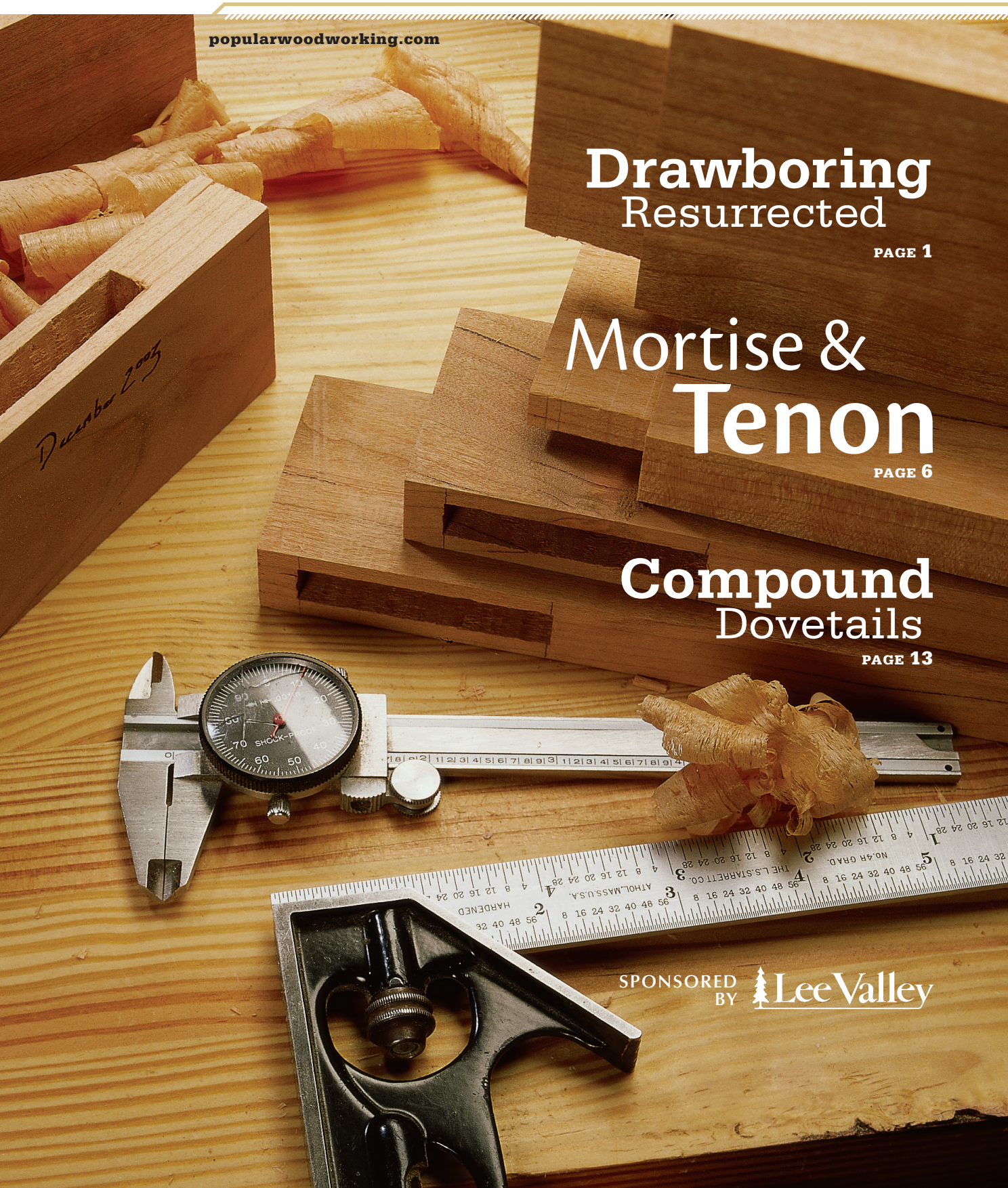
# TOP JOINERY TECHNIQUES

From the Editors of **Popular Woodworking Magazine**

popularwoodworking.com





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# Drawboring Resurrected

## Have modern glues and clamps rendered this ancient joinery technique obsolete? Absolutely not.

BY THE EDITORS OF POPULAR WOODWORKING

***Drawboring is one of the simple reasons that so much antique furniture survives today, some of it as sound as the day it was made.***

What is drawboring? It's a technique that greatly strengthens a mortise-and-tenon joint, transforming it from a joint that relies on glue adhesion into a joint that has a permanent and mechanical interlock. In essence, you bore a hole through both walls of your mortise. Then you bore a separate hole through the tenon, but this hole is closer to the shoulder of the tenon. Then you assemble the joint and drive a stout peg through the offset holes. The peg draws the joint tight.

Drawboring offers several advantages compared to a standard glued mortise and tenon:

- The joint will remain tight. A common problem with mortise-and-tenon joints is that the joint can open up and develop an ugly gap at the shoulder. Sometimes this is caused by the wood shrinking as it reaches equilibrium with a new environment (such as your living room with its forced-air heat). Sometimes this gap is caused by simple seasonal expansion and contraction, especially with woods that tend to move a lot, such as flat-sawn oak. The peg in a drawbored joint keeps the tenon in tension against the mortise during almost any shrinkage.
- The joint can be assembled without clamps. Drawboring is excellent for unusual clamping situations. Driving the peg through the joint closes it and clamps are generally not needed. Chairmakers use drawboring to join odd-shaped pieces at odd angles. It's also an excellent technique when your clamps aren't long enough. Or when you don't have enough clamps. Drawboring also allows you to assemble a project one piece at a time if need be.
- The joint can be assembled without glue. There is good evidence that drawboring allowed early joiners to assemble their wares without any glue. This is handy today when you're joining resinous woods (such as teak) that resist modern glues or when you're assembling joints that will be exposed to the weather, which will allow water to get into them and destroy the adhesive.
- The joint doesn't have to be perfect. The mechanical interlock of drawboring means that your tenon's cheeks don't have to have a piston fit with your mortise's walls. In fact, you might be surprised at how sloppy the joint can be and still be tight after hundreds of years. Drawboring requires you to be careful only when fitting the tenon's shoulder against your mortised piece. The other parts of the joint are not as important. And while I never argue against doing a good job, drawboring ensures that every joint (even the less-than-perfect ones) can be tight for many lifetimes. For this reason, I think drawboring is an excellent basic skill for beginning woodworkers.

So why has drawboring become an almost-lost art? It's a good question, and one that I cannot fully answer. I suspect that modern glues and machine-made joinery made the technique less necessary, particularly for manufactured furniture. Drawboring does require several extra steps – and the benefits are not something that is apparent to a customer.

Another reason the technique has fallen out of favor, I suspect, is that specialty tools called drawbore pins are needed. These tapered steel tools allow you to temporarily assemble the joint to check the fit and to ease the path that the wooden peg will later follow. You can drawbore without drawbore pins by relying on the peg (and luck) alone. Luckily, a few retailers like Lee Valley and Lie-Nielsen Toolworks are bringing back these tools to modern woodworkers – and you can make your own (as we'll show you on p.4).

## JOINT DETAILS

I have drawbored many joints during the last five years or so and have found the methods described here to be highly effective. My method is based on historical descriptions of the process from the 17th century and my own work.

