Folding Tips and Tricks

This section is primarily for beginning folders, or those who always dreaded having to fold their school papers in half due to no knowledge of paper folding technique – BUT there may be an idea or two an intermediate folder could learn. And as for pro folders, please read in case suggestions for additions can be made.

First off you need to look at the instructions carefully. Depending on the writer and the intended audience instructions can range from true instructions to a method of showing the design with no help on how to actually make it. The difference is that beginners want to know how but experienced folders want as short as possible writing to use as reference later. I personally tend a little in the middle but lean toward the later. As an engineer we are trained to keep design and manufacturing method separate. Hence the need for a section like this. Before we can even start we need to learn a little more about working with our primary material, paper.

Learning to work with paper can be more challenging then one would originally think. Some paper just will not work for paper airplanes due to either its texture (effects air flow on wings) or it strength/stiffness (bend-ability). For more information and paper comparison you can check out my section devoted to paper. But, even if the paper makes great airplanes doesn't mean it is problem free! Some is just hard to work with and some just won't stretch enough to make a plane like the Lunar Hawk.

If we start with an airplane, even a classic dart, we first fold in half and then fold corners down to meet the center fold. And our corners don't match! We know this is not good because "For a Good Flying Airplane Symmetry is Important". Yes this is the cornerstone rule for paper airplane success. So, we look to see where we misfolded and yet everything seems good, it just doesn't line up. Although it would not occur to most people that the problem is the paper was not cut square at the factory (we are way too trusting of factory quality). If you have this problem note the brand because some are worse then others and consider changing next time you buy paper. But the planes will work fine, just try to fudge them a little to make as symmetric as possible. I mainly point this out as a warning that we can have issues to face before we even start.

Other paper issues we will need to overcome include: difficulty in making a clean crease, fold unforgivness, excessive puffiness under folds, paper tear, and crinkling are probably the most common five. These problems arise from working with a thin, fibrous, and stretch resisting material. This along with the fact that once stretched, paper doesn't return back to its original shape, make a challenging material to work with. But the art of paper folding dates back to almost the same time as its invention.

The first of these, difficulty in making a clean crease, can be demonstrated in an exaggerated way by looking at the bend in a piece of construction paper or some card stock. The crease doesn't make a nice straight line but looks like a row in a plowed field with little zigzags and fiber damage on both side of the crease line. Most copy/printer paper isn't bad enough to cause air flow problems and so the planes fly. But, paper with this problem will normally resist reversing a fold (folding to crease in one direction, then opening and folding in the opposite direction).

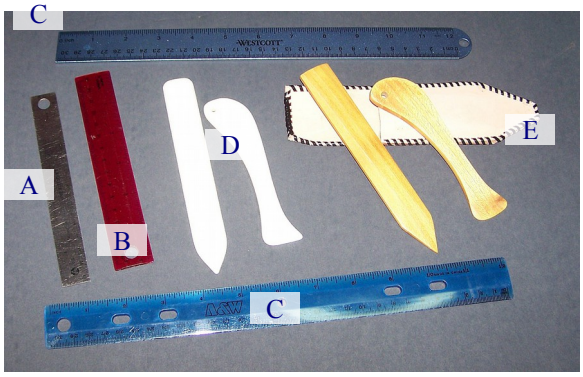
No matter how carefully we fold we are going to miss the mark a little sometimes. Many types of paper allow us to use our thumb and index finger to "roll" the error back in line, and some just won't let us do so. Fold unforgivness strikes again. Even when we try to unfold and refold it just wants to fall back on the same old, wrong crease.

