HOW TO MAKE A WOOD SHELL WITH A SCROLL SAW

VOLUME 1

STEVE GARRISON

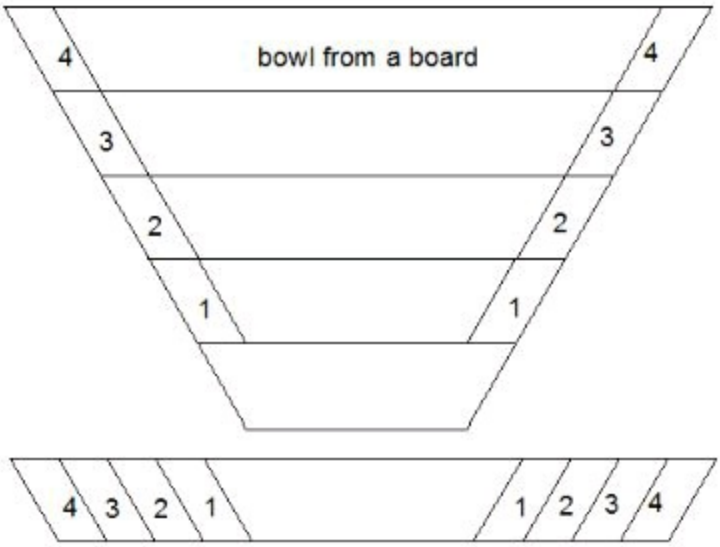
How to Make a Wood Shell with a Scroll Saw

By: Steve Garrison

Introduction

When I bought my very first scroll saw in the early 1990's I tried the usual projects with it – inlay, fretwork, compound cutting, stack cutting, intarsia, and bowl from a board. That was fun for a little while, but I became rather bored after some time and started thinking about what I could do different that would be more exciting to me. I liked bowl from a board because it was more 3-dimensional and I wondered what would happen if the thickness of the board was wedge-shaped instead of having parallel faces? I tried it with a bevel angle, and it did what I had envisioned in my imagination. It looked something like a bull horn with very thin walls, or a curved cone. The tip of the cone would have entered the base of the cone if I had been able to add enough segments to it, but the largest segment had already reached the edge of the board that the segments were being cut from. It definitely needed to have more wall thickness in order to be able to shape and sand it smooth without sanding through. After thinking about the problem for a little while I realized that the wood blank needed to be thicker – but a scroll saw is not able to cut very thick wood. That's when the idea of using several pieces of wood in rotation hit me. It would be like sawing the segments from much thicker wood, but in little bites that the saw could handle. It turns out that the idea worked great and I could use as many blanks as I needed to get enough wall thickness to allow the form to be shaped without danger of sanding through the wall of the form.

I also reasoned that the curved cone was curving around an axis that corresponded to the edge where the planes of the faces intersected. So I wondered what would happen if the segments were centered on this axis – and that produced my first shell. Since then I have made and sold many wood shells through art galleries, and given them away as hand-made gifts - I have never heard anyone say that they didn't like them. They are very unique to say the least. I wrote this book to teach others what I have taught myself about making these shell sculptures. They are a lot of fun to make, and I hope you will give it a try.


bowl from a board
4
4
3
3
2
2
1
1
4 3 2 1
1 2 3 4

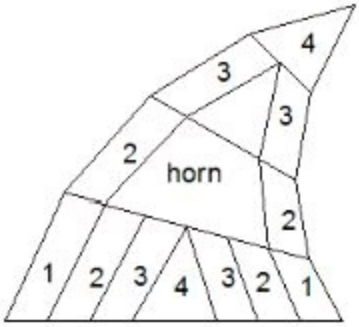

horn
4
3
3
2
2
1 2 3 4 3 2 1

Table of Contents

What you will need

Woodworking is known for being an expensive hobby, but the equipment and supplies needed for making wood shells don't have to cost a fortune. Chances are that you already have most of what you need. Here is a list of things you will need:

1. A scroll saw – it doesn't have to be expensive, but I recommend a saw that uses plain end blades instead of pinned-end blades. The table must be able to tilt at least one direction, and variable speed is nice so you can slow it down to prevent burning thick sections of hardwood.

2. Skip tooth blades – I prefer this kind of blade because they work better when cutting through thicker sections of wood. Just a suggestion, use your own preferences if you have them.

3. Surface plate or thick piece of plate glass – this is needed to back up the sandpaper while lapping the joints flat. If using glass, it should be at least a quarter inch thick to resist bending. I sometimes use a machinist's surface plate that is similar in size to a small tombstone – it is certified flat within 0.001" but that is probably overkill. The plate needs to be a little larger than a sheet of sandpaper.

4. Rotary tool and burrs – I use various kutzall-type structured carbide burrs for shaping shell interiors. My favorite burrs to use are a structured carbide roto-saw, a ball-shaped carbide burr, and a "mushroom shaping wheel" for carving the lip. The best burr for shaping the interior surface is usually the largest one that will fit. Miniature drum sanders are great for smoothing the edge of the central hole. I also use an oval shaped diamond burr to remove scratches left by the more aggressive kutzall carbide burrs before sanding the interior.

Figure 1 – Cutters that I use for shaping the interior of a shell.

5. Sandpaper – various grits. I use cloth backed strips because it is more flexible and more durable than paper backed.

6. Rotary wire-brush – optional small diameter fine steel bristle wire wheel for use in a rotary tool. These are great for texturing the exterior by eroding away the softer rings of pine or other woods that have variations in hardness in the growth rings. Make sure you wear a face-shield or safety glasses while using this tool, they have a tendency to lose bristles at high speed – the last thing you'd ever want to hit you in the eye. If you use a texture like this, you will also need a sanding mop to sand with. Sanding mops are best used on a small drill press, you can make your own or buy them in different grits and sizes.

7. Drill press with disk sanding attachment and thick foam pad. For sanding the exterior.

8. Your choice of finish. Later in this book I describe my finishing process using wipe-on polyurethane using a hand-pumped trigger sprayer.

9. Safety equipment – you are responsible for your own safety. Use safety glasses, face-shield, and respirator or dust mask particularly while sanding. Use common sense.