The first detail to tend to is the size and location of the hole through the mortise. I have found that a ¼"-diameter hole is good for cabinet work. For larger-scale work a ⅜"-diameter hole is better because the peg is stouter. Place the hole ⅜" from the opening of the mortise in furniture work and ½" in larger work. Make the hole as deep as you can. Usually this requires boring it through the entire assembly, though the hole can be stopped in thick stock. The goal is to ensure that the untapered part of the peg passes into the other wall of the mortise.

Historically, many of the drawbore pins I've encountered are a diameter that's best suited for a ⅜"-diameter hole and peg. Entryway doors and large windows are appropriate for this larger hole and peg. I have encountered (and own) a set of old pins that work with a ¼"-diameter hole, however, so this approach is historically accurate.

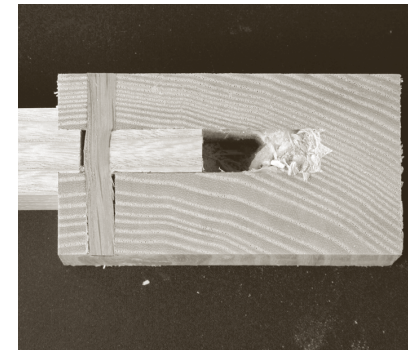
The next thing to consider is how much to offset the hole in the tenon. The bigger the offset, the sounder the joint, but the bigger the risk that you'll destroy the tenon or peg during assembly.

The traditional joiner was advised to offset the holes by the width of a shilling. According to one knowledgeable collector of English coins, a 17th-century shilling would be about 1⁄16" thick.

An offset of 1⁄16" will indeed almost always work and is easy to assemble. But I've found that it's sometimes not enough to get the job done. Some of the joints I assembled with this small offset were just a bit wiggly. For furniture-scale work, I prefer a 3⁄32" offset. For big-scale work, I'll push that offset to almost ⅛" if the parts of the joint are large and the wood is a tough species, such as ash or elm. Experience will be your guide. Begin with small offsets in a sample joint and gradually increase them. You'll know when you've found the sweet spot.

Marking the offset on the tenon must be done with a bit of care because small changes can make a significant difference and cause the tenon to split in fragile woods, such as cherry. If you mark the offset with a slightly dull pencil, it can shift your mark by 1⁄32" or so. I recommend you use a sharp mechanical pencil or (even better) a knife.

The shape of the peg is important, too. I whittle mine so the last ½" tapers to an ⅛" tip. In almost all cases, I use straight-grained white oak for my pegs.



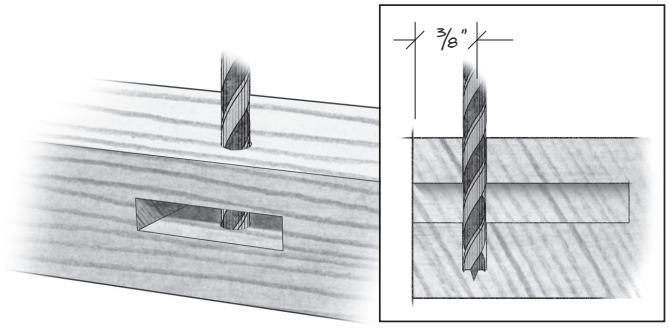
*I sawed apart a completed drawbored joint to show how the oak peg bends through the offset hole. This was a 3⁄32" offset in ash.*

It must be completely dry; wet pegs will shrink in time and allow the joint to loosen up. Typically I'll split out my pegs from some dry oak using a pocketknife and mallet. This is called "riving," and it is a technique used by chairmakers to produce durable chair parts. Wood that is shaped by riving is stronger because it splits along the wood's grain lines. Sawing cuts across the grain lines, which can create a more fragile peg in some cases. I then whittle the pegs round or roughly octagonal. When pressed for time, I'll use dowel stock, which I have found to be satisfactory as long as I choose dowels with straight grain.

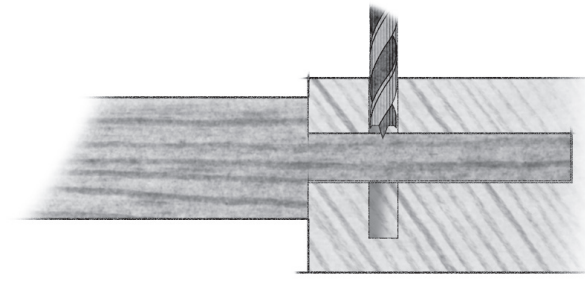
When you knock the peg home, you'll sometimes create a small gap between the hole and the peg as the peg leans heavily into one side of the mortise. If this gap is unsightly, try a different strategy on your next joint. Whittle your pegs slightly larger in diameter and switch to an octagonal shape.

Despite everything I know about drawboring, I still glue most of my joints and even coat the peg with glue before driving it in. It cannot hurt. But I do take great satisfaction in knowing that when that modern glue has given up, the peg will still keep everything in place so the joint will be just as tight as the day I made it. ‹PW›

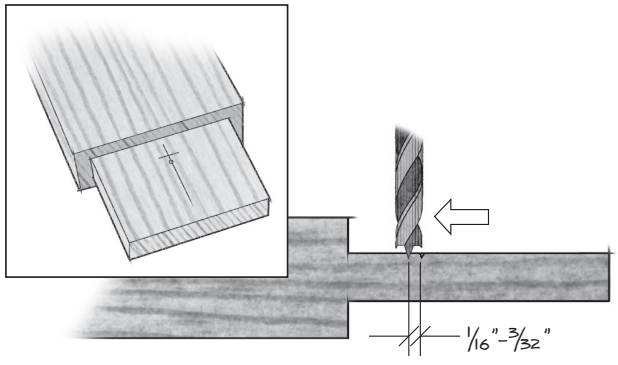
# DRAWBORING BASICS



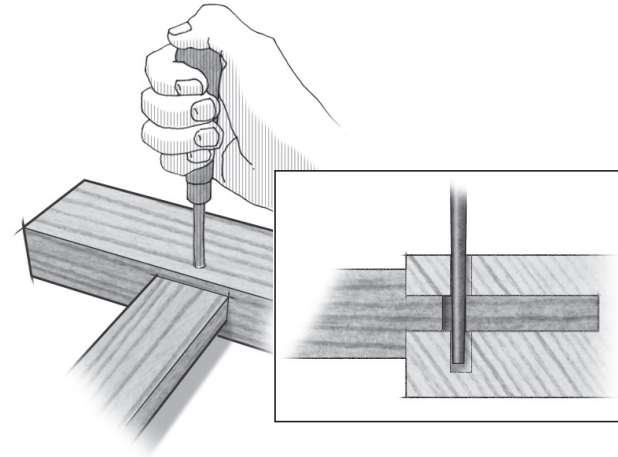

**1** *Bore ¼"-diameter hole through both mortise walls. The center of the hole should be ⅜" from the edge of the mortise.*



