Getting Started in Woodworking

A Guide for the Novice

EMGW.org
Disclaimers

- The opinions expressed in these chapters are the opinions of the authors themselves; they are not the opinion of the EMGW organization.
- No manufacturer, retailer, or other supplier of woodworking tools, equipment, or materials sponsored this booklet.
- No woodworkers were harmed in creating this guidebook.

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# A Woodworking Primer

## TABLE OF CONTENTS

**GETTING STARTED** ............................................................................................................ 1
  - Get Started - Now! ........................................................................................................... 2
  - Your First Workbench .................................................................................................. 4
  - Getting Started in Woodworking .................................................................................. 7
  - Buying Lumber ............................................................................................................. 10
  - Measuring Wood: Board Foot versus Linear Foot ....................................................... 11
  - Environmental Health in the Shop .............................................................................. 13
  - Sawing Fundamentals .................................................................................................. 15
  - Ripping Stock Safely ...................................................................................................... 17
  - Achieving Four-Square ................................................................................................. 19
  - The Need for Accuracy ................................................................................................. 23
  - Which Wood to Use ...................................................................................................... 24
  - Wood for Furniture: Kiln-Dried vs. Air-Dried .............................................................. 28

**WOODWORKING TOOLS** .................................................................................................. 30
  - Tools for Sawing Wood ................................................................................................. 31
  - Tools for Getting Started ............................................................................................. 37
  - Getting Started with Hand Tools ............................................................................... 39
  - Milling Rough Lumber .................................................................................................. 41
  - How to Read Grain ........................................................................................................ 44
  - Hand Plane Arithmetic ................................................................................................. 47
  - Dust Collection Overview ............................................................................................ 49
  - Dust Collection for Health ........................................................................................... 52

**PROJECT ASSEMBLY** ....................................................................................................... 54
  - Elements of Wood Joinery ............................................................................................ 55
  - Dry Assembly ................................................................................................................ 59
  - Jigs and Fixtures ............................................................................................................ 61
  - Hold-downs & More ...................................................................................................... 63
  - Woodworking Clamps .................................................................................................... 67
  - Woodworking Vises ...................................................................................................... 71
  - Woodworking Glues ...................................................................................................... 75
  - Hide Glue ....................................................................................................................... 78
A Woodworking Primer

Epoxy .................................................................................................................................................. .81
Mineral Spirits: A Woodworker’s Liquid Tool .................................................................................. .83
Beware the Types of Denatured Alcohol ......................................................................................... .85

FINISHING .............................................................................................................................................. .87
When Should You Apply Finish? It Depends! .................................................................................... .88
The Wonders and Utility of Shellac ............................................................................................... .90
What is Varnish? ................................................................................................................................ .94
Changing the Color of Wood ............................................................................................................. .96
What Is Milk Paint? ............................................................................................................................ .101

OTHER RESOURCES ...................................................................................................................... .104
Resources for Woodworkers ............................................................................................................ .105
PREFACE

What is the EMGW?

The Eastern Massachusetts Guild of Woodworkers (EMGW) is a non-profit organization dedicated to the promotion of excellence in the woodworking community through the sharing of information in the art, technique, and business of woodworking. We aspire to these goals in order to promote and foster interest in our craft for both the aspiring and skilled woodworker.

Woodworking is largely a solitary activity. After hours in the shop, many of us desire a means to teach, learn or otherwise share our knowledge, ideas, and experiences from woodworking. The Eastern Massachusetts Guild of Woodworkers (EMGW) provides this opportunity.

Member interests vary. Among the guild members there are period furniture makers, studio furniture makers, musical instrument makers, clock makers, carvers, turners, chair makers, hand tool advocates, and masters of many other areas. Guild members are happy to share their knowledge. Woodworkers at all levels of skill who are interested in learning and sharing an interest in woodworking are welcomed to join.

The EMGW is a non-profit tax exempt (501-C-7) organization meaning that we don't pay taxes. We are NOT a charitable institution to which contributions would be tax deductible.

Why we wrote this book

We have fielded questions for many years from individuals who were just getting started or wanted to get started in woodworking but were intimidated by their lack of knowledge and didn’t know how to begin. This guidebook is our first attempt to assemble the collected knowledge and opinions of our experienced woodworkers and explain basic principals and getting-started tips in a manner friendly to the novice.

Getting the most out of your membership:

Above all others, the best way to get the most out of your guild membership is by getting to know your fellow members. Many activities can be attended virtually as well as in-person.

- Attend monthly meetings- In addition to the presentations by nationally known woodworkers, and local experts, meetings on the 2nd Saturday of each month from September through June, provide an opportunity for members to meet each other and swap woodworking stories.
A Woodworking Primer

- Attend FIG meetings - The Furniture Interest Group (FIG) meets at members’ homes on the 3rd Monday of the month. It is a great way to get inputs on any woodworking problems or questions you may have.
- Take part in special projects - Special projects organized by guild members come up from time-to-time; they are another way to learn new skills and share with fellow members. Any guild member can organize and run a special project; if you have a special technique or project you would like to share with others, this is one way to do it.
- Use the mentor program - The mentor program is a formal system to do what happens all the time in the guild: members helping members. You can find a mentor or volunteer to be a mentor.
- Volunteer to Help run the guild - There is no paid management that runs the EMGW. In addition to being an officer, there are a number of committee positions and other jobs that need to be done to keep the guild running smoothly. Ask about joining a committee, organizing a special project or helping in some other way.
- Use the Web site - EMGW.org has a number of features to help members get the most out of their membership including:
  1. The Member map - The Member Map feature shows the locations of our members which is a great aid in carpooling to attend guild functions.
  2. Your user profile - Your photo, pictures of your work, and a description of your interests in your user profile will help other members get to know you.
  3. The forums - The Announce, Comments, and Buy and Sell forums are good ways to stay in touch with fellow members. You must subscribe to them on the website in order to receive updates.
  4. Announcements and columns - The Announcements help you to be aware of upcoming meetings. In addition, the Bevel Cut, Featured Piece, and Measure Twice Cut Once columns are a good source of information, opinion, and humor written by your fellow members. The authors are members who have volunteered to write them. If you read one and it appeals to you, send the author an email and let them know. They will appreciate it.

Come Join Us!
The Eastern Massachusetts Guild of Woodworkers
GETTING STARTED

Everything you wanted to know about woodworking but were afraid to ask
A Woodworking Primer

Get Started - Now!
A year from now you may wish you had started today
By Wyatt Mills

I waited much too long to fully enjoy woodworking as a hobby. I was convinced that a permanent, dedicated space and an array of fixed machinery was necessary to do meaningful work and build quality items. So I waited more than a decade until settled into a house with room for a shop and able to afford a table saw, dust collector, and band saw. At that point, I managed to complete a few projects expecting to “complete” the shop with more machinery.

Oddly enough, during that time I failed to appreciate or grasp the value of hand tools. I don’t know why I had this blind spot. But a few years ago, I started to notice the numerous articles, books, and on-line videos on using hand tools (some of those resources are listed below). They led me to start learning and using hand tools. And seeing how much I could by hand, I realized that I could have been enjoying the hobby long before I had the shop or the machines.

Recently I was going through old copies of Fine Woodworking Magazine and found an article on the use of chisels that my younger self apparently missed. Its advice is worth repeating.

“I cannot overemphasize the importance of practicing fundamental tool skills... I constantly find beginning woodworkers who are struggling to learn some vital technique in the course of making furniture, with no attempt to develop and perfect their skills before the main event. The result will, at best be a nondescript article of furniture that prominently features the scars of its maker’s struggle, and at worst it will be failure and disillusionment. Either way, it seems futile. On the other hand, once you have learned to use the tools, making joints is a simple procedural application of those skills... No manipulative skill is acquired without practice. The potter, the dentist, the athlete—indeed, anyone wanting motor skills—must practice, and practice hard. The woodworker is not exempt.” Ian J. Kirby. Fine Woodworking #27, March/April 1981

So the advice to my younger self is this: "Don't wait! There is a lot to be learned by starting right away! Invest in a basic set of hand tools (planes, chisels, saws) and teach yourself to flatten, joint, and square up stock. Cut joints by hand and build a simple tool chest to keep things safe and mobile. Keep practicing and honing your hand skills - small, practical projects are fine. Be persistent! Enjoy the process and permit yourself to be imperfect - you'll learn from the mistakes."

Better late than never, I am learning and practicing hand tool skills. To my surprise, the results are no less amateurish than much of my early machine work. There are times when the work can be challenging. It's a physical workout to flatten a twisted oak board with hand planes. And developing the muscle memory to hand saw consistently takes patience and practice. But the learning happens.
There are obvious advantages to hand tools: they take up less space, require no electricity, don't generate as much hazardous dust, and are quieter. Hand tools also tend to be less expensive than power tools depending on quality and price point. That's not to say that things can't add up as you acquire several hand planes, a set of chisels, and numerous saws. But these costs can be spread out more easily than for bigger-ticket machinery.

There are other benefits, too. I've found I'm more attuned to grain direction and can better read a piece of wood. And often the key to success is not how I cut piece of wood, but how I visualize, measure and layout operations ahead of time. So, what I'm learning in that regard is knowledge that helps whether I use hand tools or machines.

Finally, hand tool skills influence my use of the machinery I do have. I now regularly combine power operations (e.g. jointing with table saw; thicknessing with band saw) with hand plane cleanup. And, future purchases will be influenced by this experience. Maybe I can get by without a jointer, but a thickness planer would sure be nice. Do I need a router setup or is a plough plane sufficient for the work I do? Only time will tell as I gain experience, but one thing is clear - no more waiting - just get to work!

Resources I've discovered (there are many others I am sure)

Fine Woodworking magazine and website (https://www.finewoodworking.com/) and its many contributors. The resource I use most frequently.

Paul Sellers website (https://paulsellers.com/). Paul's numerous on-line videos of projects using primarily hand tools are very informative and easy to follow.

Christopher Schwarz, Stock Prep by Hand (https://www.youtube.com/watch?v=2_96gNMMc_g). An excellent tutorial on the use of hand planes to flatten and square stock.

Your First Workbench

Do I need a bench?

By Rob Carver

Yes, you do. Some would say that the workbench is the most essential tool in your shop. A bench, with suitable clamps or vices, holds wood securely and safely while you work it. A well-conceived bench saves your back, legs, and arms and it optimizes the distance between the work and the worker. It supports bench-top power tools, and it provides a place to lay out hand tools while you work. Often it can be the place to assemble parts into a finished piece.

Before you bring a piece of wood into contact with a tool or vice versa, either the tool or the wood must be secured firmly. This is essential for safety and for accuracy. Most hand tool operations require the use of two hands.

What kind of bench?

A quick web search reveals staggering array of options. What bench do you need? It depends, and the right bench for you today might not be the ideal choice a year from now. You probably do NOT need to spend a fortune on a handsome, massive, commercially made product. For this article, we’ll restrict attention to western-style benches where you stand. Curious readers who prefer to work while seated may want to search the Internet for Roman or Japanese workbenches.

As a starting point, think about the kind of projects you want to make. As you are just getting started, you may not know. Your ambitions will evolve over time, but for a first bench it’s helpful to have some rough parameters. Kitchen cabinets or built-in bookshelves call for a larger bench than making mantle clocks or jewelry boxes.

Until you decide upon an initial woodworking path, you might look for a second-hand bench or worktable, or even lay some 2 x 8 lumber and across store-bought sawhorses. Take notes about
your observations as you work. Then start thinking about improving your skills by building a bench. You can easily find plans online – but how do you choose the right plan?

**Materials, dimensions, and components**

When you are ready to start, find wood that is affordable and readily available. The top surface of the bench must be flat enough for precise measurement and joinery, and rigid enough to resist bouncing under the blows of a mallet. A thick top also adds weight and stability. Two-layers of ¾ plywood or MDF are adequate; a top of laminated construction lumber should be at least 1 ½ inches thick, and thicker is better. Your bench top cannot be too long, but it can be too wide. A length of 5 to 7 feet should serve you well. As for depth, you’ll need to reach across the bench for a tool so let the bench width be governed by your reach. Approximately two feet, give or take, is about right.

The bench needs to work for you in your shop. Where is your shop, and how much open floor space to you have? You should be able to work at the bench from any side, though some benches are flush with, or even attached to a wall. What else lives in the shop? cars? washing machine? cats? other large power tools? In a basement shop, are there columns that limit the size and location of the bench?

The height of your bench is critical and personal. It must fit YOU and not someone else. One common guideline is to stand next to a wall and let your hand hang loosely. Mark the point at which the first knuckle of your pinky finger (where it meets the hand) touches the wall. Opinions vary on this—some recommend the first thumb knuckle, and others use a different standard. Eventually you may want to adjust the height after using the bench for a while. For activities like carving, a higher bench or small platform on top of the bench is advisable.

The base should have stout legs and joinery that will resist side-to-side and front-to-back forces. Mortise-and-tenon joinery is ideal, and half-laps with glue and screws are also effective. If you expect to move the bench around in your shop, rugged joints are key. Do not rely on lag screws or carriage bolts for this job. Your bench should not rack or wobble. It should be heavy enough to stay put when (e.g.) using a hand plane or belt sander, but can be moved if
A Woodworking Primer

necessary. In a one-car garage, you may need a bench on locking casters. Suitable casters are available in the marketplace, but can add significant expense.

Your top must accommodate clamps. Many designs feature a top that overhangs the base far enough that you can use clamps to hold down a workpiece. Other designs align the front edges of the top and legs in the same plane. Choose the approach that makes the most sense for your work. Consult the later article on clamps and vises, but soon you will want a vise as well as dog holes—holes drilled into the benchtop that will receive “bench dogs”, essentially pegs that restrict the movement of a workpiece. Sometimes you pinch a board between the dog and your vice, sometimes you position the end of a flat board against a dog and plane towards the dog, which stops any forward sliding. Dog holes also receive other wood-holding accessories like holdfasts.

Some benches feature drawers, cabinets, or tool wells (a depressed area in the bench surface to hold tools or supplies). Here again, know thyself and know how you intend to work. Under-bench storage can be a boon when storage space is otherwise scarce, but can also become a place accumulating forgotten tools and detritus. Similarly, a tool well might be a major convenience or a collection point for wood chips, sawdust, and tools that you intended to put away.

Closing Thoughts

Your first bench is probably not going to be your last, but a bench that is suited to your intentions, space, budget, and body will serve you well for years. The most important elements are the dimensions, the rigidity, and the weight of the bench. As you work on it, you’ll improve your skills, and you will learn what to look for in your second bench.
Getting Started in Woodworking

An Approach to Moving Forward

By Bob McKee

People getting started in woodworking are often advised to “Select projects that are appropriate to your skill level.” That might be good advice for someone whose family and career commitments leave very little time for woodworking. That person might enjoy making simple, utilitarian items at their current skill level as found in home handyman magazine articles such as “Make This Fabulous Garden Bench in One Weekend!” or “Sturdy Bookcases from Pallet Wood!”

For the person who wants to take woodworking more seriously and make beautiful useful things that are a source of lasting pride, I would suggest a different strategy: “Decide what you want to make and acquire the skills to do it.” Here is a possible path for that approach.

1. **Learn how to use your tools safely and efficiently.** This will require either a mentor or taking a couple of classes, one for power and one for hand tools. Particularly on issues of safety, live instruction is key. As a home handyman, I used my table saw recklessly for 35 years without knowing it. Looking back, I’m lucky to have my fingers. Supervised woodworking classes are offered by many towns’ adult education programs. Industrial Arts Schools like the Eliot School and North Bennett Street School in Boston offer classes for hobbyists. Woodcraft and Rockler stores and others have specialized classes as well.

2. **Find something you would really like to make, use, and live with.** Decide what you need, then look online and in books for designs you like. Don’t worry about the skills required to make it. Obviously you won’t start by attempting a veneered bombe chest of drawers or a Queen Anne highboy, but if you are interested in making a Shaker chest of drawers, go for it. You can learn new skills as they are needed as long as you are not in a hurry.

3. **Buy or draw a plan.** Once you’ve collected several pictures you like, find a plan to work from that is close to what you want to make. Plans are just measured drawings that can easily be modified to change the dimensions, number of drawers, or other features. Plans are available from several sources that can be located online from magazine archives for a small fee, from books, woodworking retailers, and online videos. If available pay extra and get full size plans. Then, if what you want is a little different, redraw the plan to scale on large pieces of paper.

4. **Learn the skills you don’t have.** Don’t rush this part. My first real project after learning basic tool skills, was to make a 17’ kayak. (My power tool class resulted in a bookcase, so the kayak was technically my second project.) Making a kayak is a lengthy series of diverse processes most of which were unfamiliar, but a seaworthy wood kayak was
A Woodworking Primer

what I wanted. So I visited kayak makers and bought three books on making cedar strip kayaks. The books were used step by step throughout the process, mixing and matching their differing advice at each step. I used our old playroom as a workshop and spent the next 15 months making a boat that nine years later continues to be a joy to use and a source of pride.

Play the long game. Don’t impose deadlines on yourself. Halfway through building my kayak, I decided that it would be cool to inlay a design into the deck. I stopped work taking three months learning how it’s done, finding and ordering contrasting species of wood and so forth. The swoops on the deck became the defining feature of my boat.

5. Acquire the tools you need, as you need them, used if possible. Except for my hand saws every tool I own was purchased used. All are first quality tools purchased from sellers on Craigslist or eBay, at tool swaps or auctions. That includes my SawStop table saw (Craigslist – drove to Springfield), Bosch compound miter saw (pawn shop in Providence), Laguna band saw (cabinet shop had too many), and Grizzly 8” jointer (guy built his own house) – everything. I never lowball or argue with sellers, but pass on anything that’s worn or priced over 60% of new. You can do that if you’re not in a rush.

6. Be on the lookout for wood that excites you. Same as with tools. When people see my pieces they invariably comment on the wood, 90% of which comes from small lumberyards or Craigslist sellers at prices that were lower than white oak at Lowe’s. Of course, some of it sits unused or has to dry for a couple years, but that’s part of the fun. In the past few years I have purchased native woods including Curly Maple, Flame Birch, Pear, Apple, 3” Cherry with no immediate project in mind. I love tripping over them knowing that someday they will be the basis of something nice.

7. Do or Learn Every Day. Try to do something every day or as often as possible to keep a rhythm. Maybe just read an article at breakfast, sharpen a chisel after dinner, practice a
A Woodworking Primer

few cuts with your tenon saw before bed. Anything so you are conscious of forward momentum several times a week.

8. Join a Group. It can get lonely working alone in your shop, especially if you hit a bump in your project. By participating with active, interested woodworkers in an organization like Eastern MA Guild of Woodworkers you get to share an interest and have the support and knowledge of others when you need it. The Internet also has numerous woodworker Websites such as Lumberjocks.com and several facebook groups.

So, in summary join up, read up, don’t rush, and acquire skills as you need them for projects that truly interest you.
Buying Lumber
*The Excitement Starts Here*
By Vincent Valvo

Buying lumber can be complicated for any novice woodworker. This article assumes that the woodworker has decided on a wood species for appearance (density, color, texture, and grain), price, availability, use (indoor/outdoor, functionality), solid or plywood, kiln/air dried, and workability. Also assumed is that the woodworker has made a parts list, sized the amount to buy, added a comfortable scale factor to the minimum amount needed to account for mistakes in sizing, design, and cutting. (see below) The website of the Eastern Massachusetts Guild of Woodworkers offers a resource list of lumber yards.

**Lumber at the Lumber Yard.**

Home improvement stores generally will provide standard species of pine, oak, poplar, sometimes beech and birch, and rarely cherry. Boards are almost always designated S4S (4 sides surfaced: both faces and both edges). They almost always come in ¾” thickness even though they are designated 1 x 4 or 1 x 6 for example. This is because they were generally 1 inch thick before they were surfaced. If the woodworker has no access to a jointer and planer, these boards will do fine, assuming that they still pass inspection for squareness, cracks, knots etc. In other words, be careful that the boards are not bowed, kinked, twisted, cupped or kinked since the time they were designated S4S. The figure below illustrates these the types of warp to investigate. Boards at home improvement retailers are typically kiln dried.

<table>
<thead>
<tr>
<th>Types of Wood Warp</th>
<th>Description</th>
<th>Image</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Bow</strong></td>
<td>A form of warp in which the lumber deviates from flatness lengthwise, but not across the face</td>
<td><img src="image1" alt="Bow" /></td>
</tr>
<tr>
<td><strong>Kink</strong></td>
<td>A form of warp in which the lumber deviates edgewise from a straight-line from end to end</td>
<td><img src="image2" alt="Kink" /></td>
</tr>
<tr>
<td><strong>Twist/wind</strong></td>
<td>A form of warp in which the turning of four corners of any face of a board is no longer in the same plane</td>
<td><img src="image3" alt="Twist/wind" /></td>
</tr>
<tr>
<td><strong>Cup</strong></td>
<td>A form of warp in which the lumber deviates from a straight line across the width of the wood</td>
<td><img src="image4" alt="Cup" /></td>
</tr>
<tr>
<td><strong>Crook</strong></td>
<td>A form of warp where there is movement along one edge of the lumber</td>
<td><img src="image5" alt="Crook" /></td>
</tr>
</tbody>
</table>
Alternatively, there are retail lumber yards that provide more variety in sizes and species. They typically offer exotic and domestic woods, both soft and hardwood. In addition to boards designated S4S, they will likely offer S3S (3 sides surfaced: both faces and one edge) and S2S (2 sides surfaced: both faces) products. Often the broods will be measured in foot length (feet) and thickness (inches).

A source of confusion arises from the fact that a 1 x 4 board is only ¾” thick and sometimes only 3 ½ inches wide. Remember a 2 x 4 board at a big box retailer is actually 1 ½ x 3 1/2. Board thickness at lumber yards is typically measured and designated in inch-quarters. 4/4 (called four quarter) means about one inch or four quarters. 6/4 means six quarters of 1 ½ inch. 8/4 means 2 inches, and so on.

While boards that need milling require extra work, a woodworker can take advantage of the wide variety of available stock. A general rule of thumb is to mill boards oversized at the beginning of any project and mill to final size after the boards have had ample time to dry and adjust to the humidity in the workshop.