How it works

The construction process described in this eBook is considered a technique and is not a pattern. If several people followed the directions independently, the resulting shells would be very similar in shape. There are a few variables that affect the shape some, but any two shells will still be similar. There are other obvious factors such as wood type, color, grain, and growth ring orientation that will affect the outcome. With a little bit of imagination and seeing how the method works, you should be able to put your own spin on the concept for originality. I would suggest keeping your first few attempts simple without worrying about the outcome so that you can get a feel for how it works.

The concept is pretty simple; a beveled cut enlarges a pattern line on the bottom side of the wood as the pattern line on the top side is followed with the blade. This enlarged pattern line then becomes the pattern for the next cut and the resulting line is enlarged again by the bevel and this continues with each added segment. The difference in size of the pattern from opposite faces is small. The bowl from a board technique uses larger bevel angles in order to have enough wall thickness so that a bowl can be made from a single board. Shell construction uses smaller bevel angles, so multiple wedges must be used in rotation in order to obtain enough wall thickness. The bowl from a board technique could be used with smaller bevel angles if the wood was thicker, or if multiple pieces are used in rotation. Using multiple wedges for a shell is like using thicker wood except we don't have to saw through the total thickness in one cut. The wedge shaped wood that the segments are cut from causes the shell form to wrap around itself as the segments are glued together. A smaller wedge angle will cause the shell to have less space between whorls and requires more segments to make a full turn. Larger wedge angles cause the shell to grow faster in both diameter and width.

Preparing the wood

To begin you will need a wedge-shaped board with an angle approximately 18 to 20 degrees, about 24 to 30 inches long, and 3.5 to 4 inches wide. The angle is not critical. I started with a pine 2x4 for my demonstration shell.

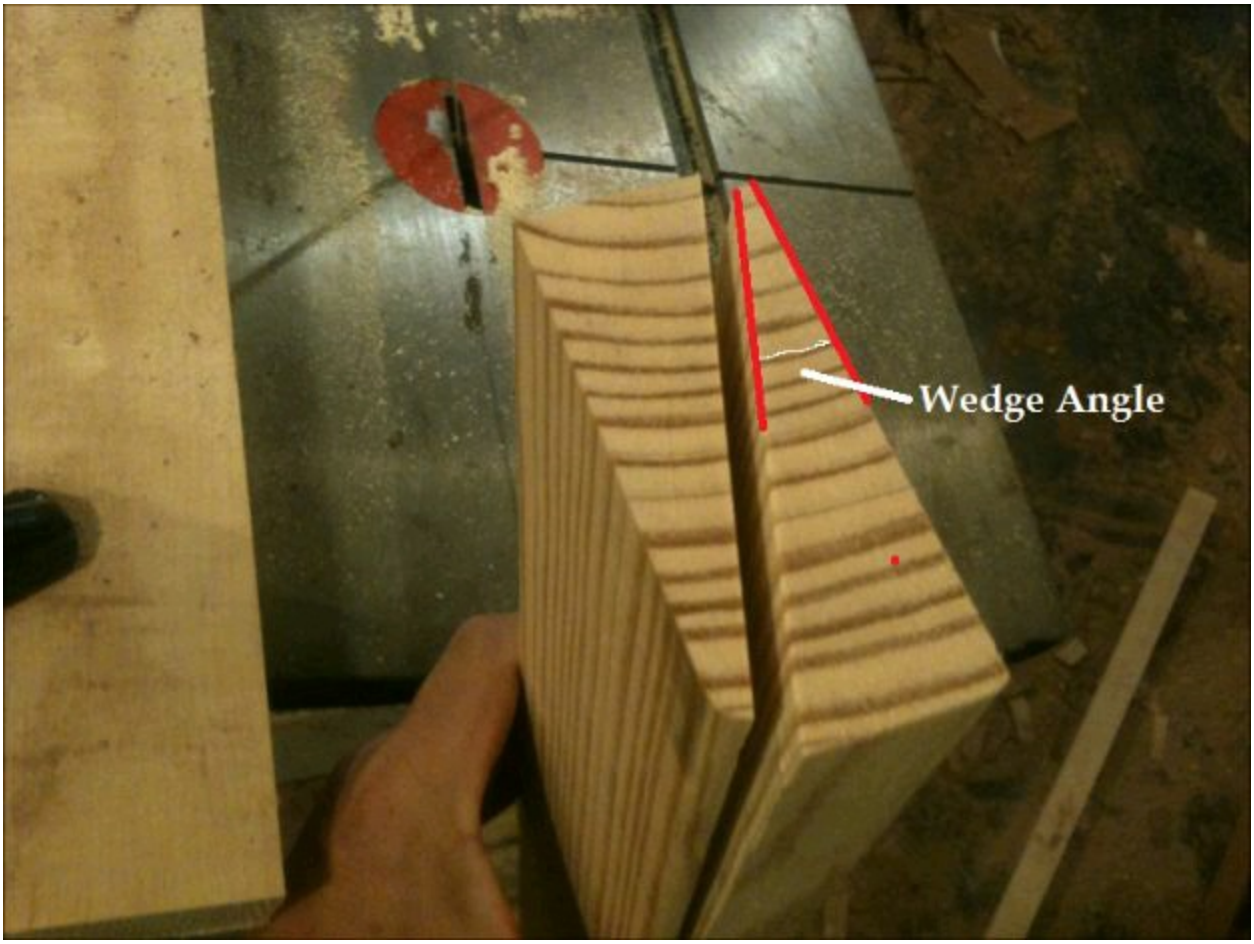


Figure 2 - A bevel ripped 2x4 cut with a band saw. One shell can be made from each half.

1. There are a couple of different ways to make the wedge-shaped pieces of wood. Possibilities including beveled ripping of a 2x4 with a band saw, or propping up one side of the 2x4 and running it through a thickness planer. I ripped a pine 2x4 at an angle with my band saw and then hot glued the two halves back together along the outside edges with the band-sawn faces facing out and then used a thickness planer to smooth both sides. Another option is to sand the faces flat after cutting the individual wedges down to size. The surfaces do not have to be perfect before starting with the shell segments because the joint surfaces will be flattened with sandpaper before being glued

together, but if the surfaces are reasonably flat it will reduce the amount of sanding needed while flattening the joints. Do not make the wedge shaped pieces too thin (too small angle), this will make the segments too flexible possibly causing them to distort during flattening, and more likely to warp from the moisture in the glue. A good wedge angle to use is from 18° to 20°.