**2** *Assemble the joint. Mark the hole's center on the tenon using a ¼" brad-point bit.*

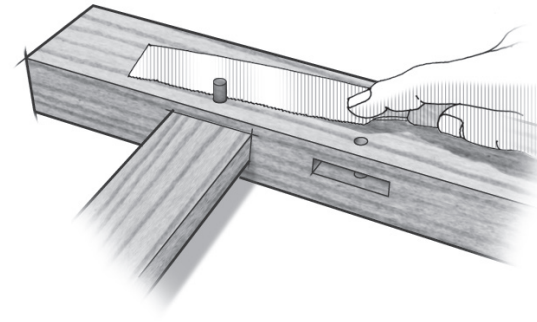



**3** *Remove the tenon and shift the mark closer to the tenon shoulder – 1/16" to 3/32". Use the same bit to bore a ¼"-diameter hole through the tenon at the offset mark.*



**4** *Reassemble the joint. Twist the drawbore pin into the joint to check the fit. Ensure there are no gaps in the joint.*

**5** *Whittle the end of a ¼" peg to about ⅛" diameter at the tip. Add glue to the joint and peg. Assemble the joint and hammer the peg through the offset holes.*



**6** *Saw (or chisel) the protruding peg material flush with the work.*

# MAKE YOUR OWN DRAWBORE PINS IN ONE HOUR

Proper drawbore pins are absolutely the key to successfully and consistently executing a drawbored joint. The pins allow you to work with bigger offsets, to know exactly how the joint will fit before final assembly and to pave the way for your peg by slightly distorting the hole through the tenon.

You can purchase traditional pins from dealers of antique English tools, though you will spend $45 to $80 for a pair, and you must sometimes search for the smaller-sized drawbore pins. Lee Valley also carries a purpose-made set of drawbore pins, for $32.50 (part # 5K01.01 or #15K01.03 for the two different sizes).

The other option is to make your own. It's easy and takes only about an hour once you have the materials in hand.

The metal part of the tool is easy to find. Machinists, bridge builders, mechanics and anyone who works with metal has a set of tools they use that are much like drawbore pins. They're sometimes called drift pins, alignment tools or line-up tools. And they come in a wide variety of sizes and tapers.

If you'd like to make your own set, I recommend you buy a set of alignment tools from Sears, Grainger or your local equivalent. Look for alignment tools that come to a relatively small point, and have enough length to be seated in a wooden handle. The pins I used came as a part of a six-piece set that also had a number of other tools included – you might save some money buying them individually.

The alignment tool in the set has a 5⁄32" tip that tapers to almost 3⁄8" over a span of almost 7". This is a decent tool for furniture-scale work, though it will be much easier to navigate the offset if you grind the tip a bit smaller.

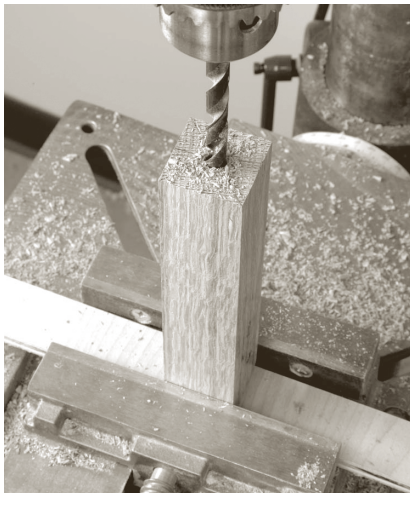
*Making your own drawbore pins is easy using an inexpensive alignment pin and a scrap of sawn (or turned) hardwood.*

The first thing to do is to sand the black paint off the tapered section of the tool, which will come off on the wood eventually. Then you need to set the alignment tool into a wooden handle. Drawbore pins must be twisted in and out of their holes to work properly in my opinion. (Striking them is not a good idea.) I prefer a traditional tapered octagonal handle, which is easy to twist in and out of the holes. However, a lathe-turned handle will work nearly as well.

First bore a hole straight into the end grain of a 1¼" x 1¼" x 6¾" scrap of wood that will accommodate the hex-shaped end of the tool. Use a 13/32" bit for the hole (this is why you bought that fancy set with so many bits!). If your bit isn't long enough to go deep enough, finish up the hole with a long auger bit that is a bit undersized (⅜" or ½").

With the holes bored, shape the handle to your liking. I tapered my handles to ⅞" or 1" square at the small end.

Now comes the fun part. Get a propane torch and heat up the hex shank of the tool for a minute or two. Then knock the handle onto the tool. The heat will char the wood as you insert the steel and prevent the handle from splitting as its driven on. Allow everything to cool down and then add a couple coats of wiping varnish to your handle. Now you are ready to explore this ancient joinery technique for yourself. ‹PW›

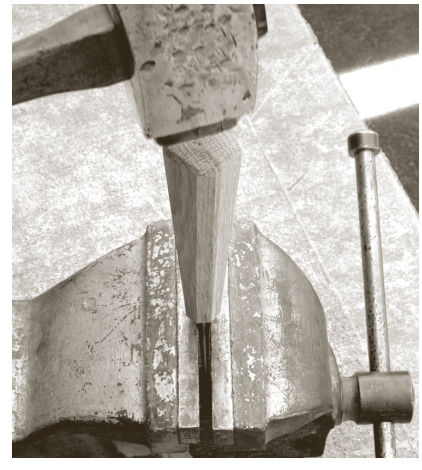


**1** *Bore a hole vertically into your handle blank. The hole should be slightly undersized compared to the largest dimension of the steel pin.*

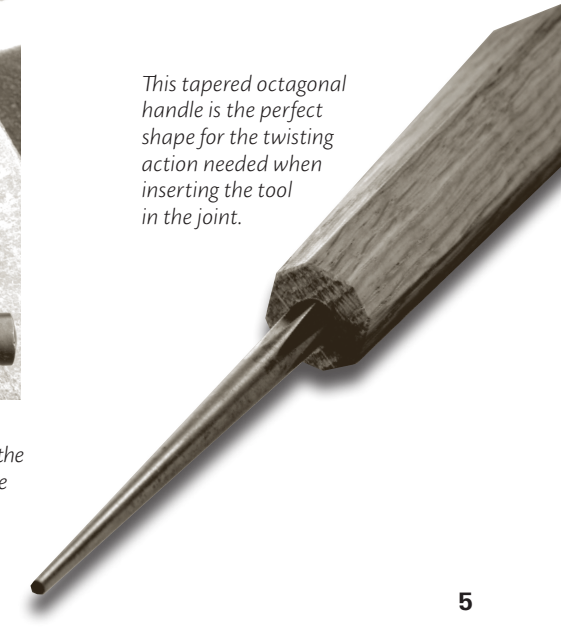
**2** *Taper the handle using your band saw. Be sure to keep the hole in the center of the blank.*

**3** *I have a clever chamfer attachment for my Veritas block plane that's sold by Lee Valley Tools. You can also do this operation freehand.*

**4** *Use a simple propane torch to heat the pin. Heat it up for two minutes. It will not change color.*



**5** *With the pin still in the vise and hot, drive the handle onto the pin. When the handle is fully seated, the sound of the mallet hitting the handle will change.*



*This tapered octagonal handle is the perfect shape for the twisting action needed when inserting the tool in the joint.*


3/8"
December 2007

# Mortise & Tenon

## A superior way to cut this superlative joint.

BY THE EDITORS OF POPULAR WOODWORKING

***A lot of woodworkers spend a lot of time, effort and money to avoid making mortise-and-tenon joints. Biscuits, dowels, commercial loose-tenon jigs and expensive router bits are just a few of the "work-arounds" developed this century so you don't have to learn to make a mortise and its perfectly matched tenon.***

But once you learn how straightforward and simple this joint can be, you will use it in every project. Why? Well, it is remarkably strong. A few years ago we decided to pit this venerable and traditional joint against the high-tech super-simple biscuit. So we built two cubes, one using biscuits and one with mortises and tenons. Then we dropped a 50-pound anvil on each cube. The results were eye-opening.

