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Tusk Tenon Table — Synchronized Simplicity

In this plan you will be getting:

- Step by Step construction instruction.
- A complete bill of materials.
- Exploded view and elevation drawings.
- How-to photos with instructive captions.
- Tips to help you complete the project and become a better woodworker.

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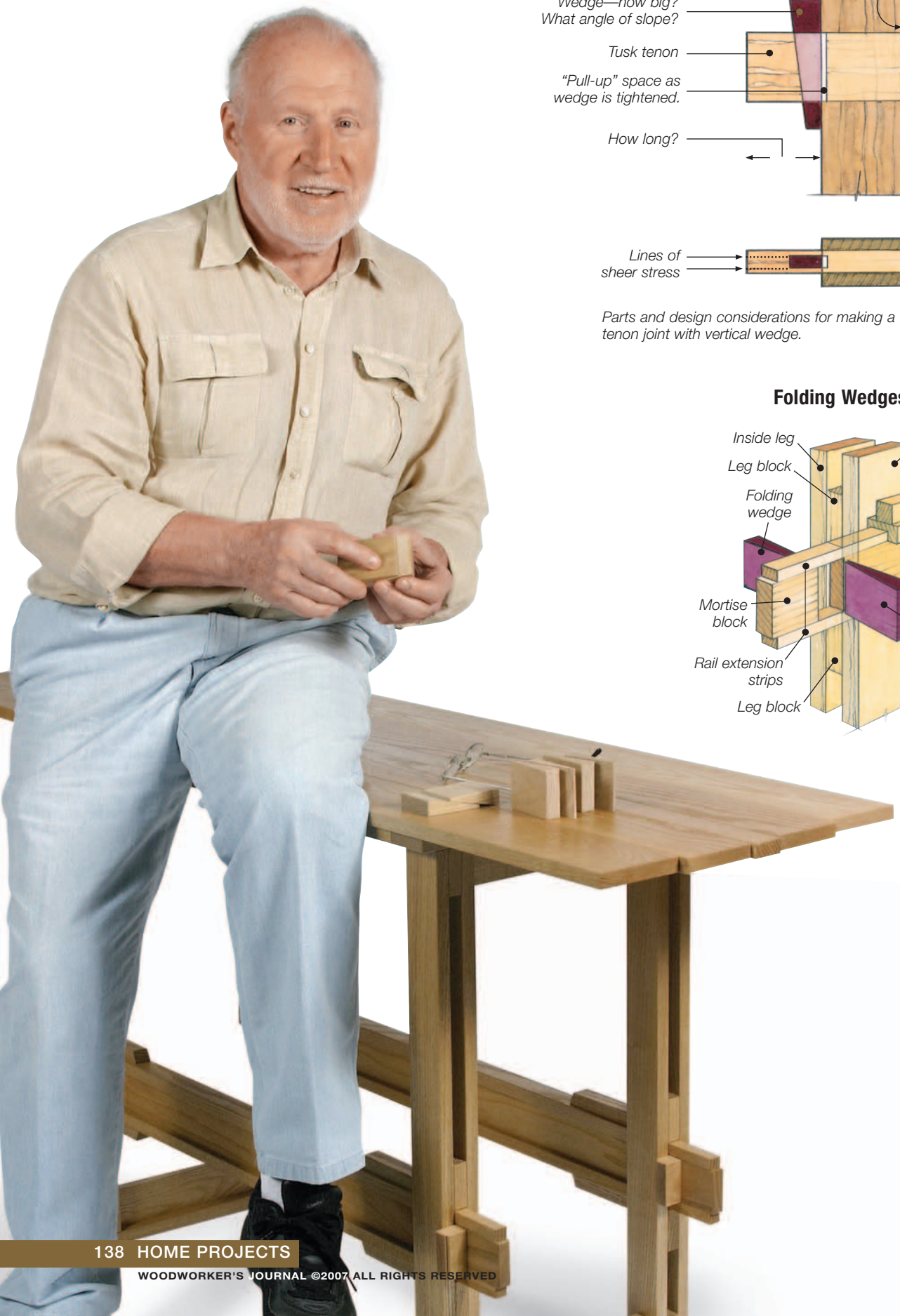


Traditional Tusk Tenon Joint

Parts and design considerations for making a traditional tusk tenon joint with vertical wedge.

Folding Wedges Joint

Tusk Tenon Table — Synchronized Simplicity

Harness the power of folding wedges by building this elegant tusk tenon table. You'll use ordinary thickness stock and joinery done by adding pieces rather than cutting out material. Master woodworker Ian Kirby shows you everything you need to know.

Elegant to the eye, this table's joinery is built up to create a knockdown capability. Folding wedges in built-up mortises are just one of the factors that make it so.

A tusk tenon is a through tenon made so that it projects way beyond the mortise. A wedge is fitted into the projection which, when driven hard, pulls the shoulder of the tenon tightly and firmly to the mortised piece. Here's Ian Kirby's thorough analysis of this joint and the elegant table it produces.

