

Notes from the Shopsmith Woodworking Academy

Furniture Joinery

Any experienced woodworker will tell you that top-quality, enduring furniture is not built piece-by-piece...but rather, joint-by-joint.

For over a hundred years, the Shakers at New Lebanon, New York manufactured chairs and benches of all descriptions. These were light, airy creations with stiles and rails no thicker than your thumb in many places. Yet, despite their delicate construction, hundreds – perhaps thousands – of these fine furniture pieces are still in service after decades of use.

The men and women who made this furniture understood the subtleties of wood and wood-working: *The strength, durability and continued appeal of a design doesn't depend on the dimensions of the lumber so much as the cut and fit of the joints.*

Apply the principles behind this joinery in your home workshop, and you can expect your own hand-built furniture to last for generations.

Just three rules

The fundamentals of joinery are simple – although you might wonder how that can be when most furniture design books show hundreds of different joints from which to choose...many requiring an often confusing collection of multiple cuts and intricate hand work.

The truth is...there really *aren't* hundreds of different joints; only a dozen. Everything else is merely a variation or combination derived from these 12 joints. The rules that govern which of these basic joints you use are even fewer – **just three**. Whenever you have two pieces to join together, remember:

1: Allow for the movement of the wood. A seasoned board is fairly stable along the length of the grain, but it will expand and contract with changes in humidity and temperature by as much as 1/4" for every 12" of width **across** the grain. In a small joint, this movement may be insignificant. However, in a joint with larger pieces, swelling, shrinking or splitting could easily cause your joint to come apart. That's why, whenever possible, you should always try to align the grain of adjoining boards so they can swell and shrink **in the same directions**. When this isn't possible, leave room for movement or make a series of smaller joints.

There are some movements you'll want to restrict. Wood has a nasty tendency to cup and warp as it grows older.. The proper joinery will the pieces of a furniture project from distorting, while still allowing the wood to expand and contract.

2: A joint must support the anticipated load. A butt joint only has one adjoining face. As a result, it will only stand up under continual stress or a load coming from **one** direction. This is fine when you're joining a tabletop to a table frame, as an example...where the only anticipated load comes from whatever's on the table. However, the legs will be bumped and pushed from many different directions. In this case, a mortise-and-tenon joint with five or more adjoining faces between the legs and table frame members is much more suitable for absorbing this kind of multi-directional stress.

Remember, too, that a board is strongest along the direction of the grain. The load-bearing members of a furniture project should **use** the grain to evenly distribute the stress throughout the piece. Cut tenons, fingers and dovetail pins parallel to the grain of the wood; otherwise, they may snap off.

3: Wood should be glued long grain to long grain, whenever possible. Every side of every board shows either the *long grain* or the *end grain* (see Fig. 1). Boards glued *end grain* to *end grain* won't hold together under heavy loads; neither will boards glued *end grain* to *long grain*. Most woodworking joints are designed to increase the *long grain* to *long grain* gluing surface...and thus, the strength of the joint.

As with anything, there are, of course, exceptions and trade-offs – you can't expect **every** joint in **every** project to fulfill all three of these requirements. For example, a dado joint may provide no *long grain* to *long grain* contact, even though it shoulders a load from three directions and allows for wood movement better than many other joints. On the other hand, a mortise-and-tenon joint leaves no room for expansion and contraction, yet provides a healthy amount of *long grain* to *long grain* gluing surface.

Sometimes, a variation on a basic joint...or a combination of two or more joints...will help your joinery design meet an important requirement. But don't get hung-up on trying to decide among the myriad variations and permutations in the furniture design books — at least, not at first. There's one other rule that you can call on if you need it: *Simple works just as well as fancy.*

Techniques – Simple But Critical

In many ways, the joints you choose to use for a project may be less critical than how you make them. Just remember...**the wood has to fit.** A poor-fitting joint that fulfills all three of the above requirements may actually weaken your project and cause it to deteriorate much faster than a well-made joint that only meets one or two of the criteria.