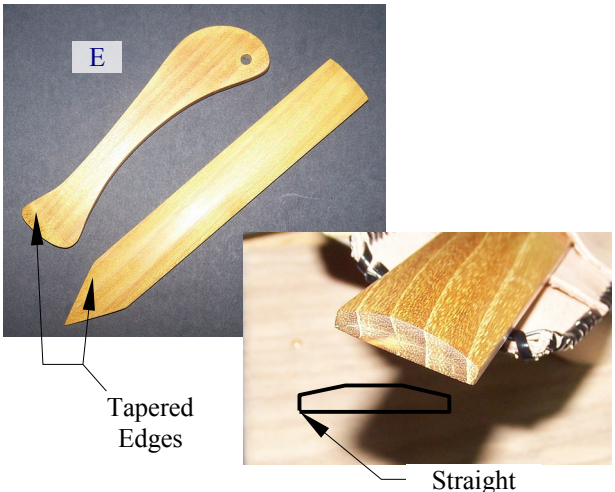
We finally get towards the end of our folding and notice that our plane won't sit flat on the table top. There is a whole lot of puffiness under the folds. This is due to the fact that the paper doesn't stretch well. The folds in step 5 start pulling against the creases made in step 2. This pull results in puffiness. Where it really causes a problem is if it is different on each side. This causes different amounts of lift on each wing and thus a plane that spirals out of control.

As we continue to fold some areas get thicker and thicker. Putting one more fold on a thick section forces the paper to stretch. That's when we find out if we have a type of paper that will stretch or if it is the type to tear. Earlier I mentioned that some paper just won't stretch enough to make a plane like the Lunar Hawk. Instead of stretching as required the paper pulls apart at the weakest point. Back a few years ago resumes were printed on special parchment paper and actually delivered or mailed more often then now. Once a job was obtained the left over resumes were useless except as paper airplane material. For such an expensive material you were limited on what designs could be folded due to the tendency to tear. Still, even today, certain special use paper can have a tendency to tear.

When bending any material there is tendency to stretch in some areas and compress in others. Thin materials don't compress well, instead they wrinkle. Most of these wrinkles can be smoothed out and don't cause any problem. Over all this is more of a cosmetic problem then an actual functional problem. But they do need to be taken care of after each step and not allowed to accumulate.

Now that we have discussed the problem it is time to move on to the solution – folding tools. The use of folding tools is again almost as old as paper folding. Just like the origin of paper folding, the best tools are modeled from tools used for centuries in Japan. Some articles I have read implicate that the tools originated with makers of Kimonos and then adapted to paper. Wither silk cloth or paper was first, use of these tools has stood the test of time. The original materials for the tools were bone and bamboo. Bone folding tools are still made and sold today. Plastic substitutes are also available. But all of these can be expensive and cheap or free substitutes can be found or made. Before going any further, I want to point out you don't absolutely need any tool but a good finger nail, the rest just make thing easier.

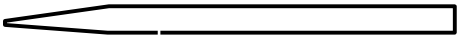




Folding Tools:

A. 6" Metal Ruler. Less then 1" wide. Good as straight edge for folding wings up. Also for marking measurements.
B. 6" Plastic Ruler. Can be used as straight edge for bending as well as a suitable smoothing tool. Only problem is they tend to break too often and it is not as easy to find good cheap ones anymore.
C. 12" Ruler (Plastic or Metal). Great as straight edge for long bends but inconvenient for travel.
D. My first official folding tools. A plastic set that came with an origami kit. Curved smoothing tool is great but pointed tool did not have a flat face to allow it to be used as a straight edge.
E. Folding tools I made from Osage Orange wood (any hard closed grain wood can be used). Pointed tool has flat bottom to allow it to be used as straight edge for bending and a single tapered face to allow it to be used as a smoothing tool. Curved tool has a double taper going toward the edge.