This joint can be designed in a variety of ways, but no matter the variation, a successful joint requires several characteristics common to all:

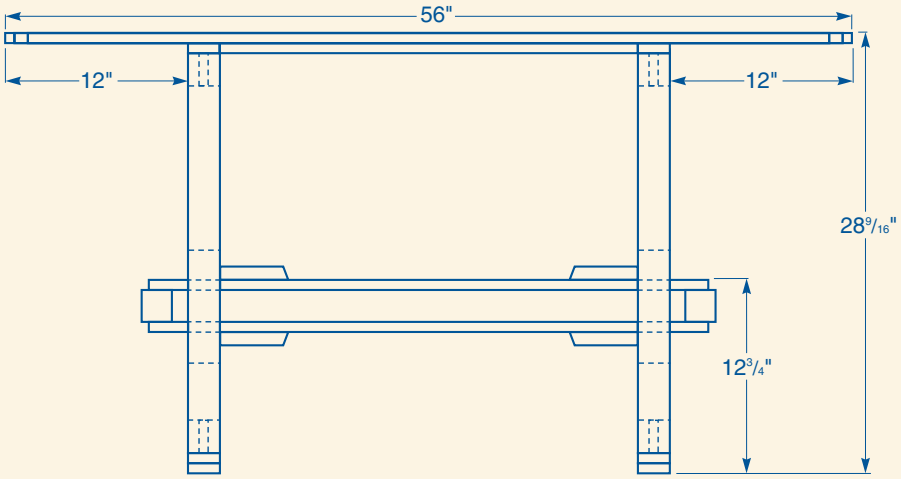
The Shoulders— I'll begin with the shoulders on the tenon piece that form the dead stop that the wedge is pulling against.

You could make the shoulders on the sides and edges of the tenon as you would for a normal glued-up tenon. However, the resistance to stress comes largely from the two outer edges (top and bottom) of the rail and less from the shoulders on the sides of the rail that would normally form the joint line. Indeed, on many tusk tenons you will find that there are no shoulders on the sides of the tenon. And there is no virtue in the tenon being a tight fit in its mortise as you would expect in a glued-up joint. In fact, the fit can be quite sloppy and still work well. Aim for a comfortable sliding fit.

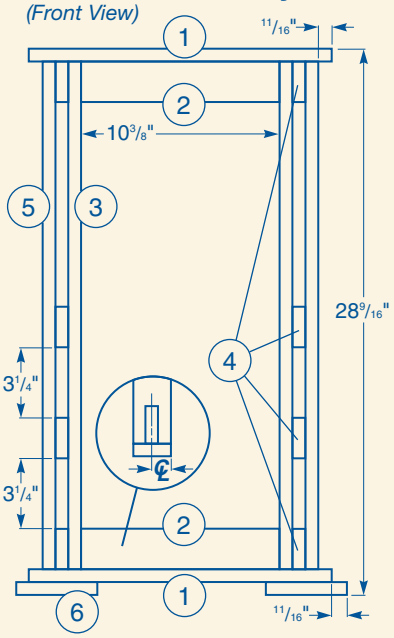
The ratio/relationship between the

Table Exploded View

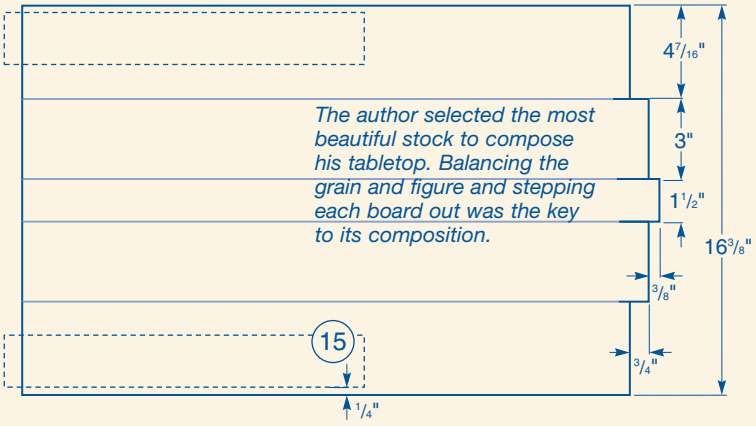
Tusk Tenon Table *(Front View)*



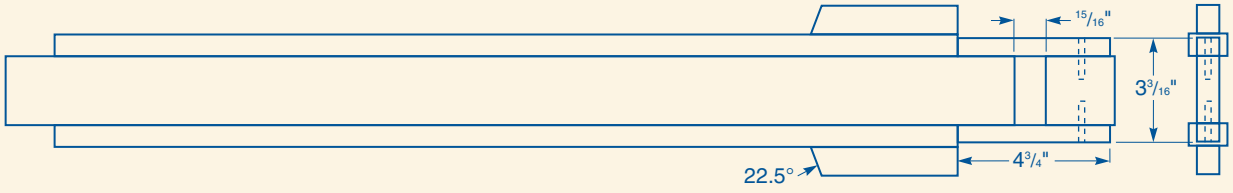
End Frame Assembly
(Front View)

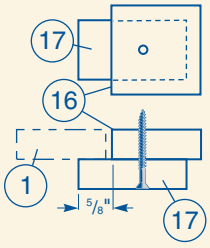


Top Board Layout *(Top View)*

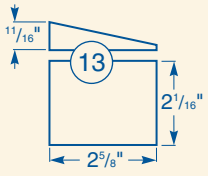


Rail Subassembly
(Front and End Views)

