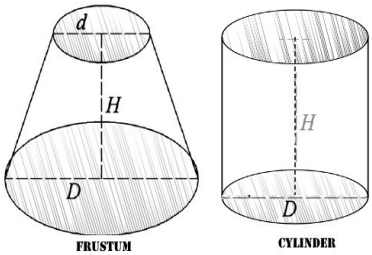
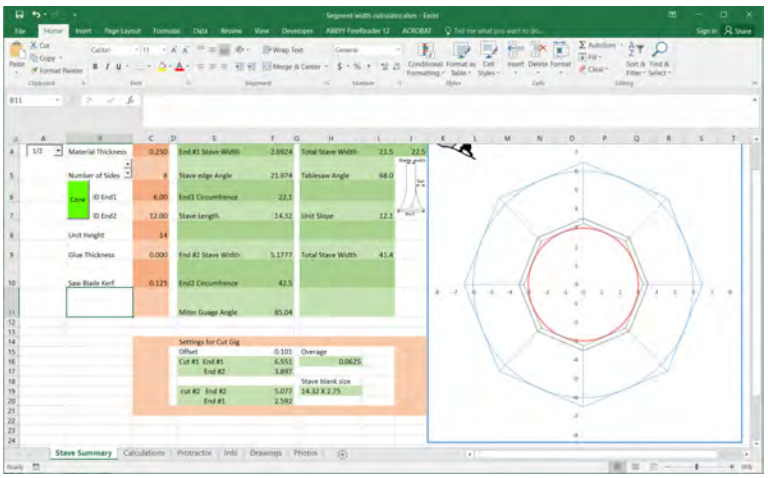
Splayed Joinery using a software tool.



Imagine a tube made from multiple flat pieces of wood. Each piece has beveled edges so when placed together form the tube. Then imagine a tube of the same construction except that the opening on one end is larger. This article is about making the pieces (staves) that when put together will make these shapes. These shapes are called a conical frustum and a cylinder. Splayed Joinery is all about making compound cuts to creating the many identical pieces that will assemble into these shapes.

I began this project as a solution for connecting my dust collector to my shop tools. Each had slightly different sized connection port. I started by using seat of the pants dimensions. I had some success, and liked the structural integrity of the connectors I managed to make, I quickly found that more precision was needed. Using Google I found several methods that were helpful in understanding the math, but most approached the subject from a different perspective than I needed.

All of the dimensions of a stave are interrelated. As the number of staves, the thickness of the material being used, the slope of the unit, and other parameters change so do the stave dimensions. I decided to use Microsoft Excel for developing my software tool. It is flexible in that one can combine a way to input dimensions, do needed calculations, display the final dimensions in table and graphic form, and supply any needed explanations. I also wanted to incorporate a means to cut the staves on my table saw using a jig. The tool would need to calculate measurements for setting up the jig. In addition I wanted an easy method to assemble the staves into the final form.



The software tool is used by entering parameters for the material thickness, number of sides, and the inside diameter of the unit ends. A graph of the unit gives a visual representation.

When making a cone the unit height is entered to calculate the stave length and fine tune other dimensions..

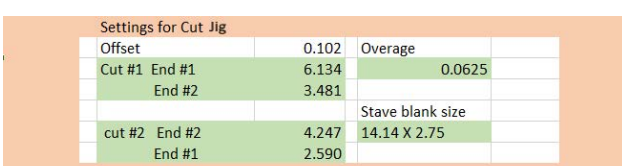
Two additional parameters are available as needed. glue thickness (rarely needed) and saw blade kerf, used to estimate amount of material needed for the unit.

Parameters ①		Measurements ②			"+Kerf"
③ Material Thickness	0.250	End #1 Stave Width	1.8640	Total Stave Width ⑰ 14.9	15.9
④ Number of Sides ⑤	8	Stave edge Angle ⑬	22.440	Tablesaw Angle ⑱	67.6
⑥ ⑦ Cone ID End1	4.00	End1 Circumfrence ⑭	15.3		
⑧ ID End2	2.00	Stave Length ⑮	14.04	Unit Slope ⑲	4.1
⑨ Unit Height	14				
⑩ Glue Thickness	0.000	End #2 Stave Width	1.0355	Total Stave Width ⑳	8.3
⑪ Saw Blade Kerf	0.125	End2 Circumfrence ⑯	8.5		
⑫ Miter Guage Angle	88.3				

The tool contains a definition tab which contains definitions and explanations for all the parameters and measurements.

Calculations can be seen by selecting the calculations tab.

The math is accomplished by using the built in VBA capability of Excel.



Settings for Cut Jig			
Offset	0.102	Overage	
Cut #1 End #1	6.134		0.0625
End #2	3.481		
		Stave blank size	
cut #2 End #2	4.247	14.14 X 2.75	
End #1	2.590		

A table provides measurements for setting up the jig used for cutting the staves. It also gives the dimensions of the blanks which the staves are cut from.

Objects made from staves

Waste Basket

Telescopic Tubes

Dust Collector

Hose Adaptor

Here are some of the items I have made using splayed joinery.

