taste. A thick, round leading edge may offer a higher maximum coefficient of lift (meaning you can trim the model for a slower glide), but it may not boost as well, and the stall behavior may be more sensitive. A thinner, more "pointy" leading edge, such as that shown on my recommended section, will probably provide slightly better boost and less "touchiness" around stall speed, but a slightly faster glide. It's up to you.

Now, you should have a rough version of the airfoil you want. Before switching to the fine paper, you might want to use this method to check the consistency of the airfoil along the span of the wing. Hold the wing up with the root end just in front of your eye, facing a light. Then take a straight edge and rest it on the upper surface so that is casts a shadow whose edge you can see. Slide it toward and away from you along the wing and see if the curved outline of the shadow remains fairly constant across the span. Then, do any touch-up sanding you feel is necessary. Once you're satisfied, take out your finer sheets and get that surface nice and smooth.

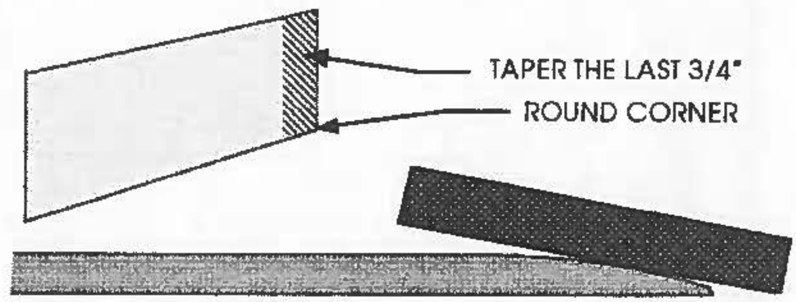


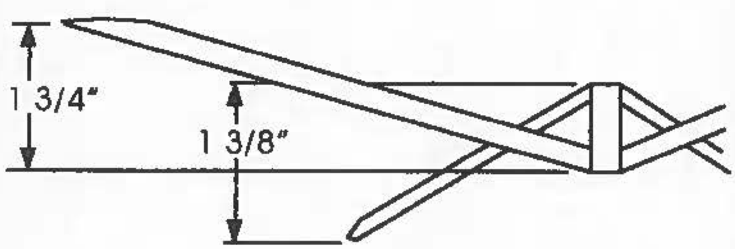
Just when you thought all the sanding was over, you still have the tail airfoil, tips, and dihedral joints to worry about. I usually don't spend more than a couple of minutes sanding in tail sections, indeed you could get by without doing anything, but this is a contest model, and you know what that means.



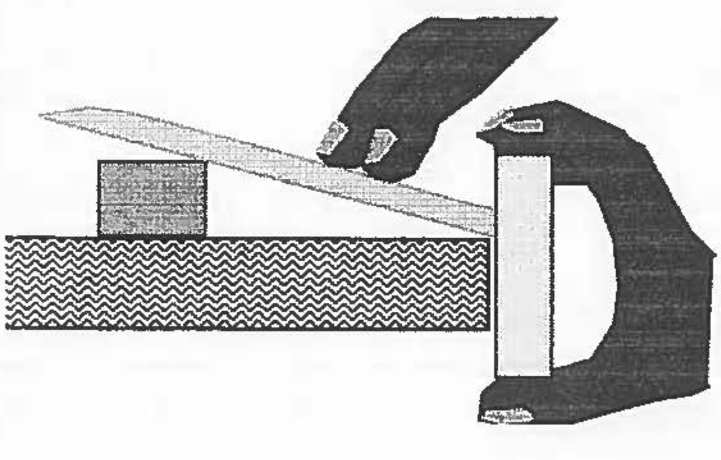
For the leading edge, you basically want the same general type of contour you had for the wing leading edge, with a round front. It can afford to be much cruder, so just freehand eyeball it with the sanding block. Now, on the trailing edge, I want you to taper the last half inch or so of the LOWER surface. This will start you out with a good reliable setup for pitch trim.