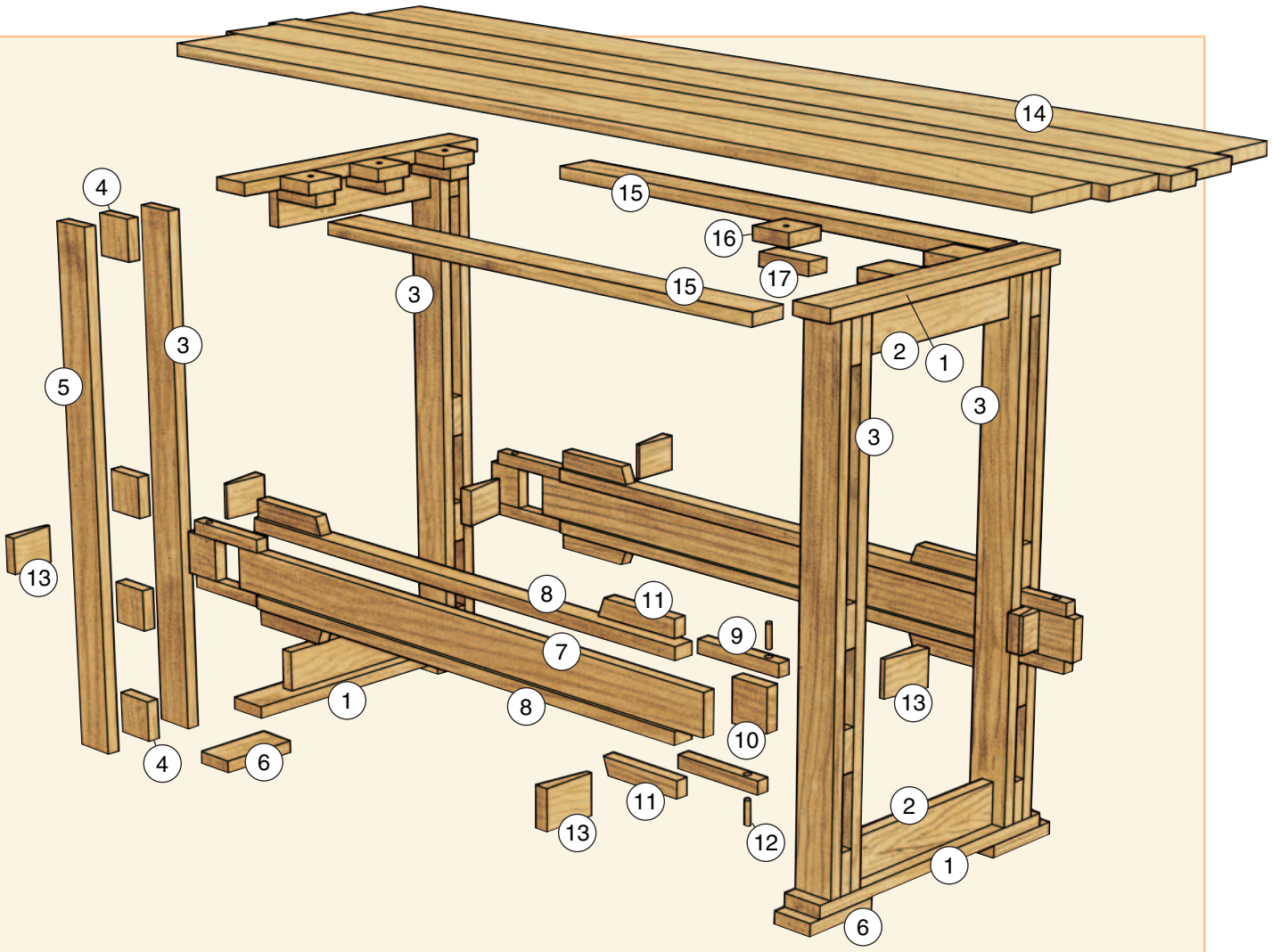




Glue and Screw Block Assembly
(Top and Side Views)



Folding Wedge
(Top and Front Views)



MATERIAL LIST – *Table*

END FRAMES	T x W x L
1 Cap Rails (4)	11/16" x 2 1/16" x 15 7/8"
2 Shoulder Rails (4)	11/16" x 2 1/16" x 10 3/8"
3 Inside Legs (4)	11/16" x 2 1/16" x 26 1/2"
4 Leg Blocks (16)	11/16" x 2 1/16" x 2 1/16"
5 Outside Legs (4)	11/16" x 2 1/16" x 26 1/2"
6 Foot Pieces (4)	4 1/4" x 11/16" x 2 1/16"

RAILS	T x W x L
7 Stretcher Rails (2)	11/16" x 2 1/16" x 31 3/4"
8 Shoulder Rails (4)	11/16" x 1 3/16" x 27 3/4"
9 Rail Extension Strips (8)	9/16" x 11/16" x 4 3/4"
10 Mortise Blocks (4)	11/16" x 2 1/16" x 2"
11 Short Shoulder Rails[1] (8)	11/16" x 7/8" x 4 1/2"
12 Dowels (16)	1/4" Dia. x 1 1/2"

WEDGES	T x W x L
13 Wedge Blocks[2] (8)	11/16" x 2 1/16" x 2 5/8"

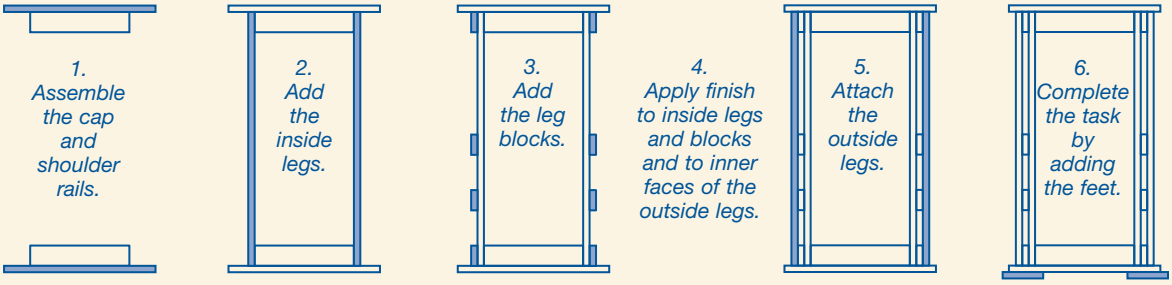
TOP BOARDS	T x W x L
14 Top Boards (5)	11/16" x varies x 60"
15 Thickener Rails (2)	11/16" x 2 1/16" x 27 3/4"
16 Glue Blocks (6)	11/16" x 2 1/16" x 2 1/16"
17 Screw Blocks (6)	11/16" x 1 3/8" x 2 1/2"