Figure 3 – The bevel ripped 2x4 is temporarily held together with a few beads of hot glue. The faces with the band saw marks are on the outside so they can be planed off with a jointer or thickness planer.

2. The thin edge of the wedge shaped wood needs to be trimmed so it is no less than 1/8 inch thick. If the edges are left with a sharp knife-like edge then this will cause warping problems with alignment and gluing. Trim the sharp edge off with a saw, sander, or hand plane. If the wood you are using has a tendency to splinter while cutting thin pieces then you can reinforce the thin edge by smearing a thin film of wood glue on the area around the thin edge of each wedge before cutting segments. This will bond the wood fibers together to eliminate splintering and chipping where the blade enters and exits along the thin edge.

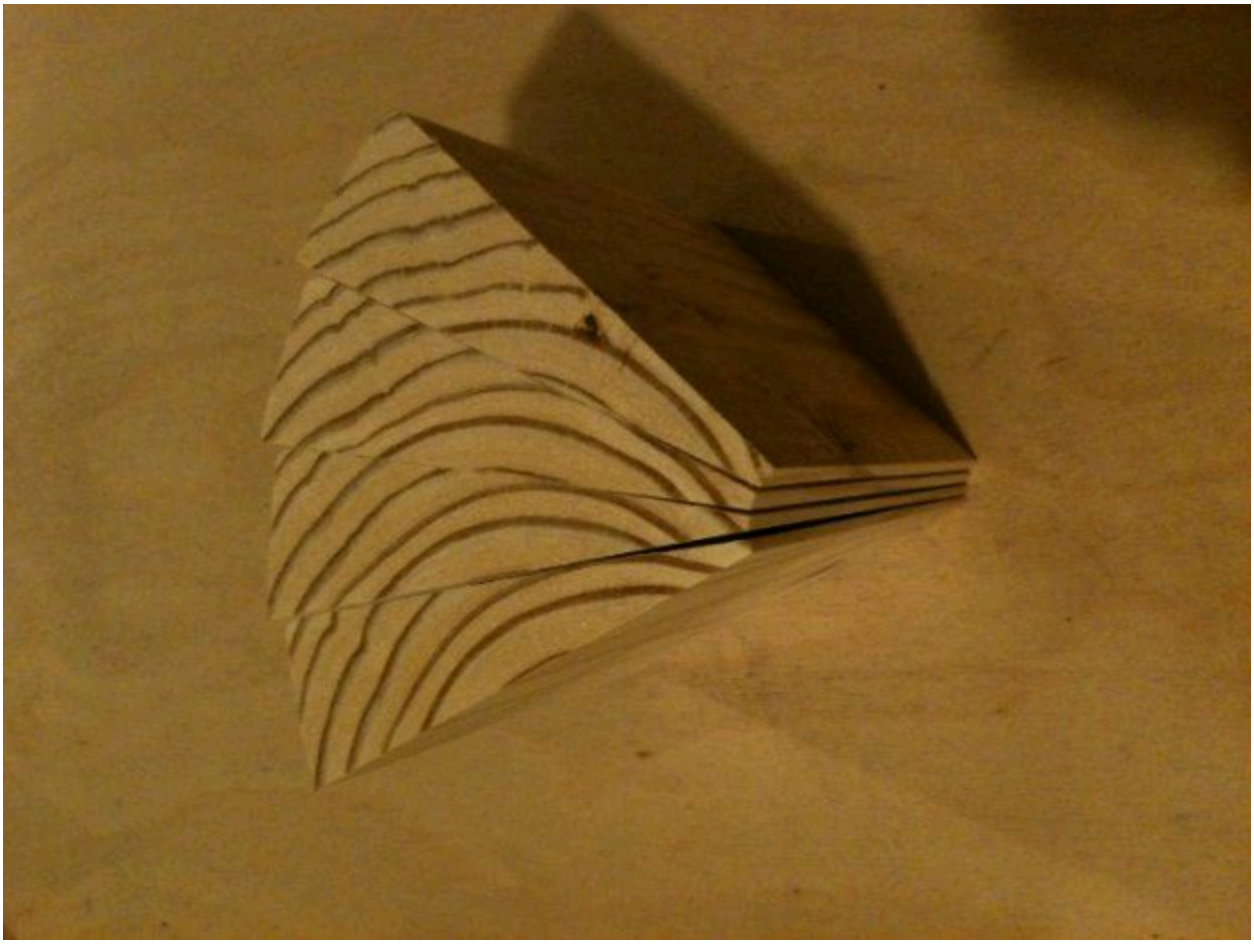


Figure 4 – The growth rings are oriented the same way. This set of wedges is ready to be numbered and used.

3. Cut the wedge shaped wood into four equal length pieces. Orient these pieces so the 90° corner is facing up, and the growth rings in the end-grain are curved the same way. The patterns formed by the growth rings will be exposed in the sides of the shell, and this is a fun aspect to experiment with. Starburst patterns can be made by placing the boundary between heartwood and sapwood in the right position. Number the wedges with a marker in a corner on the thick

side of each wedge. Multiple wedges are needed to give the shell enough wall thickness to work with. More wedges = thicker walls.