Cross section of pointed tool's tapered edge



Cross section of curved tool's tapered edge

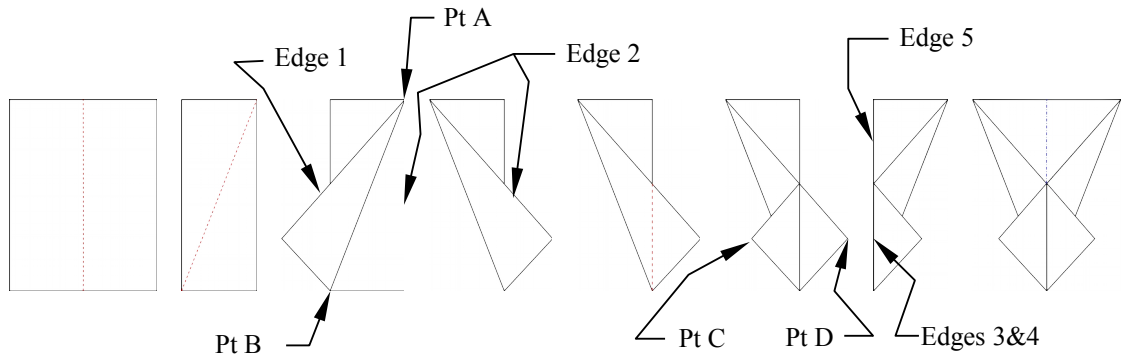
Notes: If wood working tools are available folding tools can be made from a branch discarded from pruning or after a storm. Even Bradford Pear branches (always available in many parts of the U.S. after a storm) make beautiful tools. Also, a thick plastic or an old fashion wooden ruler can be fashioned into a pointed type folding tool.
I read an article that said the scrap piece of plastic that falls out of the middle of the handle of a gallon milk jug can make a very good smoothing tool and can often be found laying in the milk refrigeration unit at the store.
Look around for ideas for usable tools.

After the essential fingernail, the next tools are rated as important. This really only consist of a 6" ruler. Regardless of what it is made from, it allows for making the airplanes that require measurements. A narrow metal one is just the right size to help folding wings because the width is just the right size for the planes fuselage. On the other hand a plastic one with a smooth bottom surface makes a good tool to smooth folds. But this does wear off the measurement marking and eventually breaks the ruler. If you can still find one an old fashion wooden 12" ruler can be modified with just a hand saw and sand paper into a wonderful all in one folding tool like the pointed one shown above.

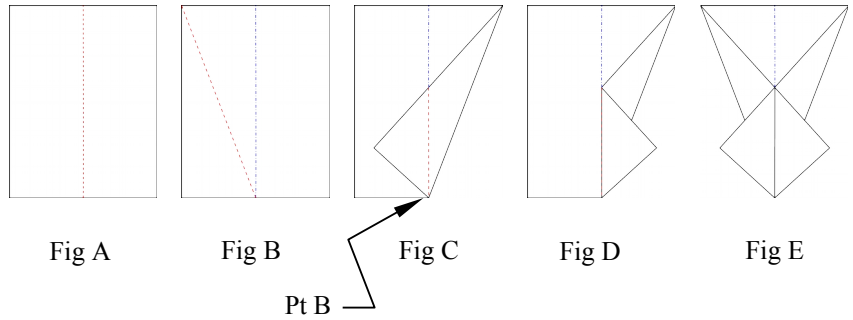
We are finally ready to talk about the actual folding. So lets start with making creases. It may seam so simple but if a crease is not correctly done there can be consequences later. Once folded the bend should be rubbed smooth and flat with the back of your fingernail, a ruler, or a smoothing tool. Without doing this it becomes difficult to unfold and the either refold or reverse fold later, essential steps in plane making. Where this can often lead to a problem is when we check out a completed airplane and start looking under the wing folds to see if all the parts are fully and properly tucked in and flat. If not we can end up with a plane that just spins out of control instead of flying.

To demonstrate the next set of tips we will do better using an actual plane as an example. Let's make a Pentagon II. We will use this plane step by step so you may want to make a copy of the instructions as I am not going to repeat every detail here.

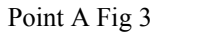
Here are the fold diagrams from the directions (The Good Method):

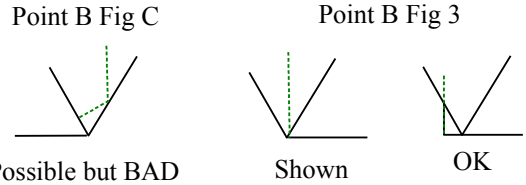


We could have diagrammed as shown below (The Bad Method):



First we will look at the good things with the first method. Starting with the first diagonal fold in Fig 3 it does not matter how close the fold line actually comes to Point A. It can miss by an inch without an effect on the plane's flying ability. But it is important that Edge 1 and Edge 2 be the same. This going to happen since we flip the paper over and match the fold. It is also unimportant if Point B is perfectly at the corner. Again because we will match fold the other side. One last point about folding this way. Notice Point B can't go past the center fold because it would have to tear the paper to attempt to do so. This can be seen by imagining trying to move Point B to the left of the centerline instead of to the right in the Fig 3 detail view. The last thing we need to do is make sure that Edges 3&4 stay in line or slightly to the right of Edge 5 and we are on our way to a nice flying plane.