Rough stock, which is stock sold directly by a sawmill, can often be found. Rough stock can be air or kiln dried, so ask. Purchasing rough stock has no sides surfaced flat thus they will need to be surfaced and squared using a jointer and planer and the expertise that goes along with these machines. Rough boards normally come no narrower than 4/4. That way there is more flexibility to mill to the exact desired thickness, assuming it is less than one inch. Additionally, these board are less expensive when measured by the board foot (see board foot discussion next) but of course there is more waste than occurs with non-rough stock.

**Measuring Wood: Board Foot versus Linear Foot.**

Unlike ounces, pints, and gallons, board-foot is not a measurement known to the general public as well as a source of confusion for many woodworking beginners. The price per board-foot is the measure used by most lumber yards although the practice appears to be in decline. A board-foot is a measure of volume. You measure the length, width, and thickness of a board in inches; multiply the three numbers; and divide by 144 to get the number of board-feet. Since many lumber sources provide the length of their boards in “feet” you would multiple the three numbers and divide by 12. So....

- An 8-foot board 4 inches wide and 2 inches thick = 4 x 2 x 96/144 = 5.33 BF = $53.30 at $10/BF
- An 8-foot board 4 inches wide and 3/4 inch thick = 4 x 1 x 8/12 = 2.67BF = $21.36 at $8/BF because you will pay for 1 inch of thickness.

Home improvement stores typically do not use board-foot prices. They use a linear measurement, which is a length of a specific sized board designated in feet. They already measure for certain lengths, widths and thicknesses and thus provide a by-the-board price (not by the board-foot price).
Lumber Grades

Besides the SXS grading system mentioned above, another grading system developed by the National Hardwood Lumber Association for milled hardwoods offers a quality system as seen in the table below. Some lumber yards may use these terms. Much if the table contents are from https://www.woodworkerssource.com/. The phrase “clear cuttings” refers to how much stock is saved from knots or other irregularities.

<table>
<thead>
<tr>
<th>Grade</th>
<th>Trade Name</th>
<th>Min. board width</th>
<th>Min. Board Length</th>
<th>Min. Cutting Size</th>
<th>Min. Area of Clear Cuttings</th>
<th>Uses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Firsts and Seconds</td>
<td>FAS</td>
<td>6”</td>
<td>8’</td>
<td>4” x 5’ or 3” x 7’</td>
<td>83⅓%</td>
<td>FAS board is graded from the poorer face. F1F board is graded from the better face. For SEL, one face side is FAS, the back side is No. 1 Common. It’s a cost-effective solution when only one side is shown. Given the needs, all in these categories are suitable for fine furniture, cabinetry and applications where clear, wide boards are needed.</td>
</tr>
<tr>
<td>FAS One Face</td>
<td>F1F</td>
<td>6”</td>
<td>8’</td>
<td>4” x 5’ or 3” x 7’</td>
<td>83⅓%</td>
<td></td>
</tr>
<tr>
<td>Select</td>
<td>SEL</td>
<td>4”</td>
<td>6’</td>
<td>4” x 5’ or 3” x 7’</td>
<td>83⅓%</td>
<td></td>
</tr>
<tr>
<td>No. 1 Common</td>
<td>1C</td>
<td>3”</td>
<td>4’</td>
<td>4”x2’ or 3” x 3’</td>
<td>66⅔%</td>
<td>Upper common grades may be suitable for the cabinet industry, most furniture parts and flooring. Could provide value as secondary stock in some furniture pieces.</td>
</tr>
<tr>
<td>No. 2A Common</td>
<td>2C</td>
<td>3”</td>
<td>4’</td>
<td>3” x 2”</td>
<td>50%</td>
<td></td>
</tr>
<tr>
<td>No. 2B Common</td>
<td>3AC</td>
<td>3”</td>
<td>4’</td>
<td>3” x 2”</td>
<td>33⅓%</td>
<td></td>
</tr>
<tr>
<td>No. 3A Common</td>
<td>3BC</td>
<td>3”</td>
<td>4’</td>
<td>1 ½” x 2’</td>
<td>25%</td>
<td></td>
</tr>
</tbody>
</table>

Practical Reality

Suppose you want to build a table with a 3/4” maple top measuring 40” x 24 ½ (a golden ratio) attached to a walnut base. Your calculator tells you that the top requires 6.80 board feet of maple. But if your only option is to purchase 6” boards (5.5” most likely in reality) and 6-foot lengths, you will need to buy five boards for a total of 15 board-feet. Save the scrap for making jigs and fixtures, cutting boards, or gifts for friends and family.
Environmental Health in the Shop

Protecting Yourself is Important

By Andrew W. Davis

Woodworking can be fun, but like any hobby, dangers exist, both hidden and overt. Fortunately, most of the dangers can be avoided with simple solutions.

Eyes

Many operations generate woodchips and dust. Using any kind of power saw or sanding device on wood is a guaranteed source of such debris. Grinding metal is a similar threat. Using safety goggles is the smartest and least expensive way to protect yourself and your eyesight. Blind woodworkers exist, but they are not common!

Ears

Many people think they need hearing protection only when they are sharing a woodshop with others. The truth is that some equipment, particularly dust collectors, shop vacs, power saws and planers create a lot of noise. If you are exposed to this repeatedly and for long times, you are liable to suffer hearing loss. Indeed, hearing loss is a cumulative effect. Using a headset is the smartest and least expensive way to protect your hearing. As an aside, I am not in favor of those headsets that also connect to a music source because most of the time the task you are working on requires a reasonable level of concentration and the music can be a deadly distraction. Dancing while using a table saw is not recommended.

Nose and Throat

We all know that breathing is an essential activity. But you want to be inhaling clean air. There are two technologies that address this challenge during woodworking. The first is to use a dust collector or shop vac connected directly to the output of your free-standing and mobile power tools. These will collect the large particle debris. For filtering out the small particles many shops have ceiling mounted air cleaners rated by the size of the dust they will collect – with one micron being generally the shop standard. Unfortunately, these collect particles that are hanging in the air and do most of their work after you have left the shop. When deciding on a dust collector look for HEPA certification of the device/bag to ensure collection of the damaging particles that you can’t see. HEPA efficiency grades generally range from H10 to H12. The higher the grade, the better the filter. For example, HEPA H13 through H14 are within the highest tier of HEPA and are considered medical grade quality.

Another tool is a mask that captures the small particles while you are woodworking. These can be disposable or have replaceable filters. Masks have become even more popular in the days of Covid.
A Woodworking Primer

Hands

Work gloves serve multiple purposes in woodworking. Thicker cloth and leather gloves are highly recommended to protect your hands from splinters when handling boards and sheet goods. Latex gloves are useful, perhaps required, when using chemicals, dyes, stains, paint and other finishes, and even glues.

Distractions

Avoid any and all distractions when doing any woodworking task, especially if a power tool is involved.
Sawing Fundamentals

Wood Structure Affects Saw Action

By Jim Tartaglia

Sawing wood, one of the most common woodworking operations, involves making smaller pieces of wood out of larger pieces in order to build something from them. The two main components to do this are wood and a saw, let’s start with wood.

Wood, as you know, comes from trees which are made up of long, tightly bound fibrous tubes; similar to a bunch of (microscopic) soda straws. Woodworkers generally prefer their wood in the form of boards, which are flat, rectilinear pieces of wood of a certain length, width, and thickness. The way in which the fibrous tubes pass through a board determines grain. Grain generally runs from end to end along the length of a board.

Trees occasionally have branches. The place in a board where a branch passed through, (when the board was part of the tree), is called a knot. Woodworkers consider knots as defects and try to avoid them unless they are part of a desired look.

Milling

Before any woodworking operation, including sawing, boards should be straight and true, in other words they should be free from cup, bow, and twist. The process to do this is called milling.

<table>
<thead>
<tr>
<th>Types of Wood Warp</th>
<th>Description</th>
<th>Image</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bow</td>
<td>A form of warp in which the lumber deviates from flatness lengthwise, but not across the face</td>
<td></td>
</tr>
<tr>
<td>Kink</td>
<td>A form of warp in which the lumber deviates edgewise from a straight-line from end to end</td>
<td></td>
</tr>
<tr>
<td>Twist/wind</td>
<td>A form of warp in which the turning of four corners of any face of a board is no longer in the same plane</td>
<td></td>
</tr>
<tr>
<td>Cup</td>
<td>A form of warp in which the lumber deviates from a straight line across the width of the wood</td>
<td></td>
</tr>
<tr>
<td>Crook</td>
<td>A form of warp where there is movement along one edge of the lumber</td>
<td></td>
</tr>
</tbody>
</table>

The above discussion applies to solid wood boards cut from trees; with manufactured lumber, (think plywood, particle board, or MDF (Medium Density Fiberboard), grain direction is less important or non-existent.
Sawing

Sawing is the action of driving a saw blade through a piece of wood. Woodworkers make boards narrower by sawing in the direction of the grain, known as ripping. The operation to make them shorter is called cross-cutting because it cuts across the grain. A third operation is known as resawing which is really a ripping cut commonly done on a bandsaw although it is possible to resaw narrow boards on a table saw.

If you start with an 8’ board measuring 4” wide and 1” of thickness you could:
- Crosscut the board to have 2 boards approximately 4’ long x 4” wide x 1” thick
- Rip the board to have 2 boards 8’ long x approximately 2” wide x 1” thick
- Resaw the board to have 2 boards 8’ long x 4” wide x approximately ½” thick

Saw Blade Elements and Styles

As any blade passes through wood, it removes an amount of wood equivalent to the thickness of the blade. This typically winds up as sawdust. This thickness of the material removed is known as the blade Kerf. Hence the above examples include the word “approximately.” Thus, if you drive a 1/8th inch thick blade (actually the measurement between the ends of the blade teeth) through the exact middle of an eight foot long board, you will not end up with 2 four foot boards, but 2 boards of 47 and 15/16 inches in length. One sixteenth of an inch is a small amount of material loss if you are building a house but a large amount if you are building a jewelry box.

To make driving this metal blade through wood easier, saws have teeth. In general, saw blades are available in three primary styles: rip, crosscut, and combination. Think of a rip saw, which is made to cut with the grain, as a series of tiny chisels. Blades optimized for ripping often have flat topped teeth, looking very much like chisels. They also have deep gullets, the space between blades.

A crosscut saw is like a series of tiny knives. Every other tooth is bent in the opposite direction. This is known as the “set.” These blades are known as Alternate Top Bevel or ATB. It is easier to rip (with the grain) because you are just splitting the long fibers of wood. When crosscutting you are severing each fiber. To illustrate, think of taking a piece of firewood and splitting it with an axe, (ripping it); difficult, but with a good hard swing you can do it. Now, think of taking the same piece of firewood and trying to make it shorter (crosscutting). It’s much more difficult and requires many blows. That is why crosscut saws have more teeth per inch than rip saws.

In addition to the three styles mentioned above, special application blades and saws are available for cutting dovetails and for making grooves and rabbets with and across the grain (dado blades).
Ripping Stock Safely

Avoiding problems during a common operation

By Vincent Valvo

This article discusses how to safely rip stock on a table saw - that is, cutting a board length wise along the grain. For example, you could rip a 6” wide board that is 4’ long into two boards measuring 3” wide x 4’ long.

When ripping, it’s best to be alert, un-hurried, and have good lighting. This is generally true when working with any power tool. Accidents often occur when performing tasks at the end of a workshop session, when you are for any one of a hundred reasons or just trying to get more done before leaving the shop. Having good visibility is also paramount.

The table saw presents the most complex challenge to maintaining control. You must keep the workpiece moving forward, flat on the table, and pressed against the fence. Failing to do any one of these three things can result in serious injury.

Avoiding Kickback

Note that the front of the spinning table saw blade is moving down into the table saw; the back of the blade, is moving UP as it comes out of the table saw. Kickback is a serious reaction that happens when the workpiece makes contact with the back of the spinning blade –If this contact does happen, the workpiece is lifted by the spinning blade and hurled in the direction of the spin – toward the operator. At a typical spin rate of 3000 to 4000 rpm, the result will be a forceful, instantaneous, and VERY dangerous situation. Kickback has been known to send pieces of wood through walls. The main purpose of a splitter is to prevent this from happening.

Hence, the workpiece must be kept parallel to the blade. Any other orientation will create kickback. If you stop moving a partly cut workpiece, the workpiece could move ever so slightly sideways. Even if you are holding down the workpiece, vibrations generated by the table saw motor can move the workpiece out of parallel. If the workpiece is not flat on the table any rocking could do the same. Assuming you are using the fence (let’s hope so) the only direction the workpiece can move is into the blade. The fence is not merely a rule for following a straight cut; it also provides a path parallel to the blade.

Body location. Position your body for comfort and safety. You should be balanced and not stretching. To reduce any harm from kickback accidents, its best to locate away from directly behind the workpiece so that you are never in the path of any eventual missile.
Accessory Tools for Ripping Stock

When ripping stock, it is necessary to hold down the workpiece on the table as well as against the fence while moving the wood forward through the blade with your hands sufficiently away from the blade and your body not directly behind the workpiece.

**Push Stick.** To move the workpiece forward, use a push stick. This is a tool composed of a beak, heel, and handle as seen in the picture to the right. The beak must be long enough to secure the workpiece on the table so that the workpiece doesn’t lift. The heel hooks over the end of the workpiece so that it pushes the workpiece as the push stick is moved forward. The handle should be sufficiently higher than the height of the blade so that the woodworker’s fingers will not come near the blade.

The orange tool in the photo is a poor version of a push stick because it grips the workpiece only at the end. It does not hold the workpiece down on the table and by inadvertently pushing down on the back of the workpiece, the push stick can accidently act as a lever to lift the work off the table.

**Splitter.** Just behind the blade, the table saw should be equipped with a splitter that keeps the workpiece firmly against the fence. The splitter is a thin fin – no thicker than the blade kerf. As the workpiece passes through the blade it then passes around the splitter such that the two resulting pieces stay separated and away from the blade. In the picture above the splitter is the metal upright piece affixed to the zero-clearance table saw insert just after the slot where the blade rises. A splitter is fixed in position; a riving knife is similar but moves up and down as you adjust the height of the table saw blade.

**Feather Board.** While one hand is used to hold the push stick, the other hand is used to keep the workpiece pressed against the fence. Once most of the workpiece is cut, the end of the workpiece moves close to the blade. You must remove your hand in plenty of time, at least six inches away from the blade, before completing the cut. As an alternative, instead of using your hand, a woodworker can use a feather board (see picture to the right). The feather board locks into place on the tabletop, either by a magnet or by using the table saw miter channel. To use a featherboard, place the workpiece against the fence then lock in your feather board against the workpiece where you would place your hand – ahead of the blade and never in line with the blade.

Feather boards can be purchased in a variety of configurations as well as made from wood in your workshop.
A Woodworking Primer

Achieving Four-Square

Everything Begins with Dimensioning Your Lumber

By Randy Hock

You have made the decision that you want to create a beautiful piece of furniture with maybe a finely tuned drawer with beautiful dovetails, some tapered legs, and book matched top....well you can see it in your mind’s eye. Or maybe it’s just a simple bookcase!

Creating any piece of furniture involves multiple steps and requires joining individual components together via joints that are precise and robust. The first step in creating strong joints is dimensioning the stock or obtaining flat and square individual components. Sometimes through careful selection of wood at the lumber store (big box store or lumber yard), individual pieces can be found that are suitable. However, almost always that is not the case. Knowing how to make your lumber pieces flat and square is an invaluable and critical technique to progressing in woodworking.

This is known as the four-square method in which each face and edge is flattened and made square (90 degrees) to the adjacent surface. Whether this is done using hand tools or with machines, the steps in the process are the same. In this introduction the process will be focused on using hand tools but I will indicate briefly the machine tools that can be used instead for each step. I have listed a minimal hand tool list for the process in Table 1 at the end of this article. While I highly recommend attending a woodworking school with an emphasis on developing hand tool skills, this may not be possible or affordable. Fortunately, the internet is available. With persistence the requisite knowledge and skills can be gleaned from this source. I have indicated some of the best of these available in video format at the end of this article.

Dimensioning Your Lumber

Step 1: Cut the board to rough width and length leaving 1/4 - 1/2” in extra width and 1 - 2” in length. Adding a little extra length and width is a corollary to measuring thrice, cutting once. The process of squaring and flattening often leaves the ends and edges a little off. So the very last step is cutting to final length. A rip saw is used to cut the board to rough width and a crosscut saw is used to cut to rough length.

Power tool approach: a jig saw or miter saw can do the cross cuts and a table saw or jig saw can make fast work of cutting to rough width.

Step 2: Flatten one surface (face #1). Inspect the board and determine which face is the flattest and if the board will rest most securely on your flat bench. Usually this will mean placing the cupped side down. You may need to shim the board so that it will be firmly in contact with the bench and not rock back and forth. Using winding sticks (see below) and a straight edge, identify the high spots (mark with pencil or dry erase maker). Using a scrub plane or a jack
plane with a cambered blade, work across the board at about 45 degrees to “scrub” the high spots down. The cutting surface of a plane blade can be precisely straight from side to side or it can form a convex curve. A curved blade is cambered (see photo) to various degrees to prevent the corners of the blade from digging into the wood and leaving tracks and to allow for faster wood removal.

To hasten progress work from the other side of the board as well, also at 45 degrees. To avoid tear-out along the edge, it should be chamfered (cut off the edge or corner). Use the winding sticks and straight edge to gauge progress. Mark the high spots and repeat the “scrubbing.” When you get closer move to a longer plane (jointer plane with a longer sole and a blade with almost no camber.) This longer plane will allow the blade to skip over the low spots and remove the high spots.

Often this action will initially be from one corner to the distant opposite corner along the length of the board. With patience and persistence as well as frequent checking, squareness is achieved. Mark this reference face.

Power tool approach: a hand-held power planer can flatten the high points quickly and a power jointer can create a flat board in a few minutes.

Step 3: Joint one edge (edge #1) to make it flat and exactly perpendicular to the reference face #1. This process is often referred to as joining because it creates surfaces that allows two boards to be edge joined together. This edge should be planed with a relatively long plane (e.g. Stanley #5, #6, #7, or #8) and while holding the plane sole perpendicular to the reference face. The goal is to remove any defects in the edge and begin the process of removing any high points. This is checked with a straight edge or using the straight edge of the plane.

Next use a combination square to carefully visualize the edge for squareness to the reference face at both ends and the middle of the board. Mark the high points and start planing. This is fairly simple to do but difficult to describe. There are excellent videos on YouTube that should
be watched to see how this is done. After squaring this edge and before proceeding to the next step mark this edge.

Power tool approach: While at the jointer rotate the reference face so that it is held firmly against the fence which is square to the cutter head and bed. A flat edge that is square to the reference face can be achieved in minutes.

Step 4: Flatten the other face surface (face #2) so that it is coplanar to face #1. Working from the reference face, use a marking gauge to mark the desired thickness of the board on both edges. These lines should run the length of the board. Depending on the amount of wood to be removed, you will start with either a scrub plane or a jointer plane. Just as in flattening the initial face, utilize your winding sticks, straight edge, and combination square to determine the location of the high points requiring planing. Accentuate the gauge marks on the sides by running a contrasting sharpened pencil down the marking gauge lines.

Power tool approach: Flatten the second face by running the board through the power planer with the reference face flat against the planer bed.

Step 5: Plane the remaining edge to be parallel to edge #1. Working from the first edge, use a marking gauge to mark the desired width of the board on both faces. These lines should run the length of the board. Using a jointer plane, plane down to these lines. Just as in flattening the initial face, utilize your winding sticks, straight edge, and combination square to determine the location of the high points.

Power tool approach: Rip the board to width using the table saw making sure that the squared edge is against the fence.

Step 6: Square the ends to length. Use your miter saw to square one end. Then carefully measure to length (measure thrice, cut once) and cut.

Power tool approach: Cut the board to length using either a miter saw or a table saw with a crosscut sled. It is noteworthy that steps done in the above order are most conducive to optimal efficiency when working with machines since the first two steps are done at the jointer.

Table 1. Tools Required for Dimensioning Lumber by Hand

- Workbench (solid with a flat surface)
- Jack plane (e.g. Stanley 4, 5, or 5 1/2)
- Jointer plane (e.g. Stanley 6, 7, or 8)
- Panel saws (e.g. vintage Disston rip and crosscut saws, or two Japanese katabas – one for cross cuts and the other for rip cuts)
- Miter box and miter saw (vintage or new, power miter saw)
- Combination square 12 inch (e.g. Starrett)
- Try square (12 inch)
- Winding sticks (make your own)
- Level or straight edge.
A Woodworking Primer

- Marking gauge (vintage or modern wheel cutting gauge)
- Marking knife
- Pencils (2 mm mechanical pencil or carpenters pencil for rough marking, 0.5 mm mechanical pencil for fine details; white lead is easier to see on dark woods)
- Clamps (or cramps if you prefer; a few hand screw clamps and a few parallel or f-style clamps)

**Winding sticks:** A pair of winding sticks is a tool, used to view the twist or “wind” in pieces of lumber. The sticks can be quite simple and are typically at least a foot and a half long. They need to be straight and with flat parallel edges. One stick is placed at the end of a board and the other stick is placed at the opposite end, parallel to the first. One then sights along the top edge of a stick and if it is perfectly in line with the other stick then the board is flat (no twist or wind). The length of the stick amplifies the degree of twist. Using highly contrasting woods allows for easy sighting. Rob Cosman has an excellent video on using winding sticks (cited below).

References:


Paul Sellers ([https://www.youtube.com/watch?v=Cl5Srx-Ru_U](https://www.youtube.com/watch?v=Cl5Srx-Ru_U))

Rob Cosman, How to Use Winding Sticks. ([https://www.youtube.com/watch?v=g60GrUufgWM](https://www.youtube.com/watch?v=g60GrUufgWM))

Rob Cosman tips for dimensioning wood. ([https://www.youtube.com/watch?v=26Rt54zVY3Q](https://www.youtube.com/watch?v=26Rt54zVY3Q)).


Dimensioning lumber with machines is the other approach. Here are a couple of videos for machine milling.


Philip Morley. ([https://www.youtube.com/watch?v=ahr7oUWhiLU](https://www.youtube.com/watch?v=ahr7oUWhiLU))
The Need for Accuracy

Accurate practices complement accurate tools

By Linda G. Smith

Good enough doesn’t usually work in woodworking. You’re not building a deck or shed; you’re building a wooden treasure. Quality measuring tools are a must-have, but the person taking the measurements is just as critical. Take your time and concentrate and learn these tricks and tips.