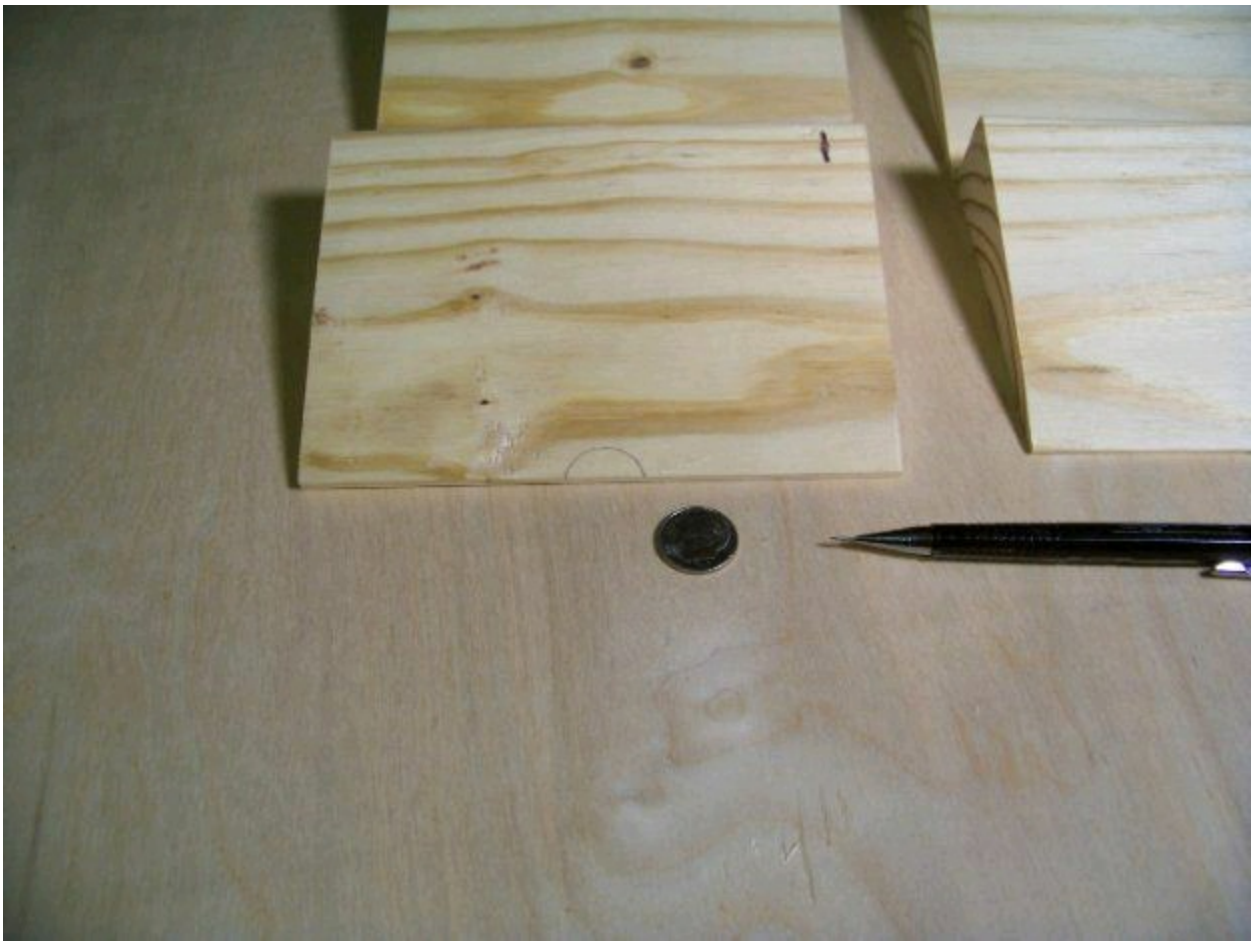


Figure 5 – A semi-circle is the pattern for the first segment cut. Subsequent segments will use the previous segment as a pattern.

4. Start with wedge number 1 and draw a semicircle centered on the thin edge. This will be the smallest and innermost segment of the shell. With the saw table tilted to the left at the same angle as the wedge angle, cut along the semicircle in the counter-clockwise direction. This will cause the outline of the bottom of the segment to be slightly larger than the outline of the top of the segment.

Figure 6 - Set the bevel angle by tilting the table until the blade is parallel to the thick edge of the wedge as shown.

Figure 7 – The cutout from the first segment is used as a pattern for the next segment. Keep the thin edges aligned when tracing.

5. Align the edges of wedge number 1 on top of wedge number 2 and trace the bottom outline onto the top of the next wedge. Make sure that the thin edges are aligned. The large side of segment number 1 will be the same size as the outline of the top of wedge number 2. This is what makes the shell grow larger with the addition of each new segment added.

Figure 8 – After each wedge has been used to cut a segment from, the next segment will be hollow. If the wall of the segment looks like it is going to be too thin then add more segments. Later as the segments become larger, they also become thicker.

6. Continue this process to cut out the first sixteen segments. The fifth segment will be traced from wedge four back onto wedge one. This will be enough to start the shape of the shell and almost enough segments to make a full turn of the shell shape. Keep the segments in order.

Figure 9 - With the table tilted to the left, segments are cut in the counter-clockwise direction. The outline of the bottom side of the cut should be larger than the outline from the top.