Anything you try to do with spill plates or winglets is going to cost you more on boost than you gain on glide, so the best tips for a boost glider are simply tapered down to a point. Here again, you probably want to leave some thickness to maintain strength, probably about 1/32" at the very tip. Taper about the last 3/4" of the wing, and maybe the last 1/4" of the tail surfaces.

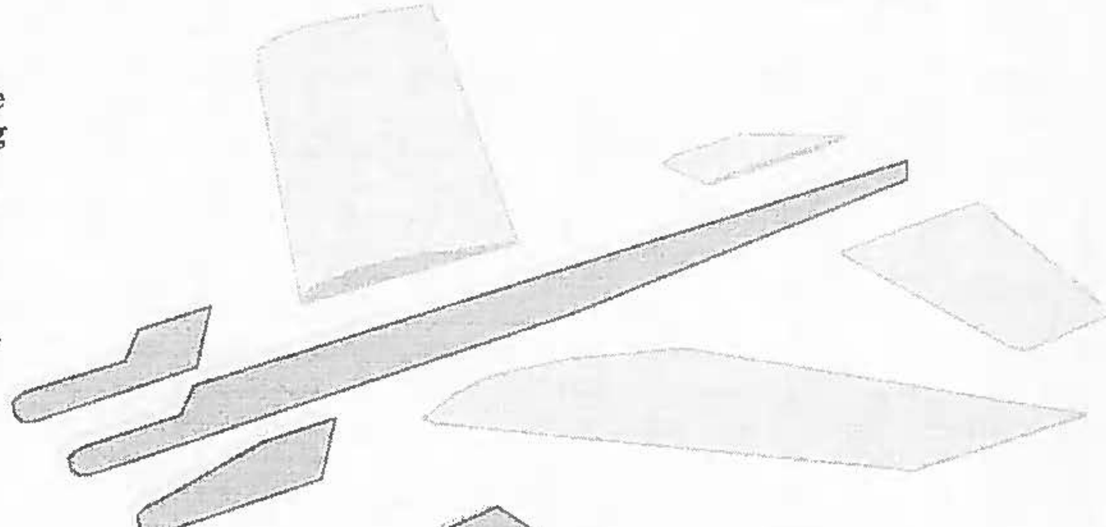




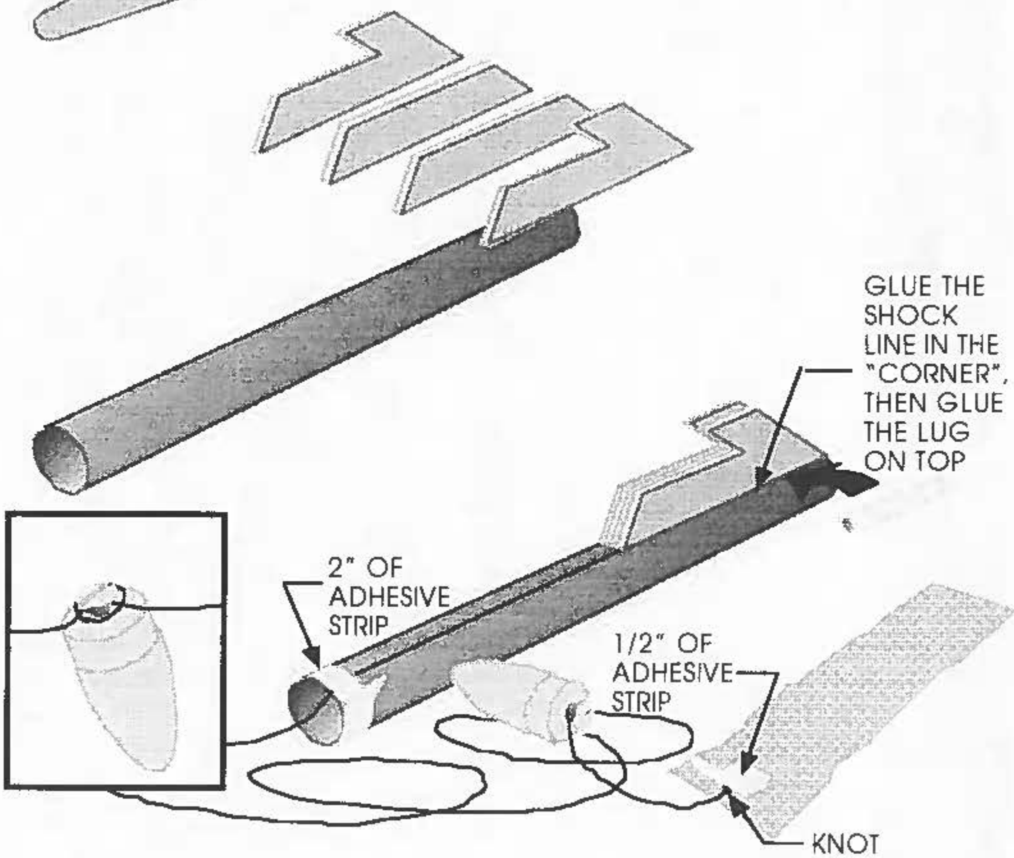
Now it's time to worry about sanding in bevels for dihedral joints. Everything on this model is stuck to the fuselage at some kind of funny angle, but the precision in these angles is not all that critical. Basically, more wing dihedral means easier glide trimming and less fear of spiral dives, at the cost of slightly reduced performance. Surprisingly, the "anhedral" or "cathedral" (both words meaning negative dihedral) angle of the tail is not very critical either, it takes very little angle to provide enough effective vertical fin area. I recommend 1 and 3/4 inches of anhedral (measured at the tip) in each wing and 1 and 1/2 inches of anhedral in each tail surface. You must sand the root edge of each surface to allow mounting to the flat fuselage side at the appropriate