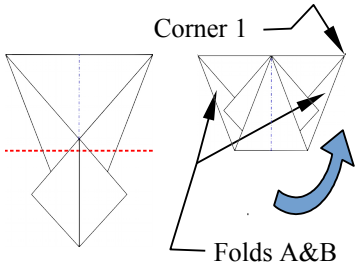


Now check out the not so good way. First none of the folds are matched so if we miss the corner for Point A or the centerline for Point B there is no way to make the other side match and we will start to lose symmetry right from the start. And what is potentially even worse is that it is possible to fold Point B past the centerline as shown in Point B Fig C detail view. Over folding to the centerline will not only make it very difficult to refold the plane later to make

the body, but will also force everything out of symmetry. It is a bad enough issue that many people even reverse fold the center and start folding even the old classic dart using this technique.

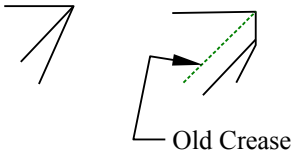
Remember how I started this section stating that instructions often show design not method of making? Note that the "bad" way to make only took five sketches to show verses eight for the "good" way. So that means that very often you are going to get instructions like the "bad" way because they are shorter and simpler. This good for an advanced folder who is using a printout of the instruction just as a reminder of what to build not a detail of how to build.

Now that we have reached this point in our plane it is time for the flatten well part. With the first folds this simply means running the back of a fingernail, or flat of a ruler, or folding tool along the creases. This sets a deep enough crease that even if we totally unfold the plane, the paper will naturally refold on the same crease later on.



Corner 1 Detail

Before After

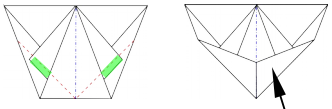


Next comes the part where we really begin to see the true nature of paper. Our instructions simply show to bend the plane in half and flatten as shown in the figures to the right. This bend really tries to stretch the paper and the paper resist. The result is puffiness under the Folds A&B. We need to flatten that puffiness out by smoothing the plane with the back of our thumbnail, ruler, or folding tool. Do this starting at the centerline and pushing out and back toward the back corner. This is where I like a flat ruler or tool that can be laid flat at the center and pushed out like a push broom on a floor. This will move the fold from the original creases a little. How much the crease moves verses how much the paper stretch varies depending on paper type (and weight). Some brands are a challenge. Take a look at the detail view of Corner 1 before and after the fold to get an idea of what to expect after flattening.

This step is so important because in order for the plane to have the amount of lift it was designed for the fold need to flat. Also if one wing had more puffiness then the other the lift on each wing would be different on the plane would be in a constant roll (and dive). Even if the amount of movement the crease makes on each side is different the plane can still fly well because much of the non symmetry will be used up in the fins. And the function of the fins, although very important, does not depend as much on symmetry.

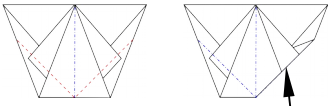
As we keep flattening after each set of folds the creases can move and really weaken the paper. This is why weak paper, like most notebook paper, can be a challenge for planes with a lot of stretching folds. But with slow careful smoothing even delicate paper can work.

As paper folds start to stack up on us we sometimes need to change our method. Looking below at Step 5 figures we see both lower corners being diagonally folded to the centerline. If we can fold both to centerline at the same time and then flatten the creases this would be very nice for symmetry. But, because we are folding multiple layers of folds, it may try to pull and puff up the earlier folds too much. It may be better to fold one side, crease, unfold, fold and crease the other side, and finally refold the first side. This particular plane, using easy folding 20-24 lb paper, is about the limit of trying to meet the folds in the middle. The same thing is true for the inside reverse folds in Step 6 (inside reverse fold is an Origami term for this type of fold). It is better to reverse fold the right side, crease, unfold, reverse fold the left side crease, refold the right side.