Both cubes were destroyed. The biscuit cube exploded on impact. Some of the biscuits held on tightly to the wood, but they pulled away chunks from the mating piece as the joint failed.

The second cube survived the first hit with the anvil – the joints held together even though the wood split at the points of impact. A second hit with the anvil ruined the cube entirely, though most of the tenons stuck tenaciously to their mortises.

The lesson here is that biscuits are indeed tough, but when they fail, they fail catastrophically. The mortise-and-tenon joints fail, too, but they take their time, becoming loose at first rather than an immediate pile of splinters.

So when you're building for future generations and you know how to make this stout joint with minimal fuss, you won't say "Why bother?" You'll say "Why not?"

### CHOOSING THE RIGHT TOOLS

There are so many ways to cut this joint that one big obstacle to mastering it is choosing a technique. I've tried many ways to cut this joint – backsaws, commercial table-saw tenon jigs and even the sweet $1,189 Leigh FMT Pro Jig.

Each technique or jig has advantages in economy, speed or accuracy. The technique I'm outlining here is the one I keep coming back to year after year. It uses three tools: a hollow-chisel mortiser for the mortises, a dado stack to cut the tenons and a shoulder plane to fine-tune your joints. Yes, this is a little bit of an investment, but once you start using this technique, these tools will become the foundation for much of your joint-making.

- **Hollow-chisel mortisers:** These machines are nothing new, but the benchtop ones are now cheaper, more powerful and more accurate than ever. For about $240, you'll get a good machine.

  Essentially, a mortiser is a marriage between a drill press and an arbor press that's designed for metalworking. The drill press part has a spinning chuck that holds an auger bit that chews up the waste wood. The auger bit is encased in a hollow four-sided chisel that cleans up the walls of your mortise, making the auger's round hole a square one.

  The arbor press part of the machine is the gear-and-lever system that pushes the tooling into your wood. This mechanism gives you an enormous mechanical advantage compared to outfitting your drill press with a mortising attachment – an accessory I don't recommend for all but the most occasional mortising jobs.

  Shopping for the proper mortiser is tough. I don't consider all the machines equal. Some are weak and stall in difficult woods such as oak, ash and maple. Many have problems holding your work down against the machine's table. In a review of the machines on the market in our August 2001 issue, we preferred the fast machines (3,450 rpm) instead of the 1,750-rpm slow machines (back issues are available


*Hollow-chisel mortisers excel at boring square holes. Here you can see the holddown (which is usually inadequate with other machines), the table (which must be squared to the chisel before use) and the lever (which makes the machine plow through almost any job).*

online at shopwoodworking.com). The fast machines were almost impossible to stall. However, the marketplace seems to prefer the slow machines. While none of the machines is perfect, I prefer the fast-speed Shop Fox and the slow-speed Jet machines.

- **Dado stack:** A good dado stack will serve you in many ways, but I use mine mostly for cutting tenons and rabbets. When it comes to choosing one, buy a set with 8" blades instead of 6" blades, unless you own a benchtop table saw.

Stay away from the bargain sets that cost $50 or less – I haven't found them to be very sharp and the teeth aren't well-ground. The expensive sets ($200 and more) are nice, but they're probably more than you need unless you are making your living at woodworking. My favorite mid-priced set is the Freud SD208. It's about $98 and does a fine job.

- **Shoulder plane:** No matter how accurately you set up your machines to cut mortises and tenons, some will need a little tuning up before assembly. And nothing trims a tenon as well as a shoulder plane. These hand tools really are secret weapons when it comes to joints that fit together and are airtight.

Why is that? Well, shoulder planes are designed to take a controlled shaving that can be as thin as .001". I can tweak a tenon to a perfect fit with just a few passes. Trying to tweak a tenon with a chisel or sandpaper is more difficult. You are more likely to gouge or round over the surface of your tenon and compromise its mechanical strength.

Buying a shoulder plane gets easier every year because there are now many quality tools on the market. Unless you build only small projects, you are going to want a plane that is at least 1" wide. Most casework tenons are 1" long, so a 1"-wide plane is perfect for trimming up the face cheeks and shoulders of the tenon.

My advice is to stay away from the newly made Stanley shoulder planes. I've had some sloppily made Stanleys go though my hands (vintage Stanley shoulder planes can be good, however).

Veritas, the tool line made by Lee Valley Tools, has a medium shoulder plane that's almost ¾" wide, quite comfortable to use and priced at $199. They also make a large shoulder plane that comes in at 1¼", priced at $235, and a small ½"-wide shoulder plane that comes to $179.

Lie-Nielsen makes two shoulder-trimming planes worth saving your money for. The #073 is a tool of great mass and presence and does the job admirably – it's a $250 investment. Lie-Nielsen also makes a rabbeting block plane that can be easily used as a shoulder plane; it costs $175.

Of course, you'll need to sharpen the tool. And that's why we offer a number of tutorials on sharpening on our web site – search "sharpening" on popularwoodworking.com to see our bevy of tutorials, tricks and tips for sharpening plane irons.

## DESIGNING A JOINT

Once you have the tools you need, you can learn about the mechanics of the joint. Study the illustration on the next page to learn what each part of the joint is called.

The first question beginners always ask is: How thick and how long should my tenons be? As far as thickness goes, the rule of thumb is that they should be one-half the thickness of your workpiece. So a tenon on a piece of ¾" material should be ⅜" thick.

As for length, that depends on your project. Typical casework tenons that are 1" long will be plenty strong. For large glass doors, make them 1¼" long. For small lightweight frames and doors, stick with ¾"- or ⅝"-long tenons.

What beginners often don't ask about is the size of the edge shoulders on their tenons. This is a critical measurement. If you make these edge shoulders too small, say 3/16" wide or so, you could run into huge problems at assembly time when building frames and doors.

Here's why: If your tenoned piece forms one of the outside members of a frame, your mortise wall is going to be only 3/16" wide and it's going to be weak. The hydraulic pressure from the glue or the smallest amount of racking will cause the tenon to blow out this weak mortise wall, ruining everything. It is

because of this that I recommend edge shoulders that are ⅜" wide in most cases. Note that your edge shoulders can be too big. Once they start getting larger than ½", you run the risk of allowing the work to twist or warp in time, ruining the alignment of the parts.

Of course, if your tenoned piece is not on the edge of a frame, you can have narrow edge shoulders without any worries. Designing the mortise is a bit simpler. It should be the same dimensions as your tenon with one exception: Make the mortise 1/16" deeper than your tenon is long. This extra depth does two things: It gives your excess glue a place to go and it ensures your tenon won't bottom out in the mortise, which would prevent you from getting a gap-free joint.