If you’re milling your stock or buying it from a big box store, one of the first things you must do is measure your pieces. When you’re roughing out wood you can use a tape measure and chalk but when it comes to your final sizing, a metal ruler with etched numbers is more accurate. Check that your stock’s sides are at right angles to each other. Use a quality machinist square to do this. The gold standard is a 12” Starrett Combination Square used by most woodworkers. However, there are cost effective machinist squares without numbers that are perfect for checking for square. The smaller sizes are handy and fit easily in your pocket or apron. Other quality measuring products are made by Woodpecker and Incra.

To check for square hold your piece and the square up to a light to be sure no light is coming through. If the stock is not at perfect right angles continue to mill it until it is. Tools for milling right angles are the jointer or a hand plane. Starting with flat and square is the first step towards accuracy and quality joinery.

When your pieces are squared up you can cut them to length. For best results cut to the outside (the waste side) of the line. Allow for the thickness of the blade. Sneak-up on your line by taking small cuts one at a time. Check your measurements until the size is as exact as you can make it. An inaccurately sized piece will cause problems all the way through your project.

When measuring for joinery (half lap, dados, grooves, or mortice and tenons) use a mechanical pencil with a 0.5 lead, your quality square, and a metal ruler. If you’re going to saw or chisel to a line mark it first with a marking knife unless it’s in an area where the scratch will be seen upon completion. The groove from the marking knife will guide the hand saw or chisel. If you’re drilling a hole, mark the exact spot with an awl to guide the bit and prevent wandering.

Almost finished with your table, box, or anything rectangular? Do a dry fit first with clamps and no glue. One key check for accuracy is to measure your two diagonals. Having the two long sides be the same length and the two short sides the same length is not sufficient. The diagonals should be the same as well. If they are not, check the size of your parts and then tighten the long side with a diagonal clamp until the two diagonals match. Then you are ready for glue-up.

Most of us start out using far less than top-quality tools. Good measuring tools and the proper respect for accuracy are essential to becoming a fine woodworker.
A Woodworking Primer

Which Wood to Use

*Different species have different properties*

By Randy Hock

An amazing array of wood species are available for building furniture and other projects. This makes it hard sometimes to decide on the optimal wood for a given project. A beginning assessment is answered by what is available and affordable. For example the Big Box stores in the Southeast carry Southern Yellow Pine, a fairly dense softwood, as dimensional lumber at a fairly inexpensive price. I have rarely seen it here in New England. Many other woods are also only regionally available. Mesquite for example is difficult to find outside of the Southwest and Sitka spruce outside of the Northwest.

Woods that are readily available in N.E. include pine, fir, ash, basswood, birch, cherry, cypress, hickory, Honduras mahogany, maple (hard and soft), oak (white and red), yellow poplar, and walnut. Additionally, a large number of non-domestic species are available at lumber yards.

A very good source for information on wood species is available on line as The Wood Database (https://www.wood-database.com/wood-articles/wood-identification-guide/) which has over 600 species characterized and is very easy to use. To show how this site appears I have included a page about white oak.

Also at this website, the main characteristics of the wood are discussed in tabular form: color/appearance, grain/texture, rot resistance, workability, odor, allergies/toxicities,
A Woodworking Primer

pricing/availability, sustainability, common uses, and general comments. Since we often choose wood for a project on its superficial appearance: color, grain structure, and finish characteristics, it seems prudent to explore other properties of the species. Hence, before deciding to use a type of wood for a project I look at the database to see if there are good reasons to NOT use a particular wood.

For example, elm has grain which is interlocked which makes it very resistant to splitting and thus makes it very challenging to work. Some articular uses of wood to be avoided include: pine for chair legs (too weak), outdoor furniture of birch and beech (poorly rot resistant), wine or spirit barrels of red oak (very porous with no tyloses so will leak like a sieve), particle board will disintegrate with any water contact, etc.

Our predecessors often used 4, 5, or 6 different types of wood when constructing chairs with each wood having characteristics optimal for a given function. A Windsor chair might have had the arms and chair back made of ash, beech, hickory or oak because these were strong woods that could be readily steamed and bent. Hard maple was used for turning legs and stretchers, and spindles were made from riven ash for strength and flexibility. Seats were often carved from a thick plank of easily carved pine. Pine was avoided for other chair parts and in no case was a softwood ever joined to another softwood. Coopers made barrels from white oak for liquids and red oak for grain storage (non-liquid). A chopping block for a butcher was typically made from end grain sycamore. Walnut was not used for chopping boards because the oils could impart flavor. So, maple or beech was used.

In the table below, common domestic woods are grouped according to their resistance to decay (bacteria, fungi, and insect). I have included this table taken from the Forest Products Laboratory Wood Handbook because it is information that is not readily available. Note that black locust, red mulberry, Osage orange, and Pacific yew are highly decay resistant. This decay resistance is due to non-structural organic compounds in the heartwood known as extractives.

Choosing wood for a project must include a discussion of wood grain. As R. Bruce Hoadley points out (references below) there are more than 50 ways that this term can be used in describing wood. A common usage is describing the direction of the dominant longitudinal cells in a tree and can be clarified by using the term “grain direction”. In the figure below the cross sectional surface X corresponds to the end grain surface (endgrain), the tangential surface T refers to the flatsawn or flat-grained surface, and the radial surface R is referred to as radial grain, vertical grain, or quarter-sawn. The cyclical growth of wood cells yields annual growth rings. In a typical hardwood (e.g. the oaks), each annual ring is divided into early wood and latewood. Red and white oaks are ring-porous woods which have very prominent early wood pores that can be seen with the naked eye and much smaller pores in the latewood. This gives oak lumber its characteristic “open grain” appearance when flat sawn boards are examined.
The term “figure” is the appearance of the grain as it is exposed on the surface of a board. This is where choosing the right wood for your project gets interesting. I am including a few examples of unusual figured woods. Highly successful and beautiful pieces of furniture are often those that manage to incorporate exquisitely beautiful figured wood with complementary, composed and balanced other elements.

The choices you make in the types of wood and the grain and figure patterns while creating furniture pieces allow you to make functional and beautiful products. And remember you can always make another one.
References:


EMGW.org 27
Wood for Furniture: Kiln-Dried vs. Air-Dried

Moisture can be your friend... or not

By Jim Allen

This subject is old as ‘which came first, the chicken or the egg’? Well, at least as old as the industrial revolution in the early 19th century that ushered in factory produced furniture for the masses. Factory owners needed a faster, albeit more consistent method to dry lumber for higher production methods.

Get any number of woodworkers in a room, start a discussion of kiln versus air and you’ll be talking for hours! Especially if the group includes turners. For those who turn bowls; the preferred method is to rough turn a piece of green wood and let sit, air trying for at least 6 months. Turning a kiln- or air-dried piece can create a lot of heat in the workpiece. For spindle turning, I’ve never heard anyone say that air-dried wood performed any differently from kiln-dried. But many non-turner furniture makers favor kiln-dried because the wood is more stable. One note of caution: stresses in kiln-dried stocks can be released in higher speed turning. This can be dangerous if kiln-dried stock cracks and releases flying scrap.

For reference the moisture content of wood is as follows:

<table>
<thead>
<tr>
<th>Moisture Content</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Green, a fresh cut tree and boards</td>
<td>30% to 45%</td>
</tr>
<tr>
<td>Air-Dried, after 12 to 24 months</td>
<td>15% to 20% depending on thickness</td>
</tr>
<tr>
<td>Kiln-Dried</td>
<td>6% to 10%</td>
</tr>
<tr>
<td>Ideal Furniture lumber?</td>
<td>7% to 9%, whether air or kiln-dried</td>
</tr>
</tbody>
</table>

Given time, the moisture content in lumber adjusts to the environment it is in to reach and equilibrium state at which point the wood neither gains nor loses moisture. With air-dried wood there are no internal tensions baked into the wood. Kiln-dried wood on the other hand can be more fragile and break off easily. Whether wood is kiln-dried or air-dried, the goal is to draw as much water out of the wood as possible to stabilize the wood for woodworking and to stop potential for fungus or insect infestation.

Kiln-Dried

Kiln drying is a process where green lumber is stacked inside an enclosed chamber with heated forced air circulation, with or without added steam for humidity conditioning. The drying process takes from six to eight weeks. Due to the faster drying conditions (compared to air drying), the wood fiber cells collapse faster. This creates an instability that can result in twisting, cupping, and bending as the lumber is worked and moisture is reabsorbed, expanding the wood cells back to the relative humidity of the environment. This exposure may also release the natural stresses embedded in the original log.
A Woodworking Primer

The kiln drying process often creates a ‘case hardening’ surface that keeps moisture out until the board is cut. You will read many woodworking articles that advise you to cut your stock to a rough finish size and stack with stickers before use. Even after the cut pieces have sat for some time, they may move again, a condition that has frustrated my woodworking more than once. This is why experienced woodworkers bring their boards into the shop to acclimate and dry further.

The good news for kiln-dried lumber is that due to the high temperature process and reduced humidity any live insects, larva, and mold in the boards are killed off. Due to some newer international regulations, a special chemical treatment may be added for mold and insect elimination. This is a cost adder and certification requirement for international shipment of wood products.

Air-Dried
Air drying is a lengthy process taking from 12 to 24 months to do. A rough rule-of-thumb is one year of air drying for each inch of board thickness. So, a 6/4 or 8/4 board can take two years to reach equilibrium.

For outside drying, rough-cut boards are stacked on platforms at least 24” above ground in an open sunny area with stickers (wood spacer boards) placed every 3’ to 4’. The completed stack is then covered with an overhanging canopy and weighted to hold it down. Many small shops will have an enclosed shed or garage space to stack wood.

Why is air-dried more stable then kiln dried? During the slow, unforced drying process the wood stresses and movement from loss of moisture content occurs gradually over time. The dried boards may have checks (cracks) on the ends, cupping, twisting, warping to deal with, but should be very stable. There will be material loss as you select sections or portions of each board for your project. Fortunately, there are many uses for the cutoffs and scraps. The last step is to bring the wood into the workshop and let sit for one to two weeks to further come to equilibrium with its new environment.

There is little to no difference between kiln or air-dried lumber when working with machines. I find that air-dried provides a cleaner cut and fewer surprises. On the other hand, I find a big difference when using hand tools - planes, chisels, and saws. It takes less effort and muscle mass to accomplish the same task with air-dried, especially squaring an end on a shooting board. Another benefit is seeing the difference in color retention. Kiln dried wood often loses up to 20% of its color. This is especially true with walnut.

When you’re starting out, you will most likely be buying kiln-dried lumber from one of the many commercial suppliers in the area. In time you will come across a supply of air-dried wood to try for a project. No one can tell you which is preferable. That decision will be made by working over time with both types of dried wood.

My one recommendation is to buy a moisture meter and check your wood before each project.
WOODWORKING TOOLS
Tools for Sawing Wood

Accuracy and safety are top concerns

By Jim Tartaglia

Saws used in furniture building are either power-driven or manual. Hand-held power saws, such as circular saws and jig saws, are used typically when you need to bring the tool to the workpiece, as is the case when you are building a house or something large or unwieldy. Hand-held tools are the tools of carpenters. Stationary power saws, like table saws or band saws, are used when you can bring the workpiece to the tool, as is the case when you are building a piece of furniture. Stationary power tools are much more precise than hand-held power tools and thus are the choice of fine woodworkers.

The most common stationary power saws are table saws, band saws, miter saws and scroll saws in about that order. The radial arm saw was popular in the last half of the last century, but it has fallen out of favor. The power behind nearly all modern woodworking power tools is electricity (air-driven tools are much less common). If you are setting up or upgrading a shop, think about getting heavy duty wiring installed. This means 20-amp circuits, like you would use in a modern kitchen. Bear in mind that that some tools may require 220-volt service as well. Recently, some vendors have introduced battery-powered track saws, miter saws, routers, and other woodworking tools for those who see an advantage in not needing to plug into a standard electrical outlet for whatever reason.

Table saws
I know at least two highly competent woodworkers who do not own table saws and use only band saws, but they are rare exceptions. By a wide margin the table saw is the most common stationary power tool in most woodworkers’ shops. Besides the saw blade itself, key elements of any table saw are the fence, which is parallel to the blade, and the miter gauge which rides in a slot in the table top also parallel to the blade. Miter gauges typically can be set at different angles to the slot, although $90^\circ$ is the most used setting. Miter gauges are available in a wide variety of price points and features.

Kickback is a hazard when using a table saw. See the article “Ripping Stock Safely” elsewhere in the guidebook. Kickback occurs when the saw teeth grab the workpiece as the teeth emerge from the table rear, lift the workpiece, and throw it back towards the operator with great speed and force. Go to youtube.com and enter “table saw kickback” to see this process in action and learn how to avoid it.

Some of the gadgets used to avoid kickback are cumbersome and cannot be used for many types of cuts. The splitter (or riving knife), a device that sits behind and in-line with the blade is the easiest and cheapest solution. The splitter works because it prevents the board from contacting the rear of the blade.
A Woodworking Primer

Good practice when using a table saw should include using push sticks and featherboards and raising the blade no more than ⅛ inch higher than the thickness of the workpiece.

Most table saws ship with a miter gauge. This one has indents for common angle settings, but ships without a miter gauge fence.

A miter gauge with an extensible fence and an embedded flip top stop.

A backer board attached to a miter gauge prevents tear-out when cross cutting.

The power, high speed, and carbide teeth of modern saw blades make the difference between ripping and crosscutting on a table saw less important. In fact, blades can be purchased for both ripping and crosscutting called combination blades. Combination blades work well but, because of the high speed and extreme sharpness of sawblade teeth, you can rip with a crosscut blade and vice versa. To rip a board on a table saw, you would set the fence to the appropriate distance and run the board against the fence. Never touch the wood with your hand until the saw blade stops.

The best way to crosscut (make a board shorter) on a table saw is to use a crosscut sled. The principal here is that the workpiece is held in place on the sled while the sled moves against the table saw. This makes the cutting operation both safer and more accurate. Many tutorials on using and making a crosscut sled are available on-line. Several vendors also sell commercial versions.

A home-made crosscut sled.

A splitter added to a table saw insert for safety.

A riving knife that will move up and down with the table saw blade.
The table saw can be used to make a wide variety of special cuts from cove molding to finger joints to dovetails. Once the basics of rip sawing and crosscutting are mastered it is easy to move on to more complicated cuts.

**Band saws**

Band saws have the ability to cut curves. Band saws cut by driving teeth straight down into the workpiece pushing the workpiece down towards the table. Hence, there is no chance of kickback so bandsaws are safer than table saws. However, a rotating bandsaw blade can still cut off your finger. Band saw blades are continuous bands of flexible metal with teeth on one side. The blade fits over two wheels, one at the top and the other at the bottom of the saw with their teeth facing down towards the saw table. The narrower the blade, the tighter the curve it will cut. The fewer the teeth per inch the thicker the workpiece it will cut. Manufacturers have charts outlining this.

Differentiating between ripping and crosscutting on a bandsaw is not important. Band saws have a fence, but it is not used when cutting curves. Curve cutting is done freehand by following a line drawn on the workpiece.

Cutting straight lines on a bandsaw involves dealing with a phenomenon known as bandsaw drift which occurs when the bandsaw blade, which is very thin, bends slightly and moves away from the nice straight line you want it to follow. There is no universal agreement on the causes and solutions to this problem, but most agree that dull blades are one definite cause.

Besides cutting curves, bandsaws are useful for resawing, an operation that makes thinner boards from thicker ones. For example, if you had a board ten inches wide and a little over two inches thick you could resaw to make two pieces ten inches wide and one inch thick. Most 10” table saws can cut through 3 inches of thickness in one pass, but band saws can handle two to four times that amount.

Bandsaws are sized by wheel diameter which also provides a measure of the depth or width between the column and the blade itself. The two measurements are nearly the same, but not exactly since the guard on the column that protects the end user from the blade as it travels from the lower wheel to the upper wheel makes the throat depth slightly smaller than the wheel diameter.
Miter Saws
Chop saw and cutoff saw are two descriptive names for miter saws. There are several popular brands with various features. These are crosscut saws that can make boards shorter either at 90 degrees or some other angle or even compound angles, hence the name miter saw. Most miter saws used by woodworkers have 10” or 12” circular blades which determines the depth of cut possible. With basic saws the blade mechanism simply moves up and down. Sliding miter saws add rails or articulated arms to let the saw blade move front to back as well as up and down so that longer cuts (on wider boards) can be made. The miter saw blade spins in the direction that drives the wood away from the operator so there is no kickback threat.

If you have a table saw and a sled the need for a miter saw is reduced, but it is handy to be able to shorten a board without having to drag out and mount a table saw sled every time. In addition, working with long boards on a table saw can be awkward. For example, if you need to shorten an 8’ board by two inches, you will need 8’ of space either to the left or right of your
table saw blade. While this is also true for a miter saw, most workshops have designed the space for the miter saw with this in mind.

Scroll saws
Scroll saws are used mostly for crafts and decorative work. There is even a magazine devoted exclusively to scroll sawing: https://scrollsawer.com. Scroll saws cut like hand saws, that is, by moving the blade up and down in the wood, cutting only on the down stroke. The blade is held at the top by a reciprocating mechanism on the end of an overreaching arm and passes through a hole in the table. The blade is held at the bottom by another reciprocating mechanism. Fine sawdust obscuring the line of cut is a problem with scroll saws and many models have some type of largely ineffective blower to puff the dust away.

Hand Saws
Hand saws are used far less frequently than power saws for several reasons. Hand saws are much slower and require more work to operate. Because they don’t use carbide blades they need more frequent sharpening, and they require far more skill and practice to use well. With about ten minutes of instruction the novice woodworker can rip a board on a table saw. To be able to rip the same board with a hand saw calls for a lot more practice. Hand saws do have an important role in the workshop and it is worthwhile to put in the time and effort to master their use. For some cuts it is easier and faster to use a hand saw than it is to take the time to set up and adjust a table saw to make the same cut.

Western hand saws cut on the forward or down stroke through the wood. Each of the teeth makes a small cut as it passes through the wood. The up or back stroke simply pulls the blade back to get ready for the next cutting stroke. In other words, almost half the energy is used to do no cutting at all, but merely to reposition the tool. On each downward, cutting, stroke maybe a hundred or so teeth make their little cut. Compare this to a table saw which is dragging teeth at about a hundred miles an hour through the wood with no wasted energy on the back stroke and you will understand the preference for power saws.
A Woodworking Primer

So why use hand saws at all? Four good reasons are: small cuts, quick cuts, specialized cuts, aesthetics. If you are cutting a ¼ inch diameter dowel to length it is quicker and easier with a hand saw. If you are making one small dovetail drawer, like in an end table, a hand saw and chisel are about as fast as doing the complicated set ups required to do it with a table saw or band saw plus, when your guest is admiring your work and pulls out the drawer to see it, you comment quietly: “hand cut”. Hand saws spew around less sawdust, make less noise, and are cheaper than power saws although a top-notch hand saw can cost hundreds of dollars. I listen to classical music in my shop and I can actually hear it over the sound of a hand saw and, when I am sawing away with the same tool my forebears used, I feel more like a woodworker and less like a machine operator.

The traditional hand saw is so seldom used that it is not even listed in some vendors catalogs. The most common hand saws used in the workshop today are various types of back saws. The back of a back saw blade is reinforced with metal, usually brass, to make the blade stiffer. Back saw types include dovetail saw, gents saw, miter saw, tenon saw, carcass saw, and others. Some of the types are difficult to tell apart. Every shop should have one or two.

Hand saw tips: Take long strokes using as many teeth as possible on each stroke. Use a bench hook to hold the workpiece, hold the saw firmly but not overtight, always put the kerf on the waste side of the cut (this applies to power saws too), practice until you can cut a straight line. Other hand saws include coping saws and fret saws for cutting curves in small work.

Japanese saws are a special case. They have very thin blades (less metal to drag through the wood), are very sharp, and the teeth have no set. They cut on the pull stroke, unlike Western saws which cut on the push stroke. Because the teeth have no set they can be used to flush cut protruding dowels without damaging the main piece. They are inexpensive and one or two belong in every shop.

A final word, which applies to all types of sawing, regarding holding the workpiece when doing crosscuts. Whenever possible the workpiece should be supported at the point where the saw exits the wood. This avoids little bits of tear-out in the end of the workpiece which will occur if the wood is not supported. Tear-out doesn’t matter if you are building a picnic table but does if you are building a picture frame. On power saws tear-out is eliminated with something called a zero-clearance throat plate, which means there is no space between the sides of the blade and the hole where it passes through the table. You can buy or make a zero-clearance throat plate to fit in a table saw. Backer boards are sacrificial pieces of wood placed behind a workpiece to support the wood fibers and prevent tear-out as the saw blade exits.
A Woodworking Primer

Tools for Getting Started
Think about what you really need
By Jim Allen & Andrew W. Davis

The following are opinions and observations from a couple of woodworkers. The tools you need are generally a function of what type of woodworking you will be doing. Some artisans are focused on hand-tools; others may use both hand and power tools. This could affect the desired height of your workbench. Similarly, some woodworkers build small models or small boxes, while others are more interested in large furniture. Finally, cost is always a factor in deciding whether to invest in a tool and at what quality level.

Power Tools

Table Saw: A table saw is the real work horse for most woodworkers, so buying the highest quality product you can afford makes sense whether a contractor, hybrid, or cabinet saw. Modern table saws include blade guards and a riving knife – important safety factors. If you watch woodworking videos online, you may notice the growing popularity of the SawStop brand over the past few years. These machines are high quality and include a patented safety mechanism to prevent injury if you come in contact with the spinning blade (you can see the video online of this in action). Whether you think the extra cost is worth the investment is a matter of personal preference. One of the authors of this chapter has a SawStop, the other does not.

Drill Press: Many consider the drill press to be the second most important machine in the shop - a must-have for drilling straight and plum holes, boring for hand cut mortises, and possible drum sanding. Drill presses are available as both floor standing or bench-top models. Generally, they provide about 3” of quill travel (up and down), but a few sport longer specifications. You will want to add a drill press table with hold-downs and stop blocks on top of whatever table ships with the machine.