angle. You may either sand by trial and error to reach the correct angle, or you may block them up at the edge of your board, holding them down with your fingers as you sand. The most important thing though is NOT TO INTRODUCE ANY CURVATURE AT ALL to the beveled edge. That whole edge must contact the fuselage for successful gluing. If any one of those four joints is inadequate, your glider will disappear in a blur of parts and smoke about a hundred feet above the pad. You won't even know which one failed. As long as you are careful to hold the block steadily and don't let its orientation drift between strokes, you will get a flat, smooth surface for gluing.

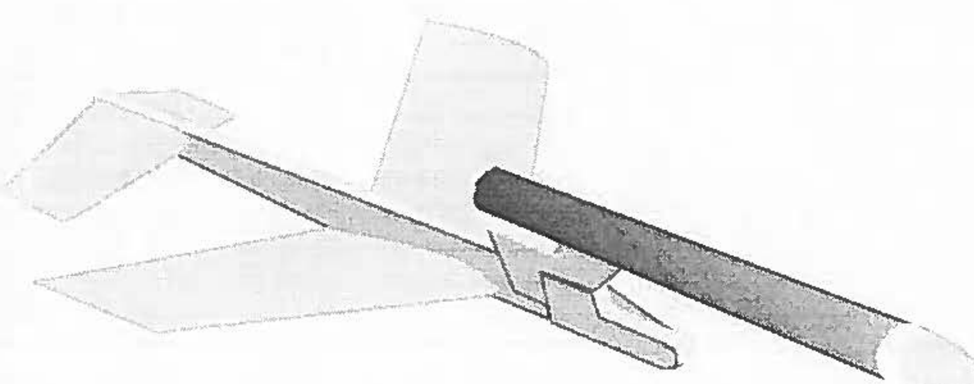


Assemble the glider with the best joints you can make. Even with Cyanoacrylate, I recommend precoating the joining surfaces and letting them dry, then applying more glue and making the actual joint. Make sure the upper surfaces of the tail pieces are aligned perfectly with the top edge of the fuselage. The bottom of the wings must align with the bottom of the fuselage. The two nose pieces form a place for the boost pod to hook onto, and leave a pocket for filling with nose weight. Glue them tightly to the sides of the nose.