Beware of other tune-ups that some books and magazines suggest. One bit of common advice is to chamfer all the sharp edges of your tenons to improve the fit. Another bit of advice is to chamfer the entry hole of the mortise. These are unnecessary if you design your joint properly.

One thing that is important, however, is to mark the outside faces on all your parts. It's important to keep these straight during machining and assembly.


▲ ***These sample mortises*** *are useful for sizing your tenons. I usually make a new one every season or two, because they can get worn from use.*

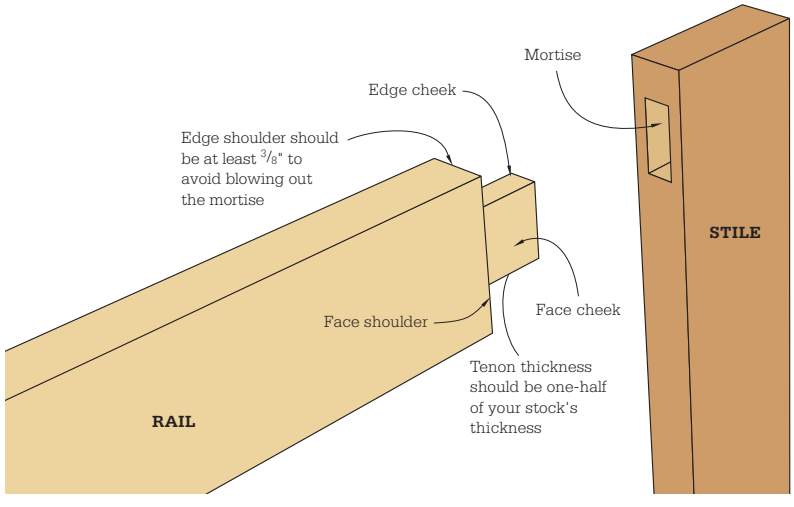
## TENONS FIRST

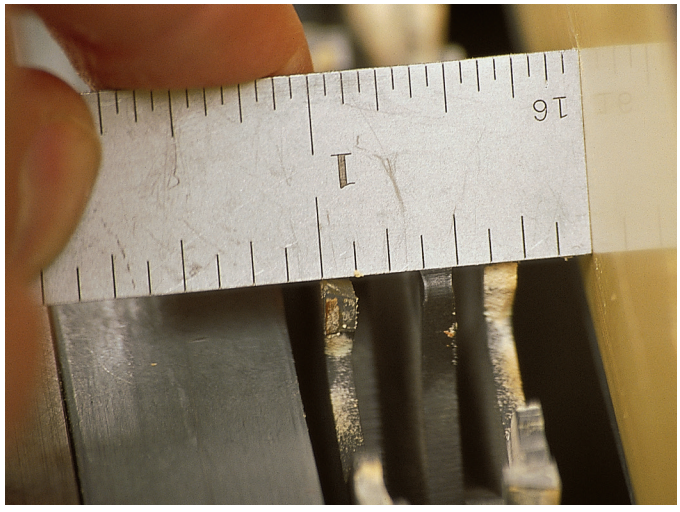
Some traditional woodworkers tell you to make all your mortises first and then make your tenons fit that. This is good advice if you cut the joint by hand with a backsaw and a mortising chisel because there is more opportunity for the mortise to be irregular in size. But you will work much faster and with much less measuring if you try it my way.

Before you cut your first tenon, you should fire up the hollow-chisel mortiser and make a sample mortise with each size of bit you use. The three most common sizes are ¼", ⅜" and ½", but make whichever sizes are relevant to your work. These mortises should have perfectly square walls and be 11/16" deep and 2" long. Write the month and year on each mortise and make a new set next season.

Why make these sample mortises? Well, because the tooling to make your mortises will always produce the same width mortise, you can merely size all your tenons to one of these sample mortises as you cut them on your table saw. This will save you time down the road, as you'll see.

With your sample mortise in hand, set up your table saw to cut your tenons. Install the dado stack blades and chip-





*A 6" rule will help you set the length of your tenon. Once you do this a couple of times you'll hit this measurement right away every time.*

pers on the saw's arbor. The rule here is to install enough blades to almost cut the length of the tenon in one pass. For example, to cut a 1"-long tenon, set up enough blades and chippers to make a ¾"-wide cut.

Next, position your saw's rip fence. Measure from the left-most tooth of your dado stack to the fence and shoot for the exact length of your tenon. A 1"-long tenon should measure 1" from the left-most tooth to the fence, as shown above.

Get your slot miter gauge out and square the fence or head of the gauge to the bar that travels in the table saw's slot. Attach a wooden fence to the face of the gauge (usually this involves screws through holes already drilled in the gauge). This wooden fence stabilizes your workpiece and controls tear-out as the dado stack blades exit the cut.

Set the height of the blades to just a little shy of the shoulder cut you're after. You want to sneak up on the perfect setting by raising the arbor of the saw instead of lowering it. This does two things: One, it produces fewer waste pieces that result from overshooting your mark. And two, because of the mechanical backlash inherent in all geared systems such as your table saw, raising the arbor eliminates any potential for it to slip downward because of backlash.

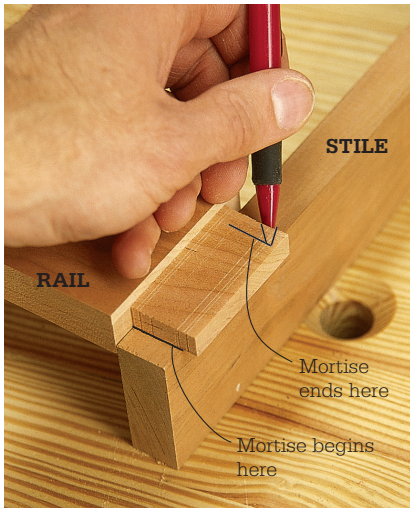
You are now ready to make a test cut. First put a scrap piece up against your miter gauge, turn on the saw and make a cut on the end of the board. Use firm downward pressure on the piece. Don't let the end of the board touch the saw's rip fence. Then bring the scrap piece and miter gauge back and make a second pass, this time with the scrap touching the rip fence as shown below.

Flip the scrap over and repeat the process on the other face. Usually you aren't supposed to use your rip fence and miter gauge in tandem, but this is an exception. This cut is safe because there isn't waste that could get trapped between the blades and the fence, producing a kickback.

*When making tenons with a dado stack in your table saw, the first pass should remove the bulk of the material. Keep firm downward pressure on your work, which will give you more accurate cuts.*

*The second pass has the work against the fence and defines the face shoulder. Note there isn't any wood between the fence and blades, so the chance of kickback is minimal. The backing board reduces the chance of tear-out at the shoulders.*

*Cut the edge shoulders the same way you cut the face shoulders and cheeks.*




*To locate the mortise, put the tenon across the edge of the stile where you want your mortise to go. Use a sharp pencil to mark the tenon's location on the edge. Bingo. You've just laid out the mortise's location.*

Check your work with your dial calipers and see if the tenon will fit your sample mortise. The tenon is likely going to be too thick. Raise the blades just a bit and take passes on both faces of the scrap until the tenon fits firmly and snugly into the sample mortise with only hand pressure.