Jointer: The purpose of a jointer is to make a surface flat – this could be the face of a board or the edge. The size of a jointer is the width of the blade – they begin at about 4” and a common hobbyist jointer is a 6” model. Larger models are heavier and need more power while also costing considerably more. You may find 10” and 12” jointers in industrial shops. Newer models often feature spiral cutterheads rather than straight blades – these are quieter, easier to sharpen or replace cutting edges, and claim to produce a superior finish. The jointer is commonly used in preparing wood for the planer.

Planer: One of us has a Delta 13” bench-top and a Grizzly 15” floor model with a Spiral Cutterhead. The large units are great, but space (and power) is a consideration. Most bench-top models now are much better than the old ones, as confirmed by recently
published tool reviews. Many EMGW members are very satisfied with their 13-inch DeWalt planer. One company, Byrd Tools, even makes a retrofit helical head for the DeWalt machine which improves cutting performance and maintenance tasks and lowers noise levels.

Full size machine belt sanders, mortisers, Chop saws (aka miter saws), band saws, wood lathes, router tables, shapers are nice to have. Some would even say necessary, particularly in the case of band saws. These should be obtained as required and budget. Band saws are invaluable for cutting curves (can also be done with a hand-held jig saw). Perhaps even more important is that there is no kick-back with a bandsaw so if you need to rip or crosscut a board that is warped, twisted, or not flat, cutting on the bandsaw is much safer than on a table saw.

**Dust Collection:** As soon as budget and time allows, dust collection is a must-have for Cabinet Saws, Jointer, Planer, Sanders. (see separate chapter on dust collection)

**Hand Tools**

Woodworkers generally have a variety of hand-held tools - drills, jig saws, routers, palm sanders etc. The general rule of thumb applies - buy the best you can afford, particularly for any tool that you believe you will use often. Note that big box stores may sell the same brands as those of the woodworking specialists but often the tools from the big box stores are customized to reduce costs and may not actually be the same quality.

**Bench Chisels:** Check online for any tool reviews and then make your cost vs. quality decision. A general tradeoff often involves the metallurgy with some alloys maintaining their sharpness longer but are more difficult to sharpen.

**Hand Planes:** #5 and #4 are good starting points; you can add others as budget and requirement dictate (see the chapter on plane numbers). There are many sources for good quality used planes - Stanley/Bailey, Clifton, and others that may need just a new plane iron and clean up for little money.

**Sharpening:** There are different schools of thought here that include sharpening with sandpaper on glass, water stones, oil stones, and diamond plates. Each has its advantages and disadvantages, but no matter how you cut it, sharpening is a crucial task for any woodworker. Many prefer to use a jig that holds chisels and plane irons at the correct angles, but others do not and use the feel of the iron as the guide. Lee Valley published a Guide pamphlet “Sharpening by Hand, A woodworker’s Resource Guide” A sales promotion, yes but a great resource.

**Clamps:** You never have too many clamps (see the chapter on clamps). One of us has found cost-effective clamps at Harbor freight.
Getting Started with Hand Tools

It’s not all about power tools

by Randy Hock

Working wood with your hands and simple tools can bring great satisfaction and rewards. Deciding which tools are necessary to get started can be a daunting task, however. The good news is that you can outfit yourself quite well with less cash outlay than is possible with high-quality power tools. Also, due to the migration of woodworkers away from hand tools to motorized hand tools as they became available, there are still excellent, vintage hand tools on the market that can be brought back to useful life. The basic considerations are laid out here.

The activities that one does in the wood workshop can be categorized as 1) measuring and marking, 2) cutting, 3) shaping and shaving, 4) drilling, 5) sharpening, and 6) holding/clamping. Combining these activities into simple steps forms the basis for success in all types of woodworking.

Measuring and Marking. A woodworker generally needs to measure with great accuracy and mark with precision. A good quality 12-inch combination square is worth every penny. You will need a tape measure, a protractor, a bevel, a try square, a compass, a set of dividers, and perhaps a folding rule. Pencils of various types are necessary for labeling but for precise marking a sharp marking knife is preferred. I have found that a Stanley 10-049 pocket knife with a frequently sharpened blade to be my go-to knife. For laying out dovetails, tenons, and mortises a wheel cutting gauge works well. Mortise gauges are available on the antique market.

Cutting. Cutting wood is the *sine qua non* of woodcraft. A basic kit for the hand tool woodworker will contain a rip panel saw, a dedicated crosscut panel saw, and a rip dovetail back saw. These saws are widely available on the vintage tool market. Eventually, sharpening a hand saw will likely become an interest. It will be advantageous to perfect the technique on saws that were obtained for a few dollars instead of on a pricey new saw.

Shaping and Shaving. Chisels come in four basic varieties: bench chisels, paring chisels, mortise chisels and carving chisels. The former three are those for most furniture work. Bench chisels are so named because they are frequently used and often are found on the bench. They are somewhat stouter than paring chisels and are often struck with a non-metal mallet. Paring chisels are much more delicate, sharpened at a lower angle, and should never be struck with a mallet. Matched sets look pretty but do not make furniture pieces look better. I love my chisels from Lie Nielson but often reach for the one of the chisels from the set I bought at the Aldi Foodstore for $8. Bargains are also readily available on the vintage market. A starter set should probably include bench chisels of 1/4”, 3/8”, 1/2” and 3/4” and paring chisels of 1/4”, 1/2” and 3/4” or 1”. Mortise chisels have just one purpose which is to cut mortises. The most common mortise sizes are 1/4” and 3/8” so having mortise chisels in these sizes makes sense.
Shaping wood can be addicting. Shaping and shaving is what spokeshaves do. Though originally used primarily to shave the spokes for wooden wheels, they are indispensable in the modern wood workshop for shaping curved components. The Stanley No. 151 is a great tool to begin with and is still available on the vintage market for $10-50. Rasps look like files but are used for shaping wood instead of smoothing like a file. The best rasps have individually set teeth (“hand stitched”) and are a joy to use.

Drilling. The hand tool enthusiast will want a hand brace and an auger bit set as well as an egg-beater hand drill. A large brace is around $100 and a complete vintage auger bit set on e-bay will be around $100.

Sharpening. Sharp and tuned hand tools are critical to enjoyment and success in working wood with hand tools. There are as many methods for sharpening as there are articles written about the process. Fortunately, today one needs only a few sharpening stones and a leather strop or two to get the job done. Personally, I have graduated to a system that uses several waterstones (1000, 4000, and 8000 grit), two diamond steel plates (coarse and fine), and a lapping plate to keep the waterstones flat. I have two honing guides (Veritas and Robert Larson) but generally sharpen without them. Spend some time on YouTube to explore the techniques that the professionals use before investing. Also think about water stones vs. oil stones vs. diamond.

Clamping and Holding. One always needs another set of hands. Clamps and vises on a bench provide this. Hand screw clamps can be awkward but there are strong reasons for their staying power. They can be used to hold an object and then the hand screw clamp can be clamped to another surface or workbench. Parallel clamps provide versatility, clamping power, and non-marring surfaces. Most woodworkers would have more of these except for their cost. F-style clamps are simpler and provide the force at a focal point rather than spread over a broad service like parallel clamps. Ratcheting bar clamps do not generate the same force as other clamps but have merit for their one-handed use and affordability.

Workbenches. My workbenches have included a small table that doubled as a kitchen table, a discarded door set on sawhorses, a nailed together bench made from 2 X 4’s, a split Roubo with leg vise and sliding deadman, and a copy of Phil Lowe’s basic work bench that has drawers and a small cabinet beneath a small solid top. Work benches are critical to success in handwork and really have only a few requirements: they should be solid with a flat top and have means for holding wood (a vise or two and components for clamping). The bench should be sufficiently heavy to not move while handplaning.

“When I look at a furniture masterpiece, I view it as a composition of rudimental tasks that represent a wonderful endeavor of the human spirit; a collection of all that is simple into something that is grand.”  Master Phil Lowe
Milling Rough Lumber

Getting Started on the Right Foot

By Dave McCormick

This section will review buying and milling rough lumber for furniture projects, and the equipment required to do the work.

Milling is the process of using power and/or hand tools to work on rough boards. The objective of milling is to create two parallel flat faces, one square edge and the desired thickness.

Why use rough lumber when you can buy lumber with both sides and one or both edges finished? Rough lumber is less expensive than finished lumber. Finished lumber is commonly milled in one session with long boards, often times leading to boards that are not flat and have noticeable cupping. Buying finished boards may make sense when a woodworker is just starting out and may not have the tools and the equipment to mill the rough lumber. Over the course of a woodworking lifetime you will save a lot of money and frustration working with rough lumber.

The first step in successful milling is buying quality lumber at the lumber yard. Before going you need to have a clear list of what you want to buy, both in species and dimensions and quality. On every new project I make out a stock list. If the project is complicated, I will make full scale drawings of the piece before developing the stock list. The drawings are also useful for laying out joints and modifying the dimensions. I build many pieces with curved elements where drawings are critical.

From the stock list I develop a good idea of what type of boards I will need to buy. I also have a limitation of a maximum 8 ft. boards in my car. My jointer is 8" wide. If possible I try to buy boards 8" wide or less. Once you are at the lumber yard, take your time. I normally go to Highland Hardwoods in New Hampshire. Between the 10 percent guild discount and no sales tax, it saves a lot money. Select lumber as straight and flat as possible. I will often go through every board in the stack to get the boards I want in the thickness and species I am going to use.

An example of a stock list is shown below. Note that the rough thickness is 1/4” more than the finished thickness; the rough width is 1/2” more than finished width and the length is 1” longer than finished length.

Once the wood is in my shop, I lay out the boards based on my rough stock list. This may take several interactions in order to obtain an efficient use of the stock and a pleasing grain orientation. Now I am ready to begin milling the rough stock. I begin by cutting the boards to rough length (1” longer than finished stock) on my radial arm saw or another type of cross-cut saw.
The main objective of milling is to develop a reference face and reference edge. Both of these are produced on a jointer. The boards are all run through the jointer until they have one perfectly flat face. If the boards are cupped, the cupped face should be down.

The flat face is marked and the grain direction is marked on the face. One edge is then jointed, with the flat jointed face against the jointer fence. Then mark the square edge. My former teacher, Phil Lowe, had a saying, “flat, straight and square, you are halfway there.”

After jointing a flat face and edge, the boards are run through a thickness planer to bring them to final thickness. If you had an original 4/4-thick rough board, and need a 3/4 in thick finished board, it is best to bring the board to 7/8” thickness the first day, sticker the boards overnight, and then bring them to final thickness in the next day or so.

If you do not have a jointer, it is possible to use a good hand plane(s) to get one flat face and one flat edge. The last steps are to rip the edge to final width and then crosscut the boards to final length.
A Woodworking Primer

Some Suggestions:

For the novice woodworker beginning to layout their shops and purchase power and hand tools, here are some suggestions.

In my current shop I have a table saw, a 14” bandsaw, an 8” jointer, a 13” thickness planer, a router table, a radial arm saw, a scroll saw, a bench top mortising machine, and a midi lathe. I also have a full assembly of high-quality chisels, hand planes, and saws.

Start with a high-quality table saw. The table saw is the work horse of any shop. The additional safety of Saw Stop type table saws is worth the investment.

A band saw is a valuable and versatile power tool. For many woodworkers, the band saw is their most-used tool.

Thickness planers are relatively inexpensive and do not need a lot of space. They are essential for bringing multiple pieces of wood to the same thickness or to make one surface of a board flat and parallel to another flat surface.

There are high schools and other programs which have woodworking classes with fully equipped state of the art shops. I help teach a woodworking class at a local high school. While many students are novices, there are some experienced students who come to the class just to mill their lumber.

My shop space is in the basement and relatively small. All of the equipment is on ‘wheels’, so they can be moved when extra space is required. My bench is also on casters for the same reason.

My hand tools were collected over a long period of time. Many of them were gifts from Santa, birthdays, and other occasions. Let people know what you want. Buy quality tools! They will last a lifetime and you can hand them down to the next generation.
How to Read Grain
Avoiding Problems and Enhancing Beauty
By Rob Carver

Introduction
The chapters about “Ripping Stock Safely” and “Sawing Fundamentals” introduce important knowledge about grain in a piece of lumber. It turns out that grain direction and the character of grain in different wood species are also important to anyone starting out in woodworking. As you develop your skills and interests, you’ll continue to learn about the ways in which grain can either frustrate your efforts or genuinely beautify your project. This section describes two important reasons for learning to read grain.

The Plain Truth
You can make some projects from prepared stock directly from the home center or lumberyard, but typically the lumber you purchase needs to be reduced in thickness or glued edge-to-edge. At that point, the wood must pass over a jointer, through a planer, or under a well-sharpened hand plane. Picture petting your dog or cat, whose fur lies naturally in one direction. Stroke Rover or Mittens from tail to head at your peril. The same is true for running a sharp edge over a piece of wood.

Every board has a two faces (or surfaces), two edges, and 2 ends, as shown in the illustration to the left below. The grain in any given piece of wood might be unruly, but let’s start with an idealized picture of straight face grain and think about planing an edge.

It is very common to glue several boards together to create a wider board, such as for a table top. One cannot rely on glue to fill gaps, so it is necessary to joint or hand plane the long edges of two boards to match closely. When you look closely at the surface and edge of a board, you should notice that the stripes of the grain slope upwards or downwards. Sometimes a magnifying glass or your cellphone camera can help you see the pattern if it is hard to discern.
You want to run your plane in the same direction as the rising grain, following the wood fibers as they emerge from the board, with each fiber supported by the ones beneath it. The result is a smooth, glassy edge that is ready to glue. If you go the other way, you’ll lift and tear the fibers and end up with a messy, torn, and fractured edge. The same is true if you are using a jointer.

Flattening or altering the thickness of a board requires the removal of material from the face of a board. Faces also have grain direction, and you can read face grain direction either from the edges or from the face and ends. When the end of the board shows concave (“smiling”) growth rings and the surface has a so-called cathedral (arrow-shaped) arches, the arrows point the way. If you’re not sure which way the grain is running, slide a dry rag in both directions and see where it catches. Plane in the catch-free direction. You can also attempt a light, short cut and see whether the grain lifts up or lies down.

This brings us to end grain, which is well-represented as the end of a bundle of straws or a broom. Visualize running your hand across the tips of a broom. They flex and do little to support one another. Similarly, if you try to slice end grain with a blade, the fibers tend to bend and break off at the edges. A blade would need to be super sharp and approach at a low angle.
Planing end grain should be done with only a hand plane, and NEVER with a power jointer or power planer. Sanding might be sufficient to clean up the end grain on a cutting board or a table leg, but a low-angle block plane is the tool of choice for end grain that will be a visible in the final product.

Everything discussed thus far also applies to using bench chisels, carving gouges, and router bits. Once you understand and watch for grain direction, it will become second nature.

Unfortunately, the next piece of wood you pick up may not conform to the simplified diagrams shown above. Grain is not always straight, and sometimes changes direction more unpredictably than a Boston driver. Dealing with squirrely grain is challenging, and beyond the scope of this chapter, but many hurdles can be avoided by reading the grain when you select wood in the first place.

**Stock Selection**

Some of the challenges of unruly grain can be avoided by choices you make when you purchase lumber. At this point, you should also read (or re-read) the chapter on “Buying Lumber” for additional valuable advice.

If your project will feature “figure” --eye-catching patterns in the wood itself—then you want to buy wood from a hardwood dealer, and you should chat up an experienced staff person there to describe your objectives. Be aware that it’s the crazy grain that produces beautiful figure, so expect challenges in milling highly figured stock. It can be difficult to discern grain patterns in unsurfaced, rough lumber and an experienced guide can point the way.

If the aesthetic appeal of your project is in the design, rather than in the lumber itself, then spend time looking at boards with straight, consistent grain. You may examine and reject many boards before finding suitable stock, but you’ll save time and aggravation back in the shop.

**Important Takeaways**

Grain direction and patterns are the product of how a tree grew and where the board was located within the growing tree. Species, age of the tree, location of limbs, healed wounds, and peculiar circumstances in the life story of the tree can all contribute. Different species have characteristic grain attributes, and individual boards from a single tree can exhibit remarkably different patterns. Wild grain can be a source of beauty as well as of challenges to the woodworker.

Learn to look at the face and edges of every board before each milling step, and you will be well on the way to achieving tight edge joints and glassy surfaces that need a minimum of sanding.
Hand Plane Arithmetic

The Plain Truth about Plane Numbers

By Andrew W. Davis

When I started woodworking I owned just one very old, and very inexpensive hand plane. It was a hand-me-down from my father who was not a woodworker. Quite frankly, the only tools I ever saw him use were a screwdriver and a hammer and maybe a non-electric drill. My eyes were opened to a whole new world a few years ago when I attended a trade show sponsored by Fine Woodworking Magazine.

One of the exhibitors there showcased a nice collection of hand planes. They were not inexpensive but I decided to take the plunge and bought a #4 smoothing plane. While there I also looked at two larger planes, a #5 and #7. But then a few days later I read a magazine review of a #60½ block plane and thought to myself, “this thing must be huge!” Who could even lift it, never mind shave wood with it?

If you look online for used hand planes, or visit antique stores, you will see that hand planes have their own cult of collectors. And then you might wonder where woodworking hand plane numbers came from for. I’m sure there are some EMGW members who could explain it all.

Nevertheless, I started some research to find an explanation of hand plane numbers.

Short answer: The numbers you see today correspond to the numbering system put in place by the Stanley company sometime in the Middle Ages. In theory, the number system classifies hand planes based on their size, not the number of paychecks it takes to buy one. At least that was the case for numbers 1-8 (bench planes). Beyond that, I can’t say much.

In the Stanley world (be aware - not all vendors follow the Stanley rules), smoothers are generally considered to be #2, #3, #4 and #4½, and are used for final surface smoothing because the lengths can follow the board. The #5 is a jack plane, i.e., "jack of all trades" and while jack planes can be used to smooth, they are not designed for that because they are too long for smoothing and too short for jointing. Jointing is the purpose of #7 and #8.

The numbering system can become quickly illogical and/or confusing. For example, a #5½ jack plane is a slightly wider, heavier version of the #5, while the #5¼ is a narrower, lighter version of the #5. You can’t make this up. A C at the end of the number indicates a corrugated sole, while an A before the number indicates aluminum.

If you want infinite details, search online for “Patrick Leach Blood and Gore” with its wealth of information on Stanley planes. It was written in numerical sequence following Stanley’s scheme.
One of the interesting and related web sites I stumbled across is
http://www.supertool.com/StanleyBG/stan0a.html which has numerous links to VERY detailed
and somewhat humorous descriptions of hand planes along with some rich images. The web
site also included the guide below on Stanley planes and numbers. Apparently, the numbers
don’t relate to sizes after you get past #8. I believe the web site author is Patrick Leach himself,
mister blood and gore.

Planes #1 - #8C (Bailey bench planes)
Planes #9 - #11 ½ (mostly block planes)
Planes #12 - #20 ½ (scrapers, more block planes, and circular planes)
Planes #21 - #37 (wood planes)
Planes #39 - #44 (dados, scrub planes)
Planes #45 - #A45 (the combination plane)
Planes #46 - #54 (combination planes, match planes, and the heavy-metal shooting board)
Planes #55 - #57 (combination plane of all and the geometric marvels of plane-dom)
Planes #60 - #70 (more block planes and more)
Planes #71 - #87 (routers, chamfer plane, rabbet planes, and scrapers)
Planes #90 - #100 (rabbet planes, side rabbets, special purpose planes)
Planes #100 ½ - #140 (more block planes, transitionals, and a #112 scraper)
Planes #141 - #196 (match planes, rabbet planes, special purpose planes, and fiberboards)
Planes #201 - #444 (block planes, special dados, scrapers, and dovetail planes)
Planes #602 - #608C (Bed Rock series)

Some might argue that the Stanley numbering system is inane. I won’t argue, but I could point
out that most of us blindly accept the Fahrenheit temperature scale, proposed in 1724 by Mr.
Daniel Fahrenheit. With that structure you have 32° for the freezing point of water and 212° for
the boiling point of water, the interval between the two being divided into 180 equal parts. I
would argue that his scheme is inane.
Dust Collection Overview

An Overview

By Jim Tartaglia

Dust collection in the shop refers to three types of “dust”:

1. The stuff commonly referred to as sawdust
2. Small chips generated by planers and jointers
3. Dust too fine to see.

All types of systems deal with the first type; two stage systems (described below) are best for the second; and collection bags rated 5 microns or less are required to collect the fine dust - the type that causes lung damage.

No dust collection system will get all the dust, thus the need for broom and dustpan, the original dust collection system.

You don’t need to go crazy. Match your dust collection system to the size of your shop and amount of dust you generate. A system with permanently mounted ductwork is helpful in a large shop and/or a shop that is used heavily. A system where the collector hose is moved from machine to machine is adequate in a small shop or one that is used occasionally.

A broom, foxtail brush, dustpan, and N95 mask make up the simplest, least expensive system and it is adequate for all three types of “dust”, but it will not collect dust at its source. It is also the least convenient and not at all sexy.

A shop vac, dust separator lid on a trash can, and flexible hose connecting the apparatus to your tools is the next level in terms of cost and sophistication. This solution will work OK for “dust”
types 1 and 2 but most shop vacs do not filter the fine stuff, so you may want to keep the N95 mask. If you upgrade to the next level, the shop vac has plenty of other uses around the house. The dust separator separates out the heavy wood chips, dropping them into a bucket; this extends the life of the dust collector/shop vac filter.

A dedicated single stage or two stage dust collector is the heart of a top-of-the-line system. Dust collectors can be single-stage or two-stage designs. A two-stage dust collector consists of a first stage cyclone, a blower (motor) and a second stage filter. A cyclone separator is a cone shaped vessel into which the dust-laden air enters. The dust particles’ inertia causes them to move toward the separators outer wall where the larger dust particles lose momentum and fall to the container below. The remaining fine dust exits through a central outlet at the top and into the blower and finally moves to the remaining filter.

In a single stage unit, coarse wood dust particles and other debris hitting the blower impeller may cause damage to the blower, will fill the collection bag more quickly, and will send more dust to the unit’s filter.