The techniques required in making a joint – layout, fitting and assembly – are not difficult, but they **do** require close attention-to-detail. Plus...they also require you to remember the three basic joinery rules.

Laying out a joint — Always measure with **just one tool.** Also measure from **just one reference point** on any given tool. For example, never measure one component of a joint with a steel rule, and another component with a tape measure. Also, never butt the end of a tape measure up against the inside edge of a joint to take one measurement, then hang it over the edge of a board to take another. The slight variations you'll get as a result of doing these things can add up to big problems that will surely ruin your joint.

Keep a hard pencil handy to mark with – and sharpen it frequently. At your pencil tip wears down, your lines will get progressively broader, making it hard for you to be precise. If you must use a pencil, get a 6H pencil from an art supply or office supply store.

A better choice – if you can get used to using it – would be a scratch awl or artist's utility knife. Their metal points will remain sharp; the lines they scribe will always be the same exact width; they will tear through the wood grain as you outline your joints (eliminating unwanted splinters and *feathers* when you make your cuts); and you'll have no unsightly pencil marks to remove when you're finished cutting your joints.

As you lay out the various joints, pay close attention to which way the wood grain runs on the mating components. Not only do you want to mate *long grain* to *long gain* as often as possible, you

also want to be careful not to chop up the *long grains* into *short grains* (See Fig. 2), since *short grains* have limited strength.

Fitting a joint — When the time comes to make your cut, remember that every piece of wood has its own idiosyncrasies. Just the act of cutting will relieve tensions in the board, often causing it to actually change shape. As a rule, these changes are minute and almost undetectable – until you attempt to assemble your joint.

Custom-fit each board to the next. When it's practical, cut just a little wide of your mark, then shave your joint down bit-by-bit until you get the fit you're trying to achieve. How can you tell when you've got the right fit? When you can assemble a joint without a mallet and there's no slop – **that's** a good fit !

Some joints, of course, require a little slop. Dowel joints, as an example, are customarily drilled a little deeper than the length of the dowels to leave room for the glue. Large panels need room to expand and contract. Movable joints (such as sliding dovetails) may require as much as 1/16" to 1/8" of slop to slide freely. Just remember which way the wood moves and fit your joints accordingly.

Assembling a joint — Always go through a *dry run* first – clamp up your mating components without glue – just to “prove” your fit. When you're satisfied, disassemble the joint and coat all the mating surfaces with glue. Always apply a little extra glue to the *end grains* – since they will absorb more glue than the *long grains*. And, even though these surfaces won't be as strong when glued-up as *long grains*, they'll still contribute to the overall strength of your joint.

Now, reassemble the joint and clamp it together. Remember that glue is much stronger when it cures under pressure. But, remember, too, that it's best not to tighten your clamps excessively, as too much pressure will cause your glue to squeeze out from between the mating boards, causing a weakened, “glue-starved” joint.

Often, it's a good idea to reinforce joints – particularly if you think they will be subjected to unusual stress or loads. Glue blocks are a great way to reinforce a joint where there is insufficient *long grain* to *long grain* contact. For example, if you back-up a corner rabbit joint with a glue block, the *long grain* of each board will contact the *long grain* of the glue block.

Nails and screws will act as tiny clamps to help hold your boards together. Nails are rarely used in fine joinery because they're unsightly and as the wood shrinks with age, the nails will loosen up and begin to come out. Screws, although often, just as unsightly, can be tightened from time-to-time, ensuring the continued strength of the joint.