If you can shake the sample mortise and the tenon falls out, you've overshot your mark and need to lower the arbor and try again. If the fit is just a wee bit tight, you can always tune that up with a shoulder plane. Let your dial calipers be your guide. Sometimes you haven't used enough downward pressure during the cut to make a consistent tenon. If something doesn't fit when you know it's supposed to, try making a second pass over the dado stack and push down a little harder during the cut.

Using this setup, mill all the face cheeks on all your tenoned pieces. When that's complete, raise the arbor to ⅜" and use the same routine to cut the edge shoulders on all your boards. Your tenons are now complete.

## USE YOUR TENONS LIKE A RULER

One of the major pains in laying out the mortise is figuring out exactly where you should bore your hole. You end up adding weirdo measurements and subtracting the measurements of edge shoulders. If you lay out mortise locations using math only, you will make a mistake someday.

Troy Sexton, one of our contributing editors, showed me this trick one day and I've never done it any other way since. Say you are joining a door rail to a stile – quite a common operation. Simply lay the tenoned rail onto the edge of the stile and line up the edges of both pieces so they're flush. Take a sharp pencil and – using the tenon like a ruler – mark where the tenon begins and ends on the stile. That's it; you've just marked everything you need to know to make your mortise.

If you are placing a rail in the middle of a stile, there is one more step. You'll need to mark on the stile where the edges of the rail should go. Then line up the edge of the rail with that mark and fire away. There's still no addition or subtraction. With all your mortises laid out, you can then get your hollow-chisel mortiser going.

## A FINICKY MACHINE

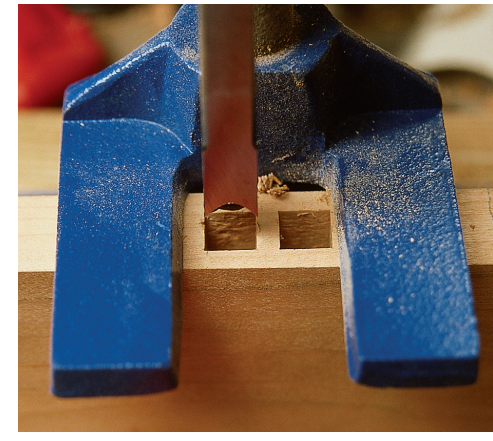
I've used a lot of hollow-chisel mortisers and find them fussy to adjust. Along with our review of the machines, we published a complete tutorial on the topic in our August 2001 issue. In a nutshell, here are some of the important adjustments not covered by some manuals:

- Make sure the chisel is at a perfect 90° angle to the machine's table. I've set up a dozen of these machines and only one has ever been perfect. The solution is to use masking tape to shim between the table and the machine's base.
- Set the proper clearance between the auger bit and the hollow chisel that surrounds it. Some people use the thickness of a dime to set the distance between the tooling. Some people measure. Either way is fine. If the clearance is too little, the machine will jam and the tooling can burn. Too much distance makes a sloppy-bottomed mortise.
- Square the chisel to the fence. The square holes made by the chisel should line up perfectly. If the edges aren't perfectly straight, your chisel isn't square to the fence. Rotate the chisel in its bushing and make sample cuts until everything is perfect.
- Center the chisel so it's cutting in the middle of your workpiece. There might be a clever trick to do this, but I've found that the most reliable method is to make a test cut and measure the thickness of the mortise's two walls with a dial caliper. When they're the same, your mortise is centered.

## SIMPLIFY YOUR MORTISING

As you make your mortises, here are a few tips for making things a whole lot easier.

- I like to cut a little wide of the pencil lines that define my mortise. Not much; just 1/32" or so. This extra wiggle



*By cutting over your line slightly, you give yourself just enough forgiveness at assembly time. A little wiggle can mean a lot when you are trying to close up the gaps as you clamp up your work.*

*Shoulder planes are capable of extraordinarily precise work. Just try to set your table saw to remove .001". It's not possible. For a shoulder plane, it's simple.*

room allows you to square up your assembly easier. It doesn't weaken the joint much – most of its strength is in the tenon's face cheeks.

- As you bore your mortises, don't make your holes simply line up one after the other. Make a hole, skip a distance and then make another hole (see the photo below). Then come back and clean up the waste between the two holes. This will greatly reduce the chance of your chisel bending or breaking.
- Keep your chisel and auger lubricated as they heat up. Listen to the sounds your machine makes. As the auger heats up, it can start to rub the inside of the chisel wall and start to screech. Some dry lubricant or a little canning wax squirted or rubbed on the tooling will keep things working during long mortising sessions.
- Finally, make all your mortises with the outside face of the work against the fence. This ensures your parts will line up perfectly during assembly.

## FINAL TWEAKS

No matter how careful you have been, some of your tenons might fit a little too tightly. This is where the shoulder plane shines. Make a couple of passes on both face cheeks and try fitting the joint again. Be sure to make the same number of passes on each cheek to keep the tenon centered on the rail. If your parts aren't in the same plane when assembled (and they're supposed to be), you can take passes on only one cheek to try to make corrections.

If the joint closes up on one face but not the other, you might have a sloppy shoulder. The shoulder plane can trim the fat shoulder to bring it in line with the other side of the tenon. If the tenon still won't seat, try chiseling out some meat at the corner where the edge shoulder meets the face cheek – but don't trim the outside edge of the shoulder itself.

Finally, get a sharp chisel and clean out any gunk at the bottom of the mortise – and careful not to leverage against your shoulders. Keep at it – a tight joint is worth the extra effort and time.

## ASSEMBLY

You really don't want any glue squeeze-out when you assemble your mortise-and-tenon joints. The trick to this is learning where to put the glue and how much to use. I run a thick bead of glue at the top of each mortise wall and then paint the inside of the mortise wall with glue using a little scrap piece. I try to leave the glue a little thick at the top of the mortise wall. Then, when the tenon is inserted, this paints the tenon with glue but drives the excess to the bottom of the mortise.

When clamping any frame – regardless of the joinery you used – you don't want to use too much pressure or you will distort the frame. Tighten the clamps until the joints close and no more. You also want to alternate your clamps over and under the assembly to keep the frame flat – no matter how fancy your clamps are.

Once you do this a couple of times, I think you'll find a whole new level of woodworking open to you. Web frames for dressers (or Chippendale secretaries) will seem like no problem. Morris chairs with 112 mortises will be within your reach.

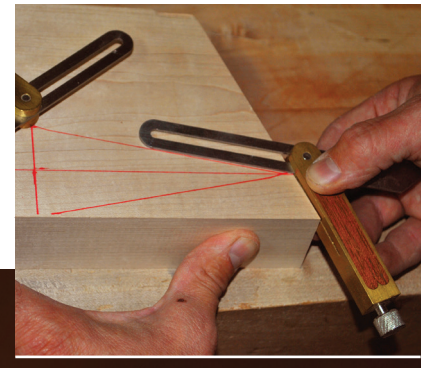
And your furniture is more likely to stand the test of time – and maybe even the occasional anvil. **‹PW›**

*A thick bead of glue at the top of the mortise wall makes the joint strong without squeezing out a lot of glue. Use a piece of scrap to paint the mortise wall before inserting the tenon.*

# Compound Dovetails

## Discover how to join oblique sides with through-dovetails.

BY TOM CALISTO



*Paring block.* *A thick block cut to the correct angles will help in paring the sockets after they are cut. It also serves to lay out the tail angles.*


***As an avid sailor and full-time furniture maker, I've always wanted to make a proper sea chest replete with rope beckets and a compass rose inlay.***

The compound-angle dovetails are the only tricky aspect of the sea chest so I designed this little handled tote to practice oblique dovetails. This tote tray is useful around the house and fun to build. The angles of the oblique dovetails offer a challenge.