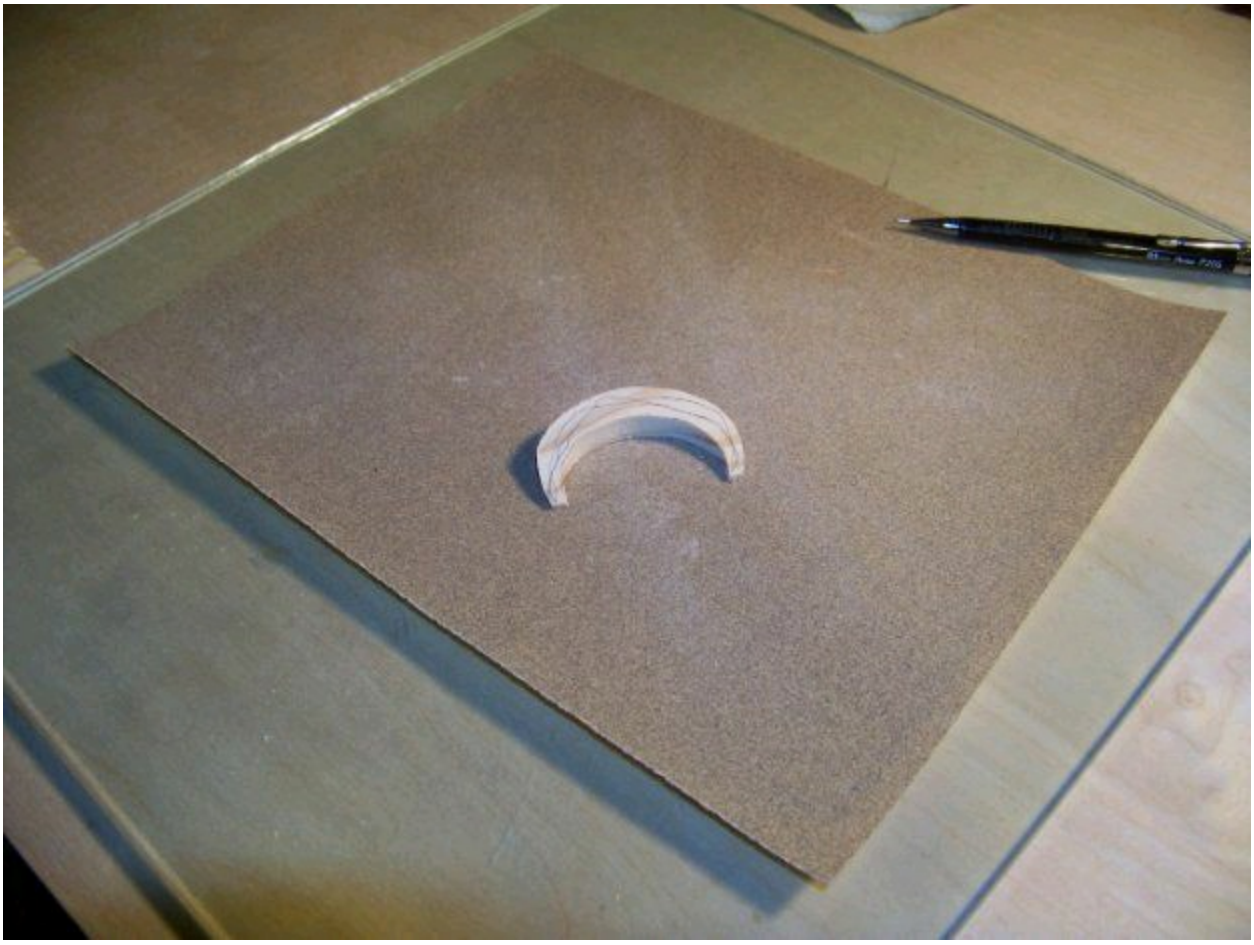


Figure 10 – Use a pencil to scribble lines on the joint surfaces and stroke the segment on the sandpaper to make it perfectly flat. Use even pressure and sand until all of the markings have been removed.

7. Pair up the segments and flatten the joint surfaces by drawing a pencil line on the joint surface and stroking it on coarse grit sandpaper (80-120 grit works well) backed up with the piece of plate glass until all the pencil mark is sanded off. This will make the joint surfaces very flat so they fit together very tight when glued. Glue segment 1 to segment 2, then segment 3 to 4 and 5 to 6 and so on. The first 16 segments will become 8 pairs. I use original Titebond glue with the red label because it grabs quickly. Parts are assembled using a "rub joint" and held with finger pressure until the glue has grabbed. Excessive glue will only make the joint take longer to grab, use just enough glue to get small beads of squeeze-out along the edges.

Figure 11 – The first 16 segments are glued to become 8 pairs of segments.

8. After the glue is set, begin flattening the joint surfaces to join the pairs into groups of 4. Only flatten the joint surfaces just before gluing, the moisture in the glue can potentially cause a bit of warping, and flattening the joint surfaces after the glue is set will remove any warping that might have occurred during the previous gluing that would affect the unglued joint surfaces. If the joint surfaces are flattened ahead of time, then they might not still be flat when it comes time to glue them. Continue pairing up the groups until all 16 segments are together. Flatten the largest joint surface where segment 16 will attach to 17 before gluing together – it will not be possible to flatten a joint in this way after the group of segments form more than a half turn.

Figure 12 – After pairing 3 times, the segment groups contain 8 segments. Don't let yourself get ahead of the interior sanding that needs to be done while it is easy access.

9. Now that the start of the shell is taking shape you need to begin shaping and sanding the interior and exterior while they are still easily accessible. The exterior is smoothed with a 5" disc sander with thick backing pad powered by a drill press to knock down the corners. Start with the smallest segments and work your way towards the edge where future segments will be added. Do not sand the last segment - wait until after more segments have been attached so you don't accidentally mar the joint surface. Use a rotary power carving tool with appropriate bit to curve the flats in the interior part of the shell. Sanding the interior and making it feel pleasing to finger tips is the most difficult part of making a shell. Use strips of sandpaper pulled under your thumb to smooth the interior.

Figure 13 – Smoothing the interior. The flat faces from the saw cut need to blend together to form a smooth continuous curve.

Figure 14 – Strip sanding an area that will be harder to reach after the next group of segments is added on.

Figure 15 - Use a disc sander with thick foam pad in a drill press to smooth and sand the exterior.

10. From this point on it is advised to add just two segments at a time that have been glued together previously to keep the interior area to be shaped near the opening of the shell before it becomes too difficult to reach as the inner whorls of the shell get in the way of sanding. Progress will become slower as the shell becomes larger. Smooth the edge of the center hole with a rotary carving tool with small drum sander as segment pairs are added.

Figure 16 - smooth the central hole with a rotary tool as segments are added before the area becomes harder to reach.

11. After the last segment is added you can then shape the lip of the shell as you like. I prefer to use a Dremel "Mushroom Shaping Wheel" to quickly remove most of the excess material.

A stand for a shell is optional. This can be just a flat piece of wood with 3 or 4 prongs extending upward to hold the shell in position. The ends of the prongs should be shaped to fit the surface of the shell. I have found that adding a tiny dot of hot glue to the area where the prongs contact the shell provides enough friction to hold the shell in position even with a slippery finish. Let the hot glue cool before testing.

Final sanding of the shell should be done by hand to get the smoothest surface possible. I use strips of cloth-backed sandpaper in various grits – paper backed sandpaper works too, but it tears easier. Hold the strip with one hand while gently pressing the strip against the shell with your thumb and pulling the strip under your

thumb. This is more effective and less tiring than the old back and forth motion, it's like using a belt sander with a lot more control. Feel for bumps and dips in the surface with your hands – they will find spots that need attention that your eyes would probably overlook. Any defect will become a lot more noticeable with a high gloss finish.

Texturing

Some woods such as pine have very distinct variations in hardness between the early wood and late wood in the growth rings. The softer layers can be "carved" away using a rotary steel wire-brush to make a very nice texture that seems to fit with the shell to look more realistic. I use the 1.5 inch diameter wire-wheel in a high-speed (20k+ rpm) flex-shaft tool. As the wire-wheel is gently dragged along parallel to the growth rings, it removes the softer part of the wood. After the wire-brushing is complete, I use a sanding mop in a drill press to smooth the shell without leveling the bumps.