Fold, crease, and unfold before folding left side. After folding left side refold the right side.

Step 5



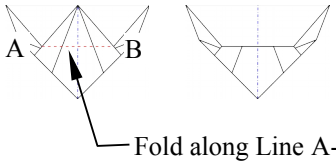
Fold, crease, and unfold before folding left side. After folding left side refold the right side.

Step 6

There is one last point from these steps. When the folds in Step 5 are made, there are folds made on the flap inside the area we are working on (highlighted in green). Make sure places like these are neatly tucked into place when you make the Step 6 inside reverse folds. On stable planes a little sloppiness can be lived with, but some planes it cannot.

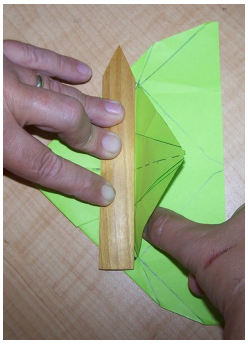
I would like to note that for many types of paper it is very helpful to fold a crease both forward and backward before completing an inside reverse fold. This is a good fold to get used to as it is used for most plane designs. Also, if you are working at a desk with a good, sharp edge; it makes a great straight edge.

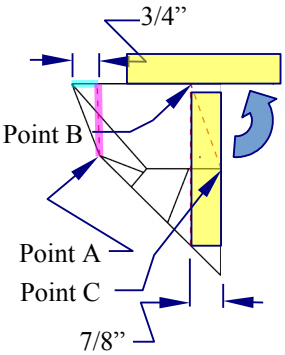
Most folds are made by bringing an edge to another edge or line, or a point to another point. The creases for these fold fall where they need to. But folds such as in Step 7 are defined by where the crease needs to be. These are best done using a straight edge. Note that the first fold in Step 2 is actually defined this way and can be done with a straight edge if a 12” ruler is available. Wings and fins also fall in this category and can be kept much more aligned with a straight edge. The best way to get a good initial crease with a straight edge is to lift the piece to be folded up 90 degrees along the straight edge and use the back of your finger nail to rub up the crease along the straight edge. As long as the straight edge is held down tightly, you should get a nice straight crease line deep enough to fold to after the straight edge is removed. Since this is a reverse fold I do bend it forward and rub a flattened crease first. After this I open it up and fold it backward. Some types of paper make this a hard fold to get smooth and neat.



Fold along Line A-B
Crease and reverse
Step 7

This plane, like most of my designs, has a squared type of body where the wings and fins fold parallel to the centerline. I try to design this way to make it easier to keep things straight and symmetrical. The rest of the plane is summed up in a single diagram in the instructions as shown. But there is really quite a bit of folding nohow that goes into actually finishing the plane off.





First to fold the fins down. More important then the actual dimension shown is symmetry. I took a real plane that I fold a little fast and was not super careful to keep side symmetrical. I then took actual measurements from the outer tip to Point A. One side measured 3/4” and the other 5/8”. I would fold both sides to match at the lower value of 5/8”. The most important factors are: that the back edge of the fin (highlighted cyan) line up with the back edge of the wings, and that the two fin fold lines (highlighted magenta) are matched.

The body dimension is also not so critical. I have a small metal ruler (see yellow highlight) that is 7/8” wide that I use as straight edge to make my plane bodies. Any straight edge tool that is between 5/8” and 1” will work. First use the straight edge to start a fold that is parallel to the centerline fold as shown. Before rubbing the crease rotate the straight edge to the back edge of the paper to make sure the fold stays straight. Then flatten the crease and fold the other side to match.

Point B Detail

Tails, when needed, are simply an inside reverse fold between Points B and C. Point C is normally not critical and defined by an existing line or edge or by an approximate dimension. Point B is defined by the intersection of the wing fold and the trailing edge. Under folding Point B is no problem but over folding will lead to a plane with too much “nose up” trimming.

After either taping the nose or smoothing the wing folds (see trimming a paper airplane instruction) the plane is ready to fly. From the first test run, with no additional trimming, the plane should fly fairly level or a little bit nose down. A small amount of trimming on the back of the wing should produce a nice flier.