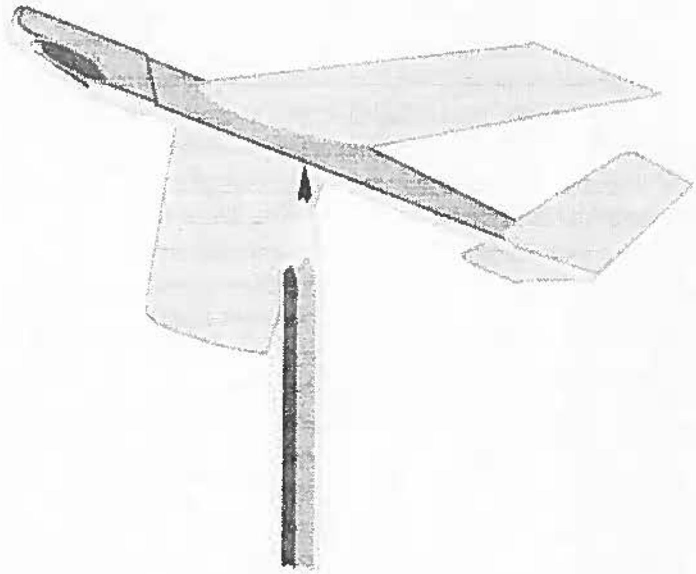
The glider hook on the pod is laminated of four pieces. You may wish to sand a bit of curve into the bottom to match the tube curvature before making the joint. The pod uses an external shock line that is glued to the glider hook and taped down at the front. Drive the screw into the back of the nosecone and tie on the shock line, leaving an extra two or three inches of line for mounting the streamer.





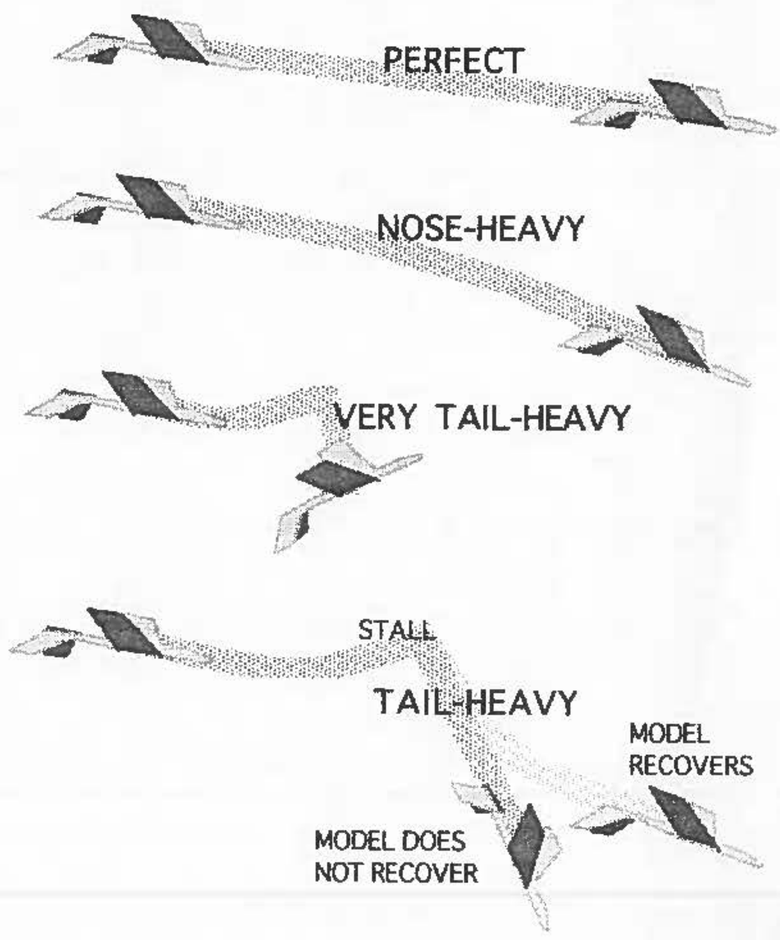
Now you have a completed airframe, and the first thing you should do is check the fit of the glider in the hook. The glider should slide right out when you hold the pod facing straight down. If it doesn't, sand a little between the tabs on the pod. After what you've been through, a little more sanding won't hurt you, but what's coming up just might. It is time to trim.