Figure 17 – A shell that has been textured. This feels really good to hold.

Finishing

You can finish your shell any way you want, but a lot of people ask me how I get a high gloss glass-like finish on my shells. It doesn't require any expensive spray systems and is easy to get good results. Here are the materials needed:

1. Sanding sealer. I use a spray can of shellac for sealing the wood to reduce the number of coats needed before the polyurethane begins to build on the surface of the wood.
2. Wipe-on gloss polyurethane finish. Minwax is a great brand.
3. Thinner – I use Naphtha, but mineral spirits would probably work too. It must be compatible with the polyurethane.
4. Hand-held pump sprayers with adjustable nozzle. These are considered disposable and the polyurethane and thinner mixture might foul the pump after a while. Use a new sprayer for each new project.
5. Stiff wire to hang the shell from.
6. Paper towels and nitrile gloves.

Raise the grain of the wood by spraying or wiping a little bit of water on the surface. The water causes the wood fibers that are not attached at one end to distort and stand up causing the surface to feel fuzzy. After the water evaporates gently sand off the fuzzy fibers using the finest grit you used before raising the grain. Wet the wood again to see if there are any fibers that are left standing. This will help make the finish smoother by eliminating the possibility of the grain raising during the application of the finish. Sand very lightly during this process to avoid sanding down deeper and exposing more partially loosened fibers. You only want to sand enough to cut the standing fibers off.

The shell is supported during spraying with a stiff wire or rod hanging from the ceiling and with the end bent into a hook so that the end goes inside the shell and supports it from underneath the high spot. The shell also needs to be tilted forward so the wet finish runs out of the shell instead of pooling up in a low spot inside. The hook should be shaped so that it only touches the shell at one point at the end of the wire.

Figure 18 – The finish is applied as a mist using a cheap pump sprayer. With the proper mixture of thinner and finish to reduce surface tension, the finish is allowed to flow to the low spot and drip off.

The bare and dry wood is sealed with at least 3 coats of spray shellac or other sanding sealer. After the sealer has hardened completely the surface should be wet-sanded with wet or dry sandpaper to smooth out any ripples, dips, or bumps within the sealer. Remove any dust with compressed air.

Finishing a shell can be hard to do without getting runs and drips in the finish because the entire surface is curved. The problem is that the surface tension of the finish right out of the can is high enough that the finish would form runs. Thinning the polyurethane approximately 3 parts thinner to 5 parts wiping poly eliminates the surface tension enough so that the finish flows over the surface as a sheet rather than pulling together forming drips. The wet finish flows to the low point and the excess drips off leaving behind a glass-like finish after a few applications. The finish is simply sprayed on heavily as a fine mist covering the surface and allowed to run off without touching it with anything else. Place a trash can directly underneath the shell

to catch the dripping finish. As the finish becomes tacky, use a folded corner of a paper towel barely touching the final drip to remove it. Sanding between coats is not necessary. If you spot an area that you missed, do not spray more finish on it if the coat has already become tacky. Make sure it gets covered when you spray it again the next day. Spray the finish in a warm room without any air circulation. Air in motion carries dust that will adhere to the surface of the finish. Leave the finish to dry without being touched or disturbed. If the wood was sealed before applying the finish then the glossy coat should start forming on the first spraying, if not then the first several coats will just soak into the wood. Three or four coats on sealed wood should be enough. Wait until each coat is hardened (I usually wait overnight between coats) before spraying on the next coat.

Drawing a Cross Section

You may be wondering what effect different angles have on the shape of the resulting shell. There are two angles to consider; the wedge angle, and the bevel angle. To keep things simple let's make them equal. A larger wedge angle will result in a spiral that grows outward faster. This also means that the wedges that segments are cut from get thicker a shorter distance from the thin edge which limits the maximum size a shell can reach due to the limitation of how thick the saw can cut. A smaller angle will result in a shell that can be larger, but the segments will be more flexible and fragile. The smaller angle spiral will also have a smaller gap between the edge and the next whorl inward which makes shaping and sanding the interior more difficult. You can change the bevel angle to be more or less than the wedge angle, but it becomes more difficult to predict the outcome. I have outlined instructions for drawing a spiral that represents the cross section through the center of a shell:

1. Using a protractor or a cad program, draw equal length radial lines from a central point with the wedge angle between them, draw enough lines to make a full circle. I will use 18° wedge angle in my illustration which will have 20 segments per turn.

2. Using the outer end of one of the lines as a starting point, use a drafting triangle or some other template with a square corner to draw a line segment from the start point to the next line over so that the line segment is perpendicular to the radial line. If you are drawing with AutoCAD, use the perpendicular object snap setting.

3. Repeat step 2 using the intersection of the line segment you just drew and the radial line as a starting point. Continue in this manner until you have drawn a spiral all the way around 360°. This will be the cross section of a shell with the same angles.