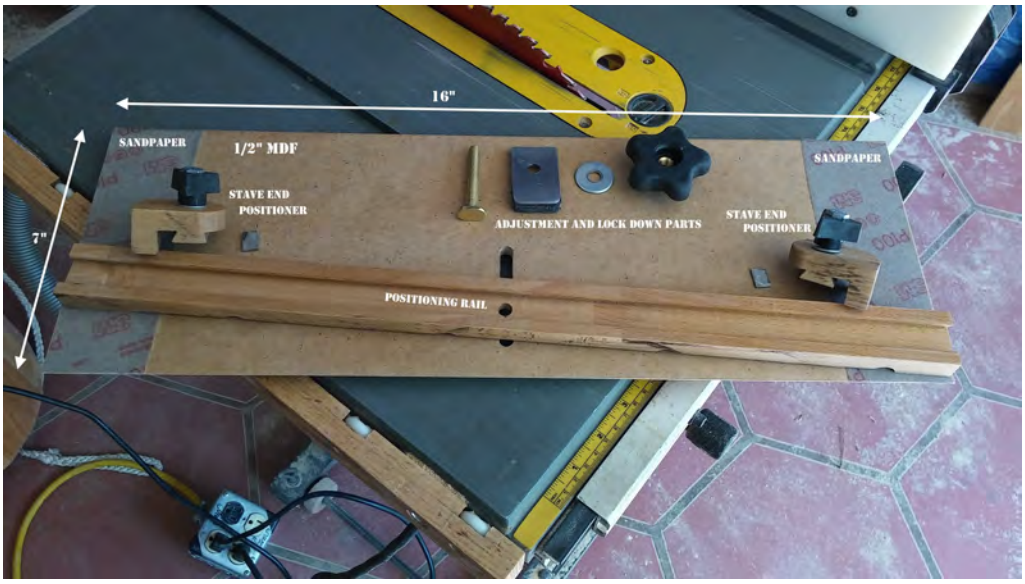
The waste basket was made from left over flooring. I cut a grove, for the bottom, on the inside of the blanks.

The telescopic tubes were to see how accurate the overall process can be.

The dust collector, including the cart it sits in and the tubing to the vacuum, was made using stave tubes and cones.

My first project, making adapters to hook up the vacuum hose to my tools.

The jig used to cut staves



The jig is simple to make. It consists of a MDF base, an adjustable stave blank holder with two adjustable stops; A position and blank locking bolt in the center of the holder and sandpaper glued to the ends to prevent movement when locked down. The exact measurements and means of attaching the stave end positioner to the positioning rail can be modified. One of the stave positioners could be fixed. The stave rail needs to be thicker than the stave material because on the second cut the inner stave edge is beveled. The saw blade edge of the base is undercut to 30 degrees so it can touch the blade when the blade is tilted to cut the stave edge angle. The stave is secured in place when cutting using the two end positioners and a piece of metal with thick rubber glued on one side. When the lock knob is tightened the metal piece wedges the metal across the positioning rail and the blank securing both. A slot in the center of the base lets the positioning bar adjust in two dimensions so the ends of the blank can be correctly positioned.

Cutting Staves using the jig

Once the dimensions of the staves to be cut have been generated by the software tool the first step is to cut stave blanks. The tool provides the dimensions of the blank in the jig Settings Table. The sizing of the blank is somewhat critical. It can be a little wider but not narrower than the tool values, and must be the given length. In the picture I have drawn the outline of the stave on the blank to show its final shape.

Settings for Cut Jig

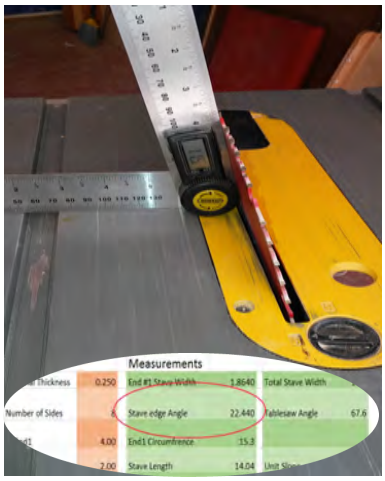
Offset		0.102	Overage
Cut #1	End #1	6.134	0.0625
	End #2	3.481	
			Stave blank size
cut #2	End #2	4.247	14.14 X 2.75
	End #1	2.590	

The jig settings give the size of the blank, measurements for setting the positioning bar for each pass, and overage which is cut away and creates edges which are beveled for the entire length of the stave.

Various material can be used to make stave blanks. If using sheet material I like to cut a large piece to the length of a stave. I can then rip the blanks to width from that piece. I find it easier to handle and get better consistency in blank size.