A 1 ½ horsepower dust collector is just right for a small shop. Larger horsepower collectors require 220-volt wiring which many shops do not have. Single stage collectors are less expensive and work fine in a small shop. Two stage cyclone systems take up more space and are more expensive.

Ductwork, which connects dust collectors to machines, comes in three types:

1. Metal ductwork
2. PVC pipe
3. Flexible hose.

Four-inch diameter hose or pipe is the standard size for dust collectors. Metal ductwork is the best and most expensive option. Metal offers less resistance to dust and metal Y connectors are
readily available, reducing the number of sharp turns. PVC pipe is cheaper but many claim there is a danger with static buildup thus ground wires need to be attached. Flexible hose has a lot of interior resistance which reduces dust carrying capacity dramatically. Hose is necessary to connect a shop machine to a permanent duct system, but attention should be paid to keep runs short.

If you are planning to install permanently mounted ductwork, remember LSSG: Large diameter, Short runs, Straight runs, Gentle curves. Large diameter refers to the size of the ducts with four inch being the standard. Larger ducts move more material. If you need to reduce duct diameter for some machines, (there are many reducers available), place reducers as close to the source of dust (the machine) as possible. Short ductwork runs use less energy than long ones so, centralize the collector near machines that make the most dust. Bends and turns in duct systems cause more friction so, plan for straight runs. Sharp curves increase friction which requires more power thus, gentle curves.

Whatever type of ductwork you use, be sure to seal up as many leaks as possible. Many leaks may be found in the housings of the machines. Duct tape works well for small leaks, pieces of cardboard duct taped in place works for larger holes.

Blast gates are the final piece if you are using permanently mounted duct work. Metal ones cost more but work better and last longer than plastic ones. Install a blast gate right at the machine for each machine and, when using your system, keep them all closed except for the one on the machine you are using.

If you are using the budget system of moving the collector hose from machine to machine, there are a variety of types of quick connectors that make it easier to do so.
Dust Collection for Health

An important Health and Safety Consideration

By Jim Allen

I waited much too long to add dust collection to my shop. As a result I spent as much time cleaning after my daily activities as I did working wood. What a difference a Dust collector makes and having machines connected to it.

Dust Control and your Health

The best motivation for dust control is an article written by Michael McCain in Fine Woodworking, volume #39, March/April 1983, p36; “Wood Dust Poses High Cancer Risk”. Also of note is the consideration of asthmatic symptoms; that I have developed over the past few years after many early years of woodworking with no consideration of dust control. Don’t delay, implement the best system for you now, Asthma Inhalers will cost you $50.00 a month!

Dust Control Solutions

Basic systems; if you are starting out with just a few hand tools and hand held power tools, i.e; circular saw, drill/driver you could start with a broom and dust pan. That said if you work in an enclosed area the saws you use will create air-borne dust when used. I would then suggest the first purchase should be a ceiling mounted air filter unit. This should be turned on before you start working. Many vendors sell these devices.

With hand-held power sanders and routers it is best to have a Shop Vac of at least 6 gallon capacity with the highest rated hp available along with a 2¼” hose and connectors. When buying your hand-held power tools check the manual for hose and connection accessories, or check the manufacturer’s website. I have found all my hand-held power sander connections this way. There is really no standard sizing for attaching your tools to the Shop Vac, and I find that having a roll of duct tape handy solves many connection issues.

With a table saw dust collection is very important. For cabinet-style saws it is essential. A shop-vac will fill up rapidly and fill the air with dust. Most woodworkers use a dust collector instead.

Dust Collectors. Begin by thinking about how many tools you want to have and connected to a dust collections system in your shop layout. Dust collection units range from portable floor models that you can roll from machine to machine, to whole shop systems with permanent piping connected to each machine. In between, many woodworkers who have a dust collector (often on wheels) with one 4” hose that they move from machine to machine as needed. This could be a perfect way to start your shop system.
A Woodworking Primer

I started with a 2 hp unit, with air flow => 1500 CFM (cubic feet per minute). I later added a switch with a wireless remote. If you are interested in knowing more about how to maximize your shop dust collection, you are invited to contact me for a tour of my shop (978-771-6471) or I can send you a write up of my system.

One last thought is the location of the Dust collector. When running, these devices are very noisy. If possible, the unit should be placed outside your main working area, with sound insulation on or in the dividing wall.

Dust collection systems are available in a wide range of price points and sold by many manufacturers and retail outlets. For whatever reason, this product category is often found on used equipment sites like craigslist and ebay. I have found really good equipment there.
PROJECT ASSEMBLY
Elements of Wood Joinery

The heart of almost all projects

By Maurice Plourde

In this article we will explore three joinery techniques commonly used in woodworking: the dowel, mortise and tenon, and floating tenon. Other types of joints are listed at the end of the chapter.

Dowel Joint:

The dowel joint is perhaps the easiest of the three methods discussed here. It is often used as an introduction to woodworkers for jointing face frames for cabinets or bookcases or other projects that do not require a stronger joint. One of the advantages for the dowel approach is that it does not require an investment in expensive equipment. There are jigs available to help a woodworker properly align holes for dowels as well as to center a dowel hole in the side of a board. The two pieces of wood are joined by drilling matching holes in each piece, inserting a dowel with glue and clamping the two pieces together. Couldn’t be simpler.

Dowels can be purchased in a variety of diameters and can be purchased or home-made in a variety of matching or contrasting wood stock. Consider using dowel diameters appropriate for the thickness of the stock being joined and the strength needed for the jointing application.

Here are the steps to create a dowel joint:

1. Match the two pieces of wood in the desired position and draw a line(s) in the center of where each dowel will go.
2. A simple dowel jig is used to help drill the dowel holes. Two or more holes are needed in each piece to prevent the pieces from twisting. The dowel jig can help a) center the hole in the thickness of the wood and b) keep the drill bit perpendicular to the wood edge when drilling the hole. Figure 1 shows the dowel jig with a line scribed in it to help align it with the centering lines from step 1.

It is worth noting that dowel holes in two pieces of wood typically need to be aligned in two dimensions. For example, if you are edge joining two boards of the same thickness to make a wider board, the holes must be the same distance from the board ends as well as the same distance from the top surface. It is helpful to label the two surfaces as reference surfaces so that you are always measuring from a reference surface. The dowels may be used to align boards without glue or with glue to add some strength to the joint.

Similarly, dowels can add strength to a mitered corner in a picture frame. The holes must be the same distance from the outer point and then drilled using either the top or bottom surface for reference.
3. Put glue in the holes from step 2 and insert the proper size dowels and clamp the two pieces tightly together.

![Figure 1 dowel jig](image1)
![Figure 2 dowel jig](image2)
![Figure 3: dowels and mortise compared](image3)

**Mortise and Tenon**

The mortise and tenon joint may be called the king of wood joinery because it is the joint most often used by traditional woodworkers. It is a very strong joint with a long history of being made with hand tools but can also be made with power tools. The terminology can be remembered simply by thinking of the components as ‘mouth’ for mortise and ‘tongue’ for tenon.

![Mortise and Tenon Joint](image4)

**Making the Mortise**

While there are no rules governing this, woodworkers often like to make the mortise first and then fit the tenon to the mortise. This is easier than doing the reverse. When deciding the size of the mortise, you should consider the strength provided by the tenon while keeping the mortise walls thick enough to avoid blow-out. The width or thickness of the mortise (as well as the tenon) often follows the rule of being 1/3 the thickness of the part. For example, if using ¾” stock the mortise would be ¼” thick. This leaves ¼” on each side for the walls of the mortise. For larger pieces that require a stronger joint, thicker mortises can be used. The length of the mortise is often less than the joining piece to allow for a hip to be cut into the tenon to provide added strength to the joint. This can be done to just one or both sides.
Also limit the depth of the mortise to make sure that enough wood is left at the end wall to prevent ‘blowout. Before making the mortise you should layout the mortise on the piece of wood with a sharp pencil, marking knife or marking gauge. The mortise can then be “chopped out’ by using a chisel. Choose a chisel that is the same width as the mortise width, e.g., use a ¼” chisel to create a ¼” mortise. It is important that the mortise is chopped out square and perpendicular to the mating surface. This can be achieved with practice. You can also create a simple jig to help you hold the chisel so that it cuts a mortise that is consistently parallel and equal distance to the top/front and bottom/back surfaces. Mechanical methods of creating a mortise include using a mortising machine or using a router with a mortising jig.

Making the Tenon
The dimensions of the tenon are determined by those of the mortise. Layout the tenon on the piece of wood. It is recommended to layout these lines with a marking knife or marking gauge. This will help create a crisp line and will result in a more securely fitting joint. Mark the tenon thickness on the end grain and the two sides with a marking gauge (a mortise marking gauge allows you to mark both wall of the mortise in one pass) and then mark the depth of cut on all four surfaces.

When cutting the tenon, I would suggest cutting the thickness a little ‘fat’ and then adjusting the fit to the mortise to achieve a ‘snug’ fit. The tenons can be cut using hand tools including a hand saw (panel saw) or tenon saw. The tenons can also be cut on a table saw by setting the blade to the correct height to remove the waste that will create the ‘cheeks’ and then the shoulders of the tenon. The waste can be removed by making multiple passes of the blade or using a dado blade to reduce the number of passes needed. Once the cheeks have been cut to the required thickness, the shoulders can be cut and then the tenon can be fit to the mortise. If the fit is too tight, it is recommended that the tenon be adjusted as opposed to the mortise.

An opinion to consider: There are two ways to attack the mortise and tenon. If you make your tenon on a table saw, it will have a rectilinear shape. So, no matter how you make your mortise, you will have to use some type of chisel to make a mortise with straight linear sides. If you make your mortise with a router, you will have a mortise with rounded ends. You can make the tenon on the table saw and then round over the ends with a file. This second approach is generally much easier to do. The strength of the mortise and tenon joint comes from the glue area on the tenon shoulders, not on the tenon ends, so rounding off the ends leads to little loss of joint strength while making the woodworking task much easier.

Floating Tenon
While similar to the mortise and tenon joint above, the floating tenon joint has a tenon that is made from a separate (third) piece of wood instead of being part of one of the pieces being joined. So, the floating tenon has much in common with the dowel joint. To join two pieces of wood, a mortise is created in each piece and then, a separate tenon is inserted in both mortises and glued to make the joint. While these components can be created by hand tools, power tools specifically designed for this purpose are normally used.
A Woodworking Primer

These power tools can be relatively expensive but the cost can be justified to offset the time required if you need to make many such joints or intend to use this joint often.

A variation of this joint uses ‘biscuits’ that are football shaped. These biscuits come in three common sizes depending on the size and strength of the joint needed. In this case the mortises are usually cut using a special power tool called a Biscuit Jointer or can be cut using special bits with a router.

![Biscuits](image)

Other Common Wood Joints
In this article we have only covered some of the techniques used in wood joinery. Other joinery techniques that you may want to explore include: butt joint, half-lap joint, pocket-hole joint, tongue and groove, through mortise and tenon, wedged mortise and tenon, tusked mortise and tenon, dovetail joint, box joint, and bridle joint.
Dry Assembly

Practice Makes Perfect

By Vincent Valvo

Dry assembly in woodworking is just that. After parts are cut to size but before gluing up, it is advantageous to assemble the parts for various reasons. Those reasons are what this article is about. You will read about the need for testing the squareness, fitting, joinery, appearance, and sturdiness as a unit; the timing of the assembly for gluing; and whether to apply finish to any of the parts prior to gluing or not.

As the popular woodworking adage goes, “Measure twice, cut once.” In this case you might say “assemble many times, glue just once.” Regarding furniture construction, the adage could be paraphrased to “Reduce the stress and mess, dry assemble.” In the assembly world, once it’s glued, live with it or start over.

Dry assembly will uncover issues that aren’t obvious or flaws that seem trivial, only to find out that they are serious once assembled. Identifying these issues early in the construction will save considerable time and unintended workarounds or even do-overs.

Dry Assembly Example

Perhaps the best way to show benefits of dry assembly is to follow an example of a woodworking project. When constructing a desk, one may need to join legs to a desktop frame using mortise and tenons. Assume, after each mortise and tenon was completed, the fit between the frame and leg was tested to ensure that each fit snugly. (Too tight-fitting joinery such as dowels or dominoes used in construction may be too difficult to remove after dry assembly.) And let’s say each leg is measured to the same length. Who’s to say that when all four legs are joined the desk stands squarely without rocking and with the best-looking legs in the front? Any of the mortise and tenon pairs may not be in alignment with the others. It won’t be obvious unless it is assembled – and it better be dry assembled.

Additionally, during a dry assembly the overall appearance can be reviewed and sometimes improved, for example, re-positioning the more attractive legs to the front. If this had been glued up without detecting these issues the desk would need to be altered for height and the suboptimal leg arrangement would need to be accepted as is. (Of course, if hide glue had been used, the woodworker could undo the glue-up, but this is a workaround that no one needs.

Also consider that the desk has a drawer that sits on rails. Clearly, that fit must be tested. In this case, it would behoove the woodworker to test the fit of the drawer before gluing for gross errors and retested after gluing for fine tuning. Sometimes a dry assembly of a large piece can highlight sections that can be glued separately. The desk drawer is a small assembly but think of a case of drawers or a cabinet where problems multiply.
Another reason for dry assembly is to detect areas of the piece that would be too difficult to finish if it were glued. That is, the woodworker should review the dry assembly for any areas with limited or restricted access, such as, a shelf that is too deep or small to reach. In this case, it’s better to apply finish to that area before gluing.

**The Big Advantage**

Even if everything is cut perfectly and everything is ready for a glue up, the biggest advantage of a dry assembly is learning the timing and choreography for planning and executing the glue-up. Because of glue’s short open time, the glue-up process can be stressful and messy, both literally and figuratively. It’s best to be organized and that’s where dry assembly comes in. This does not mean that stress and mess are eliminated, but with practice they are reduced.

You might even want to rehearse the glue-up – multiple times. For even a moderately complicated glue up job, plan your assembly without the glue. This may provide insight to identify any sections that can be glued separately in stages. As in the desk example above, the drawer, tabletop, frame, and legs to the frame are sections that can be glued separately. Observe the time it takes to assemble with clamps, tape, bands, and other “dry” tools. Remember that dry assembly times do not include applying and spreading the glue, so add that time to the estimate. Compare that estimate to the glue’s open time to determine the extent of the work that you can glue up comfortably. The manufacturer of Titebond III (for example) claims open time is 8-10 minutes at 70°F and relative humidity of 50%. This author’s experience suggests that open time may actually be less than half that.

**Lessons Learned**

- Think of dry assembly as preparation – plan for timing and process – before glue-up.
- Arrange for the space needed for the glue up.
- Have the clamps ready and set for the length needed along with and other “dry” tools.
- Have the glue and applicators in position.
- Have damp rags available for cleaning glue spillage.
- Any remedies made from a dry assembly may need to be retested, especially if substantive changes have been made since the previous one.
- The use of too tight-fitting joinery such as, dowels, dominos, or even mortises and tenons maybe difficult to remove during dry disassembly.
- Identify sections of a large piece for smaller, more controllable glue-ups.

Dry assembly offers an opportunity to fix problems in the workmanship and the gluing process before it’s too late. It leads to better quality and efficiency.
Jigs and Fixtures

Getting a Grip: Part 1

By Andrew W. Davis

When you get started in woodworking, you will read and hear a lot about jigs and fixtures. Truth be told there are several books written on the subject of “jigs and fixtures you simply must have.” Jigs and fixtures are devices that enable you to accomplish something that would either be impossible otherwise, or too dangerous, or too inaccurate. Another application is to enable multiple parts to be made with the same dimensions and geometry. Let’s start with some definitions and then look at some examples.

According to www.nitc.ad.in “the main purpose of a fixture is to locate, and in some cases, hold a workpiece during either a machining operation or some other industrial process. A jig differs from a fixture in that it guides the tool to its correct position in addition to locating and supporting the workpiece.” Wikipedia has a different spin: “A fixture differs from a jig in that when a fixture is used, the fixture must move relative to the workpiece; a jig moves the piece while the tool remains stationary. In other words, jigs and fixtures both hold something fixed while something else moves, all in the name of safety, accuracy, and repeatability.

While the difference between jigs and fixtures is not really important, most of the woodworking accessories fall into the jig category. Many jigs are available as commercial products, but plans to build your own jigs are also widely available. You will also find that some jigs will be used just once as you build some project; some in fact will be “sacrificed” during use, while others are used over and over again. Some jigs may be built with adjustable features such as the width and length of a mortise, while others are constructed with a locked-in geometry often specific to the project at hand.

Some say it is not unusual for a wise woodworker to spend 3.0 hours making a jig or fixture in order to complete a 0.03 hour saw cut or glue-up. My recent experience with jigs as problem solving tools took place when I was trying to build a 76-inch-high corner cabinet. The cabinet is six-sided, though the hexagon is not a regular hexagon, and held together by three vertical

Corner Cabinet Cross Section

Detail of joint showing construction and placement of two fixtures to accommodate a third clamp for the glue
frames. The left and right front supports are made from two stiles, each of which has a 22.5-degree beveled edge. So, the problem is “how do you hold these parts together while the glue dries?” This was my introduction to jigs and fixtures – not to perform a cutting operation, but rather to clamp parts while the glue sets. From scrap wood, I build eight fixtures of the design shown in the diagram. Two fixtures are clamped to the cabinet stiles at one location while a third clamp applies pressure across the glue line. Note that the angles in the fixtures end up parallel to the glue line, so I was clamping at 90 degrees, which is what clamps are designed for.

Woodworking magazines and online articles and videos are filled with suggestions for building your own jigs and fixtures. Many of these are intended to make equipment like table saws, drill presses, and router tables more functional or more efficient as well as safer. There are even plans for a dovetailing fixture for the table saw, something that at first would seem impossible. Some jigs and fixtures are specific to the table saw, others for the router table, and some can be used with either tool.

Commercial dovetail jigs start at about $100 and can range to over $700. Features vary widely.

Patterns made from MDF or thin plywood help get the shape just right and then make duplicate parts.

Building a crosscut sled for the table saw is a common first project for woodworkers. These sleds can range from very simple to complex.

Even when you are eager to begin working on a furniture project of any kind, you should not regret or resent the time you invest in a jig or fixture to improve the project result. If you visit the workshop of a professional or serious amateur woodworker, you are likely to find a collection of jigs and fixtures hanging on the wall. They don’t discard them. One other tip: label the jig before you put it away. Then you won’t be asking yourself three years down the road what it was for!
Hold-downs & More

Getting a Grip: Part 2

By Andrew W. Davis

Depending on whether you are planning, sawing, sanding, drilling, or whatever, and whether your workpiece needs to be oriented horizontally or vertically, holding your workpiece firmly is key to safety and accuracy. Hold-downs, combined with vises and clamps, form the trifecta of workbench accessories.

Some of the bench accessories listed in this article work by themselves, others work in pairs or in conjunction with other accessories, or in combination with clamps and vises. Many are available commercially in a variety of sizes, shapes, and features and many of them can be home-made.

Bench Dogs

Most workbenches have an array of dog holes, typically aligned with similar holes located in a wooden vise jaw. Round ones are most commonly ¾ inch in diameter, but some commercial benches have 1” round holes. Dog holes in many traditional benches are actually square or rectangular in shape and are typically designed-in (mortises created by a dado) when the bench is being built rather than after the bench top is finished. Bench dogs are the devices that go into the bench holes. When combined with a bench dog in a vise, the entire bench top can act as a clamp to hold small to large workpieces. Simple bench dogs are removed when they are not needed; more elegant bench dogs have a spring-loaded side and may be pushed down below the bench surface when not needed. Whether round, square, or rectangular, bench dogs are available in multiple sizes and in wood, metal, and plastic materials,
A Woodworking Primer

T-Tracks

T-tracks aren’t really hold downs, but they are enablers for multiple types of bench add-ons. T-tracks are aluminum rails that can be fastened to the top of fences or embedded in a bench top by routing a ¾ inch wide groove deep enough for whatever brand of track you have. Of course one end of the groove should be open so that you can install and remove whatever add-on you need to use. T-track-compatible devices are available to apply horizontal and vertical clamping forces as well as to act as bench stops.

Hold-fasts & Hold-downs

Perhaps the quickest and most secure method of holding something down is with a hold-fast, a simple piece of iron that drops into a bench hole and, with a tap on the top, secures a workpiece. This happens because the shaft of the hold-fast wedges itself in the hole and against your workpiece. The difference between the diameter of the hole and that of the hold-fast creates the action. In many benches, the dog holes are actually drilled a few degrees off of 90. Bench thickness weighs in as a factor as well. A tap on the back of the hold-fast releases the work. Hold-fasts are available from a variety of vendors in a variety of sizes, styles, and price points.
Hold-downs are a form of hold-fast. However, instead of striking the device to hold and release, hold-downs act by turning a clamping knob of some form. This is not as fast an operation as a simple tap with a mallet, but it works just as well. Some of these devices also require a nut to be applied underneath the bench top to secure the tool.

**Bench Hooks**

This is a device made from just three pieces of wood – a flat surface with a stop on the top rear and a hook on the bottom front. The force of the tool pushes the workpiece against the rear stop while the bench hook itself is held in place by the same force (and gravity) acting on the front fence (on the bottom). The bench hook itself does not need to be clamped to the bench although some may prefer to clamp the front hook in a front vise.

For working with long boards it is helpful to have pairs of bench hooks so that one of them can support the far end of the workpiece.
Bench Stops

Bench stops do exactly what they say – they stop wood from moving. This is true only when you are applying pressure, of course, against the stop as opposed to sideways. They are fast, easy, and simple, but work in a limited fashion only. Typically, the end of the board being planed simply rests against the stop and the board is held down by the pressure from the woodworker. A bench dog can also act as a bench stop although a bench stop typically has a larger surface against the workpiece.

One variation on a bench top is the bird’s mouth stop, basically a V shaped notch cut into the end of a board. This board is clamped or otherwise held to the bench top and then used to hold a workpiece on edge. A matching wedge may also be used to hold the workpiece steady within the notch.