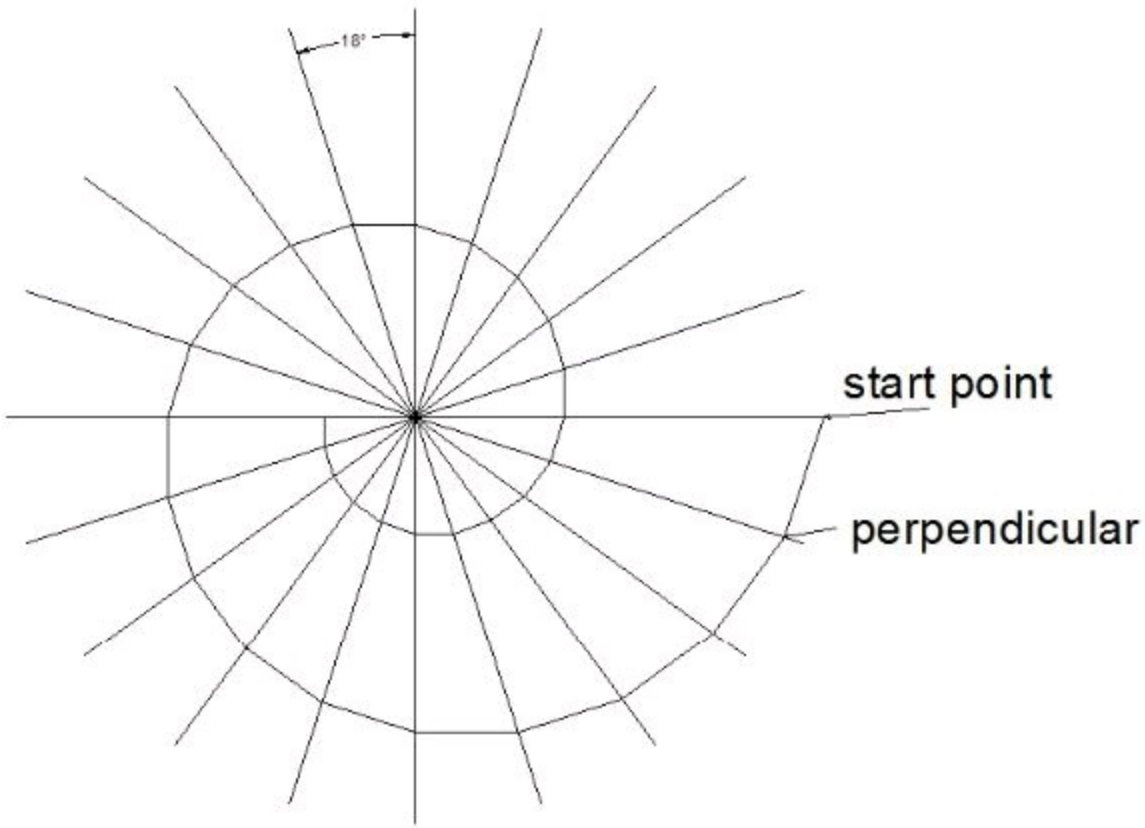


Figure 19 – A cross section of a shell.

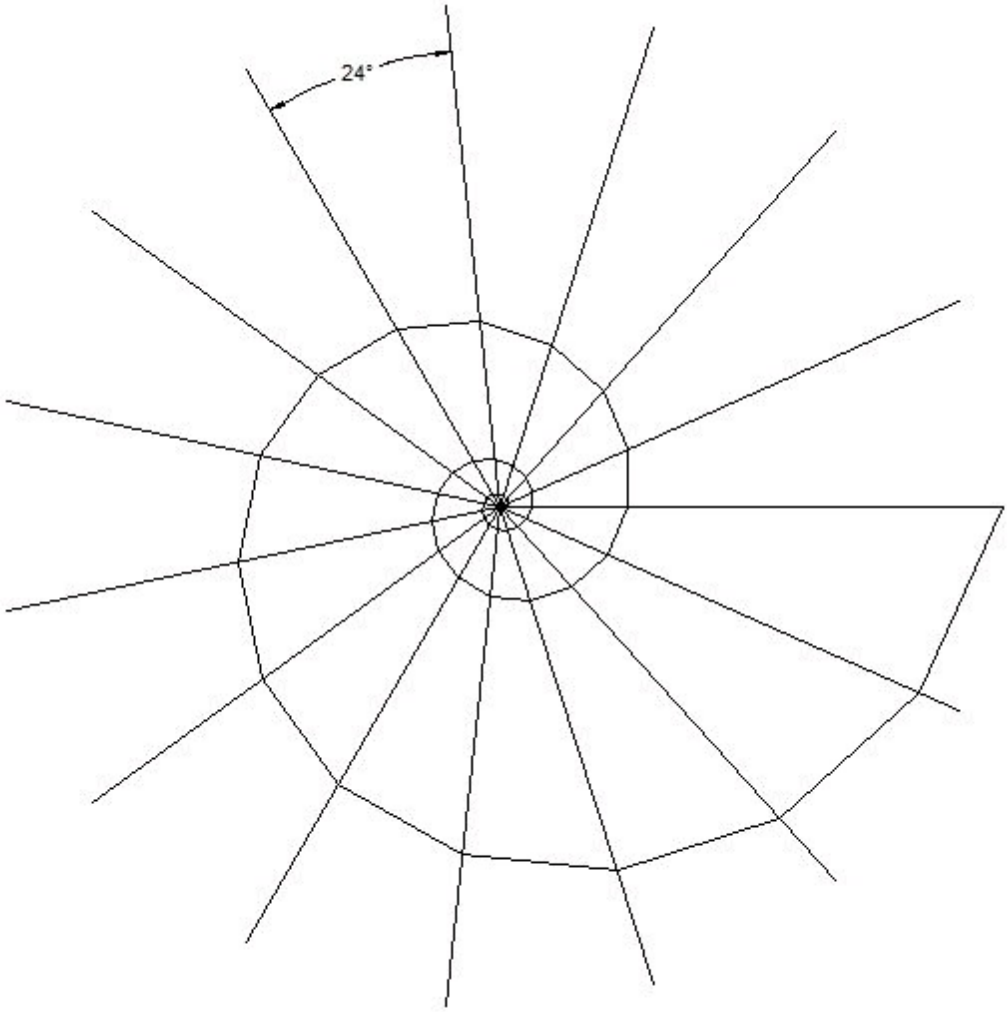


Figure 20 - A 12° logarithmic spiral with 15 segments per turn.