SPACER BLOCKS	T x W x L
18 Leg Block Spacer[3] (1)	11/16" x 2 1/16" x 3 1/4"
19 Mortise Block Spacer[4] (1)	15/16" x 15/16" x 2"

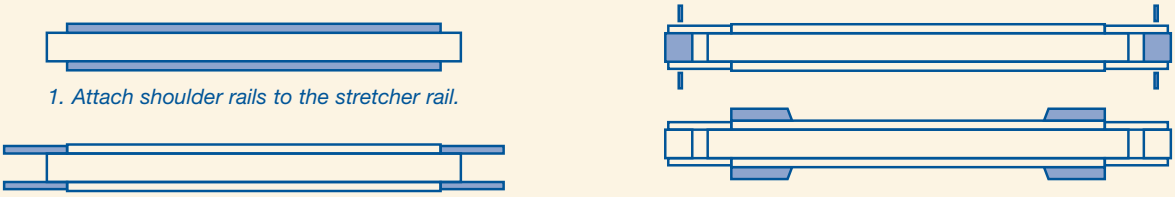
[1] End angle is 22.5°
[2] Cut in wedge jig
[3] To position leg blocks
[4] To position mortise block

Technical Drawings

Six Steps to Making the End Frames



Four Steps to Making the Rail Assembly



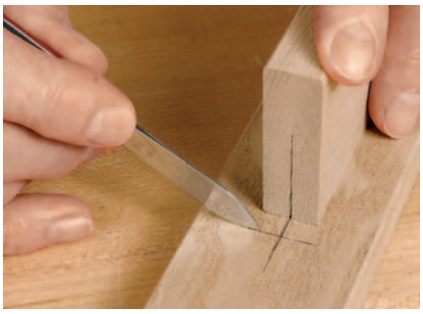


Figure 1: *To accurately position the shoulder rails on the cap rails, mark their centers with a marking gauge.*

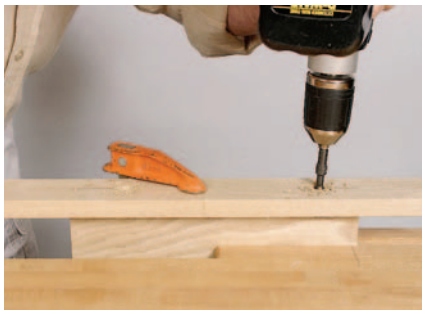


Figure 2: *Clamp, drill, and screw the parts together dry to assist with positioning them once the glue is applied.*

tenon and rail width is something you have to design, but the wedge and its mortise play a part in your decision.

The Wedge—The wedge is generally made straight on one edge and tapered on the other edge. The slope of the taper is critical. If it's too steep, the wedge will drive okay but will pop out when the assembly is racked—that is, unless it's been crushed by being driven too hard. If the slope is too slight, it will pull up the shoulders very tightly, but it takes too long a wedge to close them. I've found that a slope of 12° works well.

The Mortise for the Wedge—The outer end wall of the mortise must have exactly the same slope as the wedge. The inner end wall of the mortise must be inboard of the face of the upright leg or stile. Unless the mortise is "oversized," the wedge cannot bear against the upright and pull the shoulders tight. (See the *Traditional Tusk Tenon Joint Drawing*, page 138.) This also means that the wedge must be sufficiently beefy to withstand bending as it crosses the void. And it must be sufficiently long so there is plenty of wedge above and below the void.

The Sheer Load on the Tusk—As the wedge is driven, the shoulders pull up tight. The counter stress is transferred to the extra length of the tenon, the tusk. If the tusk is too short, the wood that is buttressing the wedge will break out. So another part of your design consideration is how long to make the tenon to prevent such a collapse. Factors include the species of wood and whether you orient the wedge up-and-down or side-to-side. For example, what would be good for elm, a resistant splitter, would not be good for quartersawn oak.

This joint design was common on early furniture. It's probably the more difficult design to make and the bigger the parts, the greater the difficulty on two counts. First, you have to chop out the narrow tenon for the wedge and,

SHORT HISTORY OF A TUSK TENON

This massive chest with its lift-up lid is made of six pieces of wood held together by six tusk tenons. Despite the wear and tear of the ages, it remains a functioning, practical piece of furniture.

Like most woodworking joints, the ancestry of the tusk tenon spans millennia and cultures around the world. We find it used to hold frames together to make beds and tables, and we find it used to hold boards together to make storage boxes. There is nothing standard about the dimensions of the tenon nor the dimensions of the wedge—they come in all manner of shapes and sizes. Because it can be made in so many different ways and can be used on such a variety of items, it's probably the most versatile of our joint repertoire. As well, it can be used as a temporary joint or a permanent one, and all without the use of glue.

This chest comes from the province of Noorestan in Afghanistan. It belongs to my friend and next-door neighbor, Prince Ali Seraj. It's believed to be about five hundred years old, and it's a perfect example of a large slab structure held together by six tusk tenons.