I'm going to recommend a balance point for your Ivee, but the only way to find out where the center of gravity (which, if you are new to gliders, is what we mean when we say "CG" all the time) really needs to be is to go out and get in touch with your aircraft while it is in the air. Remember this one thing, even though I'm going to keep saying it over and over again as we go through the trimming process. The center of gravity position controls the stability of the aircraft. You cannot substitute nose down trim for adding nose weight, if that is what is required, because nose down trim does not add pitch stability to the aircraft. Believe it or not, the best way to balance the model is upside-down on the tip of a pencil. Keep adding clay to the that little pocket in the nose until the glider balances right on the mark. If you overflow the pocket, keep going, just kind of mush it down.

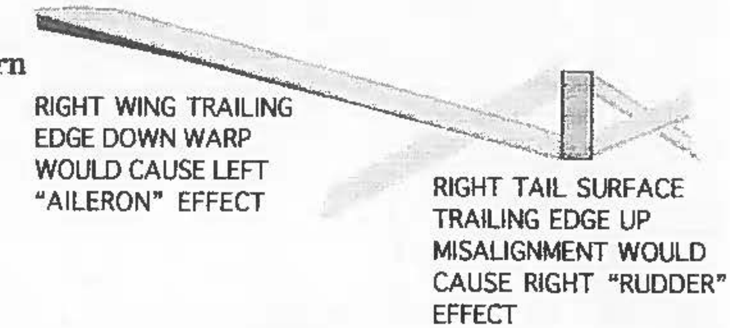


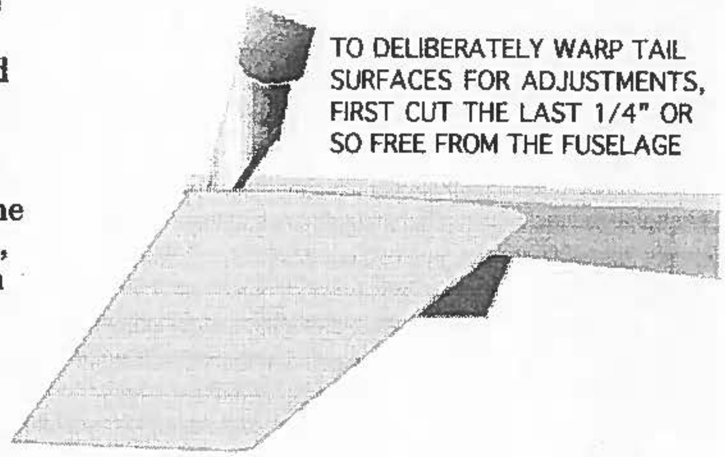
Trimming a glider well is a lofty goal, because you are fighting a delicate battle between efficiency and stability. "Efficiency" has a very specific meaning in aircraft, it is the ratio of the force of lift produced to the force of drag produced while the aircraft is flying. In normal gliding flight, the lift to drag ratio is essentially equal to the glide ratio, the forward distance traveled divided by the vertical distance dropped. For this reason, you want to do whatever you can to reduce drag. Now, the further forward you move the CG, the more stability you get. At the same time though, more nose-up trim is required, and nose up trim increases drag. What we want to do is identify the CG position that provides the absolute minimum stability to meet your needs, and then trim to glide with it there.