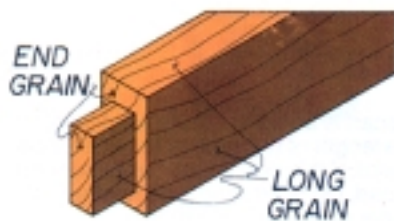


Figure 1

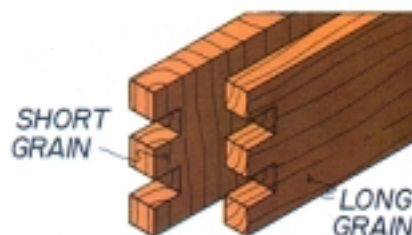
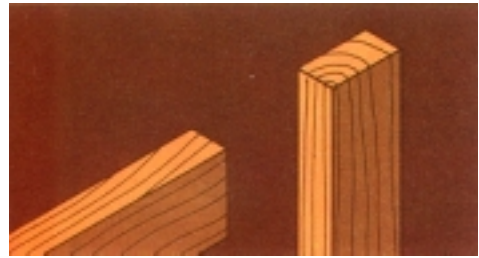


Figure 2

The 12 fundamental woodworking joints

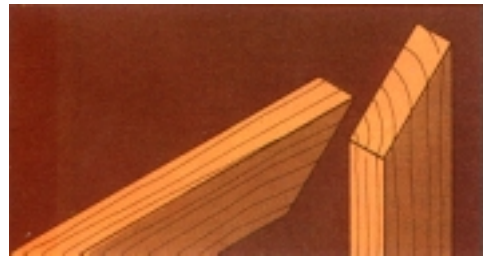
Butt Joints

A butt joint is formed by simply “butting” the edge of one board up to the side or edge of another board. They have limited strength, unless they’re reinforced with dowels, screws or biscuits.



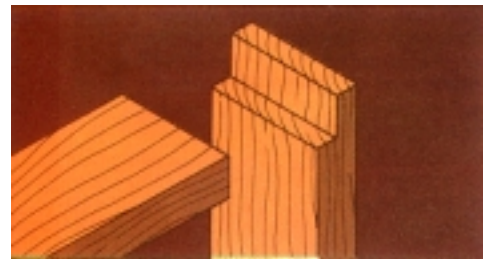
Miter Joints

A miter is a butt joint that has been cut *diagonally*. Miters are not particularly strong, but are used extensively for decorative purposes, such as joining the corners of picture frames, decorative moldings, etc. An accessory such as Shopsmith’s Miter-Pro can make easy work of cutting perfect 45-degree miter joints. Another version of this is a Beveled Joint, where the long edges of two mating boards are joined together with a 45-degree “miter-like” joint, cut by ripping your mating boards with your Saw’s table tilted to 45-degrees. As with butt joints, miter joints can be reinforced with dowels or biscuits.



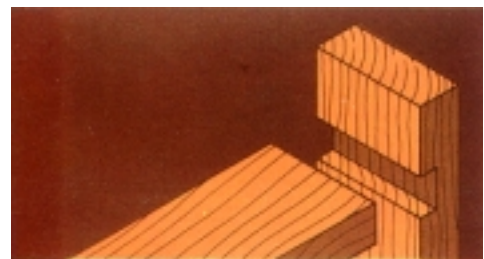
Rabbet Joints

A rabbet is a wide kerf cut into the edge of a board. Rabbet joints are most useful for joining wide boards together at right angles to form a box or furniture frame. They’re typically cut using a Dado Blade on a table saw, but can also be formed with a router.



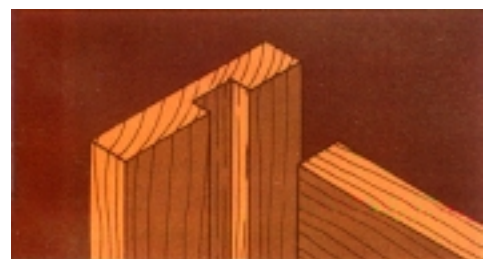
Dado Joints

A dado is an open-ended slot that runs across the grain of the wood. Dado joints are commonly used for joining *middle members*, (such as shelves or rails) to a frame. As with rabbet joints, they are usually created using a Dado Blade or Router.