The ends are two inches thick. Their faces were refined using an adze, and the edges are chip-carved with an intricate cross ribbon pattern. The lift-up lid has a hinge pivot that gets trapped in its hole as the ends are wedged in place. To make the pivot, about two inches of the ends have been cut away on the top board to leave a peg, which is modeled into a cylinder. The four slabs that make up the case are decorated with fine line carving on every show face.

What I find most interesting are the wedges. They go through the thickness of the tenon—the simplest solution—but for the job they have to do, to my mind, they are very thin.

Made to look a bit like a metal spike, the visible wear attests to their having been driven in and removed on many occasions. They all appear to be original, and their survival is a good example of how little we know and respond to the engineering qualities of this material that we fool ourselves into thinking we have mastered.

The artisans of Noorestan are believed to be some of the remnants of the army of Alexander the Great that trekked through that region. Until about 1890, their land was called Kafistan—land of the unbeliever. At that time, they were converted to Islam and had a name change. They remain makers of furniture and other domestic goods to the nation.

Honest, functional and portable. In less than a minute you could remove the wedges, part the pieces and pack them on the four-legged transport of your choice.

Figure 3: *Clamp the shoulders tight to the cap and shoulder rail assembly with the inside legs in place.*

Figure 4: *Screw through the cap rail into the end grain of the inside leg. Screws are angled towards one another for extra strength.*

second, you have to get the slope of the end of the narrow tenon to be exactly the same as the slope on the wedge.

A simpler tusk tenon variation used to assemble the table featured here, is to make a rectangular hole and use two identical wedges, called folding wedges, as shown in the *Folding Wedges Joint Drawing* on page 138.

Designed for Simplicity

The underframe of this table is designed so that it will be very simple to make while looking like a sophisticated piece of joinery.

Two characteristics make it different from more traditional structures. First, most of the parts are made from material that is the same width and thickness. So you begin with about 50 feet of wood, all milled to dimension, which you then cut up into precise lengths. Second, the cut-up pieces are glued together aided by screws or staples. Even the holes for the wedges are made by surrounding a rectangular space with wood instead of starting with a solid piece of wood and chopping out the square space. In summary, the "joinery" is done by cutting parts to length and putting them together.

I designed the legs to be square once all three elements are put together, so if you decide to use 3/4"-thick materials, then the width will be three times that—2¼". For this side table, which could serve very well as a sofa table, I wanted a slimmer look, so I milled the stock to 11/16" thick and 2$\frac{1}{16}$" wide. I've no doubt that 1/2" x 1½" material would look most elegant on the right piece. In other words, the dimensions of the stock give you a lot of design flexibility.

Choosing a Wood Species

The species you choose also plays a big role in the feel that the finished piece projects. For instance, you could use 3/4"-thick pine with its fair share of knots and bruises to produce a rustic-looking piece. I chose to use flat-sawn sassafras that looks a lot like chestnut and has a very basic wood color and appearance. No matter what your wood or dimension, begin with enough of it milled to the same thickness and width. Overall, you will need about 55' to 60' max. You'll have very little waste if you cut the long pieces first and pick the best-looking stuff for these parts.

Cutting to Length and Planing

Step 1: Chop the parts to length. Whether you use a miter saw or a table saw, you must use an end stop in order to produce equal-length parts.

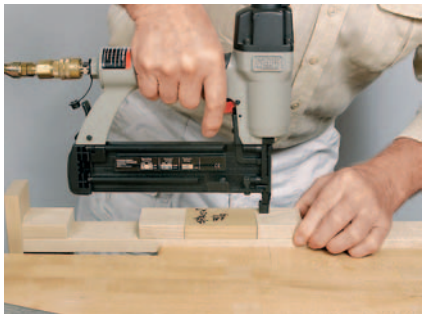


Figure 5: *Glue leg blocks, avoiding squeeze-out, then screw or staple into place. Position center leg blocks using the 3¼" spacer.*

Figure 6: *Glue and clamp the outer leg to the leg blocks.*

Figure 7: *Glue and clamp outer legs to the leg blocks, then screw them through the cap rail.*

Figure 8: *Position the overhang of the foot piece using a sliding head square, then screw into place.*

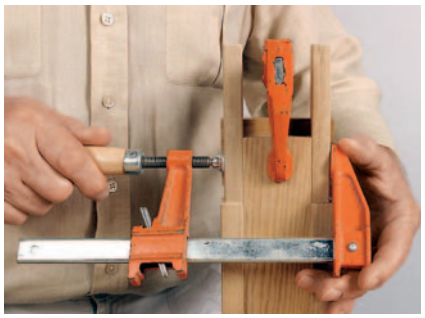


Figure 9: *Position, glue and clamp rail extension strips with the aid of an alignment block.*

Figure 10: *Position, clamp and glue the mortise block between the rail extension strips with the aid of an alignment block (at rear) and a wedge spacer strip.*

Step 2: Remove the mill marks by planing. You can't do this after assembly, so do it now. Use a sharp plane, set fine, and count the same number of passes on each piece—it takes about three. Don't plane the leg spacer blocks, because their slight extra thickness lets the rail enter between them.

Step 3: Machine some form of edge treatment. The square edge is too sharp, and the slightest misalignment of the parts looks bad. A chamfer or a radius solves the problem. I chose a 45° chamfer done on a router table. It's less than 1/16" across the flat, and it's on all exposed edges.