Since the dawn of time, it has always started with hand toss glide tests. You really need to become good at these. In fact, you might want to go buy an "expendable" glider at the toy store to practice the hand tosses. For a given trim setting, there is one and only one speed , and one and only one glide angle, at which the model will fly, and you are trying to match these with your toss, so that the model enters the air as though it had already been gliding. Tossing at the wrong speed can create the impression that something is wrong that really isn't. So, take the model, aim it at a point on the ground some distance ahead of you, and do the best you can. What you see may be somewhat difficult to interpret. If it is nose-heavy it will follow a long straight steep path and hit the ground relatively hard. Almost anything else you see indicates tailheavyness. If the model appears to go completely out of control or refuses to "go anywhere", just coming to a stop in the air, it is tail-heavy. If the model enters the "classic stall" path, it is probably pretty close to OK. Note very carefully whether or not the model begins to recover after the stall, that will be very important soon. You should attempt to cure any of theses problems by adding or subtracting noseweight.



There are some other things that can happen, but can't be cured with weight alone. These result from misaligned surfaces. If the model develops a sharp turn to one side, check for misalignments or warps in the wing and tail. Now is a good time to talk about turn trim. In airplanes with dihedral, "rudder"-type deflections in the tail cause a banked turn, and so do "aileron"-type deflections in the wing. In the case of the inverted vee tail, an "up" deflection of the trailing edge of one tail surface will cause a turn and bank toward the side it is on. A "down" deflection will cause the opposite. Likewise an "up" deflection of a wing trailing edge will cause a turn to the side of the twisted or misaligned wing, a "down" deflection the opposite. Even though the wing and tail deflections are the same, the wing deflection produces an "aileron" effect while the tail produces primarily a "rudder" effect. The difference will become important later. For right now, if there is a turn. Look at the airplane from directly in front and try to isolate which surface is warped or misaligned. If you can't find it, then start by warping upward the trailing edge of the tail surface on the side opposite the turn.





One annoying thing can happen that tries to fool you into thinking the model is nose-heavy. If you see the model dive sharply into the ground, as tough someone were pushing it down, the model may actually be tail-heavy, but the stabilizer is mounted so that it produces nose-down trim (this is not likely to happen if you sanded the lower, rather than upper, surfaces, of the tail trailing edges). The only cure is to warp the trailing edges of both tail surfaces upward until it goes away, then add the needed noseweight.