Board Jacks

Board jacks are bench accessories that work in another dimension. Rather than working on the top face of a work bench, they work on the front face. Consider the challenge to plane the long edge of a 6’ door or board. You need to hold the board level, steady, and at a comfortable height. One way to do this is to have dog holes in the front of the bench at the same height as the bars on a front vise. Put a bench dog into the hole and you have the needed support. A more flexible solution is the sliding board jack (aka sliding deadman) since it can handle long boards or doors in a variety of widths.
Woodworking Clamps

*Getting a Grip: Part 3*

By Andrew W. Davis

This article is intended to give a quick overview of woodworking clamps. While acknowledging that there are as many types of clamps currently available as there are shells on a Cape Cod beach, we are focused here on only the types most commonly used by woodworkers.

It’s a well-known fact that you can never be too thin, have too much bandwidth, or too many clamps. If nothing else, a nice collection smartly displayed in your shop is sure to impress friends and family.

**A Clamp Family Tree**

After thinking about all the clamps I’ve run into since beginning woodworking, I came up with my clamp family tree.

Most people will start with F-clamps, part of the bar family. These are the go-go clamps for most projects. F-clamps are clutch-style clamps that work by moving one end of the jaw along a rail or bar; moving metal plats use friction to support the needed force while you are cranking the handle. F-clamps are commonly described by the length of the bar (6”, 12” 18” etc.), but they also have “throats,” the length of the “F” appendage. Most F-clamps have a throat of ~2 ½ inches, but larger throat versions are also available. Of course, larger throats need heavier bars and cost more.
Parallel jaw bar clamps typically have a large clamping surface and maintain the squareness of the item being clamped. They are very handy if you are trying to glue up boards to make a larger surface for a table or bench or chair seat. Parallel clamps can deliver a lot of pressure and can also be reconfigured to spread rather than squeeze. The disadvantage is mostly cost – they are expensive, but very handy when building cabinets and even drawers. They are also heavy.

Pipe clamps provide flexibility in length (just get a longer pipe and use the same end pieces) combined with low cost. Users must be careful when using pipe clamps to avoid leaving black stains on the workpiece. Aluminum bar clamps are similar in function, and low cost as well, but avoid the “stain” problem. Aluminum bars, however, are not as strong as iron bars and cannot provide the same pressure.

Handscrew clamps were a total mystery to me for a long time. Only recently have I recognized how versatile they are. The magic is the flat surface which allows the clamp to be held on a
A Woodworking Primer

work surface or even in another clamp. I have used them to hold parts while I edged workpieces on a router table. A second piece of magic is that the jaws need not be parallel – a variety of possible closing angles can support odd-shaped workpieces. A third feature is that the clamps are made of wood, so you can shape and drill them to add some special capability.

Handscrews come in all sizes and price ranges.

Clamping non-square parts is not a problem.

A handscrew can hold a workpiece while another clamp holds the first to a bench or table.

Handscrews can make routing or drilling of small parts safer.

Handscrew jaws can be modified to hold different shapes.

A corner clamp is one of the more popular “specialty” clamps.

Some clamps are very useful because they can be used when you have only one hand available. These “squeeze” clamps can also be used for spreading, a function particularly useful when trying to disassemble furniture. One-handed clamps are widely available in a variety of “strengths” and lengths from four inches to 36 inches. Prices vary hugely.

A band clamp can be used too close joints on a variety of shapes, including picture frames.

An edge or face clamp is a three-way device that applies pressure at right angles to the

A one-handed clamp in its spreader configuration.
There are a whole family of “right angle” clamps mostly designed to meet the needs of picture framers, but some are aimed at cabinet makers as well. These include metal and plastic jigs as well as band (strap) clamps in both 90 degree and variable degree versions. I’ve had good luck with the band clamps and their ratcheting mechanisms, but not so much with the fixed versions.

If you walk through a woodworking supply store or spend time flipping through their catalogs, you will find dozens of special clamps that solve specific challenges – edging, pocket holes, face-frames, spring clamps, etc. There’s no limit on how much money you can spend on clamps. The question to ask is whether there is a material difference between cheap clamps and more costly ones. Given my experience with woodworking tools in general, I would suggest that there is. More than just mashing two pieces of lumber together; the clamp can make the experience more divine!

**A Woodworking Rule**

One other rule of woodworking to remember: the number of clamps you need to complete a glue-up is always one greater than the number you have.
Woodworking Vises

Getting a Grip: Part Four

By Andrew W. Davis

This article is intended to cover the information most relevant to beginning woodworkers by describing the most common vises, particularly those included in commercial workbench products and those sold as kits for DIYers. But, the reader should be aware that there are many specialty vises available, including some that have been around for hundreds of years.

Vises play an important role for every woodworker. If you elect to purchase your workbench, chances are that it comes with one or two vises already installed; if you are building your own workbench then you will need to consider what type of vise or vises you will need. Your vise choice will likely affect the placement of the bench legs and the design of the top. The good news is you will have an incredible number of options; the bad news is that you will have to choose from a very wide range of vise configurations, sizes, designs, features, and prices.

Face Vises

A face vise is a vise installed on the front of the workbench. While most non-woodworking vises mount on top of the workbench via a pedestal, woodworking vises mount on the underside of the bench, typically on the left or right, but sometimes in the middle. The jaws or faces of the vise may be metal or wood. Some woodworkers have opted to mount two such vises on the front of their bench (or one on the front and one on the end). Some vises feature a quick release mechanism which allows the user to disconnect the screw mechanism and move the vise face quickly without having to make multiple turns of the handle.

While most face vises have a single screw set between two guide rods, larger vises may feature a twin screw design with no guide bars. The larger distance between the twin screws means that wider boards can be accommodated. When installed on the front of a bench, the twin screw vise performs like a shoulder vise (see below). Twin screws also eliminate vise racking, a condition that occurs when clamping a workpiece on the right (or left side) of the jaws and while tightening the screw, the moving jaw pivots in the opposite direction. This prevents the workpiece from being adequately clamped while also putting destructive forces on the vise mechanism.
Face vises come in a variety of width and depth (the maximum opening) specifications. Some may feature a bench dog (see Getting a Grip: Hold-downs) built into the metal jaw. Most woodworkers will want a wooden face rather than bare metal and will install hardwood surfaces, often with holes drilled in the top to accommodate round bench dogs.

Face vises are also commonly mounted on the side of the bench, which technically makes them end vises (see below). In the end position, they often have wooden jaws that are the same dimension as that of the bench.

The shoulder vise (more popular in Europe) is integrated into the bench top itself as an “L” shaped configuration that usually requires a fifth leg for support as well as a large block to hold the front piece parallel to the bench when pressure is applied. An advantage of the shoulder vise is that there is no screw or guide rails in the way if you need to grip a wide work piece. The design itself prevents racking. Shoulder vise kits are available from several woodworking suppliers.

The leg vise probably wins out when it comes to “tradition.” I am not aware of any commercial benches that ship with a leg vise, but several vendors provide the parts for those enthusiasts.
A Woodworking Primer

building their own workbench. Without the two guide rods of the traditional iron vise, workpieces can be held right up against the screw, virtually eliminating racking and providing a better overall grip.” Leg vises can provide an enormous 9” of workable depth.

End Vises

As the name suggests, an end vise is found on the end of a workbench. While the end vise can be used for clamping stock perpendicular to the bench top, the most common application is to clamp stock flat in combination with bench dogs located in both the vise and the bench top. (The classic end vise is the tail vise, a surface-clamping design that generally holds stock between bench dogs. The moving jaw is surrounded by the bench top, providing excellent workpiece support. It resists sagging, unlike a cantilevered shoulder vise. Capacity is limited only by the length of the work surface, and since clamping force is closely aligned with the screw axis, the vise cannot rack. A tail vise nests into the front of the bench top, so it’s designed-in as original equipment when the bench is constructed, not typically added-on by a woodworker. The tail vise is also useful to holding stock for sawing by placing the work piece vertically between the movable face of the tail vise and the fixed face of the bench front.

A popular end vise is an iron vise (with single or twin screws) with jaws that are the same dimension as the bench top itself. Dog holes in the vise face align with dog holes in the bench top for clamping workpieces flat. This is also possible when the vise is on the face of the bench.

A wagon vise consists of a screw that passes through a frame buried within the bench top, creating a moving dog hole. The wagon vise is typically designed into the bench before the
A Woodworking Primer

bench is built and is typically not used for anything other than securing wood flat to the bench top.

Wagon vise

A simple cast iron screw vise can be installed on the face or the end of a workbench. Some may be based on a twin screw design.

Tail vise with square dog holes. This uses a screw to apply pressure and metal bars to guide the assembly.

Vise selection can be based on personal preferences or on reverence for tradition, but, in any case, you will want a workbench/vise combination that can accommodate a variety of tasks including surface and edge planning of large boards held flat, sawing dovetails and drilling dowel holes in workpieces held vertically, routing mortise and tenon joints, etc.
Woodworking Glues

Different glues for different needs

By Andrew W. Davis

It seems you can’t go more than 1 or 2 months before you will see an article about glues in one of the popular handyman or woodworking magazines. This isn’t because new glues are being introduced at a rapid pace, but rather because glues are important, and the choices can be bewildering. The purpose of this chapter instead is to provide a quick overview of the woodworking glue landscape, in reference to furniture making and assembly.

The diagram below is intended to show the six major categories for glue of most interest to woodworkers. Other glues such as spray adhesives, contact cement, and hot melt with glue guns have special purpose applications in the shop, but assembling furniture is not one of them.

In general, different glues have different open (assembly) times, clamp times, setting/curing times, moisture resistance, strength, flexibility/brittleness, health risks, and shelf life. Ease-of-use may be a factor as well depending on the specific project.

Yellow Glue (PolyVinylAcetate): Type I offers no water resistance and has shorter open times and clamp times. Type III has excellent waterproof capabilities, can be used outdoors, and has a much longer open time and clamp time than Type I. It is also more expensive; Type II is in-between. Titebond is one of the more popular brands for PVA glue but many other products are available from a variety of sources. PVA glues (and hide glues) are solvent-free, safe-to-use, and generally clean up with water. All-purpose white glue (aka Elmer’s glue), while popular in elementary schools, is also a suitable wood glue, with good strength and an open time of about 10 minutes, double that of yellow glue. White glue is runny so it will flow into tight joints and is
easy to clean up. Elmer’s also makes a “woodworking glue” that some find to be equal to the other yellow glues and comes in a more convenient bottle.

**Cyanoacrylate (CA):** Often marketed as superglue, CA bonds very quickly. CA glue is now available in different viscosities – thin, medium, and thick with open and clamp times varying from 2 seconds to one minute. The thin version flows like water and is touted for filling fine cracks in lumber while the thick version is useful when you need to prevent running or dripping or wish to seal the edges of MDF templates. Clean-up is with acetone. CA is expensive. It also bonds unlike materials, like skin to wood. Can also irritate skin, eyes, etc. Read safety precautions when using.

Lack of humidity can affect curing times of CA glues. In dry climates, an accelerator (typically sprayed) is often necessary to speed the drying time and force the CA glue to cure. The more glue that is used in a given bond, the slower the cure will be. CA glue accelerator can be applied before and/or after CA glue is applied.

**Epoxy:** Epoxy is a two-part adhesive that has its own unique characteristics and special applications. These include gap-filling for dealing with knots and gouges or when gluing parts together that do not have good mating surfaces. Epoxy can be cleaned up with acetone, but only before it cures. Epoxy has excellent moisture resistance and is recommended for outdoor or marine projects. See the separate chapter on Epoxy for more details.

**Hide Glue:** This is perhaps the oldest glue in the history of woodworking, having been found in the tombs of ancient Egypt. It has been the go-to glue for chair making (and other furniture) for centuries. The unique property of hide glue is that it is “reversible” - with heat and moisture and a little pressure you can take the joint apart. Liquid hide glue (aka old brown glue), available from several sources, is basically traditional hide glue to which urea has been added, making it liquid at room temperature, though it is too thick to use without first heating up. It is slippery and has a long working time (useful for complex glue-ups) and clamping time. Hot hide glue, generally available in powder or “flake” form, can be “tuned” for multiple characteristics, but generally begins to set when its temperature falls below 120° - making fast assembly time a requirement. Hide glues are “friendly” to most finishes and clean up with water. See the separate chapter on Hide Glue.

**Polyurethane Glue:** Polyurethane glues need moisture to cure properly, so wood surfaces need to be wet before applying the glue. As the glue cures, it produces a foam at the glue line. This should be scraped away or cut off with a chisel after it is dried. The foam comes in handy when filling cracks or gaps in joints. Polyurethane joints are moisture resistant and provide about the same strength as PVA and because they need moisture to work, they are ideal for working with damp woods such as treated lumber. You should use latex gloves when working with polyurethane glue. Gorilla Glue is one of the well-known brands in this category.

**Urea Formaldehyde:** Because this glue has its share of toxic elements, manufacturers recommend that you use a respirator and avoid skin contact. The glue comes in powder form,
A Woodworking Primer

mixes with water, and provides about half an hour of working time. For best results, shop temperature should be between 70° and 90°. Urea formaldehyde, like epoxy is a thermoset¹ glue and dries very hard. Being rigid, it is recommended for bent laminations since it prevents springback² as well as for veneer. Clean-up is with water.

¹ There are two general families of plastics. Thermoplastics can melt under heat after they have cured; thermoset plastics retain their shape and stay solid under heat once they have cured.

² Springback occurs when a material tries to return to its original shape. If you are laminating a curved shape for example by gluing together many thin strips of wood and then putting the material into a mold to hold the shape while the glue sets, you don’t want the shape to change when you remove the mold, i.e. you want to prevent springback. The amount of springback is difficult to predict, thereby making difficult an adjustment to the design; the best solution is to avoid springback by using the right glue.
Hide Glue

*When you need reversible, hide is your answer*

By Jim Russell

One of the most basic commodities used in woodworking is glue. If you watch woodworking shows on television or YouTube, or if you Google “glues for woodworking,” you could not be criticized for concluding that the only glue suitable for woodworking is PVA glue (Tightbond yellow glue, Elmer’s glue (white and yellow), Gorilla). I will leave it to the reader to do that Google search and read up about these glues. In instances where hide glue is even mentioned, it is relegated to occasional use to fix antiques. I can conclude only that the writers of these articles have never actually used hide glue.

Hide glue has been used in furniture making since the Egyptians built the pyramids (though they probably didn’t care about reversibility). Hide glue was still used extensively in the furniture manufacturing industry until the 1950s and is actively used today by many furniture builders, luthiers, and piano repairers.

Hide glue is manufactured from animal proteins and is available in two forms: solid – flakes or powders that need to be soaked in water and heated to 140° when they need to be used, and liquid – ready to be used at room temperature.

Like most woodworkers, I started out using PVA glue under the assumption that it must be the best glue for woodworking since it is so pervasive. PVA glue has two primary attributes that make it useful for woodworking: (1) it makes things stick together, and (2) it is ready to use out of the bottle in your workshop. Unfortunately, PVA glue creates havoc on wood finishes. Any squeeze out, smears and fingerprints that are not diligently cleaned away prior to finishing will be glaringly obvious under any and all finishes. This characteristic of PVA glue causes woodworkers to invent elaborate schemes to avoid and/or deal with squeeze out and glue smears. Even the most diligent of woodworkers will discover that his or her efforts to clear up PVA glue on the surface of their wood project failed in a spot or two.

Typical PVA glues have an open time of about 10 minutes. That is neither good nor bad. For some complicated glue ups, that open time limit can present a significant challenge, but there is no way to extend the open time of PVA glue. Yet another charming attribute of PVA glues is that they will creep under tension. Depending on the application, this can be a serious drawback (bent laminations being an example). Lastly, PVA glue is permanent. It can’t be reversed. Whatever comes out of the clamps or press, you are stuck (Get it? Stuck – glue. Pretty funny?) with it.
Liquid Hide Glue

Liquid hide glue is simply hot hide glue to which a gel suppressant (urea or salt) has been added to make the glue stay liquid at room temperature. Liquid Hide Glue has two primary attributes that make it useful for woodworking: (1) it makes things stick together, and (2) it is ready to use out of the bottle in your workshop. A third, and in my opinion as a furniture maker, very important characteristic is that hide glue does not affect the finish...no glue spots under the finish.

The open time for Liquid Hide Glue is significantly longer than PVA glue. I have not used commercial liquid hide glue, but the liquid hide glue I make in my shop has an open time of about 25 minutes. I presume the commercial ones are similar. Hide glue does not creep. There is no need to go out and buy an expensive and toxic urea-formaldehyde glue to get around the PVA creep issue. Just use the same hide glue you use for everything else. Lastly, hide glue is reversible. This makes it great for doing repairs and is super useful in veneering. Reversibility is why this is the go-to glue for many furniture makers, luthiers, and piano repairers.

Tightbond (the company makes a liquid hide glue as well as PVA glue) and Old Brown Glue are two well-known commercially available liquid hide glues. If you use hot hide glue in your shop, it is easy to make your own liquid hide glue by adding some salt or urea to your hot glue. Making my own is my preferred method since it takes only a few seconds. I can make it fresh for my project in whatever amount desired and without concerns about expiration dates. The mixing instructions can be found in the linked articles below.

Once you are set up to use hot hide glue, making a fresh batch of liquid hide glue takes seconds. It is thousands of times faster than going to your computer to order a bottle and wait days for the bottle to show up when you can then use your Captain Marvel Decoder Ring to decode the manufacturer date to discover that the distributor sent you a bottle of glue that is expiring in five minutes.

Unless you really like dealing with squeeze out, like the look of glue splotches and fingerprints under your finish, can’t envision ever needing an open time of more than 10 minutes, want your glue joints to slide around under pressure, always get it right the first time and don’t need to re-do something, you should consider Liquid Hide Glue as your go to glue in the shop.

Hot Hide Glue

If you like liquid hide glue, you will love hot hide glue. Hot hide glue is the traditional form of hide glue. Hot hide glue can be made to do an amazing variety of woodworking jobs but requires some learning and practice. However, once some simple steps have been taken, hot hide glue will take your woodworking to a new level. Below are some links that fully explain hot hide glue.
A Woodworking Primer

I use hide glue in my shop all the time. I use liquid hide glue for joinery and hot hide glue for everything else like veneering, inlay, marquetry, rub joints when a clamp is hard or impossible to use. Hot hide glue is like a good hand plane. A hand plane requires proper setup, good sharpening skills and knowledge on technique. When all three of these requirements are met, your woodworking moves to the next level. Hide glue is much the same. Once it is mastered and you learn how to modify its properties with some simple ingredients, you can do things with hide glue that you can’t do with PVA glues.

A good source of hide glue is Bjorn Industries. I buy the high purity 192-gram strength. My glue pot is a $12 variable temperature hot pot similar to this. Ok, mine was $12 when I bought it ten years ago. The hot pot becomes a double boiler when a glass jelly jar is suspended in the water.

More information on hide glue

These links provide a deep dive into hot hide glue including details on making hot hide glue into liquid hide glue.

WoodTreks and Patrick Edwards Introduction to Hide Glue – Patrick Edwards is a key knowledge source on hide glue and is the manufacturer of Old Brown Glue.

Hide Glue and Hammer Veneering This is a video of a presentation on the attributes of hide glue and some practical applications. It includes a comprehensive discussion on the use and preparation of hide glue and has a demonstration on hammer veneering. It also includes a video on making a book matched Federal table top with stringing and crossbanding and a video on using hide glue as a grain filler.

Hide Glue in the Modern Workshop – A paper on the properties and applications of hide glue in the modern workshop. It isn’t just for antiques.

Strength of Hide Glue in Woodworking Applications – This is from a manufacturer of hide glue, so it is understandably putting its thumb on the scale a bit. The bottom line is that hide glue is strong.

A luthiers view of hide glue – Luthier websites and YouTube videos are normally a good source for hide glue information.

Christopher Schwarz on Hide Glue - I must caution that his comment that “It can be turned into “hot hide glue” with 13 seconds in my microwave” is not correct. The microwave will raise the temperature of the glue, but the key characteristic of hot hide glue is that it will gel as it cools. The additives in liquid hide glue will prevent heated liquid hide glue from gelling as it cools. The added heat will make the glue less viscous, but it still has the properties of liquid hide glue. Thirteen seconds sounds like a lot to me. If the glue gets much over 160 degrees, it has become ex glue. Throw it out.
Epoxy

When the going gets tough, the tough use epoxy

By Andrew W. Davis

Lately I’ve noticed epoxy is gaining lots of attention. Magazines seem to be running countless stories about the different uses of epoxy. River tables seem to be the latest fad along with tricks for making attractive inlays.

According to https://www.hotmelt.com/blogs/blog/adhesive-academy-epoxy-explained, “The term epoxy can also be used to refer to the epoxy resins that appear after curing. Curing is a chemical process in which a material hardens after exposure to air, heat, or chemical additives. In epoxy, curing occurs with the help of a catalyst (hardener), which is a chemical additive that increases the rate of a chemical reaction. This results in an exothermic reaction that creates a cross-linkage in the polymer. This cross-linkage is responsible for the rigidity and strength of epoxy materials.”

Epoxy resin, additives, and hardener chemistry allow curing conditions to be modified along with the resultant mechanical strength, electrical properties and thermal characteristics. As a result, a variety of epoxy adhesives have been developed to suit a broad range of applications.

For woodworking, as opposed to boat building, automotive, and aerospace where epoxy is widely used, epoxy seems to come in several categories, although within each category there are multiple options and variations.

- Epoxy as an adhesive to join parts together. Epoxy is a very strong glue with set times ranging from 1 minute (fast epoxy) to several hours.

- Epoxy as a preservative when water damage or rot is present. This is often dubbed penetrating epoxy.

- Epoxy as a filler for knots, holes, cracks, river tables, etc. Different products sold for these “casting” applications have different resin-to-hardener ratios; in addition, there are a multiple hardeners available within some brands. These variations change two important specifications: the length of the curing time and the depth or a pour. Because the hardening process creates heat (exothermic), some epoxy pours should never be more than ½ inch at a time while others can be much deeper. Other variations between epoxies include water and ultraviolet resistance and some electrical characteristics.

- Epoxy as a topcoat, often called bar-top epoxy. These epoxies yield very durable surfaces with respect to water damage and scratch resistance.