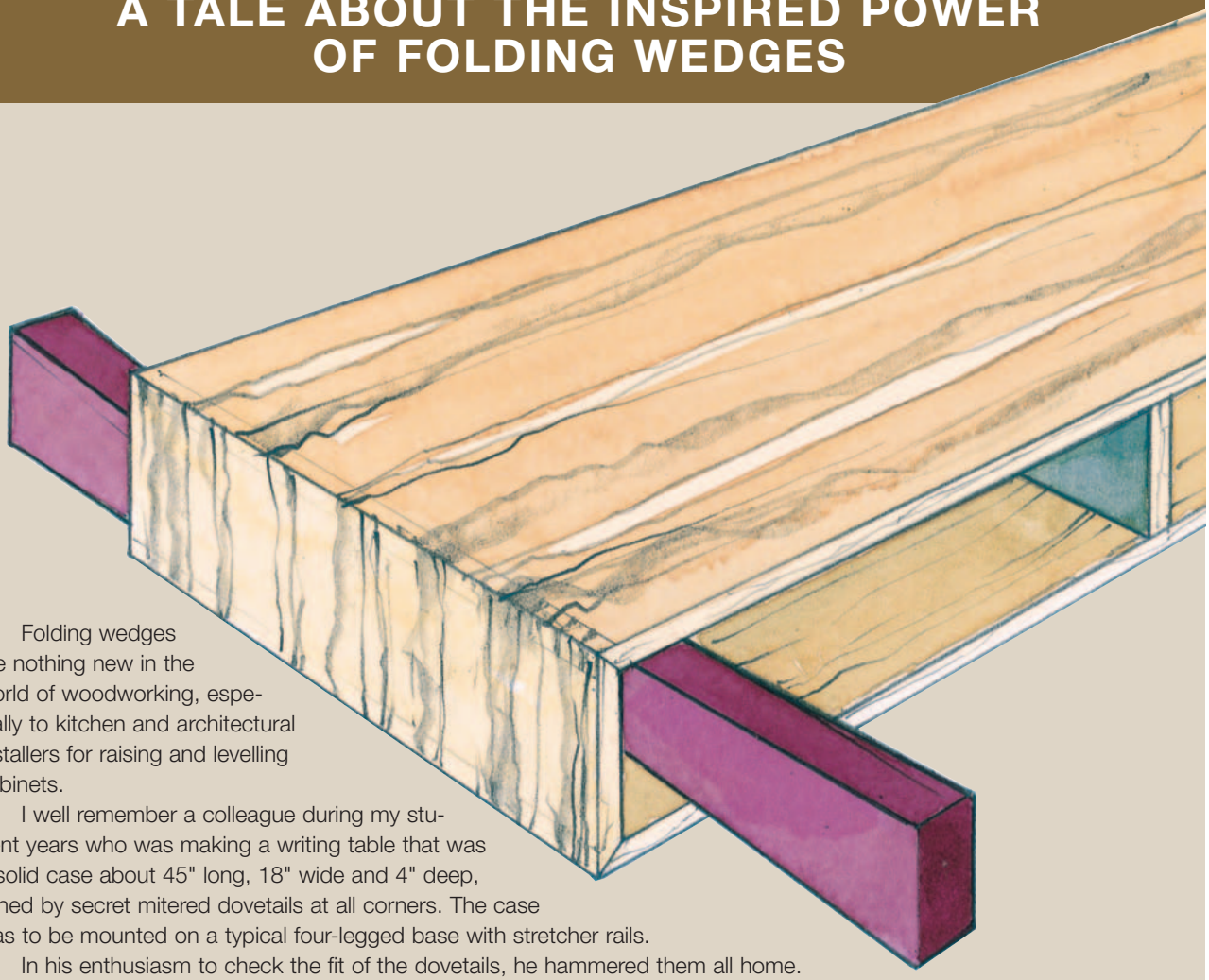
Joining the End Frames

Step 4: Join the cap rail to the shoulder rail. The shoulder rail is centered in both length and width. Mark the center on both pieces with a marking gauge (see *Figure 1* on page 142). Mark the cross grain line on the cap rail from the end of the rail using a sliding-head try square set to 2¾" (2$\frac{1}{16}$" leg and 11/16" overhang). Clamp the two parts together dry, then drill and countersink the holes for two 1$\frac{5}{8}$" screws. Drive the screws dry and remove them (see *Figure 2*). Roll glue onto the edge of the shoulder rail. Limit the glue so there is practically no squeeze-out. Put the parts back together using the already located screw holes and they will center in the correct place. Clean up any glue

Figure 11: *Position the first shoulder rail on the stretcher rail with a screw at each end, then glue and clamp in place.*

Figure 12: *(right) Position the second shoulder rail with the aid of a block clamped tight and square to the first shoulder rail.*

A TALE ABOUT THE INSPIRED POWER OF FOLDING WEDGES



Folding wedges are nothing new in the world of woodworking, especially to kitchen and architectural installers for raising and levelling cabinets.

I well remember a colleague during my student years who was making a writing table that was a solid case about 45" long, 18" wide and 4" deep, joined by secret mitered dovetails at all corners. The case was to be mounted on a typical four-legged base with stretcher rails.

In his enthusiasm to check the fit of the dovetails, he hammered them all home. They were perfect—and tight! How to disassemble the case now became a nightmare, because it was impossible to get into a 4" space with a hammer and block to part the joints. We pondered the problem to no avail. The ever-present tutor, after chuckling over the dilemma and our inability to solve it, provided the "obvious" solution: folding wedges. A few hearty taps with the wedges installed provided just the right force to separate the parts.

squeeze-out from here on as you go.

Step 5: Attach the inside legs. Clamp the frame of the leg and cap rail assembly together so the shoulders are tight (see *Figure 3*). Screw through the cap rail into the end grain of the leg. I used two 1⅝" screws angled together. (see *Figure 4*). Remove the clamps and screw through the inside leg into the end grain of the shoulder rail.