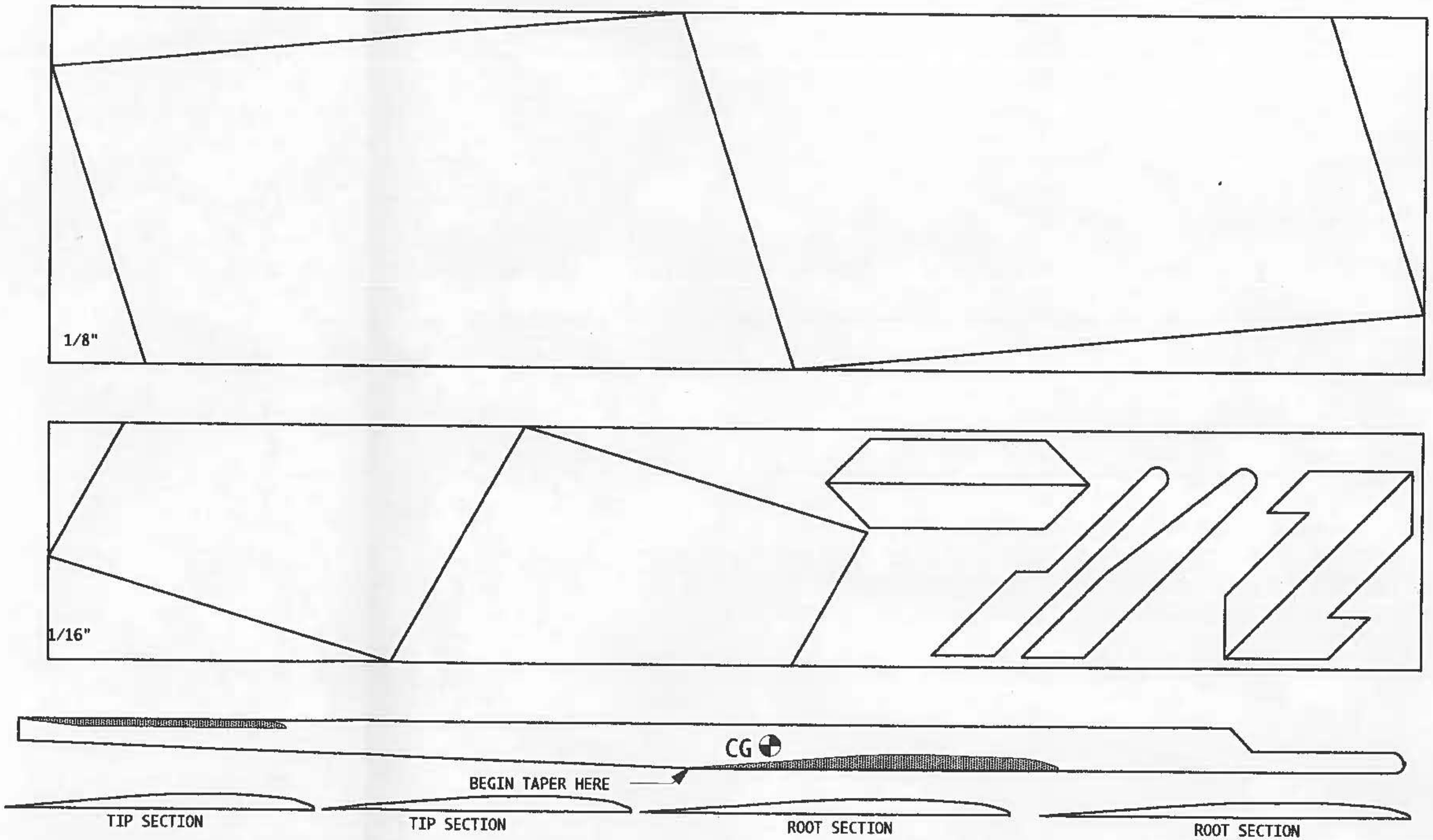
Once you've gotten the model to glide relatively smoothly, either straight ahead or in a gentle turn, it is my unfortunate duty to inform you that you aren't nearly done. You are now aware that the model is statically stable, and that there is an airspeed to which it can be trimmed, but that is all. You're model is subject to a harsh environment in boost glide. It is injected into flight at the wrong attitude and speed, then after recovering, it must spend many minutes in the air fighting countless tiny gusts. The only way you will achieve success is to master dynamic stability. It is dynamic stability problems that cause models which glide perfectly in hand toss tests to slowly drift out of control after being boosted to altitude.