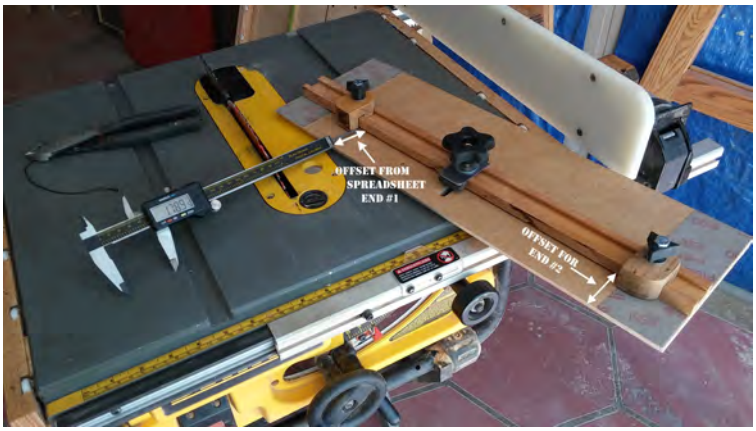
Two stave blanks ripped from a stave length piece.

Cutting Staves using the jig



The table saw blade needs to be set to the stave edge angle. I use an inexpensive digital angle gauge with a readout in tenths of a degree. For material over 1/4 inch thick accuracy becomes important. If the angle is not correct when the unit is assembled the multiple joints will be tight or loose. I find that over cut angles (looser) work better. Tight joints (under cut) distort the overall final shape.

The jig needs to be registered to the saw blade and is guided by the table saw fence. This can be tedious, to close and the edge of the jig gets clipped to far way and the stave ends up wide. For most work this is not critical. Being off by a fraction in a stand alone unit is usually acceptable. It only becomes critical when two or more units are to be mated. So my rule of thumb is move the fence till the jig touches the blade then back it off 1/32 of an inch.



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To set up the jig a stave blank is placed in the jig and the end positioners are registered to the ends of the blank. Then a caliper is used to set the positioning rail to (cut#1, end#1 / end#2) distances from the edge of the jig. The stave and the holder are then locked into position by tightening the lock knob. After cutting the first edge the jig is set for cutting the second edge (cut#2, end#1 / end#2). The half cut staves are put back in the jig rotated end to end before the second cut.

Cutting a stave from a blank is a two pass process. Each pass cuts one edge of all the stave blanks for the unit.

Cutting Staves using the jig

Here is a picture of a stave blank in the jig ready for cutting the first pass. I have marked the outline of the stave on the blank for clarity.

Here is a picture of a stave blank in the jig ready for cutting the second pass. I have marked the outline of the stave on the blank for clarity. Notice the blank has been rotated end for end.

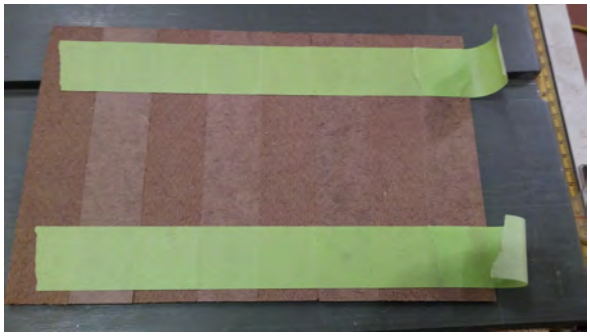
Here is a picture of the completed stave after the second cut.

Remember one edge of all the blanks are cut using the first setting. The jig is set for the second cut and all the blanks are rotated end for end and ran through the saw again.

Assembling staves to make a shape

If you have tried to built a project using staves, or thought about one, a single thought can make you change your mind. "How am I going to assemble all these pieces at once?" The ends have to be aligned, glue has to be applied to all the edges, the shape needs to be maintained! WOW!

I am not the first to try this daunting task. Luckily I found a way that works well. I said found because I used Google and was amazed at the many possible ways. For most of the projects I have done I found one that is simple and produced acceptable results.



By laying the staves on flat surface outside up, the edges and ends can be aligned. The picture shows the layout of a tube. (A cone shape would create a fan shaped layout).

It takes some practice to place the pieces. By using one hand to hold the previous piece the next piece can be adjusted so the ends line up and the edges are tight. Small pieces of tape can also be used to hold the individual stave edges together.

Once all the staves are laid down strips of tape are applied to the surface from side to side. For smaller staves two strips of tape works well. I use original, sticky, masking tape and it holds the pieces secure.

Flip the taped staves over so the inside is up. Once again this takes some practice. I find that working both hands under the edge closest to me and then lifting it up and letting it fall over using gravity as my helper works well and the staves stay together.

With the inside edges exposed glue can be applied between the staves and to one outside edge. A thin bead of glue can be applied to all the edges fairly quickly. Using standard wood glue I find I have plenty of time before the glue begins to set up.

If you take a look at the picture you can see that the strips of tape start in the middle of a stave and extend past the edge of the last stave. This helps when forming the unit. Once the glue is applied the staves can be set upright and the shape formed. The over hanging tape can be used to secure the assembled unit together. I am always amazed at how, well cut staves, almost snap into shape! When forming a cone I find placing the larger end down on the flat surface works best.

Excess glue will be forced from the joints. If the inside surface is important, it will need to be wiped smooth (messy).