The first step in building the tote is to mill the lumber to thickness and width then rip the bevels on the top and bottom edge. Tight-fitting dovetails begin with accurate compound-angle butt joints. See the chart of angles and drawing on page 3 to determine your layout. The tray in the opening photo has three tails, but for your first attempt, you may choose to make two tails as seen in the step photos.

When cutting the ends it's important to note that the bevel angle will be directed in the opposite way of what you might think. On a mitered box the angle will be directed toward the inside of the box. This is not the case for this project; the angle is directed toward the outside of the tray.

After cutting the four tray sides to length with the proper compound cuts on each end, make a "paring block." The paring block is used to trim the dovetails to their baseline and it acts as a stable platform when transferring the tails to the pin board.

The paring block should be made from a hard, closed-grain wood such as maple. Make the paring block from 8/4 stock that is roughly 8"-10" long and slightly wider than the sides of the tray. Each end of the paring block gets a compound-angle cut representing the left- and right-hand angles on the tray sides.

## LAY OUT & CUT THE DOVETAILS

Mark the baseline on both the pin boards and tail boards. I recommend using a cutting gauge instead of a marking gauge for this. A cutting gauge produces a finer line and the blade can be adjusted to compensate for the beveled ends. The baseline is referenced from the end cuts on the sides. The fence must be held tight against the end grain. Set the depth to a little over the thickness of the sides (around 1/32").

The dovetail angle in the step photos is a 1:5 slope. The dovetail angle is referenced along the grain of the wood and not the mitered ends. To set the bevel gauge to the proper dovetail angle, first lay out the angles on the paring block (above). Draw a line that is parallel to the bottom and approximately 11/2" up. Square a line from the bottom edge 5" in from one of the compound cuts.

On the perpendicular line measure up 1" and down 1" from the baseline and mark these offsets. Draw diagonal lines from where the baseline intersects the compound cut to the 1" offsets. Use these lines to set the sliding bevel gauges. Set up one for the lower edge of the dovetail angle. Set up another to the upper angle. It is easy to mix up the tools, so clearly mark each for its intended angle.

Lay out the tails on the face of the tail board with a half pin in each corner using the sliding bevels that were set for the upper and lower angles. Leave at least ¼" between the tails. Set another bevel to mark lines across the end grain that are parallel to the top and bottom edges of the tray (not square to the face).

Set this angle by lining up the blade with the top edge of a tray side and holding the body parallel to the angled end of the tray side. Check all the lines to confirm that they look right and then saw the sides of the tails to the baseline.

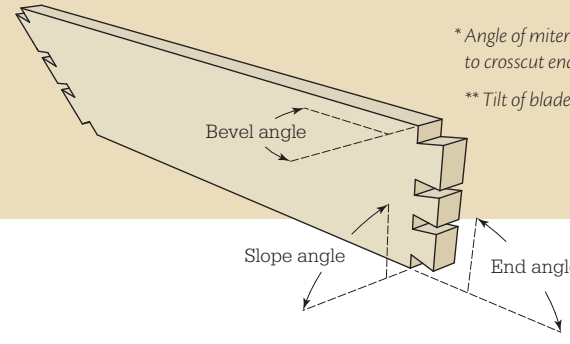
## COMPOUND ANGLES

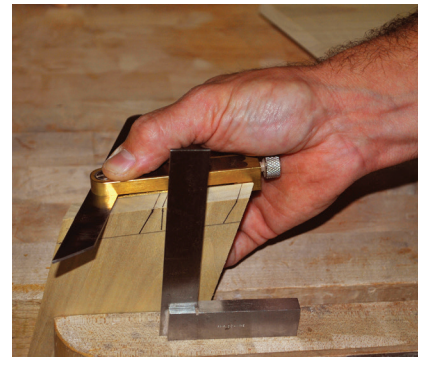
| SLOPE OF SIDES | END ANGLE* | BEVEL ANGLE** |
|---|---|---|
| 90 | 90 | 0 |
| 85 | 85 | .4 |
| 80 | 80.1 | 1.7 |
| 75 | 75.5 | 3.8 |
| 70 | 71.1 | 6.7 |
| 65 | 67.1 | 10.3 |
| 60 | 63.4 | 14.5 |
| 55 | 60.2 | 19.2 |
| 50 | 57.3 | 24.4 |
| 45 | 54.7 | 30 |

This chart gives the necessary angles (in degrees) to make four-sided boxes with butt joints, the first step in cutting the parts to make oblique dovetails. The miter angle listed is the setting for the miter gauge on the table saw, and the bevel angle is the tilt of the table saw blade. There are calculators available online that will generate angles for other slopes and more sides. —TC

** Angle of miter gauge or miter box to crosscut ends*

*** Tilt of blade when cutting ends*



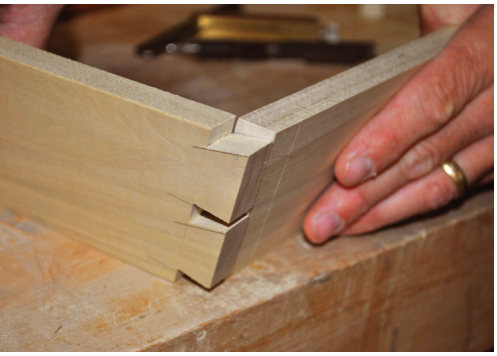



**Tail end.** *Lines across the end grain are parallel to the top and bottom of the sides and ends. Placing the piece in the vise with the cutlines vertical will aid in sawing the tails.*

**Sandwich.** *The side is clamped in the vise between a scrap and the paring block. Resting the back of the chisel on the paring block guides the cuts to the proper angle.*

Remove the bulk of the waste with a coping saw. Match the end of the paring block with the angle on the side. With the paring block in the front, align its end with the baseline on the tail board so that the "ramp" is directed upward. . Clamp the two pieces in a vise and add a backer block on the far side to avoid blowout.

Carefully pare to the baseline by nibbling away the waste. Then lay the chisel flat on the paring block for the final slices. Use one hand to keep your chisel flat on the paring block and use the other to push with. It is important to keep your fingers out of danger behind the cutting edge. All it takes is one slip with a sharp chisel to ruin your day.