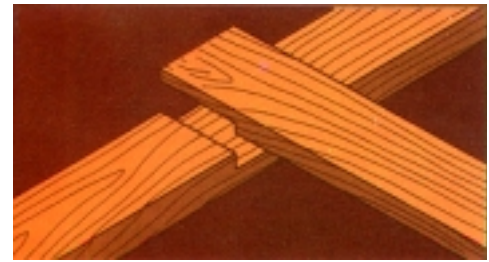
Groove Joints

A groove is similar to a dado, except running *with* the grain of the wood. It’s not as useful for joining frame members as it is for joining boards edge-to-edge or edge-to-side. Grooves can be cut with a Dado Blade, Router, Shaper or Molder.



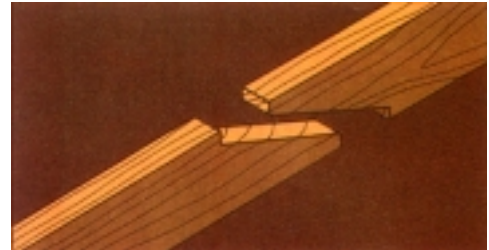
Lap Joints

Lap joints are also often referred to as “bridle joints” and are formed by lapping the end of one board over the width of another. They’re a quick, easy way to make light-duty door and cabinet frames. They’re typically formed with a Dado Blade set-up or Router.



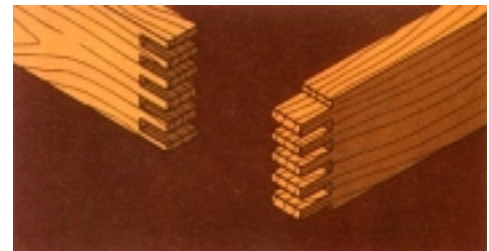
Scarf Joints

A scarf is a lap joint that’s typically used to join two short boards together to make a longer one. If the new, longer board has to support a load, the scarf should be reinforced with screws, dowels or biscuits.



Finger Joints

Finger joints are multiple grooves or dados that interlock like fingers. This increases the *long grain* to *long grain* surface (and strength of the joint) significantly. Finger joints can also be pinned with a through dowel to form a hinge. They’re typically formed with a Dado set-up and a shop-made jig...or a Router Table.



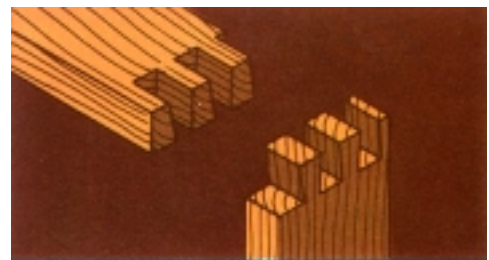
Dovetail Joints

Dovetail joints are formed so they can be pulled apart from one direction only. Similar in design to a finger joint (except with angular surfaces), they will support a load from all other directions, making them extremely strong. Usually, they’re formed with a special Dovetail Fixture and specialized Dovetail Router Bit, but larger dovetails can also be formed with a Bandsaw, with a little practice.



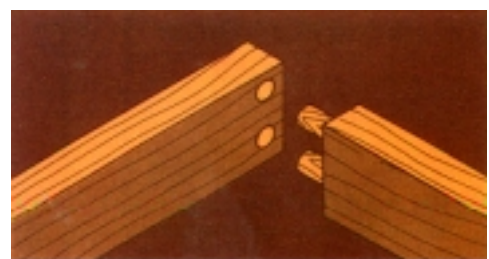
Mortise-And-Tenon Joints

A mortise is a slot that’s closed at both ends. Like a dovetail, a mortise-and-tenon joint will support a load from all directions but one. Mortises can be quickly cut using a special Mortising Bit & Chisel Attachment or a Router, then cleaned-out with a chisel. The mating Tenon is usually cut on a Table Saw using a special tenon-cutting attachment.



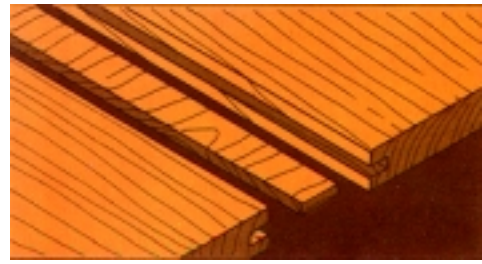
Dowel Joints

Dowels are often used to pin pieces of wood together. And although they don’t make a particularly strong joint, they can be made to last by drilling the holes at slight angles to one another.