Step 6: Glue in the leg blocks. There are four blocks to each leg. Two go tight to the corners and two are positioned 3¼" apart by the leg block spacer (see *Figure 5*). Aim to have no glue squeeze-out. Paddle a small circle of glue onto each surface, then press the leg block in place—you can lift it off to assess the spread. Align the leg block with a straightedge, then screw or staple it in place. Screws will hold the leg block in place and clamp it as well. A staple will hold the leg block in position but give marginal clamping. If you use staples, clamp the corner leg blocks using a bar clamp and the center leg blocks with a C-clamp.

Step 7: Apply finish to the inside of the legs. I used a sealer coat of a drying oil followed by beeswax. Mark the outside leg at the glue areas and keep finish off all faces that will be glued.

Step 8: Attach the outer legs as shown in *Figure 6*. Glue the blocks and the legs and clamp them like Step 6. Clamp the end blocks with a bar clamp and put two screws through the cap rail into the end grain of the outer leg (see *Figure 7*).

Step 9: Attach the feet. Position each piece with a 11/16" overhang and screw it into place (see *Figure 8*).

Joining the Rails

Step 10: Attach the shoulder rails to the stretcher rail. Mark centers on both parts using your marking gauge. Score a line 2" from the end. The shoulder rail should fit between the marks and leave a 1/16" pull-up space in the mortise so the wedges can work. To attach the shoulder rails one at a time, begin by clamping one in place dry and put in screws about 2" from each end (see *Figure 11*). Remove the screws and roll a conservative layer of glue on the edge of the stretcher rail. Screw the two parts back together, which should retain your centers and clamp the middle area. To position the second shoulder rail, clamp an alignment block square to the first shoulder tail at each end (see *Figure 12*). Position the second shoulder rail. Dry-screw and glue as you did for the first one.

Step 11: Attach the rail extension strips (see *Figure 9*). Clamp the same alignment block as you used in Step 10 to the end of the stretcher rail. Glue the extension strips, align and clamp them.

Step 12: Attach the mortise blocks. Clamp the alignment block to the extension strips and trap the wedge gap block in place with it (see *Figure 10*). Put glue on the mating contact faces of the extension strips and the mortise block. Clamp them in place.

Step 13: Peg the extension strips. I have no laboratory or field tests to prove how necessary or effective these reinforcements might be, but they feel right. You can staple the hidden area (see *Figure 14*), or you can use a dowel to peg the extensions to the stretcher rail and the mortise block. It's important to use a Forstner bit to make the 1¼"-deep hole. Drizzle some glue into the hole and wet the end of the dowel. Push the dowel home hard to force glue from the bottom of the hole. Twist the dowel to wet the walls of the hole. Saw off the dowel and clean up with a chisel (see *Figure 13*).

Figure 13: *Saw off the excess length of dowel before cleaning flush with a chisel.*

Figure 14: *The hidden parts of the joint can be reinforced with staples. A dowel is better.*

Figure 15: *Glue and clamp the short shoulder rail flush to the shoulder rail.*

Step 14: Attach the short shoulder rails. Attach one and let it cure before you do the second (see *Figure 15*). Paddle a mean amount of glue on the short shoulder rail. Hold the stretcher rail in the vise, press the short rail in place and rub it about 1/2" up and down to spread the glue and wet both faces. Pull it off and add dabs of glue where needed. Rub it into place again and position it using a straightedge taken from your try square. Center it by eye. Clamp it and check the shoulder again.

Making the Wedges

The wedges are made using a jig and a chop saw. The wedge blocks are made from the 2$\frac{1}{16}$"-wide stock cut to 2$\frac{5}{8}$" long. You need two of these blocks to make the jig. I used some 1/2" maple plywood and cut four strips 2" x 12". The strips are stapled or screwed to the blocks, which are set square 11/16" from the ends. Set your miter saw to 12°. Position the box so the cut will leave a full 11/16" thickness at one end and a full 1/8" flat at the other. It's important to clamp the wedge box securely to the fence and the bed of the saw (see *Figure 18*). The wedge blocks fit tightly into the end pocket of the jig. Once you've made the first cut, you understand why the box is made with exposed corners. To remove the wedge, pry carefully, first with the blade of the knife, followed by a screwdriver. (see *Figure 17*). The wedges are chamfered on the exposed edges and ends. (see *Figure 16*).

Making the Top

The overall dimensions of the top are 56" x 16$\frac{3}{8}$" x 11/16". I wanted the drama of the 12"-long end overhang