In the past year or two I’ve dabbled with epoxy in some woodworking projects. Mostly, I’ve used epoxy to fill cracks and voids in live edge slabs. Here are seven things I’ve learned along the way.
A Woodworking Primer

• While most epoxies are clear, you can add some color and/or interest with dyes and mica pigments. But there is a plethora of powders, liquids, dyes, and tints and they don’t all work as intended in epoxy. For example, I have a green Transtint dye that is green when used in water but red when used in epoxy. My cherry brown Transtint dye is also red when used in epoxy, but not the same red as the green! However, I did discover that you can buy pre-packaged variety packs of 10 or 20 colored powders from Black Diamond (on amazon) that are compatible with epoxy. A safe bet to avoid surprises is to look for aniline dyes that are designed for dying epoxy. As is the case with any wood coloring task – test first on scrap wood.

• When doing a pour, you must tape the bottom of your workpiece (wood is more porous than you might think) and have it level while the epoxy hardens. While the epoxy is thicker than water, it is still a liquid. I am amazed how the stuff can just disappear below the surface into wood. It is always a surprise to come back an hour after a pour and see the stuff has absolutely vanished into the ether. I always put waxed paper underneath the workpiece to avoid having a mess to clean up if the epoxy found a way out that I had missed or if my taping job was insufficient. An epoxy mess on your shop floor can be a real chore to clean up. Don’t ask me how I know this.

• Speaking of thick viscous liquids, I have found it useful to warm the resin and hardener in warm water to make measuring, pouring, mixing easier. This is practically required for me since my shop is in my unheated basement.

• It is important to measure the resin and hardener parts accurately and mix well. Failure on either front (measure or mix) can leave you with a sticky pour that will never harden. Don’t ask me how I know this as well. I suggest you stir for at least 2 minutes and then another two minutes after you add in any coloring agent. It is useful to have popsicle sticks, toothpicks, paper cups, disposable measuring cups and spoons within arm’s reach before you begin.

• Let the stuff cure fully before sanding – be patient.

• If you are filling a crack or doing an inlay, don’t make your pour too thin. You run the risk of sanding right through it down to the wood. For thin cracks, I sometimes use a router to widen the crack. On the other hand, I sometimes do a small pour first to seal off any potential openings. Then I add the final mix knowing it won’t leak out.

• And lastly, almost every demo I’ve seen shows the work piece lying on the bench with its face up. The advantage is you can see what you are doing. The disadvantage is that if the epoxy settles, you may find that the final surface of the epoxy is below the plane of the wood. Depending on what you are doing, you may need to do a second pour – this can be a problem if you need to match colors. If the crack goes all the way through the workpiece, you can tape off the top or front surface and then do the pour “upside-down.” You can be sure that your epoxy inlay will be flat with the surface of the wood.
Mineral Spirits: A Woodworker’s Liquid Tool

Keep Up Your Spirits
By Vincent Valvo

Mineral Spirits is a paint thinner that has many benefits in woodworking. Mineral spirits can be used as a cleaning agent, a temporary guide to how the wood would look with a coat of shellac, and an imperfection detector. Other paint thinners, including denatured alcohol, are similar solvents regarding wood uses. However, denatured alcohol is alcohol based with added toxic elements often including methanol. Users of paint thinners must be aware of related health concerns.

What are Mineral Spirits?

Before using any material, and in particular toxic ones, it is beneficial to know what it is. Mineral spirits is a less toxic, less odorous (due to its lower VOC content) type of paint thinner (acetone, turpentine, and naphtha being others) that is commonly used to thin paint and clean paint brushes, rollers, and other paint applicators. It is a by-product of a petroleum distillation process. For comparison, other paint thinners come from tree resin (turpentine), organic chemistry (acetone, alcohol), or a mixture of hydrocarbons (naphtha).

Therefore, a can labeled “Paint Thinner” may or may not be mineral spirits. Be sure your can reads “Mineral Spirits”.

From a health perspective, all paint thinners in general are flammable, volatile, and can be irritants to the human skin. Wearing protective gloves and, if there is a risk of splashing, wearing safety glasses or goggles to protect your eyes is a good idea. Paint thinners emit kerosene-like odorous fumes. The use of a respiratory mask in a properly ventilated area is highly recommended while using paint thinners. Also, lower toxic versions are more available all the time. Look for low VOC (Volatile organic compounds) or VOC-free solvents.

Finally, despite using gloves, always wash your hands and other exposed skin after using mineral spirits. Because it is oil-based, mineral spirits may leave your hands feeling oily. Washing with soap and water will remove this residue. Prolonged contact can lead to chemical burns. Mineral spirits can also dry the skin of your hands. It’s advisable to use hand lotion to moisturize your skin if you use mineral spirits frequently.

Mineral spirits is less flammable than other paint thinners. However, this should not encourage the user to ignore the inherent risks. The work area should be free of any possibility of sparks and high heat (105°F is an average flashpoint for mineral spirits). Even improperly discarded mineral spirits materials can cause harm. Clearly, any paint thinner should not be dumped into the water system. Additionally, rags should be unfolded and allowed to air out completely before being thrown in the trash to eliminate the possibility of internal combustion.
Mineral Spirits Use in Woodworking

The focus here is for using mineral spirits for:

- cleaning bare wood
- providing a rich, temporary view of the bare wood as if a coat of shellac were applied.
- showing any wood imperfections in the wood, such as dents
- showing exposed glue areas that will mar the final finish

Cleaning. Although mineral spirits can be used for cleaning wood cabinets and floors, that application is not addressed here. Rather, in woodworking, after sanding a board to a smooth, even surface but before applying a coat of stain or other finish, it is advisable to clean the board of any lingering sawdust. Brushing or vacuuming the dust off is a good start, but a wipe down with mineral spirits is very beneficial. Dampen a clean, soft, lint-free cloth with mineral spirits and wipe with the grain to clean all surfaces. It’s surprising how much dust will be removed.

Appearance. While the board is wet with mineral spirits the surface will provide a simulation of how the board will appear with a clear application of a matte finish – richer in color and the grain will be highlighted. Mineral spirits will not change the color of the board permanently. After 10 to 20 minutes, mineral spirits will have evaporated, returning the board to the original color with no residue. Wait for the evaporation to complete before any finish is applied. Wetting the wood with mineral spirits does not raise the grain.

Imperfection identification. Mineral spirits will alter the color of the wood, but the color will be lighter on the face and edges, deeper on the ends. Any imperfections such as dents or slight cracks in the wood will absorb more and have a contrasting color. Imperfections due to exposed or excess glue will appear as a smear and will not hold stain for the popular Timebound I, II, and III glues. For any finishing, you must remove glue from the wood surface, unless you use a stainable glue - for example, hide glue. Be sure to mark the imperfection before the mineral spirits evaporate, otherwise, it may be hard to find.
Beware the Types of Denatured Alcohol

A serious look at alcohol in the shop

By Don Micha and revised by Vincent Valvo

We’re not talking about Jamieson’s or Stolichnaya. Woodworkers often have alcohol around the shop for various uses, the most common of which are:

- Cleaning, especially glass.
- Wiping a board to see how it will look after finish is applied. Wetting it with alcohol makes the grain pop, and the alcohol quickly evaporates so you don’t have to wait long to proceed with your project. Some folks use mineral spirits the same way (see the chapter on mineral spirits), but alcohol evaporates faster and doesn’t smell as much.
- Mixing or thinning shellac (see chapter on shellac).

Not all alcohols are alike, and some are outright dangerous to use, besides being highly flammable. “Denatured” alcohol is ethanol (ethyl alcohol, also called grain alcohol) with additives to make it undrinkable (thus avoiding federal taxes). Additives may make it bitter, have a noxious odor, be poisonous, or a combination of all. The most common additive is methanol (a.k.a. methyl alcohol), another form of alcohol, which is highly poisonous, irritates sensitive tissue (eyes, lungs), affects the central nervous system, can be absorbed through the skin or affect the lungs when inhaled. In the beginning (think prohibition period) 10% methanol was generally used to “denature” ethanol; today 5% is more common. But some products have a much higher methanol content.

Most big box and hardware stores carry Kleen-Strip Denatured Alcohol in a blue can. Some cans say right on them “Fuel” because this stuff is meant as alcohol stove fuel, not shellac solvent. According to its Material Safety Data Sheet (MSDS), it is 45-50% methanol, 45-50% ethanol and 1-4% other ingredients. Sometimes is may simply say 30-60% methanol. There are other brands of denatured alcohol that are similar in composition. In fact, confusion abounds in names and numbers when it comes to labeling alcohol products.

Also, from its MSDS:

*Inhalation Acute Exposure Effects: Vapor harmful. May cause dizziness, headache, watering of eyes, irritation of respiratory tract, irritation to the eyes, drowsiness, nausea, other central nervous system effects, spotted vision, dilation of pupils, and convulsions.*

*Skin Contact Acute Exposure Effects: May cause irritation, drying of skin, redness, and dermatitis. May cause symptoms listed under inhalation. May be absorbed through damaged skin.*

*Eye Contact Acute Exposure Effects: May cause irritation*

What about alternatives? There are low- or no-methanol ethanol products available. For example, Kleen-Strip Green Denatured Alcohol in a green-labeled can is readily available at most big box and hardware stores, costs about the same as the blue-labeled can and contains 90-95% ethanol and less than 5% methanol, according to its MSDS. The green version is also labeled “Fuel.”
You may want to go further, however, for safety's sake. Remember, methanol can be absorbed through the skin or inhaled. Shellac guru Don Williams, former Curator of Furniture at the Smithsonian, once said that he will not have methanol in his shop, period! The amount of shellac in most non-commercial shops is not huge, so the extra cost of avoiding methanol altogether is not large. Furthermore, some claim that methanol is not as good a shellac solvent as ethanol anyway.

A shellac solvent is sold through Mohawk Finish Supply (mohawkfinishsupply.com), a site that also sends you to shellac.net. Mohawk markets a product called “Denatured Alcohol Shellac Solvent / Reducer.” The description references the product’s former name “Behkol” whose composition was ~91% ethanol with ~4% butanol and ~4% isopropyl alcohol.

Ethanol is mildly hygroscopic (absorbs water from the air) and only expensive lab or medical grade 200 proof (100%) supplies are essentially water-free. Butanol, like methanol, also can affect the central nervous system, but appears to be less toxic than methanol. Aside: Mohawk also sells a shellac retarder to slow shellac drying.

There are many alcohol products available at Amazon, paint stores, eBay, woodworking retailers, and big box stores. Most of them claim to be for use as a fuel, and some of them also list themselves as a shellac thinner.

Finally, there are products like Everclear 190 proof grain alcohol that sells for about $75/qal. Similar products can be found by searching for ethanol 190. Understand these are NOT denatured alcohol; they are made to be consumed. Still, they can be used as a shellac solvent without the denaturing methanol. However, some state regulations prohibit importing 190-proof ethanol.

Conclusions:

- Prolonged exposure to alcohol and, specifically methanol, is a serious health hazard. Protect yourself with gloves, goggles, and masks.
- Don’t drink and woodwork (with either hand or power tools).
- The choice is yours. Stay safe. Stay healthy.
FINISHING
When Should You Apply Finish? It Depends!

The Finishing Dilemma

By Andrew W. Davis

It’s a funny thing about finishing. By definition, finishing means to finish, which by most logic means finishing should be the last thing you do. But one of the things you learn as you do woodworking is that the order of tasks can be very important. The age old saying “measure twice and cut once” is a well-known example. Makes more sense than to cut once and then measure. So, most of the time you will adhere to the following order in any woodworking project.

Plan A

1. Make a plan and purchase materials
2. Cut parts to plan and prepare joinery
3. Glue and assemble the parts
4. Apply finish

But sometimes it makes sense to alter the order:

Plan B

1. Make a plan and purchase materials
2. Cut parts to plan and prepare joinery
3. Apply finish
4. Glue and assemble the parts

In other words, the project doesn’t end with finishing, it ends with assembly. There are a few good reasons why this might make sense. In the first case, the parts might be much easier to sand, stain, and varnish while they are separate. Think of a bookcase or a cabinet or closely spaced spindles. Once assembled, sanding all the surfaces of all the pieces can be physically challenging or even impossible. You may need to get into tight corners, blind alleys of an assembled cabinet, or in between or behind spindles. Much easier to be working with accessible, open surfaces.

There is one important point to bear in mind, however. Finished surfaces are not glue-friendly – that is, most finishes defeat the purpose of glue, which is why we use finishes in the first place. So, if you are joining pieces with a mortise and tenon connection or using dowels or a simple groove/rabbet/dado, you need to protect the joinery surfaces that will have glue applied after you apply finish. This is very important. Mortises can be protected with painter’s tape, as is also the case with dados; holes drilled for dowels can be temporarily filled with small bits of cling-wrap to keep out the finish and are easily removed later.
Another example applies to raised panel doors (and ship-lapped construction). With most raised panels, the center panel floats in grooves that are cut into the horizontal (aka rails) and vertical (aka stiles) frame pieces. Typically, the panel expands and contracts differently from the frame pieces so that changes in humidity over time will reveal unfinished panel edges. The solution is to apply finish to the full width of the panel before assembly.

Two other points are worth mentioning. i) No matter which path you choose, it is important to do a dry assembly (no glue) first to make sure that everything fits, that the order of assembly is correct, and that you have your clamps ready to go. All glues have a set time, so most gluing tasks are done under time pressure. Have everything ready and rehearse once or twice to be sure. ii) You might find the best solution is to follow Plan B for some of your project and Plan A for the rest.

As you can see, woodworkers don’t always finish last.
The Wonders and Utility of Shellac

It’s a finish, it’s an undercoat, it’s a sealer, it’s all three

By Randy Hock

Mario Rodriguez - “My first experience with shellac, at age 14, was a disaster. I almost ruined a bookcase I’d built, and I swore off shellac altogether. But in time I learned how to use it correctly, and today shellac is one of my favorite finishes.” In Finishing Wood, Editors of Fine Woodworking; The Taunton Press, 2017.

My first experience with shellac was very similar to Mario Rodriguez’s - it was a disaster. I did virtually everything wrong because of lack of knowledge and experience. I applied it with a brush, straight from the can on a hot, humid summer day. I thought it might be like varnish that I could go back over with a brush to let it flow out. Well, it really was a BAD experience. My objective in this article is to share what I have learned about shellac and to let you know that now it is my favorite finish method and almost always incorporated into the finishing process of my projects. Maybe you can avoid disasters and learn to love shellac as well.

What Is Shellac?

Shellac is a resin that originates as a sticky secretion of tiny lac insects. These insects deposit secretions on several varieties of bushes in Southeast Asia (India, Thailand, Myanmar). The word lac is an English version of the Hindi/Persian words for “hundred thousand” indicating the large number of insects necessary to produce lac - up to 100,000 to produce a pound of shellac. The twigs with insects and lac (stick lac) are harvested, ground up, and processed to extract the lac. The resulting seedlac is further processed to remove impurities and dyes before being made into buttons or flakes. It is these flakes that become the shellac we use in finishing.

Ancient Chinese and Indian civilizations used the dye extracted from lac for dying leather and cloth. The adhesive properties of the resin made it useful for sword hilts and setting stones in jewelry. It also was used in medicine as an emollient, treatment of bleeding gums, and repairing hooves of cattle and horses. Following Marco Polo’s journey to the Orient in the late 13th century, shellac and its by-products made their way to Europe as products for painters to both create and protect their masterpieces. In the early 19th century, a chemical process for chlorinating shellac was developed that produced an almost colorless shellac. The demand for this shellac led to increased production which was centered in Germany. William Zinsser was employed as a foreman in one of these plants. In 1849, he and his family emigrated to New York City and the first shellac bleachery in the U.S. began production (now manufactured in Attleboro, MA). This company makes Bulls Eye Clear Shellac (and others) which is a common finish available throughout North America.
What Types of Shellac Are Available?

Shellac is readily available as either dried flakes or as premixed alcohol-based solutions. The premixed variety comes in three forms from Zinsser: Clear Bulls Eye Shellac (the clearest), Amber Bulls Eye Shellac (light brown-yellow), and Bulls Eye Seal Coat. Both Clear and Amber Bulls Eye Shellac contain 3 - 5% natural shellac wax which give them a slightly milky appearance in the can and are sold as a three -pound cut concentration (see below). Bulls Eye Seal Coat is dewaxed and is sold as a two- pound cut.

BUYER BEWARE! You will not find a reference to the wax content on the can label for Bulls Eye Shellac. It is assumed that you know that shellac contains wax unless specifically dewaxed.

The “pound cut” is a term that is unique to the shellac world. It refers to the number of pounds of shellac dissolved in one gallon of alcohol. A 3-lb. cut contains about 29% shellac and a 2-lb. cut contains 21% shellac. For most of my finish work I use a 1-lb. cut. So, for both Clear and Amber Bulls Eye Shellac (3-lb. cut), I mix one part of the shellac with 2 parts of ethanol. For Bulls Eye Seal Coat (comes as a 2-lb. cut) I mix one part shellac with one part alcohol. For a 3lb.cut: Add 3 ounces of shellac flakes to 8 ounces of liquid ethanol.

Shellac also comes in a clear shellac spray (Zinsser’s Clear Bulls Eye Shellac) which can be very convenient for small projects or touch ups.

Processed shellac is available as flakes from a number of vendors (Woodcraft, Lee Valley, Shellac Shack, shellac.net) in both non-de-waxed and de-waxed forms in a variety of colors from super golden to ruby and garnet. (see image above) There are many advantages to mixing your own solutions of shellac. First, you can get the color you want (e.g. garnet on cherry or mahogany really brings out the tones of the woods). Second, you can make up the quantity you need and thus be less wasteful.
A Woodworking Primer

Third, you can use pure grain alcohol as the solvent. Pre-mixed Zinsser’s contains ethanol, isopropyl alcohol, methyl isobutyl ketone, and other proprietary chemicals (used to stabilize the shellac for a shelf life of over 3 years when unopened). The fourth advantage is the flakes remain stable for many years when kept dry, out of the sun, and in a temperate environment. The disadvantages of mixing your own are the need to acquire the flakes and ethanol and to have a scale that is reasonably accurate. Some well-known wood workers just estimate (see Mike Pekovich’s approach in his video cited at the end of this essay).

Shellac Strengths and Weaknesses

Shellac is remarkably water-resistant (not water-proof) and will remain clear for hours when exposed to water. Because it is soluble in alcohol, it should not be the final coat of finish in situations where it is likely to be exposed to alcohol (e.g. table tops in bars). It is not brittle like lacquer and does not scratch easily. It can be easily repaired or touched up by adding another coat. Shellac adheres very well to almost any other type of finish and almost any other finish will adhere well to a base of shellac. Bulls Eye SealCoat (dewaxed) was designed (and marketed) as a universal sealer to be used before the application of polyurethane, gel stains, and other finishes. I would recommend using dewaxed shellac just based on the potential delamination of subsequent non shellac finishes unless a sample is tested first.

Shellac is easy to use and can be applied with a brush, pad, wiping cloth, or sprayer. It dries quickly (minutes) and can be recoated and sanded in minutes. I often will use a 1-lb. cut and be able to apply 4-6 coats in a session. For small projects I may use a folded over white paper towel to pad it on with the grain overlapping each strip of application along the wet edge but not going back over the earlier strips. Often by the time I have finished with the first application, the initial side is dry and ready for another coat. Mistakes in finishing with shellac are often due to using too high a concentration of shellac or applying too thickly. Several light coats of 1 lb. cut can be applied in under an hour.

Shellac is the basis of French polishing which arguably is one of the most beautiful finishes but also one the most demanding in terms of effort and expertise. I have cited several videos below for this technique.

Shellac is non-toxic and is edible. The solvent evaporates quickly is not particularly toxic. (Ethanol is drinkable as well. An advantage of pure grain alcohol?) Many pharmaceuticals (and candy products) have coatings of shellac.

Shellac is an excellent stain/knot sealer and is impervious to odors. Because it is so easy to apply, I finish the inside of my drawers with it to prevent stains and odors from effecting the drawers. For projects to be painted, it is also an excellent first coat to seal the wood. Whether used as a sealer or first coat of final finish, the first coat of shellac dissolved in alcohol will raise the grain. You can raise the grain with a gentle wipe down with alcohol before applying the shellac and then gently sand to knock down the raised grain. Alternately, sand lightly with the grain after the first coat of shellac.
Shellac can be tinted by adding aniline dyes. There are times when you may decide color needs to be added to finish the wood. Liquid dyes (e.g. TransTint products) can be added to dewaxed shellac. You can apply as many coats as needed to get the color right.

Shellac is readily dissolved by diluted household ammonia or alcohol, making clean up easy. I have a few brushes dedicated to shellac use. When finished with the shellac session, I quickly rinse with a small amount of ethanol, shake them out, and set them aside. I rejuvenate them with a little ethanol before using the next time.

**Opinions from another woodworker**

Regarding my "love" of shellac. Assuming the goal is to put a durable film finish on a piece of furniture, I do not think shellac works well and I find it difficult to apply correctly. It's best to work with thinned shellac; the first couple of coats go on easily. I actually like shellac as a sanding sealer; it "freezes" the wood fibers so that you can sand your wood to a glass-like smoothness. But to build up a good finish with shellac, you need to put on many (some say 12 coats. In applying these coats, you need to lay on the finish using a wet edge or else you get streaking. You need to be careful not to go over a brush stroke (e.g., to pick up some excess shellac or touch up a dry spot) or you will damage the smoothness of the finish. I find keeping a wet edge on a complex project next to impossible. When you rub out each coat (or every other one) you need to be careful with your sanding – too much rubbing (heat) will soften the coat and gum up the paper. Finally, after you're all done, the shellac finish is not very protective - a glass of ice water or a drop of a martini will damage the finish (although the finish can be repaired.). As an aside, I love the white pigmented shellac primer made by Zinnser for priming a surface I am going to paint. JKG

**Shellac References**

The Story of Shellac is an excellent review of shellac which was written in 1913 and is available on line: [https://www.naturalhandyman.com/iip/infpai/shellac.html](https://www.naturalhandyman.com/iip/infpai/shellac.html) and [https://archive.org/stream/TheStoryOfShellac/TheStoryOfShellac1928cm16p230001_djvu.txt](https://archive.org/stream/TheStoryOfShellac/TheStoryOfShellac1928cm16p230001_djvu.txt)

Another article by Don Williams a noted furniture conservator is excellent as well. [https://s3.amazonaws.com/theBarn/Articles/Finishing/Williams%2CDon-Shellac_Finishing.pdf](https://s3.amazonaws.com/theBarn/Articles/Finishing/Williams%2CDon-Shellac_Finishing.pdf)

Mike Pekovich: [https://www.youtube.com/watch?v=k4_sIrEfdKM](https://www.youtube.com/watch?v=k4_sIrEfdKM)

Paul Sellers: [https://www.youtube.com/watch?v=UssYj-98oCg](https://www.youtube.com/watch?v=UssYj-98oCg)

Videos demonstrating techniques of French polishing with shellac:

French polishing by Patrice Lejeune: [https://www.youtube.com/watch?v=web_pJt0SR8](https://www.youtube.com/watch?v=web_pJt0SR8)

French polishing the German way, Fabian Hentschel [https://www.youtube.com/watch?v=MxRIPkzgUTM&t=6s](https://www.youtube.com/watch?v=MxRIPkzgUTM&t=6s)
What is Varnish?