▲ ***Maker's mark.*** *Align the two parts of each corner and mark the mating pieces before transferring the tails to the pin boards.*

▲ ***Double duty.*** *The paring block is used to support the side while the socket locations are marked with a knife.*

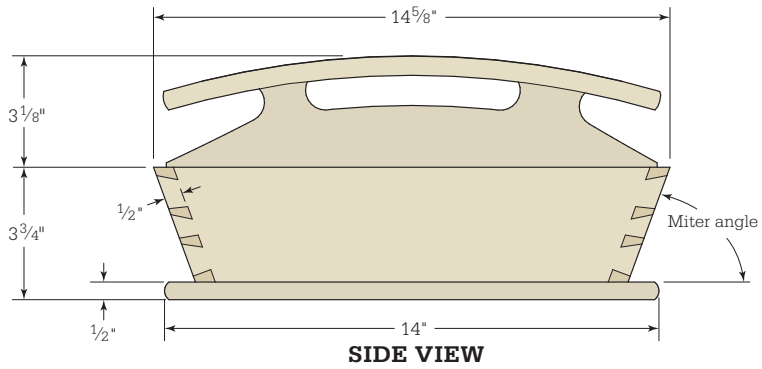
▲ ***Parallel pins.*** *On the pin board, the lines across the end grain match the miter angle on the end of the board, parallel to the top and bottom edges.*

## TRANSFER THE TAILS

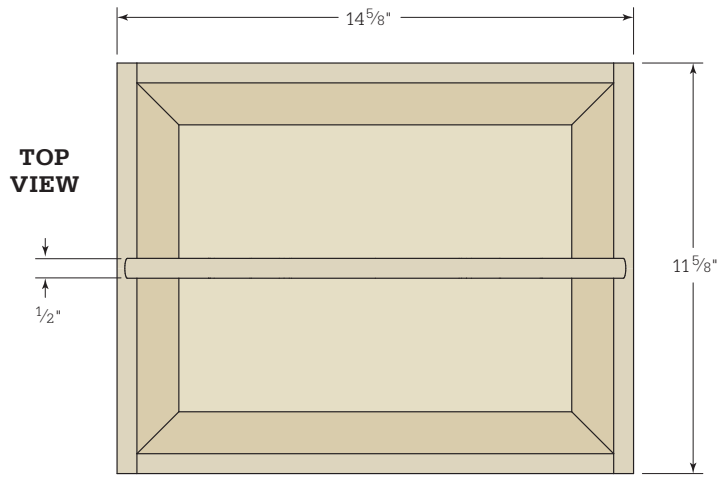
Arrange the sides to form the tray and mark each corner to maintain proper orientation. I recommend using the paring block to aid in the transfer of the tails to the pin board. It provides a solid clamping surface that will align the corners when scribing the tails to the pins. Orient the paring block with the pin board so that the angled ends match and clamp the blocks in a vise. Place the tail board on top and align its baseline with the inside edge of the pin board. Transfer the tails to the pin board with a marking knife.

Set a sliding bevel to the end angle of the pin board and use that to transfer the lines down the face grain to define the sides of the pins. These lines are parallel to the top and bottom edges. Next, saw out the pins to the baseline. Saw directly on the waste side of the line. The goal is to avoid having to trim the joints because due to the angles, it is difficult to judge where the joints aren't going together.

A standard clamp will slide on the angled parts, so make some clamping cauls to pull the joints together. Angled blocks glued to each end of a piece of scrap plywood make a simple but useful caul. The blocks should have the same compound angle as the ends of the sides.




**SIDE VIEW**




**TOP VIEW**

## OBLIQUE DOVETAIL TRAY

| NO. | ITEM | DIMENSIONS (INCHES) T | W | L | MATERIAL |
|---|---|---|---|---|---|
| ❑ 2 | Sides | ½ | 3¾ | 14⅝ | Poplar |
| ❑ 2 | Ends | ½ | 3¾ | 11⅝ | Poplar |
| ❑ 1 | Divider/handle | ½ | 6 7/16 | 14 3/16 | Poplar |
| ❑ 1 | Bottom | ½ | 11 | 14 | Poplar |

Cut four blocks with the left-hand angle and four with the right-hand angle. One end will have the compound angle and the other end will be cut at 90°. Make them roughly 1" long. The scrap plywood should match the shape of the sides and be approximately 1" shorter to ensure the caul does not interfere with the joints closing up.

Orient the blocks on the end of the plywood so the straight cuts are facing out. Firmly attach the blocks to the plywood to form a square clamping surface. I recommend a dry-fit before gluing to ensure that nothing interferes with the joints closing up. The cauls tend to shift when pressure is applied, so use small C-clamps to prevent that. If the dry-fit is successful, release the clamps and knock the joints about halfway open.

Apply a little slow-setting glue (such as liquid hide glue) to the outside of the joint and clamp it. With the mechanical nature of the dovetail joint, it is not necessary to use a lot of glue. Adding glue to the outside instead of the inside, will make it much easier to avoid squeeze-out on the inside of the tray where it is difficult to clean up. Allow the glue to cure overnight then clean up the joints with a block plane and level the top and bottom edges.

## TRAY HANDLE & BOTTOM

Start with a ½"-thick board that is a little longer than the width of the tray at the top and about 4" taller. The handle is housed in ⅛" -deep dados in the ends of the tray. Cut the dados with a backsaw and a chisel followed by a small router plane. (Be careful to keep your fingers out of the way of the chisel.)

Measure the length of the handle between the dados at the base of the tray. Cut each side and test the fit. If the handle does not make it all the way to the bottom, trim one of the ends. If it goes too deep, trim the lower edge after the handle is attached. After getting a good fit between the handle blank and the dovetailed tray, draw the curves for the top edge, handhold and the side reliefs.

Bore holes to define the rounded ends of the cutouts, then saw to the edges of the holes. The end cuts can be made with a backsaw; the center cut can be made with a coping saw. Clean up the sawn edges with a rasp.

The dowel shape of the handle is formed by scoring the offset to define the diameter with a marking gauge. Follow up with scratch stocks, rasps, files and carving tools. With the round shape established, reduce the thickness under the "dowel" with a flat gouge or a wide chisel. You need only make the relief cuts deep enough to create a strong shadow line – about 1/16".

Cut the bottom to size and plane a bullnose profile on the edges. Work the end grain first then plane the long-grain sides. The handle and bottom are nailed on with 1" cut nails. When nailing on the bottom, place the nails toward the outside edges of the tray and angle them slightly so that they do not break through the tray sides. Apply a few coats of shellac and the tote is ready for storing mail, carrying a picnic or keeping the remote controls organized. ‹PW›

***Ahead of the curve.*** *Use a gauge to score lines parallel to the curved top of the vertical divider. The upper line defines the round portion and the lower line the edge of the cutouts.*

***Begin at the end.*** *Bore holes to define the ends of the cutouts in the handle.*

***Saw then shape.*** *Rough cut the ends with a back saw and use a coping saw to remove material in the center cutout. Then use a rasp to remove the saw marks.*

***Carve then curve.*** *After defining the line at the bottom of the handle with a chisel, use a spokeshave to form the rounded surface.*

# Making Connections

The reward of developing any skill is time well spent. And while practice will certainly make perfect, the traditional hand-cut mortise-and-tenon joint need not be a daunting undertaking. The secret to a tight-fitting joint begins with precision layout, followed by proper tools to chisel out the mortises and cut the tenons. At Lee Valley, you will find all the necessary hand tools to help you perfect what you do, including mastering hand-cut joinery.

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