Figure 16: *All exposed ends and edges are chamfered, including the wedges.*

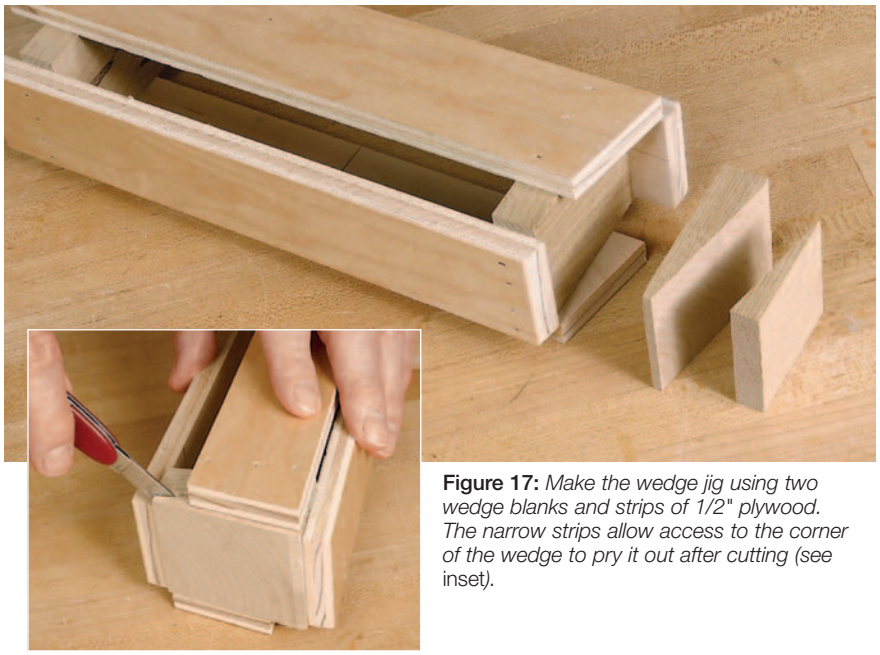


Figure 17: *Make the wedge jig using two wedge blanks and strips of 1/2" plywood. The narrow strips allow access to the corner of the wedge to pry it out after cutting (see* inset*).*

and the minimal 1/4" edge overhang in order to let the base be as visible as possible. The top dimensions also make for an elegant rectangle.

We all have to compose tops from the boards at hand. I had three whose grain went together the best but were too narrow by an inch. The solution was to split the center piece and insert the 1½" strip to make up the extra width. To make some visual connect with the step and shadow effect of the rail and tenon, I stepped the end of the boards. To help make the different grain patterns come together better and to elongate the look of the top while keeping in step with the edge detail on the base, I chamfered the top boards all round to complete it.

Connecting the Top to the Base

The top has two 11/16" x 2$\frac{1}{16}$" x 27¾" thickener rails glued to it that fit snugly between the legs and are aligned with the ends of the cap rails. As well as positioning the top, they create a visual tie between the top and the base.

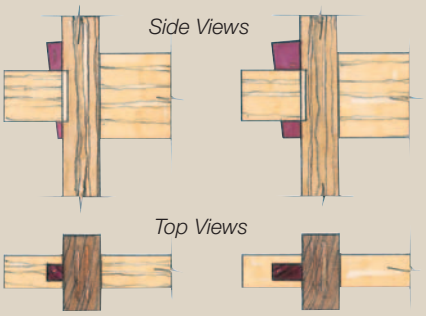
I used a variation on the traditional button method to hold the top to the base. Three 11/16" x 2$\frac{1}{16}$" x 2$\frac{1}{16}$" glue blocks are glued to the top on the inside edge of each cap rail. (see *Figure 19*). Screw an 11/16" x 1⅜" x 2½" block to each glue block so that it traps the overhang of the cap rail. The center screw block also has a screw into the cap rail that registers the top so it's centered on the base but leaves it free to shrink and expand past the outer screw blocks.

With this done, you've now accomplished two important goals: You've delved into the intricacies of making tusk tenons and also have a table to show for your efforts.

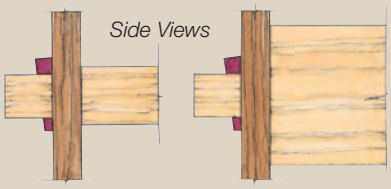
Figure 18: *Clamp the jig tight to the bed and fence of the chop saw. Holding it by hand is neither safe nor accurate.*

Figure 19: *The top is secured and fixed on center by blocks that trap one flange of the cap rail while allowing for shrinkage and expansion.*

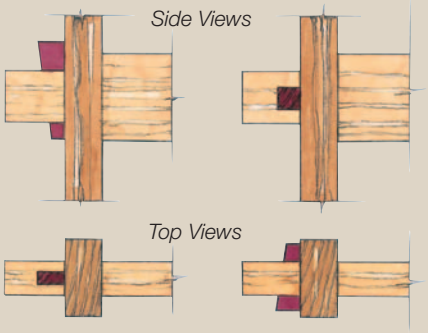
JOINT VARIATIONS



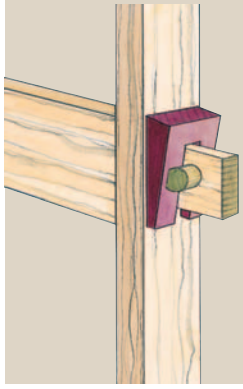
The wedge on the left is too narrow: it will bend into the pull-up space—or break. The wedge on the right is sized correctly.



Two identical joints, but the wider shoulders of the one on the right make it stronger because of triangulation.



The horizontal wedge on the right is easier to make as there is less wood to cut through. The vertical wedge on the left is more difficult to form.



In this variation, the wedge encloses the tenon instead of piercing it. The dowel acts as a dead stop.

In the "History of the Tusk Tenon" *sidebar*, I noted that the joint is used to hold together all manner of furniture forms, but there is nothing standard about its design details. You can design it any way you want, provided the wedge pulls up the shoulders and stays tight.

Vertical Wedge

In the traditional version of the joint, you can vary the shape and dimensions of the parts, but the wedge must be made wide enough so that it won't bend or break in the "pull-up" space of wedge hole.

Horizontal Wedge

To avoid the complication of making a deep narrow hole for the vertical wedge, you can make the wedge go horizontal. It works equally well, and it adds a more "locked-up" appearance to the joint.

Outside Wedge

Yet another variation is an external wedge and a hole with a dowel as the dead stop. A flat on the dowel gives the wedge a larger contact surface and improves its overall appearance.

The hole and dowel joint applies all the tusk tenon principles to hold this angled leg and rail assembly tight on this mock-up of an Arts & Crafts-inspired table.