Confusion reigns

By Randy Hock

The word “varnish” is often used as a generic term for any type of wood finish, including polyurethane (water-based and oil-based), lacquer, and shellac, but it technically refers to a specific combination of resins, oils, and solvents. Some, for example, refer to polyurethane as a synthetic varnish; others will claim that varnish has advantages over polyurethane because varnish has a higher ratio of solid material, making it more resistant to moisture and ultraviolet rays.

If you go shopping for varnish, you will find products with names like spar varnish, table-top urethane varnish, oil-based marine varnish, varnish oil, flat, satin, and gloss varnishes, water-based high-performance varnish, crystal clear solvent-based varnish, and more. You will also find many products that just use the word “topcoat.”

An object that has been varnished has a clear transparent, hard protective coating or film on its surface. In woodworking, varnishes are used to protect surfaces from water, solvents, dirt, and microbes, as well as to impart added beauty. Unlike paint, varnishes generally highlight rather than obscure the grain of the wood.

Varnishes have been around for thousands of years. Varnishes were used on mummy cases in ancient Egypt. Originally, varnishes were composed of a resin mixed with a solvent but over the centuries many modifications have been made involving linseed oil, tung oil, walnut oil, mineral spirits, amber and other elements. In general, varnish has three major components: a resin, a drying oil, and a solvent. Sometimes a drying agent is added.

The method of drying divides varnishes into three classes:

- Spirit varnishes which dry via evaporation alone (alcohol and turpentine-based finishes),
- Oil varnishes which contain drying oils that dry or harden slowly by oxidation and other chemical reactions as well as some evaporation (linseed and tung oil based varnishes)
- Synthetic resin varnishes. The best example of a spirit varnish is shellac in alcohol.

Varnishes may contain resins from a variety of sources, either fossilized (amber, copal) or living trees (kauri gum, dammar, rosin (colophony or pine resin), sandarac, balsam, elemi, and mastic).

Varnish may also be created from synthetic resins such as acrylic, alkyd, or polyurethane. Since many of the resins are poorly soluble in oils and solvents, the production of varnish involves heating or “cracking” the mixture in controlled ways. After application, the varnish can be very slow to dry so “driers” (lead, manganese, and other heavy metals) are added to the recipe. Even so, some varnishes may take weeks to finally harden.
Newer, synthetic-based varnishes have been produced that use alkyd, polyurethane, epoxy, and phenolic polymers. In general, these varnishes are composed of a resin (or mixture of resins), a solvent (mineral spirits or turpentine) and an oil [boiled linseed oil or tung oil along with a drying agents.

Some varnishes are designed for particular applications. Spar varnishes are intended for outdoor use in which a lot of wood movement (flexing, compression) is expected. Marine varnishes are intended to be resistant to salt water, extremes in temperature, and sun-exposure. Hence, they include UV protectants and surface stabilizers.

A legion of “wiping varnishes” are available for purchase or can be made simply. One mixture is attributed to Sam Maloof and is a mixture of 1/3 linseed oil (BLO), 1/3 raw tung oil, and 1/3 semigloss urethane varnish. Another approach is to dilute the varnish of your choice with mineral spirits 50-50.

The newest kids on the block are “water-based varnishes” or “emulsion varnishes.” In these cases an emulsifier is used to mix the resins, oils and water. The advantages are easy clean-up, low VOC, and they dry clear. Oil-based varnish often adds a yellow or amber tone. A disadvantage to the water-based products is that they tend to have much lower solid content so more coats are necessary to achieve the same degree of protection.


Changing the Color of Wood

Stains, Dyes, and Chemicals

By John George

There are many products on the market for coloring your wood project. Depending on the type of coloring agent you use, you can color your wood just about any color you choose. However, most colorants aim to give the wood a “natural” wood color (i.e., shades of brown, black, or gray). The majority of wood colorants available to the consumer are either stains (penetrating and gel stains) or dyes, both of which are good choices for both beginner and experienced woodworkers alike. Chemicals can also be used to color wood, but because of safety concerns and availability issues, this topic will be discussed only briefly.

There is a group of colorants I will call “home brews” that a few woodworkers use as well to color wood. These include such things as torch charring, vinegar, water and rusty nail mixtures, coffee (instant and brewed), nut shells soaked in water mixtures, etc. These colorants might be fun to experiment with, but I would not recommend them for the beginner as the results may be inconsistent, the formulas and methods are often proprietary, and the knowledge base for dealing with problems is limited.

Whatever method you choose to color your wood, it is a good practice to make a test panel of your finishing process. Preferably, you will use a scrap of the same wood used to build your project and will go through the complete finishing process including all the steps you will use including topcoat (not covered in this article). You have invested a lot of time, effort, and money in your project. The test panel is the place to make your mistakes; it would be a shame to ruin your project because you are using an unfamiliar finishing process. Once you have “mastered” a finishing process with results that please you, you can often skip the test panel unless you are using a different wood species.

This article does not purport to cover all of the products and methods available for coloring wood as the author’s knowledge and experience is limited to the more common types of colorants. Note, most wood colorants are available using various different bases; typically oil, water, or alcohol. Because these bases effect the way a colorant is applied as well as its characteristics, you cannot assume that the information provided in this article is useful for anything other than the specific product mentioned.

Oil-Based Stains

The workhorse product for coloring wood is the oil-based stain family which is sold under many brand names including MinWax and Varathane. These stains are readily available at most paint, hardware, and big box stores. Stains color the wood by depositing pigments in the pores of the wood. For a beginner, oil-based stains are a good way to color your wood project; it’s hard to
fail using an oil-based stain. There are water-based stains (different from water-based dyes) available but I have no experience working with them.

Oil-based stains come in two varieties: “regular” (liquid – frequently labeled as a penetrating stain) and gel. Regular stains will penetrate wood to some extent but most of the color from the stain tends to reside on the surface of the wood. Gel stains are formulated basically the same as regular stains but with a thickener added to make them gel-like. Gel-stains, because they penetrate even less than regular stains, are useful in reducing splotching on certain splotch prone woods such as cherry and maple. Using a gel-stain to color a vertical wood surface is an advantage because it is less likely to run than penetrating stain. Gel stains can also be used as a glaze when applied over wood that has been sealed. This is commonly done with a coating of de-waxed shellac to highlight nooks and crannies of a project. Another glazing effect can be obtained by using water-thinned latex paint instead of gel stain.

Both regular and gel stain have strong odors that linger while they dry which usually takes from 8 to 24 hours (before top coating). Some stains claim to dry quicker but I am skeptical. Another nice feature of oil-based stains is that they do not raise the grain of wood (this may not be true for water-based stains), so finishing is simplified. Other than the differences mentioned above, regular and gel stains are used in about the same way; for the rest of this discussion I will refer to them collectively as stains.

Manufacturers claim that you can darken the first coat of stain by adding a second coat. In my experience, the darkness of the stained wood changes little with a second coat. This can be an advantage because you can apply a second coat of stain as a means of getting those spots you missed when applying the first coat without significantly changing the wood’s appearance. Streaking is not a problem with stains because of their slow drying time. If you stain your work before assembly, try to keep the stain off parts that are to be glued. Some articles I have read suggest that the stain will weaken the glue joint; practically, I have not experienced this problem. But better to be sure than sorry.

Before applying stain, sand your wood up to 220 grit. Stains can be applied with either a brush or rag with equally good results. I prefer using a rag as it is less likely to leave a puddle of finish that I will need to wipe up before it dries. After applying the stain and letting it penetrate for a few minutes, wipe away any excess stain with a clean rag. It is important to remove the excess stain before it dries as dried stain will look more like paint than stain. With open-pored wood such as oak, I have found that after the stain has dried there may be small dots of stain on the surface where the stain has oozed from the pores of the wood. Often these dots can be simply wiped away if it has not been too long since the stain was applied. If you should miss cleaning

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3 What is a splotch? Merriam Webster’s Collegiate Dictionary is no help, so I’ll give it a try. A splotch is an area located amongst the long grain of a board where the grain has the look of end grain. The effect is that it absorbs stain like end grain and is consequently darker than the surrounding long grain.
up these dots or a puddle of stain before it dries, wetting a rag in the stain and rubbing the
dried dots/puddles will often eliminate the problem.

Before top coating the stain, particularly with a water-based finish, allow at least 24 hours for
the finish to dry thoroughly. (Give it the sniff test – if you can smell the stain, it has not fully
dried.) Finally, you have heard the stories of fires started from oily rags due to spontaneous
combustion. The rags you use to stain your work are oily rags (unless you used a water based
stain). I usually dry my oily rags by hanging them on the side of my shop trash barrel in a single
layer. This allows them to dry thoroughly without building up any heat which is what causes a
fire.

Dyes

My favorite way to color wood is to use water-based dyes. Dyes are less commonly used than
stains to color wood and consequently usually need to be purchased through a
store/website/catalog specializing in woodworking products (e.g., Woodcraft, Klingspor’s
Woodworking Shop, Highland Woodworking, etc.). Unlike stains, dyes do not imbibe pigment
particles in the pores of wood but actually dye the cells of the wood (and your fingers if you do
not wear gloves). Modern dyes are consumer safe and do not require special handling or safety
considerations. There are alcohol-based (non-grain raising) and water based (grain raising)
dyes. Though uncommon, there are oil-based dyes (not stains) available, but I have no
experience working with them.

Dyes are inexpensive, have no smell, dry quickly, have a very long shelf life (I am still using a
walnut dye I bought over 40 years ago.), come in many colors (including those no decent piece
of furniture would be caught dead wearing), can be intermixed with other like-type dyes for
unique colors; have better penetration than oil-based stains; can be lightened or darkened even
after application; etc. Unlike stains, dyes will not weaken a glue joint if you choose to dye your
work before you glue it together. The best feature of dyed wood is that the grain shows
through the dye perfectly. Working with dyes as opposed to stains is more work and requires
more steps but, I think, the benefits outweigh the extra work.

The disadvantages of water-based dyes are that they raise the grain and, if not applied
properly, can create a streaky coloring of your wood. Alcohol-based dyes do not raise the grain
of wood, but they are more sensitive to fading from sunlight, have a more limited selection of
colors to choose from, and are more difficult to work with (e.g., require alcohol as a thinner, dry
very fast, are less readily available, etc.).

Less conventional uses of water-based dyes include being added to water-based topcoats as a
toner and coloring epoxy and PVA glue (e.g., Titebond). Water-based dyes are available as a
liquid (e.g., Trans-Tint Dyes) or a dry powder (e.g., J.E. Moser’s Aniline Dyes); both are designed
to be added to water (or epoxy) to achieve the color strength desired by the user.
A Woodworking Primer

To start using water-based dyes, mix a pint/quart of dye solution according to the manufacturer’s directions. This we will call the “base” solution. With scraps of wood from your project, try different dilutions of the base solution until you find a color strength that is close to what you want. Use small amounts for this process, e.g., a tablespoon of base solution and three tablespoons of water. (Distilled water is probably best but tap water will do.) View the color while the sample is wet. The sample will eventually dry to a very dull finish but don’t let that concern you; under a clear topcoat the color will come alive. Once you have settled on the desired dilution, make up a pint/quart of the dye solution and label it with all the dilution details so that you can replicate it in the future. This diluted solution will last you for many projects and it will not deteriorate.

Before applying the dye solution, sand your wood up to 220 grit. Mix up a solution of 50% Zinsser Seal Coat (a 2 pound cut dewaxed shellac) and 50% alcohol. This creates a sanding sealer. Brush or wipe your sanding sealer onto your wood being careful to apply a thin, single coat. After a few hours of drying, the sanding sealer will “freeze” the fine wood fibers and allow you to re-sand your wood again up to 220 grit. At this point, your wood will feel like glass. Too bad you cannot stop here but you have not colored the wood yet.

The dye solution can now be applied with either a brush or rag. I use a brush for getting into tight corners and molding profiles. I prefer using a rag for the broader areas as it is easier to blend your strokes. You want to attempt to maintain a wet edge. This is not always possible, but with a rag wet with the dye solution, it is relatively easy to blend the dry area with the wet area. Let the wood dry; it will be appear very dull but do not despair. If the color is not dark enough (viewed wet), add a second coat of dye solution. If it is too dark, wipe down your wood with a rag wet with water.

The next step is recommended if you intend to brush on a water-based topcoat. This is important - apply (with a rag) a coat of Watco natural Danish oil. A rag as opposed to a brush is better at applying a thin coat. (A thin coat dries faster.) You will immediately notice the dyed grain “pop.” Besides making the grain stand out, the Danish oil provides a barrier between the water-based dye and the water-based topcoat. Without the Danish oil, a brush wet with a water-based topcoat can cause the dye to bleed into the topcoat. If you use spray equipment or an oil-based topcoat this bleeding is not a problem. I do this step even though I spray on a water-based polyurethane topcoat; I think it makes the grain “pop” better. It is important, no matter what topcoat you use, to let the Danish oil thoroughly dry before top coating. Use the smell test mentioned above to test for dryness.

Chemical Coloring Agents

Various chemicals, such as potassium dichromate, ammonia, and lye, can be used to color wood but are not recommended for use by beginners as they often introduce health risks. The
Varathane⁴ brand is one brand that offers a consumer safe type of chemical colorant they call an “accelerator.” It creates a chemical reaction between the tannin in the wood and the chemicals in the accelerator. Another method of coloring wood used sometimes in the finishing of Craftsman style furniture, called “fuming,” also relies on creating a chemical reaction with the tannin in wood. Fuming involves the use of industrial strength ammonia which can be hazardous to your health and is not something a beginner should attempt.

Varathane’s accelerator is relatively new and appears to be not as widely available as other finishing products. I have only experimented with it and have not used it to finish any project. Accelerator is available by the quart from a Varathane dealer (e.g., Home Depot). It has the consistency of water, goes on clear, has no odor, and is water based. Over about one hour it reacts with the tannin found in wood to create the desired effect. The color is very uniform and its intensity varies based on the species of wood used. Hopefully, your desired color is either gray or brown as I have seen no other choices. The product is designed to work on bare wood. After a couple of hours, a second coat of accelerator may be added to darken the wood’s color. If a topcoat is desired, sprayed lacquer is recommended. It is recommended that if a polyurethane finish coat is required, a lacquer spray coat be applied first.

Conclusion

Coloring wood can be a lot of work. Many woodworkers opt for just letting the natural beauty of the wood show through, “au naturel”. Others will color their work using a pigmented topcoat. (A shame - obscures the wood grain!) Clearly, the oil-based stains are the easier approach to coloring wood. However, if you appreciate the subtleties of wood grain and want greater control over the coloring process, it is worth the effort to try using dyes instead of stains. Though there are more steps to using dye, I do not think any of the steps are beyond the skills of a beginning woodworker.

⁴ Varathane sells oil-based and water-based stains as well. The “accelerators” are marketing as water-based treatments to provide an effect such as aging, weathering, or charring.
What Is Milk Paint?

A time-honored finish

By Rob Carver

If you are fond of old-school approaches, you can’t do better than milk paint. A favorite of Shakers and Windsor chairmakers, this non-toxic blend of water, casein, lime, clay, and pigments is both durable and versatile. Milk paint was well-known in ancient Egypt and has been found in the pyramids. Milk paint has no volatile organic compounds (VOCs), no nasty disposal issues, no fire risk, and cleans up with soap and water. It can be used by itself to apply a flat solid color or as an undercoat to a glaze to produce an antique effect.

Don’t be fooled by the name: casein is a protein extracted from milk, but there’s no milk in the paint and you definitely don’t want to pour it on your corn flakes. Depending on how you mix and apply it, you can achieve different effects from a thin color wash coat to a flat opaque finish. Before reading any further, please note that you can find ready-mixed cans labeled as milk paint. Buy it if you like, but that’s not what this article covers. Everything here refers to a powdered product that you mix in small batches as needed.

Milk paint powders are available from multiple vendors in different colors and price points.

A milk paint finish can take a beating. It adheres well to bare wood surfaces and some manufactured products like MDF. The lime-casein combination reacts with water to form a concrete-like coating that cures over time. Rather than chipping with use, it tends to burnish and may wear away to reveal coats below. This is a virtue that can be used to advantage.

It pays to experiment!

The following few paragraphs provide basic advice, but you will want to make test boards, preferably from the same materials as the item you plan to paint. Experiment with water-powder proportions, surface preparation, number of coats, and topcoats. Milk paint powder comes in numerous colors, and you can create custom colors by blending factory colors.
A Woodworking Primer

Chairmakers sometimes build up layers of different colors, and then lightly sand the topcoat to reveal a contrasting hue that simulates decades of aging.

Mixing the paint
In powdered form, milk paint has an indefinite shelf life if it is kept sealed and dry. Once mixed with water, it should be used or discarded within a day or two. This is because the casein in milk paint will spoil. Ordinarily, combine one part water with one part powder and agitate very well until dry clumps are dissolved. A thinner blend is preferable to thick. A wide-mouthed glass jar with a tight lid works well. Allow the bubbles to break, and wait a few minutes for all the powder to dissolve, and you are ready to go. Some authors recommend pouring through a paper strainer, but opinions differ about this step, as they do with most milk paint advice. Whether or not you strain, while you are using the paint, the solids will settle. Expect to stir periodically as you go.

Surface preparation and paint application
You want to use milk paint on bare wood. Sand the wood to 120-, 150-, or 180-grit (again, opinions vary) and remove all dust. You are not looking for a silky-smooth finish. Some authorities recommend wetting the surface with water and letting it dry to raise the grain and then knock off nibs with a light sanding. Others wet the surface lightly and then start painting.

Grab a cheap disposable bristle brush to lay down the first coat. Painting with milk paint is a unique experience. Because wood absorbs the paint, it does not flow like other paints. You’ll need to reload your brush often, and it may feel like you are dabbing and daubing more than you would with other finishes. Work the paint into the surface. Also—and this is very important—expect to be horrified by the appearance of your first coat when it dries. The color will lighten as the paint dries, and it will look splotchy and, in the words of Windsor chair guru Mike Dunbar, “the first coat will look like something the cat dragged in.” Keep calm and carry on. Dunbar recommends letting it dry thoroughly and then rubbing down with a maroon Scotch-Brite nylon pad. Others advise 220-grit sandpaper or 0000 Steel wool. If you use steel wool, it is critically important to remove fine iron residue (unless you are after an authentic rusty hue). Then apply a second coat.

Continue to apply a third or fourth coat, rubbing out between coats, until you achieve the look you are seeking. Spend some time online to research traditional color combinations and uses. Milk paint dries to an exceptionally flat appearance, so you may want to brighten things up by applying a layer of oil or wax.

For such a topcoat you can prepare your own custom blend of mineral spirits and boiled linseed oil, or use a Danish oil or similar commercial product like polyurethane (flat or matte finish is best). This author used wiping varnish to good effect, and any paste wax can also serve to protect the finish and give it a gentle glow.


A Woodworking Primer

Lessons Learned

This author has used milk paint on several shaker tables as well as Windsor chairs, and have been consistently pleased with the results. Mix up what you can use in a day and then toss the rest, making a fresh batch for the next coat. Discarding a small amount is better than trying to use spoiled paint.

Making test pieces truly is worth the time and effort. A thin layer of paint dries quickly, and before long you can see and compare a bunch of color combinations and overcoats. Once you have a recipe that you like, go for it. Milk paint is a forgiving finish, especially when you take your time, sand between coats, and let the finish build.
OTHER RESOURCES
Resources for Woodworkers

Woodworking Specialty Vendors

Garrett Wade.com
Infinity Tools
Lee Valley
Rockler
The Woodsmith Store
Woodworkers Source

Highland Woodworking
Klingspor
Peachtree Woodworking
The Lumber Shack
Woodcraft
Woodpeckers

Vendors that have Some Woodworking Products

Harbor Freight Tools
Home Depot
McFeelys

Lowe’s
Garage Organization

Magazines

Woodworker’s Journal (Rockler)
Woodsmith Magazine
Fine Woodworking
Mortise & Tenon Magazine

Wood Magazine
Woodcraft Magazine (Woodcraft)
Popular Woodworking

Websites and Other

Epic Woodworking
The Wood Whisperer
https://paulsellers.com/
Handtoolschool.net
Toolsforworkingwood.com

Stumpy Nubs
Robcosman.com
Woodtalkonline.com
Kmtools.com (Jonathan Katz-Moses)
toolorbit.com

- https://www.theunpluggedwoodshop.com/ (requires membership)
- Renaissance woodworker https://www.renaissancewoodworker.com/
- The Handtool School https://www.handtoolschool.net/
- Christopher Schwarz, author of many books, magazine articles, and youtube videos
- https://lostartpress.com
A Woodworking Primer

- The Woodworker’s Pocket Book by Charles H Hayward (sold by Lee Valley)
- [https://woodschool.org/videolibrary/](https://woodschool.org/videolibrary/)

Lumber Suppliers in Eastern New England

- Anderson McQuaid (Cambridge, MA)
- Atlantic Plywood (Woburn, MA)
- Boulter Plywood (Somerville, MA)
- Cripnik Portable Sawmill (Wilmington, MA; 978-726-2397)
- Downes and Reader (Stoughton, MA)
- Highland Hardwoods (Brentwood, NH)
- Readers Hardwood Supply (East Taunton, MA)
- Holt and Bugbee (Tewksbury, MA)
- Ralph Southwick Lumber (Barre, MA; 978-355-4042)
- The Woodery (Lunenburg, MA)
- Yankee Pine Lumber Co (Rawley, MA)