Spline Joints

A spline is a strip of wood that rests in a groove or dado to join two pieces of wood together. Splines are typically used to strengthen joints that have insufficient gluing surface. Examples are joining a series of narrow boards together to make a wider one for a tabletop or cabinet side...or for reinforcing mitered picture frame corners.



The Tools Of Precision Joinery

There is an endless array of tools available to help the modern-day woodworker create more attractive, stronger joints for his (or her) projects. Some are “Must-Have” tools, while others fall into the “Handy-To-Have” category. Let’s take a look....

Layout/Marking Tools

Here is a list of layout tools used for marking-out tight-fitting joints:

- **Precision steel rule** – 12” long is best, that measures all the way to the end
- **Precision square** – All-steel models, permanently set at 90-degrees are best
- **45-degree miter square** – For marking mitered joints. Again, all-steel models, permanently set at a 45-degree angle are best
- **Protractor/bevel** – For measuring and marking angles other than 90 or 45-degrees with precision
- **Precision Triangles** – A set of 45-degree and 30/60-degree metal triangles are often the best choice for marking-out specialized cuts and setting-up your tools for making those cuts
- **Sliding Bevel** — These are used for transferring odd angles when marking-out or setting-up your machines to make special cuts
- **Dial Caliper** — Perfect for accurately measuring the thickness of boards or the depths and/or widths of mortises and holes

Cutting & Fitting Tools

The following is a list of “Must-Have” and “Handy-To-Have” tools for creating heirloom-quality joints:

“MUST-HAVE” TOOLS

- A **Table Saw**, of course with a Hollow-Ground Planer Blade or top-quality Carbide-Tipped Combination Blade for making smooth cuts. A good quality Dado Blade Set is also a real “must”
- A **Jointer** for truing-up the mating edges of your boards.
- A **Disc Sander** for smoothing end grains and squaring-off your cuts. A **Conical Sanding Disc** will do an even better, swirl-free job of this task.
- A **Drill Press** with a good set of non-splintering, easy-centering **Brad Point Drill Bits** to bore smooth, accurately-placed holes
- A **Dovetail Fixture** with a matching Dovetail Bit and hand-held Router are a requirement for making conventional drawer and cabinet dovetails

“HANDY-TO-HAVE” TOOLS

- A **Micro-Adjustable Table Saw Indexing Fixture** such as the *Incra TSIII Ultra Fence System* simplifies and dramatically speeds the task of making minute adjustments to your machinery for creating super tight-fitting joinery
- **Miter-Cutting Attachment** for your Table Saw, such as Shopsmith’s Miter-Pro makes easy work of cutting 45-degree miters for picture frames and similar projects
- A **Miter-Setter** such as Shopsmith’s *MiterMatic* is an invaluable aid for setting-up your Table Saw for making precise angled cuts, time-after-time
- A set of precision **Dado Shims** will be of immeasurable help in making the often miniscule adjustments required for setting-up tight-fitting dado joints with a stacking Dado Blade Set
- A **Mortising Attachment** is the easiest way to cut precision mortises for mortise-and-tenon joints
- A **Tenoning Jig** is used on your Table Saw for cutting precision tenons on the ends of boards when creating mortise-and-tenon joints
- A **Biscuit Joiner** will help you reinforce butt joints when joining narrow boards together to create wide ones...or for cabinet face frames

One final thought on joinery — Of course, there’s a lot more that can be said about joinery. But the fundamentals are nothing more than good woodworking sense – governed by the three rules:

1): Allow the wood to move 2): Support the loads and 3): Join long grain to long grain. Once you understand that basic concept, you can design and build almost anything.

As you start out to build your own furniture, here’s one last thought; Design a piece around good, solid joinery; don’t add the joints to fit the design.