To test the model's dynamic properties, it has to be in the air for more than a few seconds, and this means altitude. Somehow, you need to get the model high enough to get a view of how the glide may change over time. You can attempt to throw it to altitude, but this requires holding the model in a steep bank and flinging the model into a climbing turn, and this requires a lot of practice. The real solution is to either glide it from the top of a hill or tower, or to actually boost it on a 1/4A or 1/2A motor. Once the model is gliding at altitude, watch the flight path carefully. The most obvious dynamic problem is spiral instability, wherein the model banks more and more steeply and turns more and more tightly as the nose drops until it crashes. Small gliders such as these often suffer from spiral instability, and instead of using huge dihedral angles, we usually try to trim out the spiral with opposite control deflection. My favorite method for avoiding spirals in the Ivee design is to adjust for a turn using "opposed controls". Decide which side you'd like to turn toward (for contest flying you will probably prefer right turn, because thermals in the Northern Hemisphere may acquire a leftward rotation, and right turn in the model helps keep it inside the thermal). Bend the trailing edge of the tail surface on that side.upward for a rudder-induced turn. Now, warp the trailing edge of the wing DOWN on the same side. You have made an aileron adjustment that opposes the rudder adjustment. It turns out that in most cases, models are more sensitive to rudder deflection at low speeds and aileron deflections at higher speeds. Therefore, if the model begins to spiral and speed up, the aileron deflection will take over and roll it out. Now, go back to hand tosses and make sure the model indeed turns to the desired side. Reduce the wing warp and increase the tail warp until it does. You should usually try to remove persistent spirals by warping the trailing edge of the inside wing down first unless you can see what misaligned surface is causing the spiral.

The last thing we will discuss is pitch stability. The "phugoid" mode of stability is basically the thing that makes free flight aircraft possible. It is the mode by which the aircraft seeks out its trimmed airspeed, the one and only airspeed at which it will fly with the surfaces set in a given position. Basically, if the model is going too fast, the extra lift pulls it into a climb so that it slows down. If it then becomes too slow, the nose drops into a dive and it speeds up. You can see that there is no guarantee that it will ever reach the right speed, it might repeat this cycle over and over again, getting to higher speeds and steeper climbs and then slower speeds and steeper dives every time. This is what you are seeing when you see a model that starts to stall gently, then over time enters a violent dipping action. In this case, the low speed portion of the phugoid is actually below the model's stall speed. This is why it was important to note whether the model attempted to recover from a stall in the hand toss test, if it did not, but the nose swung steeply down and stayed there, this was the first indication of a bad phugoid. In another case of bad phugoid, you may see a model that appears to glide normally at first, then gradually noses down until it is descending vertically, and maintains this attitude until the end. Believe it or not BOTH of these cases are caused by inadequate noseweight. Noseweight provides the static stability that we see in the hand toss tests, but a model that passes these may still not have enough noseweight for acceptable dynamic stability. But if the hand toss is already fine, won't the extra weight cause a dive? Yes it will, which is why you must do two things simultaneously to adjust out a phugoid problem. You must add the weight, but you must also simultaneously add the needed up-elevator to compensate for it by warping the trailing edges of both tail surfaces up. Here is how to use your phugoid knowledge to trim for truly optimum performance. Take a model that has passed the hand toss tests and launch it from altitude. If you are standing on a hill or tower, deliberately launch at the wrong speed, if you boost, the speed will take care of itself. Watch to see if the intensifying stall or the steep dive develops. If it does, add nose weight, warp the tail trailing edges up until it hand tosses fine, and start again. If it does not, remove a little nose weight at a time until you notice that the model has begun to stall and dip. Now, check to make sure that the stalls are not intensifying as the flight progresses. If they are not, do some more hand tosses and warp the trailing edge of the tail slightly DOWN until the stall has been removed. Then go back to removing noseweight and flying from altitude again. Eventually you will reach a point where removing noseweight produces the intensifying stalls. Now add back the last weight you removed and test until you are sure the intensifying stalls do not develop. What you are finding is the farthest aft point at which the CG can be for acceptable dynamic stability in the phugoid, which automatically requires the minimum nose-up trim. This is the most efficient glide trim for your aircraft.

If you have gotten to this point, you deserve your championship trophy now. You have made all the adjustments necessary to produce an airworthy craft, and you'll have that confidence when you go to fly. The only things that stand between you and victory are a couple of thermals. I wish you good luck as you compete.

Robert Del Hall Edmonds, Jr


1/8"
1/16"
CG
BEGIN TAPER HERE
TIP SECTION
TIP SECTION
ROOT SECTION
ROOT SECTION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