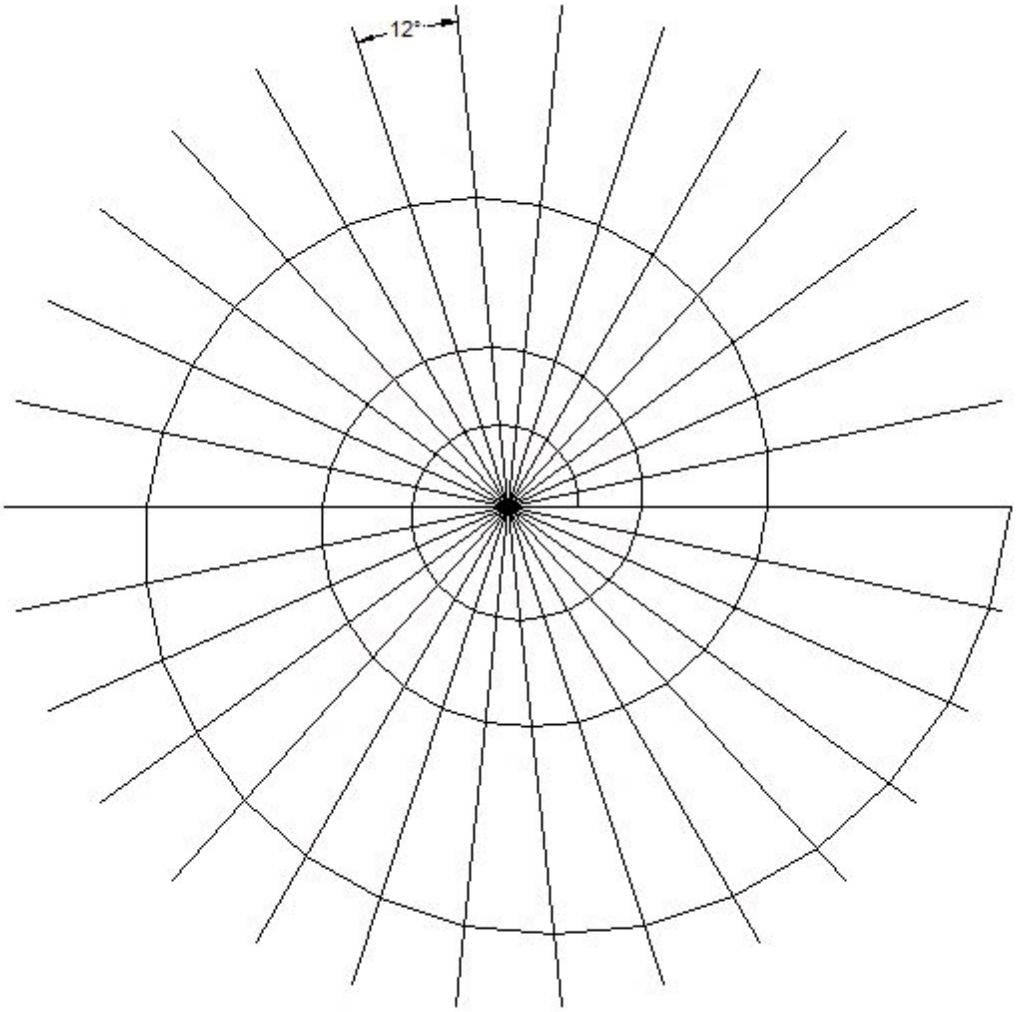


Figure 21 - A 6° logarithmic spiral with 30 segments per turn. As the wedge and spiral angles get closer to zero, the overall shape of the spiral becomes closer to a circle.

You might have noticed that what I am calling the spiral angle is equal to half of the wedge angle. A spiral angle is the angle measured between a line that is perpendicular to the radial line, and a line that is tangent to the spiral at the point where the radial line intersects the spiral after the spiral curve is smoothed out. The spiral angle of a real nautilus shell is around 10 or 11 degrees corresponding to a wedge angle of 20 to 22 degrees according to measurements I have made.

Useful Web Links

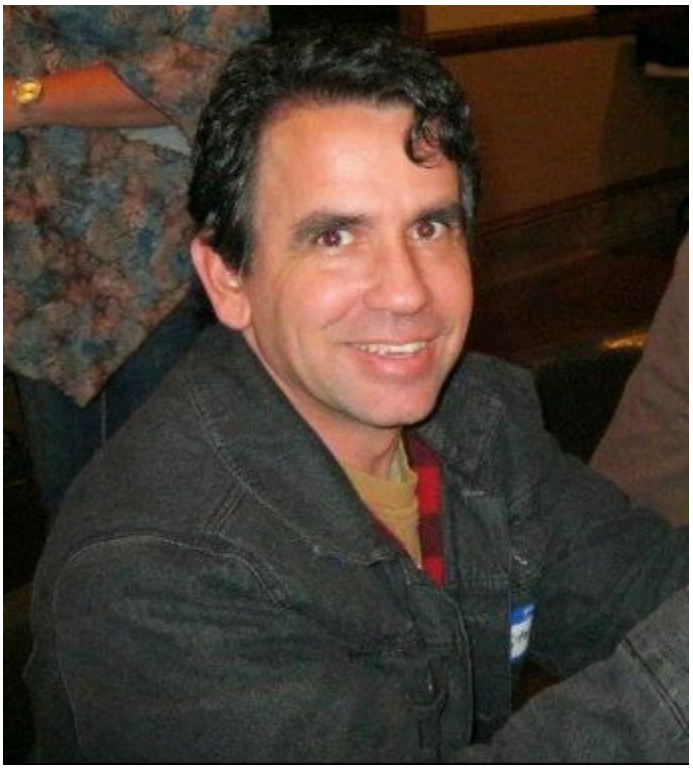
Watch my demonstration video on YouTube about making wood shells.

Visit my web site. I have pictures of shells I have made and a lot more techniques I have developed and wrote about.

I have started using Pinterest and created a board of pictures of fossil shells that I like. These nautilus and ammonite shells are the inspiration for the shells that I have made.

My Facebook page.

About the Author



I grew up in a fairly small town in Arkansas between the Arkansas River Valley and the Ozarks about halfway between Little Rock and Fort Smith. I have a degree in geology, but I have done a little bit of everything – a Jack of all trades including exploration geologist, machinist, land surveyor, pattern maker, millwright, foundry worker, pipe fitter, welder, cabinet maker, and a few other miscellaneous jobs. Now I work for myself as an artist and inventor. I like to dream up new ideas and make them happen. Growing up in this rural area we didn't have all the conveniences of a large city nearby, and I think that makes a person more resourceful. If I have something in mind that I want to do in my workshop and don't have a tool to do it I will either make or modify a machine to do what I want. People say that art and engineering don't mix, but if you look at my work you will see both. Everyone else in my family is also an artist / creative type. Using the internet and writing eBooks I am now able to teach others about my work almost anywhere in the World. Some of my other hobbies include hiking, fishing, exploring, floating a creek, camping, and hanging out with friends. If you have any questions feel free to send me an email and I will get back to you as soon as I can. Thanks, Steve Garrison

The End